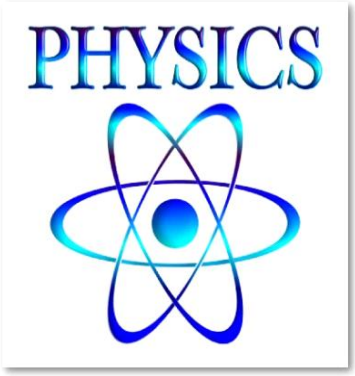
Al-Abbas Notes Physics 1st year

(Volume-1 chapter 01 to 05)

An Easy approach to objective as well Subjective

This booklet contain

- ✓ Short and Extensive Questions & Answers from topics
- ✓ Solved exercise short questions
- ✓ Solved numerical hints
- ✓ Solved BISE past papers mcqs
- ✓ Tid bits/useful information from text book in mcqs form



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Chapter 01 INTRODUCTION TO PHYSICS

What is Natural Philosophy?

The study of nature and its phenomenon in orderly manner is called Natural philosophy. It is earlier observations of man about the world around him.

Give the Classes of Study of nature OR What is difference b/w Biological and Physical science

The study of nature is further divided into two branches

Biological sciences	Physical sciences
The study of living things is called biological sciences.	The study of non-living thins is called physical sciences
For example Zoology, botany etc.	For example physics, chemistry, math

Define Physics.

The branch of Science which deals with the study of matter, energy and their relationship is called **physics**.

Write the Main frontiers of fundamental sciences.

There are **three** main frontiers of fundamental sciences

i. The world of **largest** things like universe
ii. The world of **smallest** things like electrons protons etc.
iii. The world of **middle** sized things, from molecule to Earth. These frontiers are heart of fundamental science.

Give the Areas of Physics?

There are two areas of physics

Disciplinary Areas of Physics: These are the pure branches of Physics like Mechanics, optics, sound etc.

Interdisciplinary areas of physics: These are the branches of Physics link with other fields of sciences like Bio Physics, Astro physics, Chemical Physics.

Define the Branches of Physics (Nuclear, solid state, particle physics and Relativistic mechanics).

There are many Branches of Physics, some of branches are as follows

- The branch of physics which deals with study of atomic nuclei is called **nuclear physics**
- The branch of physics which deals with study of structure and properties of solids is called **solid state physics**.
- The branch of physics which deals with elementary particles/ultimate particles is called **particle physics**
- The branch of physics which deals with motion of such objects whose speed is approaching the speed of light is called **relativistic mechanics**.

❖ **Mass is form of energy. How much energy is obtained from one kilogram mass?**

$\text{mass} = 1\text{kg}, C = 3*10^8\,\text{m/s}, E = ?$

$E = mc^2 = 1*(3*10^8)^2 = 9*10^{16}\,\text{J}$

❖ **What is light year? Write its value.**

The distance which light travel in one year is called light year. Its value is $9.5*10^{15}$ m.

Give the Importance/Role Of Physics in few lines.

- Physics plays an important role in the development of science and technology
- information media and fast mean of communication made the world global village
- The computer networks are product of **silicon chips**
- Silicon is obtained from **sand**

1.2 PHYSICAL QUANTITIES

What are Physical Quantities? Give examples

All measurable quantities are called Physical quantities like mass, temperature, force etc. It has two types, base quantities, and derived quantities.

What are Base Quantities? Give examples.

"The quantities which are not derived from other quantities are called base quantities". Like mass, length, time etc.

What are Derived Quantities? Give examples.

The quantities which are derived from base quantities are called derived quantities. For example force, velocity, acceleration etc.

What are the Steps For Measurement Of Physical Quantity?

There are two steps for measurement of physical quantity

i. Choice of standard
ii. To establish procedure to measuring physical quantity

What are the Characteristics Of An Ideal Standard?

There are **two** characteristics of an ideal standard

i. It is accessible
ii. It is invariable

What is International System Of Units? From which types of units it is built up from?

A system that was established in 1960 which describe the units of physical quantities is called SI. It is built up from three types of unit's base, derived and supplementary units.

Define Base Units. Write the table for base units.

The units of base quantities are called base units. There are **seven** base units in SI

No	Quantity	Unit	Symbol
01	Length	Meter	m
02	Mass	Kilogram	kg
03	Time	Second	s
04	Temperature	Kelvin	k
05	Electric current	Ampere	a
06	Intensity of light	Candela	cd
07	Amount of substance	Mole	mol

Define Derived Units. Give examples.

The units of derived quantities are called derived units. Like unit of force is newton, unit of pressure is Pascal.

What are Supplementary Units? OR Define Radian and Steradian.

"The units which were not classified in SI as either base or derived units called supplementary units". There are **two** types of supplementary units which are as follows.

Radian: Plane angle b/w two radii of a circle whose arc length is equal to radius of circle is called radian. It is two dimensional angle.

Steradian: Solid angle subtended at the center of sphere whose area is equal to square of its radius is called Steradian. It is three dimensional angle whose value is 4π.

Quantity	Unit	Symbol	Value	Dimensional
Plane angle	**Radian**	Rad	2π	Two
Solid angle	**Steradian**	Sr	4π	Three

What is Scientific Notation? give example

Such a technique in which numbers are expressed in standard form by using the power of ten is called scientific notation. Like 134.7 is written as $1.347*10^2$, 0.0023 is $2.3*10^{-3}$.

Write the Conventions for indicating units?/ Rules for writing units.

There are following conventions of indicating units

i. Full name of unit does not starts with capital letter if named after scientist e.g newton, ampere etc
ii. The symbol of unit after a scientist has initial capital letter e.g N for newton
iii. Prefixes should be used before unit like mA, micro meter etc
iv. Combination of base unit is written with one space apart e.g N m
v. Compound prefixes are not allowed, $10^{-3}*10^{-3}$ A, we cannot write it mmA. Its correct form is 10^{-6}A(microA)
vi. When a multiple of base unit is raised to power of ten then power is applied to whole multiple not on base unit alone like $1Km^2=(10^3m)^2=10^6m^2$.

PREFIXES TABLE					
Prefix	**Factor**	**Prefix**	**Factor**	**Prefix**	**Factor**
Atto	10^{-18}	Milli	10^{-3}	Killo	10^{3}
Femto	10^{-15}	Centi	10^{-2}	Mega	10^{6}
Pico	10^{-12}	Deci	10^{-1}	Giga	10^{9}
Nano	10^{-9}	Deca	10^{1}	Tera	10^{12}
Micro	10^{-6}	Hecto	10^{2}	Peta	10^{15}
				Exa	10^{18}

What is error? Write causes of error also differentiate b/w Random error and Systematic error.

Error: Difference of actual and observed value is called error. Error=Actual value- observed value

Causes of error: There are following causes of error

i. Negligence of person
ii. Inexperience of a person
iii. Faulty apparatus
iv. Incorrect method or technique

Types of Error: There are following types of errors

Random Error	Systematic error
Such an error which occur when repeated measurements give different values under same condition is called **random error**.	Such an error which occur due to faulty apparatus as zero error in instrument is called **systematic error.**
It is removed by taking the average of several readings.	It is removed by applying correction factor.

What are Significant Figures? Write the rules of significant figures. Also describe the rules for rounding off a number

Definition: In any measurement, the accurately known digit and first doubtful digit are called significant figures.

Rules of significant figures: There are following rules of significant figures

i. All digits 1,2,3,4,5,6,7,8,9 are significant
ii. Zero may or may not be significant
iii. Zero b/w two significant figure is significant like 102, 1.003 etc.
iv. Zero to left of significant figures is not significant like 0.003 has one significant
v. Zero to right of significant figures may or may not be significant, in decimal fraction zero to right is significant like 3.40, in this 0 is significant but in case of integers it is found by accuracy of measuring instrument.
vi. In measurement in scientific notation, the figures other than the power of ten are significant like $8.70*10^3$ has 03 significant figures

Rules for Rounding off a Number: There are following rules of rounding off a number

i. If the first digit is less than 5 then last digit retained should not change. i.e. 3.23 is round off as 3.2
ii. If the first digit is greater than 5 then last digit retained is increased by one like 3.56 is round off as 3.6
iii. If the last digit is 5 then previous digit is increased one if it odd, and no change if it is even like 3.75 as 3.8 and 3.45 as 3.4

Important rule: In multiplying or dividing numbers, keep a number of significant figures in the product or quotients not more than that contained in the factor containing least number of significant figures. Also in addition and subtraction For example

$\frac{5.348*10^{-2}*3.64*10^{4}}{1.336}=1.45768982*10^{3}$, In this the factor $3.64*10^{4}$ least accurate three significant figures so the answer should be written up to three significant figures so correct ans is $1.46*10^{3}$

$72.1+3.42+0.003=75.523$ is rounded off as 75.5, $2.7543+4.10+1.273=8.1273$ is rounded off 8.13

What is Precision And Accuracy? OR What is difference b/w Precision and Accuracy?

Precision	Accuracy
The least count of measuring instrument is called precision and measurement which has less absolute uncertainty is called precise measurement	The measurement which is less fractional or percentage uncertainty is called accurate. This property is called accuracy.
Smaller the least count more precise will be the measurement.	Accuracy means how a measured value is close to the actual value

What are Absolute uncertainty, Fractional uncertainty and Percentage uncertainty?

These have following formulas

Least count= Absolute uncertainty,
For example least count of Vernier calipers is 0.1 cm this is absolute uncertainty or precision

$$\text{Fractional uncertainty} = \frac{\text{least count}}{\text{measurment}}$$

$$\text{Percentage uncertainty} = \frac{\text{least count}}{\text{measurment}} * 100$$

Example 01: For example for instrument L.C=0.1 Cm Measurement=25.5cm calculate uncertainties

Absolute uncertainty= 0.1 cm

$$\text{Fractional uncertainty} = \frac{0.1\,\text{cm}}{25.5\,\text{cm}} = 0.004 \qquad \text{Percentage uncertainty} = \frac{0.1\,\text{cm}}{25.5\,\text{cm}} * 100 = 0.4\%$$

Example 02: For example for instrument L.C=0.01 Cm Measurement=0.45 cm calculate uncertainties

Absolute uncertainty= 0.01 cm

$$\text{Fractional uncertainty} = \frac{0.01\,\text{cm}}{0.45\,\text{cm}} = 0.002 \qquad \text{Percentage uncertainty} = \frac{0.01\,\text{cm}}{0.45\,\text{cm}} * 100 = 2\%$$

Assessment Of Total Uncertainty In Final Result

The total uncertainty in the final result is calculate in different cases, which are as follows

i. In case of Addition and Subtraction

Rule: "Absolute Uncertainties are added".

For example, distance $x_1=10.5\pm0.1$cm, $x_2=26.8\pm0.1$cm, then $x=x_2-x_1=((26.8-10.5)\pm(0.1+0.1))=16.3\pm0.2$cm

ii. In case of Multiplication and Division

Rule: "Percentage uncertainties are added"

For example:

$V = 5.2 \pm 0.1\,\text{V}$ $\quad I = 0.84 \pm 0.05\text{A}$ Calculate the value of of R with uncertainty

$$\%\ \text{uncertainty in V} = \frac{0.1}{5.2} * 100 = 2\% \qquad \%\ \text{uncertainty in I} = \frac{0.05}{0.84} * 100 = 6\%$$

$$R = \frac{\text{V}}{\text{I}} = \frac{5.2}{0.84} = 6.19 \approx 6.2 \text{ and in this \% uncertainties are added so total uncertainty} = 2\% + 6\% = 8\%$$

correct value of $R = (6.2 \pm 8\%)$ ohm OR $R = 6.2 \pm 0.5$ ohm As (8% of 6.2 is 0.5)

iii. In Case Of Power Factor

Rule: Multiply the percentage uncertainty by that power

For Example: consider we want to calculate the volume of sphere then % uncertainty in Volume is calculate by the formula as the volume of sphere=$4/3\pi r^3$ so

%uncertainty in volume= 3*%uncertainty in radius(r)

If there area of sphere then $A=4\pi r^2$, %uncertainty in area=2*%uncertainty in r

Suppose if in measurement we have percentage uncertainty in radius is 2%, then we have

%uncertainty in Volume=3*2%=6% and % uncertainty in Area=2*2%=4% etc.

iv. In Case of average value of Many Measurement

Rule: Uncertainty in average value is the mean deviation

This rule is explained by following solved example

Six readings of micrometer screw gauge to measure the diameter are 1.20, 1.22, 1.23, 1.19, 1.22, and 1.21

Step 01: Find the average value of measured values

$$\text{Average} = \frac{1.20+1.22+1.23+1.19+1.22+1.21}{6} = 1.21\,\text{mm}$$

Step 02: Find deviation of each measured value from average value (take difference of each value and average value) which is 0.01, 0.01, 0.02, 0.02, 0.01, and 0.00

Step 03: To calculate the mean deviation

$$\text{Mean Deviation} = \frac{0.01+0.01+0.02+0.02+0.01+0.00}{6} = 0.01\,\text{mm. This is uncertainty}$$

v. In Case of timing Experiment

Rule: The uncertainty in timing experiment is calculated by dividing the least count of stop watch by number of vibrations i.e uncertainty in time period=least count/ No vibrations

For example: Time of 30 vibrations of simple pendulum is 54.6 sec with least count of stop watch 0.1 sec

Uncertainty in time period= least count/ no of vibrations=0.1 sec/30=0.003 sec and

Time period =54.6/30=1.82sec, so correct time period will be T= (1.82±0.003) s

- **How many colors are used in color printing?**

There are four colors are used in color printing cyan, magenta, yellow, black.

- **Give Travel time of light**

Moon to Earth 1 min 20 sec	Sun to Earth 8 min 20 sec	Pluto to Earth 5 h 20 sec

What are the Dimensions of Physical Quantities?

Definition: Such a technique in which each physical quantity is represented by specific symbols written enclosed a square bracket is called dimension.

The dimension of length= [L], The dimension of Mass=[M], The dimension of time=[T]

It stands for qualitative nature of physical quantity

Examples of Dimensions

There are following examples of dimensions

The dimension of speed or velocity, speed=v=length/time=[L]/[T]=[LT^{-1}]

The dimension of acceleration=a=velocity/time= [LT^{-1}]/[T]=[LT^{-2}]

The dimension of force=F=ma=[M] [LT^{-2}]= [MLT^{-2}]

The dimension of work=W=Fd= [MLT^{-2}] [L] = [ML^2T^{-2}], The dimension of power=W/t= [ML^2T^{-2}]/[T]= [ML^2T^{-3}] etc.

Uses of dimension: There are following uses of Dimension

1. To check the homogeneity of physical equation OR Principle of homogeneity

To check the homogeneity of equation, we take dimension on both side of equation, if the equation are same on both sides then it is homogeneous and correct otherwise not. This is called principle of homogeneity.

2. To Derive the possible formula

To derive a relation for physical quantity depends upon the correct guess of various factor on which physical quantity depends.

Exercise short Questions

1: Name several repetitive phenomenon's occurring in nature which could serve reasonable time standards?

The phenomenon which repeat itself in equal interval of time is called repetitive phenomenon

i. Rotation of Earth around the sun and its own axis
ii. Rotation of moon around Earth
iii. Shadow of an object
iv. Sun rise and sun set

2: Give the drawbacks to use the period of a pendulum as a time standard?

As the time period of simple pendulum is $T = 2\pi\sqrt{\frac{l}{g}}$ the drawbacks to use the time period of a pendulum as a time standard are

i. The value of 'g' changes place to place
ii. Length of pendulum is changed due to change in temperature in different seasons.
iii. Air resistance may affect the time period of simple pendulum

3: Why do we find it useful to have two units for the amount of substance, the kilogram and the mole?

Kilogram is used at macro level and mole is used at micro level. Mole is used when we concerned with number of particles as one mole of different substance contain same number of particles but one kilogram of different substance have different number of particles.

4. Three students measured the length of a needle with a scale on which minimum division is 1mm and recorded as (i) 0.2145m (ii) 0.21m (iii) 0.214m which record is correct and why?

The record (iii) is correct.

Reason: As the scale used for measurement has the least count of 1 mm = 0.001 m. So the reading must be taken up to three decimal places when it is written in meters. Therefore, the reading 0.214 m is correct.

5. **An old saying is that "A chain is only as strong as its weakest link". What analogous statement can you make regarding experimental data used in a computation**?

"The results of experimental data are much accurate when its reading contain minimum error". This is analogous statement.

6: The period of simple pendulum is measured by a stop watch. What types of errors are possible in the time period?

There are two types of errors are possible

i. **Systematic error**: (due to fault or zero error in stop watch)
ii. **Personal & Random error**: due to negligence and inexperience of person like at the time to stop or start of stop watch.

7. **Does a dimensional analysis give any information on constant of proportionality that may appear in an algebraic expression? Explain**?

Dimensional analysis does not give any information about constant of proportionality in any expression. This constant can be determined experimentally. It provides the information about units of dimensional constant.

8: Write the dimensions of (i) Pressure (ii) Density?

$$\text{Pressure} = \frac{Force}{area} = \frac{[F]}{[A]} = \frac{[ma]}{[A]} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

$$Density = \frac{mass}{volume} = \frac{[M]}{[L^3]} = [ML^{-3}]$$

9. The wavelength λ of a wave depends on the speed v of the wave and its frequency f. knowing that $[\lambda] = [L]$ $[V] = [LT^{-1}] and [f] = [T]^{-1}$ **decide which of the following is correct,** $f = v\lambda \quad f = \frac{v}{\lambda}$.

$f = v\lambda$ taking dimension on both sides

$$\left[T^{-1}\right] = \left[LT^{-1} * L\right] = [L^2T^{-1}]$$

$$L.H.S \neq R.H.S$$

$f = \frac{v}{\lambda}$ taking dimensions on both sides

$$[T^{-1}] = \frac{[LT^{-1}]}{[L]} = [T^{-1}]$$

$L.H.S = R.H.S$ so it is correct

1.1: A light year is the distance light travels in one year. How many meters are there in one light year: (speed of light = $3.0 \times 10^8 ms^{-1}$**).**

$\text{Given data}: \text{Time} = t = 1\,\text{year} = 365\,\text{days} = 365 * 24\,\text{h} = 365 * 24 * 60 * 60\,\text{s},\ c = V = 3 * 10^8\ \text{m/s}$

$\text{Sol}: \text{Distance} = S = ?\ , S = Vt = (3 * 10^8\ \text{m/s})(365 * 24 * 60 * 60\,\text{s}) = 9.46 * 10^{15}\ \text{m} \approx 9.5 * 10^{15}\ \text{m}$

1.2: A) How many seconds are there in 1 year?

$\text{Sol}: \text{time} = 1\text{year} = 365\,\text{days} = 365 * 24\,\text{hours} = 365 * 24 * 60\,\text{min} = 365 * 24 * 60 * 60\,\text{sec} = 3.1536 * 10^7\ \text{sec}$

B) How many nanoseconds in 1 year?

$\text{sol}: 1\,\text{year} = 31536 * 10^7\ \text{sec},\ \text{As we know that nano} = 10^{-9}\ \text{so divide and multiply by}\ 10^{-9}$

$$1year = \frac{31536 * 10^7 * 10^{-9}}{10^{-9}}\,\text{sec} = \frac{31536 * 10^7\,\text{nano sec}}{10^{-9}} = 31536 * 10^{7+9}\ \text{nano sec} = 31536 * 10^{16}\ \text{nano sec}$$

C) How many years in 1 second?

$$\text{sol}: \text{As}\,1\,\text{year} = 3.1536 * 10^7\ \text{sec},\ \text{then}\ 1\,\text{sec} = \frac{1\,\text{year}}{3.1536 * 10^7} = 3.17 * 10^{-8}\,\text{year}$$

1.3: The length and width of a rectangular plate are measured to be 15.3cm and 12.80cm, respectively. Find the area of the plate.

$\text{Given data}: \text{Length} = L = 15.3\,\text{cm},\ \text{Width} = W = 12.80\,\text{cm},\ \text{Area of rectangular plate} = ?$

$\text{Sol}: \text{Area} = A = L * W = 15.3\text{cm} * 12.8\text{cm} = 195.84\,\text{cm}^2 \approx 196 cm^2$

1.4: Add the following masses given in kg upto appropriate precision.2.189, 0.089, 11.8 and 5.32?

$\text{Given Data}: m_1 = 2.189\text{kg},\ m_2 = 0.089\text{kg},\ m_3 = 11.8\text{kg},\ m_4 = 5.32\text{kg},\ \text{total mass} = m = ?$

$\text{solution}: m = m_1 + m_2 + m_3 + m_4 = 2.189\text{kg} + 0.089\text{kg} + 11.8\text{kg} + 5.32\text{kg} = 19.398 \approx 19.4\,\text{kg}$

1.5: Find the value of 'g' and its uncertainty using $T = 2\pi\sqrt{\frac{l}{g}}$ form the following measurements made during an experiment, Length of simple pendulum l = 100cm. Time for 20vibrations = 40.2s.

Given data : length $= L = 100cm = 1m$, time for 20 vib $= 40.2$ sec, $T = 40.2/20 = 2.01$ sec, $g = ?$

solution : Using $T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow T^2 = 4\pi^2\frac{L}{g} \Rightarrow g == \frac{4\pi^2 L}{T^2} = \frac{4(3.14)^2 * 1}{(2.01)^2} = 9.76 ms^{-2}$

1.6: What are the dimensions and units of gravitational constant G in the formula $F = G\frac{m_1 m_2}{r^2}$.

Given : $F = G\frac{m_1 m_2}{r^2}$, unit of $G = ?$ Dimension of $G = ?$ As $G = \frac{F * r^2}{m_1 m_2}$

solution : unit of $G = \frac{F * r^2}{m_1 m_2} = \frac{N * m^2}{Kg * Kg} = \frac{Nm^2}{Kg^2} = Nm^2Kg^{-2}$

dimension of $G = \frac{F * r^2}{m_1 m_2} = \frac{[MLT^{-2}][L^2]}{[M][M]} = \frac{[T^{-2}][L^3]}{[M]} = [M^{-1}L^3T^{-2}]$

1.7: Show that the expression $V_f = V_i + at$ is dimensionally correct, where V_i is the velocity at t =0, a is acceleration and V_f is the velocity at time t.

solution : $[V_f] = [LT^{-1}]$ ----- (1) Where $Vi + at = [LT^{-1}] + [LT^{-2}][T] = [LT^{-1}] + [LT^{-1}]$ --- (2)

from equation (1) and (2) both have same dimensions, so it is dimensionally correct

1.8: The speed v of sound waves through a medium may be assumed to depend on (a) the density ρ of the medium and (b) its modulus of elasticity E which is the ratio of stress to strain. Deduce by the method of dimensions, the formula for the speed of sound.

$v \propto \rho^a E^b$

$v = Constant\ \rho^a E^b$ ----------(1)

$[v] = [LT^{-1}]$, $[\rho\rho = [ML^{-3}]$, $[E] = stress/strain = [ML^{-1}T^{-2}]$, putting in eq (1)

$[LT^{-1}] = Constant\ [ML^{-3}]^a [ML^{-1}T^{-2}]^b$

$[LT^{-1}] = Constant\ [M^a L^{-3a}][M^b L^{-b} T^{-2b}]$

$[M^o LT^{-1}] = Constant\ [M^{a+b} L^{-3a-b} T^{-2b}]$

comparing powers

$T^{-2b} = T^{-1} \Rightarrow -2b = -1 \Rightarrow b = 1/2$

$M^o = M^{a+b} \Rightarrow a + b = 0 \Rightarrow a = -b \Rightarrow a = -1/2$

Putting the value of a and b in equation (1)

$v = Constant\ \rho^{-1/2} E^{1/2}$

$v = Constant\ \frac{E^{1/2}}{\rho^{1/2}} = Constant\ (\frac{E}{\rho})^{1/2}$

$v = Constant\ \sqrt{\frac{E}{\rho}}$

1.9: Show that the famous "Einstein equation" $E = mc^2$ is dimensionally consistent.

As work is stored in form of energy so $W = E = Fd = [MLT^{-2}][L]$

$[E] = [ML^2T^{-2}]$ ----------(1)

$mc^2 = [M][LT^{-1}]^2 = [M][L^2T^{-2}] = [ML^2T^{-2}]$ ------(2)

comparing both equation L.H.S = R.H.S, this proves that equation is dimensionally consistent.

1.10: Suppose, We are told that the acceleration of a particle moving in a circle of radius r with uniform speed v is proportional of r, say r^n, and some power of v, say v^m, determine the powers of r and v?

Let $a \propto r^n v^m$

$a = \text{constant}\, r^n v^m$

$[LT^{-2}] = \text{constant}\,[L]^n[LT^{-1}]^m$

$[LT^{-2}] = \text{constant}\,[L^n[L^mT^{-m}]$

$[LT^{-2}] = \text{constant}\,[L^{n+m}T^{-m}]$

comparing powers of L and T

$T^{-m} = T^{-2}$

$m = 2$

$L^{n+m} = L \Rightarrow n+m = 1 \Rightarrow n+2 = 1 \Rightarrow$

$n = -1$

TID BITS/TABLES OF TEXT BOOK

MCQS

1) According to Einstein 1kg mass is converted to energy

$9*10^9$ J	**$9*10^{16}$ J**	$9*10^{15}$ J	$9*10^{17}$ J
Sol: $m = 1kg, c = 3*10^8$ m/s as $E = mc^2$ putting values of m and c to get the result			

2) Color printing uses colors

Three	**Four**	Five	Seven

3) Which colors are used in color printing?

Cyan	Magenta	Yellow &black	**All of these**

4) Travel time of light from moon to earth is

1 min 20 sec	8 min 20 sec	5 hour 20 sec	None of these

5) Travel time of light from sun to earth is

1 min 20 sec	**8 min 20 sec**	5 hour 20 sec	None of these

6) Travel time of light from Pluto to earth is

1 min 20 sec	8 min 20 sec	**5 hour 20 sec**	None of these

7) Which of the following primary standard for the unit of time used in Colorado (USA)?

Radio telescope	**Cesium atomic frequency standard**	Technology meter	Hour technology

8) Age of universe is

$5*10^{17}$ sec	$1.4*10^{17}$ sec	$1*10^{-6}$ sec	$8.6*10^4$ sec

9) Age of earth is

$5*10^{17}$ sec	**$1.4*10^{17}$ sec**	$1*10^{-6}$ sec	$8.6*10^4$ sec

10) Period of typical radio waves is

$5*10^{17}$ sec	$1.4*10^{17}$ sec	**$1*10^{-6}$ sec**	$8.6*10^4$ sec

11) One day is equal to

$5*10^{17}$ sec	$1.4*10^{17}$ sec	$1*10^{-6}$ sec	**$8.6*10^{4}$ sec**

12) Light year is the unit of

Distance	Time	Speed	None of these

13) Time between normal heartbeats is

$8*10^{-1}$ sec	$8*10^{-2}$ sec	$8*10^{-3}$ sec	$8*10^{-4}$ sec

14) Period of audible sound waves is

$1*10^{-3}$ sec	$1*10^{-6}$ sec	$1*10^{-9}$ sec	$1*10^{-13}$ sec

15) Period of vibration of an atom in a solid is

$1*10^{-3}$ sec	$1*10^{-6}$ sec	**$1*10^{-13}$ sec**	$1*10^{-16}$ sec

16) Period of visible light waves is

$1*10^{-13}$ sec	$1*10^{-6}$ sec	**$2*10^{-15}$ sec**	$5*10^{17}$ sec

17) Which of the following is not unit of time?

Second	**Light year**	Hour	Minutes

18) One light year is equal to

$9.5*10^{15}$ m	$3.1*10^{7}$m	$1*10^{-6}$ sec	$8.6*10^{4}$ sec
Hint: See solution of numerical no 1.1, by applying formula S=vt, v is speed of light t is 1 year is time			

19) 1 year is equal to One day is equal to

$5*10^{17}$ sec	**$3.1*10^{7}$sec**	$1*10^{-6}$ sec	$8.6*10^{4}$ sec
Hint: 1 year=365 days=365*24 hours=365*24*60 min=365*24*60*60 sec=31536000 sec=$3.1*10^{7}$sec			

20) Force in terms of base units is written as

$Kgms^{-1}$	**$Kgms^{-2}$**	kgms	$Kgms^{-3}$

21) The units of E in $E=mc^2$ are

$Kgms^{-1}$	**Kgm^2s^{-2}**	kgms	$Kgms^{-3}$

22) 1 atto is equal to

10^{-15}	**10^{-18}**	10^{-12}	10^{-9}

23) 1 femto is equal to

10^{-15}	10^{-18}	10^{-12}	10^{-9}

24) 1 Pico is equal to

10^{-15}	10^{-18}	**10^{-12}**	10^{-9}

25) 1 nano is equal to

10^{-15}	10^{-18}	10^{-12}	**10^{-9}**

26) 1 micro is equal to

10^{-15}	10^{-18}	10^{-12}	**10^{-6}**

27) 1 milli is equal to

10^{-15}	10^{-18}	**10^{-3}**	10^{-9}

28) 1 centi is equal to

10^{-6}	10^{-9}	**10^{-2}**	10^{9}

29) 1 deci is equal to

10^{-6}	10^{-9}	**10^{-1}**	10^{9}

30) 1 deca is equal to

10^{1}	10^{-9}	10^{-1}	10^{9}

31) 1 killo is equal to

10^{3}	10^{9}	10^{6}	10^{12}

32) 1 mega is equal to

10^3	10^9	**10^6**	10^{12}

33) 1 giga is equal to

10^3	**10^9**	10^6	10^{12}

34) 1 tera is equal to

10^{15}	10^{18}	**10^{12}**	10^6

35) 1 peta is equal to

10^{15}	10^{18}	10^{12}	10^6

36) 1 exa is equal to

10^{15}	**10^{18}**	10^{12}	10^6

PAST PAPERS SOLVED MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	The percentage uncertainty in mass and velocity are 2% and 3%, the maximum uncertainty in measurement of K.E	11%	**8%**	6%	1%
ii.	The term 134.7 can be written as	$1.347*10^3$	**$1.347*10^2$**	$1.347*10^1$	$1.347*10^4$
Apply formula for power factor, which is= power x % uncertainty and for multiplication % uncertainties are added. As K.E=1/2 mv^2, as power of mass is 1 and velocity is 2 so= % uncertainty in K.E= 1*%uncertainty of mass+2*%uncertainty in velocity=1*2%+2*3%=2%+6%=8%					
iii.	Solid angle subtends at the center of sphere	2π	6π	8π	**4π**
iv.	Significant figures in "1.00110" are	3	1	7	**6**
v.	In scientific notation number "0.0001" written as	10^{-3}	10^3	**$1*10^{-4}$**	$1*10^4$
vi.	The quantities which can be measured accurately are	Base quantities	Derived Quantities	**Physical Quantities**	Supplementary quantities
vii.	SI unit of co-efficient of viscosity is	Kgm/s	**$Kgm^{-1}s^{-1}$**	$Kgms^{-2}$	None of these
viii.	0.00467 has significant figures	2	**3**	4	5
ix. 6	Absolute uncertainty in a measuring instrument is equal to	Accuracy	**Least count**	Fractional uncertainty	Percentage uncertainty
x.	According to Einstein $E=mc^2$ equation 1kg mass equal to energy	$3x10^8$ J	**$9x10^{16}$J**	$9x10^8$ J	$9x10^{-16}$ J
$m = 1kg, c = 3*10^8$ m/s as $E = mc^2$ $E=1*(3*108)^2=9*10^{16}$ J					
xi.	The dimension $[ML^0T^0]$ represents the	Length	**Mass**	Time	Force
xii.	Name the quantity which can be measured by using base unit 'kgm^2s^{-3}'	Weight	**Power**	Pressure	Work
xiii.	Absolute uncertainty in measuring instrument is equal to	**Least count**	Fractional uncertainty	Accuracy	% uncertainty
xiv.	The dimension of density are	**$[ML^{-3}]$**	$[ML^2T^{-2}]$	$[MLT^{-1}]$	$[ML^2T^{-1}]$
xv.	The number of significant figures in "$8.100x10^3$" Kg are	2	3	**4**	7
xvi.	The dimension of quantity light year is	**[L]**	[T]	[M]	None of these
xvii.	What is the correct record for the diameter of wire when measured	2.3cm	2.31cm	**2.312cm**	2.3124cm

	by screw gauge of least count of 0.001cm				
As least count =0.001 cm According to rule correct readings will upto three decimal places					
xviii.	A light year is the unit for	**Distance**	Time	Speed	Velocity
xix.	The formula for electric field strength is E = F/Q', where E is electric field strength and F is force and Q is charge. Which one of the following options gives the correct base units for electric field strength?	**$kgms^{-3}A^{-1}$**	$kg^2m^{-2}s^{-3}A$	$kgs^{-2}A^{-3}$	$ms^{-1}A^{-3}$
Unit of force is $kgms^{-2}$ and charge As, put in formula $E=kgms^{-2}/As= kgms^{-3}A^{-1}$					
xx.	Which is not base unit in these?	Kilogram	**Joule**	Ampere	Kelvin
xxi.	The principle of homogeneity of dimensions determines	Only variable in the equation	**Correctness of an equation**	Only constant in the equation	Constant and variable in the equation
xxii.	Force in terms of base units is written as	Kgm/s	**$Kgms^{-2}$**	Kgm^2s^{-2}	Js
xxiii.	When the dimensions of both sides of an equation are equal, then the equation is said to be	Simultaneous	Instantaneous	**Homologous**	Quadratic
xxiv.	The wavelength ' λ' of a wave depends on the speed 'v' of the wave and its frequency 'f'. Decide which of the following is correct?	f = v λ	**f =v /λ**	f =λ/ v	f = v λ-2
xxv.	The dimension power are	$[ML^3T^{-2}]$	$[ML^2T^{-2}]$	**$[ML^2T^{-3}]$**	$[ML^2T^{-1}]$
xxvi.	SI unit of pressure in terms of base units is	**$Kgm^{-1}s^{-2}$**	Kgm/s	Kgm^2s^{-2}	Pacal
xxvii.	Dimension of moment arm is	**[L]**	[M]	[LT]	[T]
xxviii.	An observer notes reading of scale from different angles (parallax) while measuring the length of wire, what type of error is possible	Systematic error	Precised error	**Random error**	Zero error
xxix.	Which of the following is least multiple?	Pico	Femto	**Atto**	Nano
xxx.	Which one is the highest power multiple?	Giga	**Tera**	Mega	Deca
xxxi.	Which set of the prefixes gives values in increasing order?	Pico, Mega, Kilo, Tera	Tera, Pico, Micro, Kilo	**Pico, Micro, Mega, Giga**	Giga, Kilo, Milli, Nano
Pico=10^{-12}, micro=10^{-6}, mega=10^6, giga=10^9					
xxxii.	The sum of three number 2.7543, 4.10, 1.273 upto correct decimal places	8.12	**8.13**	8.1273	8.127
According to rule of significant figures in addition or subtraction answer should be written upto least significant figures which are multiply or divided. So in this least significant term of 3 digits so ans will be correct upto 3 digits					
xxxiii.	Dimension of force is	$[ML^{-3}]$	**$[MLT^{-2}]$**	$[MLT^{-1}]$	$[ML^2T^{-1}]$
xxxiv.	The dimensional ratio of work to power is	Joule	Killo watt hour	**T**	L
xxxv.	A student is calculating the area of rectangular sheet whose length and	$602.64cm^2$	$602.6\ cm^2$	$602\ cm^2$	**$603cm^2$** A=l*W 27.9*21.6=602.64=603

	width are 27.9cm and 21.6cm, find correct value?				
According to rule of significant figures in multiplication or division answer should be written upto least significant figures which are multiply or divided. So in this least significant term of 3 digits so ans will be correct upto 3 digits					
xxxvi.	Which of the following pair have same dimension	Work and power	**Work and torque**	Momentum and energy	Power and pressure
xxvii.	For a student measured the length of needle whose least count is 1mm, what is correct reading?	0.2145m	0.21m	**0.214m**	0.2m
As least count 1mm=1/1000=0.001 m According to rule correct readings will upto three decimal places					
xxviii.	The ratio of dimension of K.E and power is	1:1	**T:1**	$1:T^{-1}$	M:T
As dimension of K.E=$[ML^2T^{-2}]$ and power=$[ML^2T^{-3}]$ taking ratio of these dimensions					
xxxix.	Which of the following is dimensionless quantity?	Stress	**Strain**	Surface tension	Pressure
xl.	In 5.47*19.89=108.7983 answer should be written as	0.18.8	108.9	**109**	108.79
According to rule of significant figures in multiplication or division answer should be written upto least significant figures which are multiply or divided. So in this least significant term of 3 digits so ans will be correct upto 3 digits					
xli.	How many seconds are there in one year	$3.156*10^6$ s	$3.1536*10^8$s	$3.1536*10^{10}$ s	**$3.1536*10^7$s**
Time=1year=365 days=365*24hour=365*24*60min=365*24*60*60=31536000 s=$3.1536*10^7$ s					
xlii.	Zero error belongs to	Personal error	Random error	**Systematic error**	Collective error
xliii.	Light year is a measure of	Force	Light intensity	**Distance**	Speed
xliv.	The units of E in $E=mc^2$ are	$Kgms^{-1}$	**Kgm^2s^{-2}**	kgms	$Kgms^{-3}$
As E is energy the unit of energy is above given in ans					

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Chapter 02 Vector and Equilibrium

What are Physical Quantities? Describe the Types on the basis of direction

Physical Quantities: All measurable quantities are called Physical Quantities. E.g length, temperature etc.

Types: There are two types of Physical quantities on the basis of direction

Scalar Quantities	Vector Quantities
The quantities which have only magnitude and no direction are called scalar quantities.	The quantities which have magnitude as well as direction are called vector quantities
For example mass, density, temperature etc**.**	For example force, velocity, acceleration etc

What are the Methods For Representation Of Vector?

There are two methods for representation of vector quantity

Symbolic Representation	Graphical Representation
It is represented by bold face letter. Like **A,B** It is also represented by a letter with arrow head above or below it like $\overrightarrow{A}$, and magnitude is represented by light face letter A or $\overrightarrow{\lvert A \rvert}$	It is represented by a straight line with an arrow head at its one end. The length of line show magnitude and arrow show direction of vector. Like → etc

Explain Rectangular co-ordinate system

Rectangular co-ordinate system: Two lines drawn perpendicular to each other are called co-ordinate axis and system of co-ordinate axis is called rectangular co-ordinate system.

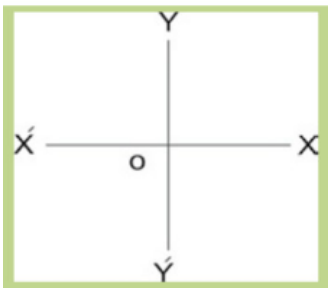
Horizontal line (axis) is called X-axis and vertical line (Axis) is called Y-axis.

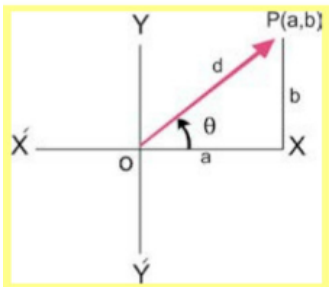
Origin: The point of intersection of two axis is called origin. And line right to and above origin is taken as positive and line left and below origin is taken as negative.

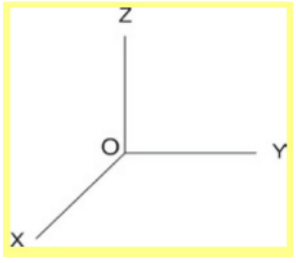
Two dimensional co-ordinate system: Such a system in there are two perpendicular lines is called two dimensional

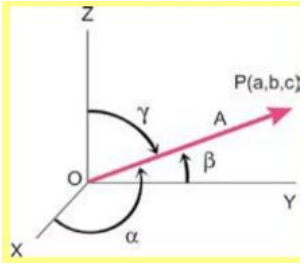
The direction of vector in plane is represented by angle which the vector makes with positive x-axis in anti-clock direction.

Three dimensional co-ordinate system: such a system in there are three perpendicular lines is called three dimensional co-ordinate system. Direction of vector in space is represented by three angle with the vector makes with x,y,z axis.







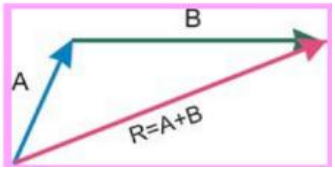


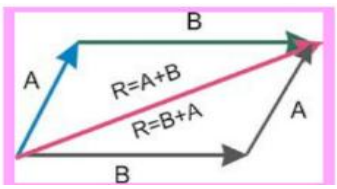
How two vectors are added (Explain head to tail rule of vector addition). OR Prove that A+B=B+A

Such a graphical method to add two vectors is called head to tail rule. There are following steps of vector addition by head to tail rule

i. Draw a representative lines vector **A**&**B**
ii. Join the tail of Vector **B** with head of vector **A**
iii. Now join the tail of vector **A** with head of **B** which gives resultant vector **R**.

As the vector sum **A+B** and **B+A** has the same results so **A+B**=**B+A**

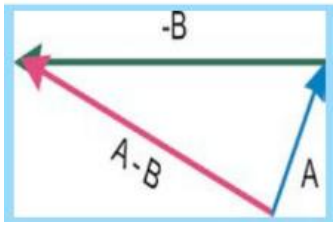


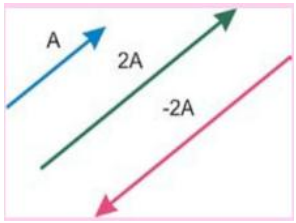


Resultant vector: Sum of two or more vector Result into a single vector is called resultant vector.

Vector Subtraction OR How Two Vectors Are Subtracted?

The subtraction of a vector is equivalent to the addition of same vector with its direction reversed.

Subtraction 



Multiplication

What is the Multiplication Of Vector

When a vector **A** is multiplied by a positive number n>0 then its magnitude is n$\vec{A}$ and in case of negative number direction is reversed**.**

What is Unit Vector? Write its formula.

A vector whose magnitude is one and used to show the direction of given vector is called unit vector. Its formula is $\hat{A}=\frac{\vec{A}}{|\vec{A}|}$, unit vector along X-axis is $\hat{\imath}$, along Y-axis is $\hat{\jmath}$ and along Z-axis is $\hat{k}$.

What is Null Vector Or Zero Vector?

A vector having zero magnitude and arbitrary direction is called null vector. $\vec{A}+(-\vec{A})=\vec{0}$ For example of position vector origin is null vector.

What are Equal Vectors?

Two vectors are said to be equal if they have same magnitude and same direction regardless of initial position.

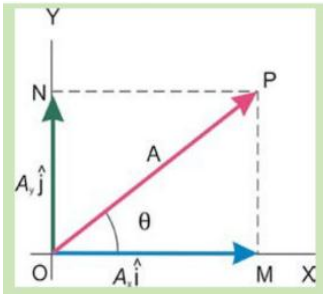
What is Position Vector? Write its formula.

The vector which locates the position of particle with respect to origin is called position vector. $\vec{r}=a_{\hat{i}}+b_{\hat{j}}$ And magnitude $|\vec{r}|=\sqrt{a^2+b^2}$ in three dimensional $\vec{r}=a_{\hat{i}}+b_{\hat{j}}+c_k$ and magnitude $|\vec{r}|=\sqrt{a^2+b^2+c^2}$.

What are Rectangular Components Of A Vector? Explain.

Component of a vector: The effective values of a vector in given direction is component of a vector.
Rectangular components of a vector: The components of vector which are perpendicular to each other are called rectangular components of vector.

Explanation: Let us consider a vector $\vec{A}$ makes an angle Θ with x-axis. Draw a projection OM of vector OP on x-axis and projection ON(ON=MP)of vector OP on y-axis as shown in figure.



Using head to tail rule **OP=OM+MP** $\vec{A}=Ax\hat{\imath}+Ay\hat{j}$

X- Component of vector: In right angle triangle OPM $Cos\theta=\frac{OM}{OP}$

$Cos\theta=\frac{Ax}{A}$ $Ax=ACos\theta$ -------- (1)

Y- Component of vector: In same triangle $Sin\theta=\frac{MP}{OP}$

$Sin\theta=\frac{Ay}{A}$ $Ay=ASin\theta$ --------- (2)

Vector and its magnitude: Squaring and adding both equation or applying Pythagoras theorem

$OP^2=OM^2+MP^2$ $A^2=A^2x+A^2y$ $A=\sqrt{Ax^2+Ay^2}$

Direction of vector: The direction of vector can be found by dividing eq (2) by eq (1)

$\frac{A\sin\theta}{A\cos\theta}=\frac{Ay}{Ax}$ $\Rightarrow$ $\tan\theta=\frac{Ay}{Ax}$ $\Rightarrow\theta=\tan^{-1}(\frac{Ay}{Ax})$

This method is also called composition of vector

Write a note on Vector addition by rectangular components

Let us consider two vectors $\vec{A}$ and $\vec{B}$ represented by lines OM and ON, using head to tail rule the resultant $\vec{R}=\vec{A}+\vec{B}$.

Step01: To find x and y components of all given vectors: To resolve the vector $\vec{R}$,$\vec{A}$ and $\vec{B}$ into rectangular components, draw perpendiculars MQ and PR from points "M" and "P" on x-axis.

Step 02: To find the resultant of X-components: As horizontal line X-axis

OR=OQ+QR OR=OQ+MS (As QR=MS)

Rx=Ax+Bx ---------- (1)

Step 03: To find the resultant of Y-components: As Vertical components are

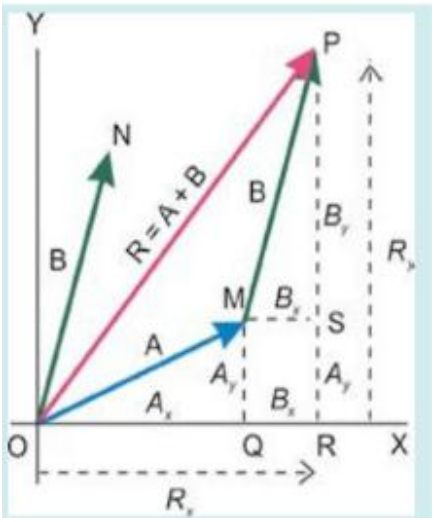
PR=RS+SP PR=MQ+SP (As RS=MQ)

Ry=Ay+By ---------- (2)

Now we can find resultant of Resultant vector R by adding (1) and (2)

$$\vec{R} = R_x\hat{i} + R_y\hat{j}$$

$$\vec{R} = (Ax + Bx)\hat{i} + (Ay + By)\hat{j}$$



Step 04: To find the magnitude of Resultant vector $\vec{R}$: Magnitude can be found By taking the magnitude of R or using Pythagoras theorem.

$$\left|\vec{R}\right|^2 = (Ax + Bx)^2 + (Ay + By)^2$$

$$\left|\vec{R}\right| = \sqrt{(Ax + Bx)^2 + (Ay + By)^2}$$

Step 05: To find the Direction of Resultant vector $\vec{R}$: The direction can be found by

$$\text{Tan}\theta = \left(\frac{\text{Ry}}{\text{Rx}}\right) \Rightarrow \quad \theta = \text{Tan}^{-1}\left(\frac{\text{Ry}}{\text{Rx}}\right) \Rightarrow \quad \theta = \text{Tan}^{-1}\left(\frac{\text{Ay}+\text{By}}{\text{Ax}+\text{Bx}}\right)$$

For any number of coplanar vectors Magnitude can be written as

$\left|\vec{R}\right| = \sqrt{(Ax + Bx + Cx + ...)^2 + (Ay + By + Cy + ...)^2}$ And Direction can be written as

$\theta = \text{Tan}^{-1}\left(\frac{\text{Ay}+\text{By}+\text{Cy}+....}{\text{Ax}+\text{Bx}+\text{Cx}+....}\right)$ This is also called reverse process of vector addition.

Determination of Angle by rectangular components

First Quadrant: Rx=+ and Ry=+ angle $\Theta=\phi$

2nd Quadrant: Rx=-, Ry=+ angle $\Theta=180°-\phi$

Third Quadrant: Rx=- and Ry=- angle $\Theta=180°+\phi$

4th Quadrant: Rx=+, Ry=- angle $\Theta=360°-\phi$

Q. What is Scalar/Dot product? Explain its characteristics.

Definition: If the product of two vectors result into a scalar quantity then this product is called scalar product.

Mathematically it can be written as $\vec{A}.\vec{B}=|\vec{A}||\vec{B}|\cos\theta=AB\cos\Theta$,

Physically $\vec{A}.\vec{B}$=Magnitude of Vector A (Projection of B on A)=A(BcosΘ)= ABcosΘ shown in fig

Example: Work is an example which is scalar product of force and displacement $W=\vec{F}.\vec{d}=FdCos\Theta$

Characteristics:

(1) Scalar product is commutative $\vec{A}.\vec{B}=\vec{B}.\vec{A}$, as ABcosΘ=BAcosΘ

(2) Scalar product of two perpendicular vector is zero, i.e Θ=90°, $\vec{A}.\vec{B}$=ABcos90°=0, where in case of unit vectors

$\hat{i}.\hat{j}=(1)(1)\cos 90^o=0$ In same case $\hat{j}.\hat{k}=0$ and $\hat{k}.\hat{i}=0$

3) Scalar product of two parallel is equal to the product of their magnitudes i.e Θ=0°,$\vec{A}.\vec{B}$=ABcos0°=AB, in case of unit vector $\hat{i}.\hat{i}=(1)(1)\cos 0^o=(1)(1)(1)=1$ In same case $\hat{j}.\hat{j}=1$ and $\hat{k}.\hat{k}=1$

4) Scalar product for two anti-parallel vector Θ=180° , $\vec{A}.\vec{B}$=ABcos180°=-AB

5) Self product of a vector A is equal to square of its magnitude A. $\vec{A}.\vec{A}$=AAcos0°=A^2 (1) =A^2

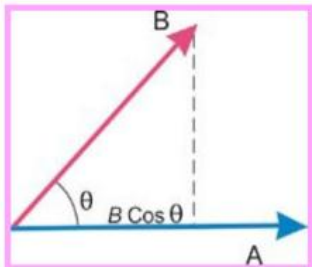
6) In case of rectangular components,

$$\vec{A}=Ax\hat{i}+Ay\hat{j}+Az\hat{k},\quad \vec{B}=Bx\hat{i}+By\hat{j}+Bz\hat{k}$$

$$\vec{A}.\vec{B}=(Ax\hat{i}+Ay\hat{j}+Az\hat{k})(Bx\hat{i}+By\hat{j}+Bz\hat{k})$$

$$AB\cos\theta=AxBx+AyBy+AzBz$$

$$Cos\theta=\frac{AxBx+AyBy+AzBz}{AB}\qquad\Rightarrow\theta=Cos^{-1}\left(\frac{AxBx+AyBy+AzBz}{AB}\right)$$



What is Vector/Cross product? Explain its characteristics

Definition: If the product of two vectors results into a vector quantity then this product is called vector or cross product. $\vec{A}x\vec{B}=AB\sin\theta\hat{n}$.In this case AB sinθ give magnitude and $\hat{n}$ give direction, which is found by right hand rule

Right Hand Rule: Rotate the fingers of your right hand through some possible angle then erect thumb will show the direction of vector product.

Example: (1) Torque $\vec{\tau}=\vec{r}*\vec{F}=rF\sin\theta\hat{n}$. (2) Angular momentum $\vec{L}=\vec{r}*\vec{P}=rP\sin\theta\hat{n}$

Characteristics: Properties of Vector/ cross product are as follows.

(1) Vector product is not commutative as $\vec{A}x\vec{B}\neq\vec{B}x\vec{A}$ but $\vec{A}x\vec{B}=-\vec{B}x\vec{A}$

(2) Vector product of two mutually perpendicular vector has maximum value Θ=90°,$\vec{A}x\vec{B}$=ABsinθ90°$\hat{n}$= AB$\hat{n}$,

$\hat{i}x\hat{j}=\hat{k},\quad \hat{j}x\hat{k}=\hat{i}\ ,\quad \hat{k}x\hat{i}=\hat{j}$, where in reverse $\hat{j}x\hat{i}=-\hat{k},\quad \hat{k}x\hat{j}=-\hat{i}\ ,\ \hat{i}x\hat{k}=-\hat{j}$ unit vector case

Proof : $\hat{i}x\hat{j}=(1)(1)\sin 90^o\hat{k}=(1)(1)(1)\hat{k}=\hat{k}$

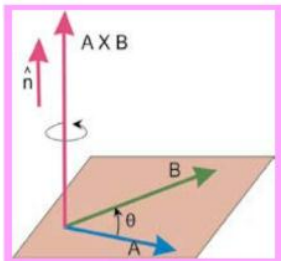
(3) Vector/Cross product two parallel or anti-parallel vector is null vector i.e. Θ=0°,180°,$\vec{A}x\vec{B}$=ABsinθ0°$\hat{n}$= $\vec{0}$

$\hat{i}x\hat{i}=\hat{j}x\hat{j}=\hat{k}x\hat{k}=\vec{0}$ as $\hat{i}x\hat{i}=(1)(1)\sin 0^o=\vec{0}$

(4) Cross product in terms of rectangular components is expressed in determinant form

$$\vec{A}x\vec{B}=\begin{vmatrix}\hat{i}&\hat{j}&\hat{k}\\Ax&Ay&Az\\Bx&By&Bz\end{vmatrix}=\hat{i}\begin{vmatrix}Ay&Az\\By&Bz\end{vmatrix}-\hat{j}\begin{vmatrix}Ax&Az\\Bx&Bz\end{vmatrix}+\hat{k}\begin{vmatrix}Ax&Ay\\Bx&By\end{vmatrix}$$

$$\vec{A}x\vec{B}=(AyBz-AzBy)\hat{i}+(AzBx-AxBz)\hat{j}+(AxBy-AyBx)\hat{k}$$



(5) The magnitude of $\vec{A}x\vec{B}$ is equal to area of parallelogram with two A and B adjacent sides.

What Is Torque? Calculate The Torque Acting On Rigid Body.

Definition: The turning effect produced in a body about axis of rotation is called torque.

Equation: $\vec{\tau} = \vec{r} * \vec{F} = rF\sin\theta\,\hat{n}$ Its **SI unit** is Nm **Dimension** $[ML^2T^{-2}]$

Moment Arm: The perpendicular distance from axis of rotation to line of action of force is called moment arm. The nut is easier to turn with moment arm of large value.

Example: Tightening and loosening of nut with a spanner.

Torque on rigid body: Consider force $\vec{F}$ is acting on rigid body at point P whose position vector relative to axis of rotation is $\vec{r}$. the Force can be resolved into two rectangular components.

(i) FsinΘ is perpendicular to $\vec{r}$

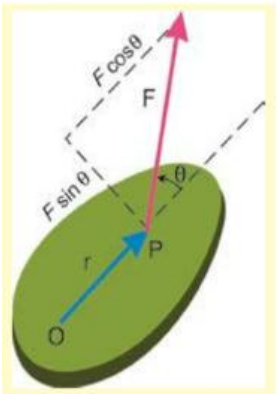
(ii) FcosΘ is along the direction of $\vec{r}$ (Torque due to this components is zero as it passes from axis of rotation)

The torque is produced due to FsinΘ only about O, which is given by

$\tau = r(F\sin\theta) = rF\sin\theta$ in vector form $\vec{\tau} = rF\sin\theta\hat{r}$ or $\vec{\tau} = \vec{r}x\vec{F}$ .....(a)

Similarly if we resolve the position vector r into its components,
Then only component which produce torque is rsinΘ

$\tau = F(r\sin\theta) = rF\sin\theta$ in vector form $\vec{\tau} = rF\sin\theta\hat{r}$ or $\vec{\tau} = \vec{r}x\vec{F}$ .....(b)



Important points about torque:

- Torque is count part of force for rotational motion
- Torque is also called moment of force
- Torque determine angular acceleration in body
- Clock wise torque is taken negative and anti-clock wise torque is taken positive.

What is Equilibrium of forces? Define its types and conditions.

Equilibrium: A body is said to be in equilibrium if it is at rest or moving with uniform velocity under the action of number of forces.

Types of Equilibrium: There are two types of equilibrium

Static Equilibrium: If a body is at rest, it is said to be in static equilibrium for example book lying on a table.

Dynamics Equilibrium: If a body is moving with uniform velocity, it is said to be in dynamic equilibrium. For example A car moving with uniform velocity.

Conditions of Equilibrium: There are two conditions of equilibrium

First condition: Sum of all the forces acting on a body is equal to zero $\Sigma\vec{F} = 0$

2nd condition: Sum of torques acting on a body is equal to zero $\Sigma\vec{\tau} = 0$

Translational Equilibrium: When first condition of equilibrium is satisfied and body has zero linear acceleration then is in translational equilibrium.

Rotational Equilibrium: When 2nd condition of equilibrium is satisfied and body has zero angular acceleration then it is in rotational equilibrium.

Complete Equilibrium: When both conditions of equilibrium are satisfied then it is said to be in complete equilibrium.

Why do you keep your legs far apart when you have to stand in the aisle of a bumpy riding bus?

When you stand in the aisle of a bumpy riding bus, you are in unstable position and you may fall. To make you stable you keep your legs far apart.

EXERCISE SHORT QUESTIONS CHAPTER 02

1: Define the terms (i) unit vector (ii) Position vector and (iii) Components of a vector?

Unit vector: A vector whose magnitude is one and used to show the direction of given vector is called unit vector. Its formula is $\hat{A} = \frac{\vec{A}}{A}$.

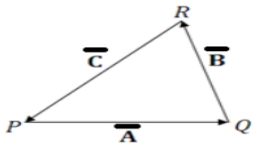
Position vector: The vector which locates the position of particle with respect to origin is called position vector. $\vec{r} = a_{\hat{i}} + b_{\hat{j}}$ And magnitude $r = \sqrt{a^2 + b^2}$.

Components of vector: The effective values of a vector in a given direction are components of a vector.

2. The vector sum of three vectors gives a zero resultant. What can be the orientation of the vectors?

If the three vectors are represented by the sides of triangle joined by head to tail rule at angle of 60°, there sum will be zero as shown in figure.

$\vec{A}+\vec{B}+\vec{C}=\vec{0}$



3) Vector A lies in the xy plane. For what orientation will both of its rectangular components be negative? For what orientation will its components have opposite signs?

When the vector lies in 3rd quadrant, then both of its rectangular components of vector will negative.

ii) The components of a vector have opposite sign when the vector lies in 2nd or 4th quadrant.

4) If one of the components of a vector is not zero, can its magnitude be zero? Explain.

No, its magnitude cannot be zero. As we know that magnitude of A is $\sqrt{Ax^2 + Ay^2}$ which shows that magnitude of vector will be zero only when all of its rectangular components are zero.

5) Can a vector have a component greater than the vector's magnitude?

No, the component of a vector can never be greater than the vector's magnitude because the component of a vector is its effective value in a specific direction and it is the part of vector and part is always less than full. So A≥Ax&A≥Ay.

6) Can the magnitude of a vector have a negative value?

No, its magnitude can never be zero. As we know that magnitude of A is $\sqrt{Ax^2 + Ay^2}$ which shows that square of real values is always positive.

7) If A + B = 0, what can you say about the components of the two vectors?

In terms of rectangular components $\vec{A} + \vec{B} = \vec{o} \Rightarrow \vec{A} = -\vec{B}$

$$Ax_{\hat{i}} + Ay\hat{j} = -(Bx\hat{i} + By\hat{j})$$

$Ax = -Bx, \quad Ay = -By$ Hence the components of both vectors are equal in magnitude but opposite in direction.

8) Under what circumstances would a vector have components that are equal in magnitude?

It is possible only when the vector makes angle of 45° with x-axis.

$$Ax = Ay \Rightarrow A\cos\theta = A\sin\theta \Rightarrow \frac{\sin\theta}{\cos\theta} = 1$$

$$\tan\theta = 1 \Rightarrow \theta = \tan^{-1}(1) = 45^{o}$$

9) Is it possible to add a vector quantity to a scalar quantity? Explain.

No it is not possible to add a vector to a scalar quantity because both are different quantities as scalars have only magnitude while vector quantities have both magnitude as well direction so cannot added be add to each other.

10) Can you add zero to a null vector?

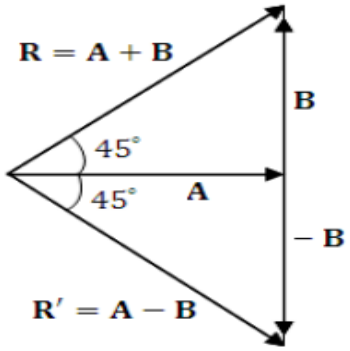
No it is not possible to add zero to a null vector because zero is scalar and null vector is vector and scalar is not added to vector quantity due to different quantities.

11) Two vectors have unequal magnitudes. Can their sum be zero? Explain.

No, the sum of two vectors having unequal magnitudes can't be zero. The sum of two vectors will be zero only when their magnitudes are equal and they act in opposite direction.

12) Show that the sum and difference of two perpendicular vectors of equal lengths are also perpendicular and of the same length?

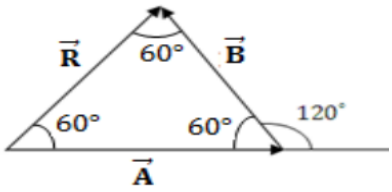
Consider two vectors **A** and **B** of equal **A=B** magnitude which are perpendicular to each other



(**A+B**).(**A-B**)=A^2-B^2=A^2-A^2=0, when dot product of two vectors is zero then they are perpendicular.

13.How would the two vectors of the same magnitude have to be oriented, were to be combined to give a resultant equal to a vector of the same magnitude?

It is possible only when the angle b/w two vectors is 120°. If the two vectors are shown by two sides of equilateral triangle then third side shows their resultant A=B=R.



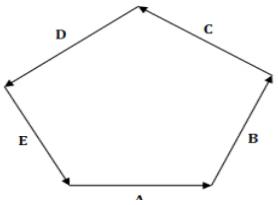
14)The two vectors to be combined have magnitudes 60N and 35N. Pick the correct answer from those given below and tell why it is the only one of the three that is correct. (i)100N (ii)70N (iii)20N.

The correct answer is 70 N.

Sum of two vector is maximum when they are parallel to each other as 60+35=95 N, sum of two vector is minimum when opposite as 60+(-35)=25N, this shows that range of resultant is from 25 N to 95 N so correct answer is 70 N

15) **Suppose the sides of a closed polygon represent vector-arranged head to tail. What is the sum of these vectors?**

Sum of these vectors will be zero, in this case the head of last vector coincides with tail of first vector as **A+B+C+D+E+F=O**



16)Identify the correct answer:

i)The actual direction of motion will be due to west

ii) Fcosɵ-mgsinɵ is correct answer by converting into rectangular components along the inclined plane

17)If all the components of the vectors $A_1 and A_2$ were reversed, how would this alter $A_1 \times A_2$?

It would not be changed when all the components of a vector were reversed.

-$\mathbf{A}_1$x-$\mathbf{A}_2$= $\mathbf{A}_1$x$\mathbf{A}_2$

18) **Name the three different conditions that could make $A_1 \times A_2$ = 0.**

This is zero when

i. A_1 or A_2 is a null vector

ii. A_1 and A_2 are parallel vector(ɵ=0°) As A_1*A_2sin0°=**0**

iii. A_1 and A_2 are anti-parallel (ɵ=180°) As A_1*A_2sin180°=**0**

19) Identify true of false statements and explain the reason. (a) A body in equilibrium implies that is not moving nor rotating. (b)If coplanar forces acting on a body form a closed polygon, then the body is said to be in equilibrium.

a) This statement is false because in dynamic equilibrium body may move or rotate with uniform velocity.

b) This statement is true only as first condition if satisfied body is said to be in translational equilibrium.

20) A picture is suspended from a wall by two strings. Show by diagram the configuration of the strings for which the tension in the strings will be minimum.

If picture is suspended from wall by two strings and tension is resolved into its rectangular components then Tsinθ+Tsinθ=W, 2Tsinθ=W T=W/2sinθ, tension will be minimum if Sinθ is maximum so at 90° tension will be minimum.

21) Can a body rotate about its center of gravity under the action of its weight?

No, A body cannot rotate about its center of gravity under the action of its weight because in this case line of action of force passes through axis of rotation so moment arm is zero and

Torque= (moment arm) force= 0*Force=0 so torque acting on it is zero.

Numericals

2.1: Suppose, in a rectangular coordinate system, a vector A has its at the point P (-2, -3) and its tip at Q (3,9). Determine the distance between these two points.

$$\text{Sol}: \text{Points P((-2,-3) and Q(3,9)}, \quad \vec{r}_1 = -2\hat{i} - 3\hat{j} \quad , \vec{r}_2 = 3\hat{i} + 9\hat{j}, \quad d = ?$$

$$\vec{d} = \vec{r}_2 - \vec{r}_1 = (3\hat{i} + 9\hat{j}) - (-2\hat{i} - 3\hat{j}) = (3\hat{i} + 2\hat{i}) + (9\hat{j} + 3\hat{j}) = 5\hat{i} + 12\hat{j}$$

$$d = \sqrt{x^2 + y^2} = \sqrt{5^2 + 12^2} = \sqrt{25 + 144} = \sqrt{169} = 13 \text{ units}$$

2.2: A certain corner of a room is selected as the origin of a rectangular coordinate system, If an insect is sitting on an adjacent wall at a point having coordinates (2,1), where the units are in meters, what is the distance of the insect from this corner the room?

$$\text{Sol}: \text{Points P((2,1) and O(0,0)}, \quad \vec{r} = 2\hat{i} + \hat{j} \quad d = ?$$

$$d = \sqrt{2^2 + 1^2} = \sqrt{4 + 1} = \sqrt{5} = 2.24 \text{ units}$$

2.3: What is the unit vector in the direction of the vector $A = 4\hat{i} + 3\hat{j}$.

$$\text{sol}: \vec{A} = 4\hat{i} + 3\hat{j} \quad \hat{A} = ?$$

$$\hat{A} = \frac{\vec{A}}{A} = \frac{\vec{A}}{\sqrt{A_x^2 + A_y^2}} = \frac{4\hat{i} + 3\hat{j}}{\sqrt{4^2 + 3^2}} = \frac{4\hat{i} + 3\hat{j}}{\sqrt{16 + 9}} = \frac{4\hat{i} + 3\hat{j}}{\sqrt{25}} = \frac{4\hat{i} + 3\hat{j}}{5}$$

2.4: Two particles are located at $r_1 = 3\hat{i} + 7\hat{j}$ **and** $r_2 = -2\hat{i} + 3\hat{j}$ **respectively. Find both the magnitude of the vector** $(r_{2\_}r_1)$ **and its orientation with respect to the x-axis.**

$$\text{Sol}:, \quad \vec{r}_1 = 3\hat{i} + 7\hat{j} \quad , \vec{r}_2 = -2\hat{i} + 3\hat{j}, \vec{r}_2 - \vec{r}_1 = ?$$

$$\vec{r}_2 - \vec{r}_1 = (-2\hat{i} + 3\hat{j}) - (3\hat{i} + 7\hat{j}) = (-2\hat{i} - 3\hat{i}) + (3\hat{j} - 7\hat{j}) = -5\hat{i} + -4\hat{j}$$

$$|\vec{r}_2 - \vec{r}_1| = \sqrt{x^2 + y^2} = \sqrt{(-5)^2 + (-4)^2} = \sqrt{25 + 16} = \sqrt{41} = 6.4 \text{ units}$$

$$\theta = \tan^{-1}\left(\frac{-4}{-5}\right) = 38.6^\circ, \text{ As in 3rd quad so angle } = 180^\circ + 38.6^\circ = 218.6^\circ \approx 219^\circ$$

2.5: If a vector 'B' is added to vector A, the result is $6\hat{i} + \hat{j}$ **.If 'B' is subtracted from A, the result is** $-4\hat{i} + 7\hat{j}$ **. What is the magnitude of vector 'A'?**

$$\vec{A} + \vec{B} = 6\hat{i} + \hat{j}, \quad \vec{A} - \vec{B} = -4\hat{i} + 7\hat{j} \quad A = ?$$

$$(\vec{A} + \vec{B}) + (\vec{A} - \vec{B}) = (6\hat{i} + \hat{j}) + (-4\hat{i} + 7\hat{j}) = 2\hat{i} + 8\hat{j}$$

$$2\vec{A} = 2\hat{i} + 8\hat{j} \Rightarrow \vec{A} = \hat{i} + 4\hat{j}$$

$$A = \sqrt{A_x^2 + A_y^2} = \sqrt{1^2 + 4^2} = \sqrt{1 + 16} = \sqrt{17} = 4.1$$

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2.6: Given that $A = 2\hat{i} + 3\hat{j}$ and $B = 3\hat{i} - 4\hat{j}$, find the magnitude and angle of (a) C=A+B, and (b) D=3A-2B.

Sol (a) : $\vec{C} = \vec{A} + \vec{B} \quad \Rightarrow \vec{C} = (2\hat{i} + 3\hat{j}) + (3\hat{i} - 4\hat{j}) = 5\hat{i} - \hat{j}$

$\left|\vec{C}\right| = \sqrt{(5)^2 + (-1)^2} = \sqrt{25+1} = \sqrt{26} = 5.1$

Direction $= \theta = \tan^{-1}(\frac{-1}{5}) = 11^o$ As φ lies in fourth quad so orintation $360^o - 11^o = 349^o$

(b) $\vec{D} = 3\vec{A} - 2\vec{B} \quad \Rightarrow \vec{D} = 3(2\hat{i} + 3\hat{j}) - 2(3\hat{i} - 4\hat{j}) = (6\hat{i} + 9\hat{j}) - (6\hat{i} + 8\hat{j}) = 0\hat{i} + 17\hat{j}$

$\left|\vec{C}\right| = \sqrt{(0)^2 + (17)^2} = \sqrt{0 + 289} = 17$

Direction $= \theta = \tan^{-1}(\frac{0}{17}) = 90^o$ As φ lies in *F*irst quad

2.7: Find the angle between the two vectors, $A = 5\hat{i} + \hat{j}$ and $B = 2\hat{i} + 4\hat{j}$.

Given data : $\vec{A} = 5\hat{i} + \hat{j}, \vec{B} = 2\hat{i} + 4\hat{j}$ angle $= \theta = ?$

Using equation of scalar product for two vectors $AB\cos\theta = AxBx + AyBy$

$$\cos\theta = \frac{AxBx + AyBy}{AB} = \frac{(5)(2) + (1)(4)}{(\sqrt{5^2 + 1^2})(\sqrt{2^2 + 4^2})} = \frac{10+4}{\sqrt{26}\sqrt{20}} = \frac{14}{5.1 * 4.5}$$

$$\theta = \cos^{-1}(\frac{14}{5.1 * 4.5}) \quad \Rightarrow \theta = 52^o$$

2.8: Find the work done when the point of application of the force $3\hat{i} + 2\hat{j}$ moves in a straight line from the point (2,-1) to the point (6, 4).

Given data : $\vec{F} = 3\hat{i} + 2\hat{j}$, point(2,-1) $\vec{r}_1 = 2\hat{i} - \hat{j}$, point(6,4), $\vec{r}_2 = 6\hat{i} + 4\hat{j}$ $W = ?$

$\vec{d} = \vec{r}_2 - \vec{r}_1 = (6\hat{i} + 4\hat{j}) - (2\hat{i} - \hat{j}) = 4\hat{i} + 5\hat{j}$

$W = \vec{F}.\vec{d} = (3\hat{i} + 2\hat{j}).(4\hat{i} + 5\hat{j}) = 12 + 10 = 22\ J$

2.9: Show that the three vectors $\hat{i} + \hat{j} + \hat{k}$, $2\hat{i} - 3\hat{j} + \hat{k}$ and $4\hat{i} + \hat{j} - 5\hat{k}$ are mutually perpendicular.

Given Data : $\vec{A} = \hat{i} + \hat{j} + \hat{k}, \ \vec{B} = 2\hat{i} - 3\hat{j} + \hat{k}, \vec{C} = 4\hat{i} + \hat{j} - 5\hat{k}$

We know that two vectors are perpendicular if if $\vec{A}.\vec{B} = AB\cos 90^o = 0 \Rightarrow \vec{A}.\vec{B} = 0$

$\vec{A}.\vec{B} = (\hat{i} + \hat{j} + \hat{k}).(2\hat{i} - 3\hat{j} + \hat{k}) = 2 - 3 + 1 = 3 - 3 = 0$

$\vec{A}.\vec{C} = (\hat{i} + \hat{j} + \hat{k}).(4\hat{i} + \hat{j} - 5\hat{k}) = 4 + 1 - 5 = 5 - 5 = 0$

$\vec{B}.\vec{C} = (2\hat{i} - 3\hat{j} + \hat{k}).(4\hat{i} + \hat{j} - 5\hat{k}) = 8 - 3 - 5 = 8 - 8 = 0$

Hence prove that given three vectors are mutually perpendicular

2.10: Given that $A = \hat{i} - 2\hat{j} + 3\hat{k}$ and $B = 3\hat{i} - 4\hat{k}$, find the projection of A on B.

Given Data : $\vec{A} = \hat{i} - 2\hat{j} + 3\hat{k}$, $\vec{B} = 3\hat{i} - 4\hat{k}$ Projection of A on B $= A\cos\theta = ?$

As $\vec{A}.\vec{B} = AB\cos\theta \Rightarrow A\cos\theta = \frac{\vec{A}.\vec{B}}{B} = \frac{AxBx + AyBy + AzBz}{B} = \frac{(1)(3) + (-2)(0) + ((3)(-4)}{\sqrt{(3)^2 + 0^2 + (-4)^2}} = \frac{-9}{5}$

2.11: Vectors A, B and C are 4 units north, 3 units west and 8 units east, respectively. Describe carefully (a) $A\times B$ **(b)** $A\times C$ **(c)** $B\times C$

Given Data : $\vec{A}=4$ unit North, $\vec{B}=3$ units west, $\vec{C}=8$ unit east, $\vec{A}x\vec{B}=?$ $\vec{A}x\vec{C}=?$ $\vec{B}x\vec{C}=?$

$\vec{A}x\vec{B}=AB\sin\theta\,\hat{n}=(4)(3)\sin 90^{o}=12$ units vertically upward (Using Right hand rule)

$\vec{A}x\vec{C}=AC\sin\theta\,\hat{n}=(4)(8)\sin 90^{o}=32$ units vertically downward (using right hand rule)

$\vec{B}x\vec{C}=BC\sin\theta\,\hat{n}=(3)(8)\sin 0^{o}=0$

2.12: The torque or turning effect of force about a given point is given by $r\times F$ **where 'r' is the vector from the given point to the point of application of F. Consider a force** $F=-3\hat{i}+\hat{j}+5\hat{k}$ **(Newton) acting on the point** $7\hat{i}+3\hat{j}+\hat{k}(m)$**. What is the torque in Nm about the origin?**

Given Data : $\vec{F}=-3\hat{i}+\hat{j}+5\hat{k}$, $\vec{r}=7\hat{i}+3\hat{j}+\hat{k}$ torque $=\vec{\tau}=?$

$$\vec{\tau}=\vec{r}\times\vec{F}=\begin{vmatrix}\hat{i}&\hat{j}&\hat{k}\\7&3&1\\-3&1&5\end{vmatrix}=\hat{i}\begin{vmatrix}3&1\\1&5\end{vmatrix}-\hat{j}\begin{vmatrix}7&1\\-3&5\end{vmatrix}+\hat{k}\begin{vmatrix}7&3\\-3&1\end{vmatrix}=\hat{i}(15-1)-\hat{j}(35-(-3))+\hat{k}(7-(-9))$$

$$\vec{\tau}=14\hat{i}-38\hat{j}+16\hat{k}$$

2.13: The line of action of force, $F=\hat{i}-2\hat{j}$**, passes through a point whose position vector is** $\left(-\hat{j}+\hat{k}\right)$ **.Find (a)the moment of F about the origin, (b) the moment of F about the point of which the position vector is** $\hat{i}+\hat{k}$ **.**

Given Data : $\vec{F}=\hat{i}-2\hat{j}$, $\vec{r}=-\hat{j}+\hat{k}$ torque $=\vec{\tau}=?$

$$(a)\ \vec{\tau}=\vec{r}\times\vec{F}=\begin{vmatrix}\hat{i}&\hat{j}&\hat{k}\\0&-1&1\\1&-2&0\end{vmatrix}=\hat{i}\begin{vmatrix}-1&1\\-2&0\end{vmatrix}-\hat{j}\begin{vmatrix}0&1\\1&0\end{vmatrix}+\hat{k}\begin{vmatrix}0&-1\\1&-2\end{vmatrix}=\hat{i}(0-(-2)-\hat{j}(0-1)+\hat{k}(0-(-1))=2\hat{i}+\hat{j}+\hat{k}$$

(b) first of all to find r, $\vec{r}=\vec{r}_2-\vec{r}_1=(-\hat{j}+\hat{k})-(\hat{i}+\hat{k})=-\hat{j}+\hat{k}-\hat{i}-\hat{k}=-\hat{i}-\hat{j}$ so $\vec{r}=-\hat{i}-\hat{j}$ and $\vec{F}=\hat{i}-2\hat{j}$

$$\vec{\tau}=\vec{r}\times\vec{F}=\begin{vmatrix}\hat{i}&\hat{j}&\hat{k}\\-1&-1&0\\1&-2&0\end{vmatrix}=\hat{i}\begin{vmatrix}-1&0\\-2&0\end{vmatrix}-\hat{j}\begin{vmatrix}-1&0\\1&0\end{vmatrix}+\hat{k}\begin{vmatrix}-1&-1\\1&-2\end{vmatrix}=\hat{i}(0-0)-\hat{j}(0-0)+\hat{k}(2-(-1))=3\hat{k}$$

2.14: The magnitude of dot and cross products of two vectors are $6\sqrt{3}$ **and 6 respectively. Find the angle between the vectors.**

Given Data : $AB\cos\theta=6\sqrt{3}$, $AB\sin\theta=6$ angle $=\theta=?$

dividing both equations, $\dfrac{AB\sin\theta}{AB\cos\theta}=\dfrac{6}{6\sqrt{3}}\Rightarrow\dfrac{\sin\theta}{\cos\theta}=\dfrac{1}{\sqrt{3}}\Rightarrow\tan\theta=\dfrac{1}{\sqrt{3}}$

$$\theta=\tan^{-1}\left(\frac{1}{\sqrt{3}}\right)=30^{o}$$

2.15: A load of 10.0N is suspended from a clothes line. This distorts the line so makes an angle of 15o with the horizontal at each end. Find the tension in the clothes line.

Given Data : Weight $=W=10$ N, Angle $=\theta=15^{o}$, $T=?$

As Tension due to X - components is zero as $\sum Fx=0$

Along $Y-$axis $\quad T\sin\theta+T\sin\theta=W\ \Rightarrow 2T\sin\theta=W$

$$T=\frac{W}{2\sin\theta}=\frac{10}{2\sin 15^{o}}=19.3N$$

PAST PAPERS MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	The magnitude of cross product and dot product are equal at angle of	**45˚**	90˚	180˚	Zero ˚
	A.B=**AxB**.. ABcosθ=ABsinθ, sinθ/cos=1, tanθ=1 θ=45°				
ii.	Magnitude of rectangular components are equal at angle of	**45˚**	90˚	180˚	Zero ˚
iii.	i^.(j^xk^)=?	**1**	0	J	I
	(j^xk^)=i^ so i^.i^=1				
iv.	Projection of B along A is written as	A.B	A	**A.B**/B	**A.B**/A
v.	A force of 10N acting on 30˚ with y axis then magnitude of X-component will be	**5N**	8.66N	10N	Zero
F= 10 N, angle with y axis is 30° then with x-axis will be 60° so Fx=Fcosθ=10cos60°=5N					
vi.	The resultant of two force 5N and 10N cannot be?	**4N**	6N	9N	13N
Max ans is 5+10=15 N and min ans=10-5=5 N, ans range is 5-15					
vii.	Resultant of two forces 30N and 40N acting at angle of 90° is	**50N** Apply Pythagoras theorem to get result	30N	40N	70N
viii.	The unit vector along y axis is	i^	**j^**	k^	y^
ix.	If the angle between two vectors of magnitude 12 and 4 is 60˚, then dot product	6	12	**24**	48
	A.B=ABcosθ= (12)(4)cos60°=48(0.5)=24				
x.	Resultant magnitude of 6N force acting on right angle with force of 8N	6N	8N	**10N** Apply Pythagoras theorem to get result	14N
xi.	A body is in a static equilibrium when it is at	**Rest**	Moving with uniform velocity	Moving with variable velocity	All of these
xii.	If body is at rest or rotating with uniform angular velocity then torque will	Maximum	**Zero**	Negative	Positive
xiii.	The magnitude of vector can never be	Positive	**Negative**	Both A&B	None of these
xiv.	The vector in space has components	Two	**Three**	Four	One
xv.	Dot product of vector A with itself is	A	2A	**A^2**	0
xvi.	A body will be in translational equilibrium if	**ΣF=0**	Σt=0	Both A&B	None of these
xvii.	Two forces of 10 N and 20 N act on a body in direction making angle 30°, Resultant of X-component is	**25.98 N**	12.5 N	30.98 N	36.36 N
xviii.	If second condition of equilibrium is satisfied then body will be in	Translational equilibrium	**Rotational equilibrium**	Dynamic equilibrium	Complete equilibrium
xix.	The magnitude of resultant of two perpendicular vector of magnitude A will be?	A	**$\sqrt{2}$A** Apply Pythagoras theorem to get result	A	A^2
xx.	Name the quantity which is vector?	Speed	**Force**	Temperature	Density
xxi.	A force 2i + j has moved its point of application from (2,3) to (6,5). What is work done?	-10	-18	+18	**+10**
W=**F.d**, **d=r2-r1**=(6i+5j)-(2i+3j)=4i+2j, W=(2i+j).(4i+2j)=8+2=10J					
xxii.	If a force of 10N acting on y axis then its x component will be	8.66 N	5 N	**0 N**	10N
For Fx=Fcosθ=10cos90°=0 as w.r.t X component angle is 90° w.r.t y axis					
xxiii.	The direction of torque is along	Position vector	Force	Parallel to plane contain r and F	**Perpendicular to plane contain r&F**
xxiv.	The magnitude of cross and dot product are6 and 6$\sqrt{3}$then what is angle b/w them	0˚	**30˚**	45˚	60˚

	See solution of numerical 2.14				
xxv.	Two vector of 60N and 35N combined then correct answer will be	15N	20N	**70N**	100N
Apply Pythagoras theorem to get result , also its max ans=60+35=95N and min ans=60-35=25N, its ans range 95-25 so					
xxvi.	A single vector having the same effect as all the original vectors taken together called	**Resultant vector**	Equal vector	Unit vector	Position vector
xxvii.	Unit vector in the direction of vector 2i − 4j will be:	$\frac{2i - 4j}{\sqrt{6}}$	$\frac{4i - 2j}{\sqrt{10}}$	$\frac{i-2j}{\sqrt{5}}$	$\frac{i - 2j}{\sqrt{7}}$
$A=\sqrt{2^2+(-4)^2}=\sqrt{20}=\sqrt{4*5}=2\sqrt{5}, \hat{A}=\frac{2i-4j}{2\sqrt{5}}=\frac{2(i-2j)}{2\sqrt{5}}=\frac{i-2j}{\sqrt{5}}$					
xviii.	The angle of A=Axi-Ayj with x-axis in b/w	0° and 90°	90° and 180°	180° and 270°	**270° and 360°**
As resultant lies in 4th quadrant so angle is b/w 270° and 360°					
xxix.	If the resultant of two vectors each of magnitude F is also of magnitude F, the angle between them will be ?	60˚	30˚	90˚	**120˚**
See solution of exp 2.3 for explanation					
xxx.	If |A+B|=|A-B| then angle between A&B is	**90˚**	0˚	180˚	45˚
Sum and difference of equal vectors are perpendicular to each other					
xxxi.	If the force of magnitude 8 N acts on a body in direction making an angle 30°, its X and Y components will be:	$F_x = 3\sqrt{3}$ $F_y = 4$	$F_x = 4\sqrt{3}$ $F_y = 8$	**$F_x = 4\sqrt{3}$** **$F_y = 4$**	$F_x = 8$ $F_y = 4\sqrt{3}$
F=8N, Fx=Fcosθ=8cos30°=$8\sqrt{3}/2=4\sqrt{3}$ Fy=Fsinθ=8sin30°=8(1/2)=4					
xxxii.	If A=2i and B=3i+4j then A.B	1	0	14	**6**
A.B=(2i).(3i+4j)=6(i,i)=6					
xxiii.	Angle between Ax and Az is	**90˚**	180˚	270˚	360˚
xxiv.	If Fx=2N and Fy=2N then F along X-axis	0˚	90˚	**45˚**	60˚
xxxv.	The scalar product of i and k is:	**Zero**	1	90°	–1
xxvi.	A force of 15 N makes an angle of 90° with x-axis, its y component will be	15 N	**0 N**	100 N	15 N
xxvii.	If vector A lies along x-axis then its component along y-axis will be?	A sinΘ	A cosΘ	A tanΘ	**Zero**
xviii.	The result of 120 N and 20 N forces cannot	**141 N**	100 N	101 N	**130 N**
xxix.	When a vector is multiplied by -1 then its direction is changed by?	90˚	120˚	360˚	**180˚**
xl.	If F=2i+3j and d=4i+4j then work will be?	12J	**20J**	32J	40J
xli.	If the two unit vectors perpendicular to each other are added, magnitude of resultant	1	**$\sqrt{2}$**	4	3
By Pythagoras theorem magnitude $\sqrt{1^2+1^2}=\sqrt{2}$					
xlii.	If the magnitude of then angle between $A.B=\frac{1}{2}AB$ A and B is	30˚	45˚	**60˚**	90˚
A.B=ABcosθ=ABcos60°=1/2 AB as Cos 60°=1/2 or 0.5					
xliii.	Torque of force t=rxF then r and F are at angle of	0˚	**90˚**	45˚	60˚
xliv.	When a vector A is added to negative vector-A then resultant will be	2A	A	0	**Null vector**
xlv.	A body will be in complete equilibrium when it satisfies	First condition	2nd condition	**Both A&B**	None of these

xlvi.	If we double the moment arm the value of torque becomes	**Two times**	Three times	Four times	Half
xlvii.	The position vector r in xz plane	$x\hat{i}+z\hat{k}$	$y\hat{i}+z\hat{k}$	$y\hat{i}+x\hat{k}$	$y\hat{j}+x\hat{i}$
xlviii.	The resultant of two forces 3N and 4N acting at right angle to each other	**5N**	6N	1N	7N
Apply Pythagoras theorem					
xlix.	What is angle between two vectors A=5i+j and B=2i+4j	66^o	**52^o**	25^o	33^o
See solution of numerical no 2.7 to get the result					
l.	The vector product rxdp/dt is	F	I	**torque**	Momentum
li.	|i-j-3k|=?	$\sqrt{5}$	$\sqrt{15}$	$\sqrt{11}$	$\sqrt{7}$
Apply formula of magnitude $\sqrt{(a^2+b^2+c^2)}$ put a=1 b=-1 c=-3 to get the result					
lii.	If position vector r and F are in same direction then torque will be	Maximum	Minimum	**Zero**	Same
liii.	Torque has zero value if angle between r and F is	**0°**	90°	45°	60°
liv.	The cross product k^ x j^	i^	j^	K^	**-i^**
lv.	The cross product i^ x k^	i^	j^	K^	**-j^**
lvi.	For maximum torque, the angle between **r&F** is	0°	**90°**	45°	60°
lvii.	If the scalar product of two vectors is $2\sqrt{3}$ and magnitude of their vector product is 2, the angle b/w them is	120°	**30°**	60°	180°
$ABcos\theta = 2\sqrt{3},\ \ ABSin\theta = 2,\ \frac{ABsin\theta}{ABcos\theta} = \frac{2}{2\sqrt{3}} \Rightarrow \tan\theta = \frac{1}{\sqrt{3}} \Rightarrow \theta = \tan^{-1}(\frac{1}{\sqrt{3}}) = 30^o$					
lviii.	The resultant of two forces 30 N and 40 N acting parallel to each other is:	30 N	40 N	**70 N**	10 N
For parallel forces, forces are sum up so 30+40=70 N					
lix.	Which is correct formula?	$\vec{\tau} = rF$	$\vec{\tau} = rF\sin\theta$	$\vec{\tau} = \vec{r}x\vec{F}$	$\vec{\tau} = rF\cos\theta$
lx.	A force of 100 N is acting on y axis 60° with y axis then its horizontal component will be	50 N	60N	70N	**86.6 N**
F= 100 N, angle with y axis is 60° then with x-axis will be 30° so Fx=Fcosθ=100cos30°=86.6N					

Chapter 03 Motion and Force

What is Difference b/w Rest and Motion?

Rest	Motion
An object is said to be in rest if it does not change its position with respect to origin	An object is said to be in state of motion if it changes its position with respect to its surroundings.
For example book lying on table	For example motion of car

What is Difference b/w Distance and displacement?

Distance	Displacement
The length of track b/w two points is called distance	"The change in position of body from its initial to final position" OR Shortest distance b/w two points is called displacement
It is scalar quantity and its unit is meter [L]	It is vector quantity and its unit is meter [L]
Magnitude of displacement is distance	Its formula is $\vec{d}=\vec{r}_2-\vec{r}_1$, where $\vec{r}_2$ and $\vec{r}_1$ are positions

What is Difference b/w Speed and velocity?

Speed	Velocity
The time rate of change of distance of body is called speed, it is denoted by v, v=distance/ time	The time rate of change of displacement of body is called velocity denoted by $\vec{v}$, $\vec{v}$=displacement/ time
It is scalar quantity	It is Vector quantity and its direction is along the direction of displacement
Formula v=d/ t and unit is meter/sec[LT^{-1}]	Formula $\vec{v}=\vec{d}$/ t and unit is meter/sec[LT^{-1}]

What is Difference b/w Average and Instantaneous velocity?

Average Velocity	Instantaneous velocity
The ratio of total displacement to the total time taken to cover displacement is called average velocity.	The velocity of a body at any instant of time is called instantaneous velocity.
$\vec{V}_{av}=\frac{\Delta\vec{d}}{\Delta t}$. Its unit is m/s	$V_{ins}=\lim \Delta t \to 0 \frac{\Delta \vec{d}}{\Delta t}$ its unit is m/s.

What is Difference b/w uniform velocity and variable velocity?

Uniform velocity	Variable velocity
If the body cover equal displacement in equal interval of time, the body is said to be in uniform velocity	If the body covers unequal displacement in equal interval of time, the body is said to be in variable velocity.
In uniform velocity, instantaneous velocity is equal to average velocity of a body	In variable velocity, instantaneous velocity is not equal to average velocity of a body, it may be changed.

Acceleration: The time rate of change of velocity of a body is called Acceleration. $\vec{a}$=change in velocity/time, $\vec{a}=\vec{v}$/t. It is vector quantity and its direction is along the direction of change in velocity. Its SI unit is ms^{-2} [LT^{-2}].

What is Difference b/w Average and instantaneous Acceleration?

Average Acceleration	Instantaneous Acceleration
The ratio of the total change in velocity to the total time taken is called average acceleration	The acceleration of a body at any instant of time is called instantaneous acceleration
Its formula is $\vec{a}_{av}=\frac{\Delta\vec{v}}{\Delta t}$	$\vec{a}_{ins}= =\lim \Delta t \to 0 \frac{\Delta \vec{V}}{\Delta t}$

What is Difference b/w uniform Acceleration and variable Acceleration?

Uniform Acceleration	Variable Acceleration
A body is said to be moving with uniform acceleration if its average and instantaneous velocity are equal	A body is said to be moving with variable acceleration if its average and instantaneous velocity are not equal

What is Difference b/w Positive and Negative Acceleration?

Positive acceleration	Negative acceleration
If the velocity of body is increasing then acceleration is positive	If the velocity of body is decreasing then acceleration is negative, it is also called retardation or deceleration.

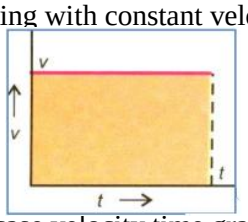
Write a note on Velocity time Graph.

Graph: The pictorial relationship b/w two quantities is called graph.

Velocity time graph: The graph which describe the relations ship b/w velocity and time is called velocity time graph.

The velocity-time graph representation for the motion along straight line is as follows:

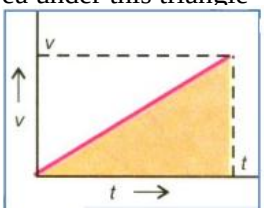
Case 01: When an object is moving with constant velocity: In this case velocity time graph is horizontal straight line parallel to X-axis or time axis. The distance covered by the object moving with constant velocity can be calculated by calculating the area of under the straight line



Distance=Area of rectangle= Length x width

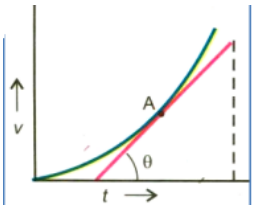
S=Vxt=Vt S=Vt

Case 02: When an object is moving with uniform Acceleration: In this case velocity time graph is straight line inclined to time axis (X-axis). The distance covered can be calculated by area under this triangle



Distance= S= 1/2 (base*height) = ½ (V*t) S= ½ Vt.

Case 03When an object is moving with variable Acceleration: In this case velocity time graph is a curve. The instantaneous acceleration at point A on curve is equal to slope of tangent.



Significance of Velocity time graph: Velocity time graph is used

- To find Average acceleration of object from slope of V-t graph
- To find the distance by calculating the area under the V-t graph.

Give Equations of motion.

Equations of motion for uniformly motion: When an object is moving with uniform acceleration then equations

I.	$V_f=V_i+at$	II.	$S=V_it+ ½ at^2$
III.	$2as=V^2_f-V^2i$	IV.	$S=(V_f+V_i)/2*t$

Note: These equations are useful for rectilinear motion of an object.

Equations of motion when a body falls with uniform gravitational acceleration g in the absence of air friction

(1) $V_f=V_i+gt$ (2) $h=V_it+ ½ gt^2$ (3) $2gh=V^2_f-V^2i$

Sign of acceleration is positive when object is falling under the action of gravity, sign of acceleration is negative when object is moving upward again the force of gravity.

State Newton laws of Motion.

These laws was stated by Isaac Newton in his famous book "Principia Mathematica" in 1687

Newton law of inertia/First law of motion:
"A body at rest will remain at rest and a body moving with uniform velocity will continue to do so, unless unbalance external force acts on it". It is also called law of inertia a=0.
Inertia: The property of a body due to which it tend to maintain its state or rest or uniform motion is called inertia.
Definition of mass in terms of inertia. Quantitative measurement of inertia is called mass.
Inertial frame of reference: The frame of reference in Newton's first law of motion hold is called inertial frame of reference. As Earth is approximately an inertial frame of reference.

Newton 2nd law of motion: When a force is applied on a body, it produces the acceleration in it own direction, which is directly proportional to applied force and inversely proportional to mass, $\vec{F} = m\vec{a}$.

Newton third law of motion: "Action and reaction are equal in magnitude and opposite in direction" e.g when two bodies interact with each other like Our walk on ground. Action and Reaction never act on same body but always act on different bodies.

What is Momentum? Write its formula and unit.

Definition of momentum: The product of mass and velocity of moving body is called momentum. $\vec{P}=m\vec{v}$
Its unit is kgm/s or Ns and dimension $[MLT^{-1}]$, it is vector quantity.
For example momentum defines how easy or difficult to stop a moving body. When two bodies of same masses moving with different velocities, then it is difficult to stop the body whose velocity is larger.

State and explain Newton 2nd law in term of linear momentum.

Statement: "Time rate of change of momentum of body is equal to the applied force". $F = \frac{mvf - mvi}{t} = \frac{\Delta P}{t}$

Proof: Let us consider an object of mass m is moving with velocity v, when external force acts on it for time t, then its velocity changes from Vi to Vf,.

$$a = \frac{V_f - V_i}{t} \text{ ---------(1)}$$

$$a = \frac{F}{m} \text{ ----------(2)}$$ comparing both equations

$$\frac{F}{m} = \frac{V_f - V_i}{t}$$

$$Fxt = m(V_f - V_i) = mV_f - mV_i = \Delta P$$

$$F = \frac{\Delta P}{t}$$ This is Newton 2nd law in terms of linear momentum

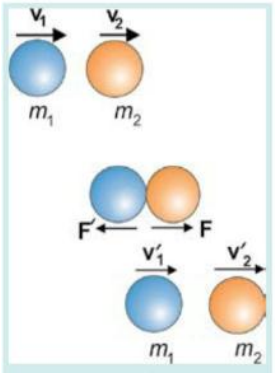
What is Impulse And Impulsive Force?

Impulse: When a large force acts on a body for a very short interval of time, then the product of force and time for which force acts, is called impulse. $\vec{I} = \vec{F}xt = \Delta\vec{P}$, its SI unit is Ns, it is vector quantity.
Impulsive Force: A force acting on a body for very short interval of time is called impulsive force. When a ball hit the bat during stroke of batsman.

State and Explain Law of conservation of linear momentum.

Isolated system: Such a system on which no external force acts is called isolated system. e.g. molecules of gas in cylinder at constant temperature.

Statement of law of conservation of linear momentum: Total linear momentum of an isolated system remains constant. **OR** For an isolated system, total momentum before collision is equal to total momentum after collision.
Equation: Total momentum before collision=Total momentum after collision $m_1v_1+m_2v_2=m_1v_1'+m_2v_2'$
Explanation/Proof: Let us consider an isolated system of two smooth hard balls of mass m_1 and m_2 moving with velocities v_1 and v_2 in same direction before collision and after collision velocities becomes v_1' and v_2'.
We can find change in momentum by using Newton 2nd law of motion



For m_1 initial momentum $P_i = m_1v_1$ and final momentum $P_f = m_1v_1'$

$$Fxt = \Delta P = P_f - P_i$$

$$Fxt = m_1v_1' - m_1v_1 \text{ ----------(1)}$$

Similarly for mass m_2 initial momentum $P_i = m_2v_2$ and final momentum $P_f = m_2v_2'$

$$F'xt = m_2v_2' - m_2v_2 \text{ ----------(2)}$$

Adding equation (1) and (2)

$$(Fxt) + (F'xt) = (m_1v_1' - m_1v_1) + (m_2v_2' - m_2v_2)$$

$$(F + F')t = m_1v_1' - m_1v_1 + m_2v_2' - m_2v_2$$

As F and F' are action and reaction forces which are equal but opposite in direction $\vec{F} = -\vec{F}'$

$$(-\vec{F} + \vec{F}) = m_1v_1' - m_1v_1 + m_2v_2' - m_2v_2$$

$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2' \Rightarrow \text{Total momentum before collision} = \text{Total momentum after collision}$$

What is Elastic collision and Inelastic collision?

Collision: When some interaction take place b/w two objects then collision is said to be occurred

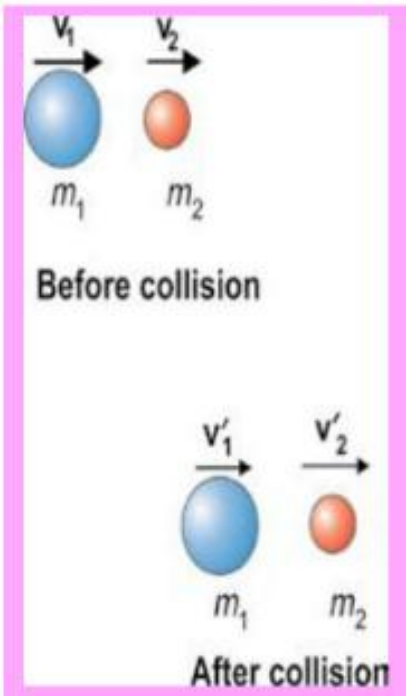
Elastic collision: The collision in which kinetic energy of system is conserved is called elastic collision. For example bouncing back of a hard ball from a marble floor.

Inelastic collision: Such a collision in which kinetic energy is not conserved is called inelastic collision. For example collision of two tennis balls.

Note: Momentum and total energy remains constant in all types of collision.

Discuss Elastic collision in one dimension.

Consider two smooth, non-rotating hard balls of masses m_1 and m_2 moving in such a way that they have linear velocities v_1 and v_2 respectively and v_1' and v_2' after collision as shown in figure.



According to law of conservation of linear momentum

$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2' \quad \text{----------(A)}$$

$$m_1v_1 - m_1v_1' = m_2v_2' - m_2v_2$$

$$m_1(v_1 - v_1') = m_2(v_2' - v_2) \quad \text{----------(1)}$$

Now applying law of conservatio of K.E

$$\frac{1}{2}m_1v^2{}_1 + \frac{1}{2}m_2v^2{}_2 = \frac{1}{2}m_1v^2{}_1' + \frac{1}{2}m_2v^2{}_2'$$

$$\frac{1}{2}(m_1v^2{}_1 + m_2v^2{}_2) = \frac{1}{2}(m_1v^2{}_1' + m_2v^2{}_2')$$

$$m_1v^2{}_1 + m_2v^2{}_2 = m_1v^2{}_1' + m_2v^2{}_2'$$

$$m_1v^2{}_1 - m_1v^2{}_1' = m_2v^2{}_2' - m_2v^2{}_2$$

$$m_1(v^2{}_1 - v^2{}_1') = m_2(v^2{}_2' - v^2{}_2)$$

$$m_1(v_1 - v_1')(v_1 + v_1') = m_2(v_2' - v_2)(v_2' + v_2) \quad \text{---(2)}$$

Dividing equation (2) by (1)

$$\frac{m_1(v_1 - v_1')(v_1 + v_1')}{m_1(v_1 - v_1')} = \frac{m_2(v_2' - v_2)(v_2' + v_2)}{m_2(v_2' - v_2)}$$

$$v_1 + v_1' = v_2' + v_2$$

$$v_1 - v_2 = v_2' - v_1'$$

$$v_1 - v_2 = -(v_1' - v_2') \quad \text{----------(3)}$$

$v_1 - v_2$ = Relative velocity of m_1 w.r.t m_2 before collision

$(v_1' - v_2')$ = Relative velocity of m_1 w.r.t m_2 after collision

Determination of velocities after collision: We can calculate the velocities of both masses by solving

From equation (3) we

$$v_1 - v_2 = v_2' - v_1'$$

$v_1' = v_2' - v_1 + v_2$ putting in equation(A)

$$m_1v_1 + m_2v_2 = m_1(v_2' - v_1 + v_2) + m_2v_2'$$

$$m_1v_1 + m_2v_2 = m_1v_2' - m_1v_1 + m_1v_2 + m_2v_2'$$

$$m_1v_1 + m_1v_1 + m_2v_2 - m_1v_2 = m_1v_2' + m_2v_2'$$

$$2m_1v_1 + (m_2 - m_1)v_2 = (m_1 + m_2)v_2'$$

$$(m_1 + m_2)v_2' = 2m_1v_1 + (m_2 - m_1)v_2$$

Dividing both sides by $(m_1 + m_2)$

$$v_2' = \frac{2m_1v_1}{m_1 + m_2} + \frac{(m_2 - m_1)v_2}{m_1 + m_2} \quad \text{-----(B)}$$

Again from equation $v_1 - v_2 = v_2' - v_1'$

$v_2' = v_1 - v_2 + v_1'$ putting in equation (A)

$m_1v_1 + m_2v_2 = m_1v_1' + m_2(v_1 - v_2 + v_1')$

$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_1 - m_2v_2 + m_2v_1'$

$m_1v_1 - m_2v_1 + m_2v_2 + m_2v_2 = m_1v_1' + m_2v_1'$

$(m_1 - m_2)v_1 + 2m_2v_2 = (m_1 + m_2)v_1'$ dividing both sides by $(m_1 + m_2)$

$$v_1' = \frac{(m_1 - m_2)v_1}{m_1 + m_2} + \frac{2m_2v_2}{m_1 + m_2} \text{ ------(C)}$$

Special Cases of collision:

Case 01: When m_1 and m_2 are equal so put $m_1=m_2=m$ equation (B) and equation (C) to get the result

$V_1'=V_2$ and $V_2'=V_1$

Case 02: When m_1 and m_2 are equal and target is at rest mean put $m_1=m_2=m$ and $v_2=0$

$V_1'=0$ and $V_2'=V_1$

Case 03: When lighter mass m_1 collide with massive mass m_2 at rest mean $m_1=0$ and $v_2=0$

$V_1'=-V_1$ and $V_2'=0$

Case 04: When massive body m1 collides with lighter body m2 at rest mean $m_2=0$ and $v_2=0$

$V_1'=V_1$ and $V_2'=2V_1$

Calculate the formula for Force due to water flow

Let the initial velocity of water is v and on striking the wall it comes to rest so final velocity becomes zero

initial velocity $= \vec{v}i = v$, initial momentum $= m\vec{v}$

final velocity $= \vec{v}_f = 0$ Final momentum $= 0$

$$\text{Force} = \frac{\text{Change in momentum}}{\text{time}} = \frac{P_f - P_i}{t} = \frac{0 - m\vec{v}}{t}$$

$$F = \frac{-m\vec{v}}{t} =, \frac{-m}{t}\vec{v}$$ This is the formula for force due to water flow

Example

Suppose water flows from a pipe at $3kgs^{-1}$ and its velocity changes from $5ms^{-1}$ to 0 on striking wall

$$\frac{m}{t} = 3kgs^{-1}, F = \frac{-m}{t}\vec{v} = 3(0-5) = 15N$$

Describe Momentum and Explosive forces

Principle: Within isolated system total momentum remains same due to explosive forces.

Examples: There are many examples of momentum and explosive forces which are as follows

1. **Explosion of a shell or bomb**: Let a shell is exploded in the mid air and its fragments are scattered in different directions then by law of vector addition, then its total momentum of its fragments is equal to initial momentum.
2. **Firing of rifle**: Let a bullet of mass m fired from a rifle of mass M with velocity $\vec{v}$

As initial momentum is zero as both bullet and rifle are initially at rest, m is mass of bullet and M is mass of rifle

final momentum $= m\vec{v} + M\vec{v}$

apply law of conservation of linear momentum

$0 = m\vec{v} + M\vec{v}'$

$$\vec{v}' = \frac{-m\vec{v}}{M}$$ This is the velocity of recoil of rifle

Describe Rocket propulsion.

Working principle of Rocket motion: It based upon law of conservation of momentum and Newton third law of motion.

Working principle of Rocket: Rocket moves up by ejecting burning gases from its rear part of engine, when fuel is burned, it turns to high pressure gases with high speed. Rocket gains momentum equal to the momentum of expelled gases but in opposite direction

Fuel of rocket: Fuel is in the form of liquid or solid and oxygen. **80%** of launch mass of rocket consist of fuel only. A typical rocket consumes **10,000 kg/s.** rocket ejects the burnt gases at speed of over **4000 m/s.**

Acceleration of rocket: The acceleration of rocket can be calculated as follows

According to Newton 2nd law of motion, the force exerted on gases by rocket

$$F = \frac{m\vec{v}}{t} = (\frac{m}{t})\vec{v} = m\vec{v} \quad \text{for t} = 1\text{sec}$$

$$\text{The force exerted on rocket } \vec{F} = M\vec{a}$$

$$M\vec{a} = m\vec{v}$$

$$\vec{a} = \frac{m\vec{v}}{M}$$

What is Projectile Motion? Derive the relations for velocity, time, height and range of projectile

Projectile motion: A two dimensional motion under the constant acceleration due to gravity is called projectile motion. And the objects which perform this type of motion are called projectile like

Examples: (i) A football kicked by a player (ii) A missile fired from a launching pad (iii) Bullet fired from gun

Trajectory of projectile: The path followed by projectile is called its trajectory. The trajectory of projectile is normally parabolic.

Horizontal Distance: Horizontal distance covered by projectile is $X=V_{ix}\,t$ using (S=vt)

Vertical Distance: The vertical motion of the ball is under the effect of gravity. For downward motion a=g. Hence the

Vertical displacement is calculated by 2nd equation of motion. $Y=Vit+ 1/2\ gt^2= (0) + 1/2\ gt^2=1/2\ gt^2$

Instantaneous velocity: Let a projectile is fired with initial velocity v at an angle Θ with horizontal

Horizontal component of velocity: As there is no force acting on horizontal axis so velocity of horizontal component remains constant so acceleration ax=0 and Vfx= Vix= VicosΘ

Vertical component of velocity: Vertical component of velocity vary point to point by using 1st eq of motion

Vfy=Vi+at= VisinΘ+(-g)t= VisinΘ-g)t Vfy=VisinΘ-gt

Magnitude of velocity: Magnitude of velocity can be calculated by using $V = \sqrt{V^2{}_{fx} + V^2{}_{fy}}$

Direction of velocity: Direction of velocity can be calculated by using $Tan\theta = \frac{V_{fy}}{V_{fx}} \Rightarrow \theta = Tan^{-1}\left(\frac{V_{fy}}{V_{fx}}\right)$.

Height of projectile: "The maximum vertical distance covered by the projectile is called maximum height of projectile". For finding the value of maximum height we consider

$$\text{At maximum height the vertical component of velocity vanishes } Vfy = 0$$

$$\text{also } a_y = -g \text{ and initial component of velocity } Viy = Visin\theta, \text{ using 3rd eq of motion}$$

$$2as = Vf^2 - Vi^2 \Rightarrow \qquad 2(-g)H = 0^2 - (Visin\theta)^2 \Rightarrow -2gH = -Vi^2\sin\theta^2$$

$$H = \frac{Vi^2\sin\theta^2}{2g}, \quad \text{This is the formula for height of projectile}$$

Time of flight: The time taken by a projectile to cover the distance from place of projection to the place where it hit the ground is called time of flight.

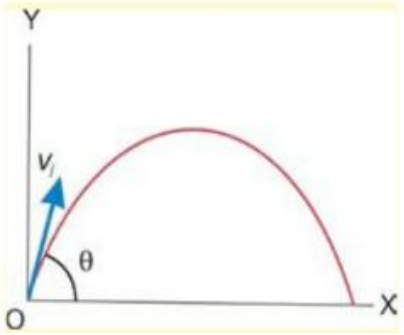
As the total vertical distance covered by body from the point of projection to a point at hitting is equal to zero so $Y = 0$, $a = -g$, $Viy = Visin\theta$, $t = T$

using eq, $Y = V_{iy}\ t + 1/2at^2$

$$0 = Vi\sin\theta T + \frac{1}{2}(-g)T^2$$

$$\frac{1}{2}(g)T^2 = Vi\sin\theta T$$

$$T = \frac{2Vi\sin\theta}{g}, \text{ This is the formula for time of flight}$$



Range of projectile: Maximum distance which a projectile covers in the horizontal direction is called range of projectile.

Range of projectile is determined by using the formula $R = Vix \times T$ $(S = vt)$

we know that $Vix = Vicos\theta$, $T = \frac{2Vi\sin\theta}{g}$

$$R = Vicos\theta\left(\frac{2Vi\sin\theta}{g}\right) \Rightarrow R = \frac{Vi^2}{g}(2\sin\theta\cos\theta) \Rightarrow R = \frac{Vi^2}{g}(\sin 2\theta) \quad \text{as } 2\sin\theta\cos\theta = \sin 2\theta$$

$$R = \frac{Vi^2\sin 2\theta}{g}, \quad \text{this is the formula for range of projectile}$$

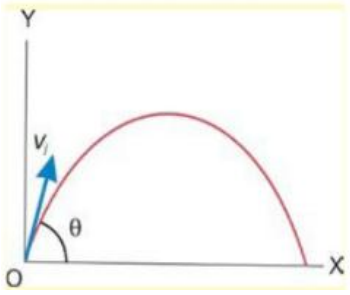
Maximum Range of projectile: The range of projectile is maximum at angle of 45°

The range of projectile is maximum when $\sin 2\theta$ has maximum value

when angle $\theta = 45^o$ put in formula of range

$$R_{max} = \frac{Vi^2}{g}\sin 2(45^o) = \frac{Vi^2}{g}\sin 90^o = \frac{Vi^2}{g}$$

$$R_{max} = \frac{Vi^2}{g}$$



Describe the Applications to Ballistic Missile?

Ballistic Flight: When a projectile is given an initial push and is allowed to move freely due to inertia under the action of gravity, then such a flight is called ballistic flight.
Ballistic Missile: The unpowered and unguided missile is called ballistic missile.
Ballistic trajectory: The path followed by the ballistic missile is called ballistic trajectory.
For flat earth (short range) the trajectory of projectile is parabolic and for spherical it is elliptical.
Uses of Ballistic missile: The ballistic missile are useful for short range and powered and remote control missile are useful for long range.

Exercise short Questions chapter 03

1. What is the difference between uniform and variable velocity. From the explanation of variable velocity, define acceleration. Give SI units of velocity and acceleration.

Uniform velocity	Variable velocity
If the body covers equal displacement in equal interval of time then velocity is called uniform velocity	If the body covers unequal displacement in equal interval of time is called variable velocity
Rate of change of velocity is called acceleration. SI unit of velocity is m/s and acceleration is ms^{-2}.	

2. **An object is thrown vertically upward. Discuss the sign of acceleration due to gravity, relative to velocity, while the object is in air**?
Since direction of initial velocity is upward. So *g* will be negative, relative to velocity. For downward motion, g is positive with reference to the direction of initial velocity.

3. Can the velocity of an object reverse direction when acceleration is constant? If so, give an example.
Ans. Yes. For bodies freely falling back in air. If a body moves upward, finally reverse direction and moves down. The acceleration due to gravity is constant for both directions of motion.

4. Specify the correct statement:
a. An object can have a constant velocity even its speed is changing.
b. An object can have a constant speed even its velocity is changing.
c. An object can have a zero velocity even its acceleration is not zero
d. An object subjected to a constant acceleration can reverse its velocity.
Ans. Statements (b), (c) & (d) are correct. Examples of: (b) circular motion. (c) total (upward & downward) velocity is zero moving under g. (d) in the air, bodies freely falling back.

5.A man standing on the top of a tower throws a ball straight up with initial velocity vi and at the same time throws a second ball straight downward with the same speed. Which ball will have larger speed when it strikes the ground? Ignore air friction.
Ans. Upward thrown ball will have larger speed when it strikes the ground. Since it will take more time and move larger downward distance under g

6.Explain the circumstances in which the velocity v and acceleration a of a car are(i) Parallel (ii) Anti-parallel (iii) Perpendicular to one another (iv) v is zero but a is not (v) a is zero but v is not zero
Ans. (i) The car moving with increasing speed. (ii) The car moving with decreasing speed. (iii) Moving a curved or circular path. (iv) When sudden brakes are applied. (v) Moving with uniform velocity

7. Motion with constant velocity is a special case of motion with constant acceleration. Is this statement true? Discuss.
Ans. Yes, it is true statement. When the body moves with constant velocity than change in velocity is zero so acceleration is zero and zero is also constant quantity.

8. Find the change in momentum for an object subjected to a given force for a given time and state law of motion in terms of momentum.
Ans. $F = ma = m(\frac{Vf - Vi}{t}) = \frac{mVf - mVi}{t} = \frac{Pf - Pi}{t} = \frac{\Delta P}{t}$
"Time rate of change of momentum of a body equals the applied force".

9. Define impulse and show that how it is related to linear momentum.
Ans. Impulse: "The product of force and time for which it acts on a body".
$\text{Impulse} = \text{F x t} = \text{ma x t} = m(\frac{Vf - Vi}{t})t = mVf - mVi = \Delta P$

10. **State the law of conservation of linear momentum, pointing out the importance of isolated system. Explain, why under certain conditions, the law is useful even though the system is not completely isolated?**
Ans. Law of conservation of linear momentum: "The total linear momentum of an isolated system remains constant". $m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$. ii) If a system is not completely isolated but external forces are very small comparing with mutual interacting forces, the law is useful. e.g. when calculating pressure of a gas and applying conservation of linear momentum, neglecting g, the external force.

11 Explain the difference between elastic and inelastic collisions.
Ans. Elastic collision: "The interaction in which both momentum and kinetic energy conserve".
Inelastic collision: "The interaction in which kinetic energy does not conserve".
In elastic collision, the bouncing ball should rebound to the original height. In inelastic collision, the bouncing ball will not rebound or will rebound to a smaller height from where it is dropped.

12. Extensive question

13 At what point or points in its path does a projectile have its minimum speed, its maximum speed?
Ans. A projectile will have its minimum speed at the highest point (maximum height). It has its maximum speed at the start and end of the projectile motion.

14 Each of the following questions is followed by four answers, one of which is correct answer. Identify that answer.

Ans (i) the correct answer is (a). A ballistic trajectory means the paths followed by an un-powered and un-guided projectile. (ii) The correct answer is (b). In elastic collision, the momentum of the system does not change.

Numerical problems

3.1: A helicopter is ascending vertically at the rate of 19.6 ms^{-1}. When it is at a height of 156.8 m above the ground, a stone is dropped. How long does the stone take to reach the ground?

$$\text{Given Data}: Vi = 19.6\ \text{m/s}, S = -156.8\ \text{m}, g = -9.8\ ms^{-2}, t = ?$$

$$\text{using equation } S = Vit + 1/2gt^2 \Rightarrow -156.8 = 19.6t + 1/2(-9.8)t^2$$

$$-156.8 = 19.6t - 4.9t^2 \Rightarrow 4.9t^2 - 19.6t - 156.8 = 0 \text{ dividing all terms by 4.9 on both sides}$$

$$t^2 - 4t - 32 = 0 \Rightarrow t(t-8) + 4(t-8) = 0 \quad \Rightarrow t - 8 = 0 \Rightarrow \quad t = 8\,\text{sec}$$

3.2: Using the following data, draw a velocity-time graph for a short journey on a straight road of a motorbike.

Velocity (ms^{-1})	0	10	20	20	20	20	0
Time (s)	0	30	60	9	120	150	180

Use the graph to calculate

(a) the initial acceleration

(b) the final acceleration and

(c) the total distance traveled by the motorcyclist.

$$\text{Sol}: (a)\ \text{initial acceleration} = a = \frac{vf - vi}{t} = \frac{20-0}{60} = 0.33 ms^{-2}$$

$$(b)\ \text{Final acceleration} = a = \frac{vf - vi}{t} = \frac{0-20}{30} = -066 ms^{-2}$$

$$(c)\ \text{Total distance} = \text{Area of } \Delta AOE + \text{Area of rectangle ABDE} + \text{Area of } \Delta BCD$$

$$S = \frac{1}{2}v*t + vt + \frac{1}{2}v*t = \frac{1}{2}20*60 + 20*90 + \frac{1}{2}20*30 = 600 + 1800 + 300 = 2700m = 2.7km$$

3.3: A proton moving with speed of $1.0\times10^{7}\,ms^{-1}$ passes through a 0.020 cm thick sheet of paper and emerges with a speed of $2.0\times10^{6}\,ms^{-1}$. Assuming uniform deceleration, find retardation and time taken to pass through the paper.

$$\text{given data}: v_i = 1*10^7\ \text{m/s}, v_f = 2*10^6\ \text{m/s}, S = 0.02\ \text{cm} = 0.02*10^{-2}\ \text{m}\ \ a = ?\ t = ?$$

$$\text{using equation } 2as = v_f^{\,2} - v_i^{\,2} \Rightarrow a = \frac{v_f^{\,2} - v_i^{\,2}}{2S} = \frac{(2*10^6)^2 - (1*10^7)^2}{2(0.02*10^{-2})} = -2.4*10^{17} ms^{-2}$$

$$vf = vi + at \Rightarrow t = \frac{vf - vi}{a} = \frac{2*10^6 - 1*10^7}{-2.4*10^{17}} = 3.33*10^{-11}\,\text{sec}$$

3.4: Two masses m_1 and m_2 are initially at rest with a spring compressed between them. What is the ratio of the magnitude of their velocities after the spring has been released?

$$\text{Sol}: \text{As initial momentum} = Pi = 0, \text{Final momentum} = m_1v_1 + m_2v_2, v_1/v_2 = ?$$

$$\text{According to law of conservation of linear momentum initial momentm} = \text{final momentum so}$$

$$0 = m_1v_1 + m_2v_2 \Rightarrow -m_1v_1 = m_2v_2 \Rightarrow \frac{v_1}{v_2} = \frac{-m_2}{m_1}$$

3.5: An amoeba of mass $1.0\times10^{-12}kg$ propels itself through water by blowing a jet of water through a tiny orifice. The amoeba ejects water with a speed of $1.0\times10^{-4}ms^{-1}$ and at a rate of $1.0\times10^{-13}kgs^{-1}$. Assume that the water is being continuously replenished so that the mass of the amoeba remains the same.

a. **If there were no force on amoeba other than the reaction force caused by the emerging jet, what would be the acceleration of the amoeba?**

b. **If amoeba moves with constant velocity through water, what is force of surrounding water (exclusively of jet) on the amoeba?**

$\text{Given data}: \text{m} = 1*10^{-12}\ \text{kg, speed} = \text{v} = 1*10^{-4}\ \text{m/s, m/t} = 1*10^{-13}\ \text{kg/s, F} = ?\ \text{a} = ?$

$$\text{F} = \frac{\text{m}}{\text{t}} * \text{v} = 1*10^{-13} * 1*10^{-4} = 1*10^{-17}\ \text{N}$$

$$\text{F} = \text{ma} \quad \text{so a} = \frac{\text{F}}{m} = \frac{1*10^{-17}}{1*10^{-12}} = 10^{-5}ms^{-2}$$

3.6: A boy places a fire cracker of negligible mass in an empty can of 40 g mass. He plugs the end with a wooden block of mass 200g. After igniting the firecracker, he throws the can straight up. It explodes at the top of its path. If the block shoots out with a speed of 3.0 ms^{-1} , how fast will the can be going?

$\text{Given Data}: \text{m}_1 = 40\text{g} = 40*10^{-3}\ \text{kg, m}_2 = 200\text{g} = 200*10^{-3}\ \text{kg}\ \ \text{v}_1 = ?\ \text{v}_2 = 3\text{ms}^{-1}$

$\text{Using law of conservation of linear momentum initial momentum} = \text{final momentum}$

$$0 = -\text{m}_1\text{v}_1 + \text{m}_2\text{v}_2 \Rightarrow \text{m}_1\text{v}_1 = \text{m}_2\text{v}_2 \Rightarrow v_1 = \frac{\text{m}_2\text{v}_2}{\text{m}_1} = \frac{200*10^{-3}*3}{40*10^{-3}} = 15ms^{-1}$$

3.7: An electron $(m = 9.1\times10^{-31}kg)$ traveling at $2.0\times10^{7}ms^{-1}$ undergoes a head on collision with a hydrogen atom $(m = 1.67\times10^{-27}kg)$ which is initially at rest. Assuming the collision to be perfectly elastic and a motion to be along a straight line, find the velocity of hydrogen atom.

$\text{Given Data}: \text{m}_1 = 9.1*10^{-31}\ \text{kg, m}_2 = 1.67*10^{-27}\ \text{kg, v}_1 = 2*10^{7}\ \text{m/s v}_2 = 0\ \ \text{v}_2' = ?$

$$\text{Using equation V}_2' = \frac{2m_1v_1}{m_1+m_2} + \frac{m_2-m_1}{m_1+m_2}v_2 = \frac{2m_1v_1}{m_1+m_2} + 0 = \frac{2m_1v_1}{m_1+m_2} \quad \text{as v}_2 = 0$$

$$\text{V}_2' = \frac{2m_1v_1}{m_1+m_2} = \frac{2(9.1*10^{-31})(2*10^{7})}{9.1*10^{-31}+1.67*10^{-27}} = 2.18*10^{4}m/s$$

3.8: A truck weighing 2500 kg and moving with a velocity of 21 ms^{-1} collides with stationary car weighing 1000 kg. The truck and the car move together after the impact. Calculate their common velocity.

$\text{Given Data}: \text{m}_1 = 2500\text{kg, m}_2 = 1000\text{kg, v}_1 = 21\text{m/s, v}_2 = 0\ \text{common velocity} = \text{v} = ?$

$\text{According to law of conservation of linear momentum}\ \text{m}_1\text{v}_1 + \text{m}_2\text{v}_2 = \text{m}_1\text{v}_1' + \text{m}_2\text{v}_2'$

$\text{as v}_1' = \text{v}_2' = \text{v} \qquad \text{m}_1\text{v}_1 + \text{m}_2\text{v}_2 = \text{m}_1\text{v} + \text{m}_2\text{v} \Rightarrow (\text{m}_1 + \text{m}_2)\text{v} = \text{m}_1\text{v}_1 + \text{m}_2\text{v}_2$

$$v = \frac{\text{m}_1\text{v}_1 + \text{m}_2\text{v}_2}{\text{m}_1 + \text{m}_2} = \frac{2500*21 + 1000*0}{2500 + 1000} = \frac{2500*21}{3500} = 15m/s$$

3.9: Two blocks of masses 2.0 kg and 0.50 kg are attached at the two ends of compressed spring. The elastic potential energy stored in the spring is 10 J. Find the velocities of the blocks if the spring delivers its energy to the blocks when released.

$\text{Given Data}: m_1 = 0.5\,\text{kg},\ m_2 = 2\,\text{kg},\ \text{P.E} = 10\text{J},\ V_1 = ?\ V_2 = ?$

$\text{using law of conservation of linear momentum Pi} = \text{Pf} \Rightarrow 0 = m_1v_1 + m_2v_2$

$0.5v_1 + 2v_2 = 0 \Rightarrow\ v_1 = -4v_2 \text{ - - - - - - - - - - - - - (1)}$

$\text{applying law of conservation of energy } \frac{1}{2}m_1v_1^{\,2} + \frac{1}{2}m_2v_2^{\,2} = 10\text{ J}$

$m_1v_1^{\,2} + m_2v_2^{\,2} = 20 \Rightarrow 0.5(-4v_2)^2 + 2v_2^{\,2} = 20 \Rightarrow 8v_2^{\,2} + 2v_2^{\,2} = 20$

$10v_2^{\,2} = 20 \Rightarrow v_2^{\,2} = 2 \Rightarrow v_2 = 1.41\text{m/s} \qquad \text{putting in (1)}$

$v_1 = -4(1.41) = -5.76\text{ m/s}$

3.10:A foot ball is thrown upward with an angle of 30^o with respect to the horizontal. To throw a 40 m pass what must be the initial speed of the ball?

$\text{Given Data}: R = 40\text{ m},\ \theta = 30^{o,},\ g = 9.8\,\text{ms}^{-2},\ v_i = ?$

$R = \frac{vi^2}{g}\sin 2\theta \Rightarrow vi^2 = \frac{gR}{\sin 2\theta} \Rightarrow \qquad vi = \sqrt{\frac{gR}{\sin 2\theta}} = \sqrt{\frac{9.8*40}{\sin 2(30^o)}} = 21.3m/s$

3.11: A ball is thrown horizontally from a height of 10 m with velocity of 21 ms^{-1}. How far off it hit the ground and with what velocity?

$\text{Given Data}: Y = h = 10\text{m},\ vi = 21\,\text{m/s},\ g = 9.8\,\text{ms}^{-1},\ t = ?\ x = ?\ v = ?$

$\text{using } Y = v_{iy}t + 1/2gt^{\,2} \Rightarrow 10 = 0 + 1/2*9.8t^2 \Rightarrow 4.9t^2 = 10 \Rightarrow\ t^2 = 10/4.9 \Rightarrow\ t = 1.42\,\text{sec}$

$x = vi_x * t = v_i\cos\theta * t = 20\cos 0^o * 1.42 = 29.98 \approx 30\text{m}$

$\text{as Vfx} = 21\,\text{m/s}\ \text{ and Vfy} = \text{Viy} + gt \Rightarrow \text{Vfy} = 0 + 9.8*1.42 = 13.99 = 14m/s$

$v = \sqrt{v_{fx}^{\,2} + v_{fy}^{\,2}} = \sqrt{(21)^2 + (14)^2} = 25m/s$

3.12: A bomber dropped a bomb at a height of 490 m when its velocity along horizontal was 300 kmh^{-1}. (a) How long was it in air? (b) At what distance from the point vertically below the bomber at the instant the bomb was dropped, did it strike the ground?

$\text{Given Data}: Y = h = 490\text{m},\ vi = 300\text{Km/h} = 300*1000/3600 = 83.3\text{m/s},\ g = 9.8\,\text{ms}^{-1},\ t = ?\ x = ?$

$\text{using } Y = v_{iy}t + 1/2gt^{\,2} \Rightarrow 4900 = 0 + 1/2*9.8t^2 \Rightarrow 4.9t^2 = 490 \Rightarrow\ t^2 = 490/4.9 \Rightarrow\ t = 10\,\text{sec}$

$x = vi_x * t = v_i\cos\theta * t = 83.3\cos 0^o * 10 = 833\text{m}$

3.13: Find the angle of projection of a projectile for which its maximum height and horizontal range are equal.

$\text{Sol}: \text{ According to given condition height} = \text{range}$

$\frac{vi^2\sin^2\theta}{2g} = \frac{vi^2}{g}\sin 2\theta \Rightarrow \frac{\sin^2\theta}{2} = 2\sin\theta\sin\theta \Rightarrow \frac{\sin\theta}{\cos\theta} = 4 \Rightarrow \tan\theta = 4 \Rightarrow \theta = \tan^{-1}(4) = 76^o$

3.14: Prove that for angles of projection, which exceed or fall short of 45^o by equal amounts, the ranges are equal.

Sol : According to given condition Range of projectile should be same for angle $\theta = 45 \pm \varphi$

$$\text{Exceed } R_1 = \frac{vi^2}{g}\sin 2(45+15)^o = \frac{vi^2}{g}\sin 2(60)^o = \frac{vi^2}{g}\sin 120^o = \frac{vi^2}{g}(0.866) ----(1)$$

$$\text{fall short } R_2 = \frac{vi^2}{g}\sin 2(45-15)^o = \frac{vi^2}{g}\sin 2(30)^o = \frac{vi^2}{g}\sin 60^o = \frac{vi^2}{g}(0.866) ----(2)$$

Hence prove ranges are equal at equal exceed or short fall in angle

3.15: A SLBM (submarine launched ballistic missile) is fired from a distance of 3000km, If the Earth is considered flat and the angle of launch is with horizontal, find the velocity with which the missile is fired and the time taken by SLBM to hit the target.

Given Data : $R = 3000\text{ km} = 3000*1000 = 3*10^6\text{ m}, \theta = 45^o, g = 9.8 ms^{-2}, v_i = ? t = ?$

$$R = \frac{vi^2}{g}\sin 2\theta \Rightarrow vi^2 = \frac{gR}{\sin 2\theta} \Rightarrow vi = \sqrt{\frac{gR}{\sin 2\theta}} = \sqrt{\frac{9.8*3*10^6}{\sin 2(45^o)}} = 5.42*10^3 m/s$$

$$t = \frac{2vi\sin\theta}{g} = \frac{2*5.42*10^3 \sin 45^o}{9.8} = 782\sec \approx 782/60\min \approx 13\min$$

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MCQS

1) Typical speed of light, radio waves, x-rays and microwaves in vacuum is

a) $3*10^8$ m/s	b) $3*10^7$ m/s	c) $3*10^6$ m/s	d) $3*10^5$ m/s

2) Speed for Earth-sun travel around the galaxy

a) 210 m/s	b) 2100 m/s	c) 21000 m/s	**d) 210000 m/s**

3) Speed for Earth around the sun is

a) 2960 m/s	**b) 29600 m/s**	c) 296 m/s	d) 29 m/s

4) Typical speed for moon around the Earth is

a) 1 m/s	b) 10 m/s	c) 100 m/s	**d) 1000 m/s**

5) The typical speed for SR-71 reconnaissance jet

a) 980 m/s	b) 98 m/s	c) 9.8 m/s	d) 9 m/s

6) Speed for commercial jet airliner

a) 67 m/s	b) 167 m/s	**c) 267 m/s**	d) 367 m/s

7) Typical speed for commercial automobile (max.)

a) 60 m/s	**b) 62 m/s**	c) 64 m/s	d) 66 m/s

8) Typical speed for falcon in a dive

a) 50 m/s	**b) 37 m/s**	c) 29 m/s	d) 10 m/s

9) Speed for Running cheetah

a) 100 m/s	**b) 29 m/s**	c) 10 m/s	d) 9 m/s

10) Speed for 100-m dash(max)

a) 100 m/s	b) 90 m/s	**c) 10 m/s**	d) 29 m/s

11) What is the typical speed for porpoise swimming

a) 100 m/s	**b) 9 m/s**	c) 10 m/s	d) 29 m/s

12) Typical speed for flying bee

a) 100 m/s	**b) 5 m/s**	c) 10 m/s	d) 29 m/s

13) Typical speed for human running

a) 2 m/s	**b) 4 m/s**	c) 6 m/s	d) 8 m/s

14) Typical speed for human swimming

a) 2 m/s	b) 4 m/s	c) 6 m/s	d) 6 m/s

15) Typical speed for walking ant

a) 1 m/s	b) 0.1 m/s	**c) 0.01 m/s**	d) 0.001 m/s

16) At the surface of the Earth, in situation where air friction is negligible, objects of different masses fall with the acceleration

a) Different	**b) Same**	c) Zero	d) None

17) "No body begins to move or comes to rest of itself" statement given by

a) Newton	**b) Abu Ali Sena(980-1037)**	c) Einstein	d) Churchil

18) Throwing a package onto shore from a boat that was previously at rest causes the boat to move--- from shore

a) Inward	**b) Outward**	c) Both A&B	d) None

19) A force of 5 N might be enough to fracture naked skull but with a covering with skin and hair, a force of – is needed

a) 10 N	b) 20 N	**c) 50 N**	d) 100 N

20) When a moving car stops quickly, the passenger move

a) Backward the windshield	**b) Forward towards the windshield**	c) Both A&B	d) None

21) In thrill machine rides at amusement park, there can be acceleration

a) 3g or more	b) 3g or less	c) Zero	d) Infinite

22) For an angle less than --- the height reached by the projectile and ranges will be less

a) 30°	**b) 45°**	c) 60°	d) 90°

23) When the angle of projectile is larger than --- the height attained will be more the range is less again.

a) 30°	**b) 45°**	c) 60°	d) 90°

24) In the presence of air friction the trajectory of a high speed projectile fall short of a ---- path

a) Straight path	**b) Parabolic path**	c) Elliptical path	d) Circular path

PAST PAPERS SOLVED MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	Laws of motion are not valid in a system which is	Moving with uniform velocity	At rest	Isolated	**Non inertial**
ii.	What is angle of projection for which the maximum height and range are equal	46˚	66˚	56˚	**76˚**
	Put H=R to get the result also see the solution of numerical 3.13 for explanation				
iii.	Horizontal range at angle of 30˚ with horizontal is same as that of angle of	0˚	30˚	45˚	**60˚**
iv.	The product of force and time is called	**Impulse**	Power	Torque	Velocity
v.	The range of projectile is directly proportional to	sinϴ	**Sin2ϴ**	2sinϴ	ϴ
vi.	For angle less then --- the height reached by projectile and range will be less	15˚	30˚	**45˚**	60˚
vii.	Rocket equation is given by	a=M/mv	a=Mv/m	**a=mv/M**	a=m/MV
viii.	If a force of 10N acts on a body of mass 5kg for one second then rate of change in momentum will be	**10 Ns**	50 Ns	5 Ns	2Ns
	As t=1sec, F=10N, then apply 2nd law in terms of momentum				

ix.	Rate of change of momentum is equal to	**Force**	Impulse	Torque	Inertia
x.	Area under velocity time graph gives	**Distance**	Displacement	Acceleration	Force
xi.	How large a force is required to accelerate a body of weight 5N with 4 m/s2	10 N	5N	**2N**	1N
xii.	Horizontal component of velocity of projectile is given by	**Remains constant**	Increase	Decrease	Zero
xiii.	SI unit of impulse is	Kgm/s	Ns	N	**Both A&B**
xiv.	A long jumper should long jump at an angle of	30˚	90˚	**45˚**	60˚
xv.	The ballistic missile are useful for	**Short range**	Long range	Medium range	None of these
xvi.	A rocket eject the burnt gas at speed of	1000 m/s	2000 m/s	3000 m/s	**4000 m/s**
xvii.	The decrease in velocity per unit time is given as	Acceleration	Uniform acceleration	**Retardation**	Negative velocity
xviii.	If no kinetic energy is lost then collision is	**Elastic**	Inelastic	Both A&B	None of these
xix.	If a body moves towards earth , neglecting air resistance and small changes in acceleration with altitude, what is such motion?	Gravitational	**Free fall**	Rectilinear	Uniform
xx.	If a force of 12 N acts on a car and changes its momentum from 36 kgm/sec to 60 kgm/sec, the time during which this change occurs will be	**2sec**	12 sec	8 sec	24 sec
$F=\frac{\Delta P}{t}, t=\frac{Pf-Pi}{F}=\frac{60-36}{12}=2\sec$					
xxi.	What never changes when two or more objects collide in isolated system	Kinetic energy of each one	Momentum of each one	**Total momentum of all objects**	Total kinetic energy of all objects
xxii.	The range of projectile is same for pair of angle	$30^o,45^o$	**$30^o,60^o$**	$60^o,90^o$	$45^o,90^o$
xxiii.	The ratio of displacement along diameter of circle and total distance along circle is	**1:π**	2:π	π:1	π:2
As displacement =2r, and total distance of circle is circumference of circle=2πr, dividing to ratio which 1:π					
xxiv.	A 1kg block slides down a smooth inclined surface whose height is 5m then velocity at bottom is	m/s	5 m/s	**9.8 m/s**	7 m/s
$V=\sqrt{2gh}=\sqrt{2*9.8*5}=9.8$					
xxv.	A ball is thrown above with angle of 30^o. The height attained by the ball is 11.5m then launching velocity of ball is	20 m/s	60 m/s	**30 m/s**	45 m/s
Put ɵ=30°, H=11.5 m, Vi=? Putting values in the formula of height to get the value of Vi					
xxvi.	Time of flight of projectile when it is projected from ground is	$\frac{Vi\sin\theta}{g}$	$\frac{2Vi\sin\theta}{g}$	$\frac{Vi\sin^2\theta}{g}$	$\frac{Vi^2\sin^2\theta}{g}$

xxvii.	The component of velocity that remains constant during motion of projectile is	Vertical	**Horizontal**	Initial	Both A&B
xviii.	For a rocket change in momentum per second of eject gases is equal to	Acceleration of rocket	Momentum of rocket	Velocity of rocket	**Thrust acting on rocket**
xxix.	One dyne is equal to	**10^{-5} N**	10^{5} N	10^{12} N	10^{9}N
xxx.	A body is moving with an initial velocity of 2 kms-1. After a time of 50 secs its velocity becomes 1.5 kms-1. Its acceleration will be	30 ms-1	20 ms-1	10 ms-1	40 ms-1
	$a = \frac{Vf - Vi}{t} = \frac{2km/s - 1.5km/s}{50} = \frac{0.5km/s}{50} = \frac{0.5*1000}{50} = \frac{500}{50} = 10ms^{-2}$				
xxxi.	Slope of velocity time graph gives	Velocity	Distance	**Acceleration**	Force
xxxii.	Arshad is driving down 7th street, he drives 150m in 18s.. Assume he does not speed up or slow down, what is his speed:	0.38 m/s	**8.33 m/s** V=S/t to get result	126 m/s	58.33 m/s
xxiii.	Motion of projectile is --- dimension	One	**Two**	Three	Four
xxiv.	For maximum range the angle of projection of projectile must be	30^{o}	60^{o}	**45^{o}**	90^{o}
xxxv.	The distance travelled by a moving car with velocity 15 m/s in 2s, decelerates at -2m/s-2 is equal to:	30m	16m	26m	34m
	$S = Vit + 1/2at^2 = 15*2 + 1/2*(-2)*(2)^2 = 30 - 4 = 26m$				
xxvi.	The distance covered by a free falling body in 2 sec will be	4.9 m	**19.6 m**	9.8 m	39.2 m
	S=1/2 gt^2= ½*9.8*2^2=19.6m				
xxvii.	The mass of an object is a quantitative measure of	Moment of force	Acceleration	**Inertia**	Velocity
xviii.	In the projectile motion the vertical component of velocity	Remains constant	**Varies point to point**	Becomes zero	Increase with time
xxix.	Change in momentum is called	Force	Acceleration	Torque	**Impulse**
xl.	Which expression represents instantaneous velocity of body	$\lim_{\Delta t \to 0} \frac{\Delta d}{\Delta t}$	$\lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$	$\lim_{\Delta t \to 0} \frac{\Delta p}{\Delta t}$	$\lim_{\Delta t \to 0} \frac{\Delta L}{\Delta t}$
xli.	An alternate unit to kgm/s is	JS	**Ns**	Nm	N
xlii.	The motion of rocket is in accordance with law of conservation of	**Linear momentum**	Energy	Mass	Angular momentum
xliii.	The formula for maximum range of projectile is given by	$\frac{V^2 i}{g}$	$\frac{V^2 i \sin\theta}{g}$	$\frac{V^2 i \cos\theta}{g}$	$\frac{V^2 i \sin 2\theta}{g}$
xliv.	Which force accelerate the car along a road	Force of car	**Force reactional force of road**	Applied force	Engine force
xlv.	Acceleration of bodies of different masses allowed to fall freely is	**The same**	Variable	Different	None of these
xlvi.	Powered and remote control guided missile are used for	Medium ranges	Short ranges	**Long range**	Half
xlvii.	Dimension of impulse are similar to the dimension of	Work	Torque	Force	**Momentum**

xlviii.	A body is allowed to fall freely from certain height, it cover a distance in first two second	**2g**	g	g/2	None of these
Apply 2nd eq of motion Vi=0, $S=1/2\ gt^2=1/2\ g(2)^2=2g$					
xlix.	The equation of motion are not useful for objects moving with	Uniform velocity	Uniform acceleration	Variable velocity	**Variable acceleration**
l.	When a ball is thrown straight up, the acceleration at its highest point is	Upward	**Downward**	Zero	Horizontal
li.	The range of projectile is same for	0^o,45^o	**35^o,55^o**	15^o,60^o	30^o,75^o
lii.	Which pair has same dimension?	Work &power	**Momentum& impulse**	Force& torque	Torque and power
liii.	If the force acting on body is doubled, then acceleration becomes	**Doubled**	Half	One fourth	Constant
liv.	When the body moves with constant acceleration, the velocity time graph is	Parabola	Hyperbola	**Straight-line**	Curve
lv.	Dimensional formula for impulse is	[MLT]	**$[MLT^{-1}]$**	$[MLT^{-2}]$	$[M^{-2}T^{-2}]$
lvi.	If the slope of velocity time graph remains constant then body is moving with	**Uniform acceleration**	Variable acceleration	Uniform velocity	Negative acceleration
lvii.	An object of mass 1Kg moving with acceleration $1ms^{-2}$ will experience force	10^{-2} N	10^{-3} N	**1 N**	1 dyne
lviii.	The velocity of projectile is maximum at	The highest point	**Point of launching and striking point**	At half of the height	After striking the ground
lix.	The path followed by a projectile is known as	Range	**Trajectory**	Cycle	Height
lx.	A ball is thrown up vertically, it takes 3 sec to reach maximum height, its initial velocity is	10 m/s	12.2 m/s	15 m/s	28.4 m/s
$a=\frac{Vf-Vi}{t}\Rightarrow g=\frac{0-Vi}{t}\Rightarrow -9.8=\frac{-Vi}{3}\Rightarrow Vi=28.4m/s$					
lxi.	The vertical velocity of ball thrown upward ___with time.	increase	**decrease**	Remains same	Zero
lxii.	A ball is thrown up with 20 m/s at angle of 60 with x-axis, the horizontal component of velocity is	0 m/s	**10 m/s**	20 m/s	16 m/s
Vix=VicosΘ=20cos60=20*0.5=10 m/s					
lxiii.	If the mass of a body is doubled, then acceleration becomes	Double	**Half**	One fourth	Constant
lxiv.	In the absence of external force, the change in momentum is	Zero	**Constant**	Decreasing	Increasing
lxv.	For which pair of angles, the range of projectile are equal	90°,20°	**70°,20°**	60°,40°	50°,10°
Equal rise and fall in 45 result into equal range, 45+25=70°, 45-25=20°					
lxvi.	When average velocity becomes equal to instantaneous then body is called moving with	Instantaneous acceleration	**Constant velocity**	Variable velocity	Maximum and zero
lxvii.	A car starts from rest and covers a distance of 100 m in one second	50 m/s^2	**200 m/s^2**	250 m/s^2	300 m/s^2

	with uniform acceleration, its acceleration				
$S = Vit + 1/2at^2 \Rightarrow 100 = 0 + 1/2(a)(1)^2 \Rightarrow a = 200m/s^2$					
xviii.	A body having uniform acceleration of 10 m/s^2 has a velocity of 100 m/s. in what time its velocity will be doubled?	8 Sec	**10 Sec**	12 Sec	14 Sec
Putting the given values in formula of acceleration $a = \frac{Vf - Vi}{t}$ so $t = \frac{Vf - Vi}{a} = \frac{200 - 100}{10} = 10$					
lxix.	At what speed the momentum and kinetic energy of body having the same value?	1 m/s	**2 m/s**	4 m/s	8 m/s
$P = mv,\ K.E = 1/2mv^2$, comparing equations to get result $mv = 1/2mv^2$, so $V = 2$					
lxx.	Area under force time graph gives	**Impulse**	Velocity	Acceleration	Distance
lxxi.	If a body is moving with constant velocity of 10 m/s , its acceleration is	1 ms-2	10 ms-2	30 ms-2	**Zero**
lxxii.	The velocity of projectile at maximum height is	Vi	Zero	Maximum	**VicosΘ**
xxiii.	In the presence of air friction, trajectory of high speed projectile	Elliptical path	Circular path	Spherical path	**Parabolic path**
xxiv.	A mass of 5000gm produce an acceleration of 10 ms^{-2}, the force acting	**50 N**	5 N	20 N	10 N
Mass=m=5000gm=5000/1000 kg=5kg, a=10 ms-2, F=ma=5*10=50 N					
lxxv.	The maximum range of projectile is 100km, take g=10ms-2, what must be initial velocity	**1km/s**	100 km/s	1000 km/s	100 m/s
R=100km, g=10 ms-2 vi=? Put these values in the formula of range of projectile to get the result					

Chapter 04 Work and Energy

What is work? Calculate the Work done on constant force.

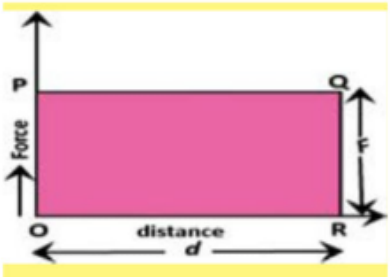
Work: "The dot product of force and displacement is called work". OR The product of the magnitudes of the displacement and the component of the force in the direction of displacement is called work.

Mathematically: $W=\vec{F}.\vec{d}$ = d (FcosΘ) or F (dcosΘ) = Fd cosΘ

Unit: As W=Fd= ($kgms^{-2}$) (s) =Kgm^2s^{-2} which is equal to joule. Its SI unit is Nm=joule. It is scalar quantity.

Definition of joule: When one newton force acts on a body and it cover distance of 1m in the direction of force, than work is said to one joule. 1N*1m=1 J

Dimension: The dimension of work are W=Fd= $[MLT^{-2}]$ [L] = $[ML^2T^{-2}]$



Important points about work: Important points about work are

a) If Θ<90°, work is positive

(As W= Fd cosΘ, as angle CosΘ is positive at less than 90°)

b) If Θ>90°, work is negative

(As W= Fd cosΘ, as angle CosΘ is negative at greater than 90°)

c) If Θ=90°, no work is done

(As W= Fd cosΘ, as angle CosΘ is zero at 90°)

d) If Θ=0°, work is maximum

Constant force: Such a force whose magnitude and direction remains same is called constant force.

Work done by constant force graphical representation: When a constant force acts through a distance d then it can be shown graphically by plotting graph b/w F and d, taking d along x-axis and F along Y axis

Graph for work done by constant force is horizontal straight line parallel to X-axis

Work from graph: Area under the force-displacement curve shows the work done by force graphically.

Area of rectangle=Length*width= Fd=Work

What is variable force? Calculate the work done by variable force.

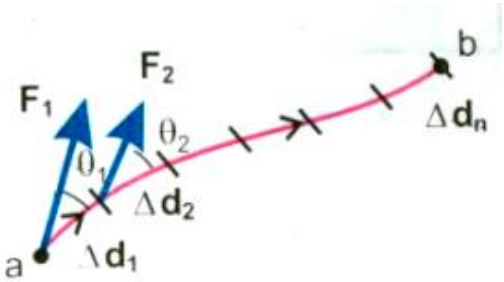
Variable force: If the magnitude or direction or both of force changes then it is called variable force. For example.

a) Force of gravity on rocket moving away from earth

b) Force exerted by spring.

Work done by variable force: Consider a particle in XY plane moving fr

short interval into displacements $\Delta\vec{d}_1, \Delta\vec{d}_2, \Delta\vec{d}_3, ...\Delta\vec{d}_n$ and forces $\vec{F}_1, \vec{F}_2$



$$\text{Work done by first interval} = \Delta W_1 = \vec{F}_1.\Delta\vec{d}_1 = F_1\Delta d_1\cos\theta_1$$

$$\text{Work done by 2nd interval} = \Delta W_2 = \vec{F}_2.\Delta\vec{d}_2 = F_2\Delta d_2\cos\theta_2$$

$$\text{Work done by 3rd interval} = \Delta W_3 = \vec{F}_3.\Delta\vec{d}_3 = F_3\Delta d_3\cos\theta_3$$

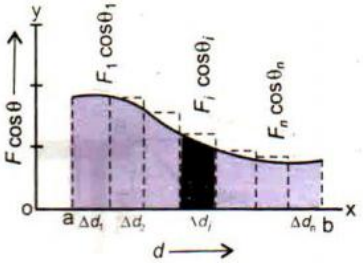
$$\text{Work done by nth interval} = \Delta W_n = \vec{F}_n.\Delta\vec{d}_n = F_n\Delta d_n\cos\theta_n$$

$$\text{Total Work} = \Delta W_1 + \Delta W_2 + \Delta W_3 + ...\Delta W_n$$

$$W = F_1\Delta d_1\cos\theta_1 + F_2\Delta d_2\cos\theta_2 + F_3\Delta d_3\cos\theta_3 + ... + F_n\Delta d_n\cos\theta_n$$

$$W = \sum_i^n F_i\Delta d_i\cos\theta_i$$

This is the work done by variable force.



Graphical Representation: We can calculate the work graphically by plotting graph b/w FcosΘ and d. Area under the graph is divided into n rectangle for each interval. Area of each rectangle show the work done during that interval.

What is gravitational field? Calculate the Work done by gravitational field.

Gravitational field: The space around the Earth in which its gravitational force acts on a body is called gravitational field.

Sign conventions for work done in gravitational field:

a) If displacement is in the direction of gravitational force work is positive
b) If displacement is against the direction of gravitational force, work is negative
c) If displacement is perpendicular to the direction of gravitational force, work is zero

Work done by gravitational field: let us consider a body of mass m being displaced with constant velocity from point A to point B along different path in the presence of gravitational force.

Path-1 Work done along path ADB: This work done is divided into two parts $W_{ADB} = W_{A\to D} + W_{D\to B}$

$W_{A\to D} = \vec{F}.\vec{d} = Fd\cos\theta = mg(d)\cos 90^\circ = 0$, $W_{D\to B} = \vec{F}.\vec{d} = Fd\cos\theta = mg(h)\cos 180^\circ = -mgh$

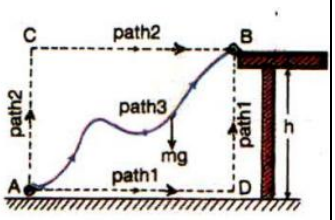
$W_{ADB} = 0 + (-mgh) = -mgh$ ---------- (1)

Path-1 Work done along path ACB: This work done is divided into two parts $W_{ACB} = W_{A\to C} + W_{C\to B}$

$W_{A\to C} = \vec{F}.\vec{d} = Fd\cos\theta = mg(h)\cos 180^\circ = -mgh$, $W_{C\to B} = \vec{F}.\vec{d} = Fd\cos\theta = mg(d)\cos 90^\circ = 0$

$W_{ADB} = (-mgh) + 0 = -mgh$ ---------- (2)

Path-3 Work done along the curved path AB: Work done along the path AB is divided into small intervals upon which work done is calculated by adding work of each interval



$W_{AB} = mg\Delta y_1 \cos 180^o + mg\Delta y_2 \cos 180^o + mg\Delta y_3 \cos 180^o + ... + mg\Delta y_n \cos 180^o$

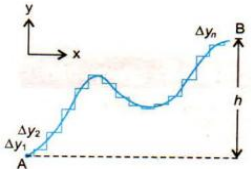
$W_{AB} = -mg\Delta y_1 + (-mg\Delta y_2) + (-mg\Delta y_3) + ... + (-mg\Delta y_n)$

$W_{AB} = -mg(\Delta y_1 + \Delta y_2 + \Delta y_3 + ... + \Delta y_n)$ as $h = \Delta y_1 + \Delta y_2 + \Delta y_3 + ... + \Delta y_n$

$W_{AB} = -mg(h) = -mgh$, ---------- (3)

Eq(1), (2) and (3) shows that work done along any path give same value so work done is independent of path followed. So work done by gravitational field is independent of path followed.

Work done along closed path:



$W_{ADBCA} = W_{A\to D} + W_{D\to B} + W_{B\to C} + W_{C\to A}$

$W_{ADBCA} = Fd\cos 90^o + Fd\cos 180^o + Fd\cos 90^o + Fd\cos 0^o$

$W_{ADBCA} = 0 + (-mgh) + 0 + (mgh) = 0$, This shows that work done along closed path is zero

Conservative field: The field in which work is independent of path followed" OR the field in which work done along closed path is zero is called conservative field for example, gravitational field, electric field, magnetic field etc.

Non conservative forces: like frictional force, air resistance, tension in string etc.

What is Power? What is average and instantaneous power?

Power: The rate of doing work is called power. Work done per unit time is called power. P=Work/time=W/t
SI unit of power is J/S= watt. It is scalar quantity.

Average power: Total work done divided the total time taken is called average power. $< P >= \frac{\Delta W}{\Delta t}$

Instantaneous power: The value of power at any instant of time in which time approaches to zero instantaneous power. $P_{ins} = Lim\Delta t \to 0 \frac{\Delta W}{\Delta t}$

Watt: The power is said to be one watt if one joule of work is done in one second. 1 J/1sec= 1 watt

Prove that $P = \vec{F}.\vec{v}$

let F is the force acting on moving body with velocity v then power

$$P = \lim \Delta t \to 0 \frac{\Delta W}{\Delta t} = \lim \Delta t \to 0 \frac{\vec{F}.\Delta \vec{d}}{\Delta t}$$

$$P = \vec{F}.(\lim \Delta t \to 0 \frac{\Delta \vec{d}}{\Delta t}) =$$

$P = \vec{F}.\vec{v}$, which show that Scalar product of force and velocity is called power.

Define KWh. Prove that 1kwh=3.6 MJ.

The work done in one hour by a source whose power is 1000 watt is called Killo watt hour. KWh is unit of energy.

$1KWh = 1000W * 3600sec$

$1KWh = 1000 * 3600 \ Wsec$

$1KWh = 36 * 10^5 \ J = 3.6 * 10^6 J$

$1KWh = 3.6 \ M J$

What is Energy? define the types of energies.

Energy: The ability of body to do work is called energy.
Types of Energy: It has two types a) kinetic energy b) potential energy.

Kinetic energy: Energy possessed by a body due to its motion is called kinetic energy. Formula is $K.E = \frac{1}{2}mv^2$.

Potential energy: Energy possessed by a body due to its position is called P.E. Its formula P.E=mgh.
Gravitational potential energy: The potential energy due to gravitational field at a height h from surface of earth is called gravitational potential energy P.E=mgh
Elastic potential energy: The energy stored in a compressed/ stretched string is called elastic potential energy it is ½ Kx^2.

State and explain Work Energy principle.

Statement: work done on a body is equal to change in Kinetic energy, W=ΔK.E
Derivation: let us consider a body mass m moving with initial vi and after some distance d its velocity becomes vf by applying force F then we can calculate the work

$W = Fd - - - - - - - - - - - - (1)$

According to the equation of motion

$2ad = v_f^{\ 2} - v_i^{\ 2}$

$d = \frac{v_f^{\ 2} - v_i^{\ 2}}{2a} - - - - - - - - - (2)$

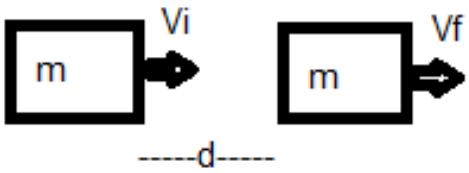
also $F = ma$ - - - - - - - - - - - - - (3)

putting in equation (1)

$W = ma(\frac{v_f^{\ 2} - v_i^{\ 2}}{2a})$

$W = m(\frac{v_f^{\ 2} - v_i^{\ 2}}{2}) = \frac{1}{2}mv_f^{\ 2} - \frac{1}{2}mv_i^{\ 2} = K.E_f - K.E_i = \Delta K.E$

Work = ΔK.E, which is required result



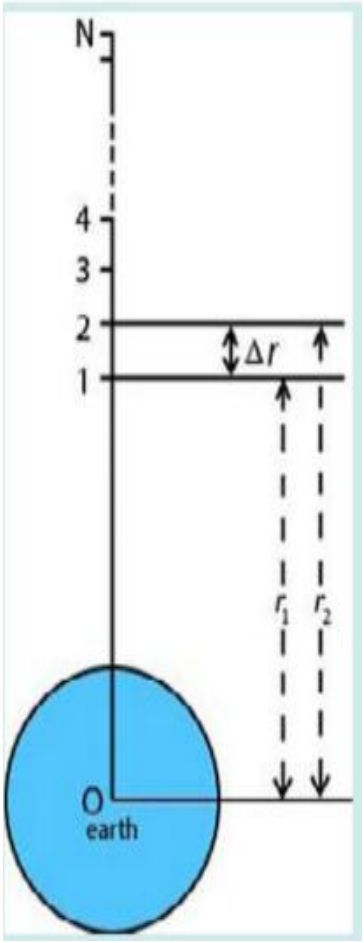
Similarly if a spring is compressed, the work done on it is equals the increase in its elastic potential energy.

What is Absolute Potential Energy? Derive its relation.

Definition: The work done by gravitational force in displacing an object from a position to infinity where the force of gravity becomes zero is called absolute P.E. $U = \frac{-GMm}{R}$.

Derivation: As the relation for work done by gravitational force P.E=mgh is true when object is near the surface of Earth and gravitational force remains constant. But if the body is displaced through a large distance, gravitational force does not remain constant, it varies inversely proportional to square of distance. In order to calculate the work done by it the distance b/w 1 to N is divided small steps so that the value of force remains constant for each step. The work done displacing a body from point 1 to point 2 can be calculated as

The distance b/w the center of this step and center of Earth will be $r = \frac{r_1 + r_2}{2}$



$r_2 - r_1 = \Delta r \quad$ then $\quad r_2 = \Delta r + r_1$

$$r = \frac{r_1 + \Delta r + r_1}{2} = \frac{2r_1 + \Delta r}{2} = \frac{2r_1}{2} + \frac{\Delta r}{2} = r_1 + \frac{\Delta r}{2}$$

$$r^2 = (r_1 + \frac{\Delta r}{2})^2 = {r_1}^2 + (\frac{\Delta r}{2})^2 + 2(r_1)(\frac{\Delta r}{2}) = {r_1}^2 + r_1(\Delta r)$$

$$r^2 = {r_1}^2 + r_1(r_2 - r_1) = {r_1}^2 + r_1 r_2 - {r_1}^2 = r_1 r_2$$

Force becomes $\quad F = G\frac{Mm}{r^2} = G\frac{Mm}{r_1 r_2}$

$$W_{1\to 2} = \vec{F}.\Delta\vec{r} = F\Delta r\cos 180^o = -G\frac{Mm}{r_1 r_2}(\Delta r) = -GMm\frac{\Delta r}{r_1 r_2} = -GMm\frac{r_2 - r_1}{r_1 r_2}$$

$$W_{1\to 2} = -GMm(\frac{r_2}{r_1 r_2} - \frac{r_1}{r_1 r_2}) = -GMm(\frac{1}{r_1} - \frac{1}{r_2}) \text{ ---------(1)}$$

Similarly $\quad W_{2\to 3} = -GMm(\frac{1}{r_2} - \frac{1}{r_3})$ ----------(2)

$$W_{3\to 4} = -GMm(\frac{1}{r_3} - \frac{1}{r_4}) \text{ ----------(3)}$$

$$W_{N-1\to N} = -GMm(\frac{1}{r_{N-1}} - \frac{1}{r_N}) \text{ ----------(N)}$$

Adding all above equations to calculate the total work

$$W_{total} = W_{1\to 2} + W_{2\to 3} + \ldots\ldots\ldots\ldots + W_{N-1\to N}$$

$$W_{total} = -GMm(\frac{1}{r_1} - \frac{1}{r_2} + \frac{1}{r_2} - \frac{1}{r_3} + \frac{1}{r_3} - \frac{1}{r_4} + \ldots\ldots\frac{1}{r_{N-1}} - \frac{1}{r_N})$$

$$W_{total} = -GMm(\frac{1}{r_1} - \frac{1}{r_N}) \qquad r_N = \infty, then \quad \frac{1}{r_N} = \frac{1}{\infty} = 0$$

$W_{total} = -GMm(\frac{1}{r_1} - 0) = -\frac{GMm}{r_1}$, this work is stored in form of gravitational P.E

$U = -\frac{GMm}{r_1}$, the general expression for distance r from center of earth is $U = -\frac{GMm}{r}$

When r increases U also increase and absolute potential on the surface of Earth is r = R

$U = -\frac{GMm}{R}$, – ive sign shows that Earth's gravitational field for mass is attravitve.

What is Escape velocity? Derive its relation.

Definition: The velocity of a body with which it goes out of Earth's gravitational field is called escape velocity. Its formula $V_{esc} = \sqrt{2gR}$. It depends upon radius and g of planet. Its value for earth 11.2 km/sec.

Derivation:

The initital K.E carries an object to infinite distance from surface of Earth

$$K.E = \frac{1}{2}mv^2 \text{ ----------(1)}$$

As work done in lifting a body from Earth's surface to infinity is equal to increase in P.E

$$\text{Increase in P.E} = (P.E)_f - (P.E)_i = 0 - (-G\frac{Mm}{R}) = G\frac{Mm}{R} \text{ ---------(2)}$$

The body will escape out the gravitational field when both energies are equal

$$\frac{1}{2}mv^2 = G\frac{Mm}{R} \quad \Rightarrow v^2 = \frac{2GM}{R}$$

$$v_{esc} = \sqrt{\frac{2GM}{R}} \text{ ----------(3)}$$

comparing the forces which are acting $mg = G\frac{Mm}{R^2}$

$GM = gR^2$, putting in equation (3)

$v_{esc} = \sqrt{\frac{2gR^2}{R}} = \sqrt{2gR}$, This is the formula for escape velocity

for Earth $g = 9.8\ ms^{-2}$, $R = 6.4*10^6$ m

$V = \sqrt{2gR} = \sqrt{2*9.8*6.4*10^6} = 11.2*10^3$

$V = 11.2$ km/s

Explain Interconversion of potential energy and kinetic energy and Conservation of Energy.

Statement: "Energy cannot be created nor destroyed but it can be transformed from one form to other".

Equation: Total energy= P.E+K.E

Consider a body of mass m at rest, at a height h above the surface the Earth. To calculate the P.E and K.E at different position can be calculated as follows

At position A: The body has P.E=mgh and K.E=0, Total Energy= P.E+K.E=mgh+0, total Energy=mgh … (1)

At position B: To calculate the Total Energy at position B when body has fallen through a distance x ignoring friction.

$P.E = mg(h - x)$ ------(i)

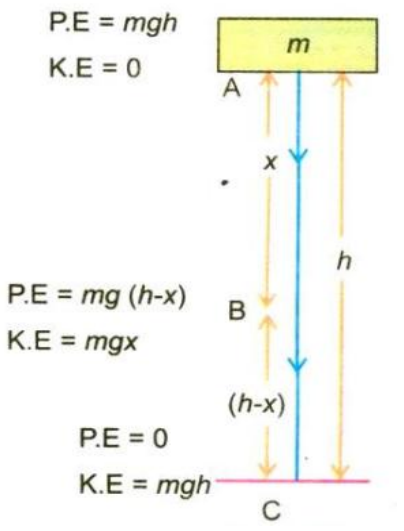
$K.E = \frac{1}{2}mv_B^2$ to calculate V_B at point B using equation

$2aS = V_f^2 - V_i^2 \Rightarrow 2gx = (0)^2 - V_B^2 \Rightarrow V_B^2 = 2gx$ put in equation of K.E

$K.E = \frac{1}{2}m(2gx) = mgx$ -----(ii) adding (i) and (ii)

$E = P.E + K.E = mg(h - x) + mgx = mgh - mgx + mgx$

$E = mgh$ ----------(2)



At point C: Just before strikes the Earth, P.E=0 and K.E= ½ mv_c^2, to find the value of Vc using the equation

$2gh = V_C^{\,2} - (0)^2 \quad \Rightarrow V_C^{\,2} = 2gh \quad \text{put in equation of K.E}$

$\text{K.E} = \frac{1}{2}\text{m}(2gh) = mgh \text{ ----- (ii) adding K.E and P.E at point C}$

$\text{E} = \text{P.E} + \text{K.E} = 0 + mgh =$

$\text{E} = mgh \text{ ----------(3)}$

From equation (1), (2) and (3) it is clear that energy can be changed from one form to other but total remains same. As

$Loss \text{ in P.E} = \text{Gain in K.E} \quad \Rightarrow \text{mg}(h_1 - h_2) = \frac{1}{2}m(v_2^{\,2} - v_1^{\,2})$

In case of frictional force present during downward motion: In this case a part of P.E is used in doing work again friction equal to W=fh the remaining P.E= mgh-fh is converted into K.E

$mgh - fh = \frac{1}{2}mv^2 \quad \Rightarrow mgh = \frac{1}{2}mv^2 + fh.$

Loss in P.E= Gain in K.E+ work done against friction

What are Non-conventional Energy sources? Explain.

Definition: The sources which are not commonly used are called non-conventional energy sources.
Names of sources: i) Energy from tides ii) Energy from waves iii) Solar Energy iv) Energy from biomass
Energy obtained from tides: Gravitational force of the moon produces tides in the sea twice a day which can be trapped in a basin by constructing a dam at high tide then water is released in control way to run the turbine and generate electricity
Energy obtained from waves: The tides and winds blow across the surface of ocean water waves produce and energy of these wave can generate electricity.
Salter's duck: The device which converts energy of waves into electricity is called salter duck. It has two parts
Duck float and balance float: The wave energy produce the movement in duck float relative to balance float which generate electricity.
Solar energy: The energy obtained from sun is called solar energy.
Solar constant & its value: Solar energy at normal incidence outside the earth's atmosphere per second per unit area is called solar constant. Its value 1.4 KWm^{-2}.
Solar cell: The device which converts sunlight into electrical energy is called solar cell.
Uses of solar cell: They are used in remote ground based weather stations and in solar calculators.
Energy obtained from biomass: Biomass include organic materials such as crops residue, natural vegetation, trees and animal dung and sewage. There are two methods for conversion of biomass into fuel. (i) Direct combustion (ii) Fermentation.
Geothermal energy: The heat energy extracted from inside the earth in the form of hot water or steam is called geothermal energy.
Digester: Rotting of biomass in a closed tank is called digester.
Aquifer: A layer of rock holding water that allow water to percolate through with pressure is called aquifer.

Renewable	Non renewable	Source of Energy	Original source
Hydroelectric	Coal	Solar, Bio mass	Sun
Wind	Natural gas	Hydroelectric,	Sun
Tides	Uranium	Wind, waves, Fossil fuels	Sun
Biomass	Oil	Tides	Moon
Sunlight	Oil shale	geothermal	Earth

How pollution can be reduced: Pollution can be reduced if (i) people use mass transportation (ii) use geothermal, solar and other renewable energy sources.
How can we save energy: (i) Turning off the light and electrical devices when not in use (ii) Using Energy saver instead bulb (iii) using solar energy (iv) Taking short hot showers.

Exercise short Questions chapter 04

4.1 A person hold a bag of groceries while standing still, talking to a friend. A car is stationary with its engine running. From the standpoint of work, how are these two situations similar?

Ans. In both cases work is zero, as there is no displacement; W = F d cos θ = F x 0 x cos θ = 0

4.2 Calculate the work done in kilo joules in lifting a mass of 10 kg (at a steady velocity) through a vertical height of 10 m.

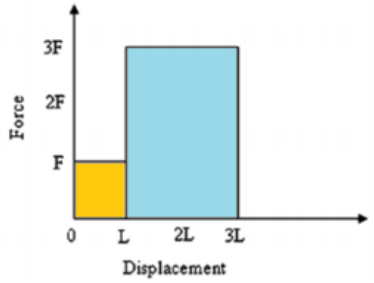
Ans. W = F d cos0o = F d =(mg) d = 10x9.8x10 = 980 J, divide and multiply by 1000 to get result =0.98 KJ

4.3.A force F acts through a distance L. the force is then increased to 3 F, and then acts through a further distance of 2 L. Draw the work diagram to scale.

$$Work = W = (F * L) + (3F * 2L)$$

$$work = FL + 6FL$$

$$work = 7FL$$



4.4 In which case is more work done? When a 50 kg bag of books is lifted through 50 cm, or when a 50 kg crate is pushed through 2 m across the floor with a force of 50 N?

Ans. For books: W = F d cos θ = mgh cos 0o = mgh = 50 x 9.8 x 0.5 = 245 J (more work)

For crate: W = F d cos θ = Fdcos 0o = Fd = 50 x 2 = 100 J More work is done in lifting bag of books.

4.5 An object has 1 J of potential energy. Explain what it means?

An object has one joule of potential energy means that body has capacity to do work of one joule, it means a force of one N is required to raise through a height of 1m. 1J=! N*1m.

4.6 A ball of mass m is held at a height h1 above a table. The tabletop is at a height h2 above the floor. One student says that the ball has potential energy mgh1 but another says that it is mg (h1 + h2). Who is correct?

Both are correct according to their own point of view.

4.7 When a rocket re-enters the atmosphere, its nose cone becomes very hot. Where does this heat energy come from?

Due to work again air friction and with dust particles in air this work converts into heat and nose cone becomes very hot.

4.8 What sort of energy is in the following:

a) Compressed spring= Elastic potential energy

b) Water in a high dam= Gravitational P.E

c) A moving car= Kinetic energy

4.9. A girl drops a cup from a certain height, which breaks into pieces. What energy changes are involved?

When the cup was in the hands of girl it has gravitational P.E when it drop it gain K.E and when it strike the ground this K.E converts into sound energy, heat energy and work in breaking the cup PE → gain in KE → sound energy + heat energy

4.10 A body uses a catapult to throw a stone, which accidentally smashes a greenhouse window. List the possible energy changes

When boy throws the stone elastic P.E is converted into K.E when stone hit the window this K.E converts into sound, heat and work done in breaking the greenhouse window.

Numerical problems

4.1: A man pushes a lawn mower with a 40 N force directed at an angle of 20° downward from the horizontal. Find the work done by the man as he cuts a strip of grass 20 m long.

$$\text{Given Data}: \mathrm{F} = 40\ \mathrm{N}, \theta = 20^\circ, \mathrm{d} = 20\mathrm{m}, \mathrm{W} = ?$$

$$\mathrm{W} = \vec{\mathrm{F}}.\vec{\mathrm{d}} = \mathrm{Fd}\cos\theta = 40 * 20 * \cos 20^\circ = 7.5 * 10^2\ J$$

4.2: A rain drop $\left(m = 3.35 \times 10^{-5} kg\right)$ falls vertically at a constant speed under the influence of the forces of gravity and friction. In falling through 100 m, how much work is done by (a) gravity and (b) fiction.

Given Data : $m = 3.35*10^{-5}$ kg, $h = 100$m, $W_{gravity} = ?$ $W_{friction} = ?$

$W_{gravity} = \vec{F}.\vec{d} = mgh\cos\theta = mgh\cos 0^{o} = 3.35*10^{-5}*9.8*100 = 0.0328$ J

$W_{fiction} = \vec{F}.\vec{d} = mgh\cos\theta = mgh\cos 180^{o} = -3.35*10^{-5}*9.8*100 = -0.0328$ J

4.3: Ten bricks, each 6.0 cm thick and mass 1.5kg, lie flat on a table. How much work is required to stack them one on the top of another?

Given data : Mass of brick = m = 1.5 kg, h = 6cm = 6/100 = 0.06m, W = ?

$W = 0 + mgh + 2mgh + 3mgh + 4mgh + 5mgh + 6mgh + 7mgh + 8mgh + 9mgh$

$W = 45mgh = 45*1.5*9.8*0.06 = 39.69J \approx 40J$

4.4: A car of mass 800kg travelling at 54kmh^{-1} is brought to rest in 60 meters. Find the average retarding force on the car. What has happed to original kinetic energy?

Given Data : mass = m = 800kg, $v_i = 54$Km/h $= 54*1000/3600 = 15$ m/s, $v_f = 0$, d = 60m, F = ?, K.E =

according to work energy principle $Fd = \frac{1}{2}m(v_f^{\,2} - v_i^{\,2}) \Rightarrow F = \frac{1}{2d}m(v_f^{\,2} - v_i^{\,2})$

$F = \frac{1}{2*60}800*(0^2 - 15^2) = -1500$N - ive sign shows the retarding force,

As velocity of body is decreasing so kinetic energy will be decrease and becomes zero due to frictional f rce.

4.5: A 1000 kg automobile at the top of an incline 10 metre high and 100 m long is released and rolls down the hill. What is its speed at the bottom of the incline if the average retarding force due to friction is 480 N?

Given Data : m = 1000kg, height = h = 10m, s = 100 m, f = 480 N $v_f = ?$

Using WE principle $Fd = \frac{1}{2}m(v_f^{\,2} - 0) \Rightarrow F = \frac{1}{2d}mv_f^{\,2} \Rightarrow v^2 = \frac{2Fd}{m}$

$v = \sqrt{\frac{2Fd}{m}} = \sqrt{\frac{2*480*100}{1000}} = 9.9 \approx 10$m/s

4.6: 100 m^3 of water is pumped from a reservoir into a tank 10 m higher than the reservoir, in 20 minutes. If density of water is 100kg m^{-3}, find (a) the increase in P.E. (b) the power delivered by the pump.

Given Data : Volume of water = $V = 100m^3$, h = 10m, t = 20 min $= 20*60 = 1200$sec, $\rho = 1000$kgm^{-3}, P.E = ? P = ?

for mass Density =, mass/volume $\Rightarrow$ mass = density * volume $= 1000*100 = 10^5$ kg

P.E = mgh $= 10^5*9.8*100 = 9.8*10^6$ J, Power $= \frac{W}{t} = \frac{P.E}{t} = \frac{9.8*10^6}{1200}8.2*10^3 Watt = 8.2KW$

4.7: A force (thrust) of 400 N is required to overcome road friction and air resistance in propelling an automobile at 80kmh^{-1}. What power (kW) must the engine develop?

Given Data : F = 400 N, velocity = v = 80Km/h = 80*100/3600 = 22.22 m/s, Power = ?

$P = \vec{F}.\vec{v} = Fv\cos\theta = Fv\cos 0^{o} = 400*22.22 = 8888 watt = 8888/1000 = 8.9KW$

4.8: How large a force is required to accelerate an electron $\left(m = 9.1\times10^{-31}kg\right)$ from rest to a speed of $2.0\times10^{7}\,ms^{-1}$ through a distance of 5.0 cm?

Given Data : mass = m = 9.1*10^{-31}kg, $v_i = 0$, $v_f = 2*10^7$ m/s, d = 5cm = 5*10^{-2} m, F = ?

using work energy principle $Fd = \frac{1}{2}m(v_f^{\,2} - v_i^{\,2}) \Rightarrow F = \frac{1}{2d}m(v_f^{\,2} - v_i^{\,2})$

$F = \frac{1}{2*5*10^{-2}}9.1*10^{-31}((2*10^7)^2 - 0^2) = 3.6*10^{-15}$ N

4.9: A diver weighing 750 N dives from a board 10 m above the surface of a pool of water. Use the conservation of mechanical energy to find his speed at a point 5.0m above the water surface, neglecting air friction.

Given Data : $W = 750\ N, h_1 = 10\ m, h_2 = 5\ m, v = ?$

As loss of potential energy = gian in kinetic energy $\Rightarrow mg(h_1 - h_2) = 1/2mv^2$

$v = \sqrt{2g(h_1 - h_2)} = \sqrt{2*9.8(10-5)} = 9.9 m/s$

4.10: A child starts from rest at the top of a slide of height 4.0m. (a) What is his speed at the bottom if the slide is frictionless? (b) If he reaches the bottom, with a speed of 6 ms^{-1}, what percentage of his energy at the top of the slide is lost as a result of friction?

Given Data : height = h = 4m, speed at bottom = v = ? % age of total energy lost = ?(if v = 6 m/s)

As loss of P.E = Gain in K.E $\Rightarrow mgh = 1/2mv^2 \Rightarrow v^2 = 2gh \Rightarrow v = \sqrt{2gh} = \sqrt{2*9.8*4} = 8.8 ms^{-1}$

$$\%\ \text{loss of Energy} = \frac{\text{loss of energy}}{\text{total energy}} * 100 = \frac{1/2mv^2 - 1/2mv'^2}{1/2mv^2} = \frac{v^2 - v'^2}{v^2} = \frac{8.8^2 - 6^2}{8.8^2} * 100 = 54\%$$

TID BITS/USEFUL INFORMATION

Q.1 Tick the right option.

1) Which of these is example of conservative forces?

a) Gravitational force	b) Elastic spring force	c) Electric force	**d) All of these**

2) Which of these is example of non-conservative force?

a) Frictional force	b) Air resistance	c) Propulsion force of rocket	**d) All of these**

3) What is the power of jumbo jet air craft?

a) $1.3*10^8$ watt	b) $1.1*10^5$ watt	c) $2*10^3$ watt	d) $7.5*10^{-4}$ watt

4) What is the power of car at 90kmh^{-1}

a) $1.3*10^8$ watt	**b) $1.1*10^5$ watt**	c) $2*10^3$ watt	d) $7.5*10^{-4}$ watt

5) What is the power of electric heater

a) $1.3*10^8$ watt	b) $1.1*10^8$ watt	**c) $2*10^3$ watt**	d) $7.5*10^{-4}$ watt

6) What is the power of pocket calculator?

a) $1.3*10^8$ watt	b) $1.1*10^8$ watt	c) $2*10^3$ watt	**d) $7.5*10^{-4}$ watt**

7) What is the power of color TV?

a) 100 watt	**b) 120 watt**	c) 140 watt	d) 160 watt

8) What is the power of flash light(two cells)

a) 0.5 watt	**b) 1.5 watt**	c) 2.5 watt	d) 3.5 watt

9) How much energy is used to make a car

a) $9*10^9$ J	b) 1000 J	c) $9*10^{15}$ J	d) $1*10^{12}$ J

10) A car uses about how much energy from petrol in its life time?

a) $9*10^9$ J	b) 1000 J	c) $9*10^{15}$ J	**d) $1*10^{12}$ J**

11) How much energy is obtained from kinetic energy of car at 90 km/h

a) $30*10^9$ J	b) $5*10^7$ J	**c) $1*10^6$ J**	d) $3*10^2$ J

12) What is the approximate energy value obtained from burning 1 ton coal?

a) $30*10^9$ J	b) $5*10^7$ J	c) $1*10^6$ J	d) $3*10^2$ J

13) How much energy is obtained from burning 1 liter of petrol

a) $30*10^9$ J	**b) $5*10^7$ J**	c) $1*10^6$ J	d) $3*10^2$ J

14) How much energy is obtained from running person at 10km/h

a) $30*10^9$ J	b) $5*10^7$ J	c) $1*10^6$ J	**d) $3*10^2$ J**

15) How much energy is obtained from fission of one atom of uranium?

a) $30*10^9$ J	b) $5*10^7$ J	**c) $1.8*10^{-11}$ J**	d) $3*10^2$ J

16) What is the approximate energy value obtained from kinetic energy of molecule of air

a) $30*10^9$ J	**b) $\underline{6*10^{-21}\ J}$**	c) $1*10^6$ J	d) $3*10^2$ J

17) All the food you eat in one day has about the same energy as --- liter of petrol

a) $\frac{1}{2}$	**b) $\frac{1}{3}$**	c) $\frac{1}{4}$	d) $\frac{1}{5}$

18) There is more energy reaching Earth in ---days of sun light than in all the fossil fuels on Earth

a) 5	**b) <u>10</u>**	c) 15	d) 20

19) More coal has been used since --- then was used in the whole of history before that

a) <u>1945</u>	b) 1940	c) 1950	d) 1955

20) Escape speed for Moon is

a) <u>2.4 km/s</u>	b) 4.3 km/s	c) 5 km/s	d) 10.4 km/s

21) Escape speed for Mercury

a) 2.4 km/s	**b) <u>4.3 km/s</u>**	c) 5 km/s	d) 10.4 km/s

22) Escape speed for Mars is

a) 2.4 km/s	**b) <u>5 km/s</u>**	c) 10.4 km/s	d) 11.2 km/s

23) Escape speed for Venus is

a) <u>10.4 km/s</u>	b) 11.2 km/s	c) 22.4 km/s	d) 25.4 km/s

24) Escape speed for Uranus is

a) 10.4 km/s	b) 11.2 km/s	**c) <u>22.4 km/s</u>**	d) 25.4 km/s

25) Escape speed for Neptune

a) 10.4 km/s	b) 11.2 km/s	c) 22.4 km/s	**d) <u>25.4 km/s</u>**

26) Escape speed for Saturn is

a) 10.4 km/s	**b) <u>37 km/s</u>**	c) 22.4 km/s	d) 25.4 km/s

27) Escape speed for Jupiter

a) 10.4 km/s	b) 11.2 km/s	**c) <u>61 km/s</u>**	d) 25.4 km/s

28) Escape speed is maximum for planet?

a) Moon	b) Mercury	**c) <u>Jupiter</u>**	d) Saturn

29) Escape speed is least for which planet?

a) <u>Moon</u>	b) Mercury	c) Mars	d) Jupiter

30) Sun is the original source of

a) Biomass	b) Fossil fuels	c) Wind	**d) <u>All of these</u>**

31) Which of these is renewable energy source?

a) Hydroelectric	b) Wind	c) Tides	**d) <u>All of these</u>**

32) Which of these is non-renewable energy source

a) Coal	b) Natural gas	c) Oil, uranium	**d) <u>All of these</u>**

33) Tidal effect can distort the continents pulling land up and down by as much as

a) 15 cm	b) 20 cm	**c) <u>25 cm</u>**	d) 30 cm

34) Original source of tides is

a) Sun	b) Earth	**c) <u>Moon</u>**	d) None

35) Original source of geothermal energy

a) Sun	b) Moon	**c) <u>Earth</u>**	d) None

PAST PAPERS SOLVED MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	If direction of force and displacement are perpendicular then work will be	Minimum	**Zero**	Maximum	Infinity
ii.	A stone is thrown up from the surface of earth when it reaches at maximum height its kinetic energy is equal to	Mgh	½ mv^2	2mgh	**Zero**
iii.	Which is renewable source of energy?	Coal	Natural gas	**Sunlight**	Uranium
iv.	Which one is non renevable source of energy	Wind	Biomass	**Coal**	Sunlight
v.	Which one is conservative force?	**Electric**	Tension in string	Propulsion force of motor	Normal force
vi.	1 KWh=?	$3.6*10^5$ J	**$3.6*10^6$ J**	$3.6*10^7$J	$3.6*10^8$J
vii.	The dimension of work are	$[MLT^{-2}]$	**$[ML^2T^{-2}]$**	$[MLT^{-1}]$	$[ML^{-2}T^{-2}]$
viii.	Source of tidal energy is	**Moon**	Sun	Earth	Uranium
ix.	A body at rest may have	**Energy**	Momentum	K.E	Torque
x.	Which one is not the unit of work	Watt second	Nm	Joule	**Kgm/s**
xi.	When do high tides occur in the ocean	**When moon is b/w sun and earth**	On a rainy day	When there is full moon	During day time
xii.	Nonrenewable source of energy is	**Uranium**	Wind	Biomass	Sunlight
xiii.	Escape velocity on the surface of earth is given by Vesc=?	$v = \frac{2\pi R}{T}$	$v = \sqrt{GM/R}$	$v = \sqrt{2gR}$	$v = \sqrt{\frac{2GM}{R}}$
xiv.	To evaluate gravitational P.E , final point must be consider at	0 m	1000Km	**Infinity**	None of these
xv.	6 joule of work is done in 3 sec then power is	6Watt	3 watt	18 Watt	**2 watt**
	P=work/time=6/3=2watt				
xvi.	Work done is maximum if the angle between the force and displacement is	**0˚**	30˚	180˚	90˚
xvii.	Escape velocity of a body of mass 1000 kg is 11 km/s, if the mass of body is doubled then escape velocity is	**11 km/s**	5.5 km/s	22 km/s	44 km/sec
	Escape velocity is independent of mass				
xviii.	Killo watt hour is the unit of	Power	Force	**Energy**	Weight
xix.	1KWh=?	0.36 MJ	**3.6MJ**	36MJ	360MJ
xx.	As we move up a body above the surface of earth, the change in potential energy will be	Negative	**Positive**	Zero	Infinity
xxi.	Rate of doing work is known as	Impulse	Energy	**Power**	Momentum
xxii.	Which one is biggest unit of energy and commercial unit	Erg	Joule	Watt hour	**Killo watt hour**
xxiii.	Joule is a unit of	K.E	P.E	Heat energy	**All of these**
xxiv.	Kinetic energy can be defined as dot product of	Momentum and force	Force and velocity	**Average momentum and velocity**	None of these
xxv.	If mass of moving body is doubled then its kinetic energy becomes	**2 times**	4 times	8 times	16 times
xxvi.	A field will be conservative when work done	By centripetal force is zero	By a frictional force is negative	**In closed path is zero**	None of these

xxvii.	Power is equal to the dot product of force and	Displacement	Acceleration	**Velocity**	Position vector
xviii.	Value of escape velocity for the surface of the earth is 11 km/sec. Its value for surface of the moon is	11 km/sec	**2.4 km/sec**	10.4 km/sec	4.3 km/sec
xxix.	KW/m^2 is the unit of	Power	**Intensity**	Energy	work
xxx.	The area under the curve force displacement graph represents	Force	Displacement	**Work**	Power
xxxi.	If velocity is doubled then	Momentum increase 4 times and k.E 2 times	Momentum and K.E remains same	Momentum increase 2 times and K.E remains same	**Momentum increase 2 times and K.E increase 4 times**
Momentum is directly to velocity and kinetic energy is directly to square of velocity					
xxxii.	If by some means the diameter of earth increases to 4 times the escape speed will becomes	Same	**Double**	Half	One fourth
As escape speed is directly proportional to sq.rt of radius/diameter, so sq.rt of 4 is two					
xxiii.	Solar cell converts light energy into	Heat energy	Chemical energy	**Electrical energy**	Atomic energy
xxiv.	A body of mass 2kg moving with velocity of 4m/s has K.E equal to	**16J**	8J	32J	2J
As m=2kg, v=4 m/s, put in formula K.E=1/2 $mv2=1/2*2*4^2=16$					
xxxv.	The value of solar constant is	**1.4 KW/m^2**	1 KW/m^2	4.1 KW/m^2	0.1 KW/m^2
xxvi.	Work will be negative when angle is	<90°	**>90°**	0°	45°
xxvii.	Work has dimension like	**Torque**	Momentum	Velocity	Power
xviii.	Earth receives large amount of energy directly from	Wind	Water	**Sun**	Moon
xxix.	Original source of energy for biomass is	Earth	Moon	**Sun**	Star
xl.	A layer of rock holding water that allows water percolate through it with pressure is called	Geyser	**Aquifer**	Steam vent	Hot spring
xli.	The value of escape velocity is	1 Km/h	**11 Km/s**	1.1 Km/h	1.1 m/s
xlii.	3 J of work is done in 3 sec then power is	6W	3W	18 W	**1W**
P=work/time=3/3=1watt					
xliii.	All the food we eat in one day has about the same energy as:	One liter of petrol	½ liter of petrol	**1/3 liter of petrol**	¼ liter of petrol
xliv.	The work done is negative when angle between force and displacement is	45˚	90˚	**180˚**	0˚
xlv.	On a clear day at noon, the intensity of solar energy reaching the earth's surface is about	1.4 kWm-2	**1.0 kWm-2**	1.4 Wm-2	1.4 kWm-2
xlvi.	Bio mass is converted into fuel by	Evaporation	Scattering	Reflection	**Fermentation**
xlvii.	Which of these is not conservative force?	**Frictional force**	Gravitational force	Electric force	Elastic restoring force
xlviii.	Escape velocity is independent of	**Mass**	Radius	Gravitational acceleration	All of these
xlix.	A body has P.E=mgh when it is height h from ground, at the point distance x below from top, its P.E will be	mgx	mgh	**mg(h-x)**	mg(h+x)
l.	The dimension of power is	$[MLT^{-2}]$	**$[ML^2T^{-3}]$**	$[MLT^{-1}]$	$[ML^{-2}T^{-2}]$

li.	If 50 kg crate is pushed through 2m across the floor with force of 50 N, work will be	245 J	**100 J**	500 J	50 J
lii.	Work done will be zero if angle between force and displacement is:	0°	**270°** Put in W=Fdcosθ	60°	360°
liii.	100 joules work has been done by an agency in 10 seconds. What is power of agency	1000 watt	0.10 watt.	100	**10 watt**. Apply P=W/t
liv.	Escape velocity for mars is	10.4 km/s	2.4 km/s	4.3 km/s	**5 km/s**
lv.	The escape velocity corresponds to _____ energy gained by body, which carries it to an infinite distance from the surface of earth.	Total	Initial kinetic.	**Absolute** **Potential**	None of these
lvi.	The power needed to lift a mass 5000g to height 1m in 2 sec	2.45 W	**24.5 W**	245 W	2.45 KW
P=W/t=mgh/t= 5*9.8*1/2=49/2=24.5 W					
lvii.	If a body of mass 5kg is raised vertically through a distance of 1m, then work done is	**49 J**	4.9 J	490 J	0.49 J
W=Fd=mgh=(5)(9.8)(1)=49J					
lviii.	The consumption of energy by 60-watt bulb in 2 seconds is:	20 J	30 J	0.02 J	**120 J**
POWER =energy/time, Energy = power*time= 60*2= 120 J					
lix.	If a certain force acts on an object and changes its kinetic energy from 65 J to 130 J, then work done by the force will be	92.5 J	**65 J**	97.5 J	130 J
Apply work energy principle as work done is equal to change in kinetic energy so=130-65=65J					

CHAPTER 05 CIRCULAR MOTION

Circular motion: The motion of an object in circular path is called circular motion. For example motion of satellite in orbit around the earth.

What is Angular displacement? State right hand rule.

Angular displacement: The angle subtended at the center of circle by a moving body in given time is called angular displacement. SI unit of angular displacement is radian.

Right hand rule to find the direction of angular displacement: "Rotate the fingers of your right hand through some possible angle then erect thumb will show the direction of angular displacement.

Radian: The angle subtended at the center of circle by an arc whose length is equal to radius of circle is called radian.

Prove that S=rϴ.

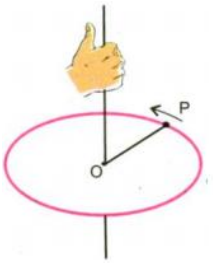
let S is the length of circle of radius r

which makes an angle θ at the center

$$\theta = \frac{\text{arc length}}{\text{radius}}(rad)$$

$$\theta = \frac{S}{r}$$

$$S = r\theta$$



Prove that 1 radian=57.3°

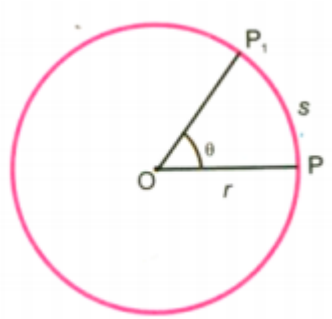
As we know that in one revolution distance covered by a particle is equal to circumference $S = 2\pi r$ so

$$\theta = \frac{S}{r} = \frac{2\pi r}{r}(\text{rad}) = 2\pi \text{ radian}$$

as angle for circle is $\theta = 360^\circ$ so

$$360^\circ = 2\pi \text{ radian} \Rightarrow 1 \text{ radian} = \frac{360^\circ}{2\pi}$$

$$1 \text{ radian} = 57.3^\circ \text{ which is required result}$$



What is Angular velocity? What is average and instantaneous angular velocity?

Angular velocity: Time rate of change of angular displacement is called angular velocity. Its formula is $\omega = \frac{\Delta\theta}{\Delta t}$.

SI unit is radian/sec. It is vector quantity. Its dimension are [T^{-1}]. Its direction is along the axis of rotation.

Average angular velocity: The ratio of total change in angular displacement to total time is called average angular velocity. $< \omega >= \frac{\Delta\theta}{t}$

Instantaneous angular velocity the angular velocity at any instant of time when limiting value approaches to zero is called instantaneous velocity. $\omega = \lim \Delta t \to 0 \frac{\Delta\theta}{\Delta t}$

Define Angular acceleration? what is average and instantaneous angular acceleration?

Definition: The time rate of change of angular velocity is called angular acceleration.

Its formula $\alpha = \frac{\Delta\omega}{\Delta t}$. It is vector quantity and SI unit is rad/sec^2 and [T^{-2}], its direction is along the axis of rotation.

Average angular acceleration: The ratio of total change in angular velocity to the total time interval is called average angular acceleration. $< \alpha >= \frac{\Delta\omega}{t}$.

Instantaneous angular acceleration: The angular acceleration at any instant of time when limiting value approaches to zero is called instantaneous angular acceleration $\alpha = \lim \Delta t \to 0 \frac{\Delta\omega}{\Delta t}$.

Relation b/w linear and angular velocities OR prove that $v = r\omega$

let a point P in rigid body at perpendicular distance r from axis of rotation with linear velocity v,

$\Delta S = r\Delta\theta$

dividing both sides by Δt

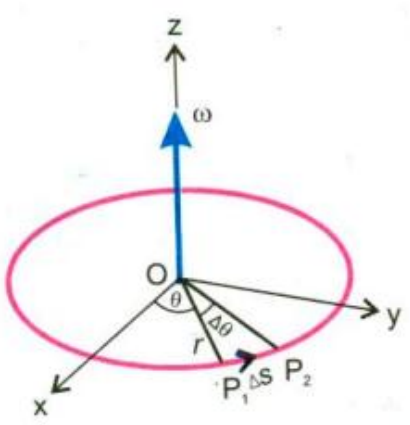
$\frac{\Delta S}{\Delta t} = r\frac{\Delta\theta}{\Delta t}$ taking limit on both sides

$\lim \Delta t \to 0 \frac{\Delta S}{\Delta t} = \lim \Delta t \to 0\, r\frac{\Delta\theta}{\Delta t}$ ----(1

As $\lim \Delta t \to 0 \frac{\Delta S}{\Delta t} = v, \lim \Delta t \to 0 \frac{\Delta\theta}{\Delta t} = \omega$

put in eq (1

$v = r\omega$ which is required result



Relation b/w angular and linear acceleration. OR prove that $a = r\alpha$

let a point P in rigid body at perpendicular distance r from axis of rotation with with angular acceleration α,

$\Delta v = r\Delta\omega$

dividing both sides by Δt

$\frac{\Delta v}{\Delta t} = r\frac{\Delta\omega}{\Delta t}$ taking limit on both sides

$\lim \Delta t \to 0 \frac{\Delta v}{\Delta t} = \lim \Delta t \to 0\, r\frac{\Delta\omega}{\Delta t}$ ----(1

As $\lim \Delta t \to 0 \frac{\Delta v}{\Delta t} = a, \lim \Delta t \to 0 \frac{\Delta\omega}{\Delta t} = \alpha$

put in eq (1

$a = r\alpha$ which is required result

Write Equations of motion in case of angular motion

Uniform acceleration	Angular velocity
Vf=Vi+at	$\omega_f = \omega_i + \alpha t$
$S=Vit+1/2\ at^2$	$\theta = \omega_i + \frac{1}{2}\alpha t^2$
$2as=Vf^2-Vi^2$	$2\alpha\theta = \omega_f{}^2 - \omega_i{}^2$

What is Centripetal force and centripetal acceleration? derive their relations.

Centripetal force: The force which move the body in circular path is called centripetal force. For example force acting on Earth around the sun. $Fc=mv^2/r$.

Centripetal acceleration: The acceleration which is produced by centripetal force is called centripetal acceleration. Its formula is $a=v^2/r=w^2r$. It is also called radial acceleration. The direction of centripetal acceleration is along the radius towards the center of circle.

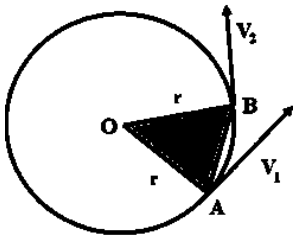
Expression for centripetal acceleration and centripetal force: Let us consider a particle of mass moves from point A to point B with uniform speed v. the velocity of the particle changes its direction but magnitude remains same. This change in velocity is shown in fig produce acceleration whose value

$a = \frac{\Delta V}{\Delta t}$ ---------- (1)

Let $\vec{V}_1$ and $\vec{V}_2$ are the velocities at point A and point B so magnitude of both speed are equal. $V_1 = V_2 = |V| = V$. so time taken to travel distance S or AB is Δt which is Δt=S/V put in equation (1)

$a = \frac{\Delta V}{S/V} = \frac{V\Delta V}{S}$---------- (2)

For calculation of ΔV we draw a triangle ΔPQR such that PQ is parallel to $\vec{V}_1$ and PR is parallel to $\vec{V}_2$

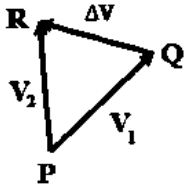


So from isosceles triangle PQR the value of angle $\theta = \frac{QR}{PR} = \frac{\Delta V}{V}$ ----- (i)

Similarly From triangle OAB, the value of angle $\theta = \frac{AB}{r} = \frac{S}{r}$ ---------- (ii)

Comparing both (i) and (ii) we get $\frac{\Delta V}{V} = \frac{S}{r}$ $\Delta V = \frac{SV}{r}$ putting in equation (2)

$a = \frac{V(\frac{SV}{r})}{S} = \frac{V^2}{r}$, this is the formula for centripetal acceleration



Expression for centripetal force: As we know that F=ma, and $a=\frac{V^2}{r}$ putting in formula to get result

$F=\frac{mV^2}{r}$ this is the formula for centripetal force, in case of angular motion V=rω so we get

$F_c=\frac{m(r\omega)^2}{r} = \frac{mr^2\omega^2}{r} = mr\omega^2$, this is centripetal force, its unit is newton and dimension $[MLT^{-2}]$, and it is only force which perform no work.

What is Moment of Inertia? Calculate the torque in terms of moment of inertia on rigid body.

Definition: The product of mass of particle and square of its perpendicular distance from axis of rotation is called moment of inertia. It is scalar and unit is kgm^2. Its formula is $I=mr^2$ and its dimension is $[ML^2]$.

Significance: Moment of inertia plays the same role in angular motion as mass play in linear motion.

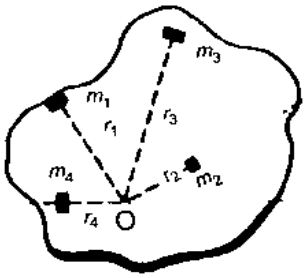
Explanation: consider a mass which is attached to a massless rod which can rotate about a frictionless axis of rotation O. let the system be in horizontal place. A force F acts on the mass perpendicular to rod,

F=ma. This force rotates the mass in angular motion a=rα, equation of force

F=mrα multiplying both sides by r, $rF=mr^2\alpha$

As $\tau = r F$, $\tau = mr^2\alpha$ as we know that $I= mr^2$

$\tau = I\alpha$, is the torque acting on a body of mass.



Moment of inertia of rigid body:

Consider a rigid body made up of n small pieces of masses $m_1, m_2, m_3 \ldots m_n$

Magnitude of torque acting on m_1 $\tau_1 = m_1r_1^2\alpha_1$

Magnitude of torque acting on m_2 $\tau_2 = m_2r_2^2\alpha_2$

Magnitude of torque acting on m_n $\tau_n = m_nr_n^2\alpha_n$

Total torque $\tau = \tau_1 + \tau_2 + \ldots\ldots\ldots + \tau_n = m_1r_1^2\alpha_1 + m_2r_2^2\alpha_2 + \ldots\ldots\ldots + m_nr_n^2\alpha_n = (m_1r_1^2 + m_2r_2^2 + \ldots + m_nr_n^2)\alpha = I\alpha$

$\text{Thin rod} = I = \frac{1}{12}mL^2$, $\text{Thin Ring or Hoop} = I = mr^2$, $\text{solid cylinder} = I = \frac{1}{2}mr^2$, $\text{sphere} = I = \frac{2}{5}mr^2$

What is Angular momentum? Prove that L=Iω.

Definition: The cross product of position vector **r** about axis of rotation and linear momentum **P** of rotating body is called angular momentum. Its SI unit is kgm^2/s or Js , whose dimension are $[ML^2T^{-1}]$.

Explanation: Consider a body mass m moving with v and linear momentum relative to origin then angular momentum

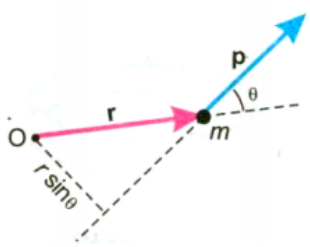
$\text{As we know taht } \vec{L} = \vec{r} * \vec{P} = rP\sin\theta\,\hat{r}$

$\text{put } P = mv \text{ and } \theta = 90^o$

$L = r(mv)\sin 90^o = mvr$

$\text{as we know that } v = r\omega$

$L = m(\omega r)r = mr^2\omega = I\omega$



The direction of angular momentum is perpendicular to plane containing $\vec{r}$ and $\vec{P}$.

Angular momentum of rigid body: Consider rigid body rotating body about a fixed axis through center of mass m as shown in fig, each particle rotates about the same axis in circle with same angular velocity ω.

Magnitude of angular momentum acting on m_1 $L_1= m_1r_1^2\omega_1$

Magnitude of angular momentum acting on m_2 $L_2= m_2r_2^2\omega_2$

Magnitude of angular momentum acting on m_n $L_n= m_nr_n^2\omega_n$

Total $L= L_1+ L_2+\ldots\ldots\ldots + L_n = m_1r_1^2\omega_1 + m_2r_2^2\omega_2 +\ldots\ldots\ldots + m_nr_n^2\omega_n = (m_1r_1^2 + m_2r_2^2 +\ldots+ m_nr_n^2)\omega= I\omega$

Spin angular momentum: Angular momentum of spinning body is called spin angular momentum L_s.

Orbital angular momentum: Angular momentum of orbiting in circular path is called orbital angular momentum.

Point object: Such an object whose radius is larger as compared to size of the body is called point object.

State and explain Law of conservation of angular momentum.

Statement: If no external torque acts on a system, total angular momentum remains constant. $I_1\omega_1 = I_2\omega_2$

Explanation: This law has great importance for Earth as it moves around the sun. No other sizable torque is experience the Earth, because the major force acting on it is the pull of the sun, the Earth's axis of rotation, therefore, remains fixed in one direction with reference to the universe around us.

Other examples: (1) a man diving from diving board (2) Diving (3) Gymnastics (4) Ice-skating.

What is Rotational Kinetic Energy? calculate rotational kinetic energy and speed for disc and hoop.

Definition: The energy possessed by a body due to its rotation about an axis is called rotational kinetic energy. **OR** the kinetic energy of rotating or spinning body is called rotational kinetic energy.

Derivation: To derive the relation for rotational kinetic energy, consider a piece of mass dividing into (m_1, m_2,m_n) from a distance (r_1,r_2,r_3,….r_n), also we know v=rω then

K.E= ½ mv^2=½ $m(r\omega)^2$=½ $mr^2\omega^2$,

for each part its sum will be

K.E rot=½ $m_1r_1^2\,\omega^2_1$ + ½ $m_2r_2^2\,\omega^2_2$ +……+ ½ $m_nr_n^2\,\omega^2_n$ = ½ $(m_1r_1^2 + m_2r_2^2 +\ldots+ m_nr_n^2)\,\omega^2$

K.E rot =½ $I\omega^2$

Uses: It is used by fly wheel which are compulsory parts of many engines. A fly wheel stores energy b/w the power strokes of piston.

Rotational kinetic energy of a disc	**Rotational kinetic energy of hoop**
We know that $K.E_{rot}$= ½ $I\omega^2$	We know that $K.E_{rot}$= ½ $I\omega^2$
For a disc I= ½ mr^2 as we know v=rω	For a hoop I= mr^2 as we know v=rω
$K.E_{rot}$= ½ (½ $mr^2)\omega^2$= ¼ $m(r^2\omega^2)$= ¼ $m(r\,\omega)^2$= ¼ mv^2	$K.E_{rot}$= ½ $(mr^2)\omega^2$= ½ $m(r^2\omega^2)$= ½ $m(r\,\omega)^2$= ½ mv^2

Velocity of a disc	**Velocity of hoop**
Consider a disc starts moving down an inclined place of height h, its motion consists of both rotational and translational motion as shown in fig $P.E = K.E_{tran} + K.E_{rot}$ $mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$ for disk $K.E_{rot} = \frac{1}{4}mv^2$ $mgh = \frac{2mv^2 + mv^2}{4} = \frac{3mv^2}{4}$ $v^2 = \frac{4gh}{3}$ $v = \sqrt{\frac{4gh}{3}}$ 	Consider a hoop starts moving down an inclined place of height h, its motion consists of both rotational and translational motion as shown in fig $P.E = K.E_{tran} + K.E_{rot}$ $mgh = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$ for disk $K.E_{rot} = \frac{1}{2}mv^2$ $mgh = \frac{mv^2 + mv^2}{2} = \frac{2mv^2}{2} = mv^2$ $v^2 = gh$ $v = \sqrt{gh}$ conclusion: it is concluded from both equations that $D_{isc} > V_{hoop}$

What is Artificial satellite? Derive the formula for speed and time period of artificial satellite.

Satellite: The objects which orbits around the Sun are called satellites.

Artificial satellite: The man-made objects that orbit around the Earth is called artificial satellite. They are put into orbits by rockets and era held in orbits by gravitational pull of Earth. The low flying satellites have acceleration 9.8 ms^{-2} towards the center of Earth.

Critical velocity for artificial satellite: "The minimum velocity required to put the satellite into orbit around Earth"

Formula for critical velocity: consider a satellite moving in a circle of radius R having centripetal force which is supplied by gravitational force.

$$\text{Centripetal force} = \frac{mv^2}{R} \quad \text{--------(1)} \qquad \text{Gravitational force} = mg \quad \text{----------(2)}$$

$$\text{comparing both equations} \quad \frac{mv^2}{R} = mg \qquad \Rightarrow v^2 = gR$$

$$v = \sqrt{gR} \qquad \Rightarrow v = \sqrt{9.8*6.4*10^6} = 7.9*10^3 \text{ m/s} = 7.9 \text{ km/s}$$, this is the numerical value of critical velocity.

Time period: "The time required by the satellite to complete one revolution around the Earth is called Time period".

$$\text{As we } S = vt \qquad \Rightarrow t = \frac{S}{v} = \frac{2\pi\pi}{v} = \frac{2*3.14*6.4*10^6}{7.9*10^3} = 5060\text{sec} \approx 84\text{min}$$

If the satellite moves at height h from surface the earth, thus higher the satellite, the slower will be the required speed and longer it will take to complete one revolution around the earth. Closest orbiting satellite the Earth at a height of 400Km.

Global positioning system: There are twenty four satellites close orbiting satellites form the global positioning system. With help of this system, an airline pilot, sailor or any other person can now use a pocket size instrument or mobile phone to find his position on the Earth's surface to within 10m accuracy.

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What is Real and apparent weight? Discuss its different cases.

Real weight: The gravitational pull of Earth on object is called real weight,
Apparent weight: Weight is generally measured by spring balance and the readings of spring balance is called apparent weight.
Apparent weight of an object in a lift: Consider the apparent weight of an object mass m suspended by a string and spring balance in a lift, the tension T in the string can be measured with help of spring balance.
Case 01: When the lift at rest or moving with uniform velocity: In this case, acceleration is zero as net force is zero on the object, if W is the gravitational force (Real weight) and T is tension (apparent weight) then using Newton's law

$T + (-W) = ma \qquad \Rightarrow T - W = m(0) \qquad a = 0$ so

$T = W$, Result : Apparent weight of an object is equal to real weight

Case 02: When the lift is moving upward with acceleration a: In this case upward force T is greater than real weight W then net force acting on the body will be T + (-W)= ma

$T - W = ma \qquad \Rightarrow T = W + ma$, Result : Apparent weight of object is increased by an amount ma than actual weight.

Case 03: When the lift is moving downward with acceleration a: In this case real weight W is greater than real apparent weight T then net force acting on the body will be W + (-T)= ma

$-T + W = ma \qquad \Rightarrow T = W - ma$, Result : Apparent weight of object is decreased by an amount ma than actual weight.

Case 04: When the lift is falling freely: When the lift is falling freely then a=g
T=W-ma= W-mg=mg-mg=0 as W=mg, ma=mg in this case apparent weight is zero.
Weightlessness: When the apparent weight of object is zero than this condition is called weightlessness.

Write a note on Weightlessness in satellite and gravity free system.

Weightlessness: When a satellite is falling freely in space under the action of force of attraction of Earth, then this state is called weightlessness.
Explanation:

- An Earth's satellite is freely falling object.
- To explain this if the projectile is thrown continuously at larger speeds then during its free fall to the Earth, the curvature of the path decrease with increasing horizontal speeds.
- If object is through fast enough parallel to the Earth, the curvature of its path will match the curvature of the Earth and space ship simply circle round the Earth.
- Its free fall acceleration is simply g.
- In fact the space ship is falling towards the center of Earth at all times but due to spherical shape of Earth, it never strikes the surface of Earth.

Gravity free system: When a satellite is moving under weightlessness then no force is required to hold it, such a system is called gravity free system.

What is Orbital velocity? Derive its formula.

Definition: The velocity of satellite with which it revolves around the Earth is called orbital velocity.

Formula: $v = \sqrt{\frac{Gm}{r}}$ Where r=R+h

Formula derivation: Let us consider a satellite of mass m moving with orbital velocity v around the Earth of mass.

If r is the radius of orbit then centripetal force $F = \frac{mv^2}{r} ------(1)$

It is provided by gravitational force b/w Earth and satellite $F = G\frac{Mm}{r^2} -----(2)$

equating (1) and (2) $\frac{mv^2}{r} = G\frac{Mm}{r^2} \qquad \Rightarrow v^2 = \frac{GM}{r}$

$v = \sqrt{\frac{GM}{r}}$, G = Gravitation constant, M = mass of Earth, r = R + h, R = radius of Earth, h = height of orbit from equator

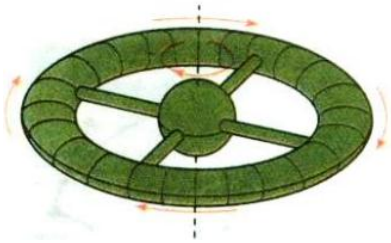
What is Artificial Gravity? Derive the expression for frequency of spaceship.

Artificial Gravity: The gravity produced in an orbiting satellite by spinning it around its own axis is called artificial gravity. Formula for frequency of spaceship for artificial gravity is $f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$.

Need of artificial gravity: If the spaceship is to stay in orbit for longer times, then weightlessness creates many problems for astronauts present in spaceship, to overcome this problem, artificially gravity is created.

How it produced: Artificial gravity is produced by rotating the spaceship around its own axis, the astronauts then pressed the outer rim and exert a force on the floor of spaceship in much as same way as on the Earth.

Expression for Frequency: Let us consider a spacecraft having radius R which rotates around its axis with angular speed ω, linear speed v=Rω. As force of gravity provides the centripetal acceleration so in this case a=g.



$$a_c = \frac{v^2}{R} = \frac{(R\omega)^2}{R} = \frac{R^2\omega^2}{R}$$

$$a_c = R\omega^2 \text{ ----------(1)}$$

as Angular frequency is $\omega = \frac{2\pi}{T}$ puttingin (1)

$$a_c = R\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2 R}{T^2} = 4\pi^2 R\left(\frac{1}{T^2}\right) \qquad \text{As } f = \frac{1}{T} \Rightarrow f^2 = \frac{1}{T^2}$$

$$a_c = 4\pi^2 R(f^2)$$

$$f^2 = \frac{1}{4\pi^2}\frac{a_c}{R} = \frac{1}{4\pi^2}\frac{g}{R} \qquad \text{As } a_c = g \text{ so}$$

$$f = \frac{1}{4\pi^2}\frac{g}{R}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}, \text{ This is the formula for frequency of spaceship required to provide artificial gravity}$$

What is Geostationary Orbit? write its uses and derive the formula for radius of geostationary orbit.

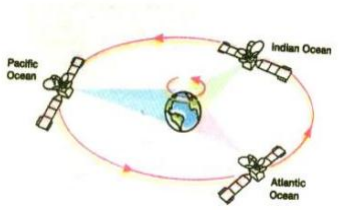
Geo stationary orbit: The orbit in which the period of rotation of satellite is equal to period of rotation of Earth about its axis is called geo stationary orbit. A geostationary satellite orbits the Earth once per day(24h) over the equator.

Uses of Geostationary orbit: There are following uses of geostationary orbit

Such satellite are used in communication system, weather observation and other military uses.

Expression for orbital radius of Geo stationary orbit: As we know that the orbital speed necessary for the circular orbit is given as $v = \sqrt{\frac{GM}{r}}$ ----------(1), r is the distance of satellite from Earth, M= Mass of earth

This speed must equal to speed s $v = \frac{S}{T} = \frac{2\pi r}{T}$ ----------(2), t is the period of revolution of satellite



Equating both equation $\frac{2\pi r}{T} = \sqrt{\frac{GM}{r}}$, squaring both sides

$\frac{4\pi^2 r^2}{T^2} = \frac{GM}{r} \quad \Rightarrow r^3 = \frac{GMT^2}{4\pi^2}$, Taking cube root on both sides

$r = \left(\frac{GMT^2}{4\pi^2}\right)^{1/3}$, This is the formula for orbital radius of geostationary satellite

$r = \left(\frac{6.67*10-11*6*1024*(86400)^2}{4(3.14)^2}\right)^{1/3} = 4.23*10^4 \text{ km}$

The height above the equator comes out to be 36000 km.

What is Communication satellite? Explain.

Definition: Such a satellite which is used for worldwide communication is called communication satellite.

- A communication system can be set up by placing many geostationary satellites in orbit over different point on surface of Earth.
- One such satellite covers 120° of longitude, so whole populated Earth surface covered 03 correctly position satellites.
- Solar cells provides the energy to amplify and retransmit the signal
- About 200 Earth stations transmit and receive signals via satellite from other countries

Why Microwaves are used in communication satellite?: Micro waves are used in communication satellite because they travel in straight line and can pass easily through atmosphere of the earth.

What is INTELSAT?: INTELSAT mean international satellite organization. It is managed by 126 countries. It works at the microwaves frequencies 4, 6, 11, 14 GHz and capacity of 30000 two way telephone calls plus 3 tv channels.1 GHz=10^9 Hz.

Describe Newton and Einstein views of gravitation.

Newton views about gravitation: "Gravitation is the intrinsic property of matter and gave law of gravitation which is

Law of gravitation: "Every particle of matter attract every particle with a force that is directly proportional the product of their masses and inversely proportional to the square of distance b/w them", $F=Gm_1m_2/r^2$.

Einstein Views about gravitation: According to Einstein gravity is due to the curvature of space and time, to observe this we take example of thin rubber sheet, if a heavy weight is hung from it, it curves.

According to Einstein bodies and light rays move along

Geodesics: Such path which is equailent to straight line in plane geometry is called geodesics.

What is Differences b/w Einstein and Newton views about gravitation?

Newton views	Einstein views
Newton discovered inverse square law but give no explanation of it	Einstein theory gives a physical picture of how gravity works
According to Newton gravitation is due to force b/w masses.	According to Einstein gravity is due to the curvature of space and time

Why Einstein theory of gravity is better than Newton theory of gravitation?: It is better than Newton theory because it gives explanation of inverse square law of gravitation and deflection of light must bend light due to gravity by definite amount. So Einstein theory about gravity is better than Einstein theory.

Exercise short Questions chapter 05

1. Explain the difference between tangential velocity and the angular velocity. If one of these is given for a wheel of known radius, how will you find the other?

Ans. **Tangential velocity (v)** "The linear velocity, along the direction of the tangent at any point on that curve which is followed by the moving particle".

Angular velocity (ω): "The rate of change of angular displacement of a particle moving along a curved path". Both are related as: $\mathbf{v} = r\,\omega$

2. Explain what is meant by centripetal force and why it must be furnished to an object if the object is to follow a circular path

The force needed to move a body around a circular path". Mathematically, $F = mv^2 / r = mr\omega^2$.Its direction is towards the center of the circle. Fc is furnished for an object moving in a circular path (of constant radius). For m & r constant, $F \propto \omega^2$,

3. What is meant by moment of inertia? Explain the significance.

The product of mass of particle and square of its perpendicular distance from axis of rotation is called moment of inertia. $I=mr^2$

I plays the same role in angular motion as that of mass in linear motion.

4. What is meant by angular momentum? Explain the law of conservation of angular momentum.

The cross product of position vector and linear momentum". Mathematically, $\mathbf{L} = \mathbf{r} \times \mathbf{p}$

"If no external torque acts on a system, the total angular momentum of the system remains constant". Mathematically, $T_{total} = L_1 + L_2 + \ldots.= \text{constant}$.

5. Show that orbital angular momentum Lo = mvr.

$$\text{As we know taht } \vec{L} = \vec{r} * \vec{P} = rP\sin\theta\,\hat{r}$$

$$\text{put } P = mv \text{ and } \theta = 90^o$$

$$L = r(mv)\sin 90^o = mvr$$

$$Lo = mvr$$

6. Describe what should be the minimum velocity, for a satellite, to orbit close to the Earth around it.

The minimum velocity needed to orbit a satellite close to earth is called critical velocity. Its formula is

$v = \sqrt{gR}$ Its value is 7.9 km/sec

7. State the direction of the following vectors in simple situations; angular momentum and angular velocity.

The direction of angular velocity and angular momentum is along the axis of rotation stated by right hand rule " Grasp the axis of rotation in your right hand then erect thumb show the direction of angular velocity and moment and curled fingers show the direction of rotation".

8. Explain why an object, orbiting the Earth, is said to be freely falling. Use your explanation to point out why objects appear weightless under certain circumstances.

An object is given certain tangential velocity for orbiting the earth. It is like freely falling due to force of gravity. It will follow curved path due to two forces. The curvature of its path will match the curvature of the earth. Its centripetal acceleration equals its acceleration due to gravity; i.e. a = g, so T = mg – mg = 0. Hence it appears weightless.

9. When mud flies off the tyre of a moving bicycle, in what direction does it fly? Explain.

Ans. The mud will fly in a direction tangent to the wheel. When mud separates from the tyre, centripetal force is ceased from the mud particles

10. A disc and a hoop start moving down from the top of an inclined plane at the sametime. Which one will be moving faster on reaching the bottom?

Disc will be moving faster on reaching the ground

Because $v = \sqrt{\frac{4gh}{3}}$ For disc $v = \sqrt{gh}$ for hoop

$V_{disc} = \sqrt{\frac{4}{3}}\,gh = 1.15V_{hoop}$ so $V_{disc} > V_{hoop}$

11. Why does a diver change his body positions before diving in the pool?
To increase angular velocity, the diver changes his body positions. $L = I\omega = mr^2\omega$ for smaller r, ω will be greater. The diver closed his legs and arms to make smaller r so that his angular velocity increases to make more somersaults. $I_1\omega_1 = I_2\omega_2$.

12 A student holds two dumb-bells without stretched arms while sitting on a turntable. He is given a push until he is rotating at certain angular velocity. The student then pulls the dumbbell towards his chest. What will be the effect on rate of rotation?
His rate of rotation will increase, due to smaller r, the distance from the axis of the distribution of mass m. $L = I\omega = mr^2\omega$ When he pulls the dumbbells towards his chest, his moment of inertia decreases and he spins faster.

13 Explain how much minimum number of geo-stationary satellites are required for global coverage of T.V. transmission.
Three correctly positioned satellites are sufficient for global coverage of TV transmission. As one such satellite covers 120° of longitude.

Numerical problems

5.1: A tiny laser beam is directed from the Earth to the Moon. If beam is to have a diameter of 2.50 m at the Moon, how small must divergence angle be for the beam? The distance of Moon from the Earth is $3.8\times10^8 m$.

$$\text{Given Data}: S = 2.5\,\text{m},\ r = 3.8*10^8\ \text{m},\ \theta = ?$$

$$\theta = \frac{S}{r} = \frac{2.5}{3.8*10^8} = 6.6*10^{-9}\,rad$$

5.2: A gramophone record turntable accelerates from rest to an angular velocity of 45.0 rev min^{-1} in 1.60s. What is its average angular acceleration?

$$\text{Given data}: \omega i = 0,\ \omega_f = 45\,\text{rev/min} = 45*2\pi\pi/6 = 1.5\pi\ \text{rad/sec},\ t = 1.60\,\text{sec},\ \alpha = ?$$

$$\alpha = \frac{\omega_f - \omega i}{t} = \frac{1.5\pi - 0}{1.6} = 2.95\text{rad s}^{-2}$$

5.3: A body of moment of inertia $I = 0.80\ kg\,m^2$ **about a fixed axis, rotates with a constant angular velocity** $100\ rad\ s^{-1}$**. Calculate its angular momentum L and the torque to sustain this motion.**

$$\text{Given Data}: I = 0.80\,\text{kgm}^2,\ \omega = 100\,\text{rads}^{-1},\ \alpha = 0,\ L = ?\ \tau = ?$$

$$L = I\omega = 0.80*100 = 80\text{Js},\ \tau = I\alpha = I(0) = 0$$

5.4: Consider the rotating cylinder shown in fig. 5.26. Suppose that m=5.0 kg, F=0.60 N and r=0.20 m. Calculate (a) the torque acting on the cylinder, (b) the angular acceleration of the cylinder. (Moment of inertia of cylinder $= \frac{1}{2}mr^2$**).**

$$\text{Given data}: m = 5\text{kg},\ F = 060\ \text{N},\ r = 0.2\,\text{m},\ \theta = 90^o,\ \tau = ?,\ \alpha = 0$$

$$\tau = rF\sin\theta = 0.2*0.6*\sin90^o = 0.12\text{Nm},\quad I = 1/2mr^2 = 1/2*5(0.2)^2 = 0.1\text{kgm}^2$$

$$\text{As}\tau = I\alpha \Rightarrow \alpha = \frac{\tau}{I} = \frac{0.12}{0.1} = 1.2\text{rads}^{-2}$$

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5.5: Calculate the angular momentum of a star of mass $2.0\times10^{30}kg$ and radius $7.0\times10^{5}km$. If it makes one complete rotation about its axis once in 20 days, what is its kinetic energy?

Given Data : $m = 2*10^{30}$ kg, $r = 7*10^{5}$ km $= 7*10^{5}*10^{3}$ m $= 7*10^{8}$ m,

$T = 20\,\text{days} = 20*24*60*60 = 1.728*10^{6}\,\text{sec}$ Angular momentum = L = ?, K.E = ?

$$L = I\omega = \frac{2}{5}mr^2\frac{2\pi}{T} = \frac{2}{5}(2*10^{30})(7*10^{8})^2\frac{2*3.14}{1.728*10^{6}} = 1.42*10^{42}\,Js$$

$$K.E = \frac{1}{2}I\omega^2 = \frac{1}{2}\frac{2}{5}mr^2(\frac{2\pi}{T})^2 = \frac{1}{5}(2*10^{30})(7*10^{8})^2\left(\frac{2*3.14}{1.728*10^{6}}\right)^2 = 2.5*10^{36}\,J$$

5.6: A 1000 kg car travelling with a speed of 144km h^{-1} round a curve of radius 100m. Find the necessary centripetal force.

Given Data : $m = 1000$kg, $v = 144$ km/h $= 144*1000/3600 = 40$ m/s, $r = 100$ m, $F_c = ?$

$$F_c = \frac{mv^2}{r} = \frac{(1000)(40)^2}{100} = 16000N = 1.6*10^{4}\,N$$

5.7: What is the least speed at which an aeroplane can execute a vertical loop of 1.0km radius so that there will be no tendency for the pilot to fall down at the highest point?

Given Data : $R = 1000$m, $v = ?$ $g = 9.8\,ms^{-2}$

$$v = \sqrt{gR} = \sqrt{9.8*1000} = 99m/s$$

5.8: The Moon orbits the Earth so that the same side always faces the Earth. Determine the ratio of its spin angular momentum (about its own axis) and its orbital angular momentum. (In this case, treat the Moon as a particle orbiting the Earth). Distance between the Earth and the Moon is $3.85\times10^{8}m$. Radius of the Moon is $1.74\times10^{6}m$.

Given data : Radius of moon $= r_m = 1.74*10^{6}$ m, Distance b/w Earth and moon $= r = 3.85*10^{8}$ m

$$\frac{Ls}{Lo} = \frac{\frac{2}{5}mr^2{}_m\omega^2}{mr^2\omega^2} = \frac{2r^2{}_m}{5r^2} = \frac{2(1.74*10^{6})^2}{5(3.85*10^{8})^2} = 8.17*10^{-6}$$

5.9: The Earth rotates on its once a day. Suppose, by some process the Earth contracts so that its radius is only half as large as at present. How fast will it be rotating then? (For sphere $I = \frac{2}{5}MR^2$).

Given Data : $T_1 = 1\,\text{day} = 24\,\text{hour}$, $T_2 = ?$ if radius of earth becomes half of present.

Using law of conservation of angular momentum $I_1\omega_1 = I_2\omega_2 \Rightarrow \frac{2}{5}mR_1^2*\frac{2\pi}{T_1} = \frac{2}{5}mR_2^2*\frac{2\pi}{T_2}$

$$R_1^2*\frac{1}{T_1} = (R_1/2)^2*\frac{1}{T_2} \Rightarrow \frac{R_1^2}{T_1} = \frac{R_1^2}{4T_2} \Rightarrow 4T_2 = T_1 \Rightarrow T_2 = \frac{T_1}{4} = \frac{24}{4} = 6\,\text{hour}$$

5.10: What should be the orbiting speed to launch a satellite in a circular orbit 900 km above the surface of the Earth? (Take mass of the Earth as 6.0×10^{24} and its radius as 6400 km).

Given Data : $M = 6*1024$ kg, $R = 6400$Km, $h = 900$km, $r = 600 + 900 = 7300$Km, $v = ?$

$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{6.673*10^{-11}*6*10^{24}}{7300*10^{3}}} = 7.4*10^{3}m/s = 7.4Km/s$$

TID BITS/ USEFUL INFORMATION

MCQS

1) As the wheel turns through an angle, it lays out a ----distance S=rθ

Circular	**Tangential**	Linear	Angular

2) Which are needed for turn that taken so quickly that friction alone cannot provide energy for centripetal force

Banked tracked	Linear track	Circular track	None

3) Curved flight at high speed requires a --- centripetal force that make the stunt dangerous even if the air planes are not so close

Small	**Large**	Zero	Maximum

4) Two cylinders of equal mass, which mass has greater rotational inertia?

Smaller diameter	**Larger diameter**	Both have equal diameter	None

5) As the sphere rolls to the bottom of inclided surface, its gravitational potential energy is changed to

Kinetic energy of rotation	Kinetic energy of translation	**Both A&B**	None

6) As the wheel rolls, it has

Translational K.E	Rotational K.E	**Both A&B**	None

7) Global positioning system tracked immediately the ---when switch on mobile phone

Time	**Location**	Both A&B	None

8) Your apparent weight differ from your true weight when the velocity elevator changes

At the start	At the end	**Both A&B**	None

9) Which satellite is first human satellite of Earth

Bruce McCandless	Hawaii	Island	None

10) When Hawaii island stepped into space the first human satellite

1987	1985	**1984**	1986

11) First human satellite was above the height of Hawaii island

100 km	200 km	300 km	400 km

12) Bruce McCandless have speed

290 km/h	29000 km/h	2900 km/h	29 km/h

13) The surface of rotating spaceship pushes on an object with which it is in contact provides—to keep object moving on a circular path

Linear force	**Centripetal force**	Angular motion	None

14) 1GHz=?

10^6 Hz	**10^9 Hz**	10^{12} Hz	10^{15} Hz

15) Which can bend light

Mass	**Gravity**	Acceleration	All of these

16) --- could be used to focus light from stars

Gravity of star	Mass of star	Radius of star	Atmosphere of star

17) Coasting rotating system slows down as water drip into beaker in order to conserve?

Momentum	**Angular momentum**	Mass	Torque

PAST PAPERS SOLVED MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	SI unit for angular displacement is	Meter	Degree	Revolution	**Radian**
ii.	A satellite moving around the earth makes	**Inertial frame of reference**	Non inertial frame of reference	Both A&B	None of these
iii.	The angular velocity of minute hand of a clock is	2π rad/s	π rad/sec	π/60 rad/s	**π/1800 rad/s**

$$\omega = \frac{\theta}{t} = \frac{2\pi\,\text{rad}}{3600\,\text{sec}} = \frac{\pi}{1800}\,rad/\text{sec}$$

iv.	The period of revolution for geostationary satellite is	84 sec	84 min	84 hour	**24 hour or 1 day**
v.	The force which do not work on the body on which it acts is	Elastic force	Frictional force	Gravitational force	**Centripetal force**
vi.	The angular momentum L is given by	**mxW**	**rxP**	Mv	None of these
vii.	Minimum number of geostationary satellite to cover whole of the world	2	**3**	4	5
viii.	When a body moves in circle then angle between linear and angular velocity	**90˚**	0˚	180˚	45˚
ix.	One geostationary satellite coves the longitude of	90˚	**120˚**	180˚	45˚
x.	The light from stars can be focused by their	Mass	Distance	Radius	**Gravity**
xi.	If angular velocity of rotating body in circle is doubled then moment of inertia	**Remains same**	Becomes half	Becomes double	Becomes four times
xii.	Rotational kinetic energy for disc is given by	**¼ mv^2**	½ mv^2	1/3 mv^2	1/5mv^2
xiii.	Largest satellite system is managed by the countries	24	**126**	200	3
xiv.	If a gymnastic sitting on stool with his arms stretched out lowers his arms	Angular speed decreases	**Angular speed increases**	Both inertial and non-inertia	Neither inertia nor non inertial
xv.	SI unit of angular velocity is	m/s	Radian	**Radian/sec**	Joule second
xvi.	Angular speed of daily rotation of earth is given by	2π	π	4π	**$7.3*10^5$ rad/sec**
$\theta = \text{wt}, \text{w} = \frac{\theta}{\text{t}} = \frac{2\pi rad}{1day} = \frac{2\pi}{86400\sec} rad = 7.3*10^5 rad/s$					
xvii.	When torque acting on a system is zero then which of the following quantity remains same	Linear momentum	Force	**Angular momentum**	Impulse
xviii.	Centripetal force performs work	Maximum	**Zero**	Minimum	Negative
xix.	A diver spin faster by reducing its	Torque	Angular momentum	**Moment of inertia**	Inertia
xx.	Linear acceleration is	r times linear acceleration	**r times angular acceleration**	r times speed	None of these
xxi.	When happened to moment of inertia of thin rod if its length is doubled ?	1/12 ML^2	**1/3ML^2**	2/5 ML^2	ML^2
xxii.	The expression for spinning frequency to create artificial gravity in satellite is given by	$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$	$f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$	$f = \frac{1}{2\pi}\sqrt{\frac{m}{R}}$	None of these
xxiii.	As the wheel turns out, it cover	Radial distance	**Tangential distance**	Circular distance	Straight distance
xxiv.	SI unit of rotational kinetic energy is	Rad/Sec	Js	**J**	Kgm2
xxv.	20 N centripetal force move a body circle of radius 1m, work done by it	10 J	50 J	**0 J**	100 J
xxvi.	The SI unit of angular momentum is	**JS**	Ns	Joule	Newton
xxvii.	Which theory is better about gravitation?	**Einstein**	Newton	Plank	Michelson
xviii.	The direction of angular velocity is given by	Left hand rule	Head to tail rule	**Right hand rule**	General rule
xxix.	Dimension of angular momentum is	$[MLT^{-1}]$	**$[ML^{-2}T^{-1}]$**	$ML^2T]$	None of these
xxx.	The dimension of angular acceleration	$[T^{-1}]$	**$[T^{-2}]$**	$[LT^{-2}]$	$[LT^{-1}]$
xxxi.	A man standing in an elevator is acted upon	One force	**Two force**	Three forces	Four forces

xxxii.	The time period of artificial satellite is given by	T=1/f	$T=\frac{2\pi R}{v}$	$T=\sqrt{GM/R}$	$v=\sqrt{gR}$
xxiii.	If a body is at rest or moving with uniform angular velocity then torque will be	**Zero**	Minimum	Maximum	None of these
xxiv.	A man of weight w is standing on an elevator which is ascending with acceleration a the apparent weight of the man	**W+ma**	W-ma	W	Ma
xxxv.	Rotational kinetic energy of a hoop moving down frictionless inclined plane with velocity v	**½ mv^2**	¼ mv^2	¾ mv^2	Mv^2
xxvi.	Rotational kinetic energy K.Erot=?	**½ mr^2w^2**	½ mr^2w	½ mrw	1/2mrw^2
xxvii.	The weight of man in an elevator moving with acceleration g will be	Half	Double	Four times	**Zero**
xviii.	According to Einstein space time is	Linear	**Curved**	Circular	Elliptical
xxix.	Rotational inertia of two equal masses cylinder but one has larger diameter will be	Lesser	**Larger**	Same	None of these
xl.	A ball tied to the end of a string is swing in vertical circle under the action of gravity tension in string when ball is maximum height	Equal to centripetal force	**Zero**	Equal to weight of ball	Maximum
xli.	A body of mass 8kg moves along a circle of radius 4m with constant speed of 8m/s , the centripetal force on the body is	48N	8N	**128N**	72N
	Put m=8kg, r=4m, v=8 m/s in formula of centripetal force $Fc=mv^2/r$				
xlii.	Two cylinder of same mass but different diameter are	Same I	**I is larger for larger diameter**	I is smaller for larger diameter	Depends upon angular velocity
xliii.	The angle subtended at the centre by circumference of the circle whose arc length is equal to radius	Π radian	3	2π radian	**Radian**
xliv.	The minimum velocity necessary to put a satellite into orbit is	7.1 Km/s	7.3 Km/s	**7.9Km/s**	8.9 Km/s
xlv.	Angular acceleration is produced by	Momentum	**Torque**	Pressure	Power
xlvi.	SI unit of angular momentum are JS they can also be expressed as	Kgm/s	**Kgm^2/S**	Kgm^2s^{-2}	$Kgm^{-2}s^{-1}$
xlvii.	A particle is moving in circle with constant speed, the direction of centripetal force will be	Along the tangent	**Along radius towards centre**	Along radius away from the centre	Changing with the motion
xlviii.	A 100 kg man is standing in an elevator, which accidently falls freely. What will be the weight of the person in the freely falling elevator (take g=10 m/s_2)	1000 N	500 N	10 N	**Zero** Due to free fall weightlessness condition occur so apparent will be equal to zero
xlix.	The weight of man in an elevator descending with an acceleration 4.9m/s^2 will	Twice	**Half**	Zero	Unchanged
l.	Which is unimportant in describing the satellite orbit	Distance from earth centre	Gravitation constant	**Mass of satellite**	Mass of earth
li.	1 revolution is equal to	57.3^o	180^o	**360^o**	90^o
lii.	Which is larger for a hoop of mass M and radius R that is rolling without	Translational kinetic energy	Rotational kinetic energy	**Both are same**	Answer depends upon the radius

	slipping, its translational or rotational kinetic energy?				
liii.	The direction of angular momentum of a body moving in a circle is	Along the tangent	**Perpendicular to the plane of circle**	Radially outward	Radially inward
liv.	The counter part of force for rotational motion is called	Linear momentum	Angular momentum	Angular acceleration	**The torque**
lv.	A man in an elevator descending with an acceleration will conclude that his weight has	Increased	**Decreased**	Reduced to zero	Not changed
lvi.	Moment of inertia of 100 kg sphere of radius 50cm will be	**10 kgm^2**	5 kgm^2	500kgm^2	2.5 kgm^2
$I=2/5\ mr^2=2/5*100(50/100)^2=2/5*(100)*(1/4)=10kgm^2$					
lvii.	The apparent weight of a man in an ascending lift moving with acceleration "a"	**Increase**	Decrease	Remains constant	Becomes zero
lviii.	A body rotates with constant angular velocity of 100 rad/sec about a vertical axis, the required torque to sustain motion	**Zero Nm**	10 Nm	100 Nm	50 Nm
lix.	The ratio of moment of inertia of disc and hoop is	¼	**2/4=1:2**	¾	4/4
$I_{disc}=1/2\ mr^2\ I_{hoop}=mr^2$ dividing to get the result					
lx.	The velocity of stone whirled in a circle increase from 10 rev/min to 20 rev/min it has	Centripetal acceleration	**Centrifugal acceleration**	Tangential acceleration	No acceleration
lxi.	Velocity of hoop V_h and velocity of sphere Vs are related by	$V_h>Vs$	**$V_h<Vs$**	$V_h=Vs$	$V_h=2Vs$
lxii.	Ratio of moment of inertia of two objects 'A' and 'B' is 2:3. Which one of the following is the ratio of torques of 'A' and 'B' respectively, if both are being rotated with constant angular acceleration?	3:4	3:2	**2:3** Torque=Iα For constant α torque is proportional to I. so same ratio occur	4:3
lxiii.	A wheel of radius 50cm having angular speed of 5 rad/sec will linear speed in m/s is	1.5	**2.5**	3.5	4.5
As r=50cm=50/100=0.5m V=rw=0.5*5=2.5					
lxiv.	When a diver change his position during jumping, which of the following quantities remains constant?	Moment of inertia	**Angular momentum**	Angular velocity	Linear momentum
lxv.	A body is moving in a circle under centripetal force F, if its linear velocity and radius both are made twice, the centripetal force will be	Fs	Fs/2	**$2F_s$**	4Fs
As centripetal force is directly proportional to square of velocity and inversely to radius					
lxvi.	The angular displacement of one revolution is equal to	1 radian	π/2 radian	Π radian	**2π radian**
lxvii.	INTELSAT operates at microwaves frequencies of	4,6,8 and 10 Hz	4,6,8,10 MHz	4,6,8,12 Hz	**4,8,11,14 GHz**
xviii.	When a body is whirled in a horizontal circle by means of a string, the centripetal force is supplied by	Mass of body	Velocity of body	**Tension in string**	Centripetal acceleration
lxix.	If a car moves with uniform speed of 2m/s in a circle of radius 0.4m its angular speed is	4 rad/sec	**5 rad/sec**	1.6 rad/sec	2.8 rad/sec

V=rw w=v/r= 2/0.4=5					
lxx.	Weight of a 60kg man in moving elevator(downward) with constant acceleration g/2(g=10 m/s^2)	Zero	**300N**	600N	200N
T=w-ma=mg-mg/2=mg/2=60*10/2=600/2=300 N					
lxxi.	The ratio of orbital velocity to escape velocity is	1	1/2	$1/\sqrt{2}$	$\sqrt{2}$
as $Vesc = \sqrt{\frac{2GM}{R}}$ and $Vo = \sqrt{\frac{GM}{R}}$ dividing both eq to get the result					
lxxii.	One radian is equal to	**1/2π rev**	Π rev	π/2revolution	360 rev
1 rev=2π radian. 1radian=above result					
xxiii.	If m=100kg, r=50cm then moment of inertia	**25kgm^2**	50 kgm^2	500kgm^2	5000 kgm^2
As m=100kg, r=50cm=50/100=0.5m I=mr^2= 100*0.5^2=100*0.025=25					
xxiv.	36^o is equal to	π/8	π/6	**π/5**	π/12
To convert into radian multiply by π/180, 36*π/180=π/5					
lxxv.	Centripetal acceleration is also called	Tangential Acceleration	**Radial Acceleration**	Angular Acceleration	Rotational Acceleration
xxvi.	Weight of a body at the center of earth is	Maximum	Minimum	**Zero**	Infinite
xxvii.	Satellite are the objects that orbit around the	Moon	Sun	**Earth**	Star
xviii.	A body moves in a circle with increasing angular velocity, at time't'= 6s the angular velocity is 27rad/s... What is the radius of circle where linear velocity is 81cm/s	6cm	7cm	9cm	**3cm** V=rw r=v/w 81/27=3
xxix.	A wheel of radius 1 m covers an angular displacement of 180°. Its linear displacement is	3.14 m	6.28 m	**π rad** 180=π rad S=rθ	0.157 m
lxxx.	If linear velocity and radius are both made to half of a body moving around a circle, the centripetal force becomes	F	$\frac{F}{2}$	$\frac{F}{4}$	2F
As Centripetal force is directly to square of velocity and inversely to radius so, Fc=m(v/2)^2/(r/2)=1/2(mv^2/r)=F/2					
xxxi.	A man of mass 5kg is falling freely, the force acting on it will be	5 N	9.8 N	19.6 N	**Zero**
xxxii.	A disc at rest without slipping, rolls down a hill of height (3 x9.8) m. What is its speed in m/sec when it reaches at the bottom?	11.4	22.8	**19.6**	9.8
apply disc formula $= v\sqrt{\frac{4gh}{3}} = \sqrt{\frac{4g*(3*9.8)}{3}} = \sqrt{4*9.8*9.8} = 19.6$					
xxiii.	A body is having weight 20 N, when the elevator is descended with a =0.1 ms-2, then the value of tension 'T' is:	196 N	1.98 N	**19.8 N**	2 N
$w = mg = 20, m = 2kg,, soT = w - ma = 20 - 2*0.1 = 20 - 0.2 = 19.8N$					
xxiv.	Si unit of angular momentum is given by	J/S^2	**Js**	J/S	Jm
xxxv.	1 rev/min is equal to	$\frac{\pi}{6} rads^{-1}$	$\frac{\pi}{15} rads^{-1}$	$\frac{\pi}{20} rads^{-1}$	$\frac{\pi}{30} rads^{-1}$
1rev=2π rad, 1min=60sec, w=2π rad/60sec= π/30 rad/sec					

xxvi.	Which one of the following is not directed along the axis of rotation?	Angular acceleration	Angular momentum	**Centripetal acceleration**	Angular displacement
xxvii.	If a body revolves under centripetal force, its angular acceleration is	Non zero	Variable	**Zero**	Increasing
xviii.	A wheel of diameter 1m makes 60 rev/min. the linear speed of point in m/s	π	2π	$\pi/2$	3π
$d = 1m, r = d/2 = 1/2 = 0.5m, w = 60 * 2\pi$ rad/60sec $= 2\pi \Rightarrow v = rw = 0.5 * 2\pi = \pi$					
xxix.	The diver spins faster when moment of inertia becomes	Greater	**Smaller**	Constant	None of these
xc.	Direction of angular acceleration is always along	X-axis	**Axis of rotation**	Y axis	Z axis
xci.	A body starting from rest attains angular acceleration of 5 rad/s^2 in 2 sec, find angular velocity	14 rad/s	**10 rad/s**	3 rad/s	2 rad/s
$\alpha = \Delta\omega / t \Rightarrow \Delta\omega = \alpha * t = 5 * 2 = 10$					
xcii.	The angular version of F=ma is	$\tau = Iw$	$\tau = I\alpha$	$I = \tau\alpha$	$F = mv/t$
xciii.	In angular motion, the centripetal force Fc is	mr^2w	mr^2w^2	**mrw^2**	r^2w^2
xciv.	When a lift is accelerated upward, the apparent weight of an object in it will be	Equal to its real weight	Zero	Less than its real weight	**Greater than its real weight**
xcv.	All points on a rigid body rotating about a fixed axis do not have same	**Speed**	Angular speed	Angular acceleration	Angular displacement
xcvi.	Radian is a unit of angular displacement which can also be measured in degrees. How many radians are equal to one degree?	$\frac{180}{\pi}$	$\frac{2\pi}{180}$	$\frac{\pi}{180}$	$\frac{\pi}{57.3}$
2π rad $= 360^o, 1^o = \frac{2\pi}{360} = \frac{\pi}{180}$					
xcvii.	Linear velocity or tangential velocity of any particle moving in a circular path of radius 2 m with angular velocity 8 rads^{-1} will be:	**16 ms^{-1}**	10 ms^{-1}	4 ms^{-1}	6 ms^{-1}
V=rw=2*8=16 m/s					
cviii.	Moment of inertia of a solid sphere is	½ M^2r	Mr^2	**2/5 Mr^2**	Mr
xcix.	Two cylinders of equal mass are made from same material. The one with the larger diameter accelerates _____ the other under the action of same torque	**Faster than**	Equal to.	Slower than	None of these.
Acceleration is related to diameter of mass as acceleration is more for more diameter					
c.	The value of 2 radian	57.3^o	180^o	**114.6^o**	90^o
1radian=57.3°, 2radian=2*57.3°=114.6°					
ci.	Close orbiting satellite orbit the earth at a height of	**400 Km**	4000Km	400m	400cm
cii.	In rotational motion, torque is equal to the rate of change of	**angular momentum**	Angular velocity	Linear momentum	Angular acceleration
As force is equal to rate of change of momentum so its analogues is					
ciii.	An elevator is moving upwards with constant velocity of 'v'. What is a weight of a person of a mass 'm' inside the elevator during upward motion?	mg + mv	mg — mv	**mg** as T=W+ma a is zero so T=W=mg	zero
civ.	An object of mass 'm' is suspended in an elevator moving downward with acceleration equal to acceleration due to gravity. What is the apparent weight of object?	**Zero** Due to free fall weightlessness	mg	2mg	mg/2

cv.	Speed of moon around the Earth is	**1000 m/s**	1100 m/s	1200 m/s	1300 m/s
cvi.	The ratio of velocity of disc to velocity of hoop is	$\frac{2}{\sqrt{3}}$	$\frac{4}{\sqrt{3}}$	$\frac{2}{3}$	$\frac{\sqrt{4}}{3}$
cvii.	In dryer, water is pushed out of wet clothes due to	Retarding force	Abundance of centripetal force	**Lack of centripetal force**	Friction
cviii.	Due to some mechanical fault, a lift falls freely from the top of a multistory building. Which of the followings is the apparent weight of a man inside the lift, if mass of man is 80 kg while value of 'g' is 10 ms^{-2}?	**Zero** Due to free fall weightlessness condition occur so apparent will be equal to zero	mg	2mg	mg/2
cix.	The relation between escape velocity and orbital velocity is	Vesc=1/2 Vo	$Vesc = \sqrt{2}Vo$	Vesc=Vo	Vesc=2Vo
as $Vesc = \sqrt{\frac{2GM}{R}}$ and $Vo = \sqrt{\frac{GM}{R}}$ dividing both eq to get the result					
cx.	The law of gravitation was introduced by	Huygen	Boyle	**Newton**	Pascal
cxi.	Angular momentum of rigid body	I^2w	Iw^2	**Iw**	I^2w^2
cxii.	If the body is rotating with uniform angular velocity, then its torque is	**Zero**	Maximum	Clockwise	Remains the same
When uniform angular velocity then angular acceleration is zero so torque=Iα=0					
cxiii.	A man in a lift moving upward with constant velocity will conclude that his weight has	Increased	Decreased	Reduced to zero	**Not changed**
cxiv.	One degree is equal to	$\frac{2\pi}{260} rad$	$\frac{2\pi}{180} rad$	$\frac{\pi}{180} rad$	$\frac{\pi}{360} rad$
As 2π radian=360°, 1°=2π/360 r= π/180					
cxv.	The apparent weight of man moving upward with acceleration g is	mg	**2mg**	Zero	½ mg
cxvi.	The rate of change of angular momentum is equal to	Applied force	**Applied torque**	Acceleration	Momentum
cxvii.	A body of mass 2kg is suspended from the ceiling of an elevator moving up with an acceleration g, its apparent weight in elevator is	0	**39.2 N**	9.8 N	19.6 N
T=W+ mg=mg + mg=2mg=2*2*9.8=39.2 N					
xviii.	Height of geostationary satellite from Earth surface	42300 Km	900 km	**36000 km**	400 km
cxix.	What is torque 'τ' in a circular motion?	$\tau = mr^2\pi$	$\tau = mr\alpha$	**$\tau = mr^2\alpha$**	$\tau = mr^2/\alpha$
cxx.	If $\omega = 60$ rev min^{-1} is equal to	π rad/sec	2π rad/sec	$\frac{1}{\pi}$ rad/sec	$\frac{2}{\pi}$ rad/sec
As 1rev=2π rad, 1min=60sec, w=60*2π rad/60sec= 2π rad/sec					

Note: Errors and omissions are accepted.

Give your suggestions to improve these notes.

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Al-Abbas Notes Physics 1st year

(Volume-2 chapter 06 to 11)

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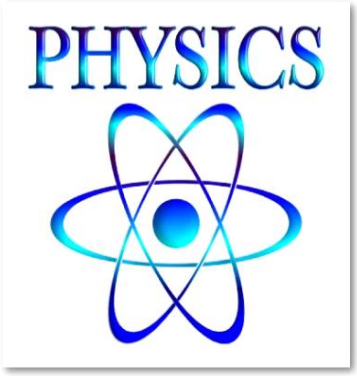

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CHAPTER 06 FLUID DYNAMICS

Fluid: Any substance that can flow from one place to other place is called fluid. e.g water, honey. Fluid is combination of liquid and gases.

Fluid statics: The branch of Physics which deals with the study of fluid at the state of rest is called Electrostatics. Fluid statics is based upon Newton's first and third law.

Fluid dynamics: The branch of Physics which deals with study of fluids in motion is called Fluid dynamics.

A fluid is studied on the basis of (1) Law of conservation of mass (Eq. of continuity) (2) Law of conservation of energy (Bernoulli eq).

What is Viscous drag and Stokes law

What is Viscosity? Write formula and unit. Frictional force effect b/w different layers of flowing fluid is called viscosity. Its SI unit is $kgm^{-1}s^{-1}$ and its dimension is $[ML^{-1}T^{-1}]$. Co-efficient of viscosity is denoted by symbol η from stokes law **F=6πηrv.**

The fluids which can flow easily have small co-efficient of viscosity. For example air, water etc

The fluids which cannot flow easily have large co-efficient of viscosity. For example honey, tar etc.

What is the Effect of temperature on viscosity of liquid and gases?

Viscosity of gases increase with increase in temperature (due to random motion)

Viscosity of liquids decreases with increase of temperature.

What is Drag force? Upon which factors it depends?

An object moving through a fluid experiences a retarding force is called drag force. F=6πηrv

For example, when we switch our hand out of the window of a fast moving car, we feel a force opposite to our motion.

Factors upon which drag force depends: (1) speed of sphere (2) radius of sphere (3) viscosity of sphere.

State Stokes law. "Drag force acting on a sphere is equal to 6π time the product of co-efficient of viscosity, radius and fluid speed" $F = 6\pi\eta rv$. Stokes law is valid only for spherical bodies moving slowly. At high speed it is not valid.

What is Terminal velocity? Derive its relation. OR Prove that terminal velocity is directly proportional to the square of radius.

Terminal velocity: When the magnitude of drag force becomes equal to the weight of droplet, then it will start moving downward with constant and maximum velocity, this velocity is called terminal velocity. $V_t = \frac{2\rho g r^2}{9\eta}$.

Derivation: consider a droplet falling vertically downward under the influence of gravity and drag force. The drag force increases as the velocity of droplet increases. The net force on the droplet is

Net force = weight - drag force

$ma = mg - 6\pi\eta r v$

as the droplet moves with constant velocity so acceleration is zero so above eq becomes

$m(0) = mg - 6\pi\eta r v_t$

$mg = 6\pi\eta r v_t$

$v_t = \frac{mg}{6\pi\eta r}$ ----------(1)

now we have to find the value of m, as Density= mass/ volume

mass= Density x volume= $\varrho * 4/3\ \pi r^3$, putting in eq (1)

$$v_t = \frac{\rho * \frac{4}{3}\pi r^3 g}{6\pi\eta r} = \frac{\rho * 4\pi r^3 g}{18\pi\eta r}$$

$$v_t = \frac{2\rho g r^2}{9\eta}$$

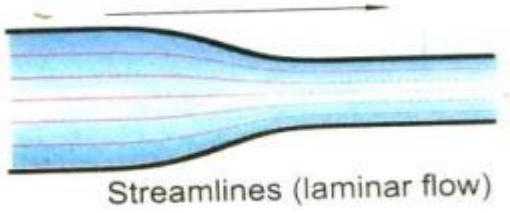
$$\frac{2\rho g}{9\eta} = \text{Constant}$$

$$v_t = Constant\ r^2$$

$$v_t \propto r^2,$$

This shows that terminal velocity is proportional to square of radius of droplet.

Difference b/w laminar and turbulent flow.

Laminar flow	Turbulent flow
The regular, steady and smooth flow of fluid is called laminar flow.	The irregular and unsteady flow of fluid is called turbulent flow.
Laminar flow usually occurs at slow speed	Turbulent flow usually occurs at very high speed
	

Steady flow condition: For steady flow, different streamline can never intersect each other, this is called steady flow condition.

Ideal fluid: A fluid which is non-viscous (no viscosity), incompressible (density is constant) and steady is called ideal fluid.

State and Explain Equation of continuity.

Statement: "For an ideal, the product of cross sectional area of pipe and fluid speed at any point along the pipe remains constant, this constant equals the volume flow per second of fluid or simply flow rate." $A_1v_1 = A_2v_2$

Derivation: Consider a fluid flowing through a pipe of non-uniform size. The particles in the fluid move along the streamline in steady state flow as shown in fig. In the small time Δt, the fluid at the lower end of the tube moves a distance Δx_1, with velocity v_1. If A1 is the area of cross section of this end,

Volume of fluid in lower side= $A_1\Delta x_1$

$$\text{As density of fluid} = \rho = \frac{\Delta m_1}{\text{Volume}} \Rightarrow \Delta m_1 = \rho V$$

$$\Delta m_1 = \rho_1 A_1 \Delta x_1$$

$$\text{As } S = vt \Rightarrow \Delta x_1 = v_1 \Delta t$$

$$\Delta m_1 = \rho_1 A_1 v_1 \Delta t \text{ ----------(1)}$$

similarly the fluid at the upper cross section of pipe

$$\Delta m_2 = \rho_2 A_2 v_2 \Delta t \text{ ----------(2)}$$

$$\text{As } \Delta m_1 = \Delta m_2$$

$$\rho_1 A_1 v_1 \Delta t = \rho_2 A_2 v_2 \Delta t$$

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2 \quad \text{As density is same so } \rho_1 = \rho_2 = \rho$$

$$\rho A_1 v_1 = \rho A_2 v_2$$

$A_1v_1 = A_2v_2 \Rightarrow Av = \text{constant}$..this is called volume flow rate whose unit is m^3/sec.

This is required Equation of continuity. This is according to law of conservation of mass.

State and Explain Bernoulli equation

Statement: For an incompressible, non-viscous fluid, sum of pressure, kinetic energy per unit volume and potential energy per unit volume remains constant. $P+\frac{1}{2}\rho v^2+\rho gh=\text{Constant}$. This is according to law of conservation of energy.

Explanation: let us consider the flow of incompressible and steady fluid through the pipe in time t.

Pressure on upper end of pipe $P_1=F_1/A_1$, the force on upper end= $F_1=P_1A_1$

The work done through $\Delta x_1 = W_1 = F_1\Delta x_1 = P_1A_1\Delta x_1$

similarly at lower end the work $= W_2 = -P_2A_2\Delta x_2$ (W_2 is taken as - ive as work is against the fluid force)

The net work done $= W = W_1 + W_2$

$W = (P_1A_1\Delta x_1) + (-P_2A_2\Delta x_2) = P_1A_1\Delta x_1 - P_2A_2\Delta x_2$

As According to Eq of continuity $A_1\Delta x_1 = A_2\Delta x_2 = V$

$W = P_1V - P_2V$

$W = (P_1 - P_2)V$ ----------(1)

As $V = m/\rho$ put in above $W = (P_1 - P_2)m/\rho$ ---------(A)

As part of this work is stored in form of potential and part in form of Kinetic energy so,

$W = \Delta K.E + \Delta P.E$ ----------(2)

$\Delta K.E = K.E_f - K.E_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$ ----------(B)

$\Delta P.E = P.E_f - P.E_i = mgh_2 - mgh_1$ ----------(C),

putting the value of (A), (B) and (C) in equation (2)

$(P_1 - P_2)m/\rho = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_2 - mgh_1$

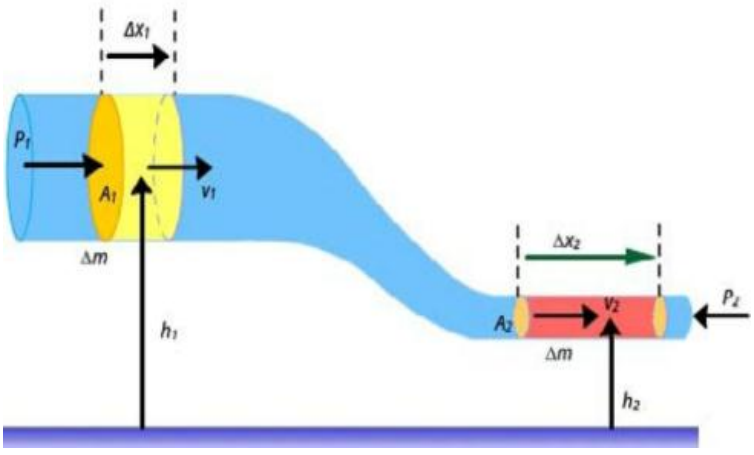
$(P_1 - P_2)m/\rho = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgh_2 - mgh_1$

$(P_1 - P_2)m/\rho = m(\frac{1}{2}v_f^2 - \frac{1}{2}v_i^2 + gh_2 - gh_1)$

$(P_1 - P_2)1/\rho = (\frac{1}{2}v_f^2 - \frac{1}{2}v_i^2 + gh_2 - gh_1)$

$(P_1 - P_2) = (\frac{1}{2}\rho v_f^2 - \frac{1}{2}\rho v_i^2 + \rho gh_2 - \rho gh_1)$

$P_1 + \frac{1}{2}\rho v_i^2 + \rho gh_1 = P_2 + \frac{1}{2}\rho v_f^2 + \rho gh_2$



$P+\frac{1}{2}\rho v^2+\rho gh=\text{Constant}$, This is required Bernoulli equation

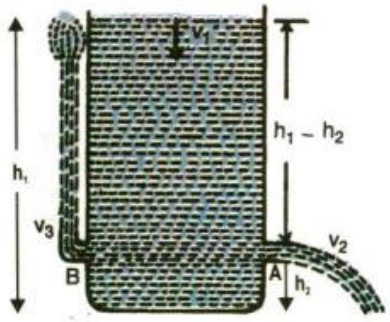
State and prove Torricelli theorem

Statement: "Speed of efflux is equal to the velocity gained by the fluid in falling through distance (h_1-h_2) under the action of gravity" $v = \sqrt{2g(h_1 - h_2)}$.

Proof: Let us consider a large tank of fluid has two orifices A and B on it as shown in fig. to the find the speed the speed with which the water flow from A, speed v_1 is so small approximate zero. Using Bernoulli equation

$$P_1 + \frac{1}{2}\rho v_1^{\,2} + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^{\,2} + \rho g h_2$$

$$P_1 = P_2 = P = \text{Atmospheric pressure}, v_1 = 0 \Rightarrow P + \frac{1}{2}\rho(0)_1^{\,2} + \rho g h_1 = P + \frac{1}{2}\rho v_2^{\,2} + \rho g h_2$$



$$\rho g h_1 = \frac{1}{2}\rho v_2^{\,2} + \rho g h_2$$

$$\frac{1}{2}\rho v_2^{\,2} = \rho g h_2 - \rho g h_1 = \rho g(h_2 - h_1)$$

$$v_2^{\,2} = 2g(h_2 - h_1)$$

$$v_2 = \sqrt{2g(h_2 - h_1)},\ \text{This is called Torricelli Theorem}$$

What is Relation b/w pressure and speed of fluid

Statement: "Where the speed is high, pressure will be low"

Let us consider water flows through a pipe as system , the water will flow faster at B , than does at A or C. let suppose speed=v_1=0.20 m/s, v_2= 2m/s, so we can compare pressure at A and B and having same P.E, so

$$P_1 - P_2 = \frac{1}{2}\rho(v_2^{\,2} - v_1^{\,2})$$

$$P_1 - P_2 = \frac{1}{2} * 1000 * (2^2 - (0.2)^2)$$

$$P_1 - P_2 = 1980\text{pa}, \text{This show that pressure is high where speed is low}$$

What is Dynamic lift in aero plane?

It is produced due to the effect, where the speed of fluid is high, its pressure will be low because when air moves faster at upper side of wing than lower side pressure is lower at the top of wind so the wing feels a net upward force.

How Perfume bottle works?

A stream of air passing over a tube dipped in a liquid will cause the liquid to rise in tube. This effect is used in perfume bottles and pain sprayers.

Why the chimney works best when it is tall?

Chimney works best when it is tall and exposed to air currents which reduces the pressure at the pressure at the top and force the flow of smoke.

Swing of fast moving cricket ball

The velocity of the air on one side of the ball increases due to spin and air speed in the same direction and so pressure decreases. This gives swing to the ball.

What is Venture meter? Give its principle

Definition: A device which measures the fluid speed is called venture meter

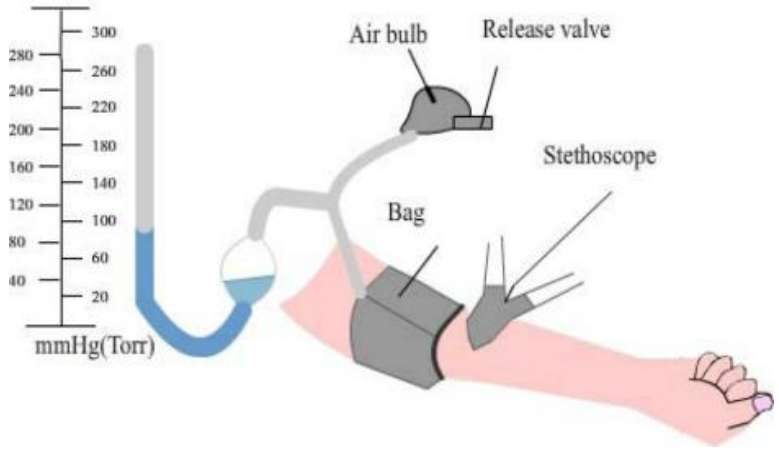
Its working principle is venture relation. $P_1 - P_2 = \frac{1}{2}\rho v^2$

Briefly describe about Blood flow

- Blood is incompressible fluid. Density of blood is nearly equal to water.
- Viscosity of blood increase 3 to 5 times that of water.
- High concentration of red blood cells is 50%.
- The pressure exerted by circulation of blood on the walls of the blood vessels is called blood pressure
- High blood pressure is systolic and low blood pressure is diasystolic.
- Systolic Bp is 120 torr and diastolic pressure is 75-80 torr.
- Blood pressure is measured in torr or mm of Hg. 1 torr= 133.3 Nm^{-2}.
- Blood pressure is measured by an instrument which is called sphygmomanometer.

How blood pressure is measured?

- An inflatable bag is wound around the arm of a patient and external pressure on the arm is increased by inflating the bag. This effect is to squeeze the arm and compress the blood vessels inside.
- When the external pressure applied becomes larger than the systolic pressure, the vessel collapse and flow of blood stop.
- By opening the release valve on the bag gradually decrease the pressure.
- A stethoscope detects the instant at which the external pressure becomes equal to systolic pressure. At this point the blood flow through it produce a high flow speed in turbulent flow
- As the pressure drops, the external pressure eventually equals the diastolic pressure, from this point, the vessel no longer collapse during any portion of the flow cycle. The flow switches from turbulent to laminar and gurgle in stethoscope disappears, this is the signal to record diastolic pressure.



Exercise short Questions chapter 06

Q.1 Explain what do you understand by the term viscosity?

Frictional effect b/w different layers of flowing fluid is called viscosity. Its SI unit is $kgm^{-1}s^{-1}$ and its dimension is $[ML^{-1}T^{-1}]$.

Q.2 What is meant by drag force? What are the factors upon which drag force acting upon a small sphere of radius r, moving down through liquid, depend?

"The retarding force experienced, when an object move through a fluid". According to Stoke's Law, the drag force, F is; $F = 6\pi\eta rv \Rightarrow$ F depends upon η = coefficient of viscosity, r = radius of the sphere v = speed of the sphere through the fluid.

Q.3 Why fog droplets appear to be suspended in air?

Due to drag force. As fog droplet falls, soon its weight becomes equal to the drag force. And net force becomes zero. So it appears to be suspended in air. Putting F=0 in equation to get the required equation

$F=\text{weight}-F_D \quad \ldots> \quad mg=6\pi\eta rv$

Q.4 Explain the difference between laminar flow and turbulent flow. The regular, steady and smooth flow of fluid is called laminar flow. The irregular and unsteady flow of fluid is called turbulent flow.

In laminar flow each particle of fluid moves along smooth path, in turbulent flow pattern is not smooth.

Q.5 State Bernoulli's relation to a liquid in motion and describe some of its applications.

For an incompressible, non-viscous fluid, sum of pressure, kinetic energy per unit volume and potential energy per unit volume remains constant.

$P + \frac{1}{2}\rho v^2 + \rho gh = \text{Constant}$. Its applications are Torricelli theorem, Venture relation, blood flow etc

Q.6 A person is standing near a fast moving train. Is there any danger that he will fall towards it?

Yes, He will fall towards the train. As the relative speed of air is high, the pressure will be low. So the greater air pressure behind the person will push him towards low pressure.

Q.7 Identify the correct answer. What do you infer from Bernoulli's theorem?

Where the speed of the fluid is high the pressure will be low.

Q.8 Two row boats moving parallel in the same direction are pulled towards each other. Explain.

Relative speed of water and air between the boats is high, the pressure will be low, so both boats pulled towards each other.

Q.9 Explain, how the swing is produced in a fast moving cricket ball.

The velocity of the air on one side of the ball increases due to spin and air speed in the same direction and so pressure decreases. This gives swing to the ball.

Q.10 Explain the working of a carburetor of a motor car using Bernoulli's principle.

"An apparatus used to charge air with gas from petrol for producing light or power" is called carburetor. Air is drawn outward through small pipe with a piston. High velocity of air produces low pressure. So petrol-air mixture is drawn inside.

Q.11 For which position will the maximum blood pressure in the body have the smallest value. (a) Standing up right (b) Sitting (c) Lying horizontally (d) Standing on one's head?

(c) Lying horizontally, position will have smallest value of maximum blood pressure in the body have the smallest value. In this position all parts of the body are nearly in level with the heart

Q.12 In an orbiting space station, would the blood pressure in major arteries in the leg ever be greater than the blood pressure in major arteries in the neck?

No. Due to lack of force of gravity, (as we use to experience on the earth) The blood pressure in major arteries in the leg will be equal than in arteries in the neck, due to weightlessness.

CHAPTER 06

6.1: Certain globular protein particle has a density of 1246 kgm^{-3}. It falls through pure water $\left(\eta = 8.0 \times 10^{-4}\, Nm^{-2}s\right)$ with a terminal speed of 3.0 cm h^{-1}. Find the radius of the particle.

$$\text{Given Data}: \text{Density} = \rho = 1246\text{kgm}^{-3}, \eta = 8*10-4Nm^{-2}s, v_t = \frac{3*10^{-2}m}{3600\text{sec}} = 8.33m/s, r = ?$$

$$\text{As we know that } v_t = \frac{2\rho gr^2}{9\eta} \Rightarrow r^2 = \frac{9\eta v_t}{2\rho g} \Rightarrow r = \sqrt{\frac{9\eta v_t}{2\rho g}} = \sqrt{\frac{9*8*10-4*8.33}{2*1246*9.8}} = 5*10^{-5}m.$$

6.2: Water flows through a house, whose internal diameter is 1cm at a speed of 1ms^{-1}. What should be the diameter of the nozzle if the water is to emerge at 21ms^{-1}?

$\text{Given Data}: d_1 = 1\text{cm} = 1*10^{-2}\,\text{m}, v_1 = 1\text{ms}^{-1}, v_2 = 21 ms^{-1}, d_2 = ?$

$\text{sol}: \text{Using } A_1v_1 = A_2v_2 \Rightarrow (\pi r_1^{\,2})v_1 = (\pi r_2^{\,2})v_2 \Rightarrow (d_1/2)^2 v_1 = (d_2/2)^2 v_2 \;\; (d_1)^2 v_1 = (d_2)^2 v_2 \Rightarrow$

$(d_2)^2 = \frac{v_1}{v_2}(d_1)^2 \Rightarrow d_2 = \sqrt{\frac{v_1}{v_2}(d_1)^2} = \sqrt{\frac{1}{21}(1*10^{-2})^2} = 0.002m$

6.3: The pipe near the lower end of a large water storage tank develops a small leak and a stream of water shoots from it. The top of water in the tank is 15m above the point of leak. (a) With what speed does the water rush from the hole? (b) If the hole has an area of 0.060 cm², how much water flows out in one second?

$\text{Given Data}: h = 15\text{m}, A = 0.06\text{cm}^2, v = ?, \text{water flow out in one sec} = ?$

$\text{sol}: v = \sqrt{2gh} = \sqrt{2*9.8*15} = 17.1\text{ms}^{-1} = 17.1*100 cms^{-1} = 1710 cms^{-1}$

$\text{volume flow out in one sec} = Av = 0.06\text{cm}^2 * 1710 cms^{-1} = 102\text{cm}^2$

6.4: What is flowing smoothly through a closed pipe system. At one point the speed of water is 3.0 ms^{-1}, while at another point 3.0m higher, the speed is 4.0 ms^{-1}. If the pressure is 80 kPa at the lower point, what is pressure at the upper point?

$\text{Given Data}: v_2 = 3\text{ms}^{-1}, v_1 = 4\text{ms}^{-1}, P_1 = 80*10^3\, pa, h_1 - h_2 = 3m, P_2 = ?$

$\text{sol}: \text{using Bernoulli eq, } P_1 + 1/2\rho v_1^{\,2} + \rho g h_1 = P_2 + 1/2\rho v_2^{\,2} + \rho g h_2$

$P_2 = P_1 + 1/2\rho(v_1^{\,2} - v_2^{\,2}) + \rho g(h_1 - h_2) = 80*10^3 + 1/2(10^3)(1000*9.8*3) = 47*10^3\, pa = 47 Kpa$

6.5: An airplane wing is designed so that when the speed of the air across the top of the wing is 450 ms^{-1}, the speed of air below the wing is 410ms^{-1}. What is the pressure difference between the top and bottom of the wings? (Density of air = 1.29kgm^{-3})

$\text{Given Data}: v_1 = 450\,\text{ms}^{-1}, v_2 = 410\,\text{ms}^{-1}, \rho = 1.29\text{kgm}^{-3}, P_2 - P_1 = ?$

$\text{sol}: \text{using } P_2 - P_1 = \frac{1}{2}\rho(v_1^{\,2} - v_2^{\,2}) = \frac{1}{2} * 1.29(450^2 - 410^2) = 22*10^3\, Pa = 22 KPa$

6.6: The radius of the aorta is about 1.0cm and the blood flowing through it has a speed of about 30 cms^{-1}. Calculate the average speed of the blood in the capillaries using the fact that although each capillary has a diameter of about , there are literally millions of them so that their total cross section is about 2000 cm².

$\text{Given Data}: r_1 = 1\text{cm}, A = \pi r_1^{\,2} = 3.14*1 = 3.14\text{cm}^2, v_1 = 30\text{cm/s}, A_2 = 2000\text{cm}^2$

$\text{Sol}: \text{Using } A_1v_1 = A_2v_2 \Rightarrow v_2 = \frac{A_1}{A_2}v_1 = \frac{3.14}{2000} * 30 = 4.7*10^{-2} cm/s = 4.7*10^{-4} m/s$

6.7: How large must a heating duct be if air moving 3.0ms^{-1} along it can replenish the air in a room of 300 m³ volume every 15min? Assume the air's density remains constant.

$\text{Given Data}: \text{speed} = v = 3\text{m/s}, \text{Volume} = V = 300\text{m}^3, t = 15\,\text{min} = 15*60 = 900\,\text{sec}, r = ?$

$\text{using}: Av = \text{volume/t} \Rightarrow \pi r^2 v = V/t \Rightarrow r^2 = V/\pi/\pi \Rightarrow r = \sqrt{V/\pi/\pi} = \sqrt{300/3.14*3*900} = 0.19m$

6.8: An airplane design calls for a "lift" due to the net force of the moving air on the wing of about 1000Nm^{-2} of wing area. Assume that air flows past the wing of an aircraft with streamline flow. If the speed of flow past the lower surface is 160ms^{-1}, what is the required speed over the upper surface to give a "lift" of 1000Nm^{-2}? The density of air is 1.29 Kgm-3 and assume maximum thickness of wing to be one metre.

$$\text{Given Data}: P_1 - P_2 = 1000 Nm^{-2}, v_1 = 160 ms^{-1}, \rho = 1.29 kgm^{-3}, v_2 = ?$$

$$\text{using } P_1 - P_2 = \frac{1}{2}\rho(v_2^{\,2} - v_1^{\,2}) \Rightarrow v_2 = \sqrt{\frac{2(P_1 - P_2)}{\rho} + v_1^{\,2}} = \sqrt{\frac{2(1000)}{1.29} + (160)^2} = 165 ms^{-1}$$

6.9: What gauge pressure is required in the city mains for a stream from a fire hose connected to the mains to reach a vertical height of 15.0m?

$$\text{Given data}: \text{height} = h = 15\text{m}, g = 9.8\ \text{ms}^{-2}, \rho = 1000\text{kgm}^{-3}, P_1 - P_2 = ?$$

$$\text{using Bernoulli equation } P_1 - P_2 = \rho g h = 1000 * 9.8 * 15 = 147 * 10^3\ pa = 147 KPa$$

TID BITS/ USEFUL INFORMATION OF TEXT BOOK

MCQS

1) Viscosity of air at 30° is ----------x10^{-3} Nsm^{-2}

0.019	0.295	0.510	0.564

2) Viscosity of acetone at 30° is ----------x10^{-3} Nsm^{-2}

0.019	0.295	0.510	0.564

3) Viscosity of methanol at 30° is ----------x10^{-3} Nsm^{-2}

0.019	0.295	**0.510**	0.564

4) Viscosity of benzene at 30° is ----------x10^{-3} Nsm^{-2}

0.019	0.295	0.510	**0.564**

5) Viscosity of water at 30° is ----------x10^{-3} Nsm^{-2}

0.801	1.000	1.6	6.29

6) Viscosity of ethanol at 30° is ----------x10^{-3} Nsm^{-2}

0.801	**1.000**	1.6	6.29

7) Viscosity of plasma at 30° is ----------x10^{-3} Nsm^{-2}

0.801	1.000	**1.6**	6.29

8) Viscosity of glycerin at 30° is ----------x10^{-3} Nsm^{-2}

0.801	1.000	1.6	**6.29**

9) Formula one racing car have a -----design

Streamlined	Circular	Elliptical	None

10) Dolphins have ------ bodies to assist their movement in water

Streamlined	Circular	Elliptical	None

11) As the water falls, its speed increases so its cross sectional area--- as by eq. of continuity

Zero	Increase	Remains same	**Decrease**

12) A stream of air passing over a tube dipped in a liquid will cause the liquid to rise in tube/capillary action is used in

Perfume bottles	Paint sprayer	**Both A&B**	None

13) A chimney works best when it is

Small	Large	**Tall**	None

14) A chimney works best when it is tall and exposed to air current, which can

Reduce the pressure at top	Force the upward flow of smoke	**Both A&B**	None

15) Carburetor of a car uses --- to feed the correct mix of air and petrol to the cylinders.

Small pipe	**Venture duct**	Gas	None

16) Drag force acts along --- to direction of motion of object

Same	**Opposite**	Both A&B	None

BISE AND UHS PAST PAPERS SOLVED MCQS

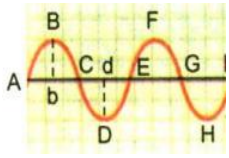
Q #	Questions	Option A	Option B	Option C	Option D
i.	One torr is equal to	1.33 N/m^2	**133.3 N/m^2**	0.133 N/m^2	1333.3 N/m^2
ii.	Stokes law hold good for bodies having shape	Circular	**Spherical**	Rectangular	Triangular
iii.	The device used for liquid flow is called	Mano meter	Baro meter	Hydrometer	**Venture meter**
iv.	The maximum force drag force on falling sphere is 9.8N then its weight will be?	1N	**9.8 N**	19.6 N	Zero
Explanation: When a sphere is falling then its drag force is equal to weight so in this case weight is equal to 9.8N					
v.	Venture relation is given by P1-P2=?	**½ ϱv²**	½ v^2	½ $(v_2^2-v_1^2)$	½ $ϱ(v_2^2-v_1^2)$
vi.	The term ½ $ϱv^2$ in Bernoulli equation has same unit as	Work	Volume	**Pressure**	Force
vii.	Drag force depends upon	Density	Acceleration due to gravity	Linear acceleration	**Radius of sphere**
viii.	Velocity of efflux is	$\sqrt{2gh}$	$\sqrt{2g(h1-h2)}$	St	Dt
ix.	The study of properties of fluid in motion is called	Fluid	**Fluid dynamics**	Fluid statics	None of these
x.	Drag force increase as the speed of object	**Increase**	Decrease	Remains same	None of these
xi.	Laminar flow occurs at	**low speed**	High speed	Very high speed	None
xii.	Blood pressure is measured by	Barometer	Galvanometer	Stigmometer	**Sphygmo manmeter**
xiii.	The blood pressure in vessel is always	Less thenatm pressure	**Greater then atm pressure**	Equal to atm pressure	133.3 N/m^2
xiv.	Turbulent flow is	Unsteady and regular	Steady and regular	**Unsteady and irregular**	Steady and irregular
xv.	Bernouli equation is based upon law of conservation of	Mass	Momentum	Pressure	**Energy**
xvi.	The property of fluid by which its own molecules are attracted is said to be	Surface tension	Adhesion	Cohesion	**Viscosity**
xvii.	Drag force on sphere of radius r moving with speed v	$6\pi\eta rv$	$6\pi\eta r^2 v$	$6\pi\eta r$	Ma
xviii.	A paratrooper moves downward with	**Zero acceleration**	Constatn acceleration	Positive acceleration	Negative acceleration
As it moves with terminal velocity which is constant value so acceleration is zero					
xix.	The density of blood is nearly equal to	Air	**Water**	Milk	Honey
xx.	A fog droplet falls vertically through air with acceleration	Equal to g	**Zero**	Less than g	Greater than
xxi.	The dimension of co-efficient of viscosity are	$[MLT^{-2}]$	$[ML^2T^{-2}]$	**$[ML^{-1}T^{-1}]$**	$[ML^2T^{-1}]$
xxii.	The ratio of velocities of water in pipe lying horizontally at two ends is 1:4. The ratio of diameters of pipe at these ends	1:2	**2:1**	1:4	4:1
As we know that Vt is proportional to square of radius/diameter so, diameter is sq.rt of velocities					
xxiii.	Venture meter is used to measure --- of fluid	Viscosity	Density	Pressure	**Speed**
xxiv.	Law of conservation of mass gives us	Bernoulli equation	**Equation of continuity**	Torricelli theorem	None of these
xxv.	Bunsen burner works on the principle of	Venture effect	**Bernoulli effect**	Torricelli effect	None
xxvi.	The maximum constant velocity of an object falling vertically downward is called	Final velocity	**Terminal velocity**	Initial velocity	None of these
xxvii.	Ball pen function of the principle of	**Surface tension**	Viscosity	Gravitational force	All of these

xxviii.	If the radius of droplet becomes half then its terminal velocity will	Half	Double	**<u>One fourth</u>**	Four times
xxix.	η is denoted as co-efficient of	Friction	**<u>Viscosity</u>**	Gravitational customer	Linear expansion
xxx.	Swing is produced to	Increase the speed of ball	Decrease the speed of ball	**<u>Deceive the player</u>**	Apply the force on ball
xxxi.	SI unit of rate of "flow rate"	m^2/sec	m^3sec	**<u>m^3/sec</u>**	m2sec
xxxii.	The working of carburetor of car uses	Equation of continuity	Gravitation law	**<u>Bernoulli equation</u>**	Stokes theorem
xxxiii.	Which fluid has minimum viscosity?	Tar	**<u>Water</u>**	Acetone	Plasma
xxxiv.	An object having spherical shape of radius 'r' experiences a retarding force F from a fluid of coefficient of viscosity 'η' when moving through the fluid with speed 'v'. What is the ratio of retarding force to speed?	6πη r_2	**<u>6πη r</u>** By stokes law divided both sides by v to get result	6πη/r_2	6πη/r
xxxv.	Which has max viscosity	Air	Water	Blood	**<u>Glycerin</u>**
xxxvi.	SI unit of pressure is	Nm^2	**<u>Nm^{-2}</u>**	N^2m	Js
xxvii.	The mathematical relation is $V2 = \sqrt{2g(h2-h1)}$	Equation of continuity	Bernoulli equation	**<u>Torricelli theorem</u>**	Venture relation
xxviii.	For the horizontal pipe, the fluid inside it is flowing horizontally then Bernoulli's equation can be written as	P + ρv_2 = constant	P + 2ρv^2 = constant	**<u>2P + ρv^2 = constant</u>**	2P + 2ρv_2 = constant
$P+1/2\rho v2+\rho gh = \text{constant}, \text{put } h=0 \text{ and multiplying both sides by 2 to get said result}$					
xxxix.	Stokes law holds for	Motion through free space	**<u>Motion through viscous medium</u>**	Bodies of all shape	All medium
xl.	Bernoulli theorem is applicable to	Solids	**<u>Fluids</u>**	Gases	None of these
xli.	When a body is falling under the action of gravity with terminal velocity its acceleration is	Constant	**<u>Zero</u>**	Variable	9.8 m/s2
xlii.	Law of conservation of energy is the basis of	Stream line flow	Equation of continuity	**<u>Bernoulli equation</u>**	Venture relation
xliii.	Potential energy per unit volume is given by:	mgh	gh	Mgh/ρ	**<u>ρgh</u>**
xliv.	In Bernoulli's equation the term ½ ρv^2 is called	**<u>K.E. per unit volume</u>**	K.E. per unit area	K.E	K.E. per unit length
xlv.	SI unit of viscosity is	**<u>$Kgm^{-1}s^{-1}$/ Nsm^{-2}</u>**	Kgm/s	Js	$Kgm^{-1}s$
xlvi.	When fluid is incompressible, the quantity is constant is:	Mass	Pressure	**<u>Density</u>**	Force
xlvii.	Mass flow per second of the fluid is given by	**<u>ρAv</u>**	ρv	Av	Av/ρ
xlviii.	If speed of efflux through a small hole in a large tank is 9.8 m/s. Find the height at the fluid above the hole	1 m	**<u>4.9 m</u>** Apply Torricelli theorem to get height	9.8 m	19.6 m
xlix.	Pressure will be low where speed of fluid is	Zero	**<u>High</u>**	Low	Medium
l.	The blood vessels collapse when	**<u>External pressure applied becomes greater than the systolic pressure</u>**	External pressure applied is equal to systolic pressure	External pressure applied is less than the systolic pressure	External pressure applied is zero

li.	The word "FLUID" means	to rise	To fall	**To flow**	To oppose
lii.	When the drag force is equal to the weight of the droplet, the droplet will fall with:	High Speed	Certain acceleration	Low Speed	**Constant Speed**
liii.	If cross sectional area of pipe decrease the speed of fluid must increase according to	**Venture relation**	Bernoulli equation	Vibration	Time period
liv.	Flow speed of the fluid through a non-uniform pipe increases from 1 m/sec to 3 m/sec. If change in P.E. is zero, then pressure difference between two points will be: (density of the fluid =1000kg/m^3)	1000 N/m^2	8000 N/m^2	9000 N/m^2	**4000 N/m^2** Apply venture relation to get the result
lv.	Systolic pressure of normal healthy person	**120 Torr**	130 Torr	110 Torr	11 torr
lvi.	The terminal velocity of a droplet falling down under gravity is directly proportional to the square of	Its density	**Its radius**	Its viscosity	Its elasticity
lvii.	The product of cross-sectional area of the pipe and the fluid speed at any point along the pipe:	**Remains constant**	Exponentially increases	Is zero	Exponentially decreases
lviii.	What is the speed of an incompressible non-viscous liquid flowing out Where h = 5 m and g = 10 m/s^2.	A) 5 m/s	2 m/s	**10 m/s** Apply Torricelli theorem put h=5m	50 m/s
lix.	When water falls from top,its cross sectional area decrease due to	Decrease of speed	**Increase of speed**	Air pressure	Gravity increase
lx.	A 6m high tank is full of water. A hole appear at it middle. What is the speed of efflux?	**7.66 m/s**	5.66 m/s	6.66 m/s	8.66 m/s
$V=\sqrt{2g(h_1-h_2}$ putting values h_1-h_2=3m and g=9.8 to get the result$\sqrt{2*9.8*3}$=7.66					
lxi.	Which has minimum viscosity?	**Air**	Water	Glycerin	Acetone
lxii.	The instrument which detect the instant at which external pressure equal to systolic	manometer	Sphygmo manometer	Barometer	**Stethoscope**
lxiii.	Stokes law is valid only for speed	**Slow**	High	Medium	All of these
lxiv.	A small leak is developed in a large water storage tank. If the height of water above leakage is 10 m, then find the speed of efflux through the leak	**14 m/sec** Apply Torricelli theorem put h=10m	9.8 m/sec	10 m/sec	20 m/sec
lxv.	Let A=area of cross section, v=fluid speed, then Av is called	**Volume flow rate**	Energy flow rate	Mass flow rate	Pressure flow
lxvi.	The dimension of potential energy per unit volume is equal to	**Pressure**	Work	speed	Density
lxvii.	A pipe varies uniformly in diameter from 2 m to 4 m. An incompressible fluid enters the pipe with velocity 16m/sec. What is velocity of fluid when it leaves the pipe?	64 m/sec.	**8 m/sec.** Diameter varies double change the velocity half	32 m/sec.	4 m/sec.

Chapter 07 Oscillations

Oscillatory motion/vibratory motion: To and fro motion of a body about a mean position is called vibratory or oscillatory motion. For example motion of mass suspended from a spring and motion of bob of simple pendulum.
Periodic motion: The vibratory motion that repeats itself in equal interval of time is called periodic motion.
Restoring force: The force which brings the system back to its equilibrium position is called restoring force. F=-Kx.
Requirements for oscillations: There are two requirements for oscillations
(1) Oscillating system must have restoring force (2) Oscillating system has inertia
How oscillations are produced: A body is pulled away on one side from its equilibrium position and then released the body starts to oscillate due to restoring force.
Hook's law: Within elastic limit, the applied force is directly proportional to the displacement. F=Kx.
Spring constant: Force per unit extension is called spring constant. K=F/x its SI unit is N/m and dimension $[MT^{-2}]$
Simple harmonic motion: A type of motion in which acceleration is directly proportional to displacement from mean position and directed towards mean position is called SHM. $a \propto -x$
Conditions for SHM: The system must have inertia, restoring force and frictionless for SHM.
Waveform of SHM: The curve which shows the variations of displacement with time is called wave form. Wave form of SHM is sine wave.
Characteristics of wave form of SHM:
Instantaneous displacement: The displacement of vibrating body at any instant of time
Amplitude: the maximum displacement of vibrating body on either position from its mean position
Vibration: one complete round trip of vibrating body about is mean position
Time period: The time required to complete one vibration. It is shown by T and its unit is second
Frequency: the number of vibrations completed in one second f=1/T.



The product of frequency and time period is equal to 1, fT=1
Angular frequency: If time period is T of a body executing SHM, its angular frequency $\omega = 2\pi / T = 2\pi f$. Basically the angular frequency is the property of circular motion.

Prove that $a \propto -x$?

Consider a mass m attached to one end of spring which can move freely on horizontal surface by applying force

According to Hook's law F = Kx and opposing force brings the mass towards mean position which is

F = -Kx - - - - - - - - - - - - - - - - - (1)

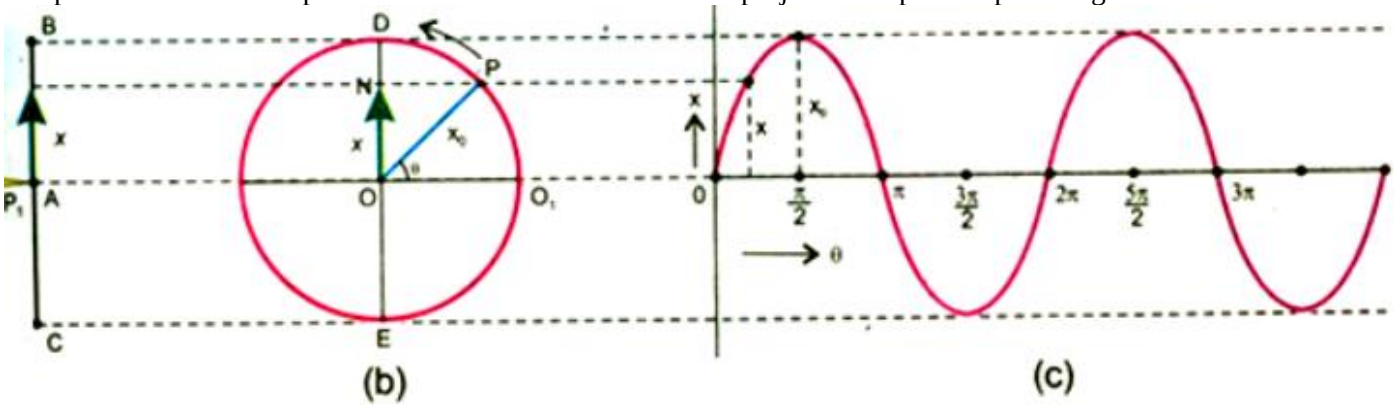
According to Newton 2nd law acceleration is produced by force F = ma - - - - - - - -(2)

comparing (1) and (2) - Kx = ma

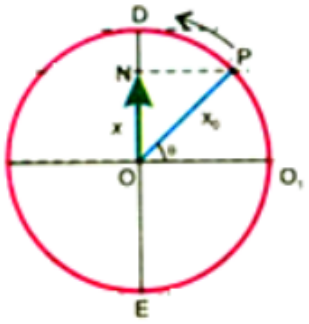
$a = \frac{-K}{m}x \Rightarrow a \propto -x$ which is req result as $\frac{K}{m} = \text{constant}$

EXPLAIN SHM AND UNIFORM CIRCULAR MOTION.

Consider a mass m attached with end of vertically suspended spring. It vibrates simple harmonically with period T, frequency f and amplitude x_o. The motion of mass is displayed by the pointer P_1 on the line BC with A as mean position and "B" and "C" as extreme position as shown in fig.
At t=0 pointer is at position A then at position B, A, C and back to A at instant T/4, T/2, 3T/4 and T respectively.
In circular motion pointer P is moving in a circle of radius xo with uniform angular frequency ω. Let us consider the motion of point N, the projection of P on diameter DE, the levels of D and E are similar to points B and C, hence the comparison of motion of point N and P1 shows that motion of projection of particle p moving in a circle is SHM.



Instantaneous Displacement: let N be the projection of a particle P moving in a circle of Angular frequency ω and angle subtended is Θ=ωt in radius of circle x_o.



From right angle triangle(OPN)

$$\text{Sin}\theta = \frac{\text{ON}}{\text{OP}} \Rightarrow ON = OP\sin\theta$$

$$x = x_o \sin\theta$$

$$x = x_o \sin\omega t$$

$$at\ \theta = \omega t = 0^o \Rightarrow x = x_o \sin 0^o = 0 \qquad \text{at} \quad \theta = \omega t = 90^o \Rightarrow x = x_o \sin 90^o = x_o$$

$$\text{at} \quad \theta = \omega t = 180^o \Rightarrow x = x_o \sin 180^o = 0 \quad \text{at} \quad \theta = \omega t = 270^o \Rightarrow x = x_o \sin 270^o = -x_o$$

$$\text{at} \quad \theta = \omega t = 360^o \Rightarrow x = x_o \sin 360^o = 0 \quad \theta = \omega t \text{ is the phase of vibration}$$

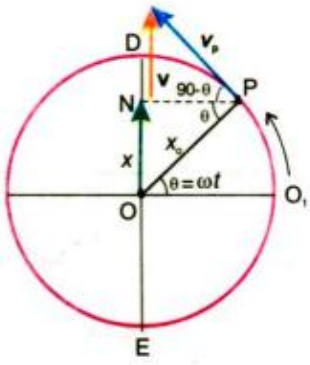
Instantaneous velocity: The velocity of point P at the instant t, will directed along the tangent to the circle at P and its magnitude is Vp=x_oω. The velocity of N is actually the vertical component of velocity Vp in direction parallel to DE.

The component of velocity parallel to DE is

$$V = V_p \sin(90^o - \theta)$$

$$V = V_p \text{Cos}\theta$$

$$V = x_o \omega \text{Cos}\theta \text{ ----------(1)}$$



From fig $\text{Cos}\theta = \frac{\text{NP}}{\text{OP}} = \frac{\sqrt{x_o^2 - x^2}}{x_o}$, putting the value in eq(1)

$$V = x_o \omega \frac{\sqrt{x_o^2 - x^2}}{x_o} = \omega\sqrt{x_o^2 - x^2}$$

At mean position velocity is maximum and at extreme position velocity is minimum

Instantaneous Acceleration (a): The acceleration at any point P along the circle is $a_p = x_o\omega^2$ which is directed towards the center O. the acceleration of point N will be the component of acceleration ap along the diameter DE as $a = a_p \sin\Theta$

$$a = x_o \omega^2 \text{Cos}(90 + \theta)$$

$$a = -x_o \omega^2 Sin\theta$$

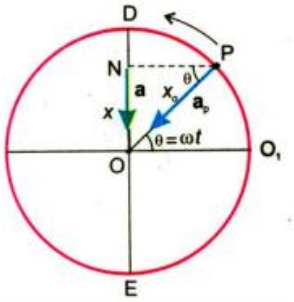
as $\text{Sin}\theta = \frac{x}{x_o}$, putting in equation (1)

$$a = -x_o \omega^2 (\frac{x}{x_o}) =$$

$$a = -\omega^2 x$$

$$a = -\text{constant } x$$

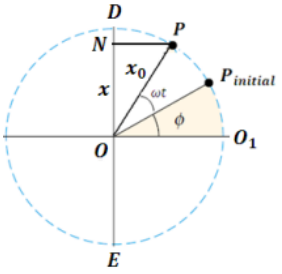
$a \propto -x$, This shows that acceleration is directly proportional to displacement and directed towards mean position



What is Phase? Give its two cases.

The angle $\theta = \omega t$ which gives the displacement as well as the direction of motion executing SHM is called phase. This angle is obtained when SHM is related with circular motion. Phase determine the state of motion of vibrating body.

Case 01: When motion starts from mean position its phase would at this point be 0.
Let at t=0 the angle made by rotating radius OP with reference line OO1=ϕ, after a time t, the radius rotate through angle=ωt and angle made by rotating radius OP is (ωt+ϕ) and displacement is $x=x_o \sin(\omega t+\phi)$. This is shown in fig 1



Case 02: When motion starts at the extreme position, its phase would be π/2.
In this case we take initial phase as 90° or π/2 as shown in fig 2 then displacement is $x=x_o\sin(\omega t+90)= x_o\text{Cos}\omega t$

Write a note on characteristics of Horizontal mass spring system.

Let us consider a mass which is attached with a spring at one side and at the other side
Spring is fixed with rigid support

Instantaneous Acceleration of spring system: let the Restoring force produces acceleration then

$F = ma$ ----------(1) $F = -Kx$ ------(1) comparing both eqs

$ma = -Kx$

$a = \frac{-Kx}{m}$ This is the formula for acceleration of mass spring system

$a = -\text{constant}\, x$ as $\frac{K}{m} = \text{constant}$

$a \propto -x$, This shows that acceleration is directly proportional to displacment and directed towards mean position

Angular frequency: as we know that acceleration for simple harmonic motion is

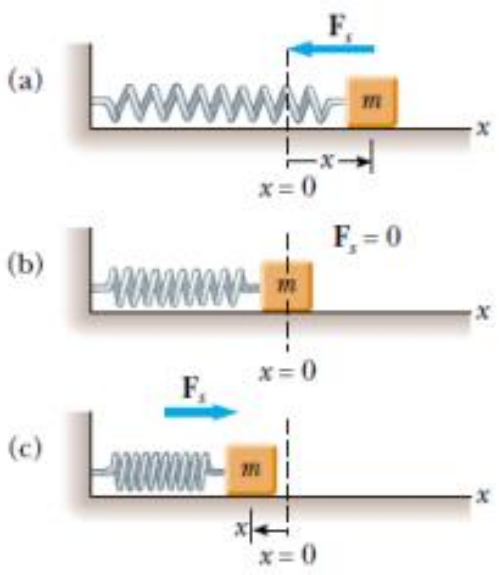
$a = -\omega^2 x$ ---------(1)

$a = \frac{-K}{m}x$ ---------(2) comparing both eqs

$-\omega^2 x = \frac{-K}{m}x$

$\omega^2 = \frac{K}{m}$

$\omega = \sqrt{\frac{K}{m}}$, This is the formula for angular frequency



Time period and frequency: Time period and frequency of mass spring system having SHM are

$T = \frac{2\pi}{\omega}$

$T = \frac{2\pi}{\sqrt{\frac{K}{m}}}$

$T = 2\pi\sqrt{\frac{m}{K}}$, this is the formula for time period

$f = 1/T = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$ This is the formula for frequency of mass spring system

Instantaneous displacement: The displacement at any instant of time is calculate as $x = x_o \sin\omega t = x_o \sin\sqrt{K/m}\,t$.

Instantaneous velocity: The velocity at any instant of time is calculated as

$v = \omega\sqrt{x_o^2 - x^2}$

$v = \sqrt{K/m}\sqrt{x_o^2 - x^2} = \sqrt{K/m}(x_o^2 - x^2)$

$v = x_o\sqrt{K/m}(1 - x^2/x_o^2)$

Max velocity at mean position at $x = 0$ $v = x_o\sqrt{K/m}$

Min velocity at extreme position $x = x_o$, $v = 0$

Relation b/w maximum velocity and instantaneous velocity: $v = v_o\sqrt{1-\frac{x^2}{x_o^2}}$.

What is Simple pendulum? Prove that motion of simple pendulum is SHM. Also derive the relation for time period of simple pendulum.

Definition: A small heavy mass suspended by a weightless and inextensible string with frictionless support is called simple pendulum.

Motion of simple pendulum: Let us consider an object of mass m attached with the end of a light weight string whose length is l

When the pendulum is displaced from mean position through a small angle Θ and released then it start to oscillate to and fro motion about mean position. Two forces acting on it

Equation: Weight mg of bob acting vertically down and Tension T of string acting upward

The weight has two components mgsinΘ and mgcosΘ, the only component mgsinΘ is responsible for motion of pendulum which brings the bob back towards the mean position

Restoring force = F = -mg $\sin\theta$ ----------(1) - ive sign shows that force is directed towards mean position

F = ma ---------- (2) comparing both equation

ma = -mg $\sin\theta$ where angle is very small so for small angle $\sin\theta \approx \theta$

ma = -mgθ

$a = -g\theta$ as we know from fig $\theta = x/l$

$a = -g\frac{x}{l} \Rightarrow \quad \frac{g}{l} = \text{constant}$

a = –constant x

$a \propto -x$ This relation shows that acceleration is directly proportional to displacment and directed towards mean position

Angular frequency

$a = -\omega^2 x$ ---------(1)

$a = \frac{-g}{l}x$ ---------(2) comparing both eqs

$-\omega^2 x = \frac{-g}{l}x$

$\omega^2 = \frac{g}{l}$

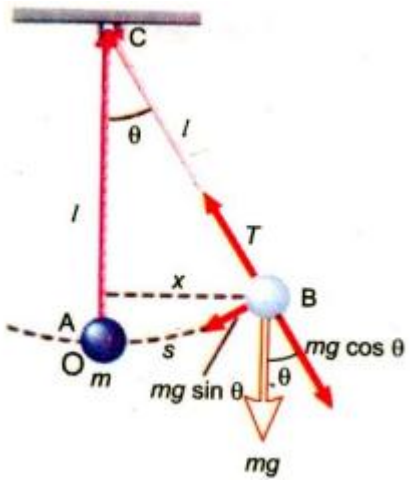
$\omega = \sqrt{\frac{g}{l}}$, This is the formula for angular frequency

$T = \frac{2\pi}{\omega}$

$T = \frac{2\pi}{\sqrt{\frac{g}{l}}}$

$T = 2\pi\sqrt{\frac{l}{g}}$, this is the formula for time period

$f = 1/T = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$ This is the formula for frequency of simple pendulum

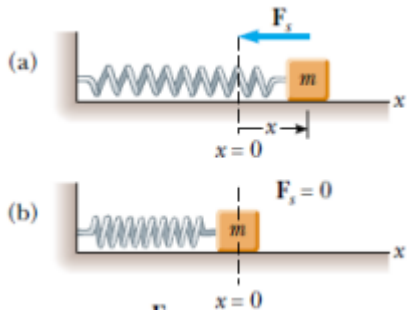


Double pendulum: A simple pendulum whose time period is 2 second. Its frequency is 0.5 Hz and length is 99.2 cm.

Explain Energy conservation in SHM.

Let us consider a mass spring system. when the mass is pulled and stretched the spring by distance xo along horizontal frictionless surface. Instantaneous potential energy can be calculated

According to Hook's law $F = Kx$ when displacment is x at extreme position



$F = 0$ when displacment is zero at mean position

average force is $F = \frac{0 + kx}{2} = \frac{kx}{2}$,

work done is equal to P.E in this case so

$$W = Fd = Fx = (\frac{kx}{2})x = \frac{1}{2}kx^2$$

$P.E = \frac{1}{2}kx^2$, if displacment is at maximum value xo at extrement position then

$P.E = \frac{1}{2}kx_o^2$ this is maximum P.E and at mean position $x = 0$ so $P.E = 0$ min

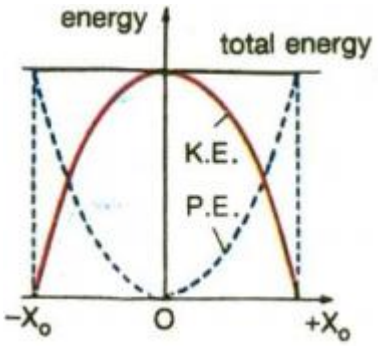
Instantaneous kinetic energy can be calcualted by using the formula $K.E = \frac{1}{2}mv^2$

$$v = x_o\sqrt{\frac{K}{m}(1 - \frac{x^2}{x_o^2})}$$

$$K.E = \frac{1}{2}m(x_o\sqrt{\frac{K}{m}(1 - \frac{x^2}{x_o^2})})^2$$

$$K.E = \frac{1}{2}mx_o^2\frac{K}{m}(1 - \frac{x^2}{x_o^2})$$

$$K.E = \frac{1}{2}Kx_o^2(1 - \frac{x^2}{x_o^2})$$



at mean position $x = 0$, kinetic energy will be maximum

$$K.E = \frac{1}{2}Kx_o^2(1 - \frac{0^2}{x_o^2}) \Rightarrow K.E = \frac{1}{2}Kx_o^2 \text{ ---------(2)}$$

Kinetic energy at extreme position will be minimum at at $x = x_o \Rightarrow K.E = 0$

Total Energy $= P.E + K.E$

$$E = \frac{1}{2}Kx^2 + \frac{1}{2}Kx_o^2(1 - \frac{x^2}{x_o^2})$$

$$E = \frac{1}{2}Kx^2 + \frac{1}{2}Kx_o^2 - \frac{1}{2}Kx^2$$

$$E = \frac{1}{2}Kx_o^2, \text{----------(3)}$$

Equation (1), (2) and (3) show that total energy remains constant in SHM.

What are Free and forced oscillations? Give example of each.

Free oscillations: If a body executes oscillations with its natural frequency without the interference of external force, then these oscillations are called free oscillations. For example a simple pendulum vibrates freely with its natural frequency.

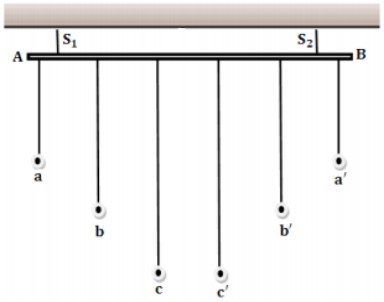
Free oscillations: A body is said to be executing forced vibrations if it oscillate under the action of an external force. for example if mass of simple pendulum is struck repeatedly then forced vibrations are produced.

Driven harmonic oscillator: The physical system that undergoes forced vibrations is called driven harmonic oscillator.

What is Resonance? Describe Barton pendulum experiment. And examples of resonance.

Resonance: The phenomenon in which the amplitude of vibrating body increase when the frequency of applied force is equal to natural frequency of harmonic oscillator is called resonance.
For example, motion of swing, tuning of a radio, microwave oven etc.

Barton pendulum experiment: Consider a horizontal rod AB is supported by two strings
Three pairs of pendulums, and are suspended to this rod.
If one of these pendulums, say c, is displaced
from its mean position, then its resultant oscillatory motion causes
Slight disturbance motion in rod AB.
This causes the pendulum to oscillate back with steadily increasing amplitude.
However, the amplitude of the other pendulums remains small.
The increase of the amplitude of pendulum is due to effect of resonance,
Because the periods as well as the natural frequencies of pendulum and are equal.



Examples of Resonance

Mechanical Resonance for the case of swing: A swing is the good example of mechanical resonance. It is like a pendulum with a single natural frequency depending on its length. If a series of regular pushes are given to the swing, its motion can be built up enormously. If pushes are given irregularly, the swing will hardly vibrate.

March of soldiers on bridge: The column of soldiers, while marching on a bridge of long span is advised to break their steps. Their rhythmic march might set up oscillation of dangerously large amplitude in the bridge structure.

Electrical Resonance in Tuning of a Radio: Tuning of a radio is the best example of electrical resonance. When we turn the knob of a radio, to tune a station, we are changing the natural frequency of electrical circuit of receiver, to make it equal to the transmission frequency of the radio station. When the two frequencies match, energy absorption is maximum and this is the only station we hear.

Cooking of a Food in Microwave Oven: Another good example of resonance is the heating and cooking of food very efficiently and evenly by microwave oven. The waves produced in this type of oven have a frequency of 2450 MHz. At this frequency the waves are absorbed due to resonance by water and fat molecules in the food.

Why microwave oven use 2450 MHz?

Microwave oven use 2450M Hz frequency because at this frequency the waves are absorbed due to resonance by water and fat molecules in the food, heating them up and so cooking the food.

What is undamped and damped oscillations? Also define damping.

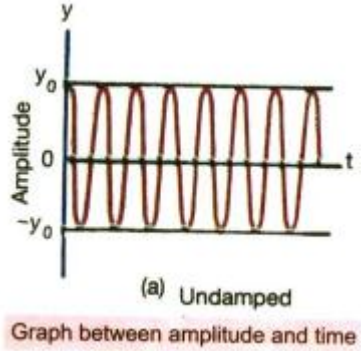
The oscillations in which amplitude remains same with time are called undamped oscillations. For example oscillations of an ideal simple pendulum.
The oscillations in which amplitude decrease with time due to energy dissipation are called damped oscillations. Its example is the shock absorber of a car
Damping is the process whereby energy is dissipated from the oscillating system.

What is Effect of damping on vibration of a body?

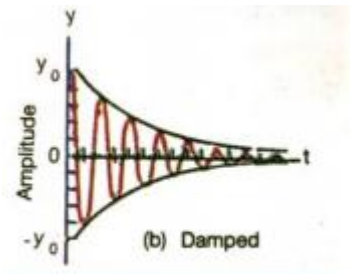
The amplitude of vibration of a body increases when the damping is small and amplitude decrease when damping is large. A heavily damped system has fairly flat resonance curve.
Smaller the damping, greater will be the amplitude and more sharp will be the resonance

What is Sharpness of resonance?

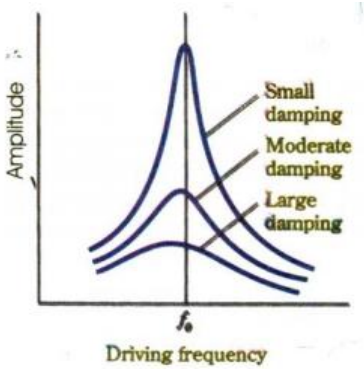
Such a type of resonance in which amplitude of vibration of a body increase at maximum value when damping is very small is called sharpness of resonance.



Graph between amplitude and time



Graph between amplitude and time



Exercise short Questions

Q.1 ***Name two characteristics of simple harmonic motion.***

i) a ∝ - x Acceleration is directly proportional to the displacement and directed towards mean position

ii) Total Energy remains constant K.E+P.E=constant

Q.2 ***Does frequency depends on amplitude for harmonic oscillators?***

No. Frequency of harmonic oscillator is independent of amplitude. Because for simple pendulum $f = \frac{1}{2\pi}\sqrt{g/l}$ it depends upon length and g where for mass spring system $f = \frac{1}{2\pi}\sqrt{K/m}$ it depends upon mass and spring constant K.

Q.3 ***Can we realize an ideal simple pendulum?***

No. Due to friction and weight of the string. For an ideal simple pendulum, the string should be massless, inextensible and suspended from frictionless support and these condition are difficult to achieve.

Q.4 ***What is the total distance traveled by an object moving with SHM in a time equal to its period, if its amplitude is A?***

Total distance traveled will be 4A. Time period is time during which vibrating body completes one round trip and in one round trip total distance is A+A+A+A=4A.

Q.5 ***What happens to the period of a simple pendulum if its length is doubled? What happens if the suspended mass is doubled?***

As we know that simple pendulum, $T = 2\pi\sqrt{l/g}$ for doubling the length $T = 2\pi\sqrt{2l/g} = \sqrt{2} \times 2\pi\sqrt{l/g} = \sqrt{2}\,T$ So the time period increases by √2 (=1.414) times, as length is doubled. ii) There will be no change, when suspended mass is doubled. Since time period, T, is independent of mass, m.

Q.6 ***Does the acceleration of a simple harmonic oscillator remain constant during its motion? Is the acceleration ever zero? Explain.***

No. Acceleration depends upon x, $a = -\omega^2 x$ the acceleration is zero at mean position (x = 0) and it becomes maximum at extreme position ($x = x_o$) so the acceleration of simple harmonic oscillator does not remain constant during its motion

Q.7 ***What is meant by phase angle? Does it define angle between maximum displacement and the driving force?***

i) Phase angle (or phase): "The angle θ = ωt which specifies the displacement as well as the direction of motion of the point executing SHM". It indicates the state and direction of motion of a vibrating particle.

ii) No, It does not define angle between maximum displacement and the driving force.

Q.8 ***Under what conditions does the addition of two simple harmonic motions produce a resultant, which is also simple harmonic?***

The addition of two simple harmonic motion produce a resultant, which is also simple harmonic when

i. They have same frequency
ii. Same phase
iii. They are parallel

Q.9 ***Show that in SHM the acceleration is zero when the velocity is greatest and the velocity is zero when the acceleration is greatest.***

We have for SHM; $v = \omega\sqrt{xo2 - x2}$ & $a = -\omega^2 x$ At mean position, from the above equations, X = 0 then a = 0 & v = ω xo—maximum value, i.e. acceleration is zero and velocity is greatest. &

at extreme positions; x = xo then v = 0 & $a = -\omega^2 xo$—maximum value. i. e. velocity is zero when acceleration is greatest.

Q.10 ***In relation to SHM, explain the equations;***

(i) y = A sin (ω t + ϕ)

(ii) a = - ω^2 x

y = A sin (ω t + ϕ) initial phase

Instantaneous displacement y and A is Amplitude angle subtended in time t this equation shows that displacement of SHM as a function of amplitude and phase angle depending upon time.

a = - ω2 x where a = acceleration of a particle executing SHM ω = constant angular frequency x = instantaneous displacement from the mean position.

Q.11 Long Q

Q.12 ***Describe some common phenomena in which resonance plays an important role.***
1) **Tuning radio/TV** we change the frequency with knob. When it becomes equal to a particular transmitted station, resonance occurs. Then we receive amplified audio/video signals.
2) Microwave oven Microwaves (of frequency 2450 MHz) with $\lambda = 12$ cm, are absorbed due to resonance by water and fat molecules in the food, heating them up and so cooking the food.
3) Musical instruments In some instruments (e.g. drums) air columns resonate in the wooden box. In string instruments (e.g. sitar) strings resonate with their frequencies and loud music is heard.
Q.13 ***If a mass spring system is hung vertically and set into oscillations, why does the motion eventually stop?***
Due to friction and air resistance mass-spring oscillating system eventually stops. When it oscillates, due to frictional forces energy is dissipated into heat and finally it stops.

Chapter 07

No.7.1: A 100.0 g body hung on a spring elongates the spring by 4.0cm. When a certain object is hung on the spring and set vibrating, its period is 0.568s. What is the mass of the object pulling the spring?

$\text{Given Data}: \text{m} = 100\text{g} = 10/1000\text{kg} = 0.1\text{kg},\ \text{x} = 4\text{cm} = 4/100\text{m} = 0.04\text{m},\ \text{T} = 0.568\text{sec},\ \text{mass of object} = \text{m}' = ?$

$\text{As F} = \text{Kx} \Rightarrow\ \text{mg} = \text{Kx}\ \Rightarrow \text{K} = \dfrac{\text{mg}}{\text{x}} = \dfrac{0.1*9.8}{0.04} = 24.5 Nm^{-1}$, Now using the formula for time period of mass spring

$$\text{T} = 2\pi\sqrt{\frac{m'}{K}} \Rightarrow m' = \frac{T^2K}{4\pi^2} = \frac{(0.568)^2 * 24.5}{4(3.14)^2} = 0.2Kg$$

7.2: A load of 15.0g elongates a spring by 2.00 cm. If body of mass 294 g is attached to the spring and is into vibration with an amplitude of 10.0 cm, what will be its (i) period (ii) spring constant (iii) maximum speed of its vibration.

$\text{Given Data}: \text{m} = 15\text{g} = 15/1000 = 0.015\text{kg},\ \text{x} = 2\text{cm} = 0.02\text{m},\ \text{m}' = 294\text{g} = 0.294\text{kg},\ \text{x}_o = 0.1\text{m},\ \text{T} = ?, \text{K} = ?, \text{V}_o = ?$

$$\text{F} = \text{Kx}, \Rightarrow\ \text{mg} = \text{Kx} \quad \Rightarrow K = \frac{mg}{x} = \frac{0.015 * 9.8}{0.02} = 7.35 Nm^{-1}$$

$$T = 2\pi\sqrt{\frac{m}{K}} = 2 * 3.14\sqrt{\frac{0.294}{7.35}} = 1.26\,\text{sec}$$

$$v_o = x_o\sqrt{\frac{K}{m+m'}} = 0.1\sqrt{\frac{7.35}{0.015+0.29}} = 0.49 ms^{-1}$$

7.3: An 8.0kg body executes SHM with amplitude 30 cm. The restoring force is 60 N when the displacement is 30 cm. Find (i) Period (ii) Acceleration, speed, kinetic energy and potential energy when the displacement is 12m.

$\text{Given Data}: \text{m} = 8\text{kg},\ \text{xo} = 0.3\text{m},\ \text{F} = 60\ \text{N},\ \text{x} = 0.3\text{m},\ \text{T} = ?,\ \text{a} = ?,\ \text{v} = ?\ \text{k.E} = ?\ \text{P.E} = ?(\text{when x} = 0.12\text{m})$

$$\text{F} = \text{Kx}, \Rightarrow\ K = \frac{F}{x} = \frac{60}{0.3} = 200 Nm^{-1} \Rightarrow\ T = 2\pi\sqrt{\frac{m}{K}} = 2 * 3.14\sqrt{\frac{8}{200}} = 1.3\,\text{sec}$$

$$\omega = \sqrt{\frac{K}{m}} = \sqrt{\frac{200}{8}} = 4.82 Hz \Rightarrow a = \omega^2 x = (4.82)^2 * 0.12 = 3 ms^{-2}$$

$$v = \omega\sqrt{x_o^{\,2} - x^2} = 4.82\sqrt{(0.3)^2 - (0.12)^2} = 1.33 ms^{-1}$$

$$K.E = \frac{1}{2}Kx_o^{\,2}\left(1 - \frac{x^2}{x_o^{\,2}}\right) = \frac{1}{2} * 200 * (0.3)^2\left(1 - \frac{(0.12)^2}{(0.3)^2}\right) = 7.6J$$

$$P.E = \frac{1}{2}Kx^2 = \frac{1}{2}(200)(0.12)^2 = 1.44J$$

7.4: A block of mass 4.0 kg is dropped from a height of 0.80 m on to a spring of spring constant k = 1960 Nm^{-1}, Find the maximum distance through which the spring will be compressed.

$$\text{Given Data}: m = 4Kg,\ h = 0.8m,\ K = 1960\ Nm^{-1},\ x_o = ?$$

$$P.E = mgh \text{ also } \frac{1}{2}Kx_o^{\ 2} = mgh \Rightarrow x_o^{\ 2} = \frac{2mgh}{K} \Rightarrow x_o = \sqrt{\frac{2mgh}{K}} = \sqrt{\frac{2*4*9.8*0.8}{1960}} = 0.18m$$

7.5: A simple pendulum is 50.0 cm long. What will be its frequency of vibration at a place where g = 9.8 ms^{-2}?

$$\text{Given Data}: l = 50cm = 50/100m = 0.5m,\ g = 9.8ms^{-2},\ f = ?$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}} = \frac{1}{2*3.14}\sqrt{\frac{9.8}{0.5}} = 0.7Hz$$

7.6: A block of mass 1.6 kg is attached to a spring with spring constant 1000 Nm^{-1}, as shown in Fig.7.14. The spring is compressed through a distance of 2.0 cm and the block is released from rest. Calculate the velocity of the block as it passes through the equilibrium position, x=0, if the surface is frictionless.

$$\text{Given data}: m = 1.6kg,\ K = 1000\ N/m,\ x_o = 2cm = 0.02m,\ v = ?$$

$$v = x_o\sqrt{\frac{K}{m}} = 0.02\sqrt{\frac{1000}{1.6}} = 0.5ms^{-1}$$

7.7: A car of mass 1300 kg is constructed using a frame supported by four springs. Each spring has a spring constant 20,000 Nm^{-1}. If two people riding in the car have a combined mass of 160 kg, find the frequency of vibration of the car, when it is driven over a pot hole in the road. Assume the weight is evenly distributed.

$$\text{Given Data}: m_1 = 1300kg,\ m_2 = 160\ kg,\ m = m_1 + m_2 = 1300 + 160 = 1460kg$$

$$\text{for one spring, } K = 20{,}000N/m, \text{ for 4 spring} = 4*20000 = 80000\ N/m,\ f = ?$$

$$\text{using } f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2*3.14}\sqrt{\frac{80000}{1460}} = 1.18Hz$$

7.8: Find the amplitude, frequency and period of an object vibrating at the end of spring, if the equation for its position, as a function of time, is $x = 0.25\cos\left(\frac{\pi}{8}\right)t$ what is the displacement of the object after 2.0s?

$$\text{Given Data}: t = 20\sec,\ \text{amplitude} = x_o = ?,\ f = ?,\ T = ?,\ x \text{ when } t = 2\sec = ?$$

$$\text{comparing given eq } x = 0.25\cos\left(\frac{\pi}{8}\right)t \text{ with } x = x_o\cos(\omega)t \Rightarrow x_o = 0.25m$$

$$\omega = \frac{\pi}{8} \Rightarrow 2\pi\pi = \frac{\pi}{8} \Rightarrow f = \frac{1}{16}Hz \qquad T = \frac{1}{f} = \frac{1}{1/16} = 16\sec$$

$$x = 0.25\cos\left(\frac{\pi}{8}\right)*2 = 0.25\cos\left(\frac{\pi}{4}\right) = 0.18\ m$$

BISE AND UHS PAST PAPERS SOLVED MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	Distance covered by oscillating body during one vibration of amplitude A	2A	**4A**	0	A^2
ii.	Which of these quantity has unit kgs^{-2}	Surface tension	**Spring constant**	Force	Momentum
	$K=F/x=N/m=Kgms^{-2}/m=Kgs^{-2}$				
iii.	The product of frequency and time period	**1**	0	3.14	2
	As $f=1/T$, $fT=1$				
iv.	The frequency of second pendulum is	2 Hz	**0.5 Hz**	1 Hz	0.25 Hz
	Time period=2sec, $f=1/T=1/2=0.5Hz$				
v.	Angle of projection of projectile moving around a circle is given by relation a =?	-gx/l	**$-w^2x$**	-x	$-g\sin\Theta$
vi.	In mass spring system mass 'm' is attached with spring of spring constant 'k' with time period 'T_1'.. Then the mass is replaced by '2m' with same spring, what is the time period 'T_2'	$T_2 = T_1$	**$T_2 = \sqrt{2}\, T_1$** Time period is directly proportional to sq root of mass so	$T_2 = 2T_1$	$T_2 = T_1/\sqrt{2}$
vii.	Mass attached to spring is pulled slowly from mean position to x0 then work done will be ?	$\frac{1}{2} Kx_0$	**$\frac{1}{2} Kx_0^2$**	Kx_0	W^2x_0
viii.	Angular displacement of a point moving in a circle 10cm when displacement of projection of this point along vertical diameter of circle is 8.66cm will	30°	**60°** Sinx=x/xo =10/8.66 Sin-(0.866) 60°	45°	75°
ix.	A body performing SHM with displacement $x=x_o \sin(wt+fi)$, when t=0, $x=x_o$.. Then what is the phase angle fi??	π	$\pi/4$	**$\pi/2$** at this angle $x=x_o$	$-\pi$
x.	If distance covered by wave is 20 cm then what is the amplitude is	10cm	**5cm**	15cm	20cm
	Distance=4*amplitude, 20=4A. A=5cm				
xi.	The motion of simple pendulum is SHM is only if	Amplitude is large	Mass is small	**Amplitude is small**	Length is small
xii.	The expression for instantaneous displacement of particle executing SHM is given as	$a = -w^2x$	$x = x_0 \sin \omega t$	$F = kx$	All of these
xiii.	If a load of 15g is elongated a spring by 2cm, then K	7.5 N/m	7 N/m	**7.35 N/m**	0.75 N/m
xiv.	Instantaneous potential energy of spring mass system is given by	$\frac{1}{2} Kx^2 o$	$\frac{1}{2} Kx^2$	Mgh	None of these

xv.	At which place the motion of simple pendulum is slowest	Karachi	**K-2**	Murree	Lahore
As we know that frequency and speed is directly to g so the value of g is minimum in these places at K-2 so at that point motion of simple pendulum is slowest					
xvi.	A simple pendulum 50cm long its frequency of vibration at place where g=9.8 m/s^2	**0.70 Hz** To see n#7.5	7 Hz	70 Hz	10 Hz
xvii.	A simple pendulum is moved from Earth to moon, how does it change the period of oscillation(g at moon=1.6)	Remains same	**Increased by factor $\sqrt{6}$**	Increased by factor four	Decreased by factor $\sqrt{6}$
As we know that T is inversely proporitional to sq.rt of g so at moon the value of g is g/6 so it increased T by $\sqrt{6}$ times					
xviii.	The frequency of waves produced in microwave oven is	2450 Hz	**2450 MHz**	2450 KHz	12 Hz
xix.	Tunning of radio is an example of	Mechanical resonance	Light wave resonance	**Electrical resonance**	Physical resonance
xx.	A spring of spring constant 10 N/m amplitude 2m. the maximum P.E	10 J	**20 J**	30 J	40 J
P.E=1/2 Kx^2=1/2*10*(2)^2=20 J					
xxi.	A particle takes 0.2 sec to complete one revolution, its frequency is	10Hz	**5Hz** f=1/T=1/0.2=5 Hz	50Hz	None of these
xxii.	In SHM the restoring force is directly proportional to	Velocity	Acceleration	**Displacement**	Time period
xxiii.	The waveform of simple harmonic motion is	**Sine wave**	Square wave	Pulsed wave	Cosine wave
xxiv.	If f is frequency of body executing SHM, its angular frequency w is	**2πf**	1/f	4πf	2π/f
xxv.	If mass of pendulum is doubled then its time period will be	Double	Half	Four times	**Remains same**
xxvi.	SI unit of frequency is	Radian	m/s	**Hertz**	Meter
xxvii.	If F=0.08N and x=4cm then K=?	6 N/m	4 N/m	8N/m	**2 N/m**
K=F/x=0.08/4cm=0.08/4*10-2=2 N/m					
xviii.	The phase angle $\theta = wt$ of a body performing SHM indicates	Only direction of amplitude	Only magnitude of displacement	**Both A&B**	None of these
xxix.	The process in which energy is dissipated in oscillating system is called	Resonance	Forced oscillations	**Damping**	None of these
xxx.	If the frequency of oscillator is 5Hz then time period will be	0.1 Sec	**0.2 Sec**	0.4 Sec	0.5 Sec
Time period =1/f=1/5=0.2 sec					
xxxi.	Angular frequency is basically a property of	**Circular motion**	Linear motion	Vibratory motion	Elliptical motion
xxxii.	If the mass attached with a spring becomes four times, the time period of vibration becomes:	One fourth	Half	**Double**	3/4
xxiii.	The displacement of projection is given as	Xo	W	t	**Wt**

	$x = x_o \sin wt$, which quantity represents phase				
xxiv.	In a simple pendulum, the tension of the string is	g cos θ	mg cos θ	**mg sin θ**	mg
xxxv.	An oscillating body is at mean position at t = 0. At t = T/4 it will be at	**Extreme position**	Between extreme and mean position	Mean position	Beyond extreme position
xxvi.	At mean position during SHM	P.E is Max and K.E min	**P.E is min and K.E max**	Both K.E and P.E maximum	Both K.E and P.E min
xxvii.	What is kinetic of body executing SHM when displacement form mean position is half of its displacement	½	**¼**	3/2	¾
Energy is directly proportional to square of amplitude, so when half then its square is ¼					
xviii.	Which expression is correct for the time period of simple pendulum	$T \alpha l$	$T \alpha \sqrt{l}$	$T \alpha m$	None of these
xxix.	If time period of simple pendulum is 2sec its frequency will be	1 Hz	2 Hz	**0.5 Hz**	4 Hz
Frequency=1/T=1/2=0.5Hz					
xl.	SI unit of spring constant are	m^{-1}	**Nm^{-1}**	Nm^{-2}	Nm^2
xli.	Time period of simple pendulum only depends on	Mass of bob	**Length of pendulum**	Amplitude of vibration	Size of bob
xlii.	A simple harmonic oscillator has a time period of 10 seconds. Which equation rotates its acceleration 'a' and displacement 'x'?	a = -2 x	a = -(20π)x	a = $-(20\pi)^2$x	**a =-(2π /10)^2 x** by applying a=-w^2x a=-$(2\pi/T)^2$x
xliii.	The oscillation in which amplitude decreased steadily with time are called	Natural oscillations	Free oscillations	**Damped oscillations**	Forced oscillations
xliv.	When the length of a simple pendulum is doubled, find the ratio of the new frequency to the old frequency?	1/4	√2	1/2	**1/√2**
xlv.	In SHM the velocity of particle is maximum at	Extreme position	**Mean position**	Between extreme and mean position	None
xlvi.	What is the period of mass spring system during SHM if the ratio of mass to spring constant is ¼?	**π** apply time period formula to get result	1/π	2 π	½ π
xlvii.	Acceleration of mass spring system is	Uniform	Variable due to change in direction	Variable due to change in magnitude	**Both B&C**
xlviii.	The unit used for factor $\sqrt{\frac{l}{g}}$ may be	Meter	**Second**	Kilogram	Radian
As T=2π$\sqrt{\frac{l}{g}}$ in this formula 2π has no dimension, so $\sqrt{\frac{l}{g}}$ has unit of time also $\left(\frac{m}{ms^{-2}}\right)^{1/2} = \left(s^{-2}\right)^{1/2} = s$					
xlix.	The acceleration of body performing SHM depends upon its	Mass	Time period	Amplitude	**Displacement**

l.	If the time period of simple pendulum is doubled its amplitude becomes	**Remains same**	Doubled	Half	1.41 as large
Time period is independent of amplitude of simple pendulum					
li.	The wave length used in micro wave oven is	**12cm**	10cm	24 cm	2470 cm
lii.	10cm extension is produced in a spring due to a force of 20N. the spring constant is	2 N/m	20 N/m	**200 N/m**	2000 N/m
As extension x=10cm=10/100=0.1m, F=20N, K=F/x= 20/0.1=200 N/m					
liii.	If length of simple pendulum becomes double then time period	Increase double	**Increase 1.41 times**	Increase 4 times	Decrease 1.41 times
As time period is directly proportional to sq.rt of length					
liv.	One complete round trip of body in motion is called	Frequency	Amplitude	**Vibration**	Time period
lv.	The expression for restoring force is	F=Kx	F=ma	F=dp/dt	**F= -Kx**
lvi.	A quantity which indicates the state and direction of vibrating body is called	Time period	Amplitude	**Phase**	Frequency
lvii.	For vibrating mass-spring system, the expression of kinetic energy at any displacement 'x' is given by:	$\frac{1}{2}kxo^2(1-\frac{x^2}{x_o^2})$	$\frac{1}{2}m\omega(1-\frac{x^2}{x_o^2})$	$\frac{1}{2}kx_o^2$	$\frac{1}{2}mx_o w^2$
lviii.	When soldiers cross a bridge, they are advised to march out of step due to	**Resonance**	High frequency	Noise produced	Fact that bridge is weak
lix.	Which of the following quantity can be expressed in Kgs^{-2}	**Spring constant**	Density	Momentum	Force
lx.	The wavelength of transverse wave travelling with speed v having frequency f is equal to	f/v	Vf	**V/f**	f/V^2
lxi.	When a particle is moving along a circular path, its projection along the diameter executes	Linear motion	Vibratory motion	Rotatory motion	**SHM**
lxii.	A simple pendulum complete 20 vibrations in 5 sec, frequency will be	2 Hz	3 Hz	5Hz	**4Hz**
lxiii.	the dimension of spring constant are	$[MT^{-1}]$	**$[MT^{-2}]$**	$[MT^{-3}]$	[MT]
lxiv.	Oscillations of shock absorber of car is an example of	SHM	Forced oscillations	**Damped oscillations**	Undamped oscillations
lxv.	Potential energy at mean position in SHM	Maximum	Equal to K.E	**Zero**	Negligible
lxvi.					
lxvii.	The maximum velocity in SHM	$x_o\omega$	$x_o\omega^2$	$x\omega$	$x\omega^2$
xviii.	Food being cooked in microwave oven is an example	Beats	**Resonance**	Overtones	Stationary waves

lxix.	What should be the ration of kinetic energy to total energy for simple harmonic oscillator? Hint take ratio of both to get the result	$1-\frac{X^2}{X_o^2}$	$(Xo^2 - X^2)$	1	$\frac{1}{2}X^2$
lxx.	Resonance occurs when the driving frequency is:	Greater than natural frequency	Less than natural frequency	Unequal the natural frequency	**Equal to the natural frequency**
lxxi.	What should be the length of simple pendulum whose period is 6.28 second at a place where g = 10 ms^{-2}.	0.28 m	6.28 m	10 m	10.8 m
apply formula of time period, $6.28 = 2\pi\sqrt{\frac{l}{10}} = l = 10m$ as T=6.28m and 2pi has 6.28 value					
lxxii.	A body performs simple harmonic motion with a period of 0.063 s. The maximum speed of 3.0 ms^{-1}. What are the values of the amplitude 'x_o (m) and angular frequency 'ω ($rads^{-1}$)	$x_o = 5.3$, $\omega = 16$	**$x_o = 0.03$, $\omega = 100$**	$x_o = 0.19$, $\omega = 16$	$x_o = 3.3$, $\omega = 100$
$\omega = \frac{2\pi}{T} = \frac{2*3.14}{0.063} = 100, x_o = \frac{v}{w} = \frac{3}{100} = 0.03m$					
xxiii.	Frequency of simple pendulum of length 9.8 m will be	2 π Hertz	**1/2π Hertz**	π/2 Hertz	π/4 Hertz
Apply formula for frequency of pendulum to put l=9.8m and g=9.8ms^{-2}, to get the result					

Chapter 08 waves

Wave: It is the mechanism by which energy is transferred from one place to another.

Types of waves: There are following types of waves

Mechanical waves: The waves which need material for their propagation are called mechanical waves. For example water waves, sound waves, string waves.

Electromagnetic waves: The waves which do not need material medium for their propagation are called electromagnetic waves. For example radio waves, light waves etc.

Matter waves: The waves which are associated with motion of particles are matter waves. For example motion of electron.

Progressive/travelling waves: The waves which transfer energy by moving away from the source of disturbance are called progressive or travelling waves. They have two types (i) transverse waves (ii) longitudinal waves.

Transverse waves: The waves in which particles of medium are perpendicular to direction of propagation of waves are called travelling waves. Waves produced in water and rope.

Longitudinal/compressional waves: The waves in which particles of medium are parallel to direction of propagation of waves are called longitudinal waves. For example sound waves.

Why sound waves are longitudinal in nature: Both types of waves can be set up in solids. In fluids, however, transverse wave die out very quickly and usually cannot produced at all. That's why, sound waves in air are longitudinal in nature.

Periodic waves: The waves which are produced by the continuous and rhythmic disturbances in medium are called periodic waves. For example waves in oscillating mass spring system.

Transverse periodic waves: The periodic waves in which the displacement of particles of medium is perpendicular to the direction of motion of waves are called transverse periodic waves.

Crest: The part of transverse waves which is above the mean level is called crest

Trough: The part of transverse wave which is below the mean level is called trough

Wavelength: The distance b/w two consecutive crest or two trough denoted by Greek letter λ is wavelength.

Amplitude: The maximum displacement of point in crest or trough of wave is called amplitude

Time period: The time for which a wave travel a distance of wavelength is called time period.

Frequency: The number of waves passing through a medium in one second is called frequency. f=1/T.

Speed of wave: The distance covered by a wave in 1 second is called speed of wave.

Prove that v=fλ:

$$\text{Speed} = \frac{\text{Distance covered by wave}}{\text{Time interval}}$$

$$v = \frac{\lambda}{T} = \lambda * \frac{1}{T} = \lambda f \quad \text{as} \ \frac{1}{T} = f$$

$$v = f\lambda$$

Phase angle of wave: $\varphi = \frac{2\pi x}{\lambda}$

Longitudinal/ Compressional periodic waves: The periodic waves in which particles of medium vibrate along the direction of motion of waves are called longitudinal periodic waves.

Derive Newton and Laplace formula for Speed of sound in air.

Speed of sound depends upon as $v = \sqrt{E/\rho}$

(i) Compressibility of medium
(ii) Inertia(density) of medium

Newton formula for speed of sound in air: Newton assumed that sound waves passing through air at constant temperature (isothermal process) so by using Boyle law, he calculated the formula for speed of sound

$P_1V_1 = P_2V_2$

When sound waves passes pressure increases and volume decreases so,

$PV = (P + \Delta P)(V - \Delta V)$

$PV = PV - P\Delta V + V\Delta P - \Delta P\Delta V$, As $\Delta P\Delta V$ is small quantity so it is neglected

$PV = PV - P\Delta V + V\Delta P$

$0 = -P\Delta V + V\Delta P$

$P\Delta\Delta = V\Delta\Delta$

$$P = \frac{\Delta P}{\Delta V/V} = \frac{\text{Stress}}{\text{Strain}} = E$$

$P = E$ putting in speed of sound formula $V = \sqrt{E/\rho}$ we get

$V = \sqrt{P/\rho}$, AT STP, $P = 1.01*10^5\ Nm^{-2}$, $\rho = 1.29\ kgm^{-3}$,

$V = \sqrt{1.01*10^5/1.29} = 280$ m/s. and experimental value of speed of sound is 332 m/s which is 16% more this.

Laplace correction: Laplace assumed that during compression and rarefaction temperature of system changes but during compression and rarefaction energy is transferred from one place to other due to fast response under adiabatic. $PV^\gamma = \text{Constant And } \gamma = Cp/Cv$ and for air $\gamma = 1.4$.

Process. In this case Boyle law becomes

$PV^\gamma = (P + \Delta P)(V - \Delta V)^\gamma$

$PV^\gamma = (P + \Delta P)V^\gamma(1 - \frac{\Delta V}{V})^\gamma$

$P = (P + \Delta P)(1 - \frac{\Delta V}{V})^\gamma$, now using bionomial expansion $(1-x)^n = 1 - nx + \text{higher power terms...}$

$P = (P + \Delta P)(1 - \gamma\frac{\Delta V}{V} + ...)$

$P = P - \gamma P\frac{\Delta V}{V} + \Delta P - \gamma\Delta P\frac{\Delta V}{V}$, neglecting $\gamma\gamma\Delta\frac{\Delta V}{V}$ due to small value

$P = P - \gamma P\frac{\Delta V}{V} + \Delta P$

$\gamma P\frac{\Delta V}{V} = \Delta P$

$$\gamma P = \frac{\Delta P}{\frac{\Delta V}{V}} = \frac{stress}{strain} = E$$

$\gamma P = E$ putting the formula of speed of sound in air $v = \sqrt{\frac{E}{\rho}}$

$v = \sqrt{\frac{\gamma P}{\rho}}$ This is the laplace formula for speed of sound in air.

$\gamma = 1.4$ $P = 1.01*10^5$ Pa, $\rho = 1.29\ kgm^{-3}$

$v = \sqrt{\frac{1.4*1.01*10^5}{1.29}} = 333$ m/s This is close to the experimental value of speed of sound.

Describe Effects of variation of pressure density and temperature on speed of sound in air.

Effect of pressure on speed of sound: Speed of sound remains same $v = \sqrt{\frac{\gamma P}{\rho}}$ as density is proportional to the pressure. When pressure of gas is increased, density of gas also increases.

Effect of density on speed of sound: As $v = \sqrt{\frac{\gamma P}{\rho}}$, so at constant temperature and pressure Speed of sound is inversely proportional to square root of density. $v \propto \frac{1}{\sqrt{\rho}}$.

Speed of sound is four time to its speed in oxygen as density of oxygen is 16 times as that of oxygen.

Effect of temperature on speed of sound: As when a gas is heated at constant pressure then its volume increased and density decreased so speed of sound increased due to increase of temperature. $v_t = v_o + 0.61t$.

The formula for ratio of speed at t°C and 0°C is $\frac{v_t}{v_o} = \sqrt{\frac{T}{T_o}}$

Prove that Vt=Vo+0.61t.

Using the formula For ratio of speed of sound at 0°C and t°C, The ratio of speed of sound

$$\frac{v_t}{v_o} = \sqrt{1 + t/273}$$

$$\frac{v_t}{v_o} = \left(1 + t/273\right)^{1/2}$$

$$v_t = v_o\left(1 + t/273\right)^{1/2}, \text{ using bionomial expansion}$$

$$v_t = v_o\left(1 + \frac{1}{2}\, t/273\right)$$

$$v_t = v_o + v_o t/546$$

$$v_t = v_o + 333t/546$$

$$v_t = v_o + 0.61t.$$

This shows that with one degree Celsius rise in temperature, speed of sound increased by 0.61 m/s.

State Principle of superposition. Define its three cases.

Principle of superposition. "If a particle of medium is simultaneously acted upon number of waves then the resultant displacement of particle is algebraic sum of their individual displacements" $Y = Y_1 + Y_2 + Y_3 + ...$

Cases of superposition principle: There are following three cases of principle of superposition.

Interference: The phenomenon in which two waves having same frequency travelling in same direction

Beats: The phenomenon in which two waves of slightly different frequencies and travelling in same direction

Stationary waves: The phenomenon in which two waves of same frequency travelling in opposite direction.

What is Interference? Define constructive interference and destructive interference.

Interference: The phenomenon in which two waves having same frequency travelling in same direction superpose is called interference.

Constructive interference: when the path difference is an integral multiple of wavelength, displacement of two waves are added up $\Delta s = n\lambda$, this effect is called constructive interference

Destructive interference: when path difference is odd integral multiple of half of the wavelength, the displacement of two waves cancel the effect of each other. This effect is called destructive interference.

$\Delta s = (n + 1/2)\lambda$.

What are Beats? Write its uses.

The phenomenon in which two waves of slightly different frequencies travelling in same direction overlap each other is called beats. f_1-f_2= no of beats per second.

Beats are the periodic vibration of sound b/w maximum and minimum loudness.

Beats are the result of constructive and destructive interference. It means basic principle of beats is interference.

If the frequency difference b/w two waves is greater than 10Hz, than it is difficult to recognize.

Uses of beats: there are following uses of beats

i. Beats produce variety in music
ii. To find unknown frequency of vibrating body
iii. To tune a musical instruments.

What is Reflection of waves? State two cases of reflection in media?

The bouncing back of wave from the boundary of medium is called reflection of waves..

i. When a wave in rare medium is incident on denser medium, it is reflected such that phase of 180° is produced(path difference of λ/2)
ii. If transverse wave in denser medium is incident on a rare medium is reflected without any change in phase(no path difference).

What are Stationary waves?

The waves which are produced by superposition of two waves of having same frequency travelling in opposite direction are called stationary waves.

Node: The points of zero displacement in stationary waves are called node

Antinode: The points of maximum displacement in stationary waves are called antinodes

The distance b/w two consecutive nodes and anti-nodes is **λ/2**. The distance b/w node and anti-node is **λ/4.**

When antinodes are at their extreme position the whole energy is P.E while at passing through equilibrium position, the whole energy is K.E.

Why stationary waves are called standing waves: As nodes remains at rest so the energy remains standing in medium b/w nodes so energy cannot flow through these points, that's why stationary waves are called standing waves.

What are stationary waves? Explain Stationary waves in a stretched string.

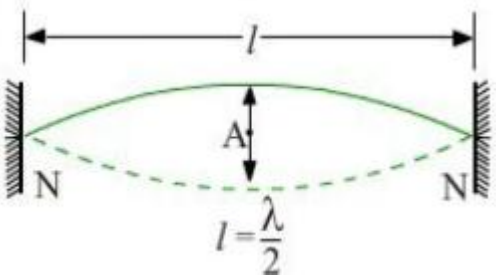
The waves which are produced by superposition of two waves of having same frequency travelling in opposite direction are called stationary waves.

Let us consider a string of length l stretched and is clamped at its two ends with rigid support. The tension in the string is F.

Speed of wave depends upon tension F in the string and mass per unit length $v = \sqrt{\frac{F}{m}}$.

Case 01: First mode of vibration: when the string is plucked at the middle of its length then string vibrates in a single loop as shown in fig. such a mode is called fundamental mode of vibration.

$\text{Distance b/w two consecutive nodes} = l = \lambda/2$



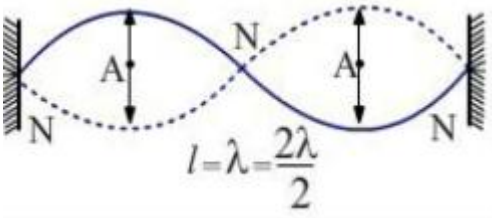
$l = \frac{\lambda_1}{2} \Rightarrow \lambda_1 = 2l$

$\text{As speed of wave} = v = f_1\lambda_1$

$f_1 = \frac{v}{\lambda_1} = \frac{v}{2l}$

$f_1 = \frac{1}{2l}\sqrt{\frac{F}{m}}$ This is the formula for fundamental frequency

Case 02: second mode of vibration: When the string is plucked from one quarter (1/4) of its length the string vibrates into two loops as shown in fig. f_2 is the frequency of 2nd mode vibration.



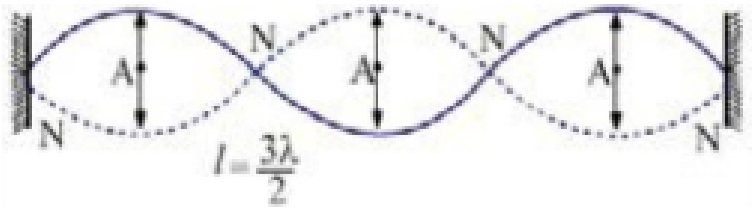
$$l = \frac{\lambda}{2} + \frac{\lambda}{2}$$

$$l = \lambda_2 \qquad \Rightarrow \lambda_2 = l$$

$$f_2 = \frac{v}{\lambda_2} = \frac{1}{l}\sqrt{\frac{F}{m}}$$

$$f_2 = 2 * \frac{1}{2l}\sqrt{\frac{F}{m}}$$

$$f_2 = 2 f_1$$



Thus when the string vibrates in two loops, its frequency becomes double then when it vibrates in one loop.
Similarly by plucking the string properly, it can be made to vibrate in 3 loops then
$f_3=3f_1$ and so on for nth loop
$f_n=nf_1$ n=1,2,3…..
As these discrete and quantized value of frequencies f_1, $2f_1$,$3f_1$,….nf_1 which are called harmonic series.
If the frequency of string on musical instrument changes by changing the tension in string and length of string.

What are stationary waves? Explain Stationary waves in air column?

The waves which are produced by superposition of two waves of having same frequency travelling in opposite direction are called stationary waves.

Organ pipe: An organ pipe is a wind instrument in which sound is produced due to setting up of stationary waves in air column is called organ pipe.

Stationary waves can be set up in air column inside a pipe or tube. A common example of vibrating air column is an organ pipe.

It consists of a hollow long tube both ends open or with one end open and other is closed.

Case 01: Mode of vibration when both ends are open: Let us consider an organ pipe of length l which is open at both ends. In fundamental mode of vibration there is only one node at the middle of the pipe and two anti-nodes at ends. If λ1 is the wavelength of wave then

$$l = \frac{\lambda}{4} + \frac{\lambda}{4} = \frac{\lambda}{2}$$

$$\lambda_1 = 2l$$

$$f_1 = \frac{v}{\lambda_1}$$

$f_1 = \frac{v}{2l}$ This frequency is called fundamental frequency or first harmonic

In second mode of vibration there are anti nodes and two nodes

$$l = \frac{\lambda}{4} + \frac{\lambda}{2} + \frac{\lambda}{4}$$

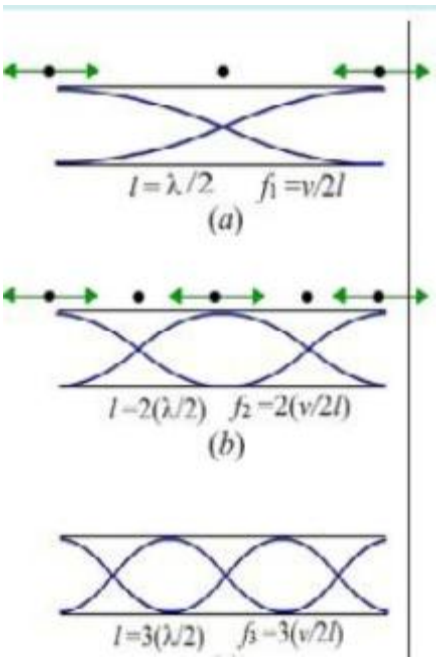
$l = \lambda_2$ for 2nd mode of vibration

$$f_2 = \frac{v}{\lambda_2}$$

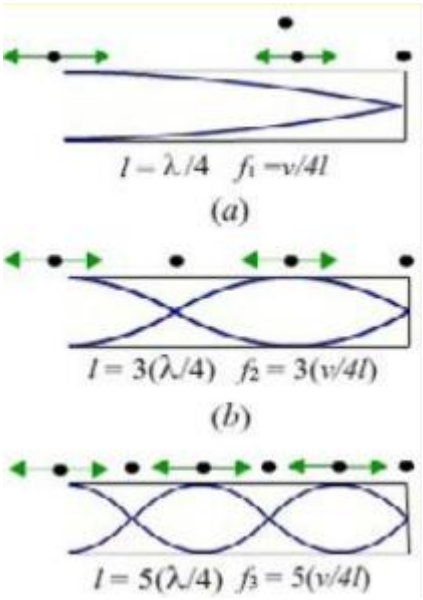
$$f_2 = \frac{v}{l} = 2 * \frac{v}{2l} = 2 f1$$

$f_2 = 2 f_1$ This frequency is for 2nd harmonic, and similarly for nth mode of vibration

$f_n = nf_1$ where $n = 1,2,3....$



Case 02: Modes of vibration in organ pipe closed at one end: let us consider an organ pipe of length l which is closed at one end. At closed end we get



$$l = \frac{\lambda}{4}$$

$$\lambda_1 = 4l$$

$$f_1 = \frac{v}{\lambda_1}$$

$$f_1 = \frac{v}{4l}$$ This is frequency for fundamental frequency

In second mode of vibration there are anti nodes and two nodes

$$l = \frac{\lambda}{4} + \frac{\lambda}{2}$$

$$l = \frac{3\lambda}{4}$$

$$\lambda_2 = 4l/3$$

$$f_2 = \frac{v}{4l/3} = 3\frac{v}{4l}$$

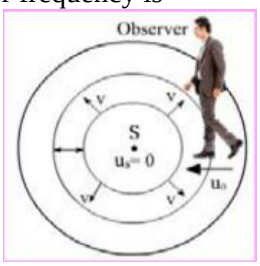
$f_2 = 3f_1$ This frequency is for 2nd harmonic, and similarly for nth mode of vibration

$f_n = nf_1$ n is odd

What is Doppler Effect. Explain its cases.

Definition: The apparent change in the frequency of waves due to relative motion b/w source and observer is called Doppler Effect. This effect was firstly observed by John Doppler while he was observing the frequency of light emitted from a star. In this topic we take the example of source of sound S and an observer O and their relative motion is studies

Case 01: When observer moves towards stationary source: Let us consider an observer A moves towards the source with velocity u_o then the relative velocity of waves and observer is $v+ u_o$. The relation for frequency is

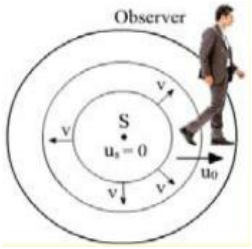


$$f_A = \left[\frac{v + u_o}{\lambda}\right] = \left[\frac{v + u_o}{v/f}\right]$$

$$f_A = \left[\frac{v + u_o}{v}\right] f \quad \text{as} \quad \left[\frac{v + u_o}{v}\right] > 1$$

$f_A > f$ Result : The apparent frequency/pitch of sound heared by observer will increase

Case 02: When observer moves away from the stationary source: Consider observer B moves away from the source with velocity uo then relative velocity of waves and observer $v- u_o$.



$$f_B = \left[\frac{v - u_o}{\lambda}\right] = \left[\frac{v - u_o}{v/f}\right]$$

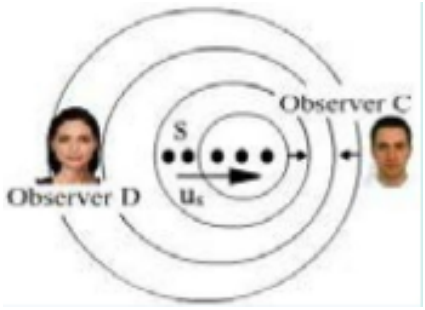
$$f_B = \left[\frac{v - u_o}{v}\right] f \quad \text{as} \quad \left[\frac{v - u_o}{v}\right] < 1$$

$f_B < f$ Result : The apparent frequency/pitch of sound heared by observer will decrease

Case03: When source moves towards the stationary observer: When source moves towards the stationary observer C with velocity then waves are compressed and wavelength is reduced , this decrease in wavelength in one second is called Dopper shift.and is calculated as follows

$$\lambda_c = \frac{v - u_s}{f} = \frac{v}{f} - \frac{u_s}{f}$$

$$\lambda_c = \lambda - \Delta\lambda \qquad \text{as} \quad \Delta\lambda = \frac{u_s}{f} \quad \text{also we know that}$$



$$f_c = \frac{v}{\lambda_c} = \frac{v}{\frac{v - u_s}{f}}$$

$$f_c = \left[\frac{v}{v - u_s}\right] f \qquad \frac{v}{v - u_s} > 1$$

$f_c > f$ Result : Apparent frequency/pitch of sound heard by observer will increase

Case04: When source moves away from the stationary observer: When source moves away the stationary observer D with velocity then waves are expanded and wavelength is increased and is calculated as follows.

$$\lambda_D = \frac{v + u_s}{f} = \frac{v}{f} + \frac{u_s}{f}$$

$$\lambda_D = \lambda + \Delta\lambda \qquad \text{as} \quad \Delta\lambda = \frac{u_s}{f} \quad \text{also we know that}$$

$$f_D = \frac{v}{\lambda_D} = \frac{v}{\frac{v + u_s}{f}}$$

$$f_D = \left[\frac{v}{v + u_s}\right] f \qquad \frac{v}{v + u_s} < 1$$

$f_D < f$ Result : Apparent frequency/pitch of sound heard by observer will decrease.

Explain Applications of Doppler Effect.

There are following applications of Doppler Effect

1) **RADAR:** RADAR stands radio detection and ranging, it is a device which transmits and receives radio waves and used to find the height and speed of aero plane is called RADAR. The system emits radio waves which are reflected from aero plane and received by system.
2) **SONAR**: SONAR stands for sound navigation and ranging. It is technique for detecting the presence of objects under water by echo location. This system uses ultra sound waves because they travel longer distance in water.
3) **Speed of satellite:** Speed of satellite determined by sending EM waves from earth, when these waves are reflected back after striking with satellite, then these waves are received on earth. The value of Doppler shift in wavelength gives the speed of satellite.
4) **Speed of star:** Doppler effect can be used to calculate the speed of star w.r.t Earth. It is done by comparing the line spectrum of light coming from a distant star and the light emitted from lab source.

Blue shift: The frequency of light emitted by star increases (wavelength decreases) if it is moving towards the Earth as compared to light emitted.

Red shift: The frequency of light emitted by star decreases (the wavelength increases) if it is moving away (receding) from earth red shift.

5) **Speed of car:** Microwaves are emitted from a source in form of short bursts. Each burst is reflected back by any moving car, in their way the reflected bursts are detected and Doppler shift is observed and speed is calculated by computer program.

Uses of ultrasonic waves and high frequency radio waves: Ultrasonic waves are useful for undersea communication and detection systems. High frequency radio waves used in radar travel just a few centimeter in water. Whereas highly directional beams of ultrasonic waves can be made to travel many kilometers.

Range of hearing

Organisms	Frequencies(Hz)
Dolphin	150-150,000
Bat	1000-120,000
Cat	60-70,000
Dog	15-50,000
Human	20-20,000

Types of gas	γ
Monoatomic	1.67
Diatomic	1.40
Polyatomic	1.29

1) What happens when a jet plane like Concorde flies faster than speed of sound? OR What is sonic boom?

A conical surface of concentrated sound energy sweeps over the ground as a supersonic place passes overhead. It is known as sonic boom.

2) Under what condition a standing wave pattern is formed?

A standing wave pattern is formed when the length of string is an integral multiple of half wavelength, otherwise no standing wave is formed.

3) **What is primary driving mechanism in organ pipe**?

It is wavering. Sheet like jet of air from flute slit which interacts with the upper lip and air column in pipe to maintain a steady oscillation.

4) How dolphin use echolocation?

Echolocation allows the dolphins to detect small differences in the shape, size and thickness of objects.

5) How Doppler Effect used to monitor blood flow?

Doppler Effect can be used to monitor blood flow through major arteries. Ultrasound waves of frequencies 5MHz to 10MHz are directed towards the artery and receiver detects the back scattered signal.

6) **On which apparent frequency of blood flow depend**?

The apparent frequency depends on the velocity of flow of the blood.

7) **How bat navigate & find food**?

Bat navigate and find food by echolocation

Exercise Short Questions chapter 08

1 .*What features do longitudinal waves have in common with transverse waves?*

1) In both waves, particles of the medium vibrate about their mean position. 2) Transport energy and momentum but not matter. 3) When propagate in a medium they obey, $v = f\lambda$

2. (a) trace B represents the loudest note. b) trace B represents the highest frequency**.**

3. *Is it possible for two identical waves travelling in the same direction along a string to give rise to a stationary wave?*

No. It is not possible. For stationary waves two identical waves should travel in opposite direction along a string.

4.A wave is produced along a stretched string but some of its particles permanently show zero displacement. What type of wave is it?

Stationary wave. Here nodal points show permanently zero displacement.

5 *Explain the terms crest, trough, node and antinode.*

Crest: "The portion of a transverse wave above the mean level".

Trough: "The lower portion of transverse wave below the mean level".

Node: "The point of zero displacement in stationary waves" are called nodes

Antinode: "The point of maximum displacement on a stationary wave" are called anti nodes.

6. Why does sound travel faster in solids than in gases?

In the relation $v = \sqrt{E / \rho}$ Elastic modulus E is greater for solids than in gases. The effect of density, ρ is very less as compared to E. so sound travel faster in solids then in gases.

7. *How are beats useful in tuning musical instruments?*

A new instrument is tuned. The new, and standard musical instruments are sounded together, beats are produced. The frequency of the new instrument is made to change until the resonance occurs.

8. Correct answer is (iii) ($f_1 - f_2$)

Number of beats per second is equal to the difference between the frequencies of the tuning forks.

9. As a result of distant explosion, an observer senses a ground tremor and then hears the explosion. Explain the time difference

Sound waves travel faster in solids than in air. The sound waves produced by the explosion travel two paths. One through earth reaches faster than traveling through atmosphere. This accounts for the time difference.

10 ***Explain why travels sound faster in warm air than in cold air.***

$v \propto \sqrt{T}$ The speed of sound varies directly as the square root of absolute temperature. That's why sound travels faster in warm air than in cold air. As the temperature of air increases, the pressure increases and density decreases. So speed of sound increases.

11 ***How should a sound source move with respect to an observer so that the frequency of its sound does not change?***

If the relative velocity b/w source and observer is zero, there will no change in frequency of sound. For example when observer is at origin and source moves along the circumference of circle or both source and observer are moving in same direction with same velocity.

Chapter 08

8.1: The wavelength of the signals from a radio transmitter is 1500 m and frequency is 200 kHz. What is the wavelength for a transmitter operating at 1000 kHz and with what speed the radio waves travel?

$$\text{Given data}: \text{wavelength} = \lambda_1 = 1500\text{m},\ f_1 = 2000KHz,\ f_2 = 1000KHz, \lambda_2 = ?, v = ?$$

$$sol: v = f_1\lambda_1 = 2000*10^3 \text{x} 1500 = 30*10^8 \text{m/s},\ \text{v} = \text{f}_2\lambda_2 \Rightarrow \lambda_2 = \frac{\text{v}}{\text{f}_2} = \frac{3*10^8}{1000*10^3} = 300m$$

8.2: Two speakers are arranged as shown in fig. 8.24. The distance between them is 3m and they emit a constant tone of 344 Hz. A microphone P is moved along a line parallel to and 4.00 m from the line connecting the two speakers. It is found that tone of maximum loudness is heard and displayed on the CRO when microphone is on the center of the line and directly opposite each speakers. Calculate the speed of sound.

$$\text{Given Data}: \text{frequency} = \text{f} = 344\,\text{Hz}, \text{path diff} = \lambda = \text{S}_2\text{P} - \text{S}_1\text{P} = 5 - 4 = 1m, v = ?$$

$$sol: v = f\lambda = 344*1 = 344Hz$$

8.3: A stationary wave is established in a string which is 120 cm long and fixed at both ends. The string vibrates in four segments, at a frequency of 120 Hz. determine its wavelength and the fundamental frequency?

$$\text{Given Data}: \text{length of string} = \text{l} = 120\text{cm} = 120/100 = 1.2\text{m},\ \text{n} = 4,\ \text{f}_4 = 120\ \text{Hz}, \lambda = ?, \text{f}_1 = ?$$

$$\text{sol}: \lambda = \text{l}/2 = 1.2/2 = 0.6\text{m}, \quad \text{f}_\text{n} = \text{nf}_1 \Rightarrow \text{f}_4 = \text{nf}_1 \Rightarrow \text{f}_1 = \frac{\text{f}_4}{n} = \frac{120}{4} = 30Hz$$

8.4: The frequency of the note emitted by a stretched string is 300 Hz. What will be the frequency of this note when; (a) the length of the wave is reduced by one-third without changing the tension. (b) The tension is increased by one-third without changing the length of the wire.

$$(\text{a})\ \text{f} = 300, \text{f} = ? \text{ when wavlength is reduced by one third}$$

$$v = f\lambda ---(1), v = f'(\lambda - \lambda/3) = 2f'\lambda/3 -----(2) \text{ comparing both (1) \& (2)}$$

$$\text{f}\lambda = 2\text{f}'\lambda/3 \ \Rightarrow \text{f} = 2\text{f}'/3 \Rightarrow \text{f}' = 3\text{f}/2 = 3*300/2 = 450\ \text{Hz}$$

$$(\text{b})\ \text{f} = \frac{1}{2\text{l}}\sqrt{\frac{\text{F}}{\text{m}}} \text{----(1)}, \text{f}' = \frac{1}{2\text{l}}\sqrt{\frac{\text{F}+\text{F}/3}{\text{m}}} = \text{f}' = \frac{1}{2\text{l}}\sqrt{\frac{4\text{F}/3}{\text{m}}} -----(2) \text{dividing both eq}$$

$$\frac{\text{f}'}{\text{f}} = \frac{\frac{1}{2\text{l}}\sqrt{\frac{4\text{F}/3}{\text{m}}}}{\frac{1}{2\text{l}}\sqrt{\frac{\text{F}}{\text{m}}}} \Rightarrow \text{f}' = \sqrt{\frac{4}{3}}f = \sqrt{\frac{4}{3}}*300 = 346Hz$$

8.5: An organ pipe has a length of 50 cm. Find the frequency of its fundamental note and the next harmonic when it is (a) Open at both ends. (b) Closed at one end. $(Speed\ of\ sound = 340 ms^{-1})$.

length of pipe = l = 50cm = 50/100m = 0.5m, v = 350 m/s, fundamental frequencies in both cases = ?

(a) when pipe is open at both ends: $f_n = \frac{nv}{2l}, f_1 = \frac{(1)(350)}{2(0.5)} = 350Hz, f_2 = \frac{(2)(350)}{2(0.5)} = 700Hz$

(a) when pipe is closed at one end: $f_n = \frac{nv}{4l}, f_1 = \frac{(1)(350)}{4(0.5)} = 175Hz, f_2 = \frac{(3)(350)}{4(0.5)} = 525Hz$

8.6: A church organ consists of pipes, each open at one end, of different lengths. The minimum length is 30 mm and the longest is 4 m. calculate the frequency range of the fundamental notes $(Speed\ of\ sound = 340 ms^{-1})$

given data: $l_{min} = 30mm = 30*10^{-3} m, l_{max} = 4m, v = 340\ m/s, f_{min} = ?, f_{max} = ?$

$f_{max} = \frac{nv}{4l_{min}} = \frac{1*340}{4*30*10^{-3}} = 2833Hz, f_{min} = \frac{nv}{4l_{max}} = \frac{1*340}{4*4} = 21.25Hz$

8.7: Two tuning forks exhibit beats at a beat frequency of 3 Hz. The frequency of one fork is 256 Hz. Its frequency is then lowered slightly by adding a bit of wax to one of its prong. The two forks then exhibit a beat frequency of 1Hz. Determine the frequency of the second tuning fork.

Given Data: $f_1 = 256$ Hz, beat frequency before load wax = 3Hz, Beat f after loading = 1Hz, $f_2 = ?$

$f_1 - f_2 = \pm n \Rightarrow f_2 = f_1 \pm n = 256 \pm 3 = 259$Hz or 253Hz, As the no. of beats per sec decrease on loading first fork is one so correct answer is 253Hz

8.8: Two cars P and Q are travelling along a motorway in the same direction. The leading car travels at a steady speed of 12ms^{-1}; the other car Q, travelling at a steady speed of 20 ms^{-1}, sound its horn to emit a steady note which P's driver estimates, has a frequency of 830 Hz. What frequency does Q's own driver hear? $(Speed\ of\ sound = 340 ms^{-1})$.

given data: speed of car $= v_p = 12$m/s, $u_Q = 20$m/s, v = 340 m/s, $f_p = 830$ Hz, $f_Q = ?$

$u_s = u_Q - u_p = 20 - 12 = 8$m/s, $\Rightarrow f' = (\frac{v}{v - u_s}) f \Rightarrow 830 = (\frac{340}{340 - 8}) f \Rightarrow f = 810.5Hz$

TID BITS/USEFUL INFORMATION

1) Which waves are particularly useful for undersea communication an detection system?

a) Ultra sonic waves	b) Micro waves	c) Radio waves	d) Sound waves

2) High frequency radio waves travel --- in water

a) Few meter	**b) Few centimeter**	c) Few kilometer	d) Few milli meter

3) Highly directional beam of ultrasonic waves can be mad to travel

a) Few meter	b) Milli meter	**c) Many kilo meter**	d) None

4) Speed of sound in lead at 20°C

a) 1320 m/s	b) 3600 m/s	c) 5100 m/s	d) 5130 m/s

5) Speed of sound in copper at 20°C

a) 1320 m/s	**b) 3600 m/s**	c) 5100 m/s	d) 5130 m/s

6) Speed of sound in aluminum at 20°C

a) 1320 m/s	b) 3600 m/s	**c) 5100 m/s**	d) 5130 m/s

7) Speed of sound in iron at 20°C

a) 1320 m/s	b) 3600 m/s	c) 5100 m/s	**d) 5130 m/s**

8) Speed of sound in glass at 20°C

a) 5100 m/s	**b) 5500 m/s**	c) 5130 m/s	d) 3600 m/s

9) Speed of sound in methanol at 20°C

a) 1320 m/s	b) 3600 m/s	c) 5100 m/s	**d) 1120 m/s**

10) Speed of sound in water at 20°C

a) 1320 m/s	**b) 1483 m/s**	c) 5100 m/s	d) 5130 m/s

11) Speed of sound in CO_2 at STP

a) 258 m/s	b) 315 m/s	c) 332 m/s	d) 972 m/s

12) Speed of sound in oxygen at STP

a) 315 m/s	b) 332 m/s	c) 333m/s	d) 345 m/s

13) Speed of sound in helium at STP

a) 258 ms	b) 315 m/s	**c) 972 m/s**	d) 1286 m/s

14) Speed of sound in hydrogen at STP

a) 258 ms	b) 315 m/s	c) 972 m/s	**d) 1286 m/s**

15) Range of hearing for dolphin is(Hz)

a) 150-150,000	b) 1000-120,000	c) 60-70,000	d) 15-50,000

16) Range of hearing for bat is(Hz)

a) 150-150,000	**b) 1000-120,000**	c) 60-70,000	d) 15-50,000

17) Range of hearing for cat is(Hz)

a) 150-150,000	b) 1000-120,000	**c) 60-70,000**	d) 15-50,000

18) Range of hearing for dog is(Hz)

a) 150-150,000	b) 1000-120,000	c) 60-70,000	**d) 15-50,000**

19) Range of hearing for human is(Hz)

a) 150-150,000	b) 1000-120,000	c) 60-70,000	**d) 20-20,000**

20) Which waves cause the candle flame to flicker

a) Light waves	**b) Sound waves**	c) Heat waves	d) None

21) A conical surface of concentrated sound energy sweeps over the ground as supersonic place passes overhead is known as

a) Beats	b) Echo	**c) Sonic beam**	d) Doppler shift

22) A standing/stationary wave pattern is formed when the length of string is an integral multiple of--

a) Half wavelength	b) Wavelength	c) Double wavelength	d) One fourth wavelength

23) In organ primary driving mechanism is

a) Beats	b) Stationary waves	c) Sound waves	**d) Wavering**

24) Which allow the dolphin to detect small differences in the shape, size and thickness of objects?

a) Beats	b) Sound waves	**c) Echo location**	d) None

25) Doppler effect can be used to monitor blood flow through major arteries in which ultrasound of frequencies are directed toward the artery and receiver detect the back scattered signal

a) 5 MHz to 10 MHz	b) 5 KHz to 10 KHz	c) 5 Hz to 10 Hz	d) 5 GHz to 10 GHz

26) The apparent frequency in artery of blood flow depends upon

a) Velocity of flow of blood	b) Shape of flow of blood	c) Size of flow of blood	d) None

27) --- is used in radar to detect the motion of an aero plane

a) Frequency shift	b) Wave shift	c) Nature of medium	d) Shape of medium

28) Bats navigate and find food by

a) Echo location	b) Shape of flow of blood	c) Size of flow of blood	d) None

BISE AND UHS PAST PAPERS SOLVED MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	The distance between compression and adjacent rarefaction	**λ/2**	λ/4	λ	2λ
ii.	A 2m long pipe is open at both ends. What is its harmonic frequency?	42.5 Hz	220 Hz.	**85 Hz**	None of these.
Put L=2m, v=340, n=1 in formula to get the result		f=nv/2L= 1*340/2*2=340/4=85 Hz			
iii.	A standing wave pattern is formed when the length of string is an integral multiple of _____ wavelength.	Triple	**Half**	Full	Double
iv.	Transverse waves cannot be setup in	Metals	**Fluids**	Solids	Soil
Because there is no mechanism for driving motion perpendicular to the propagation of wave					
v.	The error in the speed of sound calculated by Newton at S.T.P is about	14%	15%	**16%**	17%
vi.	Speed of the waves is equal to:	fλ	λ/T	λT	**Both A and B**
vii.	What is it that we use to calculate the speeds of distant stars and galaxies?	**Doppler Effect**	Beats	Interference	All of the above
viii.	The profile of periodic waves generatred by a source executing SHM is represented by	**Sine wave**	Circle	Tangent wave	Cosine wave
ix.	If the pressure of gas is doubled then speed of sound	Is doubled	Is half	**Is not affected**	Becomes four times
x.	Two sound waves having the same amplitudes are moving in the same direction are out of phase. The amplitude of the resultant wave is	**Zero amplitude**	Difference of the amplitudes of the two waves	The sum of amplitude of the two waves	Double the amplitude of either wave
xi.	On increasing the tension, the frequency of vibration is	**Increases**	Decreased	Remains same	None of these
xii.	A source 'Y' of unknown frequency produces 4 beats with a source of 240 Hz and 8 beats with a sound of 252 Hz. Frequency of the source 'Y' is	**244 Hz** Apply beats formula to get result as 252-8=244 Hz with y source	248 Hz	236 Hz	246 Hz
xiii.	The wavelength of fundamental node of vibration of both end closed pipe of length l is	l	l/2	**2l**	4l
xxiv.	The spectrum of a star's light is measured and the wavelength of one of the lines as the sodium's line is found to be 589 nm. The same line has the wavelength of 497 nm when observed in the laboratory. This means the star is	**Moving away from the earth** By applying Doppler shift relation	Stationary	Moving towards the north	Revolving around the planet
xiv.	A source of sound wave emits waves of frequency 'f'. If 'v' is speed of sound waves, then what will be the wavelength of the waves	$\frac{\mathbf{v}}{\mathbf{f}}$ **ans**	vf	$\frac{v + u_o}{f}$	$(v - u_o)f$
xv.	An organ pipe closed at one end has a length of 25 cm. Wavelength of the fundamental note is	25 cm	**100 cm** λ=4L=4*25=100cm	50 cm	75 cm
xvi.	Speed of sound has maximum value in	Oxygen	**Hydrogen**	Helium	Air
xvii.	The distance between two consecutive anti node is	**λ/2**	λ/4	λ	2λ
xviii.	If 332 waves pass through a medium in one second with speed of 332 m/s, then wavelength is	**1 m**	7 m	332 m	664 m
As we know that frequency is no of waves passes in one second so f=332 Hz, v=332 m/s, λ=v/f=332/332=1m					
xix.	Louder the sound, the greater will be its	**Amplitude**	Wavelength	Speed	Frequency

xx.	A metallic wire of length 2m hooked between two points has tension 10N. If mass per unit length is 0.004 kg/m, their fundamental frequency emitted by wire on vibration is	48 Hz	6.25 Hz	24 Hz	**12.5 Hz** apply formula for fundamental frequency of vibration
xxi.	Beats are used to find	**Frequency**	Wavelength	Speed	Intensity
xxii.	Speed of sound in air depends upon	Temperature	Density	Humidity	**All of these**
xxiii.	Which one of these media both transfer longitudinal and transverse waves?	**Solid**	Liquid	Gas	Plasma
xxiv.	Audible frequency range for younger person is	20-200 Hz	20-2000 Hz	**20-20000 Hz**	2000-20000Hz
xxv.	For same mass and length if tension of vibrating string is four times then speed of wave increase by	**2 times**	4 times	6 times	8 times
	Speed of wave is directly proportional to sq.rt of tension				
xxvi.	Beats are easily detectable upto frequency upto two frequency difference between two sounds	2 Hz	6Hz	**10 Hz**	32 Hz
xxvii.	The velocity of sound is maximum at 20°C in	Lead	Copper	**Glass**	Iron
xxviii.	Which one is correct relation for one end closed pipe fn=?	2l/n	4l/n	nv/l	**nv/4l**
xxix.	Speed of sound at t°C is given by	**Vt=v0+0.61t**	V0=vt+0.61t	Vt=0.61t	Vt=280+0.61t
xxx.	Distance between crest and trough is	λ	λ/2	**λ/4**	2λ
xxxi.	Speed of sound at 2°C is given as at 0°C is 332 m/s	**333.2 m/s**	33 m/s	335 m/s	232 m/s
	As Vt=Vo+0.61t, put Vo=332, t=2, Vt=332+0.61*2=332+1.2=333.2 m/s				
xxxii.	Stationary waves are generated on string of length l its fundamental frequency is given by	$f_1 = v/l$	$f_1 = 2v/l$	$f_1 = v/2l$	$f_1 = v2l$
xxxiii.	Two identical tuning fork vibrating simultaneously, the number of beats per second is equal to	**Zero**	One	Two	Three
xxxiv.	Sound waves can only travel through	Vaccume	Ether	**Material medium**	Non metals
xxxv.	Laplace formula for velocity of air	$v = \sqrt{\frac{P}{\rho}}$	$v = \sqrt{\frac{\gamma P}{\rho}}$	$v = \sqrt{\frac{\gamma}{\rho}}$	None of these
xxxvi.	In stationary waves, particle velocity at node is	Maximum	Minimum	**Zero**	Medium
xxvii.	Longitudinal waves do not show	Reflection	Diffraction	Refraction	**Polarization**
xxviii.	Speed of sound is greater in solids then in gases due to high value of	Density	Pressure	**Elasticity**	All of these
xxxix.	When two note of f1 and f2 and f1>f2 then frequency of beat is	**f_1-f_2**	f_2-f_1	½ (f_1-f_2)	½ (f_2-f_1)
xl.	How much velocity of sound changes when rise of 1°C temp	0.61 cm/sec	**0.61 m/s**	61 m/s	6.1 m/s
xli.	Speed of sound at 20°C is given as at 0°C is 332 m/s	348.2 m/s	**344.2 m/s**	340m/s	348 m/s
	As Vt=Vo+0.61t, put Vo=332, t=20, Vt=332+0.61*20=332+12.2=344.2 m/s				
xlii.	Number of node between two consecutive anti node is	**1**	2	3	0
xliii.	Periodic alternation between sound of maximum and minimum loudness is called	Destructive interference	**Beats**	Reflection	Diffraction

xliv.	The frequency of vibration for nth mode of vibration for stationary longitudinal waves in a pipe open at both ends	$fn = \frac{nv}{4l}$	$fn = \frac{nv}{2l}$	$fn = \frac{2l}{nv}$	$fn = \frac{4l}{nv}$
xlv.	The waves which propagate by the oscillation of material particle are called	**Matter waves**	Magnetic waves	EM waves	Mechanical waves
xlvi.	To monitor blood flow ultrasonic waves of frequency are used	**5MHz to 10 MHz**	25MHz to 30 MHz	9MHZ to 90MHz	20MHz to 200MHz
xlvii.	Density is increased four times then speed of sound	Increase four times	**Decrease two times**	Decrease four times	Remains same
xlviii.	The portion of wave below the mean level is	Crest	**Trough**	Node	Anti-node
xlix.	When a transverse waves is reflected on going from a denser medium to a rare medium then	There is 180^o phase shift	**There is no change in phase**	A crest is covered with trough	A trough is covered into crest
l.	A set of frequencies which is the multiple of fundamental frequency is called	Beat frequency	**Harmonics**	Doppler frequencies	Nodal frequencies
li.	The ratio Cp/Cv for diatomic gas is	1.67	1.5	**1.4**	1.29
lii.	The waves which donot require any medium for their propogation	Mechanical waves	Matter waves	**EM waves**	Compressional waves
liii.	When a star is receding the earth it show	Blue shift	**Red shift**	Green shift	Yellow shift
liv.	The louder the sound, greater will be	Speed	**Amplitude**	Frequency	Wavelength
lv.	Speed of sound is independent of	**Pressure**	Density	Temperature	All of these
lvi.	The point of maximum displacement on a stationary wave is called	Node	**Anti-node**	Crest	Trough
lvii.	Speed of sound in vacuum is	332 m/s	340 m/s	**0 m/s**	1000 m/s
lviii.	Star moving away from the earth shows	**Red shift**	Blue shift	Doppler shift	Frequency shift
lix.	A mechanical wave is represented by	Light	Sound	**Compressional wave**	Heat
lx.	The fixed ends of a vibrating string are	Anti-node	**Node**	Over tones	Neither node nor anti node
lxi.	The distance b/w 1^{st} node and 4^{th} anti node is	**7λ/4**	5λ/4	13λ/4	11λ/4
As distance b/w two consecutive node and anti node is λ/4 so distance from 1^{st} node to 4^{th} anti node is					
lxii.	The string of length l fixed at both ends is vibrating in two segments the wavelength of wave is	**l**	2l	l/4	4l
lxiii.	When two identical wave move in the same direction they give rise to	Standing wave	**Interference**	Beats	None of these
lxiv.	A stretched string 4m long and it has 4 loops of stationary wave. Wavelength	1m	**2 m**	3 m	4m
As for 4 loops l=2λ so λ=l/2=4/2=2m					
lxv.	Theory of waves used in "Sonar" are	EM waves	Matter waves	Water waves	**Sound waves**
lxvi.	With rise of temperature the velocity of sound	Decrease	**Increase**	Remains constant	Becomes zero
lxvii.	The wavelength of stationary waves produced in a string of length l in first mode of vibration will equal	l/2	L	**2l**	l/4
lxviii.	Two waves having same frequency and travelling in opposite direction will produce	**Stationary waves**	Constructive interference	Destructive interference	Beats
lxix.	At the open end of an organ pipe	Nodes are formed	**Anti-nodes are formed**	Both node and anti-node formed	Neither anti node nor node formed
lxx.	A stationary wave is established in a string which vibrates in four segments at	15Hz	**30 Hz**	60 Hz	480Hz

	a frequency of 120Hz, its fundamental frequency is				
As $f_n=nf_1$, $120=4f_1$, $f_1=120/4=30$ Hz					
lxxi.	Which EM waves are used as medium in satellite communication system	**Micro waves**	Radio waves	Infra-red waves	Ultra violet waves
lxxii.	The portion of wave above mean level is	**Crest**	Trough	Node	Anti-node
lxxiii.	The location of submarines can be detected by	**Doppler effect**	Temperature effect	Diffraction	Compton effect
lxxiv.	Sound waves cannot be	Reflected	Refracted	**Polarized**	Diffracted
lxxv.	Radar system is an application of	Interference	Beats	Stationary waves	**Doppler effect**
lxxvi.	Sound waves cannot travel through	Air	Water	Material medium	**Vaccum**
xxvii.	The speed of sound in air would become double then its speed at 20°C at	313°C	586°C	1172°C	**899°C**
For explanation see exp no 8.1, T=20°C=20+273=293K by using short formula Vt=factor^2*given temperature $=2^2*293=1172$K again conversion into centigrade, 1172-273=899°C					
xxviii.	Two fork of frequencies 260Hz and 257 Hz are sounded together, number of beats per second is	Zero	4	**3**	257
No of beats=f1-f2=260-257=3					
lxxix.	Car A has siren sounding a note of 540Hz. A listener in car B has 544 Hz move in same direction one conclude that	B lead A and moves faster	B is behind A and moves slower	Both moves with same speed	**B lead A and moves slower**
lxxx.	Two waves can interfere only if they have	**Phase coherence**	Same velocity	Different frequencies	Different wavelength
lxxxi.	On reflection from denser medium light wave undergoes a phase change of	π radian	**2π radian**	3 $\pi/2$ radian	$\pi/2$ radian
xxxii.	The stationary waves consist of	Crest and trough	Compression and elongations	**Nodes and anti-node**	Reflection and rarefaction
xxxiii.	The pitch of sound depends upon	Intensity of sound	Loudness of sound	Wavelength of sound	**Frequency of sound**
xxxiv.	In order to produce beats, the two waves should have	Same amplitude	Slightly different amplitude	The same frequency	**Slightly different frequencies**
xxxv.	When a wave is reflected from the denser medium then phase of wave changes by	0°	90°	**180°**	270°
xxxvi.	A star is moving towards earth show	**Blue shift**	Violet shift	Red shift	White shift
xxvii.	The basic principle of beats is	**Interference**	Reflection	Diffraction	Refraction
xxviii.	Newton calculated the value of speed of sound in air?	332 m/s	340 m/s	350 m/s	**280 m/s**
xxxix.	Speed of sound is greatest in	Air	**Steel**	Ammonia	Water
xc.	The distance covered by wave in 1 second	Wavelength	Wave number	Frequency	**Wave speed**
xci.	Tuning fork is a source of	Energy	Heat	Light	**Sound**
xcii.	Longitudinal waves are also known as	Stationary waves	Transverse waves	**Compressional waves**	Electro Magnet waves
xciii.	The value of "γ for monoatomic	**1.67**	1.40	1.29	1
xciv.	Half wavelength corresponds to	0°	90°	**180°**	360°
xcv.	Sound travels faster in	CO_2	**H_2**	O_2	He
xcvi.	What is the value of β in expression? $Vt = Vo + \beta t$	273	1/273	**0.61**	1.42

xcvii.	The apparent change in the pitch of sound due to relative motion is called	Carnot theorem	Interference	**Doppler effect**	Beats
xcviii.	Tuning fork is a source of	Energy	Heat	Light	**Sound**
xcix.	Speed of sound in hydrogen is higher than oxygen is	1	2	3	**4**
c.	A spectator watching a cricket match sees the bat striking the ball and hears the sound this about half sec later due to light wave and sound waves difference of	Amplitude	Intensity	Frequency	**Speed**
ci.	If 20 waves are passing through a medium in 1 sec with speed 20 m/s, the wavelength is	0.5 m	**1 m**	20m	2m
Time period=time/no of vib=1/20 then λ=vT=20*1/20=1 m					
cii.	A standing wave pattern is formed when length of string is	**Integral multiple of half wave length**	Integral multiple of full wavelength	Both A and B	None
ciii.	In organ pipe,primary driving mechanism	Slattering	**Wavering**	Fighting	Vibrating
civ.	Sound waves are	Electromagnetic Waves	**Compressional waves**	Transverse waves	Matter waves
cv.	The speed of sound at 40°C is if at 0°C is 332 m/s	340.6 m/s	346.6 m/s	**356.4 m/s**	332 m/s
As Vt=Vo+0.61t, put Vo=332, t=40, Vt=332+0.61*40=332+24.4=356.4 m/s					
cvi.	If a stretched string vibrates in three loops, the relation b/w its length and wavelength of stationary wave is	$l=\frac{\lambda}{3}$	$l=\frac{2\lambda}{3}$	$l=\frac{3\lambda}{2}$	$l=3\lambda$
$L=\frac{\lambda}{2}+\frac{\lambda}{2}+\frac{\lambda}{2}=3\frac{\lambda}{2}$					

CHAPTER 09 PHYSICAL OPTICS

Physical optics: The branch of Physics which deals with study of light and its different phenomenon is called physical optics.

Light: A type of energy which produce the sensation of vision is called light.

What is Wave front, spherical and plane wave front. Also define ray of light.

Wave front: The surface on which all the points of waves have same phase of vibration is called wave front.

Spherical wave front: The wave front in which the light waves are propagated in spherical form with the source is called spherical.

Plane wave front: At very large distance from the source, a small portion of spherical wave front will becomes very nearly plane wave front. As light reaches from sun to earth.

Wavelength and ray of light: The distance b/w two consecutive wave fronts is called wavelength.

Ray of light: The line normal to wave front is called ray of light.

In 1678, a Dutch scientist Huygens proposed that light consists of wave nature.

State Huygens's principle.

Huygens's principle is used to find shape and location of wave front. It has two parts

i. Every point of wave front may be consider as a source of secondary Wavelets which spread out in forward direction with speed equal to speed of wave

ii. The new position of the wave front after a certain interval of time can Be found by constructing a surface that touches all the secondary wavelets.

What is Interference of light? Also define its types and condition for detection of interferometer.

Interference of light: The phenomenon in which when two identical waves travelling in the same direction are superimposed is called interference.

Constructive interference: If the crest of one wave falls on the crest of wave and trough of wave fall on trough then it is called constructive interference.

Destructive interference: If crest of one wave falls on the trough of other wave then they cancel each other such interference is called destructive interference.

Condition for detection of interference: Following conditions are necessary for detection of interference. (i) Monochromatic (ii) coherent etc.

Explain Young Double slit experiment.

Definition: Such an experiment which was performed by Thomas Young in 1801 by applying the principle of interference and prove the wave nature of light is called young Double slit experiment.

Experimental arrangement: A screen having two narrow slits is illuminated by a beam of monochromatic light and portion of wave fronts incidents on the slits behave as source of secondary wavelets and superposition of these waves' results in a series of bright and dark fringes and are seen on screen placing at distance L from slits. The bright fringes are called maxima and dark fringes are called minima

Equation of path difference for maxima and minima: let us consider an arbitrary point P on the screen on one side of central point O. The path Difference b/w wavelets leaving the slits and arriving at point P is BD

For maxima or constructive interference: If point P is to have bright fringe then path difference must be an integral multiple of wavelength

$$\text{Path difference} = BD = m\lambda \text{ ------(1)} \quad \text{where m is order of fringes } m = 0,1,2,...$$

$$\text{from the fig}, \sin\theta = \frac{BD}{d}$$

$$BD = d\sin\theta \text{ ----------(2)}$$

comparing both equations

$$d\sin\theta = m\lambda \quad \text{This is the equation for path differnce of maxima or bright fringes}$$

For Destructive interference or minima: In case of dark fringes then path difference must half integral multiple of wavelength so above equation for minima becomes $d\sin\theta = (m+1/2)\lambda$.

Position of dark and bright fringes: Let Y is the distance of point P from central point O and a bright fringe is formed at P then using triangle POC.

$$\text{Tan}\theta = \frac{OP}{OC} = \frac{Y}{L}$$

$$Y = L\,\text{Tan}\theta \quad \text{For small value of angle } \sin\theta \approx \tan\theta$$

$$Y = L\sin\theta ----------(3)$$

using path difference equation $d\sin\theta = m\lambda\lambda$ $\sin\theta = m\lambda\lambda/$ putting in eq (3)

$$Y = L(m\lambda(m\lambda$$

$$Y = \frac{m\lambda\lambda}{d} \quad \text{This is the position for bright fringes}$$

$$Y = (m+1/2)\frac{\lambda L}{d} \quad \text{This is the position for dark fringes}$$

Fringe spacing: The distance b/w two consecutive bright or dark fringes is called fringe spacing.

$$\text{For bright fringes : For mth order } Y_m = \frac{m\lambda L}{d} \text{ and } (m+1)\text{th fringe } Y_{m+1} = \frac{(m+1)\lambda L}{d}$$

$$\Delta y = Y_{m+1} - Y_m$$

$$\Delta y = \frac{(m+1)\lambda L}{d} - \frac{m\lambda L}{d} = \frac{m\lambda L}{d} + \frac{\lambda L}{d} - \frac{m\lambda L}{d}$$

$$\Delta y = \frac{\lambda L}{d}$$

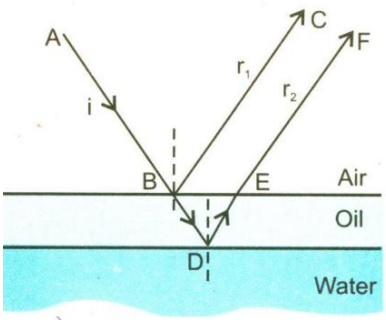
Similarly same results will obtained for dark fringes $\Delta y = \frac{\lambda L}{d}$.

What is Thin film? Give the factors upon which path difference of thin film depend.

Definition: A transparent medium whose thickness is very small as comparable to the wavelength of light is called thin film.

For example,

- Oil film on the surface of water.
- Surface of soap bubble etc
- The vivid iridescence of peacock feathers due to interference of light.



Explanation: Brilliant and beautiful colors in soap bubbles and oil film on the Surface of water due to interference of light reflected from the Two surfaces of the film as shown if fig.

Factors upon path difference depends: Path difference depends upon

i. Thickness of the film
ii. Nature of the film
iii. Angle of incidence

Write a note on Newton Rings.

Definition: Circular and bright fringes obtained by Newton which are concentric circles are called Newton rings.

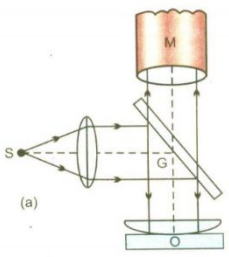
Explanation: When a Plano-convex lens of long focal length is placed in contact with a plane glass plate, air film is enclosed b/w them to form circular dark and bright fringes due to interference of light, these fringes are in the form of concentric circles termed as newton rings.

When a monochromatic light is incident on the Plano convex lens system, light rays reflect And interfere constructively and destructively.

From upper and lower layers of the air present b/w lens and glass plate.

Central spot in newton rings is dark when observed with reflected light

Central spot in newton rings is bright when observed with transmitted light.



Why central spot is dark in Newton rings: At the point of contact of lens and glass Plate. The thickness of film is zero due to reflection at lower surface of air film from Denser Medium an additional path difference λ/2 is introduced so center of newton rings Is dark due to destructive interference.

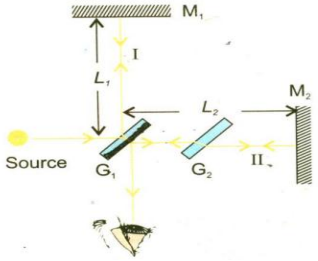
What is Michelson Interferometer? Explain its principle, construction and working.

Definition: An instrument that can be used for ultra-precise measurement of wavelength light and distance is called Michelson interferometer. It was devised by Michelson in 1881

Principle: Working principle of Michelson interferometer is interference. i.e when light from a single source is splitted into two parts and then interfere, it forms interference pattern.

Construction: Michelson interferometer consists of following parts

Source of light
Two glass plate(beam splitter and compensator)
One fixed mirror
One moveable mirror
Telescope



Explanation: let us consider a monochromatic light from a light source falls on half silver glass plate G1(beam splitter) G1 that partially reflects it and partially transmit it towards the fixed and moveable mirror. Both beams reflects from both mirrors and interfere constructively and destructively observed by observer's eye through telescope.

If mirror is moved

If mirror M1 is displaced through a distance equal to λ/2, a path difference of double of this displacement is produced equal to λ.

By counting the number of fringes m, shifted displacement of mirror L can by calculated by formula $L = \frac{m\lambda}{2}$.

Definition of standard meter: "Standard meter is equal to 1553163.5 times the wavelength of red cadmium light".

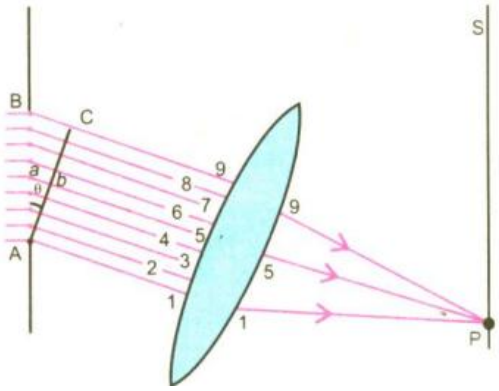
What is Diffraction of light? Explain diffraction due to narrow.

The phenomenon of bending of light around obstacles and spreading of light into geometrical shadow of an obstacle is called diffraction. Diffraction is also a special case of interference.

Diffraction is prominent when the wavelength of light is large as compared to size of obstacle. Smaller the size of object or obstacle the higher degree of diffraction is observed.

Diffraction due to narrow slit: The slit AB of width d is illuminated by a parallel beam of monochromatic light of wavelength. The screen S is placed parallel to the slit AB. Rays of light are brought to focus on the screen. A small portion of the incident wave front passes through the narrow slit. Diffraction due to a narrow slit has central Maxima and alternate minima and maxima.

In order to find the value of path difference ab we consider the Right angle triangle aAb as shown in fig.



$$\text{Sin}\,\theta = \frac{ab}{AB/2} = \frac{ab}{d/2}$$

$$ab = \frac{d}{2}\sin\theta$$

$$\text{As path difference } ab = \lambda/2 \text{ so}$$

$$\lambda/2 = \frac{d}{2}\sin\theta$$

$$\lambda = d\sin\theta \quad \text{This is the equation for first minima and for mth order}$$

$$d\sin\theta = m\lambda \quad \text{where } m = 0, \pm1, \pm2, \ldots$$

Diffraction grating: A diffraction grating consists of a glass plate having number of slit ruled on it

A typical diffraction has 400 to 5000 lines per centimeter.

Grating element: the distance b/w the centers of two adjacent lines is called grating element. d=L/N

Grating equation: the path difference for constructive interference b/w two consecutive rays should be integral multiple of wavelength so path difference difference=ab=λ and equation is $d\sin\theta = m\lambda$, m is order of fringes.

What are X-rays? Explain Diffraction of X rays through crystals and derive Bragg's law.

X-rays: A type of electromagnetic waves of much shorter wavelength having order of 10^{-10}m called X-rays.

Diffraction of X-rays through crystals: The study of atomic structure of crystals by X-rays was initiated in 1914 by WH Bragg and his son WL Bragg and found that a monochromatic beam of X-rays was reflected from a crystal plane as if it acted like mirror.

Let us consider an X-rays beam is incident at angle Θ on one of the planes. The beam can be reflected from both the upper and lower planes of atoms. The beam reflected from the lower plane travel some extra distance as compared to the beam reflected from the upper plane.

Bragg law: let an X-rays beam is incident at angle Θ the beam reflected from the lower plane travels some extra distance (BC+CB') as an effective path difference. From triangle ABC we have

$$\text{Sin}\,\theta = \frac{BC}{AC}$$

$$BC = AC\sin\theta \qquad AC = d$$

$$BC = d\sin\theta \text{ - - - - - - - - - (1)}$$

Similarly from triangle ACB', we have

$$\text{Sin}\,\theta = \frac{CB'}{AC}$$

$$BC = AC\sin\theta \qquad AC = d$$

$$CB' == d\sin\theta \text{ - - - - - - - - - (2)}$$

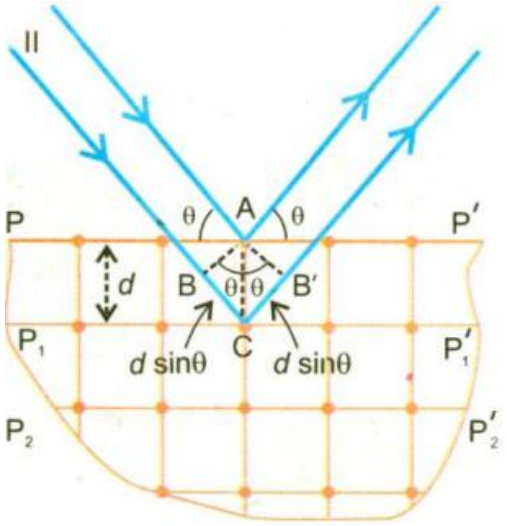
Adding both equations

$$BC + CB' = d\sin\theta + d\sin\theta$$

$$\text{total path difference} = 2d\sin\theta$$

also we know that $\text{path difference} = n\lambda$ and comparing with above eq

$2d\sin\theta = n\lambda$ This is called Bragg' s equation



Uses of X-rays diffraction/Bragg equation.

i. This is used to find inter planer spacing
ii. It is used to determine the structure of biologically important molecule such as hemoglobin.
iii. It is used to find wavelength of light.

What is Polarization? Steps for detection and production of plane polarized light.

Polarization: The process of confining the beam of light into one plane of vibration is called polarization.

Polarized and un-polarized light:

A beam of ordinary light consisting of large number of planes of vibration is called un-polarized light.

A beam of light in which all vibration confined in one plane is called polarized light.

Steps for detection and production of plane polarized light:

i. Selective absorption
ii. Reflection from different surfaces
iii. Scattering by small particles
iv. Refraction through crystal

Light waves are transverse in nature: light waves are transverse wave. If the light waves were longitudinal then they would never disappear even if the two Polaroid's were mutually perpendicular.

Optical rotation: Such a process in which a plane polarized light passes through certain crystals and they rotate the plane of polarization. e.g. Quartz crystals and sodium chlorate.

Polarizer/concentration in solution: A few millimeter thickness of such crystals will rotate the plane of polarization by many degrees and they show optical rotation when they are in solution this property of optical active substance is used to find concentration in solutions. This device is called Polari meter.

Exercise short Questions chapter 09

1. ***Under what conditions two or more sources of light behave as coherent sources?***

Two or more waves having a constant phase difference (same λ & T) are called coherent sources.

i. One method of producing two coherent light beams is to use monochromatic source to illuminate a two holes screen. The light emerging from the two slits is coherent because a single source produces two parts.

ii. Light with its mirror image also show coherent beam.

2. ***How is the distance between interference fringes affected by the separation between the slits of Young's experiment? Can fringes disappear?***

We have Fringe spacing = $\Delta y = \lambda L / d$ The relation shows that fringe spacing is inversely proportional to the separation 'd' between the slits. If separation is increased the distance between fringes will decrease.
Ultimately fringes disappear for larger distance between the slits.

3 ***Can visible light produce interference fringes? Explain.***

Yes. Visible light can produce interference fringes, if it has phase coherence. White light will produce colored interference fringes.

4.In the Young's experiment, one of the slits is covered with blue filter and other with red filter. What would be the pattern of light intensity on the screen?

No interference pattern will be observed as blue and red light not being in phase coherence.

5 ***Explain whether the Young's experiment is an experiment for studying interference or diffraction effects of light.***

Diffraction is a special type of interference. Young's experiment is basically for studying interference. But diffraction is observed. Light is diffracted from two slits. So it is a combination of diffraction and interference.

6 ***An oil film spreading over a wet footpath shows colors. Explain how does it happen?***

Due to interference of light waves, colours are seen on the oil film. At a certain place of the film, its thickness and the angle of incidence of light are such that the condition of destructive interference of one colour is being satisfied.

7. ***Could you obtain Newton's rings with transmitted light? If yeas, would the pattern be different from that obtained with reflected light?***

Yes. We can obtain Newton's rings with transmitted light. The difference will be that, the central spot will be bright.

8.*In the white light spectrum obtained with a diffraction grating, the third order image of a wavelength coincides with the fourth order image of a second wavelength. Calculate the ratio of the two wavelengths.*

Ans. $d \sin\theta = n\lambda$; $d \sin\theta = 3\lambda 1$, & $d \sin\theta = 4\lambda 2 \Rightarrow$

$3\lambda 1 = 4\lambda 2$ or $\lambda 1 / \lambda 2 = 4/3$

9.*How would you manage to get more orders of spectra using a diffraction grating?*

We have, $d \sin\theta = m\lambda$ To increase more orders of spectra (m), we should increase the grating element (d), i.e. a grating with lesser number of ruled lines.

10.*Why the Polaroid sunglasses are better than ordinary sunglasses?*

Polaroid sunglasses reduces glare, as they produce plane polarized light and they protect the eyes from bright rays of sun light.

11 ***How would you distinguish between un-polarized and plan-polarized lights?***

If a Polaroid is rotated in front of un-polarized light, a component of light will pass for each angle. But for plane-polarized light, at certain orientation, no light will pass

TID BITS/USEFUL INFORMATION

MCQS

1) Small segments of large spherical wave fronts approximate a

Spherical wave front	**Plane wave fronts**	Both A&B	None

2) Sodium chloride in a flame gives out pure---

Ordinary light	Red light	green light	**Yellow light**

3) The value of sinθ and tanθ are equal/comparable upto angle

6°	8°	**10°**	4°

4) Colors seen on oily water surface are due to ----- incident white light

Diffraction	Reflection	**Interference**	Polarization

5) The vivid iridescence of peacock feathers due to--- of light reflected from its complex layered surface?

Diffraction	Reflection	**Interference**	Polarization

6) The fine ruling each --- wide on CD function as a diffraction grating

0.5 m	0.5 mm	0.5 cm	**0.5μm**

7) Light reflected from smooth surface of water is ----- parallel to the surface

Completely polarized	**Partially polarized**	Both A&B	None

8) Which part of polarimeter stops the light when rotated from vertical positions

Polarizer	**Analyser**	Both A&B	None

BISE AND UHS PAST PAPERS SOLVED MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	Bending of light around the obstacle of light is called	Refraction	Reflection	Interference	**Diffraction**
ii.	The equation of Michelson interferometer	**L=mλ/2**	L=mλ	L=mλ/4	L=2m/λ
iii.	The distance between two adjacent dark fringes is given by	$\Delta y = \lambda L / d$	$\Delta y = m\lambda L / d$	$\Delta y = (m+1/2)\lambda L / d$	$\Delta y = \lambda d / L$
iv.	The phase difference between two points on a wave front is	**0**	π	π/2	π/4
v.	If a polarized light is made incident on a sheet of polariod then transmitted beam of light will be	Non plane polarized	**Plane polarized**	Un polarized	Diffraction
vi.	Diffraction is special case of	Polarization	Reflection	Refraction	**Interference**
vii.	Which property of travelling wave differ from stationary wave	Amplitude of wave	Frequency of wave	Direction of wave	Propagation of energy
viii.	For destructive interference path difference between two sound waves is	$s = n\lambda + \lambda$	$s = (2n+1)\frac{\lambda}{2}$	$s = (2 + \frac{1}{\lambda})$	None of these
ix.	The distance between two consecutive wave front is called	Time period	Frequency	**Wavelength**	Displacement
x.	The distance between two adjacent bright fringes is	$\Delta y = \lambda L / d$	$\Delta y = m\lambda L / d$	$\Delta y = (m+1/2)\lambda L / d$	$\Delta y = \lambda d / L$
xi.	In diffraction grating the distance between two adjacent slits is called	**Grating element**	Normal to grating	Diffraction	Fringes
xii.	In the diffraction of light around an obstacle, the angle of diffraction is increased then	**The wavelength of incident light wave is increased**	The amplitude of the incident light wave is increased	The wavelength of incident light wave is decreased	The amplitude of the incident light wave is decreased
xiii.	Color seen on oily water surface due to ---- property of light	**Interference**	Diffraction	Polarization	Refraction
xiv.	When one mirror of Michelson interferometer is moved a distance of 0.50mm,2000 fringes are observed the wavelength of light used is	5000 nm	**5000 A°**	500cm	2000A°
	L=0.5 mm, m=2000, by apply λ=2L/m putting the values to get the result where A°=10^{-10}m				
xv.	Sodium chloride in a flame gives out pure	Blue light	**Yellow light**	Red light	White light
xvi.	Which phenomenon shows that light waves are transverse waves	Interference	Diffraction	**Polarization**	Refraction
xvii.	One angstrom is equal to	10^{-9} m	10^{-8} m	**10^{-10} m**	10^{-12} m
xviii.	Polarization proves that light waves are	Longitudinal	**Transverse**	EM	Monochromatic
xix.	Light from sun reaches the earth in the form of -------- spherical wavefront	Spherical	**Plane**	Elliptical	Hyperbolic
xx.	The theory of wave nature of light proposed by	Thomas young	**Huygen**	Marwel	Fresnel

xxi.	The distance between atoms is 0.30 nm. What will be the wavelength of X-rays at angle θ = 30_o for 1_{st} order diffraction?	λ = 0.60 nm	λ = 0.20 nm	**λ = 0.30 nm**	λ = 0.90 nm
By using $2d\sin\theta = n\lambda$ put angle=30°,n=1,d=0.30nm, 2*0.30nmsin30°=1λ, λ=2*0.30nm*1/2=0.30 nm					
xxii.	Sound waves cannot be	Reflected	Refracted	**Polarized**	Diffracted
xxiii.	Which property of light is evident of polarization of light	Wave nature	Particle nature	Dual nature	**Light waves are transverse Waves**
xxiv.	Newton rings are formed as a result of	**Interference**	Dispersion	Diffraction	Polarization
xxv.	In Young's Double Slit Experiment, slit separation x = 0.05 cm, distance between screen and slit D = 200 cm, fringes separation x = 0.13 cm, then the wavelength 'λ' of light is	λ = 1.23 x 10_{-2} m	λ = 4.55 x 10_{-5} m	**λ= 3.25 x 10^{-7} m** put d=0.05*10-2m L=2m, Δy=0.13*10-2m λ=Δyd/L to get result	λ = 5.1 x 10_{-7} m
xxvi.	Phase angle of $180^o$is equailent to path difference of	λ/4	**λ/2**	λ	2λ
xxvii.	first dark fringe appears from 'm' will be equal to in (m+1/2)λ	1	**0**	3	2
xxviii.	According to modern idea about the nature of light shows	Wave nature of light	Particle nature of light	**Dual nature of light**	None of these
xxix.	A maxima is produced at points where path difference of monochromatic wave is	λ/4	λ/2	**λ**	2λ/3
xxx.	What happens to the interference pattern produced by double slit arrangement by doubling the slit spacing	Fringe spacing is doubled	**Fringe spacing is halved**	Intensity increase	Fringe spacing is not changed
Fringe spacing is inversely proportional to slit separation					
xxxi.	Michelson interferometer is used to	**Measure distance with high precision**	Find speed of light	Study interference in thin films	Study diffraction of light
xxxii.	A surface on which all the points have same phase of vibration is known as	Crest	Trough	**Wave front**	Wavelength
xxxiii.	The process of confining the beam of light to vibrate in one plane is called	Interference	Diffraction	Total internal reflection	**Polarization**
xxxiv.	When Newton rings are observed with reflected light, the central spot	Red	Blue	**Dark**	Bright
xxxv.	The wavelength of light which produces second order spectrum on diffraction grating on which 5000 lines/cm are ruled at an angle of 30° will be:	6 x 10_{-7} m	**5 x 10_{-7} m**	4 x 10_{-6} m	3 x 10_{-6} m
dsinθ=mλ L/Nsinθ=mλ, θ=30°, m=2 L=1cm, N=5000 put in formula to get the result					
xxxvi.	Angle between ray of light and wave front is	0^o	**90^o**	60^o	120^o
xxvii.	Basic principle of beats are	**Interference**	Diffraction	Total internal reflection	Polarization
xxviii.	In case of point source the shape of wave front is:	Plane	**Spherical**	Circular	Elliptical
xxxix.	Fringe spacing increases if we use	**Red light**	Blue light	Yellow light	Green light

xl.	In 10min sun light covers a distance of	$0.18*10^{10}$ m	$18*10^{10}$ m	**$1.8*10^{10}$ m**	$0.018*10^{1}$m
Time=10 min=10*60=600 sec, $S=vt=3*10^{8}*600=1800*10^{8}=1.8*10^{8+2}=1.8*10^{10}$ v is speed of light					
xli.	Vivid iridescence of peacock feather due to	Reflection	Refraction	**Interference**	Diffraction
xlii.	Fine ruling each wide on CD function	0.5 cm	0.5 mm	0.5 m	**0.5µm**
xliii.	A typical diffraction grating has lines per centimeter	400-500	**400-5000**	40-50	400-50000
xliv.	When newton rings are observed with transmitted light then central ring is	Dark	**Bright**	Blue	Red
xlv.	An object 15 cm from a lens produces a real image 30 cm from the lens. What is the focal length of the lens?	+15 cm	**+10 cm**	+20 cm	+25 cm
Apply lens formula 1/f=1/p+1/q=1/15+1/30=(2+1)/30=3/30=1/10, f=10cm					
xlvi.	In Newton ring apparatus, at the point of contact of the lens and glass plate, the additional path difference introduced is	λ/4	λ	**λ/2**	λ/3
xlvii.	The image of an object placed inside the focal length of a convex lens will be largest and clearest when it is at the	Less than 25 cm	Greater than 25 cm	**Near point**	Infinity
xlviii.	What is the formula for critical angle in case of light through two mediums having refractive indexes n_1 and n_2 such that $n_1 > n_2$?	**$\sin^{-1}(n_2/n_1)$**	$\cos^{-1}(n1/n2)$	$\cos^{-1}(n2/n1)$	$\sin^{-1}(n\ 1/n2)$
xlix.	The concentration of a sugar solution can be determined by	Un-polarized light	Interference of light	**Plane polarized light**	Diffraction of light
l.	In Young's Double Slit Experiment, if the distance between slits and screen is doubled, then fringe spacing becomes	Zero	**Doubles** Δy α L	One	Half
li.	In Michelson's interferometer 792 bright fringes pass across the field of view when its movable mirror is displaced through 0.233 mm using the equation l = mλ/2 the wavelength of light used is:	**588 nm** See solution of numerical no 9.4	348 nm	620 nm	400 nm
lii.	A yellow light of wavelength 500 mm emitted by a single source passes through two narrow slits 1 mm apart. How far apart are two adjacent bright fringes when interference is observed on a screen 10 m away?	**5000m** Δy=λL/d Put λ=500mm L=10m,d=1mm	0.5 mm	1.33 mm	50 mm
liii.	According to Huygen principle, each point on a wave front acts as a source of	**Secondary wavelet**	Primary wavelet	New wave front	Sound
liv.	Blue color of sky is due to	**Scattering**	Reflection	Diffraction	Polarization
lv.	Fringe spacing is inversely proportional to	**Slit separation**	Wavelength	L	Frequency
lvi.	Newton rings are formed as result of	**Interference**	Dispersion	Diffraction	Polarization
lvii.	Michelson interferometer is used to find	**Wavelength of light**	Wavelength of sound	Velocity of sound	Velocity of light
lviii.	Light is polarized by using	Nacl	**Dichoric substance**	Optical fiber	Plane glass

Chapter 10 Optical Instruments

Optical instruments: The instruments which are based on the principles of reflections and refractions are called optical instruments. For example microscope, telescope etc.

Visual angle: The angle made by an object at the eye is called visual angle.

Least distance of distinct vision/ near point: The minimum distance from the eye at which an object to be distinct is called least distance of distinct vision or near point. It is denoted by d

Least distance of distinct vision increase with increase of age. Its value is 25 cm or 10 inches.

Linear magnification: The ratio of size of image to size of object is called linear magnification.

$\text{Magnification} = \frac{\text{Size of object}}{\text{Size of image}} = \frac{I}{O}$. It has no unit.

Angular magnification: The ratio of angle subtended by the image as seen through optical device to that angle subtended by the object at the unaided eye.

$\text{Magnification} = \frac{\text{angle subtended by image}}{\text{angle subtended by object}} = \frac{\beta}{\alpha}$. It has no unit.

Resolving power of an instrument: The resolving power of an instrument is its ability to show the minor details of object under examination.

Formulas of resolving power: The resolving power is the reciprocal of minimum angle of resolution Releigh showed this formula

(1) $R = \frac{1}{\alpha_{\min}} = \frac{D}{1.22\lambda}$, D is diameter of lens and λ is wavelength of light

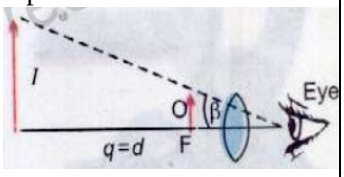
(2) $R = \frac{\lambda}{\Delta\lambda}$ $\lambda \approx \lambda_1 \approx \lambda_2$ and $\Delta\lambda = \lambda_2 - \lambda_1$

(3) R= N*m were N is number of rules lines on grating and m is order of diffraction

What is Simple microscope? Give Working principle and magnification?

Definition: A device which is used to see the magnified image of very small and near object is called simple microscope. A convex lens can be used for magnification.

Working principle of simple microscope: "When the object is placed b/w focal point and optical center of biconvex lens then an erect, virtual and enlarged image is obtained".



Magnification of simple microscope: Magnification for simple microscope

$M = 1 + \frac{d}{f}$ Where d is least distance distinct vision and f is focal length of lens.

It shows that focal length should be small for higher magnification.

What is Compound microscope? Give Working principle and magnification?

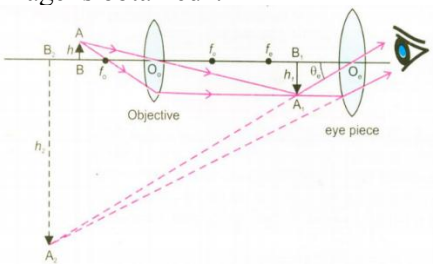
Definition: A compound microscope is used when high magnification is required.

It consists of two convex lenses objective of short focal length, eye piece of large focal length.

Principle of compound microscope: "When the image formed by the objective of small focal length is within focal length of eye piece of large focal length then a virtual, inverted and magnified image is obtained".

Magnification of compound microscope:

Formula for magnification of compound microscope is $M = \frac{q}{p}\left(1 + \frac{d}{f_e}\right)$.



For higher magnification we use eye piece of short focal length..

High resolving power: High resolving power can be achieved by

i. Using wider objective
ii. Using blue light of shorter wavelength to produce less diffraction.

Astronomical telescope? Give Working principle and magnification?

Definition: The telescope used to see the distinct image of distant heavenly objects like planets or moon is called astronomical telescope. It consists of two lens objective of large focal length and eye piece of short focal length.

Principle of astronomical telescope: "A real, inverted and diminished image formed by the objective serves as an object for eye piece which is at the focal point of both the lenses then a virtual and magnified image is formed at infinity".

Magnification of astronomical telescope: The magnification of astronomical telescope is $M = \frac{f_o}{f_e}$ by using objective of large focal length and large aperture for higher magnification of telescope.

What is Spectrometer? Give its three parts.

Definition: An optical device which is used to study the spectrum of various sources of light is called a spectrometer.

Name of its parts: There are three main parts of spectrometer (i) Collimator (ii) turn table (iii) telescope.

Function of collimator: To make the light beam parallel coming from a nearby source of light. Collimator consists convex lens at one end and adjustable slit at other end, when slit is just at the focus of convex lens then light rays entering from slit become parallel after passing through lens.

Uses of spectrometer: Spectrometer is used to

i. Study the deviation of light by glass prism
ii. Study the spectra of different sources of light
iii. Calculate the wavelength of light and refractive index of material.

Give Michelson formula for Speed of light.

Michelson formula for speed of light C=16fd, the value of speed of light in vacuum $C=3*10^8$ m/s. speed of light in other materials is less than C and it depends upon the nature of medium.

What is Optical fiber? Give advantages and principle.

Definition: Number of glass fibers combine together to transmit light from one part to other is called optical fiber.

Advantages of fiber optics: There are following advantages of fiber optics

i. It is used to transmit light around the corners and into inaccessible places
ii. It has wider band of capability and free from electromagnetic interference
iii. It increased the efficiency of word processing, image transmission and reception
iv. Fiber optic consist of much smaller and light weight cables

A fiber optic its protective case is about 6 mm, in diameter, which can replace by 7.62cm diameter bundle of copper wires carrying same amount of signals

What is Principle of propagation through fiber optics?

The propagation of light within optical fiber through

i. Total internal reflection
ii. Continuous refraction

Total internal reflection: When a light ray travelling from a denser medium towards a rare medium, makes angle of incidence greater then critical angle of medium, then ray is totally reflected back into the same denser medium, this phenomenon is called total internal reflection.

What is Critical angle? The angle of incidence in denser medium for which its corresponding angle of refraction is 90° is called critical angle.

What is Refractive index? The ratio of speed of light in vacuum to the speed of light in transparent medium is called refractive index. n= C/V.

State Snell's law? The ratio of sines of angle of incidence to angle of refraction is constant. $n = \frac{\sin\theta_i}{\sin\theta_r}$. Also written as $n_1 \sin\theta_1 = n_2 \sin\theta_2$.

Calculate the value of critical angle for glass air boundary

When $\theta_1 = \theta c$, and $\theta_2 = 90^o$, $n_1 = 1.5$ for glass, $n_2 = 1$ for air

Snell's law becomes $\Rightarrow n_1 \sin\theta c = n_2 \sin 90^o \Rightarrow \sin\theta c = \frac{n_2}{n_1}$

$\theta c = \sin^{-1}(\frac{1}{1.5}) = 41.8^o$

State Conditions for total internal reflection? There are two conditions for total internal reflection

i. Light should travel from denser to rare medium
ii. The angle of incidence should be greater than critical angle

What is Continuous refraction? such a process in which propagation of light through fiber is continuously refracted within the fiber is called continuous refraction.

Give the Name of types of optical fiber?

There are three types of optical fiber

i. Single mode step index fiber
ii. Multimode step index fiber
iii. Multimode graded index fiber

What is Single mode step index fiber?

Single mode step index fiber has very thin core about 5µm diameter. It has relative large cladding and use monochromatic light source i.e laser. It can carry more than 14 tv channels and 14000 phone calls.

What is Multimode step index fiber?

Multimode step index fiber is central core has diameter 50µm and high refractive index. The central core has a constant refractive index of core 1.52 and cladding 1.48. It is used for carrying white light but due to dispersion effects it is used for short distance only.

What is Multimode graded index fiber?

Multimode graded index fiber central core has high refractive index. The diameter of core ranges from 50µm to 1000µm. there is no particular boundary b/w core and cladding. The light is continuously refracted within the fiber optics. It is useful for long distance.

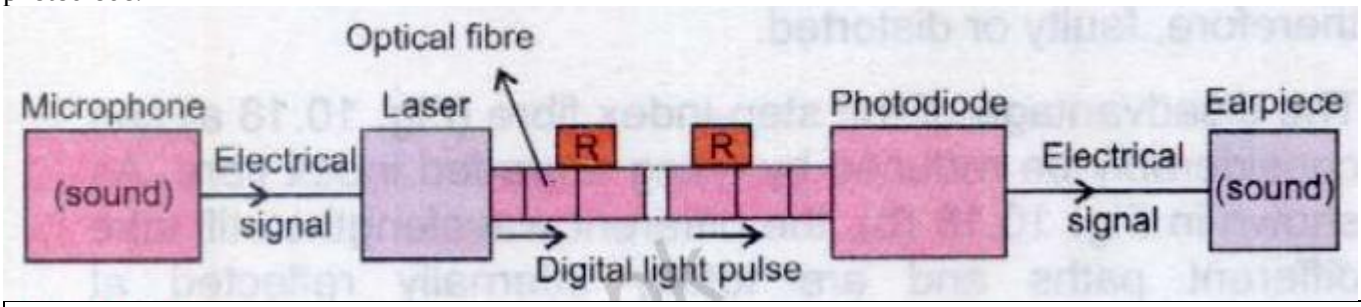
Explain Components of fiber optic communication system.

There are three major components of fiber optic communication system, transmitter, optical fiber, and receiver.

Transmitter: The transmitter converts electrical signal into light signal which is obtained from microphone. The light signal is invisible infrared of typical wavelength 1.3µm which moves faster than visible or UV light.

Optical fiber: The modulated pulse travel through the optical fiber by total internal reflection and continuous refraction with very fast speed. The light signals while through optical fiber become dim and must be degenerated by a device called repeater. Repeaters are typically placed 30km apart, but in newer system this separation is 100 km.

Receiver: Receiver captures the light signals at the other end, and convert the light signal into electrical signal by photodiode.



What are the power losses in fiber optics?

Power is lost in optical fiber by following factors

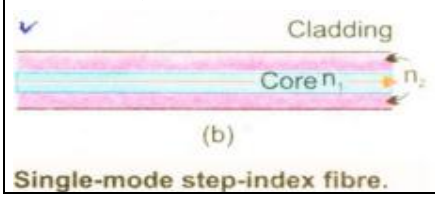
i. Scattering
ii. Absorption
iii. Dispersion

How Power lost by scattering and absorption in fiber optics?

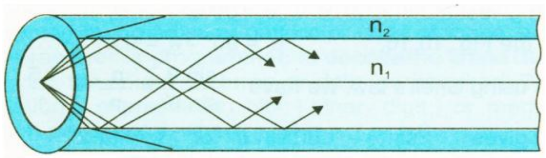
When the light travel along fibers by multiple reflections, some of light energy is absorbed by the glass medium. It is due to the impurity of glass medium. Some part of energy of light signal is scattered by group of atoms such as joints It can be reduced by careful manufacturing.

Give Time difference in step index fiber.

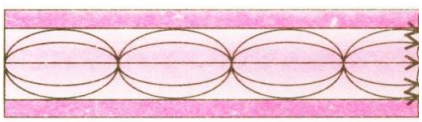
In step index fiber, the overall time difference b/w different wavelengths may about 33 ns per km. but using a graded index fiber, the time difference is reduced to about 1ns per km.



Single-mode step-index fibre.



Light propogation through Multi-mode step-index fibre.


Light propogation through Multi-mode graded-index fibre

Exercise short Questions chapter 10

1. What* do *you understand by linear magnification and angular magnification? Explain how a convex lens is used as a magnifier?

Linear magnification: The ratio of size of image to size of object is called linear magnification.

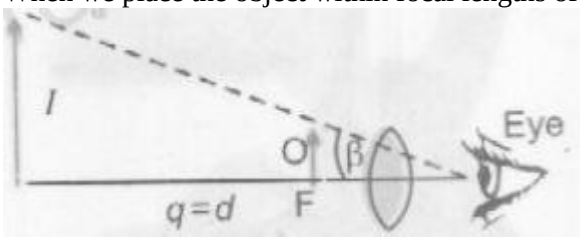
$$\text{Magnification} = \frac{\text{Size of object}}{\text{Size of image}} = \frac{I}{O}$$

Angular magnification: The ratio of angle subtended by the image as seen through optical device to that angle subtended by the object at the unaided eye.

$$\text{Magnification} = \frac{\text{angle subtended by image}}{\text{angle subtended by object}} = \frac{\beta}{\alpha}$$

Both have no units.

When we place the object within focal lengths of convex lens then the image formed is erect, virtual and magnified.



2.*Explain the difference between angular magnification and resolving power of an optical instrument. What limits the magnification of an optical instrument?*

Angular magnification:"The ratio of the angles subtended by the image as seen through the optical device to that subtended by the object at the unaided eye"; M = β / α $R = \frac{1}{\alpha_{\min}} = \frac{D}{1.22\lambda}$. **Resolving power** (αmin): "The ability of an instrument to reveal the minor details of the object under examination..

Limits: Due to chromatic and spherical aberrations, the magnification of the optical instruments is limited.

3.*Why would it be advantageous to use blue light with a compound microscope?*

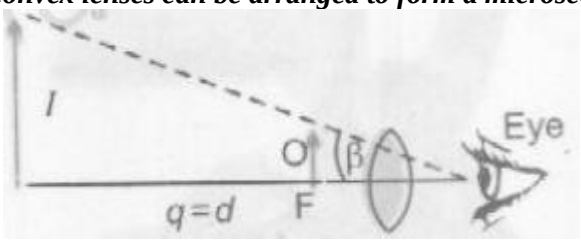
By using wider objective and Blue light increases the resolving power and more details of an object can be seen. As blue light produce less diffraction due to short λ. $R = \frac{1}{\alpha_{\min}} = \frac{D}{1.22\lambda}$.

4. One can buy a cheap microscope for use by the children. The image seen in such a microscope have colored edges. Why is this so?

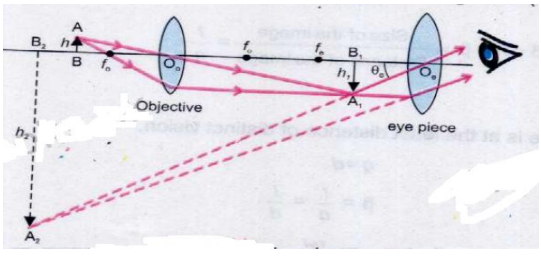
Due to chromatic aberration, we see colored edges in cheap microscope. It is due to non-focusing of light of different colors. These colors arise due to dispersion.

5. ***Describe with the help of diagrams, how (a) a single biconvex lens can be used as a magnifying glass. (b) Biconvex lenses can be arranged to form a microscope.***

(a)



(b)



6 .*If a person were looking through a telescope at the full moon, how would the appearance of the moon be changed by covering half of the objective lens?*

The intensity of the image become half and there will be no change of shape. Less transmitted light due to half-covered objective, still he will see full image of the moon.

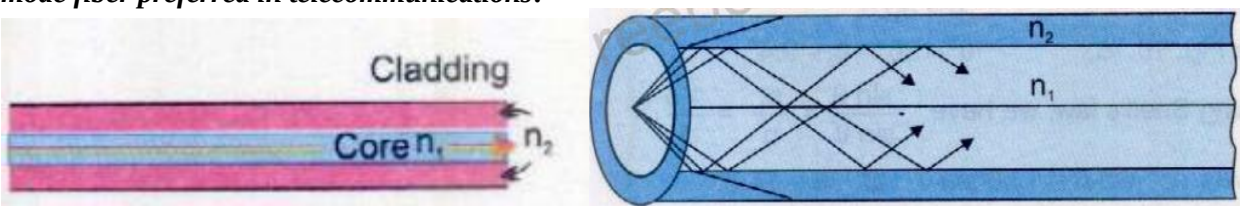
7. ***A magnifying glass gives a five times enlarged image at a distance of 25 cm from the lens. Find, by ray diagram, the focal length of the lens.***

M = 5, d = 25cm, f = ?

$$M = 1 + \frac{d}{f} \Rightarrow 5 = 1 + \frac{25}{f} \Rightarrow \frac{25}{f} = 5 - 1 \Rightarrow f = \frac{25}{4} = 6.25cm$$

8. Both have same options. The diameter of the objective lens.

9. Draw sketches showing the different light paths through a single-mode and multimode fiber. Why is the single-mode fiber preferred in telecommunications?



Single-mode fiber is preferred in telecommunications because they are digital and use monochromatic laser light. Here the transmission is free from dispersion.

10 ***How the light signal is transmitted through the optical fiber?***

By total internal reflection on continuous refraction light signals is transmitted through the optical fiber. A transmitter converts electrical signal into light signal and at the receiving end these are converted back to electrical signals. The most common method of transmission is digital modulation, in which the laser is flashed on and off at extremely fast rate. The communication is represented by code of 1s and 0s. The receiver is programmed to decode 1s and 0s.

11. ***How the power is lost in optical fiber through dispersion? Explain.***

Power is lost due to scattering and absorption of light signals during travel through the optical fiber. The information received can be faulty and distorted due to dispersion, i.e. spreading of light signals into component wavelengths. Due to impurities in the glass and multiple reflections along the fiber is occurred

BISE AND UHS PAST PAPERS SOLVED MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	For normal adjustment length of astronomical telescope is	**fo+fe**	fo-fe	fo/fe	fe/fo
ii.	The image formed by simple microscope is	Real and inverted	**Erect and virtual**	Erect and real	Inverted and virtual
iii.	Which of the following lights travels the fastest in optical fibers?	Visible light	Ultra-violet	**Invisible infra-red**	Ordinary light.
iv.	If a single convex lens is placed close to eye then it is being used as	Telescope	**Magnifying glass**	Microscope	None of these
v.	A watch maker uses ____to repair the watches.	Telescope	**Convex lens**	Convex mirror	Concave lens.
vi.	The ratio of the _ is called magnification	**Image size to object size**	Eyepiece size to object size	Object size to image size	None of these
vii.	Using a graded index fiber, the time difference is reduced to about	33ns per 100Km	33 ns per km	**1ns per km**	1ns per 100km
viii.	The information received at the other end of a fibre can be inaccurate due to _____ of the light signal.	Longer wavelengths	Intensity	Frequency	**Dispersion or Spreading**
ix.	If focal length of objective and eye piece is 0.5m and 10cm respectively then magnifying power of telescope will be?	**5**	0.5	10	20
Solution: M=? fo=0.5m=0.5*100cm=50cm, fe=10cm, M=fo/fe= 50/10=5					
x.	Final image of compound microscope is	Virtual and erect	**Virtual and inverted**	Real and inverted	Real and erect
xi.	Which of the following device works on the principle of interference?	Compound microscope	**Newton rings apparatus**	Telescope	Diffraction grating
xii.	Least distance of distinct vision	**Increase with increase in age**	Decrease with increase in age	Remains same	First decrease then increase
xiii.	The power of lens of one meter focal length is	**1 D**	2D	0.5 D	4 D

xiv.	The normal human eye can focus a sharp image of an object on the eye if the object is located at certain distance called	Least Point	Far Point	**Near Point**	Distinct Point
xv.	Magnifying power of astronomical telescope increase by	**Increase of fo**	Decrease of fo	Increase of fe	Decrease of fe
xvi.	An astronomical telescope having magnifying power 5 consists consist of two thin lenses 24cm apart. Focal length of lenses is	**4cm, 20cm**	20cm,30cm	16 cm, 20cm	None of these
As M=5, L=24, as M=fo/fe, 5=fo/fe…fo=5fe & L=fo+fe, 24=5fe+fe, 6fe=24, fe=4cm, put again then fo=20 cm					
xvii.	Light emitted from LED has wavelength	**1.3µm**	1.3 nm	1.3 mm	1.3cm
xviii.	At some angle of incidence when angle of refraction become 90°C this angle is called	Phase angle	**Critical angle**	Refractive angle	Incident angle
xix.	In case of X-ray diffraction by crystal, the wavelength can be found by using the equation	$d\sin\theta = n\lambda$	$2d\sin\theta = n\lambda$	$2d\cos\theta = n\lambda$	None
xx.	To find interplaner spacing we used equation	$d\sin\theta = n\lambda$	$2d\sin\theta = n\lambda$	$2d\cos\theta = n\lambda$	None
xxi.	A convex lens acts as diverging lens if object is placed at	f	2f	b/w f and 2f	**Within f**
xxii.	In a multimode step index fiber, density of optical material decrease from	Edge to core	**Core to edge**	Even	Multiple
xxiii.	Glass air boundary acts as a/an	**Mirror**	Glass	Water	Air
xxiv.	Wavelength of X-rays is of the order of	**10^{-10} m**	10^{10} m	10^{-12} m	10^{-14} m
xxv.	The minimum distance from the eye at which an object appear to be distinct	15cm	10cm	20cm	**25cm**
xxvi.	A convex lens of focal length f is cut into two identical halves along the lens diameter, the focal length of each half	3/2 f	½ half	4 f	**2f**
xxvii.	The technique used to study the structure of hemoglobin is	**X-Rays diffraction**	Newton rings	Polarization	Interference
xxviii.	Near point of normal human eye is	25 m	**250 mm/25cm**	2.5 cm	None of these
xxix.	The speed of light in vacuum is	**$3*10^8$ m/s**	$3*10^9$ m/s	$3*10^7$ m/s	0 m/s
xxx.	A lens whose power is 2 diopter its focal length is	75cm	**50cm**	25cm	5cm
As power=1/f= focal length =1/f= ½=0.5 m to convert into cm 1m=100cm, 0.5*100=50 cm					
xxxi.	Light reaches from the sun to the Earth in the from of	Spherical wave front	**Plane wave front**	Cylindrical wave front	Circular wave front
xxxii.	A double convex lens acts as diverging lens when the object is	**Inside the focus**	Between f and 2f	At the focus	At a large distance
xxxiii.	The diameter of single mode step index fiber is	10µm	50µ	100µm	**5µm**
xxxiv.	If a convex lens is used as magnifying glass, which lens will give higher magnification?	Short size	Long focal length	Large size	**Short focal length**
xxxv.	In a compound microscope, the magnification by objective = 20,	M = -220	M = -0.05	M = -0.19	**M = 220** M=M1*M2

	magnification by eyepiece = 11, then the total magnification is				20*11=220
xxxvi.	The information from one place to another can be transmitted very safely and easily by	Copper wire	Photodiode	Aluminum wire	**Optical fiber**
xxvii.	In normal adjustment of compound microscope, the eye piece is positioned so that the final image is formed at	Optical Center	Principle Focus	Infinity	**Near Point**
xxviii.	When light passes through a pinhole type opening , it seems to spread out , this phenomenon is known as	Dispersion	Reflection	**Diffraction**	Polarization
xxxix.	The speed of light in other material is always	**Less than c**	Greater then c	Equal to c	None of these
xl.	Magnifying power of convex lens of focal length 10cm is	7	9.6	11	**3.5**
	M=1+d/f= 1+25/10=1+2.5=3.5 d=least distance of distinct vision=d=25cm				
xli.	For the phenomenon of total internal reflection the angle of incidence should be	Equal to critical angle	Smaller then critical angle	**Greater then critical angle**	Zero
xlii.	The optical fiber are of types	Two	**Three**	Four	Five
xliii.	A transparent refracting medium bounded by two curved surface is called	**Lens**	Glass	Mirror	Prism
xliv.	A real object placed inside the focus of a convex lens gives	Real image but diminished	Real but enlarge image	Virtual but diminished image	**Virtual but enlarged image**
xlv.	Television signals are converted into light signals by	**Decoder**	Transistor	Photodiode	Optical fiber
xlvi.	If the object is placed within the focal length of convex lens its image will be	Magnified	Erect	Virtual	**All of these**
xlvii.	The power of lens is measured in	Watt	Joule	**Diopter**	Minutes
xlviii.	Multi-mode step index fiber is useful for	**Short distance**	Long distance	No distance	Infinite distance
xlix.	The optical fiber in which the central core has higher refractive index and its density gradually decrease towards its periphery is called	Single mode index fiber	Multi-mode index fiber	**Multi-mode graded index fiber**	None of these
l.	The value of critical angle for glass air boundary	**41.8°**	41.5°	42.8°	42°
li.	Which is optical instrument	**Telescope**	Galvanometer	Ammeter	Voltmeter
lii.	Resolving power of a lens is expressed by relation	$\alpha_{\min} = 1.22\frac{D}{\lambda}$	$\alpha_{\min} = 1.22\frac{\lambda}{D}$	$\alpha_{\min} = 1.22\lambda D$	$\alpha_{\min} = 1.52\lambda D$
liii.	Propagation of light in an optical fiber takes place by two phenomenon which are	Total internal reflection & dispersion	**Total internal reflection & continuous refraction**	Interference and dispersion	Interference and continuous refraction
liv.	The collimator in a spectrometer is used to	Disperse the light beam	Reflect the light beam	**Make the light beam parallel**	Converge the light beam
lv.	Magnification of a convex lens of focal length 25 cm is	**2**	5	6	20
	M=1+d/f=1+25/25=1+1=2				
lvi.	The medium in which speed of light is the same in all direction is called	Homogenous	Heterogeneous	Non homo genous	**Free space**

lvii.	Which of the phenomenon of light is used in propagation of light through optical fiber	**Total internal reflection**	Polarization	Interference	Diffraction
lviii.	Which combination can ensure less diffraction and more details to be seen by compound microscope	A wider objective and red light	**A wider objective and blue light**	A wider eye piece and red light	A wider eye piece and blue light
lix.	In Michelson experiment, the equation used to find the speed of light c=?	**16fd**	16f/d	16d/f	1/16fd
lx.	A layer over the central core of the jacket is called	Jacket	Plastic	**Cladding**	Rubber
lxi.	The refractive index of water is 1.33. the speed of light in water is:	$3*10^8$ m/s	$1.8*10^8$ m/s	**$2.3*10^8$ m/s**	Zero
As n=c/v 1.33=$3*10^8$/v v=$3*10^8$/1.33= $2.33*10^8$ m/s					
lxii.	In newer system of fiber optics signals regenerated by placing repeater may separated by as much as	30Km	50Km	**100Km**	500Km
lxiii.	Effective path difference between two reflected beam in X-rays diffraction	$d\sin\theta = n\lambda$	$2d\sin\theta = n\lambda$	$2d\cos\theta = n\lambda$	None
lxiv.	Spectrometer is used to	Study diffraction of light	Measure wavelength of light	Measure refractive index of material	**All of these**
lxv.	Bragg equation is given by	V=ft	$d\sin\theta = n\lambda$	$2d\sin\theta = n\lambda$	$2d\cos\theta = n\lambda$
lxvi.	The image of an object 5mm high is only 1cm high the magnification produced by lens is	0.5	0.2	1	**2**
M= size of image/size of object= 1cm/5mm= 1*10-2/5*10-3= 10/5=2					
lxvii.	If n1 and n2 are refractive index of core and cladding then for optical fiber	**n1>n2**	n1<n2	n1=n2	None of these
lxviii.	Snell law is expressed as	$n1\sin\theta1 = n2\sin\theta2$	$n\sin\theta = 0$	1/sinϴc	None of these
lxix.	If N is the number of ruling on the grating then resolving power of nth order diffraction is equal	**R=Nm**	R=N/m	R=1/Nm	R=m/N
lxx.	Compound microscope forms final image at	**Near point**	Focus of eye piece	Focus of objective	Infinity
lxxi.	If d is the least distance of distinct vision, then magnification of convex lens of focal length f will be	**1+d/f**	1-d/f	1+f/d	1-f/d
lxxii.	Optical rotation a property of optically active substance can be used to	Determine density	Determine viscosity	**Determine concentration of sugar**	Determine elasticity
lxxiii.	The ratio of size of image to size of object is called	Focal length	Visual angle	Resolving power	**Magnification**
lxxiv.	Optical fiber is covered for the protection by a	Glass jacket	**Plastic jacket**	Copper jacket	Aluminum jacket
lxxv.	If magnifying power of magnifying glass is 3 then focal length will be	25cm	**12.5 cm**	5 cm	3 cm
M=1+d/f 3=1+25/f 3-1=25/f 2=25/f f=25/2=12.5 cm					
lxxvi.	Convex lens act as magnifying glass when object is placed	At 2F	At F	**Inside F**	At 3F

xxvii.	Which of the following will travel must faster than other through optical fiber	UV light	Visible light	**Invisible infrared light**	White light
lix.	Using the relation for the magnifying power L_o, M = 1 + d/f, if f = 5 cm and d = 25 cm then M will be	5	**6**	7	8
xxviii.	The focal length of convex lens	Negative	**Positive**	Large	Small
lxxix.	The final image seen through eye piece in telescope	Real, englarged, inverted	Virtual, enlarge, and erect	**Virtual, enlarge and inverted**	Real, enlarge ad erect
lxxx.	Magnifying power of telescope	fo+fe	fo-fe	**fo/fe**	fe/fo
lxxxi.	Rayleigh formula for resolving power is	$R = \frac{\lambda}{1.22D}$	$R = \frac{D}{1.22\lambda}$	$\alpha_{min} = 1.22\lambda D$	$\alpha_{min} = 1.52\lambda D$
xxxii.	Multimode graded index fiber has core whose diameter range lie from	5 to 50µm	50 to 100µm	**50 to 1000µm**	50 to 10,000µm
xxxiii.	If a convex lens of focal length 5cm is used as simple microscope then magnifying power will be	5	**6**	10	25
M=1+d/f=1+25/5=1+5=6					
xxxiv.	Which is not essential component of spectrometer?	Collimator	Telescope	Turntable	**Microscope**
xxxv.	If p=5cm and d=25cm then linear magnification	5cm	25	**5**	25cm
Linear magnification= size of image/size of object=25/5=5					
xxxvi.	The light signal in optical fiber must be regenerated by a device is called	Regenerator	Generator	**Repeater**	Diode
xxvii.	SI unit of magnifying power of telescope	Watt	Diopter	**No unit**	None
xviii.	Final image obtained by astronomical telescope is	Erect	Magnified	**Virtual**	None
xxix.	When the object is placed within the focal length of convex lens then its image will be	Real	Inverted	**Virtual**	Of same size
xc.	The detector in photo phone is made up of	Cadmium	Germanium	**Selenium**	Silicon
xci.	X-rays diffraction has been very useful in determining the structure of	**Hemoglobin**	Stars	Galaxies	Stones
xcii.	If speed of light in vacuum is C, then its velocity in a medium of refractive index is 1.3	**C/1.3**	1.3C	1.3/C	C
As n=c/v, 1.3=c/v, v=C/1.3					

Chapter 11 Heat and Thermodynamics

Thermodynamics: A branch of Physics which deals with conversion of heat energy into other forms of energy is called thermodynamics.

Temperature: The degree of coldness or hotness is called temperature. SI unit of temperature is kelvin.

Kinetic molecular theory of gases: Such a theory which explains the behavior of gases and relationship of macroscopic properties (Temp,Volume etc) with microscopic properties(k.E) is called kinetic molecular theory.

Give four Postulates of KMT: There are following postulates of KMT

i. A finite volume of gas consists of very large number of molecules
ii. Size of molecule is much smaller than separation b/w molecules
iii. The gas molecules are in random motion
iv. Collision b/w gas molecules is perfectly elastic.

Pressure of gas: The momentum transferred to the wall of the container per second per unit area due to continuous collision of molecules of gas is called pressure of gas. P=F/A

Effect of pressure and temperature on average translational kinetic energy: Pressure of gas is directly proportional to average translational kinetic energy $P = \frac{1}{3}\rho < v^2 >$

Temperature of an ideal gas is directly proportional to average translational kinetic energy $T \propto < K.E >$

Boyle's law: At constant temperature, pressure of gas is inversely proportional to volume of given mass of gas

$P = \frac{2N}{3V}\langle K.E\rangle \Rightarrow as\ \langle K.E\rangle remains$ constant so PV = constant

$\mathrm{P} = \frac{\text{constant}}{\mathrm{V}} \Rightarrow P \propto \frac{1}{V}$

Charles law: At constant pressure, volume of given mass of gas is directly proportional to absolute temperature of gases. According to KMT at constant temperature means average kinetic energy is constant so $V \propto T$.

What is internal energy?

Definition: The sum of all forms of molecular energies of substance such as K.E and P.E is called internal energy. It is directly proportional to its temperature.

We can increase the internal energy by heating a substance or by doing mechanical work. Internal energy is state function as it depends upon the initial and final states of system.

Sign conventions for work and heat: There are following conventions for work and heat

Work done by the system is positive and work done on the system is taken as negative

Heat added to system is taken as positive and heat leaving the system is taken as negative

Derive an Expression for work by gas on piston:

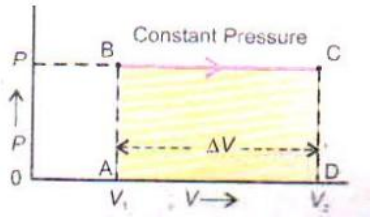
Consider a gas enclosed in cylinder with moveable piston

the force exerted per unit area P = F/A is F = PA

work done by thegas is $W = \vec{F}.\vec{d}$ taking d = Δy

W = FΔΔ= PA(ΔA(= PΔΔ

work is calculated by area under P - V diagram



State First law of thermodynamics. Describe its applications.

Statement: "When heat Q is added to a system, this heat energy appears as increase in internal energy ΔU plus system work on surrounding" Q=ΔU+W.

Examples: For example bicycle pump and human metabolism

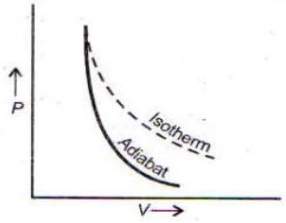
Applications of first law of thermodynamics: There are two applications of first law of thermodynamics

Isothermal process: Such a process in which temperature of system is constant is called isothermal process. First law of thermodynamics in isothermal process is Q=W. the curve represent this process is called isotherm.

Adiabatic process: Such a process in heat no heat enters or leave the system is called adiabatic process. For example rapid escape of air and cloud formation in air. First law of thermodynamics in adiabatic process is W=-ΔU.

Such a process in gas is expanded and do external work and temperature of gas falls is adiabatic expansion W=-ΔU

Such a process in gas is compressed and work is done on the gas and increase the temperature is called adiabatic compression –W=ΔU. The curve represent this process is called adiabate.



Define Specific heat of gas. Define Cp and Cv. and prove of Cp-Cv=R

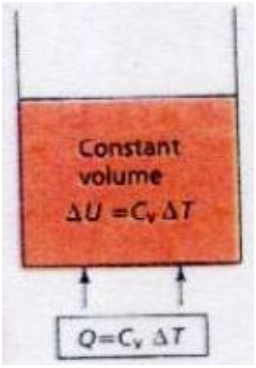
Specific heat: The amount of heat required to increase the temperature of one kilogram of substance upto one kelvin is called specific heat.

Molar specific heat: The amount of heat required to increase the temperature of one mole of gas through 1 kelvin is called molar specific heat. Its unit is $Jmol^{-1}K^{-1}$.

Molar specific heat at constant pressure Cp: The amount of heat at constant pressure required to increase the temperature of 1mole of gas through 1K

Molar specific heat at constant volume Cv: The amount of heat at constant volume required to increase the temperature of 1 mole of gas through 1 K. both are related Cp-Cv=R.

Derivations of Cp-Cv=R: To derive the relation consider one mole of an ideal gas at constant volume so that its temperature rise by ΔT then heat transferred Qv and derived as



$Qv = Cv\Delta v$

Using first law of thermodynamics

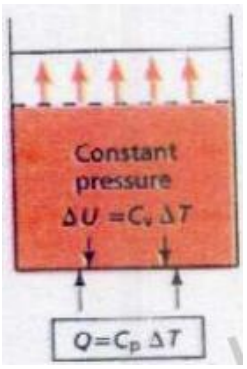
$Qv = \Delta U + W$

$Qv = \Delta U + P\Delta V$ As volume is constant so change in volume is zero $\Delta V = 0$

$Cv\Delta T = \Delta U + P(0)$

$\Delta U = Cv\Delta T$ ----------(1)

Now at constant pressure, if one mole of an ideal gas is heated then rise in temperature ΔT and heat transferred is $Qp = Cp\Delta T$



using First law of TD $Qp = \Delta U + P\Delta V$

from equation (1) $\Delta U = Cv\Delta T$ and Qp put in above equation

$Cp\Delta T = Cv\Delta T + P\Delta V$ ----------(2)

for one mole of an ideal gas equation becomes

$PV = RT \Rightarrow P\Delta V = R\Delta T$ then equation(2) becomes

$Cp\Delta T = Cv\Delta T + R\Delta T$

$Cp = Cv + R$

$Cp - Cv = R$ from this we can say that $Cp > Cv$

What is Reversible process and irreversible process?

A process which can be retraced exactly in reverse order without producing any change in surrounding is called reversible process. i.e liquefaction and evaporation.

A process which cannot be retraced exactly in reverse order, without producing any change in surroundings. For example explosion or work done against friction.

What is Heat engine?

Definition: A device which converts heat energy into mechanical work is called heat engine.

Main parts: It has three main parts. Hot reservoir, cold reservoir and working substance.

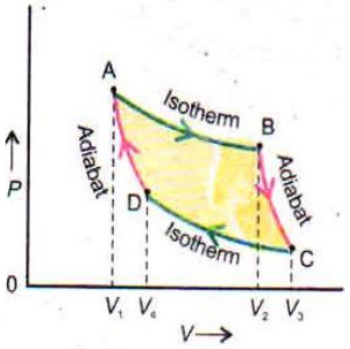
State 2nd law of thermodynamics. Why we have to need the 2nd law of thermodynamics.

Kelvin statement: " It is impossible to make a heat engine which converts all the heat absorbed from a hot reservoir into work without rejecting heat into sink".

Need the 2nd law of thermodynamics: As first law of thermodynamics tells us that heat energy can be converted into equivalent amount of work but not give any information about the conditions under which this conversion takes place so we have to need the 2nd law for this conversion.

Explain Carnot engine and Carnot cycle. Also derive the relation for efficiency.

In 1840 Sadi Carnot proposed a hypothetical engine that operates in reversible cycle using the isothermal and adiabatic process. He showed that a heat engine operating in an ideal reversible cycle b/w two heat reservoirs at different temperature would be most efficient engine.



Carnot cycle: A Carnot cycle consists of four steps as shown in PV diagram.

Step01: In this step, gas is allowed to expand isothermally at temperature T, absorbing heat from hot reservoir. This process is represented by the curve AB.

Step 02: The gas is then allowed to expand adiabatically until its temperature drops. this process is represented by the curve BC.

Step 03: The gas at this stage is compressed isothermally Rejecting heat to the cold reservoir. This process is represented by the curve CD.

Step04: In this step finally the gas is compressed adiabatically to restore in initial state at temperature .This process is represented by the curve DA.

Efficiency of Carnot engine:

work done during one cycle equals to the area enclosed by path ABCDA of PV diagram.

from first law of thermodynamics $Q = \Delta U + W$

$W = Q_1 - Q_2$

$$\text{Efficiency of heat engine} = \eta = \frac{\text{output(work)}}{\text{input(Energy)}} = \frac{Q_1 - Q_2}{Q_1}$$

$$\eta = \frac{Q_1}{Q_1} - \frac{Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

$\%\eta = (1 - \frac{Q_2}{Q_1}) * 100$ This is the formula for efficiency of carnot engine.

$\%\eta = (1 - \frac{T_2}{T_1}) * 100$ In terms of temperature $T_1 =$ temperature of HTR, $T_2 =$ Temperature of LTR.

Carnot theorem: "No heat engine can be more efficient than a Carnot engine operating b/w the same two temperatures".

What is Thermodynamic scale of temperature? What is triple point cell.

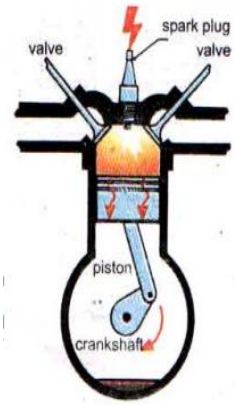
Definition: Such a scale of temperature which is independent of nature of working substance is called thermodynamic scale of temperature. If heat 'Q1' is absorbed at temperature 'T' and heat 'Q2' is absorbed at temperature of triple point of water, then unknown temperature of system (in K) is $T = 273.16\frac{Q_1}{Q_2}$. SI unit is kelvin.

Triple point cell: A triple point cell in which solid ice liquid water and water vapors coexist in thermal equilibrium. Its value is 273.16 K.

Kelvin: one kelvin is defined as 1/273.16 of thermodynamic temperature of triple point of water.

Write a note Petrol engine and Diesel engine?

A typical four stroke petrol engine is based on the principle of Carnot cycle.



Intake Stroke The cycle starts on the intake stroke in which piston moves outward and petrol air mixture is drawn through an inlet valve in to the cylinder from the carburetor at atmospheric pressure.

Compression Stroke On compression stroke, the inlet valve is closed and the mixture is compressed adiabatically by inward movement of the piston.

Power Stroke On power stroke, a spark fires the mixture causing rapid increase in pressure and temperature. The burning mixture expands and forces the piston to move outward. This is the stroke which delivers power to the crank shaft to drive the flywheels.

Exhaust Stroke On the exhaust stroke, the outlet valves opens. The residual gases are expelled and piston moves inward. Efficiency of petrol engine is 25 to 30%.

Diesel engine: No spark is needed in diesel engine. Diesel is sprayed into cylinder at maximum compression because air is at high temperature after compression the fuel mixture ignites on contact with air in cylinder and pushes the piston outward. The efficiency of diesel engine is 35% to 40%.

What is Entropy? Write its formula and unit.

Definition: The measure of disorderness of molecules of system is called entropy. Its formula $\Delta S = \frac{\Delta Q}{T}$ and unit is J/K. It is state function. Concept of entropy was given by Rudolph clausius in 1856.

State 2nd law of thermodynamics in terms of entropy? "If a system undergoes a natural process, it will go in the direction that entropy of system plus the environment increase".

What Heat death of universe? When the entropy of the universe will reach at maximum value, everything will be at same temperature and there will be no way to convert heat into useful work is called heat death of universe.

What is Refrigerator? A refrigerator transfers heat from a low temperature reservoir to higher temperature reservoir with help of external work. It is heat engine operating in reverse order.

DESCRIBE ENVIRONMAENTAL CRISIS AS ENTROPY CRISIS

According to 2nd law of thermodynamics, Environmental crisis is an entropy or disorder crisis. According to which, any increase in the order in a system will produce an even larger increase in entropy in the environment

- Energy methods we use are not very efficient. As a result most of the energy is lost as heat to the environment
- Most energy transformation processes such as heat engines used for transportation and for power generation causes air pollution.

It is because of the reason that even for small changes in temperature, the environment can have significant effects on metabolic rates in plants and animals. This can causes serious disturbance of the overall ecological balance.

Exercise short Questions chapter 11

1. Why is the average velocity of the molecules in a gas zero but the average of the square of velocities is not zero?

The molecules of the gas moves in random direction. We assume that the same number of molecules move in both directions, so the average of each component velocity is zero. $\langle v \rangle = \frac{v + (-v)}{2} = 0$

But the average of the squares of the velocities of the molecules is not zero because square of negative is positive.

$$\langle v \rangle^2 = \frac{v^2 + (-v)^2}{2} \neq 0$$

2 Why does the pressure of a gas in a car tyre increase when it is driven through some distance?

In driving, the car tyre gets hot due to force of friction. This heat goes inside the tyre and increases translational kinetic energy. So increase of KEtrans makes pressure increase.

3.A system undergoes from state P1 V1 to state P2 V2 as shown in the fig. What will be the change in internal energy?

The change in internal energy (ΔU) will be zero. In the figure the graph is isotherm. It means temperature remain constant. So ΔU = 0

4 Variation of volume by pressure is given in the fig. A gas is taken along the paths ABCDA, ABCA and A to A. What will be the change in internal energy?

In the figure, all three paths returns to the initial state, so there is no change in internal energy.

5.Specific heat of a gas at constant pressure is greater than specific heat at constant volume. Why?

Specific heat at constant pressure (Cp) is greater than Cv , because a part of heat is used to do work on piston and rest of heat is used to increase the temperature through 1K and at constant volume all the heat absorbed is used to increase temperature through 1K.

6 Give an example of a process in which no heat is transferred to or from the system but the temperature of the system changes.

Adiabatic process, for example rapid escape of air from a burst tyre, rapid expansion and compression of air, cloud formation in the atmosphere.

7. Is it possible to convert internal energy into mechanical energy? Explain with example.

Yes. In adiabatic expansion of a gas internal energy converts into mechanical energy or work. Gases can be liquefied by this process.

8 Is it possible to construct a heat engine that will not expel heat into the atmosphere?
No. It is not possible. Because according to 2nd law of thermodynamics it is not possible to construct an engine without a sink or cold body to reject a part of heat to it, the atmosphere (or cold body).

9 A thermos flask containing milk as a system is shaken rapidly. Does the temperature of milk rise?
Yes. As KE of the molecules increases due to rapid shaking, so the temperature of the milk rises.
10 What happens to the temperature of the room, when a air conditioner is left running on a table in the middle of the room?
The temperature of the room remains same. Because heat absorbs from the room is expelled in the same room. Rather the temperature will rise due to work done by the compressor will change into heat.
11.Can the mechanical energy be converted completely into heat energy? If so give an example.
Yes, in a adiabatic compression, work done on the gas, increased the internal energy, i.e. converting mechanical energy (work) into heat energy (ΔU).
12 Does entropy of a system increases or decreases due to friction?
The entropy of the system increases, due to friction. As work done against friction changes into heat and this irreversible process increases its entropy.
13 Give an example of a natural process that involves an increase in entropy.
i) Melting of ice into water: The heat Q transferred to the ice at absolute temperature from the surroundings. $\Delta S = Q / T$ Since heat is added, Q is +ve and entropy increases. ii) Free expansion: In a free expansion of a gas in a chamber, which is irreversible process. Here the gas molecules confined to one half of a box are permitted to fill the entire box, which is irreversible process.
14 .An adiabatic change is the one in which. Correct answer is (a) No heat is added to or taken out of a system in the adiabatic change.
15 Which one of the following process is irreversible?
Correct answer is (d) a chemical explosion is irreversible process
16 An ideal reversible heat engine has
Correct answer is (b), an ideal reversible heat engine has highest efficiency. From the knowledge of 2nd law of TD, a heat engine cannot have 100 % efficiency and is independent of the working substance

Chapter 11

11.1: Estimate the average speed of nitrogen molecules in air under standard conditions of pressure and temperature.

$$\text{Given Data: STP, T} = 0^{o}\text{C, P} = 1\text{atm} = 1.01*10^{5}\ \text{pa}, < v >= ?, \text{m} = \text{molar mass/N}_{A} = 28*10-3/6.02*1023 = 4.65*10^{-26} kg$$

$$< v >= \sqrt{\frac{3KT}{m}} = \sqrt{\frac{3*1.38*10^{-23}*273}{4.65*10^{-26}}} = 493 m/s.$$

11.2: Show that ratio of the root mean square speeds of molecules of two different gases at a certain temperature is equal to the square root of the inverse ratio of their masses.

$$\text{As } < V_1 >_{rms} = \sqrt{\frac{3KT}{m_1}}, < V_2 >_{rms} = \sqrt{\frac{3KT}{m_2}}, \text{ dividing both equations}$$

$$\frac{< V_1 >_{rms}}{< V_1 >_{rms}} = \frac{\sqrt{\frac{3KT}{m_1}}}{\sqrt{\frac{3KT}{m_2}}} = \sqrt{\frac{m_2}{m_1}} \Rightarrow \frac{< V_1 >_{rms}}{< V_1 >_{rms}} = \sqrt{\frac{m_2}{m_1}} \text{ which is required result}$$

11.3: A sample of gas is compressed to one half of its initial volume at constant pressure of $1.25\times10^{5}\,Nm^{-2}$. During the compression, 100J of work is done on the gas. Determine the final volume of the gas.

$\text{Given Data}: V_i = V,\ V_f = V - V/2 = V/2,\ P = 1.25*10^{-5}\,\text{Pa},\ W = -100\text{J},\ V_f = ?$

$W = P\Delta V = P(V/2 - V) \Rightarrow W = -PV/2 \Rightarrow -100 = P(-V/2) \Rightarrow V/2 = 100/P, V_f = 100/1.25*105 = 8*10^{-4}\,m^3$

11.4: A thermodynamic system undergoes a process in which its internal energy decreases by 300 J. If at the same time 120 J of work is done on the system, find the heat lost by the system.

$\text{Given Data}: \Delta U = -300\text{ J},\ W = -120\text{ J},\ Q = ? \Rightarrow Q = \Delta U + W = -300 + (-120) = -420J$

11.5: A Carnot engine utilizes an ideal gas. The source temperature is $227^{\circ}C$ and the sink temperature is $127^{\circ}C$. Find the efficiency of the engine. Also find the heat input from the source and heat rejected to the sink when10000 J of work is done.

$T_1 = 227^{o}C = 227 + 273 = 500K,\ T_2 = 127^{o}C = 127 + 273 = 400K,\ W = 10000\text{ J},\ \eta = ?,\ Q_1 = ?\ Q_2 = ?$

$\eta = (1 - \frac{T_2}{T_1})*100 = (1 - \frac{400}{500})*100 = 0.2 = 20\%,\ \text{using formula}\ \eta = W/Q_1 = 0.2 = 10000/Q1 \Rightarrow Q_1 = 50000J$

$\text{Now using}\ W = Q_1 - Q_2,\ Q_2 = Q_1 - W = 50000 - 10000 = 40000J$

11.6: A reversible engine works between two temperatures whose difference is $100^{\circ}C$. If it absorbs 746 J of heat from the source and rejects 546 J to the sink, calculate the temperature of the source and the sink.

$\text{Given Data}: T_1 - T_2 = 100^{o}C = 100K,\ Q_1 = 746\text{ J},\ Q_2 = 546\text{ J},\ T_1 = ?\ T_2 = ?$

$\eta = 1 - Q_2/Q_1 = 1 - 546/746 = \eta = 0.268 - - - (1)$

$\eta = 1 - \frac{T_2}{T_1} = \frac{T_1 - T_2}{T_1} \Rightarrow 0.268 = \frac{100}{T_1} \Rightarrow T_1 = \frac{100}{0.268} = 373.13K = 373.16 - 273.16 = 100^{o}C$

$\text{again using}\ T_1 - T_2 = 100 \Rightarrow T_2 = T_1 - 100 = 373.16 - 100 = 273.16K = 273.16 - 273.16 = 0^{o}C$

11.7: A mechanical engineer develops an engine, working between $327^{\circ}C$ and $27^{\circ}C$ and claims to have an efficiency of 52%. Does he claim correctly? Explain.

$T_1 = 327^{o}C = 327 + 273 = 600K,\ T_2 = 27^{o}C = 27 + 273 = 300K,\ \text{claimed}\ \eta = 52\%,\ \text{claim} = ?$

$\text{using}\ \eta = (1 - \frac{T_2}{T_1})*100 = (1 - \frac{300}{600})*100 = 50\%,\ \text{His claim is not correct.}$

11.8: A heat engine performs 100J of work and at the same time rejects 400 J of heat energy to the cold reservoirs. What is the efficiency of the engine?

$\text{given data}: W = 100\text{ J},\ Q_2 = 400\text{ J},\ W = Q_1 - Q_2 \Rightarrow Q1 = W + Q_2 = 100 + 400 = 500\text{J},\ \eta = ?$

$\%\eta = (1 - \frac{Q_2}{Q_1})*100 = (1 - \frac{400}{500})*100 = 20\%$

11.9: A Carnot engine whose low temperature reservoir is at $7^{\circ}C$ has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees the temperature of the source be increased?

Given Data : $T2 = 7^{o}C = 7 + 273 = 280\ K, \eta_1 = 50\% = 0.5, \eta_2 = 70\% = 0.7, T_1 = ?, T_1' = ?, T_1' - T_1 = ?$

$$\eta_1 = 1 - \frac{T_2}{T_1} \Rightarrow 0.5 = 1 - \frac{280}{T_1} \Rightarrow \frac{280}{T_1} = 0.5 \Rightarrow T_1 = 560K,$$

$$\eta_2 = 1 - \frac{T_2}{T_1'} \Rightarrow 0.7 = 1 - \frac{280}{T_1'} \Rightarrow \frac{280}{T_1'} = 0.3 \Rightarrow T_1' = 933.3K$$

$$T_1' - T_1 = 933.3 - 560 = 373K$$

11.10: A steam engine has a boiler that operates at 450K. The heat changes water to steam, which drives the piston. The exhaust temperature of the outside air is about 300K. What is maximum efficiency of this steam engine?

Sol. $T_1 = 450K, T_2 = 300K, \eta = ?$ $\quad \%\eta = (1 - \frac{T_2}{T_1}) * 100 = (1 - \frac{300}{450}) * 100 = 33\%$

11.11: 336J of energy is required to melt 1 g ice at $0^{\circ}C$. What is the change in entropy of 30 g of water at $0^{\circ}C$ as it is changed to ice at $0^{\circ}C$ by a refrigerator?

given Data : $L_f = 336\ J, m = 30\ g, T = 0^{o}C = 273\ K, \Delta S = ?$

$$\Delta S = -\frac{\Delta Q}{T} = -\frac{mL_f}{T} = -\frac{30 * 336}{273} = -36.92\ J/K$$

Negative sign shows decrease in entropy

TID BITS/USEFUL INFORMATION

MCQS

1) A diatomic gas molecule has

Translational kinetic energy	Rotational kinetic energy	Vibrational energy	**All of these**

2) The constant downward applied force F acting on frictionless piston is

PA	PV	VT	ma

3) According to Kelvin statement of 2nd law of thermodynamics heat from a source at a single temperature ---- be converted into work

Can	**Cannot**	May	None of these

4) A heat engine operating in reverse order is called

Diesel engine	**Refrigerator**	Petrol engine	Carnot engine

5) A----- transfer heat from a low temperature reservoir to high temperature surrounding with the help of external work

Diesel engine	**Refrigerator**	Petrol engine	Carnot engine

6) A triple point cell in which solid, ice, liquid water and water vapor coexist in ----

High temperature	Low temperature	**Thermal equilibrium**	Neutral equilibrium

7) The value of triple point cell is

273.16 K	273.16°C	0K	32°C

8) Approximate efficiency of electric generator is

70-80 %	70-90%	80-90%	**70-99%**

9) Efficiency of electric motor is

50-60%	60-70%	**50-93%**	90%

10) Efficiency of dry cell battery is

60%	70%	80%	**90%**

11) Efficiency of domestic gas furnace

50-60%	60-70%	**70-85%**	80-90%

12) Efficiency of storage battery is

12%	62%	**72%**	92%

13) Efficiency of hydrogen oxygen fuel cell is

50%	70%	80%	**60%**

14) Efficiency of liquid fuel rocket is

65%	37%	83%	**47%**

15) Efficiency of steam turbine is

35-40%	**35-46%**	35-56%	35-65%

16) Efficiency of fossil fuel power plant is

10-20 %	20-30%	**30-40%**	40-50%

17) Efficiency of nuclear power plant is

10-20 %	20-30%	**30-35%**	40-50%

18) Efficiency of nuclear reactor is

50%	70%	80%	**39%**

19) Efficiency of air craft gas turbine engine

50%	**36%**	87%	60%

20) Efficiency of solid state laser is

50%	70%	80%	**30%**

21) Efficiency of internal combustion gasoline engine

10-20 %	**20-30%**	30-35%	40-50%

22) Efficiency of gallium arsenide solar cells are

>20%	<20%	<10%	<5%

23) Efficiency of florescent lamp is

20%	30%	10%	5%

24) Efficiency of silicon solar cell is

12-14%	**12-16%**	12-18%	12-20%

25) Efficiency of steam locomotive is

5%	**8%**	1%	20%

26) Efficiency of incandescent lamp is

5%	8%	1%	20%

27) Efficiency of watt steam engine is

5%	8%	1**%**	20%

28) The jet engine on air crafts convert

Thermal energy to work	Thermal energy to electrical energy	Thermal energy to heat energy	None

29) Considerable---------- is lost as waste heat in jet air craft is

Mechanical energy	**Thermal energy**	Electrical energy	None

BISE AND UHS PAST PAPERS SOLVED MCQS

Q#	Questions	Option A	Option B	Option C	Option D
i.	Which is not the example of adiabatic process	Rapid escape of air from burst tyre	Rapid expansion of air	**Conversion of water into ice in refrigerator**	Cloud formation in atmosphere
ii.	Isothermal process is carried out at constant	Pressure	Volume	**Temperature**	All of these
iii.	The pressure on the other sides and everywhere inside the vessel will be according to the:	**Pascal's Law**	Boyle's Law	Hook's Law	Charles's Law
iv.	The entropy of the universe always	Decreases	Remains the same	**Increases**	Both A and B
v.	Boltzmann constant is written as K=?	**R/N_A**	N_AR	N/R	None of these
vi.	The efficiency of Carnot engine depends	Sink temperature	Source temperature	**Both A&B**	Working substance

vii.	The pressure exerted by column of mercury 76cm high and at 0˚C is called	**1atm**	1 N/m2	1 Pascal	None of these
viii.	Average translational kinetic energy of molecules for an ideal gas is given by	2/3 KT	$\frac{3KT}{2}$	2T/3K	3T/2K
ix.	Pressure of gas is given by the relation	**1/3 ϱ<v²>**	3/2 ϱ<v²>	ϱ<v²>	None of these
x.	J/K is the unit of	Efficiency	**Entropy**	Heat of fusion	Internal energy
xi.	Which of the following relation shows adiabatic process	$W = \Delta U$	$W = -\Delta U$	$W = 0$	$W = Q$
xii.	The value of triple point of water is given by	0 K	100 K	**273.16 K**	373.16 K
xiii.	The relation R/NA = 1.38 x 10^{-23} JK^{-1} in a gas law is known as	Avogadro's constant	Newton's constant	Charles constant	**Boltzmann's constant**
xiv.	Number of spark plugs needed in diesel engine is	1	2	3	**0**
xv.	Unit of thermodynamics scale of temperature is given as	**Kelvin**	Fahrenheit	Centi grade	Celsius
xvi.	The relation 'PV = nRT' shows which law of physics	Charles Law	Newton's Constant	Avogadro's Law	**Ideal Gas Law**
xvii.	When heat is added to a system then entropy change is	**Positive**	Negative	Zero	None
xviii.	For monoatomic gas Cv=3R/2 then gamma?	3/5	**5/3**	4/15	15/4
Cp-Cv=R, Cp-3R/2=R, Cp=R+3R/2=5R/2, put Cp=5R/2, Cv=3R/2 in γ=Cp/Cv= 5/3					
xix.	An ideal reversible heat engine has	100% Efficiency	**Maximum highest Efficiency**	Efficiency depends on working substance	None of these
xx.	The efficiency of diesel engine is	25-30%	30-35 %	40-45%	**35-40%**
xxi.	A process in which no heat enter or leave the system is called	Isothermal process	**Adiabatic process**	Isobaric process	Isochoric process
xxii.	Thermal pollution is inevitable consequence of thermodynamics	First law	**2nd law**	1st law of motion	None of these
xxiii.	The efficiency of heat engine is increased by increasing temperature of	Engine	Cold reservoir	**Hot reservoir**	None of these
xxiv.	The unit of entropy is	JK	K/J	**J/K**	J
xxv.	The concept of entropy was introduced by Rudolph clausius in	1840	**1856**	1864	1870
xxvi.	The cloud formation in atmosphere is an example of	Isothermal process	**Adiabatic process**	Isobaric process	Isochoric process
xxvii.	The relationship between absolute temperate of an ideal gas and average translation kinetic energy is T=?	$\frac{2}{3k}\langle\frac{1}{2}mv^2\rangle$	$\frac{3}{2k}\langle\frac{1}{2}mv^2\rangle$	$\frac{3}{2}k\langle\frac{1}{2}mv^2\rangle$	$\frac{2}{3}k\langle\frac{1}{2}mv^2\rangle$

xviii.	Pressure of the gas depends upon	Only on molecular speed	Only on mass of molecule	Only on number of molecule in a unit volume	**Number of molecule in unit volume and speed of molecule**
xxix.	No entropy change is associated with	Isothermal process	**Adiabatic process**	Isochoric process	Boyle law
xxx.	One is an example of reversible process	Work done against friction	Heat produced by a current	**Melting of ice**	Explosion
xxxi.	Gas law $PV^{\gamma} = cons\tan t$ is for	Isothermal process	**Adiabatic process**	Isobaric process	Isochoric process
xxxii.	The highest efficiency of a heat engine whose lower temperature is 17°C and high temperature is 200°C is	70%	60%	**38%**	135%
T_2=17°C=17+273=290K, T_1=200°C=200+273=473K. put T_1=473 K, T_2=290 K in efficiency formula to get result					
xxiii.	The change in entropy of a system is given by	$\Delta S = \frac{\Delta Q}{T}$	$\Delta S = \frac{\Delta T}{Q}$	$\Delta Q = \frac{\Delta T}{S}$	None of these
xxiv.	The efficiency of petrol engine is	**25-30%**	30-35 %	40-45%	35-40%
xxxv.	At constant temperature and pressure, if volume of given mass of a gas is doubled then density	**Half**	Double	One fourth	Remains same
xxvi.	Absolute zero corresponds to	-400°F	**0K**	0°C	273.16°C
xxvii.	Which of the following is the expression of root mean square speed of a gas having n number of molecules contained in the container	$\sqrt{\frac{V_1^2+V_2^2+V_3^2+....V_n^2}{N}}$	$\sqrt{\frac{V_1+V_2+V_3+....V_n}{N}}$	$V_1+V_2+V_3+....V_n$	None of these
xviii.	The expression for isothermal process is	Q=U	**Q=W**	U=W	U= -W
xxix.	A gas sample contains three molecules each having speed 1 ms-1, 2 ms-1, 3 ms-1. What is the mean square speed?	**14/3 m/s** $1^2+2^2+3^2/3$ 1+4+9/3=14/3	2 m/s	6 m/s	$\sqrt{14/3}$ m/s
xl.	A heat engine operating according to second law of thermodynamics rejects one fourth of the heat taken from high temperature reservoir. What is the percentage efficiency of heat engine?	100%	50%	25%	**75%**
$T1 = T, T2 = T/4, then\ \eta = (1 - T2/T1)*100 = (1 - \frac{T/4}{T})*100 = (1 - \frac{1}{4})*100 = (\frac{3}{4})*100 = 75\%$					
xli.	If 'Q' is the amount of heat supplied to a system and 'W' is the work done, then change in internal energy can be defined as	Q/W	W/Q	**Q – W** Apply first law of thermodynamics	1 + Q/W
xlii.	If the temperature of sink is decreased the efficiency	Decrease	**Increase**	Remains same	None of these
xliii.	For an ideal gas, potential energy associated with its molecules is	Maximum	**Zero**	½ kx	None

xliv.	What is the factor upon which change in internal energy of an ideal gas depends?	Change in volume	**Change in temperature**	Change in temperature and volume	Path followed to change internal energy
xlv.	Change in entropy of a reversible process is	Positive	Negative	Zero	Maximum
xlvi.	For a heat engine 'A' ratio of Q_1 to Q_2 is 3/2 while that of heat engine 'B', ratio of Q_2 to Q_1 is 1/3. What is the value $\eta_A : \eta_B$?	1:3	2:3	**1:2**	2:1
$Q1\,\text{to}\,Q2 = 3/2\,\text{so}\,Q2/Q1 = 2/3,\ \eta_A = (1 - Q2/Q1) = (1 - 2/3) = 1/3$ $Q2/Q1 = 1/3,\ \eta_B = (1 - Q2/Q1) = (1 - 1/3) = 2/3\,\text{so}\ \eta A : \eta B = (1/3) : (2/3) = 1 : 2$					
xlvii.	Celsius scale starts from	32°F	273°K	**0°C**	373°K
xlviii.	The turbine in a steam power plant takes steam from a boiler at 427 °C and exhausts into a low temperature reservoir at 77 °C. What is the maximum possible efficiency?	**50%**	60%	40%	70%
Apply efficiency formula by putting T1=700 K, T2=350 K,, efficiency=$(1-T_2/T_1)*100$ $(1-350/700)*100 = 50\%$					
xlix.	In an adiabatic process first law of thermodynamics becomes	$\Delta Q = \Delta U$	**$\Delta W = -\Delta U$**	$\Delta W = \Delta U$	$\Delta Q = W + \Delta U$
l.	Which one of the following is a postulate of kinetic theory of gases?	**Molecules do not exert force on each other**	The size of molecules is much larger than separation between the molecules	A finite volume of gas consists of a very small number of molecules	The gas molecules are not in random motion
li.	The increase in the entropy means increase in	Disorder	Unavailability of energy	Randomness	**All of these**
lii.	For a gas of volume V in its equilibrium state, if the pressure does change with time then total kinetic energy of gas is constant because	Collisions between gas molecules occur	**Collisions must be elastic**	Collisions between gas molecules occur linearly	Collisions must be inelastic
liii.	Which one is not an irreversible process?	**Slow compression of a gas into a cylinder**	Explosion	Changes due to friction	Dissipation of energy
liv.	Which is the average translational kinetic energy of molecule in a gas at temperature 27°C	**$6.21*10^{-21}$ J** See exp 11.1 for solution	$6.21*10^{-26}$ J	$6.23*10^{23}$J	$6.21*10^{26}$J
lv.	the value of triple point of water is	373.16 K	**273.16 K**	173.16 K	0K
lvi.	Which is isothermal process?	Rapid escape of air from burst tyre	**Slow expansion of gas in cylinder at const temp**	Rapid expansion of gas in cylinder	Cloud formation
lvii.	A gas containing 'N' number of molecules of a gas having mass of each molecule 'm' is in a cubic container having length of	N/a^2	**Nm/a^3** Density is mass per unit volume So density- Nm/a^3	m/a^3	Na^3/m

	each side 'a'. What is the density of gas contained in cube?				
lviii.	Entropy remains constant in	Isothermal process	**Adiabatic process**	Isobaric process	Isochoric process
lix.	In 'General Gas Equation PV=nRT', 'n' represents the number of moles of gas. Which of the following represents the relation of 'n'?	$n = NN_A$	$n = N_A/N$	**$n = N/N_A$**	$n = N + N_A$
lx.	A device based upon thermodynamic property of matter is called	Calorimeter	Heat engine	**Thermometer**	Voltmeter
lxi.	At triple point of water, the pressure of gas is 2680 Pa, by changing 'T' the pressure increases to 4870 Pa. Then 'T' is:	**496.38 K**	Zero	438.96 K	496.38 ^oF
As pressure is directly proportional to average kinetic energy of molecules/temperature so in this case pressure is increased 1.8 times, so for finding the value of new temperature 1.8*273.16=496.38 k					
lxii.	The most important factor regarding the significance of Carnot engine is that	It practically possible	Its efficiency is 100%	**It set an upper limit on the efficiency**	It sets a lower limit on the efficiency
lxiii.	Which is called internal energy of an ideal gas ?	Potential energy	Translational kinetic energy	**Both A&B**	Vibrational kinetic energy
lxiv.	The process which is carried out at constant temperature is called	**Isothermal**	Adiabatic	Isochoric	Isobaric
lxv.	At what temperature both Celsius and Fahrenheit scales give the same reading?	-100^o	-180^o	**-40^o**	-273^o
lxvi.	A heat engine working according to second law of thermodynamics has 50% efficiency. What will be the temperature of its low temperature reservoir if high temperature reservoir is 327°C?	**27°C**	300°C	127°C	600°C
$\eta = 50\% = 0.5, T2 = 600K, \eta = (1 - T2/T1),, 0.5 = (1 - T2/600), T2/600 = 0.5, T2 = 300K = 300 - 273 = 27^oC$					
lxvii.	Working cycle of a typical petrol engine consists of	Two strokes	**Four strokes**	Six strokes	Eight strokes
xviii.	Carnot cycle is	**Reversible**	Irreversible	Both A&B	None of these
lxix.	Two sample of gases '1' and '2' are taken at same temperature and pressure but the ratio of number of their volume is $V_1:V_2$ = 2:3. What is the ration of number of moles of the gas sample?	3:2	4:9	**2:3** Apply ideal gas eq	$\sqrt{2}:\sqrt{3}$
lxx.	The curve represents an adiabatic process is called	Isotherm	**Adiabate**	Adiabatic	Isothermal
lxxi.	Which of these is not an example of a irreversible process ?	Work done against friction	Heat produced by current	**Melting of ice**	Explosion

lxxii.	Kinetic energy of an ideal gas at absolute zero will be ?	Infinite	**Zero**	Very high	Below zero
xxiii.	One of the following is true for Carnot engine	$\eta_{>1}$	$\eta_{=1}$	$\eta_{<1}$	W=U
xxiv.	Internal energy of a substance is directly proportional to	Pressure	Volume	**Temperature**	None of these
lxxv.	A carnot engine discharge 3J of heat into the LTR for every 2J of work. The efficiency of carnot engine will be	33%	**40%**	60%	66%
Q2=3J, W= 2J, W=Q1-Q2, Q1=W+Q2=2+3=5J, applying efficiency formula η=W/Q1*100=2/5*100=40%					
xxvi.	An adiabatic process is that which has constant	**Entropy**	Volume	Pressure	Temperature
xxvii.	What is the 273 k on the Celsius scale of temperature?	0.15°C	**-0.15°C**	273.15°C	-273.15°C
As 1C=273.15K so convert Celsius into kelvin subtract it 273-273.15=-0.15°C					
xviii.	The efficiency of carnot engine depends on	Nature of working substance	Size of engine	Construction of engine	**Temperature of hot and cold reservoir**
xxix.	When the rate of gas changes without change in temperature, the gas is said to undergo	**Isothermal Process**	Isochoric Process	Adiabatic Process	Isobaric Process
lxxx.	Which of the following processes is practically reversible	Explosion	Human metabolism	**Evaporation**	Cloud formation
xxxi.	An ideal gas is one whose molecule have energy	**K.E only**	P.E only	K.Erot	Vibration &K.E only
xxxii.	Boyle law is applicable to	Isochoric process	Isobaric process	**Isothermal process**	Adiabatic process
xxiii.	For a diatomic Cv=5R/2 then gamma is	5/7	4/35	**7/5**	35/4
Cp-Cv=R, Cp-5R/2=R, Cp=R+5R/2=7R/2, put Cp=7R/2, Cv=5R/2 in γ=Cp/Cv= 7/5					
xxiv.	According to first law of thermodynamics the quantity which is conserved	**Energy**	Force	Momentum	Power
xxxv.	A system does 600J of work and at the same time its internal energy increased by 320J. how much heat has been supplied	280J	**920J**	600J	200J
Apply first law of thermodynamics Q=ΔU+W=600+320=920 J					
xxvi.	Latent heat of fusion of ice is Lf	**$3.36*10^5$ J/Kg**	$336*10^5$ J/kg	$3.6*10^{-5}$ J/Kg	$3.36*10^{-5}$ J/kg
xxvii.	If Cv is the molar specific heat at constant volume and ΔT is temperature then CvΔT gives	Area	**Energy**	Volume	Density
xviii.	Heat is form of	Power	Momentum	**Energy**	Torque
xxix.	An isothermal process is represented by equation	**PV=constant**	P/V=constant	P/T=constant	None
xc.	The ratio of Cp/Cv for diatomic gas is equal to	1.67	1.50	**1.40**	1.29
xci.	Environmental crises are known as	Population crises	**Entropy crises**	War crises	Mass crises
xcii.	Ideal gas equation is	PT=NUK	P=NKT	**PV=nRT**	P=nRT

xciii.	Difference between Cp and Cv is equal to	Planks constant	**Universal gas constant**	Molar gas constant	Boltzmann constant
xciv.	In thermodynamic system internal energy decrease by 100 J and 100 of work is done on the system then heat lost will be?	Zero	100 J	200J	**-200J**
Apply first law of thermodynamics ΔU=-100 J, W=-100 J, so Q=-100+(-100)=-200 J, as work done on system is -iv					
xcv.	According to Charles law	$V\alpha T$	$P\alpha V$	$V\alpha 1/P$	None of these
xcvi.	Which is an example of irreversible process?	**Explosion**	Evaporation	Slow compression	Liquefaction
xcvii.	The value of molar gas constant R in J/mol K	8314	831.4	**8.314**	83.14
cviii.	1 mole of a gas occupies volume 1.00 x 10^{-2} m^3 in a gas cylinder whose pressure is equal to 2.50 x 10^5 Pa. The temperature of cylinder is	227K	370K By using PV=nRT	**300K**	390K
By using ideal eq PV=nRT,,, $2.5*10^5*1*10^{-2}=1*R*T$, $RT=2.5*10^3$, $T=2.5*10^3/8.31=2500/8.31=300$ K					
xcix.	Estimate pressure of air molecules at 273K, if mean square speed is 500 m^2/s^2 and density of air is 6 kg/m^3:	**1 x 10^3 Pa**	1 x 10^2 Pa	2.5 x 10^2 Pa	2.7 x 10^3 Pa
By using $P=1/3\ \varrho\langle v^2\rangle=1/3*6*500=3000/3=1000$ pa$=1*10^3$ pa					
c.	For obeying Boyle law, if pressure is doubled then volume	**One half**	Double	One fourth	Same
Pressure of gas is inversely proportional to volume so doubling the pressure half the volume					
ci.	Pressure of gas is directly proportional to	Potential energy	**Average Kinetic energy**	Wind energy	Sound energy
cii.	The dimension of entropy are	$[MLT^{-2}]$	$[ML^2T^{-2}]$	$[ML^2T^{-2}K^{-1}]$	$[ML^2T^{-2}K]$
Apply entropy formula put dimensions heat=$[ML^2T^{-2}]$, Temperature=[K]					
ciii.	Entropy of universe with passage of time is	**Increase**	Decrease	Remains same	Increase and decrease
civ.	An ideal heat engine can only be 100% efficient if its cold temperature reservoir is	**0K**	0˚C	273 K	100 K
By using efficiency formula, there is only one condition under which efficiency will be 100% when T_2=0K					
cv.	Diatomic molecule has energy	Translational energy	Rotational energy	**Both A&B**	None
cvi.	For diatomic gas molecule γ=1.4 and Cv=$\frac{5R}{2}$ the value of Cp	$\frac{2}{5}R$	$\frac{9}{2}R$	$\frac{7}{2}R$	$\frac{11}{2}R$
Solution As Cp-Cv=R, so Cp-5R/2=R, Cp=R+5R/2, taking LCM then we get Cp=7R/2					
cvii.	If the temperature of gas is constant then $\left\langle \frac{1}{2}mv^2 \right\rangle$ of molecules of gas is	**Constant**	Zero	Increased	Decreased
As temperature is directly proportional to average kinetic energy of gas molecules					

cviii.	A heat engine operating b/w temperatures 400K and 1000 K, its efficiency will be	**60%**	50%	40%	70%
Apply efficiency formula by putting T1=1000 K, T2=400 K,, efficiency=$(1-T_2/T_1)*100$ (1-400/1000)*100= 60%					

Paper pattern Physics 1st year Physics 2019 and onward

Chapter # Number	MCQs 17/17 Q.1	Short Questions 22/33	Extensive Questions 03/05
01	2	2	In Q.9
02	2	3	Q.5 (a)+(b) a or b part may be selected from chapter 02 or 03
03	1	4	
04	1	2	Q.6 (a)+(b) a or b part may be selected from chapter 04 or 08
05	2	4	
06	2	2	None
07	1	3	Q.7 (a)+(b) a or b part may be selected from chapter 05 or 07
08	2	4	
09	1	3	Q.8 (a)+(b) a or b part may be selected from chapter 09 or 10
10	1	2	
11	2	4	Q.9 (a)+(b) a or b part may be selected from chapter 01 or 11
Short Questions portion is divided into 03 Questions which are as follows Q.2 Chapter (01+02+04+06+07) Attempt any 08 from 12 questions Q.3 Chapter (03+05+08) Attempt any 08 from 12 questions Q.4 Chapter (09+10+11) Attempt any 06 from 09 questions			
Total Marks	**17**	**44**	**(5+3)*3=24**

ASAD ABBAS

(Subject Specialist Physics)

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Physics paper 1st year annual 2019(BISE Sargodha)

Objective

Q.1 MCQs **17**

Q#	Statement	Option A	Option B	Option C	Option D
01	The term 134.7 can be written in scientific notation as	**$1.347*10^2$**	$1.347*10^3$	$1.347*10^1$	$1.347*10^4$
02	The quantity 0.00467 has significant figures	**3**	4	5	6
03	If the two components of a vector are equal in magnitude, the vector making angle with x-axis	30^o	**45^o**	60^o	90^o
04	Two forces of magnitude 10N and 20N act on a body in direction making angle 30^o,X-components of resultant force will be	**25.98N**	30.98 N	20.98N	17.98N
05	If the maximum height of projectile is equal to range of projectile the angle of projection	30^o	45^o	**76^o**	90^o
06	If 50kg crate is pushed through 2m across the floor with a force of 50N, the work done will	245 J	150 J	200 J	**100J**
07	A body rotates with constant angular velocity of 100rad/s about vertical axis, the required torque	**Zero Nm**	100 Nm	200 Nm	300 Nm
08	Moment of inertia of 100kg sphere having radius 50cm will be	**10 kgm^2**	5 kgm^2	500kgm^2	2.5kgm^2
09	Laminar flow occurs at	High speed	**Low speed**	Zero speed	Very high speed
10	High concentration of red blood cells increases the viscosity of blood from	2-3 times of water	**3-5 times of water**	5-7 times of water	7-9 times of water
11	Distance covered by a body in one vibration is 20cm , the amplitude of the vibration will be	**5cm**	10cm	15cm	20cm
12	Speed of sound in hydrogen is higher than in oxygen by times	**4**	6	8	16
13	Sound waves cannot pass through	Liquids	Solids	Gases	**Vacuum**
14	Which of the following cannot produce colors with white light?	Diffraction	Interference	**Polarization**	Dispersion
15	The image formed by eye piece of compound microscope	Real and magnified	Real and diminsed	**Virtual and enlarge**	Virtual and diminished
16	The direction of flow of heat b/w two bodies in thermal contact is determined by	**Internal energies**	**Kinetic energies**	Potential energies	Atmospheric pressure
17	A carnot engine has efficiency of 50%, when its sink temperature is 27^oC, the temperature of source is	300^oC	**327^oC**	373^oC	273^oC

Physics 1st year Annual 2019 (BISE Sargodha) Subjective

Section--------I

Q.2 Answer briefly any Eight parts from the followings:- 16

i. Write any two point which should keep in mind while using units?
ii. How many microsecond in one year?
iii. Find the angle b/w $\vec{A} = 2\hat{i} - 2\hat{j}$ and $\vec{B} = 2\hat{i} + 2\hat{j}$.
iv. Can the magnitude of a vector ever be zero? Explain.
v. What are the steps taken to add vectors by rectangular components?
vi. In which case more work is done? When a 50kh crate is pushed through 10m across the floor with a force of 30 N or same crate is lifted through 5m height?
vii. Derive work energy principle.
viii. Explain how swing is produced in fast moving cricket ball?
ix. What do you know about viscosity and drag force?
x. What are the factors upon which frequency of mass spring system depends?
xi. What is difference b/w free and driven harmonic oscillator?
xii. Explain phase and initial phase?

Q.3 Answer briefly any Eight parts from the followings:- 16

i. Can the velocity of an object reverse direction when acceleration is constant? If so give example.
ii. Define impulse and show how it is related to linear momentum?
iii. What does the slope of velocity time graph represent?
iv. An object is thrown vertically upward. Discuss the sign of acceleration due to gravity?
v. Define angular velocity? How its direction is determined?
vi. Prove that 1 radian=57.3^o.
vii. When mud flies off the type of moving bicycle. In what direction does it fly? Explain.
viii. Show that orbital angular momentum Lo=mvr.
ix. What is difference b/w interference and beats?
x. What is difference b/w constructive and destructive interference?
xi. Explain why sound travel faster in warm air than in cold air?
xii. How should a sound source move with respect to an observer so that frequency of its sound not change?

Q.3 Answer briefly any Six parts from the followings:- 12

i. Can visible light produce interference fringes? Explain.
ii. Why the polaroid sunglasses are better than ordinary sunglasses?
iii. How coherent light beam can be produced? Explain.
iv. How the light signal is transmitted through optical fiber? Explain.
v. How can the resolving power of compound microscope be increased?
vi. Specific heat at constant pressure is greater than specific heat at constant volume. Why?
vii. What would be the average speed of oxygen molecule in the air at S.T.P
viii. Difference b/w isothermal and adiabatic process.
ix. Is it possible to convert internal energy into mechanical energy? Explain with example.

Section----------II

Note: Attempt Any three questions. 24

Q.5 (a) What is Carnot engine? Discuss Carnot cycle and derive the formula for its efficiency.
(b) Suppose, We are told that the acceleration of a particle moving in a circle of radius r with uniform speed v is proportional of r, say r^n, and some power of v, say v^m, determine the powers of r and v?
Q.6(a) what is isolated system? State and explain law of conservation of linear momentum.
(b) Two particles are located at $r_1 = 3\hat{i} + 7\hat{j}$ and $r_2 = -2\hat{i} + 3\hat{j}$ respectively. Find both the magnitude of the vector $(r_{2\_}r_1)$ and its orientation with respect to the x-axis.
Q.7 (a) Define Doppler effect. Discuss the case when source moves towards the stationary observer and when observer moves towards the stationary sources.
(b) A brick of mass 2.0 kg is dropped from a rest position 5.0 m above the ground. What is its velocity at a height of 3.0 m above the ground?
Q.8(a) what is meant by gravity free system? How gravity like earth is produced in space ship? Explain.
(b) A simple pendulum is 80 cm long. What will be its frequency of vibration at a place where g = 9.8 ms^{-2}?
Q.9 (a) what is magnifying glass? How is it used as microscope? Derive the relation for its magnifying power?
(b) In a double slit experiment the second order maximum occurs at $\theta = 0.25^\circ$. The wavelength is 700 nm. Determine the slit separation.