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AZEEM ACADEMY
22-Urdu Bazar Lahore.
Ph: 042-37231448
042-37232129
PUBLISHERS & BOOKSELLERS
Website: www.azeemgroups.com E-mail: info@azeemgroups.com

Head Office:

Lahore: *Riwaz Garden, Lahore,*
042-37115470, 042-37115471, 37171207

Sale Point:

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Book Name:

Azeem Solved Past Papers (2011 – 2019) Physics [Part-I]

Authors:

Aleem Ch. Nadeem Ahmad, Muhammad Naveed Aslam, Naseer Ch. Muhammad Shakeel, Ahsan Farooq

Published by:

Project Director

Composing by :

Azeem Ali , Naveed Ali , Malik Ishfaq

Final Formatting:

Ejaz Rasheed Sheikh (Umer Ashraf Graphics)

Printed by:

Tehami Art Press, Lahore. (A-8820-10)

Price: Rs. **125/-**

105

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CHAPTER — 1

MEASUREMENTS

SECTION I

Multiple Choice Questions

From Punjab Boards:-

1) A positron is: (GUJ 2011)
(a) An electron
(b) A proton
(c) An antiparticle of electron
(d) An antiparticle of proton

2) One light year is equal to (GUJ 2016) (MUL 2012 , 2016)
(a) 9.5×10^{15}m (b) 9.5×10^{-15}m
(c) 9.5×10^{14}m (d) 9.5×10^{12}m

3) Uncertainty in the measurement of radius of sphere is 1% the error in the calculates value of its area is: (GUJ 2018)
(a) 1% (b) 2%
(c) 3% (d) 4%

4) A light year is a unit for: (MUL 2011 Annual) (DGK 2017)
(a) intensity of light (b) Time
(c) Distance (d) Velocity

5) The dimension of force is: (GUJ 2018) (MUL 2012 Supply) (BAH 2013)
(a) $[MLT^{-1}]$ (b) $[ML^{-1}T^{-1}]$
(c) $[MLT^{-2}]$ (d) $[ML^{-2}T^{-2}]$

6) Giga is equal to: (BAH 2014)
(a) 10^3 (b) 10^6
(c) 10^9 (d) 10^{12}

7) The dimensional formula for the quantity light year is: (FAS 2011)
(a) $[LT^{-1}]$ (b) [T]
(c) $[ML^2T^2]$ (d) [L]

8) The dimension ML^0T^0 represent the quantity: (FAS 2012)
(a) Length (b) Mass
(c) Time (d) Velocity

9) The dimensions of gravitational constant 'G' are (FAS 2016)
(a) $[M^{-1}L^3T^{-2}]$ (b) $[ML^3T^{-2}]$
(c) $[ML^2T^{-2}]$ (d) $[ML^{-2}T^2]$

10) Which pair has same dimensions? (FAS 2016)
(a) Work and power (b) Momentum and impulse
(c) Force and torque (d) Toque and power

11) The dimension of $\sqrt{\frac{l}{g}}$ is same as that of: (FAS 2017)
(a) Time (b) Energy
(c) Velocity (d) Force

12) The mass of earth is equal to (RAW 2016)
(a) 6×10^{24} kg (b) 5×10^{24} kg
(c) 6×10^{20} kg (d) 5×10^{20} kg

13) The approximate age of earth is (RAW 2016)
(a) 1.4×10^{16}S (b) 2.8×10^{16}S
(c) 1.4×10^{17}S (d) 2.8×10^{17}S

14) The dimension of density are: (RAW 2017)
(a) $[ML^{-2}]$ (b) $[M^2L^{-2}]$
(c) $[ML^{-3}]$ (d) None of these

15) The dimensions of Coefficient of viscosity is: (SAG 2012)
(a) $[M^2L^{-1}T^{-1}]$ (b) $[ML^{-1}T^{-2}]$
(c) $[ML^{-1}T^{-1}]$ (d) [MLT]

16) The dimension of work is: (SAG 2013)
(a) MLT (b) MLT^{-1}
(c) $[ML^2T^{-2}]$ (d) $ML^{-1}T^{-1}$

17) The absolute uncertainty for vernier calipers of v.c = 0.01 cm is: (SAG 2017)
(a) 0.1 mm (b) 0.01 m
(c) 0.001 cm (d) 0.001 mm

18) The dimensions of the relation $\sqrt{\frac{F \times l}{m}}$ are equal to the dimensions of: (SAG 2017)
(a) Force (b) Momentum
(c) Acceleration (d) Velocity

19) Which of the following measurements of length is most precise? (SAW 2014)
(a) 5 cm (b) 5.4 cm
(c) 5.41cm (d) 5.412 cm

20) How many seconds are there in one year: (SAR 2018 GI)
(a) 3.156×10^6 S (b) 3.1536×10^8 S
(c) systematic error (d) 3.1536×10^7

21) In $5.47 \times 19.89 = 108.7983$; answer should be written as (SAR 2018 GII)
(a) 108.8 (b) 108.9
(c) 109 (d) 10.8.79

22) The quantity 1 $(km)^2$ is equal to: (LHR 2019 GI)
(a) 1×10^6 m^2 (b) $1 \times 10^5 m^2$
(c) $1 \times 10^7 m^2$ (d) $1 \times 10^4 m^2$

23) Dimensions of $\sqrt{\frac{g}{l}}$ is same as: (RAW 2019 GI)
(a) Angular frequency (b) Force
(c) Torque (d) Time period

24) Mass is highly concentrated form of: (RAW 2019 GI)
(a) Inertia (b) Energy
(c) Plasma (d) Charge

25) Which is the base quantity? (MUL 2019 GI)
(a) Area (b) Volume
(c) Length (d) Density

26) The time taken by light from moon to earth is: (DGK 2019 GI)
(a) 1 min 10 sec. (b) 1 min 20 sec.
(c) 1 min 30 sec. (d) 1 min 40 sec.

27) Absolute uncertainty in a measuring instrument is equal to: (SAG 2019 GI)
(a) Least count (b) Accuracy
(c) Fractional uncertainty
(d) Percentage uncertainty

28) Light year is the unit of: (SAW 2019 GI)
(a) time (b) distance
(c) energy (d) time and distance

29) How many years in one second: (SAW 2019 GI)
(a) 3.1536×10^7 years (b) 3.1536 years
(c) 3.1×10^{-8} years (d) 3.1×10^8 years

30) The numerical value of constants in any formula cannot be determined by dimensional analysis, however it can be found by: (BAH 2019 GI)
(a) Addition (b) Physical Quantities
(c) Experiments (d) Uncertainity

Entry Test MCQ's

1) Light year is a measure of: (2008)
(a) Distance (b) Time
(c) Intensity of light (d) Velocity

2) The dimensions of gravitational constant "G" are: (2009)
(a) $[ML^{-2}T^{-1}]$ (b) $[M^2L^{-2}T^{-1}]$
(c) $[ML_2T^{-2}]$ (d) $[M^{-1}L^3T^{-1}]$

3) SI unit of charge is _____. (2010)
(a) Ampere (b) Volt
(c) Coulomb (d) Calorie

4) When the dimensions of both sides of an equation are equal, then the equation is said to be: (2011)
(a) Simultaneous (b) Homologous
(c) Instantaneous (d) Quadratic

5) Radian is a unit of angular displacement which can also be measured in degrees. How many radians are equal to one degree? (2011)
(a) $\frac{180}{\pi}$ (b) $\frac{\pi}{180}$
(c) $\frac{2\pi}{180}$ (d) $\frac{\pi}{57.3}$

6) If 'm' is the mass, 'c' is the velocity of light and $x = mc^2$, then dimensions of 'x' will be: (2012)
(a) [LT-1] (b) $[ML^2T^2]$
(c) $[MLT^{-1}]$ (d) $[MLT^{-2}]$

7) 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? (2014)
(a) $kgms^{-3}A^{-1}$ (b) $kgs^{-2}A^{-3}$
(c) $kg^2m^{-2}s^{-3}A$ (d) $ms^{-1}A^{-3}$

8) Which set of the prefixes gives values in increasing order? (2014)
(a) Pico,Mega,Kilo,Tera
(b) Pico,Micro,Mega,Giga
(c) Tera,Pico,Micro,Kilo
(d) Giga,Kilo,Milli,Nano

9) The unit of temperature in base unit is: (2015)
(a) Celsius (b) Kelvin
(c) Degree (d) Fahrenhence

SECTION II

Short Questions

From Punjab Boards:

1. What are the dimensions and units of gravitational constant "G" in the formula $F = \frac{Gm_1m_2}{r^2}$? (RAW 2011)
(LHR 2012,2015: GI) (GUJ 2011) (MUL 2016 , 2017) (DGK 2017) (SAW 2013)

Ans. Gravitational force $= F = \frac{Gm_1m_2}{r^2}$

Dimensions of G = ?

Units of G = ?

$\Rightarrow G = \frac{Fr^2}{m_1m_2}$

Dimensions of gravitational $= \frac{\text{(Dimensions of force) (Dimension of length)}}{\text{(Dimensions of mass) (Dimensions of mass)}}$

$[G] = \frac{[F][L^2]}{[M][M]}$

$[F] = [MLT^{-2}]$

$[G] = \frac{[MLT^{-2}][L^2]}{[M^2]}$

2. $[G] = [M^{-1}L^3T^{-2}]$ (LHR 2017)

Ans. (i) Units of 6:

$G = \frac{Fr^2}{m_1m_2}$

$= \frac{Nm^2}{kg^2}$

Units of G $= Nm^2kg^{-2}$

3. Write the dimensions of: (i) Velocity (ii) Density.
(LHR 2013 : GI) (GUJ 2016) (BAH 2012, 2013) (FAS 2016) (RAW 2013, 2014) (SAG 2013)

Ans. (i) Dimensions of velocity:

$V = {}^{d}/_{t} = {}^{m}/_{sec}$

$\Rightarrow \boxed{[V] = [LT^{-1}]}$

(ii) Dimensions of density:

$f = mass/v = kg/m^3$.

$\Rightarrow \boxed{[F] = [ML^{-3}]}$

4. Show that the equation, $s = vit + \frac{1}{2}at^2$ is dimensionally correct. (LHR 2013 : GII)

Ans. Second equation of motion is $s = vit + ½ at^2$.

Where

Vi = initial velocity, a = acceleration

Now

Dimensions of L.H.S of equation = {S} = [L].

Dimensions of R.H.S of equation $= [V_i][t] + [a][t^2]$

$= [LT^{-1}][T] + [LT^{-2}][T^2]$

$= [L] + [L]$.

Hence

Dimension of L.H.S = dimension o R.H.S.

[L] = [L] + [L]

[L] = 2[L] 2 is dimension less. Se equation is correct

5. Write down the two uses of dimensional analysis: (LHR 2015, GI, 2019 GI)

Ans. Using the method of dimensions is known as dimensional analysis. Its two uses are:

- Derivation of a possible formula, for a physical quantity.
- Checking the homogeneity of physical equation by showing that the dimensions of the quantities on both sides of the equation are the same, irrespective of the form of the formula.

6. Find the dimension of co-efficient of viscosity η from relation. $F = 6\pi\eta rv$. (LHR 2017) (GUJ 2011, 2014) (SAG 2017) (DGK 2014) (MUL 2014)

Ans. It is given that :

$F = 6\pi\eta rv_t$

$\eta = \frac{F}{6\pi rv_t}$

$[\eta] = \left[\frac{MLT^{-2}}{LLT^{-1}}\right]$

$[\eta] = [ML^{-1}T^{-1}]$

7. Differentiate between precise and accurate measurement. (GUJ 2011, 2015)

Ans. (i) A precise measurement is the one, which has less precision or absolute uncertainty.

(ii) An accurate measurement is the one which has less fractional (or percentage) uncertainty or error.

8. The period of a simple pendulum is measured by stop-watch. What type of errors are possible in the time period? (LHR 2011, 2015 GII, 2017), (GUJ 2012) (MUL 2012, 2013, 2014, 2016), (BAH 2012, 2013, 2014), (FAS 2012 , 2013), (RAW 2013 , 2016,2019 GI), (RAW 2013 , 2016), (DGK 2017), (SAW 2013 , 2014)

Ans. Following could be the sources of errors:

(a) Manufacturer's fault which could result in incorrect measurement of time.
(b) Error due to calibration of stop-watch.
(c) Zero error in stop-watch.
(d) Human error. Delay or early starting / stopping of stop-watch.

9. Write the dimension of (a) pressure (b) density. (GUJ 2011: ANNUAL, 2013: ANNUAL)

Ans. (i) Pressure:

$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{[M^1L^1T^{-2}]}{[L^2]} = [M^1L^{-1}T^{-2}]$

(ii) Density:

$\text{Density} = \frac{\text{mass}}{\text{Vol}} = \frac{[M]}{[L^3]} = [M^1L^{-3}T^0] = [ML^{-3}]$

10. Show that the equation $E = mc^2$ is dimensionally correct. (GUJ 2011: ANNUAL, 2014: ANNUAL), (RAW 2012), (SAG 2017), (BAH 2019 GI), (DGK 2011, 2014) (SAW 2014)

Ans. $E = mc^2$

Dimension of L.H.S $= [E] = {}^1/_2 mv^2]$

$= [M][L^2T^{-2}] = [ML^2T^{-2}]$

Dimensions of R.H.S $= [ms^2] = [M][L^2T^{-2}]$

$= [ML^2T^{-2}]$

L.H.S = R.H.S.

$E = mc^2$ is dimensionally correct.

11. Access the total uncertainty in the final result of a timing experiment with the help of an example. (MUL 2014)

Ans. For The Uncertainty In A Timing Experiment

The uncertainty in the time period of a vibrating body is found by dividing the least count of timing device by the no. of vibrations.

For example: -

Time of 30 vibrations of a simple pendulum recorded by a stop watch accurate up to one tenth of a second is 54.6 S. then.

$T = \frac{54.6S}{30} = 1.82$ s with

Uncertainty $\frac{0.1S}{30} = 0.003S$

Thus $T = 1.82 \pm 0.003$

Hence count large no. of swings to reduce timing uncertainty.

Example 1.1

The length, breadth and thickness of sheet are 3.233 m. 2.105 m and 1.05 cm resp. calculate the volume of sheet correct up to the appropriate significant figures.

Sol:

l = 3.233 m, b= 2.105 m.

h = 1.05 cm (min. no. of sig. Fig).

$= 1.05 \times 10^{-2}$ m

Volume $= V = l \times b \times h$

$= 3.233 \times 2.105 \times 1.05 \times 10^{-2}$

$= 7.14573825 \times 10^{-2}\ m^3$

$V = 7.14\ m^3$

12. Write the dimension of: (MUL 2016)

(a) Pressure (b) Density

Ans.

$P = \frac{F}{A} = \frac{[MLT^{-2}]}{L^2} = [ML^{-1}T^{-2}]$

$P = \frac{m}{v} = \frac{[M]}{L^3} = [ML^{-3}]$

13. Write two use/application of dimension. (MUL 2016)

Ans. (1) Dimensional analysis can be sued to check the correctness of a given formula or equation.

(2) It is also used for deriving a formula by considering the certain rules.

14. Show that the relation $v = f\lambda$ is dimensionally correct. (BAH 2011)

Ans. L.H.S = $v = [v] = [LT^{-1}]$

R.H.S = $F\lambda = [F\lambda] = [T^{-1}][L] = [LT^{-1}]$

L.H.S = R.H.S

15. Describe the principle of homogeneity of dimension analysis. (BAH 2011)

Ans. In order to check the correctness of an equation, we show that dimension of the quantities on both sides of the equation. This is called the principle of homogeneity.

16. Add the given masses in kg, upto appropriate precision. 2.189, 0.089, 11.8 and 5.32. (BAH 2012)

Ans. Total mass = 2.189kg + 0.089kg + 11.8kg + 5.32kg = 19.398kg

$\Rightarrow$ Total mass = 19.4kg

17. How can you determine the uncertainty in time period? (BAH 2014) (SAG 2019 GI)

Ans. The uncertainty in time period is found by dividing the least count of timing device by its number of vibrations. i.e.

$$\text{Uncertainty} = \frac{\text{Least count of vibrating body}}{\text{Number of vibrations}}$$

18. According to Einstein's mass energy equation find the energy of mass 1 kilogram. (FAS 2011)

Ans. $E = mc^2$

$E = 1 \times (3 \times 10^8)^2$

$= 9 \times 10^{16}$ J.

19. What are the dimensions and unit of gravitational constant "G" in the formula $F = G\frac{m_1m_2}{r^2}$. (FAS 2012)

Ans. $F = G\frac{m_1m_2}{r^2} \Rightarrow G = \frac{Fr^2}{m_1m_2} \Rightarrow G = \frac{[Fr^2]}{[m_1m_2]}$

$G = \frac{[MLT^{-2}][L^2]}{[M^2]} = M^{-1}L^3T^{-2} \Rightarrow G = [M^{-1}L^3T^{-2}]$

Unit of $G = Nm^2Kg^{-2}$

20. Write the dimensions of pressure and density. (FAS 2014)

Ans. (i) $\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{F}{A} = \frac{mA}{A}$

$\text{Dimension of pressure} = \frac{[MLT^{-2}]}{[L^2]}$

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

(ii) $\text{Density} = \frac{\text{Mass}}{\text{Volum}} = \frac{m}{V}$

$\text{Dimension of density} = \frac{[M]}{[L^3]} = [ML^{-3}]$

21. The wave length "ℓ" of a wave depends on the speed "v" of the wave and its frequency "f". knowing that: (2014)

$[l] = [L]$, $[V] = [LT^{-1}]$ and $[f] = [T]^{-1}$

Decide which of the following is correct. (FAS 2012)

$f = \lambda f$ or $f = \frac{V}{\lambda}$

Ans. First we do dimensional analysis on

$f = v\lambda$

$[f] = [LT^{-1}][L] = [L^2T^{-1}]$ which is incorrect.

Now we take

$f = \frac{v}{\lambda}$

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

$= [T^{-1}]$ which is correct.

Hence $\left(f = \frac{v}{\lambda}\right)$ is correct expression.

22. How can you assess the uncertainty in the average value of many measurements. (FAS 2017)

Ans. For uncertainty in the Average Value of many Measurements:

(i) Find the average value of measured values.

(ii) Find deviation of each measured value from the average value.

(iii) The mean deviation is the uncertainty in the average value.

(iv) For example, the six readings of the micrometer screw gauge to measure the diameter of a wire in mm are.

1.20, 1.22, 1.23, 1.19, 1.22, 1.21

Then,

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

$= 1.21$mm

The deviation of the readings, which are the difference without considering the sign, between each reading and average value are 0.01, 0.01, 0.02, 0.02, 0.01, 0

(Deviation = Each reading – Average value)

$\text{Mean of deviation} = \frac{0.01+0.01+0.02+0.02+0.01+0}{6}$

$= 0.01$mm

Thus, uncertainty in the mean diameter (1.21mm) is 0.01mm recorded as.

$\boxed{1.21 \pm 0.01\ \text{mm}}$

23. Differentiate between precision and accuracy. (RAW 2014)

Ans. (i) A precise measurement is the one, which has less precision or absolute uncertainty.

(ii) The precision of measurement is determined by the instrument being used. Precision is also called absolute uncertainty, which is equal to the least count of the instrument.

24. Write the dimensions of (RAW 2014)

(i) Pressure (ii) Angular momentum

Ans. (i) $P = F/A = ma/A$

$[P] = [MLT^{-2}]$

$[L^2] = [ML^{-1}T^{-2}]$

(ii) $L = mvr$

$= [MLT^{-1}L]$

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

25. What is physical significance of dimension of physical quantity. (RAW 2017)

Ans. Using the method of dimensions called the dimensional analysis, we can check the correctness of a given formula or an equation and can also derive it. Dimensional analysis makes use of the fact that expression of the dimensions can be manipulated as algebraic quantities.

(i) Checking the Homogeneity of Physical Equation:

In order to check the correctness of an equation, we are to show that the dimensions of the quantities on both sides of the equation are the same, irrespective of the form of the formula. This is called the principle of homogeneity of dimensions.

(ii) Derivation of a Possible Formula:

The success of this method for deriving a relation for a physical quantity depends on the correct guessing of various factors on which the physical quantity depends.

26. Write the dimension of (a) pressure (b) force. (SAG 2012)

Ans. (i) $\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{F}{A} = \frac{ma}{A}$

$\text{Dimension of pressure} = \frac{[MLT^{-2}]}{[L^2]}$

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

(ii) $F = ma \Rightarrow [F] = [ma] = [MLT^{-2}]$

27. Define precision. Which instrument can measure precise value meter rod or vernier caliper. (SAG 2017)

Ans. A precise measurement is the one which has less precision or absolute uncertainty precision is also called absolute uncertainty which equal the least count of the instrument. As the least count of vernier caliper is less than meter rod. So vernier caliper measure more precise value than meter rod.

28. Distinguish between precision and accuracy. (MUL 2019 GI) (SAG 2017)

Ans. A precise measurement is the one which has less precision or absolute uncertainty.

An accurate measurement is the one which has less fractional (or percentage) uncertainty or error.

The precision of measurement is determined by the instrument (or device) being used. Precision is also called absolute uncertainty which is equal to the least count of the instrument.

The accuracy of a measurement depends upon the fractional (or percentage) uncertainty in the measurement.

29. Show that the expression, $V_f = v_i + at$ is dimensionally correct. (DGK 2013)

Ans. $V_f = V_i + at$

$[LT^{-1}] = [LT^{-1}] + [LT^{-2}][T]$

$[LT^{-1}] = [LT^{-1}] + [LT^{-1}]$

$[LT^{-1}] = [LT^{-1}]$

30. Does a dimensional analysis give any information of constant of proportionality that may appear in an algebric expression? Explain. (DGK 2014: GI), (LHR 2017), (RAW 2011)

Ans. Dimensional analysis does not give any information about the constant of proportionally. The value of constant of proportionally is determined experimentally or theoretically. Its presence on any one side of an algebric expression does not change the result of dimensional analysis.

31. Check the correctness of the relation $V = \sqrt{\frac{F \times l}{m}}$ where V is the speed of transverse wave on a stretched string of tension 'F', length 'l' and mass 'm'. (DGK 2017)

Ans. Data:

The given equation $V = \sqrt{\frac{F \times l}{m}}$

To find:

To check the correctness of the above equation.

Solution:

As the equation, $V = \sqrt{\frac{F \times l}{m}}$

Dimensions of L.H.S. of the equation=$[V]=[LT^{-1}]$.... (i)

Dimensions of R.H.S of the equation = $[F]\times[l]\times[m^{-1}]^{1/2}$

$= ([MLT^{-2}] \times [L] \times [M^{-1}])^{1/2}$

$= (L^2T^{-2})^{1/2}$ $(M^1 \times M^{-1} = 1)$

$= [LT^{-1}]$ ..... (2)

Result: Equation s(1) and (2) show that dimensions of both sides (R.H.S and L.H.S) of the equation are the same. Hence, equation is dimensionally correct.

32. Differentiate between precise measurement and accurate measurement. (SAW 2013)

Ans. Precise measurement: The least count of the measuring instrument i-e smaller the least count of the measuring instrument, the more precise measurement could find.

Accurate measurement: Accuracy depends upon fractional uncertainty or percentage uncertainty. It

means that a measurement will be more accurate if it has less fractional uncertainty.

$$\text{Fractional uncertainty} = \frac{\text{Least count}}{\text{Measurement}}$$

$$\%\text{ age uncertainty} = \frac{\text{Least count}}{\text{Measurement}} \times 100$$

33. Write the dimension of force and pressure. (SAW 2014)

Ans. Dimension of force:

$F = ma$

$= [MLT^{-2}]$

Dimension of pressure:

$$P = \frac{F}{A} = \left[\frac{MLT^{-2}}{L^2}\right] = [ML^{-1}T^{-2}]$$

34. How do you assess total uncertainty in the final result for multiplication and division explain with example. (GUJ 2018)

Ans. For multiplication and Division?

For multiplication and division percentage uncertainties use added. For example, we determine maximum uncertainty in the value of resistance R of a conductor determined by formula.

$$R = \frac{V}{I}$$

V = Potential difference

and I current

The given values of V and I are:

$V = 5.2 \pm 0.1$ v

and $I = 0.84 \pm 0.05$ A

The % age uncertainty for I is $= \frac{0.05A}{0.84A} \times \frac{100}{100} \frac{-6}{100} = 6\%$

35. Given that V = (5.2 ± 0.1) volt. Find its percentage uncertainty. (BAH 2019 GI)

Ans. The given value of V is

$V = (5.2 \pm 0.1)$ volt

$$\%\text{ age uncertainty for V} = \frac{0.1}{5.2} \times 100$$

% age uncertainty for V = 1.9%

%age uncertainty for V ≅ 2%.

SECTION III

Long Questions

From Punjab Boards:-

1. Suppose use are told that acceleration of a particle moving in a circle of radius r with uniform speed V is proportional to some power of r say r^n and some power of V say V^m. Determines the power of r and V.(LHR 2019) (SAG 2019 GI)

2. The speed V of sound waves through a medium may be assumed to depend on (i) The density ρ of the medium (ii) Its modulus of elasticity E which is the ratio of stress to strain. Deduce by the method of dimension, the formula for speed of sound. (LHR 2019)

3. Derive a relation for the time period of simple pendulum by using dimensional analysis. (MUL 2019)

4. The diameter and length of metal cylinder measured with. The help of vernier Calliper of least count 0.01cm are 1.22cm and 5.35cm. Calculate the volume of cylinder and uncertainty in it. (SAG 2019)

5. Show that the famous "Einstein Equation $E = mc^{2n}$" is dimensionally consistant. Calculate equivalence energy of one Kilogram. (BAH 2019)

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CHAPTER — 2

VECTORS & EQUILIBRIUM

SECTION I

Multiple Choice Questions

From Punjab Boards:-

1) The magnitude of vector product of two non-zero vectors $\vec{A}$ and $\vec{B}$ making an angle θ with each other, is: (LHR 2011) (FAS 2016), (SAG 2017) (DGK 2017)
(a) AB sinθn (b) AS sinθ
(c) ABCosθ (d) AB

2) The resultant magnitude of 6N force acting at right angle is a 8N force is: (LHR 2011)
(a) 2N (b) 14N
(c) 8N (d) 10N

3) Mathematically unit vector is given by: (LHR 2012), (MUL 2012)
(a) $\hat{A} = A\bar{A}$ (b) $\hat{A} = \frac{A}{\bar{A}}$
(c) $\hat{A} = \frac{\vec{A}}{A}$ (d) $\hat{A} = \bar{A}.\bar{A}$

4) Position vector of a point P(a,b,c) in YZ-Plane is given by: (LHR 2012)
(a) $\bar{r} = a\hat{i} + b\hat{j}$ (b) $\bar{r} = a\hat{i} + c\hat{k}$
(c) $\bar{r} = b\hat{j} + c\hat{k}$ (d) $\bar{r} = a\hat{i} + b\hat{j} + c\hat{k}$

5) The magnitudes of rectangular components of a vector are equal, if its angle with x-axis is: (LHR 2013 GI), (FAS 2012) (RAW 2016)
(a) 0° (b) 30°
(c) 45° (d) 90°

6) $\hat{i}.(\hat{j}.\hat{k})$ is equal to: (LHR 2013 GI) (SAR 2018 GI)
(a) $\hat{k}$ (b) 1
(c) 2 (d) 0

7) If $\vec{A} = 2\hat{i} + \hat{j} + 2\hat{k}$ then |A| is (LHR 2016)
(a) Zero (b) 3
(c) 5 (d) 9

8) The x-component of force making an angle of 45° with x-axis is 10N. Its y-component is (LHR 2016)
(a) 10N (b) 5N
(c) 20N (d) 100N

9) If |a+b| = |a−b| then angle between $\vec{a}$ and $\vec{b}$ is. (LHR 2017)
(a) 0° (b) 45°
(c) 90° (d) 180°

10) The resultant of 120N and 20N forces cannot be. (LHR 2017)
(a) 141N (b) 100N
(c) 101N (d) 130N

11) If a single vector having the same effect as all the original vectors taken together, is called: (GUJ 2012), (MUL 2017)
(a) Resultant vector (b) Equal vector
(c) Position vector (d) Unit vector

12) The magnitudes of cross product and dot product of two vector are equal. The angle between the vectors is: (GUJ 2013)
(a) Zero (b) 90°
(c) 180° (d) 45°

13) The magnitude of dot and cross product of two vectors are $6\sqrt{3}$ and 6, respectively. The angle between them will be: (GUJ 2011)
(a) 0° (b) 30°
(c) 45° (d) 60°

14) Two vectors to be combined have magnitudes 60 N and 35 N. The correct answer will be (GUJ 2011)
(a) 15 N (b) 20 N
(c) 70 N (d) 100 N

15) Dot product of vector with it self is (GUJ 2016) (FAS 2016)
(a) Zero (b) 2A
(c) A^2 (d) A

16) $\vec{A} = \hat{i} + \hat{j} + \hat{K}$ then magnitude of |A| is (GUJ 2016)
(a) 1 (b) 2
(c) $\sqrt{3}$ (d) $\sqrt{2}$

17) If R_x is positive and R_y is negative the resultant lies in the: (MUL 2011 annual)
(a) First quadrant (b) Second quadrant
(c) Third quadrant (d) Fourth quadrant

18) The resultant of two vectors having magnitude 10N and 8N cannot be: (MUL 2014)
(a) 2N (b) 9N
(c) 18N (d) 20N

19) SI unit of torque is: (MUL 2012 Supply)
(a) $N-Kg^{-1}$ (b) $N^{-2}-Kg$
(c) N − m (d) $N-m^{-2}$

20) Projection of $\vec{B}$ along $\vec{A}$ will be given as: (MUL 2013)
(a) $\frac{\vec{A}.\vec{B}}{A}$ (b) $\bar{B}.\hat{A}$
(c) $\frac{\vec{A}.\vec{B}}{B}$ (d) $\frac{\vec{A}.\vec{B}}{Cos\theta}$

21) If $\bar{F} = 2\hat{i} + 3\hat{j}$ N and $\bar{d} = 4\hat{i} + 4\hat{j}$ m, then work done is (MUL 2011 annual)
(a) 13 J (b) 18 J
(c) 20 J (d) 24 J

22) $\hat{i}.(\hat{j} \times \hat{k})$ is equal to: (MUL 2012 Supply), (BAH 2011) (RAW 2011)
(a) Zero (b) 1
(c) i (d) j

23) _____ is a vector quantity (MUL 2016)
(a) Pressure (b) Velocity
(c) Power (d) Energy

24) Vector has both of its components as negative, then resultant lies in (MUL 2016) (SAW 2013)
(a) I quadrant (b) II quadrant
(c) III quadrant (d) IV

25) If two non zero vectors $\vec{A}$ and $\vec{B}$ are parallel to each other then (MUL 2016)
(a) $\vec{A}.\vec{B}$ (b) $\vec{A}.\vec{B} = AB$
(c) $|\vec{A} \times \vec{B}| = AB$ (d) $|\vec{A} \times \vec{B}| = \vec{A}.\vec{B}$

26) When a force of 100N is acting on an object along x-axis then its vertical component will be: (MUL 2017)
(a) 50N (b) 25N
(c) 10N (d) 0N

27) The direction of Torque can be found by: (BAH 2012)
(a) Head to tail rule (b) Right hand rule
(c) Left hand rule (d) Fleming rule

28) The resultant of two forces 30 N and 40 N acting at angle of 90° with each other is"(BAH 2013) (SAG 2016)
(a) 30 N (b) 40 N
(c) 50 N (d) 70 N

29) $\vec{A} + \vec{B} = \vec{B} + \vec{A}$ this show that addition of vectors is: (BAH 2012)
(a) Associative (b) Commutative
(c) Additive (d) Additive inverse

30) Reverse process of vector addition is called: (BAH 2011)
(a) Subtraction of vector
(b) Resolution of vector
(c) Obtaining unit vector
(d) Making a vecto0r negative

31) Which one is a vector? (FAS 2011)
(a) Length (b) Volume
(c) Velocity (d) Work

32) The vector in space has components: (FAS 2012)
(a) One (b) Two
(c) Three (d) Four

33) $AB\sin\theta\,\hat{n} \times AB\sin\theta\,\hat{n}$ is = (FAS 2017)
(a) $A^2B^2\sin^2\theta$ (b) A^2B^2
(c) $A^2B^2\hat{n}$ (d) $\vec{0}$

34) A paratrooper moves downward with: (FAS 2017)
(a) Zero acceleration (b) Constant acceleration
(c) Positive acceleration (d) Negative acceleration

35) The resultant of two force 3N and 4N acting at right angle to each other is: (RAW 2011)
(a) 5N (b) 6N
(c) 2N (d) 7N

36) A force of 10N makes an angle of 30° with y-axis. The magnitude of x-component will be: (RAW 2013)
(a) 5N (b) 8.66N
(c) 10N (d) Zero

37) Dot product of a vector with itself is (RAW 2016)
(a) Zero (b) 2A
(c) A^2 (d) A

38) $A \times B = 0$, then angle between the vectors is: (RAW 2017)
(a) 90° (b) 180°
(c) 0° (d) None of these

39) If r = 5m and F = 4N are along same direction, the torque is: (RAW 2017)
(a) 20 N.m (b) 5 N.m
(c) 10 N.m (d) Zero

40) The cross product of vectors will be minimum when angle between vectors is: (SAG 2012)
(a) 35° (b) 90°
(c) 0° (d) 45°

41) The angle of $\bar{A} = Ax\hat{i} - Ay\hat{j}$ with x-axis will be in between: (SAG 2017)
(a) 0° and 90° (b) 90° and 180°
(c) 180° and 270° (d) 270° and 360°

42) It both components of a vector are negative then resultant lies in: (DGK 2011)
(a) 1st quadrant (b) 2nd quadrant
(c) 3rd quadrant (d) 4th quadrant

43) The self dot product of a vector A is: (DK 2012)
(a) 0 (b) 1
(c) A (d) A^2

44) Name the quantity which is a vector: (DGK 2014)
(a) Speed (b) Force
(c) Temperature (d) Density

45) The direction of resultant vector Rx and –Ry will lie the quadrant: (DGK 2013)
(a) 1st (b) 2nd
(c) 3rd (d) 4th

46) The result of adding A into –A is: (DGK 2012)
(a) A (b) 2A
(c) 0 (d) 1

47) If the body is at rest or rotating with inform angular velocity, then torque will be: (DGK 2011)
(a) Maximum (b) negative
(c) Zero (d) Positive

48) Two vectors can be added by simple arithmetical method when they are at an angle of: (DGK 2017)
(a) 120° (b) 90°
(c) 45° (d) 0°

49) If $\vec{A} = -4\hat{i}$ and $\vec{B} = 6\hat{j}$ then $\vec{A}.\vec{B}$ will be: (DGK 2017)
(a) $24\hat{k}$ (b) 24
(c) Zero (d) –24k

50) In third quadrant, direction of resultant vector is $\left(\phi = \tan^{-1}\frac{R_y}{R_x}\right)$ (SAW 2014)
(a) $180° - \phi$ (b) $180° + \phi$
(c) $360° - \phi$ (d) $360° + \phi$

51) If $\vec{A} = 2\hat{i} + 3\hat{j} - \hat{k}$ and $\vec{B} = 4\hat{i} + 6\hat{j} - 2\hat{k}$. The angle between them will be. (GUJ 2018)
(a) 0° (b) 45°
(c) 60° (d) 90°

52) The cross product of two anti-parallel vectors is: (GUJ 2018)
(a) 0 (b) 1
(c) maximum (d) negative

53) A force for 100N makes an angle of 60° with y-axis has horizontal component is: (SAR 2018)
(a) 50N (b) 60N
(c) 70.7N (d) 86.6N

54) The direction of torque is (SAR 2018)
(a) Along the position sides
(b) Perpendicular to both $\bar{r}$ and $\bar{F}$
(c) Alone with direction force $\vec{F}$
(d) Opposite to the direction of $\vec{R}$

55) Which pair has same unit: (LHR 2019 GI)
(a) Work and power
(b) Momentum and impulse
(c) Force and torque (d) Torque and power

56) If $\vec{F} = (2i + 4\hat{j})$ N; $\vec{d} = (5i + 2\hat{j})$m work done is: (LHR 2019 GI)
(a) 15 J (b) 18 J
(c) Zero (d) –18 J

57) If R_x and R_y both are negative then resultant lies in the quadrant. (LHR 2019 GI)
(a) 1st (b) 2nd
(c) 3rd (d) 4th

58) The sum of two perpendicular forces 8 N and 6 N is: (LHR 2019 GI)
(a) 2 N (b) 14 N
(c) 10 N (d) - 2N

59) Cross product of $\hat{j} \times \hat{k}$ is: (LHR 2019 GI)
(a) Zero (b) 1
(c) $\hat{i}$ (d) $-\hat{i}$

60) In which quadrant vector $-2\hat{i} - 3\hat{j}$ lies. (RAWP 2019 GI)
(a) 1st (b) 2nd
(c) 4th (d) 3rd

61) Force of 10N makes an angle of 30° with y-axis, its x-component will be: (RAW 2019 GI)
(a) 5N (b) 8.66
(c) $\frac{10}{\sqrt{2}}$ N (d) $10\sqrt{2}$ N

62) Unit vector of a given vector $\bar{A} = 4\hat{i} + 3\hat{j}$ is: (MUL 2019 GI)
(a) $\frac{4\hat{i}+3\hat{j}}{25}$ (b) 1
(c) $\frac{4\hat{i}+3\hat{j}}{5}$ (d) $\sqrt{\frac{4\hat{i}+3\hat{j}}{5}}$

63) If the magnitudes of scalar and vector product of two vectors are $2\sqrt{3}$ and 2 respectively. The angle between vectors is: (DGK 2019 GI)
(a) 30° (b) 60°
(c) 120° (d) 180°

64) The resultant of two perpendicular vectors each of magnitude A is: (DGK 2019 GI)
(a) A (b) 2A
(c) $\sqrt{2}$ A (d) A^2

65) The force of 15 N makes an angle of 90° with x–axis, its y–component is: (SAG 2019 GI)
(a) 15 N (b) Zero N
(c) 30 N (d) 45 N

66) Two forces of magnitudes 10 N and 20 N act on a body in directions making angle of 30°, The X–component of the resultant force will be: (SAG 2019 GI)
(a) 25.98 N (b) 30.98 N
(c) 20.98 N (d) 17.98 N

67) Dimension of moment arm is: (SAG 2019 GI)
(a) [M] (b) [T]
(c) [LT] (d) [L]

68) The position vector $\vec{r}$ in xz – plane is: (SAG 2019 GI)
(a) $y\hat{i} + z\hat{k}$ (b) $x\hat{i} + y\hat{k}$
(c) $x\hat{i} + z\hat{k}$ (d) $x\hat{i} + y\hat{j} + z\hat{k}$

69) Magnitude of unit vectors $\hat{i} \times \hat{j}$ is: (SAW 2019 GI)
(a) 1 (b) –1
(c) $-\hat{j}$ (d) $+\hat{k}$

70) If cross product of two vectors $\vec{A} \times \vec{B}$ points along positive z–axis, then the vector $\vec{A}$ and $\vec{B}$ must lie in: (SAW 2019 GI)
(a) yz – plane (b) xz – plane
(c) xy – plane (d) No plane

71) Magnitude of Resultant Vector of 6N and 8N which are perpendicular to each other is: (BAH 2019 GI)
(a) 14 N (b) 10 N
(c) 20 N (d) 2 N

72) If $\bar{A} \times \bar{B}$ is along y – axis, then $\vec{A}$ and $\vec{B}$ are in: (BAH 2019 GI)
(a) x – y Plane (b) y – z Plane
(c) Space (d) x – z Plane

73) If a Force of 5N is applied parallel to Moment Arm of 5m, then Torque is equal to: (BAH 2019 GI)
(a) 25 Nm (b) 5 Nm
(c) 10 Nm (d) Zero. Nm

74) The Unit Vector in the direction of $\vec{A}$ is: (BAH 2019 GI)
(a) $\hat{A} = \frac{A}{\vec{A}}$ (b) $\hat{A} = A\vec{A}$
(c) $\hat{A} = \frac{\vec{A}}{A}$ (d) $\vec{A} = \frac{A}{\hat{A}}$

ENTRY TEST MCQ'S

1) The scalar product of $\hat{i}$ and $\hat{k}$ is: (2009)
(a) zero (b) 90°
(c) 1 (d) – 1

2) If the body is rotating with uniform angular velocity, then its torque is: (2009)
(a) Zero (b) Clokwise
(c) Maximum (d) Remains the same

3) What is torque 't' in a circular motion? (2009)
(a) $t = mr^2\pi$ (b) $t = mr^2\alpha$
(c) $t = mr\alpha$ (d) $t = mr^2/\alpha$

4) Unit vector in the direction of vector $2\hat{i} - 4\hat{j}$ will be: (2009)
(a) $\frac{2\hat{i}-4\hat{j}}{\sqrt{6}}$ (b) $\frac{4\hat{i}-2\hat{j}}{\sqrt{10}}$
(c) $\frac{\hat{i}-2\hat{j}}{\sqrt{5}}$ (d) $\frac{\hat{i}-4\hat{j}}{\sqrt{7}}$

5) For a body to be in complete equilibrium: (2010)
(a) Linear acceleration is zero
(b) Angular acceleration is zero
(c) Linear acceleration is zero but angular acceleration is not zero
(d) Linear acceleration and angular acceleration both should be zero

6) If length of a spanner is 'l' and a force 'F' is applied on it to tighten a nut such that it passes through the pivot point, then torque is: (2010)

(a) Zero (b) Ff

(c) Fl sin θ (d) Fl sin θλ

7) If a force of magnitude 8 N acts on a body in direction making an angle 30, its x and y compoenents will be: (2010)

(a) $F_x = 4\sqrt{3}$ and $F_y = 8$

(b) $F_x = 8$ and $F_y = 4\sqrt{3}$

(c) $F_x = 4\sqrt{3}$ and $F_y = 4$

(d) $F_x = 8\sqrt{3}$ and $F_y = 4$

8) The difference of a vector $\vec{B}$ and its negative vector $-\vec{B}$ is: (2010)

(a) A null vector

(b) Equal to magnitude of vector $\vec{B}$

(c) Twice the magnitude of vector $\vec{B}$

(d) Smaller than magnitude of vector $\vec{B}$

9) If we double the moment arm the value of torque becomes: (2016)

(a) Half (b) Three–times

(c) Two–times (d) Four–times

SECTION II

Short Questions

From Punjab Boards:

1. If all the components of vectors $\vec{A_1}$ and $\vec{A_2}$ were reversed, how would alter $\vec{A_1} \times \vec{A_2}$. (LHR 2011, 2013: GI) (SAG 2019 GI)

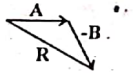
Ans. If all components of vectors were reversed, there will be no change in $\vec{A_1} \times \vec{A_2}$.

e.g., $(-\vec{A_1}) \times (-\vec{A_2}) = \vec{A_1} \times \vec{A_2}$

2. What is negative of a vector? How a vector $\vec{B}$ is subtracted from a vector $\vec{A}$? (LHR 2012, 2019 GI)

Ans. A vector with its reverse direction is called negative vector.

Vector subtraction: A subtraction of a vector is equivalent to the addition of the same vector with its direction



reversed. Thus, to subtract vector $\vec{B}$ from vector $\vec{A}$, reverse the direction of $\vec{B}$ and add it to $\vec{A}$. $\vec{A} \longrightarrow \uparrow B \downarrow -B$.

3: Find the unit vector of the vector $\vec{A} = 4\hat{i} + 3\hat{j}$ (LHR 2012, 2019 GI) (BAH 2012) (FAS 2016) (RAW 2011) (DGK 2011)

Ans. $\hat{A} = ?$

Using the formula:

$$\hat{A} = \frac{\vec{A}}{A}$$

$$\vec{A} = 4\hat{i} + 3\hat{j}$$

$$A^2 = 42 + 32$$

$$\sqrt{A^2} = \sqrt{4^2 + 3^2}$$

$$A = \sqrt{16 + 9}$$

$$A = \sqrt{25}$$

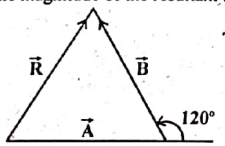
$$A = 5$$

Putting the values in formula.

$$\hat{A} = \frac{4\hat{i} + 3\hat{j}}{5}$$

4. How would the two vectors of the same magnitudes have to be oriented, if they were to be combined to give a vector to the same magnitude? (LHR 2013 : GII)

Ans. When the angle between two vectors of same magnitude is 120°, the magnitude of the resultant is also same.



5. Define the terms: (LHR 2014 : GI)

(a) Unit vector (b) Position vector:

(GUJ 2012) (FAS 2016) (BAH 2019 GI) (SAG 2011) (SAW 2017, 2019 GI) (DGK 2011)

Ans. (a) Unit vector

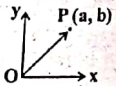
A unit vector in a given direction is a vector with magnitude "one" in that direction.

A unit vector in the direction of $\vec{A}$ is written as $\hat{A}$, which we read as "A hat" thus.

$$\hat{A} = \frac{\vec{A}}{|A|}$$

(b) Position vector:

The position vector $\vec{r}$ is a vector that describes the location of a point with respect to the origin



$\vec{r} = a\hat{i} + b\hat{j}$.

6. Define: (LHR 2014 : GII) (DGK 2019 GI)

(i) Null vectors (ii) Equal vectors:

Ans. A vector of zero magnitude and arbitrary direction is called null vector. For example: The sum of a vector and its negative vector is a null vector, i-e.

$$\vec{A} + (-\vec{A}) = \vec{0}.$$

i) Equal vectors:

Two vectors $\vec{A}$ and $\vec{B}$ are said to be equal if they have the same magnitude and direction, regardless of the position of their initial points.

Parallel vectors of the same magnitude are equal to each other.

Is it possible to add a vector quantity to a scalar quantity? (LHR 2014: GII) (FAS 2016) (RAW 2016) (SAG 2017) (DGK 2019 GI) (SAW 2014, 2019 GI)

ns. No, it is not possible to add a vector quantity to a scalar quantity.

Both physical quantities are different in their physical nature. Scalars can be added by simple arithematic rules while the vector can be added by specific rules.

Can you add zero to a null vector. (LHR 2014, GII, 2015 GI, 2017)) (GUJ 2013 , 2014 , 2015, 2016) (MUL 2016, 2019 GI) (RAW 2011, 2014) (FAS 2011) (SAG 2016) (BAH 2016) (DGK 2014) (SAW 2013)

s. No, zero is not added to a null vector because zero is a scalar and null vector is a vector quantity.

Define position vector and resultant vector. (LHR 2017, 2019 GI) (RAW 2012)

s. Position Vector:

A vector which describe the location of particle w.r.to origin is called position vector.

Resultant Vector:

Sum of two or more vector is a single vector which has the same effect as the combine effect of all the vectors to be added.

What is scalars and vectors. Give examples. (LHR 2017)

. Scalars:

Definition: A physical quantity which is completely described by magnitude with proper units is called a scalar quantity. OR

A scalar is a physical quantity which has magnitude only but no direction.

Examples of Scalars:

Mass, distance, speed, energy, work volume, temperature, time, electric charge, area, atmospheric pressure, potential and wavelength are all scalar quantities.

The scalars are added subtracted, multiplied and divided by ordinary rules of arithmetic.

Basic Concepts of Vectors:

(i) Vectors:

A physical quantity which is completely described by magnitude with proper units and direction is called vector quantity. OR

Vector is a physical quantity which has both magnitude and direction.

Examples of Vectors:

Displacement, velocity, acceleration, force, weight, momentum, torque, electric intensity, angular velocity and angular acceleration are all vector quantities, because all these quantities require magnitude and direction for their complete description. Hence, vectors are completely expressed.

11. Write any two characteristics of cross product. (GUJ 2016)

Ans. (i) Cross product of two perpendicular vector is maximum as.

$\vec{A} \times \vec{B} = AB \sin\theta \hat{n}$ $(\theta = 90°)$

$\vec{A} \times \vec{B} = AB (\sin 90°) \hat{n}$

$\vec{A} \times \vec{B} = AB (i) n = AB \hat{n}$.

(ii) Cross product of two parallel (i.e $\theta = 0°$) vector will not exist.

$\vec{A} \times \vec{B} = AB \sin 0 = AB \sin 0° = 0$.

12. Define torque. What is the condition of equilibrium relating to torque? (MUL 2011 ANNUAL) (RAW 2016) (SAW 2014)

Ans. Torque:

The product of force and moment arm is called torque.

Second condition of equilibrium:

According to second condition of equilibrium, the sum of all the torques acting on a body must be zero i-e. $\Sigma\tau = 0$.

13. What are rectangular components of a vector? At what angle there components are equal? (MUL 2012: annual)

Ans. The components of a vector which are perpendicular to each other are called rectangular components of a vector.

When a vector "A" makes an angle of 45° with x-axis then magnitude of its rectangular components will be equal.

$Ax = A \cos 45° = 0.707\ A$

$Ay = A \sin 45° = 0.707\ A$

14. Write any two characteristics of vector product. (MUL 2012: Annual) (RAW 2019 GI)

Ans. • The vector product is not commutative.

$\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$

• The vector product of two perpendicular vectors has maximum magnitude.

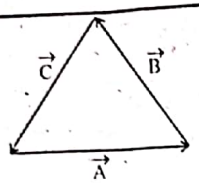
$\vec{A} \times \vec{B} = AB \sin 90° \hat{n} = AB\hat{n}$

15. Find the magnitude of unit vector? (BAH 2011)

Ans. A unit vector is a vector having magnitude 1 in any particular direction.

16. The vector sum of three vectors give a zero resultant. What can be possible orientation of the vectors? (BAH 2014) (FAS 2011, 2014) (RAW 2014)

Ans. Vector sum of three vector is zero only when these are represented by three sides of a closed triangle.



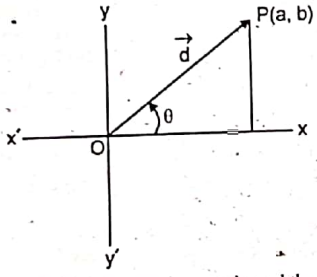
Let $\vec{A}$, $\vec{B}$, $\vec{C}$ are three vectors. There resultants vector can be find by head to tail rule. From fig. it is evident that

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

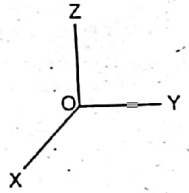
17. Explain rectangular co-ordinate system. (FAS 2015)

Ans. Rectangular Coordinate System:

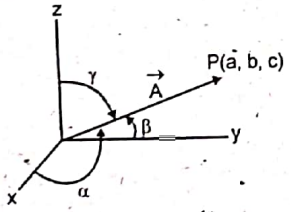
Two reference lines drawn at right angles as shown in figure. They are known as coordinate axes and their point of intersection is known as origin. This system of coordinate axes is called Cartesian or rectangular coordinate system.



One of the lines is named as x-axis, and the other the y-axis. Usually the x-axis is taken as the horizontal axis, with the positive direction to the right, and they y-axis as the vertical axis with the positive direction upward.



The direction of a vector in a plane is denoted by the angle which representative line of the vector makes with positive x-axis in the anti-clockwise direction as shown in fig.



The direction of a vector in space requires another axis which is at right angle to both x and y axes, as shown in figure which is called z-axis.

The direction of a vector in space is specified by the three angles which the representative line of the vector makes with x, y and z axes respectively as shown in figure. The point P of a vector A is thus denoted by three coordinates (a, b, c).

18. What is the difference between moment arm and moment of force. (FAS 2016)

Ans. Moment Arm:

It is defined as the perpendicular distance of line of action of force from axis of rotation (or pivot point).

Torque or Moment of Force:

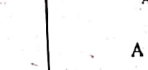
Torque is defined as the turning effect of a force produced in a body about an axis. It is denoted by τ(tau).

$$t = \vec{r} \times \vec{F}$$

19. Prove that addition of two non-zero vector $\vec{A}$ and $\vec{B}$ is commutative. (RAW 2011) (SAG 2017)

Ans. Let $\vec{A}$ and $\vec{B}$ are two vectors shown in the figure.

then by head to tail rule.

$A + B =$ and $B + A =$  are same. So, we can say that addition is commutative.

20. Prove that: $\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$ (RAW 2013)

Ans. As we know

$$\vec{A} \times \vec{B} = AB \sin\theta \hat{n} \quad \text{.....(i)}$$

By applying right hand rule the direction of vector product $(\vec{A} \times \vec{B})$ is upward. By applying same rule the direction of vector product $(\vec{B} \times \vec{A})$ is downward ie – ve sign while magnitude ABsinθ has same value

$$\vec{B} \times \vec{A} = -BA \sin\theta \hat{n} \quad \text{.....(ii)}$$

$$(\vec{A} \times \vec{B}) = AB \sin\theta \hat{n} \quad \text{.....(iii)}$$

By comparing (i) & (ii)

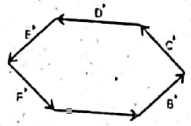
$$\boxed{\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}}$$

21. What do you understand by positive and negative torque. (RAW 2016)

Ans. If body is rotate in Anticlockwise direction then torque is positive and if a body is rotate in clockwise direction, the torque is negative.

22. Suppose the sides of a closed polygon represent vector arranged head to tail. What is the sum of these vectors? (RAW 2016)

Ans. The sum of these vector is zero. Because the resultant of a number of vectors which complete closed path is always equal to zero. So in this case also resultant vector (sum) is zero.



23. Prove that $A.B = A_xB_x + A_yB_y + A_zB_z$? (DGK 2012) (SAW 2014)

Ans. $\vec{A}.\vec{B} = \hat{A}_xB_x + A_yB_y + A_zB_z$

As $\vec{A}.\vec{B} = (A_x\hat{i} + A_y\hat{j} + A_z\hat{k})(B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$

$= A_xB_x(\hat{i}.\hat{i}) + A_xB_y(\hat{i}.\hat{i}) + A_xB_z(\hat{i}.\hat{k})$

$+ A_yB_x(\hat{j}.\hat{i}) + A_yB_y(\hat{j}.\hat{j}) + A_yB_z(\hat{j}.\hat{k})$

$+ A_zB_x(\hat{k},\hat{i}) + A_zB_z(\hat{k}.\hat{j}) + A_zB_z(\hat{k}.\hat{k})$

But $\hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 1$ (dot product of equal vectors)

and $\hat{i}.\hat{j} = \hat{j}.\hat{i} = \hat{j}.\hat{k} = \hat{k}.\hat{j} = \hat{k}.\hat{i} = \hat{i}.\hat{k} = 0$

(∴dot product of perpendicular vectors = 0)

Putting these values, we get

$$\vec{A}.\vec{B} = A_xB_x + A_yB_y + A_zB_z$$

Hence, it is clear that the scalar product of two vectors is equal to the sum of the products of their corresponding components.

Find the angle between two forces of equal magnitude when the magnitude of resultant is also equal to the magnitude of either of these forces. (DGK 2017) (SAW 2019 GI)

Ans. Angle between two forces F_1 and F_2 $\theta = ?$

Such that

$F_1 = F_2 = F$

Also $R = F$

Solution:

Using $R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$

$\because F_1 = F_2 = R = F$

$\therefore F = \sqrt{F_2^2 + F_2^2 + 2F\cos\theta}$

$F = \sqrt{2F^2 + 2F^2\cos\theta}$

Squaring both sides

$F^2 = 2F^2 + 2F^2\cos\theta$

$F^2 = 2F^2(1 + \cos\theta)$

$1 = 2(1 + \cos\theta)$

$\frac{1}{2} = 1 + \cos\theta$

$\cos\theta = \frac{1}{2} - 1$

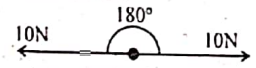
$= -\frac{1}{2}$

$0 = \cos^{-1}\left(-\frac{1}{2}\right)$

$0 = 120°$

25. Two vectors of magnitude 10 each making angle 180° with each other. Find the magnitude of their resultant. (LHR 2019 GI) (DGK 2017)

Ans. As the two vectors making an angle 180° with each other having equal magnitude, then their resultant should be equal to zero.



i – e 10 N – 10 N = 0

26. Explain how a vector can be subtracted from the other vector? (SAR GII 2018)

Ans. Vector subtraction:

The subtraction of a vector is equal to the addition of the same vector with its direction reversed. To subtract vector $\vec{B}$ from vector $\vec{A}$ reverse the direction of $\vec{B}$ and add it to $\vec{A}$ i.e.,

$= \vec{A} + (-\vec{B})$

$= \vec{A} - \vec{B}$

27. A force 10N makes an angle of 60° with x-axis find its x and y components. (SAR GI 2018)

Ans. Data

$F = 100$ N, $\theta = 60°$

$Fx = ?$

$Fy = ?$

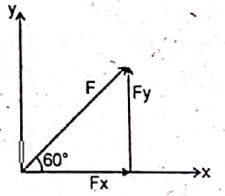
Formula

$Fx = F\cos\theta$

$= 100 \times \cos 60°$

$= 100 \times \frac{1}{2}$

$\boxed{Fx = 50N}$



$Fy = F\sin\theta$

$= 100 \times \sin 60°$

$= 100 \times \frac{\sqrt{3}}{2}$

$\boxed{Fy = 50\sqrt{3}}$

28. Prove that dot product is commutative: **(SAR GII 2018)**

Ans. Scalar product is commutative

Proof: $\vec{A}.\vec{B} = \vec{B}.\vec{A}$

$\vec{A}.\vec{B} = AB\cos\theta$

$\vec{B}\,\vec{A} = BA\cos\theta$ ——— (I)

since AB = BA

$\vec{B}\,\vec{A} = AB\cos\theta$ ——— (II)

eq(I) and (2)

$\vec{A}.\vec{B} = \vec{B}\,\vec{A}$

29. Write down the names of two example of scalar quantities. **(SAR GII 2018)**

Ans. Those physical quantities which are complete described by magnitude with proper units are called scalars e.g. Time current speed etc.

30. If $\vec{A} = 4\hat{i} - 4\hat{j}$ what is the orientation of $\vec{A}$. **(LHR 2019 GI)**

Ans. It is clear from vector $\vec{A}$ that x – component of vector is positive and y – component of vector is negative. So this vector lies in 4th quadrant.

31. Find the unit vector in the direction of vector $\vec{A}$ $\vec{A} = 8\hat{i} + 4\hat{j}$. **(RAW 2019 GI)**

Ans. $\vec{A} = 8\hat{i} + 4\hat{j}$

$\hat{A} = ?$

$\hat{A} = \dfrac{\vec{A}}{|A|}$ .....(i)

$|A| = \sqrt{8^2 + 4^2} = 4\sqrt{5}$

Now by equation (i)

$\hat{A} = \dfrac{8\hat{i} + 4\hat{j}}{4\sqrt{5}}$

32. If a vector lies in x – y plane, is it possible, one of its rectangular component zero. **(MUL 2019 GI)**

Ans. If a vector lies in x – y plane the it has its both rectangular components directed along x – axis and y – axis. So it is not possible that one of its rectangular component is zero.

33. Find the angle between $\vec{A} = 2\hat{i} - 2\hat{j}$ and $\vec{B} = 2\hat{i} + 2\hat{j}$. **(SAG 2019 GI)**

Ans. $\vec{A} = 2\hat{i} - 2\hat{j}$

$\vec{B} = 2\hat{i} + 2\hat{j}$

$\theta = ?$

$\theta = \dfrac{\cos^{-1}\vec{A}.\vec{B}}{AB}$ .....(i)

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

$= 4 - 4 = 0$

$|A| = \sqrt{8}$

$|B| = \sqrt{8}$

Now

$\theta = \cos^{-1}\dfrac{0}{\sqrt{8} \times \sqrt{8}}$

$\theta = \cos^{-1} 0$

$\theta = 90°$

The angle between $\vec{A}$ and $\vec{B}$ is 90°.

34. Define components of a vector what are rectangular components. **(SAG 2019 GI)**

Ans. **Component of a vector:**

Splitting up of a vector into its parts is called components of a vector.

Rectangular Components:

Generally a vector resolve into two components which are at right angle to each other are called rectangular components.

35. What are the steps taken to add vectors by rectangular compounents. **(SAG 2019 GI)**

Ans. **Steps for vector addition by rectangular:**

The vector addition by rectangular components consists of the following steps:

- Find x and y components of all given vectors.
- Find x – components R_x of the resultant vector by adding the x – components of all the vectors.
- Find y – component R_y of the resultant vector by adding the y – components of all the vectors.
- Find the magnitude of resultant vector $\vec{R}$ using

$$|\vec{R}| = \sqrt{R_x^2 + R_y^2}$$

- Find the direction of resultant vector $\vec{R}$ by using

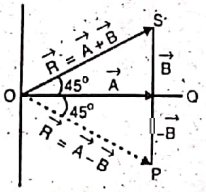
$$\theta = \text{Tan}^{-1}\left(\frac{R_y}{R_x}\right)$$

Where θ is the angle, which the resultant vector makes with positive x – axis.

36. Show that the sum and difference of two perpendicular vectors of equal lengths are also perpendicular and of the same length? **(BAH 2019 GI)**

(Federal 2003, DGK 2005, FSD 2005)

Ans. Suppose we have two vectors $\vec{A}$ and $\vec{B}$ of equal magnitudes and these are perpendicular to each other as shown in fig.



Magnitude of sum of vectors.

$R = \sqrt{(A)^2 + (B)^2}$

$= \sqrt{A^2 + B^2}$ .....(1)

Magnitude of difference of vectors.

$R' = \sqrt{(A)^2 + (-B)^2}$

$= \sqrt{A^2 + B^2}$ .....(2)

From (1) and (2)

$R = R'$

In right angled triangle SOQ.

Since A = B

$\Rightarrow$ <SOQ = 45° and <QOP = 45°

<OPS = <SOQ + <QOP

<OPS = 45° + 45°

<OPS = 90°

It mean OP (R) is perpendicular to OS (R').

SECTION III

Long Questions

From Punjab Boards:-

1. Given that $\vec{A} = \hat{i} - 2\hat{j} + 3\hat{k}$ and $\vec{B} = 3\hat{i} - 4\hat{k}$. Find the projection of $\vec{A}$ on $\vec{B}$. **(LHR 2012: GI) (MUL 2011)**
2. Define rectangular component of a vector. How two vectors can be added by rectangular component method. **(LHR 2013: GI) (MUL 2013) (BAH 2014, 2019 GI) (SAG 2017)**
3. Find the angle between two forces of equal magnitude when the magnitude of their resultant is equal to the magnitude of either of these forces. **(LHR 2013: GII) (MUL 2011, 2016)**
4. Define scalar product, writer down its any four characteristics. **(LHR 2014: GI) (GUJ 2013) (SAG 2012) (SAW 2014) (DGK 2019 GI)**
5. 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. **(LHR 2014: GII)**
6. Find the projection of vector $\vec{A} = 2\hat{i} - 8\hat{j} + \hat{k}$ in the direction of $\vec{B} = 3\hat{i} - 4\hat{j} - 12\hat{k}$. **(LHR 2015: GI, 2017) (MUL 2012) (RAW 2013) (DGK 2013)**
7. Define vector product of two vectors. Also write the characteristics of vector product of two vectors. **(LHR 2015: GII) (GUJ 2016) (FAS 2013, 2016)**
8. Define components of a vector. Describe the addition of vectors by rectangular components. **(LHR 2017)**
9. Two forces of magnitude of 10N and 20N act on a body in directions making angle 30° and 60° respectively with x-axis. Find the resultant force and direction.**(LHR 2017)**
10. What is Torque? Calculate the torque due to force acting on a rigid body. **(LHR 2017) (GUJ 2012) (MUL 2019 GI) (SAW 2019 GI)**
11. The magnitude of dot and cross product of two vectors are $6\sqrt{3}$ and 6 respectively. Find the angle between the vectors. **(LHR 2016) (DGK 2012)**
12. What is unit vector in the direction of the vector $\vec{A} = 4\hat{i} + 3\hat{j}$? **(GUJ 2015) (MUL 2012)**
13. Explain the method of vector addition by rectangular components for two vectors. **(LHR 2019 GI) (BAH 2012)**
14. Define scalar product with two examples. Also discuss its four characteristics. **(BAH 2011) (RAW 2012) (FAS 2017)**
15. Find resultant of $\vec{A}$ and $\vec{B}$ using addition of vectors by rectangular components. **(RAW 2014)**
16. (a) Write scalar product of two vectors and describe its four characteristics.
17. Describe addition of two vectors $\vec{A}$ and $\vec{B}$ by using rectangular components. **(SAW 2017)**
18. Define vector product or cross product. Explain with right hand rule and give four characteristics of cross product. **(LHR GII 2018, 2019 GI) (DGK 2014)**
19. Two forces of magnitude 10N and 20N act on a body in direction making angles 30° and 60° respectively with x-axis. Find the resultant force and direction. **(GUJ GI 2018)**
20. Add two vectors by using their rectangular components. Determine the magnitude and direction of the resultant. **(SAR GI 2018)**
21. Define and Explain Rectangular Components of a Vector. **(SAR GII 2018)**
22. Define cross product of two vectors Also, write down four characteristics of cross product. **(DGK GI 2018)**
23. Describe vector addition by rectangular components. First find the resultant of two vector and then generalize for 'n' vectors. **(SAW GI 2018)**
24. How can a vector resolved into its rectangular components. How a vector is determined if its rectangular components are given. **(RAW 2019)**
25. Derive expression for the magnitude and direction of resultant of two vectors added by rectangular method. **(SAG 2019)**

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CHAPTER — 3

MOTION AND FORCE

SECTION I

Multiple Choice Questions

From Punjab Boards:-

1) The range of projectile is directly proportional to: **(LHR 2013 GI) (FAS 2016)**

(a) $\sin^2\theta$ (b) $\sin 2\theta$

(c) $\sin\theta$ (d) $2\sin\theta$

2) A projectile is thrown upward with initial velocity "v_i" making an angle with the horizontal. The maximum horizontal range is given by: (LHR 2011)

(a) $\frac{V_i^2}{g}$ (b) $\frac{V_i^2}{2g}$

(c) $\frac{V_i^2}{g}\sin 20$ (d) $\frac{V_i^2}{2g}\sin 20$

3) A cricket ball is hit so that it travels straight up in air and it acquires 3 seconds to reach the maximum height. Its initial velocity is: (LHR 2013 GI)

(a) $10ms^{-1}$ (b) $15ms^{-1}$

(c) $29.4ms^{-1}$ (d) $12.2ms^{-1}$

4) Change in momentum is also (called). (LHR 2013 GII) (MUL 2012 , 2017) (BAH 2014) (FAS 2013) (RAW 2013)

(a) Force (b) Acceleration

(c) Torque (d) Impulse

5) The horizontal range of projectile at 30° with horizontal is the same as that at an angle of. (LHR 2013 GII)

(a) 45° (b) 60°

(c) 90° (d) 120°

6) SI unit of impulse is (LHR 2016)

(a) Kg ms^{-1} (b) N.m

(c) N.S (d) Nm^2

7) The trajectory of a projectile is (LHR 2016)

(a) Circle (b) parabola

(c) Hyperbola (d) Straight line

8) The dimension of impulse is (LHR 2016)

(a) [MLT] (b) $[ML^{-1}T]$

(c) $[MLT^{-1}]$ (d) $[MLT^{-2}]$

9) The horizontal range of a projectile at 30° with horizontal is same at an angle. (BAH 2013) (DGK 2017) (LHR 2017)

(a) 40° (b) 45°

(c) 60° (d) None

10) The horizontal component of velocity of projectile. (LHR 2017)

(a) Increases (b) Decreases

(c) Increases or decreases (d) Remains constant

11) Height of projectile is maximum at an angle of. (LHR 2017) (BAH 2014) (FAS 2013)

(a) 45° (b) 60°

(c) 30° (d) 90°

12) The area under the curve of force displacement graph represents: (GUJ 2012)

(a) Force (b) Displacement

(c) Work (d) Power

13) What is the angle of projection of a projectile for which its maximum height and horizontal range are equal? (GUJ 2013) (MUL 20

(a) 46° (b) 56°

(c) 66° (d) 76°

14) Speed of moon around the earth is (GUJ 20

(a) 1200 ms^{-1} (b) 11 ms^{-1}

(c) 1000 ms^{-1} (d) 900 ms^{-1}

15) No body begins to move or comes to rest of itself unless given by (GUJ 20

(a) Newton (b) Pascal

(c) Bernoulli (d) Bu-Ali sena

16) For an angle less than _____ the height reached by projectile and the range both will be less: (MUL 201

(a) 15° (b) 30°

(c) 45° (d) 60°

17) The ballistic missiles are useful only for (MUL 2016) (BAH 201

(a) Long range (b) Short range

(c) Intermediate range (d) Zero range

18) Motion of projectile is (MUL 2016) (DGK 2013) (SAW 201

(a) One dimensional (b) Two dimensional

(c) Three dimensional (d) Four dimensional

19) The shape of trajectory of short range projectile is (MUL 2016)

(a) Straight line (b) Circle

(c) Elliptical (d) Parabolic

20) Maximum height of projectile is (MUL 2016)

(a) $h=\frac{Vi^2\sin^2\theta}{2g}$ (b) $h=\frac{Vi^2\sin^2\theta}{g}$

(c) $h=\frac{Vi^2}{g}$ (d) $h=\frac{Vi^2}{g}\sin 2\theta$

21) The mass of fuel consumed by a typical rocket to overcome earth's gravity is (MUL 2016)

(a) 10000 KgS^{-1} (b) 1000 KgS^{-1}

(c) 100 KgS^{-1} (d) 10 KgS^{-1}

22) The time of flight of the projectile is given by the relation: (MUL 2017)

(a) $T=\frac{Vi\sin\theta}{g}$ (b) $T=\frac{2Vi\sin\theta}{g}$

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

23) The horizontal component of velocity of projectile: (BAH 2013)

(a) Remain constant (b) Increases

(c) Decreases (d) None of these

24) Total change in momentum of a moving body is equal to its: (BAH 2011)

(a) K.E (b) Impulse

(c) Force (d) Inertia

25) Motion of projectile is _____ dimension. (FAS 2012)

(a) One (b) Two

(c) Three (d) Four

26) The relation for acceleration $\bar{a}$ of the rocket is (FAS 2016)

(a) $\bar{a}=\frac{m\bar{v}}{M}$ (b) $\bar{a}=\frac{\bar{v}}{m}$

(c) $\bar{a}\frac{m}{M\bar{v}}$ (d) $\bar{a}\frac{M}{\bar{v}}$

27) Velocity of an object dropped from a building at any instant 't' is given by: (FAS 2017)

(a) $\frac{1}{2}gt^2$ (b) $Vit+\frac{1}{2}gt^2$

(c) at (d) gt

28) If a force of 10N acts on a body of mass 5kg for one second, then its rate of change of momentum will be: (RAW 2013)

(a) $10kg.msec^{-2}$ (b) $50kg.msec^{-2}$

(c) $2kg.msec^{-2}$ (d) $2kg.msec^{-2}$

29) The velocity of a projectile is maximum. (RAW 2014)

(a) at the highest point

(b) at point of launching and just before striking the ground

(c) at half of the height

(d) after striking the ground

30) Impulse can be defined as: (RAW 2014)

(a) $\vec{I}=\vec{F}\times\vec{d}$ (b) $\vec{I}=\vec{F}\times t$

(c) $\vec{I}=\vec{F}\times\vec{V}$ (d) $\vec{I}=\frac{\vec{F}}{t}$

31) The time of flight of a projectile, when it is projected from the ground is: (RAW 2011)

(a) $\frac{V_i\sin\theta}{g}$ (b) $\frac{2v_i\sin\theta}{g}$

(c) $\frac{V_i\sin^2\theta}{g}$ (d) $\frac{V^2{}_i\sin^2\theta}{g}$

32) The force due to water flow is (RAW 2016)

(a) $F=mv$ (b) $F=\frac{mv}{t}$

(c) $F=\frac{ma}{t}$ (d) $F=\frac{mt}{V}$

33) The acceleration along x-axis direction in case of projectile is: (RAW 2017)

(a) Zero (b) Equal to gravity

(c) Maximum (d) Constant

34) Horizontal component of velocity of projectile. (SAG 2013)

(a) Remains constant (b) Increases

(c) Decreases (d) Zero

35) SI unit of impulse is: (SAG 2013)

(a) Kgmsec^{-1} (b) Newton sec

(c) Newton (d) Both a, b

36) A typical rocket consumes about 10000 kgs^{-1} of fuel and ejects the burnt gases at speeds of over: (SAG 2017)

(a) 2000 ms^{-1} (b) 3000 ms^{-1}

(c) 4000 ms^{-1} (d) 5000 ms^{-1}

37) The acceleration of a projectile along x-axis: (SAG 2017)

(a) Zero (b) Increases

(c) Decreases (d) Equal to 'g'

38) For a rocket, the change in momentum per second of the ejecting gases is equal: (SAG 2017)

(a) Acceleration of the rocket

(b) Momentum of the rocket

(c) Velocity of the rocket

(d) Thrust acting on rocket

39) If a body of mass 2 kg moving with 15 m/s collides with stationary body of same mass, then after elastic collision second body will move with velocity of: (DGK 2011)

(a) 15 m/s (b) 30 m/s

(c) zero m/s (d) none of these

40) The time of flight of a projectile is: (DGK 2012)

(a) $\frac{Visin\theta}{g}$ (b) $\frac{2\,Visin\theta}{g}$

(c) $\frac{Visin\theta}{2g}$ (d) $\frac{2Visin\theta}{2g}$

41) SI unit of impulse is: (DGK 2013)

(a) NKg (b) NS

(c) Kgs (d) Nm

42) For which pair the horizontal ranges of a projectile is same: (DGK 2017)

(a) (30°, 45°) (b) (50°, 70°)

(c) (20O, 40°) (d) (30°, 60°)

43) Motion of a body along y-axis is: (SAW 2014)

(a) one dimensional (b) two dimensional

(c) three dimensional (d) four dimensional

44) The disc used by a woman athlete has a mass of 1 kg, its weight in Newton is: (SAW 2014)

(a) 98 N (b) 100 N

(c) 80 N (d) 9.8 N

45) For maximum range, the angle of projection must be: (SAW 2013)

(a) 30° (b) 45°

(c) 60° (d) 90°

46) Work has the same dimensional formula as: (GUJ 2018)
(a) torque (b) momentum
(c) Force (d) Angular acceleration.

47) If the mass of a body is doubled, then acceleration becomes. (GUJ 2018)
(a) One fourth (b) half
(c) double (d) constant

48) When speed of a body is doubled then is: (GUJ 2018)
(a) K.E is doubled (b) P.E doubled
(c) acceleration (d) momentum is doubled

49) If a body of mass 1kg is allowed to fall freely then its weight becomes (GUJ 2018)
(a) 1N (b) 9.8N
(c) 980N (d) Zero

50) A mass of 500gm moves an acceleration of $10ms^{-1}$ force acting on it is: (SAR 2018)
(a) 5N (b) 500N
(c) 50N (d) 5000N

51) Change in momentum is called (GUJ 2016)
(a) Torque (b) Impulse
(c) Pressure (d) Force

52) Rocket equation is given as: (MUL 2013)
(a) $a = \frac{M}{mv}$ (b) $a = \frac{Mv}{m}$
(c) $a = \frac{mv}{M}$ (d) $a = \frac{m}{Mv}$

53) To overcome gravity, fuel consumed by rocket is (RAW 2016)
(a) $40000kgS^{-1}$ (b) $30000kgS^{-1}$
(c) $20000kgS^{-1}$ (d) $10000kgS^{-1}$

54) Rocket ejects the burnt gasses at a speed of over (consuming fuel at rat of 10000 kg / s): (LHR 2019 GI)
(a) 4000 m/s (b) 400 m/s
(c) 4000 cm/s (d) 400 cm/s

55) The distance covered by a freely falling body in first 2 seconds, when its initial velocity was zero: (LHR 2019 GI)
(a) 9.8m (b) 39.2m
(c) 19.6 m (d) 4.9m

56) Distance travelled by free falling object in first second is: (RAW 2019 GI)
(a) 4.9m (b) 9.8m
(c) 19.6m (d) 10m

57) If the initial velocity of a projectile becomes doubled. The time of flight will become: (MUL 2019 GI)
(a) Double (b) Same
(c) 3 times (d) 4 times

58) Time of flight of a projectile is: (MUL 2019 GI)
(a) $\frac{vi\sin\theta}{g}$ (b) $\frac{vi\sin\theta}{2g}$
(c) $\frac{vi^2\sin\theta}{g}$ (d) $\frac{2vi\sin\theta}{g}$

59) Ballistic missiles are used for: (DGK 2019 GI)
(a) short ranges (b) long ranges
(c) very long ranges (d) any range

60) If maximum height of the projectile is equal to ¼ range then angle of projection of projectile will be: (SAG 2019 GI)
(a) 30° (b) 60°
(c) 45° (d) 76°

61) If a shell explodes in mid air, its fragments fly off different direction. The total momentum of fragments: (SAW 2019 GI)
(a) decreases (b) increases
(c) becomes zero (d) remains the same

62) Everything in the vastness of space is in a state of: (BAH 2019 GI)
(a) Rest (b) Rectilinear Motion
(c) Perpetual Motion (d) Projectile Motion

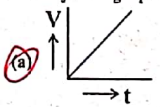
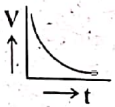
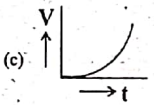
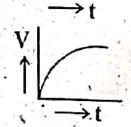
Entry Test MCQ's

1) The vertical velocity of ball thrown upward ____ with time. (2008)
(a) Descreases linearly (b) Remains constant.
(c) Doubles (d) Descreases parabolically

2) A disc at rest without slipping, rolls down a hill of height (3 × 9.8)m. What is tis speed in m/secf when it reaches at the bottom? (2008)
(a) 11.4 (b) 19.6
(c) 22.8 (d) 9.8

3) An _____ missile is called a ballistic missle. (2008)
(a) Un-powered as guided.
(b) Un-guided and powered
(c) Powered and guided
(d) Un-powered and un-guided.

4) 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 accelerationw will be: (2009)
(a) 30 ms^{-1} (b) 40 ms^{-1}
(c) 20 ms^{-1} (d) 10 ms^{-1}

5) When a car moves with constant acceleration, the velocity-time graph is a: (2009)
(a) 
(b) 
(c) 
(d) 

6) In elastic collisio, when a massive body collides with light body at conditions $m_1 >> m_2$ and $v_2 = 0\ ms^{-1}$, then the change in velocity will be written as: (2009)
(a) $v_1' \approx -v_1; v_2' \approx v_1$ (b) $v_1' \approx v_1; v_2' \approx 0$
(c) $v_1' \approx v_1; v_2' \approx 2v_1$ (d) $v_1' \approx -v_1; v_2' \approx 0$

7) The horizontal range of a projectile, at a certain place, is completely determined by: (2010)
(a) The angle of projection
(b) The initial velocity of projection
(c) The mass of the projectile
(d) Speed and mass of the projectile

8) If velocity is double, then. (2010)
(a) Momentum increase 4 times and K.E increases 2 times
(b) Momentum and K.E remain same
(c) Momentum increases 2 times and K.E increase constant
(d) Momentum increases 2 times and K.E increases 4 times

9) The consumption of energy by 60-watt bulb in 2 seconds is: (2010)
(a) 20 J (b) 120 J
(c) 30 J (d) 0.02 J

10) Time of projectile's flight is: (2010)
(a) $\frac{V_i^2\sin^2\theta}{g}$ (b) $\frac{2V_i\sin\theta}{g}$
(c) $\frac{V_i^2\sin\theta}{g}$ (d) $\frac{V_i^2}{g}\sin 2\theta$

11) If the velocity of the body changes by equal amount in equal intervals of time, the body is said to have: (2010)
(a) variable acceleration (b) uniform acceleration
(c) uniform velocity (d) negative acceleration

12) In order to determine the maximum height of the projectile, the equation of motion used is: (2010)
(a) $aS = v_f^2 - v_i^2$ (b) $2aS = v_f^2 - v_i^2$
(c) $2 = a(v_f^2 - v_i^2)$ (d) $aS = 2(v_f^2 - v_i^2)$

13) If a force of 12N 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: (2010)
(a) 24 sec (b) 2 sec
(c) 12 sec (d) 8 sec

14) Which one of the following is a non-conservative force? (2010)
(a) Electric force (b) Gravitational force
(c) Elastic spring force (d) Frictional force

15) 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? (2012)
(a) Zero (b) 2 mg
(c) mg (d) $\frac{mg}{2}$

16) 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? (2013)
(a) 3:4 (b) 2:3
(c) 3:2 (d) 4:3

17) In order to determine the maximum height of the projectile, the equation of motion used is: (2015)
(a) $as = vf^L - vi^L$ (b) $2S = a(vf^2 - vi^2)$
(c) $2as = vf^2 - vi^2$ (d) $as = 2(vf^L - vi^L)$

SECTION II

Short Questions

From Punjab Boards:

1. Define elastic and inelastic collisions: (LHR 2011, 2013: GI) (FAS 2011, 2014) (RAW 2012, 2013, 2014)

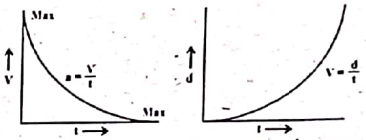
Ans. **Elastic collision:**
A collision in which both kinetic and linear momentum are conserved is called elastic collision.
Inelastic collision:
A collision in which linear momentum is conserved but K.E is not conserved is called inelastic collision.

2. At what point or points in its path does a projectile have its minimum speed, its maximum speed? (LHR 2011, 2014: GI)

Ans. A projectile has its maximum speed at launching and landing point where vertical components attains maximum value. As the highest point reached, the projectile attains maximum speed as at this point, vertical component of its velocity becomes zero.

3. Show graphically how does the displacement and velocity of a vertically thrown ball very with time. (LHR 2011) (FAS 2014)

Ans. When a ball is thrown vertically its velocity decreases and on reaching highest point it becomes zero as shown in graph. The displacement increase with time as shown.



4. Differentiate between elastic and inelastic collision. (LHR 2012) (MUL 2019 GI) (DGK 2019 GI)

Ans.

Elastic collision	Inelastic collision
• A collision in which momentum and kinetic energy are conserved i-e, remains constant.	• A collision during which the total momentum is conserved but total K.E before and after collision is not conserved.
• Example: When a hard ball is dropped on a certain height, it rebounds to very nearly the initial height. Thus the ball loses negligible amount of energy in the collision with the floor.	• Example: When a tennis ball collides with the floor, it rebound with the velocity, less than the velocity before collision. During collision, some K.E is lost.

5. What is projectile motion? In what direction acceleration is zero in this motion? (LHR 2012) (FAS 2012, 2014) (RAW 2013)

Ans. Projectile motion is two dimensional motion under constant acceleration due to gravity.
Consider the motion of a ball, when it is thrown horizontally from certain height. The ball travels forward as well as falls down wards, until it strikes something. No

external force is acting along horizontal direction as the motion is completely horizontal.

According to Newton's Law of motion, there will be no acceleration in horizontal direction, unless a horizontally directed force acts on the ball.

Hence a = 0

6. Why you wear your seat belts? (BAH 2014)

Ans. When a moving car stops suddenly, the passengers mve forward toward the wind shield. Seat belt changes the force of motion and prevent the passengersd from moving. Thus the change of injury is greatly reduced.

7. Define impulse and show that how it is related to linear momentum. (LHR 2012, 2014: GI, 2019 GI) (GUJ 2011, 2013, 2015) (SAG 2019 GI)

Ans. Impulse: The impulse provided by a force is the product of force and time for which it acts. It equals to change in momentum of the object.

$$\text{Impulse} = \vec{F} \times \vec{t} = m\vec{V}_F - m\vec{V}_i$$

Relation between impulse and linear momentum:

According to Newton's second law of motion, the force is defined as the rate of change of momentum. Thus, if a force $\vec{F}$ acting on a body for time $\Delta \vec{t}$, changes its momentum from $m\vec{V}_F$ to $m\vec{V}_i$. Then the force is written as.

$$\vec{F} = \frac{m\vec{V}_F - m\vec{V}_i}{t}$$

When $m\vec{V}_F$ and $m\vec{V}_i$ and final and initial momentum respectively. The equation is written as.

$$\vec{F} \times t = m\vec{V}_F - m\vec{V}_i$$

$\vec{F} \times t$ is known as impulse.

$$\text{Impulse} = m\vec{V}_F - m\vec{V}_i \quad \text{——— (2)}$$

The above equation (2) shows the relation between impulse and linear momentum.

8. Show that $\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$. (LHR 2013: GII, 2019 GI) (MUL 2011, 2012) (FAS 2012, 2014) (SAG 2013)

Ans. Consider a body of mass "m" moving with an initial velocity "vi". Suppose an external force "F" acts upon if for time "t" after which velocity becomes V_F. The acceleration "a" produced by this force is given by.

$$a = \frac{\vec{V}_F - \vec{V}_i}{t} \quad \text{——— (i)}$$

By Newton's second law, the acceleration is given as.

$$a = F/m \quad \text{——— (ii)}$$

From equations (i) and (ii), we get

$$F/m = \frac{mV_F - mVi}{t}$$

$$\Rightarrow \quad F \times t = mV_F - mVi \quad \text{——— (1)}$$

Where mVi = initial momentum.

mV_F = final momentum.

From eq (1).

$$F = \frac{mV_F - mVi}{t}$$

$$\Rightarrow \quad \vec{F} = \frac{\Delta \vec{p}}{\Delta t}$$

9. Why is it useful to use a safety halmet? (FAS 2011) (LHR 2014: GI)

Ans. A motorcycle safety halmet is padded so as to extend the time of any collision to prevent serious injury.

10. Define range and time of flight of a projectile. (LHR 2015: GII) (GUJ 2015) (MUL 2014) (FAS 2014)

Ans. **Range:**

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

Mathematically it is expressed as:

$$R = \frac{vi^2}{g} \sin 2\theta$$

Time of flight:

The time taken by body to cover the distance form the place of its projection to the place where it hits the ground is called the time of flight.

Mathematically we can write t as:

$$t = \frac{2vi \sin\theta}{g}$$

11. A 20 g ball hits the wall of squash court with a constant force of 50N. If the time of impact of force is 0.5 Sec. Find the impulse. (LHR 2017)

Ans.

$F = 50\ N$

$t = 0.5\ Sec$

$\text{Impulse} = ?$

$\text{Impulse} = F \times t$

$= 50 \times 0.5$

$= 25\ NS$

12. Show that range of projectile is maximum when projectile is thrown at angle of 45° with horizontal. (LHR 2017) (MUL 2011, 2012, 2013, 2015) (BAH 2019 GI) (SAG 2019 GI) (SAW 2014)

Ans. As we know

$$R = \frac{v_i^2 \sin 2\theta}{g}$$

Range is maximum when

$\sin 2\theta = 1$ $\qquad \sin 90° = 1$

$\sin 2\theta = \sin 90°$

$2\theta = 90°$

$\theta = \frac{90°}{2}$

$\theta = 45°$

So range will be maximum when a projectile is fired at an angle of 45°.

13. What is an isolated system. Give an example. (LHR 2017) (BAH 2019 GI)

Ans. A system in which no external force acts upon is called isolated system.

A gas enclosed in a cylinder constitute isolated system.

14. Define impulse and show that how it is related to linear momentum. Write its unit. (LHR 2017) (MUL 2015, 2016) (BAH 2011, 2012, 2019 GI) (FAS 2012, 2016) (RAW 2012, 2016, 2017) (SAG 2013) (DGK 2011, 2014) (SAW 2013)

Ans. Product of force and time interval for which force acts is called impulse and is written as

$$\text{Impulse} = F \times t = mv_f - mv_i$$

The unit of impuls is $kg \times ms^{-1}$ or NS.

15. Is the range of projectile is same for angle of 30° and 60°. If your answer is yes, then prove it. (LHR 2017)

Ans. yes. the range is same for angle of 30° and 60° because

$$R = \frac{v_i^2 \sin 20}{g}$$

For 30° $\quad \sin 2(30°) = \sin 60° = 0.866$

For 60° $\quad \sin 2(60°) = \sin 120° = 0.866$

So for 30° and 60° sin 20 has same value. So ranges are same for a projectile fired at an angle of 30° or 60°.

16. Find the angle of projection of a projectile for which its maximum height and horizontal range and equal. (LHR 2017) (RAW 2016, 2017) (DGK 2017)

Ans. Maximum height $= H = \frac{v_i^2 \sin^2\theta}{2g}$

Range $= R = \frac{v_i^2 \sin 2\theta}{g}$

To determine:

Angle of projection $= \theta = ?$ (When H = R)

Calculations:

Hence, $\frac{v_i^2 \sin^2\theta}{2g} = \frac{v_i^2 \sin 2\theta}{g}$

or $\frac{\sin^2\theta}{2} = \sin 2\theta$

or $\frac{\sin^2\theta}{2} = 2 \sin\theta \cos\theta$

$(\because \sin 2\theta = 2 \sin\theta \cos\theta)$

$\frac{\sin\theta}{2} = 2\cos\theta$

$\frac{\sin\theta}{\cos\theta} = 4$

or $\tan\theta = 4$

or $\theta = \tan^{-1}(4)$

or $\boxed{\theta = 76°}$ Ans.

17. Explain the difference between elastic and inelastic collisions. Explain how would a bouncing ball behave in each case? Give plausible reasons for the fact that K.E is not conserved in most cases? (LHR 2016)

Ans. **Elastic Collision:** These collision in which kinetic energy remains constant is called elastic collisions.

Inelastic Collision: These collision in which kinetic energy does not remain constant is called inelastic collisions.

In case of Bouncing Ball: If the ideal bouncing ball returns to the same height where it is dropped then the collision is elastic collision. If the bouncing ball will not returned to the same height then the collision is inelastic. So due to change of energy, kinetic energy does not remain constant.

For example: When a heavy ball is dropped on to the surface of earth, it rebounds upto very little height because maximum K.E is lost due to friction and also changes into heat and sound energies. So in most cases, the K.E is not conserved. Thus momentum and K.E. are conserved in all types of collisions. However, the K.E is conserved only in elastic collision.

18. Show that the rate of change of momentum is equal to force. (LHR 2019 GI) (GUJ 2012, 2014) (DGK 2014) (SAW 2014)

Ans. Let body of mass 'm' moving with an initial velocity v_i.

If an external force $\vec{F}$ acts upon it for time 't' then velocity becomes v_f, and acceleration $\vec{a}$ produced by this force can be written as,

$$\vec{a} = \frac{\vec{vf} - \vec{v_i}}{t}$$

Also acceleration is given by Newton's second law of motion as,

$$\vec{a} = \frac{\vec{F}}{m}$$

Comparing these two expressions we get

$$\frac{\vec{F}}{m} = \frac{\vec{vf} - \vec{v_i}}{t}$$

or $\boxed{\vec{F} = \frac{m\vec{v_f} - m\vec{v_i}}{t}}$

19. Write down two characteristics of a ballistic missile. (GUJ 2014)

Ans. Two characteristics of ballistic missile are:

(i) It is un-powered (ii) It is un-guided

20. Derive the relation for maximum height reached by the projectile. (GUJ 2016)

Ans. For maximum height we use the equation.

$$2as = V_f^2 - V_i^2$$

We also use the following data initial velocity $= V_i \sin\theta$.

acc $= -g$

distance $= h$

final velocity $= 0$

Thus

$2(-g)h = (0)^2 - (V_i \sin\theta)^2$

$-2gh = -V_i^2 \sin^2\theta$

$h = \frac{V_i^2 \sin^2\theta}{2g}$

21. How is a seat belt useful while driving?
(MUL 2011: ANNUAL, 2011, SUPPLY)

Ans. When a moving car stops quickly, the passengers move forward towards the windshield. Seat belts prevent the passengers form moving. Thus the chance of injury is reduced.

22. Find the velocity of a heavy body when it elastically collides with a stationary light body. (MUL 2013)

Ans. When heavy body collides with stationary light body.

As we know

$$V1' = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) V_1 + \left(\frac{2m_2}{m_1 + m_2}\right) V_2 \quad \text{.....(1)}$$

$$V2' = \left(\frac{2m_1}{m_1 + m_2}\right) V_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right) V_2 \quad \text{.....(2)}$$

In this case $m_1 >>> m_2$ and $V_2 = 0$ So $m_2 = 0$

Now equation (1) and (2) becomes.

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

Thus after collision, there is no change in the velocity of the heavy body, but the lighter body moves in the forward direction with twice the velocity of heavy body.

23. What is the ballistic flight? (MUL 2016) (RAW 2016)

Ans. A flight in which a projectile is given an initial push and is then allowed to move freely due to inertia and under the action of gravity is called ballistic flight

24. When a bullet is fired from a rifle why does the rifle move back word. Discuss it with reference to momentum. (LHR 2019 GI) (MUL 2012)

Ans. Consider another example of bullet of mass m fired from a rifle of mass M with a velocity $\vec{v}$. Initially, the total momentum of the bullet and rifle is zero. From the principle of conservation of linear momentum, when the bullet is fired, the total momentum of bullet and rifle still remains zero, since no external force has acted on them. Thus if $\vec{v'}$ is the velocity of the rifle then.

$$mv \text{ (bullet)} + Mv' \text{ (rifle)} = 0$$

$$Mv' = -mv$$

$$\text{or} \quad v' = \frac{-mv}{M}$$

Thus the momentum of the rifle is equal and opposite to that of the bullet. Since mass of rifle is much greater than the bullet, it follows that the rifle moves back or recoils with only a fraction of the velocity of the bullet.

25. A ball is thrown with a speed of 30m/s in a direction 30° above the horizon. Determine height of ball.
(BAH 2014)

Ans. $V_i = 30\text{m/s}$, $\theta = 30°$, $h = ?$

$$h = \frac{V_i^2 \sin^2\theta}{2g} = \frac{(30)^2 \times (\sin 30)^2}{2 \times 9.8} = 11.5\text{m}$$

26. A body is projected with a speed of $20ms^{-1}$ with an angle $\theta = 45°$. Find its horizontal range. (FAS 2011)

Ans. $R = \dfrac{V_i^2 \sin 2\theta}{g}$

$$R = \frac{(20)^2 \sin 2(45)}{10} = \frac{400 \times 1}{10} = 4 \text{ meter}$$

27. At what point or points in its path does a projectile have its minimum speed, its maximum speed?
(FAS 2014, 2016) (BAH 2019 GI)
(MUL 2011: SUPPLY, 2012: SUPPLY, 2013, 2014)
(DGK 2019 GI) (RAW 2011, 2012, 2017)

Ans. The speed of the projectile is maximum at the point of projection and also at the point where it hits the target. While the speed of projectile is minimum when it reaches the maximum height.

28. Define ballistic flight and ballistic trajectory.
(RAW 2011, 2019 GI) (DGK 2019 GI)

Ans. **Ballistic flight:**

The flight in which a projectile is given an initial push and is then allowed to move freely due to inertia under gravitational force.

Ballistic trajectory:

The path followed by a ballistic missile is called ballistic trajectory.

29. A 1500kg has its velocity reduced from 20 ms^{-1} to 15 ms^{-1} in 3.0 sec. How large was the retarding force.
(LHR 2019 GI) (RAW 2016)

Ans.

$m = 1500\text{kg}$

$V_i = 20\ ms^{-1}$

$V_f = 15\ ms^{-1}$

$T = 3\ \text{Sec}$

$F = ?$

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

$$= \frac{1500(15 - 20)}{3}$$

$$= 500(-5)$$

$$F = -2500\ \text{N}$$

-ive sign shows that force is retarding.

30. Water is projected from two rubber pipes at the same speed V from one at 30° and other at 60° why are the ranges equal. (SAG 2017)

Ans. As, $R = \dfrac{V_i^2}{g} \sin 2\theta$

As, $\sin 2\theta = \sin 2(30) = \sin 60°$

$= 0.866$

$\sin 2\theta = \sin 2(60) = \sin 120°$

$= 0.866$

So, Ranges are equal.

31. An athlete wishes to generate a long jump. At what angle should he jump? (DGK 2012)

Ans. The relation for horizontal range.

$$R = \frac{v_i^2 \sin\theta}{g}$$

If the velocity of projection v_i and 'g' are constant, then the horizontal range 'R' depends upon the value of

$\sin 2\theta$ (i.e. R varies with $\sin 2\theta$). It means that 'R' is maximum when $\sin 2\theta$ = maximum.

The maximum value of $\sin 2\theta = 1$

But $\sin 90° = 1$

$\sin 2\theta = \sin 90°$

Or $2\theta = 90°$

OR $\theta = 45°$

32. What is ballistic flight? (DGK 2013)

Ans. A ballistic flight is that in which a projectile is given an initial push and it allowed to move freely due to inertia and under the action of gravity.

33. State only law of conservation of linear momentum.
(DGK 2017) (SAW 2019 GI)

Ans. Linear momentum of an isolated system should remain conserve is called law of conservation of linear momentum

i.e. $m_1v_1 + m_2v_2 = m_1 v_1' + m_2 v_2'$

34. How does a rocket move? Explain? (SAW 2013)

Ans. The propulsion of rocket depends. Upon the principle of momentum and the Newton's third law. Rocket's move by expelling burning gas through engines at their rear. The rocket gain momentum equal to the momentum of gas expelled from he engine but in opposite direction.

35. Find the angle of projection of a projectile for which its maximum height and horizontal range are equal.
(SAW 2017)

Ans. **Data:**

Maximum height = horizontal range

To Find:

Angle of projection = θ = ?

Formula:

$$\text{Maximum height} = h = \frac{V_i^2 \sin^2\theta}{2g}$$

$$\text{Range of projectile} = R = \frac{V_i^2 \sin 2\theta}{g}$$

$$\text{or} \quad \frac{\sin^2\theta}{2} = \sin 2\theta \qquad (\sin 2\theta = 2\sin\theta\cos\theta)$$

$$\text{or} \quad \frac{\sin^2\theta}{2} = 2\sin\theta, \cos\theta$$

$$\frac{\sin\theta}{\cos\theta} = 4$$

$$\tan\theta = 4$$

$$\theta = \tan^{-1} 4 = 76°$$

36. What is ballistic missile and ballistic flight.
(SAW 2017)

Ans. An un powered and unguided missile is called ballistic missile and path followed by it is called ballistic trajectory.

37. State Newton third law of motion and give its two examples. (GUJ 2018)

Ans. This law states that action and reaction re equal but in opposite direction.

Example I:

The action is by the ballon that pushes the air out of it when set free. The reaction of the air which escapes out from the ballon acts on the ballon. It is due to this reaction of the escaping air that moves the ballon forward.

Example II:

Let a body A exerts a force on another body B, the body reacts against this force and exerts a force on body A. The force exerted by body A on B is the action force where as the force exerted by body B on A is called the reaction force.

38. Calculate the distance conversed by a free falling body initially at rest after first second of its motion.
(SAR GI 2018)

Ans. **Data**

$v_i = 0$

$t = 1\text{sec}$

$s = ?$

$$s = vit + \frac{1}{2} gt^2$$

$$s = 0 + \frac{1}{2}(9.8)(1)^2$$

$$s = 4.9\ \text{m}$$

39. If angle of projection of a projectile is 90°. Find its range. (SAW 2019 GI)

Ans. As we know that the range of projectile is calculated a.

$$R = \frac{vi^2}{g} \text{in} 2\theta$$

If $\theta = 90°$. Then

$$R = \frac{vi^2}{g}(\sin 2 \times 90°)$$

$$R = \frac{vi^2}{g} \sin 180°$$

$$R = \frac{vi^2}{g}(0)$$

$R = 0$ Ans.

40. Derive formula for the time of flight of a projectile.
(BAH 2019 GI)

Ans. **Time of Flight:**

The time taken by body to cover the distance from the place of its projection to the place where it hits the ground is called time of flight.

Since the body goes up and come back to same level (covering no vertical distance)

$\therefore \quad s = h = 0$

If the body is projected with velocity v at an angle of θ, then its vertical component will be $v_{iy} = v_i \sin\theta$.

Using equation

$$s = v_{iy}t + \frac{1}{2} g t^2$$

Putting values.

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

$$\text{or} \quad \frac{1}{2} g t^2 = (v_i \sin\theta)\, t$$

$$\text{or} \quad g t = 2v_i \sin\theta$$

$$\Rightarrow t = \frac{2 v_i \sin\theta}{g}$$

SECTION III

Long Questions

From Punjab Boards:

1. Discuss the elastic collision of two smooth balls after the collision. (LHR 2011) (FAS 2014) (SAG 2017)
2. Define elastic collisions. Show that for elastic collisions in one dimension, the velocity of approach is equal to the velocity of separation. (LHR 2012: GI, 2014: GII) (GUJ 2014) (RAW 2013) (SAG 2017) (DGK 2013)
3. A truck weighing 2500 kg and moving with a velocity of 21 m/s, collides with stationary car weighing 1000 kg. The truck and the car move together after the impact. Calculate their common velocity. (LHR 2012: GII, 2017: GII) (SAG 2017) (SAW 2017) (DGK 2019 GI)
4. Find angle of projection of a projectile for which its maximum height and horizontal range are equal. (LHR 2013: GI, 2018: GII)
5. What is the projectile motion? Derive the relation for: (i) Time of flight. (ii)Maximum height for projectile. (LHR 2013:GII), 2015: GII) (MUL 2016) (FAS 2016) (BAH 2013) (FAS 2012, 2013) (DGK 2011, 2012) (SAG 2013)
6. Two blocks of masses 2 kg and 0.50 kg, are attached at the two ends of a compressed spring. The elastic potential energy stored in the spring is 10J. Find the velocities of the blocks when released, if the spring delivers its energy to the blocks. (LHR 2014: GI) (BAH 2014)
7. A football is thrown upward with an angle of 30°, with respect to the horizontal. To throw a 40m pass what must be the initial speed of ball? (GUJ 2013) (LHR 2015: GI, 2019 GI) (MUL 2013, 2017) (FAS 2016) (SAG 2019 GI) (DGK 2017) (SAW 2013, 2014)
8. What is projectile? Derive expressions for the: (i) Height (ii) Horizontal range. (LHR 2017)
9. State and prove the law of conservation of linear momentum.(LHR 2017) (GUJ 2011,2 015) (MUL 2011)
10. A 100 gm golf ball is moving toward right with a velocity of 20 m/sec. It makes a head on collision with a 8 kg steel ball, initially at rest. Compare velocities of the balls after collision. (GUJ 2012)
11. A hose pipe ejects water at a speed of $0.3ms^{-1}$ through a hole of area $50cm^2$. If the water strikes a wall normally, calculate the force on the wall, assuming the velocity of water normal to the wall is zero after striking.(GUJ 2016)
12. Define Momentum with unit. Explain law of conservation of linear of momentum. (MUL 2012: Annual)
13. Define projectile motion. A projectile is thrown upward with initial velocity "V," making angle. "θ" with the horizontal. Find the following expression. (i) Height of projectile range and maximum range of projectile) (MUL 2011: Annual)
14. Define Linear Momentum with unit. Also state and prove law of conservation of linear momentum. What is isolated system. (MUL 2012: Supply) (BAH 2019 GI) (SAG 2019 GI)
15. A ball is thrown upward with an angle of 30° with respect to the horizontal. To throw a 40m pass, what must be the initial speed of the ball? (BAH 2011) (FAS 2016) (DGK 2014)
16. A ball is thrown with a speed of $30ms^{-1}$ in a direction 30° above the horizon. Determine the time of flight. (BAH 2012)
17. A ball is thrown horizontally from a height of 10m with velocity $21ms^{-1}$. How far off it hit the ground and with what velocity. (FAS 2017) (RAW 2013, 2017) (BAH 2019 GI) (SAW 2019 GI)
18. A 1500 kg car has its velocity reduced from $20ms^{-1}$ to$15ms^{-1}$ in 3.0 seconds. How large was the average retarding force. (RAW 2011, 2013)
19. A 1500 kg car has its velocity reduced from 20 ms^{-1} to $15ms^{-1}$ in 3s. How large was the average retarding force. (SAG 2012, 2018: GII) (DGK 2017)
20. What is projectile motion? Derive the relation for maximum height and range of projectile.(GUJ GI 2018)
21. A 100 g golf ball is moving to the right with a velocity of $20ms^{-1}$, it makes a head on collision with 8kg steel ball initial at rest. Compute velocities of ball after collision. (DGK GI 2018)
22. Describe elastic collision in one dimension. Show that relative velocity before collision = Relative velocity after collision. (LHR GI 2018) (RWP GI 2018)
23. 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 200 g. After igniting the fire cracker, he throws the can straight up. It explodes at the top of its path. If the block shoots out with a speed of 3 m/s, how fast will the can be going? (LHR 2019)
24. A ball is thrown with a speed of 30ms−1 in a direction of 60° with horizontal. Calculate the range of the ball. (RAW 2019)

CHAPTER — 4

WORK AND ENERGY

SECTION I

Multiple Choice Questions

From Punjab Boards:

1) A stone is thrown up from the surface of earth when it reaches at maximum height, its K.E. is equal to: (LHR 2013 GI)

(a) mgh (b) $\frac{1}{2}mv^2$

(c) zero (d) 2mgh

2) SI units of pressure are: (LHR 2012)

(a) Nm^{-1} (b) $N^2 - m$

(c) $N - m^2$ (d) N^{-2} m

3) The ratio between orbital and escape velocities are: (LHR 2011)

(a) 1 (b) 2

(c) $\sqrt{2}$ (d) $\frac{1}{\sqrt{2}}$

4) Water flows out from a pipe at 3 kg / sec and its velocity changes from 5 m / s to zero on striking the wall the force due to water flow is: (LHR 2012)

(a) 15N (b) 5N

(c) 10 N (d) 3N

5) Power can be defined as the product of: (LHR 2012)

(a) Force and displacement

(b) Force and velocity

(c) Force and time (d) Force and mass

6) The value of 'g' at the center of the earth is (LHR 2016)

(a) Infinite (b) 2g

(c) 3g (d) Zero

7) Work done will be maximum when angle between $\vec{F}$ and $\vec{d}$ is (LHR 2016) (MUL 2011) (BAH 2013) (DGK 2017)

(a) 180° (b) 90°

(c) 60° (d) 0°

8) The unit $kgms^{-1}$ can also be written as (LHR 2016)

(a) NS (b) Joule

(c) NS^{-2} (d) Nm^2

9) Which one is non-renewable source of energy.(LHR 2017) (DGK 2017)

(a) Wind (b) Biomass

(c) Coal (d) Sunlight

10) The original source of tidal energy is. (LHR 2017) (FAS 2012)

(a) Moon (b) Earth

(c) Sun (d) Sea

11) If the direction of force is perpendicular to the direction of motion of body, then work done is: (GUJ 2014)

(a) Minimum (b) Maximum

(c) Zero (d) Infinity

12) $kW\ m^{-2}$ is the unit of: (GUJ 2011, 2012)

(a) Power (b) Intensity

(c) Energy (d) Energy per unit area

13) SI unit of work is (GUJ 2016)

(a) Newton (b) Watt

(c) Pascal (d) Joule

14) Kilo watt hour is unit of (GUJ 2016) (FAS 2013)

(a) Power (b) Momentum

(c) Energy (d) Force

15) If by some means, the Radius of earth increases to 4-times, the escape velocity will become/remain: (MUL 2011 Supply)

(a) Same (b) Double

(c) Half (d) one-fourth

16) The escape velocity is maximum for: (MUL 2014)

(a) Moon (b) Mercury

(c) Earth (d) Jupiter

17) A solar cell converts light energy into: (MUL 2012 annual)

(a) Heat Energy (b) Chemical Energy

(c) Electrical Energy (d) Atomic Energy

18) Which of the following pair has same dimensions? (MUL 2011 annual)

(a) Work and power (b) Momentum and energy

(c) Work and torque (d) Power and pressure

19) The escape velocity can be determined by relation: (MUL 2012 Supply , 2017) (RAW 2011)

(a) Vesc = gR (b) Vesc = 2gR

(c) Vesc = $\sqrt{gR}$ (d) Vesc = $\sqrt{2gR}$

20) The SI unit of power is called (MUL 2016)

(a) Joule (b) Newton

(c) Watt (d) Kilowatt

21) Energy stored in spring is (MUL 2016)

(a) Elastic P.E. (b) Gravitational P.E.

(c) K.E. (d) Chemical P.E.

22) Escape velocity on the surface of earth is 11.2 KmS^{-1}. If the escape velocity on the surface of an other planet of same mass as that of earth but of $\frac{1}{4}$ times of the radius of earth is. (MUL 2016)

(a) 5.6 KmS^{-1} (b) 11.2 KmS^{-1}

(c) 22.4 KmS^{-1} (d) 44.8 KmS^{-1}

23) The ratio between the escape velocity and orbital velocity is: (MUL 2017)

(a) $\sqrt{2} : 1$ (b) $\sqrt{2} : 2$

(c) $1 : \sqrt{2}$ (d) 1 : 1

24) The value of Escape Velocity for earth is: (BAH 2014)

(a) 11 km/h (b) 11 kms^{-1}

(c) 1.1 km/h (d) 1.1 ms^{-1}

25) Which one is Biofuel: (BAH 2012)

(a) Water (b) Petrol

(c) Ethanol (d) Oil

26) Absolute P.E of an object at infinite height w.r.t earth is taken as: (BAH 2011)

(a) Negative (b) Zero

(c) Minimum (d) Virtual

27) The dimensions of kinetic energy are: (FAS 2011) (RAW 2017)

(a) $[ML^2T^2]$ (b) $[ML^{-2}T^2]$

(c) $[ML^2T^{-1}]$ (d) $[ML^2T^{-2}]$

28) A force acting at right angle to the displacement performs (FAS 2016)
(a) Positive work (b) Negative work
(c) No work (d) Maximum work

29) All the food we eat in one day has about the same energy as (FAS 2016)
(a) One liter of petrol (b) $\frac{1}{2}$ liter of petrol
(c) $\frac{1}{3}$ Liter of petrol (d) $\frac{1}{4}$ liter of petrol

30) The power needed to lift a mass of 5000g to height of 1m in 2 second is: (FAS 2017)
(a) 2.45 watt (b) 24.5 watt
(c) 245 watt (d) 2.45k watt

31) Which one is conservative force? (RAW 2013)
(a) Frictional force (b) Gravitational force
(c) Propulsion force of motor (d) Normal force

32) Biomass is a potential source of: (RAW 2014)
(a) Renewable energy (b) Non-Renewable
(c) Both (A) and (B) (d) Tidal energy

33) 1 kilowatt hour is a unit of (RAW 2016)
(a) Energy (b) Power
(c) Pressure (d) Force

34) 1 Kwh is equal to (RAW 2016)
(a) 10^6 watt (b) 36×10^6 joule
(c) 36×10^6 watt (d) 3.6×10^6 joule

35) The value of escape velocity is: (RAW 2017)
(a) 1.1 km/s (b) 11 km/s
(c) 1.1 km/h (d) 1.1 cm/s

36) If a body of mass 5kg is raised vertically through a distance of 1m, then work done is: (RAW 2017)
(a) 49J (b) 4.9J
(c) 490J (d) 0.49J

37) Source of tidal energy is: (SAG 2013)
(a) Moon (b) Sun
(c) Earth (d) Uranium

38) Nm is equal as: (SAG 2012)
(a) Pascal (b) Newton
(c) Henry (d) Joule

39) According to Einstein's equation $E = mc^2$ 1kg mass is actually energy. (DGK 2011)
(a) 3×10^5 J (b) 9×10^{16} J
(c) 9×10^8 J (d) 3×10^8 J

40) Commercial unit of electrical energy is: (DGK 2013)
(a) Kilowat (b) Kilo watt hour
(c) Joule (d) Watt

41) Work has same dimensions as that of: (DGK 2014)
(a) Torque (b) Power
(c) Momentum (d) Force

42) As we move up a body above the surface of Earth, the change in potential energy will always be. (DGK 2011)
(a) Negative (b) Positive
(c) Zero (d) Infinity

43) Work is negative when angle between $\vec{F}$ and $\vec{d}$ is: (SAW 2013)
(a) 0° (b) 90°
(c) 45° (d) 180°

44) A body has P.E = mgh when it is at height "h" from the ground. At the point at a distance "x" below from the top its P.E will be (SAR I 2018)
(a) mgx (b) mgh
(c) mg + h (d) mg (h – x)

45) The dimensions of potential energy per unit volume are same as that of: (SAR GI 2018)
(a) Work (b) Pressure
(c) Speed (d) Density

46) The Potential energy of a spinning mass vibrating system as its mean position is: (SAR GII 2018)
(a) Maximum (b) minimum
(c) Equal 10 kg (d) Zero

47) The ratio between orbital velocity and escape velocity is: (LHR 2019 GI)
(a) 1 (b) $\frac{1}{2}$
(c) $\sqrt{\frac{1}{2}}$ (d) $\sqrt{2}$

48) Choice of zero potential energy level is:(RAW 2019 GI)
(a) Surface of the Earth
(b) at infinity
(c) Just above the surface of the Earth
(d) arbitrary

49) Power of an electric heater is (approximate power) (DGK 2019 GI)
(a) 1 KW (b) 2 KW
(c) 3 KW (d) 4 KW

50) When the finite force is parallel to the direction of motion of the body, the work done is: (SAG 2019 GI)
(a) Minimum (b) Maximum
(c) Infinity (d) Varies

51) If 50 kg crate is pushed through 2m across the floor with a force of 50 N, the work done will be: (SAG 2019 GI)
(a) 245 J (b) 150 J
(c) 200 J (d) 100 J

52) One Watt Hour is equal to: (BAH 2019 GI)
(a) 3.6 MJ (b) 3.6 KJ
(c) 36 KJ (d) 36 MJ

53) Which one of the following is not a unit of energy: (BAH 2019 GI)
(a) Kilowatt (b) Erg
(c) Joule (d) Kilowatt hour

54) Consumption of Energy by a 60 Watt Electric Bulb in 2 Seconds is: (BAH 2019 GI)
(a) 120 J (b) 60 J
(c) 30 J (d) 0.5 J

Entry Test MCQ's

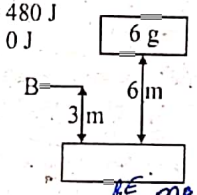
1) 100 Joules work has been done by an agency in 10 seconds. What is power of agency? (2008)
(a) 1000 watt (b) 100
(c) 10 watt (d) 0.10 watt

2) Work down on a body equals change in its _____ energy. (2008)
(a) Total (b) Potential
(c) Kinetic (d) All of these

3) A force 2i + j has moved its point of application from (2,3) to (6,5). What is work done? (2008)
(a) –10 (b) +10
(c) –18 (d) +18

4) If a certain force acts on an object and changes its kinetic energy from 65 J to 130 J, then work doen by the force will be: (2009)
(a) 92.5 J (b) 97.5 J
(c) 65 J (d) 130 J

5) A body of mass 6 kg falls under action of gravity. At initial position 'A' its P.e. is 480 J and K.E. is 0 J. During its downward journey at point 'B' its energies will be ($g = 10\ ms^{-2}$): (2009)



(a) P.E. = 300 J and K.E. = 180 J
(b) P.E. = 180 J and K.E. = 300 J
(c) P.E. 230 J and K.E. = 250 J
(d) P.E. = 250 J and K.E. = 230 J

6) A particle carrying charge of 2e falls through a potential difference of 3.0 V. Calacualted the energy required by it: (2009)
(a) 9.6×10^{-19}J (b) 9.1×10^{-19}J
(c) 1.6×10^{-19}J (d) 6.0×10^{-19}J

7) Solar energy at normal incidence outside the earth's atmosphere is about: (2009)
(a) 2.5 kWm^{-2} (b) 0.6 kWm^{-2}
(c) 1.4 kWm^{-2} (d) 2.0 kWm^{-2}

8) Value of escape velocity for the surface of the earth is 11 km/sec. Its value for surface of the moon is: (2010)
(a) 11 km/sec (b) 10.4 km/sec
(c) 2.4 km/sec (d) 4.3 km/sec

9) If 'V' is applied potential diffrence across resitance 'R', then loss in potential energy per unit time is: (2010)
(a) VI (b) I^2R
(c) $\frac{V^2}{R}$ (d) All of the above

10) 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? (2011)
(a) mg + mv (b) mg
(c) mg – mv (d) zero

11) Name the quantity which can be measured by using base 'kgm^2s^{-3}'. (2013)
(a) Weight (b) Pressure
(c) Power (d) Work

12) Kinetic energy of electrons by applying potential difference V_1 across x-rays tube is KE_1 while V_2 potential difference produce kinetic energy equal to KE_2. What will be the value of KE_1: KE_2 if ratio of potential difference $V_1:V_2 = 2:3$?
(a) 3:2 (b) 4:9
(c) 9:4 (d) 2:3

13) Strain energy in a deformed energy is stored in the form of: (2015)
(a) Elastic Energy (b) Potential Energy
(c) Plastic Energy (d) Kinetic Energy

14) 'F' is maximum force acting on a conductor. Now if we change the direction of conductor by making an angle of 45° with the magnetic field then the force becomes: (2016)
(a) $\frac{F}{2}$ (b) 2F
(c) $\frac{F}{\sqrt{2}}$ (d) $\sqrt{2}$ F

SECTION II

SHORT QUESTIONS

From Punjab Boards:

1. Define conservative and non conservative forces. (LHR 2011) (MUL 2019 GI) (FAS 2017) (SAW 2013)

Ans. **Conservative force:**
A conservative force is a force with a property that the work done in moving a particle between two points is independent of path taken.

For example:
Gravitational force, electrostatic force and magnetic force.

Non-conservative force:
The frictional force is a non-conservative force, because an object is moved over rough surface between two points along different paths. The work done against the frictional force is certainly different.

For example:
Air resistance, frictional force, tension in string, normal force, propulsion force of a rocket and motor.

2. A person holds a bag of groceries while standing still. A car is stationary with its engine running. How are the two situations similar from the point of view of work? (LHR 2011)

Ans. In both cases, the displacement is zero, i-e., d = 0 and hence no work done.

As:

$$\text{Work} = \vec{F} \cdot \vec{d} = \vec{F} \cdot (\vec{0}) = 0$$

There fore, these two situations are similar.

3. Show that 1 kwh = 3.6×10^6 j. (LHR 2012, 2015: GII) (FAS 2016) (RAW 2014) (SAG 2012) (DGK 2019 GI)

Ans. One kilowatt hour is the work done in one hour by an agency whose power is one kilowatt.

1 kwh = 1000 W × 3600 sec.

1 kwh = 3.6×10^6 j = 3.6 Mj

4. An object has 1j of potential energy. Explain what does its mean. (LHR 2012, 2013 GII, 2017) (MUL 2011, 2012) (GUJ 2018) (FAS 2012, 2016) (BAH 2014,2 019 GI) (RAW 201, 2014, 2016) (DGK 2013, 2014) (SAG 2011, 2013, 2015, 2017) (SAW 2013, 2014)

Ans. An object having 1j of potential energy means that the work done stored in the object in the form of potential energy has the capacity to do work of 1j.

For example:

If an object is lifted up by a force of 1N, through a height of 1m, the work done is stored in the object as potential energy of one joule. If the object is allowed to fall vertically downward, it has the capacity to do 1j work.

5. Define power. Write its SI unit. (SAR 2018 GII) (LHR 2012, 2014: GII)

Ans. Power is the measure of the rate at which work is being done.

If work Δw is done in a time interval Δt, then the average power P_{av} during the interval Δt is.

$$P_{av} = \frac{\Delta w}{\Delta t}$$

The SI unit of power is watt, defined as one joule of work done in one second.

6. When a rocket re-enters the atmosphere, its nose cone becomes very hot? Where does this energy come from? (LHR 2013: GII , 2015: GI, 2017) (MUL 2012, 2014) (BAH 2013, 2014, 2019 GI) (FAS 2012, 2016, 2017) (DGK 2011) (SAG 2012, 2014)

Ans. There is a large number of dust particles and water vapours present in the air. When a rocket re-enters the atmosphere, it has to face the resistance due to particles. Some K.E of the rocket is converted into heat energy. There fore, cone nose of the rocket becomes very hot due to the heat energy produced by the fluid friction of atmosphere.

7. Prove that $P = \vec{F} \cdot \vec{V}$. (LHR 2013: GII) (GUJ 2018) (SAG 2014) (DGK –2013, 2014: GI)

Ans. If work Δw is done in a time interval Δt is defined as.

$$P_{av} = \frac{\Delta w}{\Delta t}$$

It work is expressed as function of time, the instantaneous power "P" at any instant is defined as.

$$P = \underset{\Delta t \to 0}{\text{Limit}} \frac{\Delta w}{\Delta t}$$

Where Δw is the work done in short interval of time Δt following the instant t.

Now

$$P = \underset{\Delta t \to 0}{\text{Limit}} \frac{\Delta w}{\Delta t}$$

As $\Delta w = \vec{F} \cdot \Delta \vec{d}$

So $P = \underset{\Delta t \to 0}{\text{Limit}} \frac{\vec{F} \cdot \Delta \vec{d}}{\Delta t}$

Since $\underset{\Delta t \to 0}{\text{Limit}} \frac{\Delta d}{\Delta t} = \vec{V}$

$\Rightarrow$ $P = \vec{F} \cdot \vec{V}$

8. Define escape velocity. Write its value. (LHR 2014: GI) (BAH 2011)

Ans. The escape velocity corresponds to the initial kinetic energy gained by the body, which carries it to an infinite distance from the surface of earth.

Mathematically we can express it as

$$\text{Vesc} = \sqrt{2gR}$$

The value of "Vesc" comes out to be approximately 11kms^{-1}.

9. Calculate the work done in kilo joules in lifting mass of 10kg (at a steady velocity) through a vertical height of 10m. (LHR 2014 : GI, 2014 : GII, 2017, 2019 GI) (GUJ 2011, 2014) (MUL 2013, 2014, 2016) (FAS 2011, 2014) (BAH 2011, 2012, 2013) (DGK 2017) (RAW 2012, 2019 GI) (SAW 2013, 2019 GI)

Ans. Mass = m = 10kg

Vertical height = h = 10m.

Value of g = 9.8ms^{-2}

Work done = w = ?

As

W = P.E = mgh

W = 10 × 9.8 × 10

W = 980j

In kilojoules:

W = 980/1000 × 1000 = 0.980kj

W = 0.980kj.

$\Rightarrow$

10. State law of conservation of energy.(LHR 2014 : GI)

Ans. Energy cannot be destroyed. It can be transformed from one kind into another kind, but the total amount of energy remains constant.

11. A girl drops a cup from certain height, which breaks into pieces. What energy changes are involved. (GUJ 2011, 2012, 2013, 2014, 2015) (LHR 2014 : GII) (MUL 2011, 2013, 2014) (BAH 2011, 2012, 2014) (RAW 2013, 2014) (SAG 2016, 2017) (DGK 2011, 2019 GI) (SAW 2014)

Ans. When a cup is dropped from a certain height, its potential energy is converted into kinetic energy, when the cup collides with floor, it breaks into pieces and makes noise. The kinetic energy of cup becomes zero on the floor. Some of K.E is used to break the cup into pieces and some of K.E is converted into sound energy which produces the noise and heat energy.

12. Define work-energy principle. Also write down its equations. (LHR 2015 : GI) (MUL 2013, 2016) (FAS 2011, 2014) (RAW 2012) (SAG 2019 GI) (SAW 2013)

Ans. According to work-energy principle, the work done on the body is equal to change in its kinetic energy.

$$F.d = \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2.$$

13. Why does negative sign show in the expression. (LHR 2017)

$$U_g = -\frac{GMm}{R}$$

Ans. The above relation is used to calculated the absolute P.E. The negative sign in this equation indicates that the earth gravitational field for mass m is attractive. The equation :

$$U_g = \frac{-GMm}{R}$$

Gives the work or energy required to take the body out of earth gravitational field where its P.E. w.r. to earth is zero.

14. A 70 kg man runs up a long flight in 4 second. The vertical height of stairs is 4.5 m. Calculate his power out put in watts. (LHR 2017)

Ans.

m	=	70 kg	
t	=	4 Sec	
h	=	4.5 m	
P	=	$\frac{work}{t}$	work = mgh
P	=	$\frac{mgh}{t}$	
P	=	$\frac{70 \times 9.8 \times 4.5}{4}$	
	=	7.7×10^2 watt.	

15. What s escape velocity and its mathematical expression? (GUJ 2013) (MUL 2011, 2013)

Ans. The minimum initial velocity of body that thrown vertically upward, form surface of earth, due to which it crosses the earth's gravitational field, is called escape velocity".

It is denoted by $v_{esc} = \sqrt{2gr}$

16. Drive a relation between power and velocity. (GUJ 2016) (MUL 2016)

Ans. Consider a constant force $\vec{F}$ is applied on a body for time t and it covers a distance d. So we can write.

Work done = F.d

As we know that

$$P = \frac{Work}{t}$$

$$P = \frac{F.d}{t}$$

$$P = F.\frac{d}{t} \qquad \left(\frac{d}{t} = V\right)$$

$$P = F.V$$

So equation given above shows the relation b/w power, force and velocity.

17. Define work and its S.I unit. (MUL 2011: SUPPLY) (BAH 2019 GI)

Ans. **Work:** When force is applied on a body and body is displaced through some distance, then work is said to be done.

W = Fd

Joule: It is the amount of work done when a force of one Newton acts on a body and body covers distance of one meter in the direction of force.

1J = 1 N × 1m

18. 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 meter, across the floor with a force of 50 N? (MUL 2011: SUPPLY, 2016) (BAH 2014) (FAS 2013) (RAW 2016, 2017) (SAG 2017, 2019 GI)

Ans. Let us check the work done in both cases:

First Case:

M = 50Kg,

d = h = 50cm = 0.5m, F=50N

W = mgh

W = 50 × 9.8 × 0.5

W = 245 J

Second Case:

M = 50Kg. D = 2m, F = 50N.

W = Fd

W = 50 × 2

W = 100 J

So, in first case more work is done.

19. What is conservative field give two example. (MUL 2014) (SAG 2019 GI)

Ans. **Conservation Field:**

The field in which the work done is independent of the path followed and work done in a closed path be zero, is called a conservative field.

For Example:

Gravitational field and electrostatic field.

20. Show that work done on a body is equal to the change in its kinetic energy. **(BAH 2012)**

Ans. As we knot that

$2ad = v_f^2 - v_i^2$

$d = \frac{1}{2}(v_f^2 - v_i^2)$ ..... (1)

Bnow we know that

$F = ma$ ..... (2)

Multiplying eq. (1) and (2) ..... (2)

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

$W = \frac{1}{2}m(v_f^2 - v_i^2)$

$W = \frac{1}{2}mv_f^2 - v_i^2$

$W = K.E_f - K.E_i$

W = change in kinetic energy

21. Define joule and watt. **(BAH 2014)**

Ans. Joule: It is the amount of work done when a force of one Newton acts on a body and body covers distance of one meter in the direction of force.

$1J = 1 N \times m$

Watt: If a body does work of 1 J in 1 sec then that is called watt.

22. Show 1 KWh = 3.6 MJ. **(LHR 2019 GI) (FAS 2012) (SAG 2019 GI)**

Ans. 1 KWH = 1 KW × 1 hours

= $1000 \times 3600 = 3600000$ J

= 3.6×10^6 MJ

23. Under what condition, the instantaneous and average velocities of a moving object become equal? **(FAS 2013)**

Ans. The instantaneous and average velocities of a moving object becomes equal when the object is moving with uniform velocity.

24. Name some non-conventional energy sources. **(FAS 2014)**

Ans. These are the energy sources which are not very common these days. However, it is expected that these sources will contribute substantially to the energy demand of the future. Some of these are

(i) Energy from tides
(ii) Energy from waves
(iii) Solar energy
(iv) Energy from biomass
(v) Energy waste product
(vi) Geothermal energy

25. What sort of energy is in the following: **(FAS 2016)**

(a) Compressed spring
(b) Water in a high dam
(c) A moving car

Ans. (a) A compressed spring has elastic potential energy.

(b) A water in a high dam has gravitational potential energy.

(c) A moving car has kinetic energy.

26. What is conservative field and non conservative field. **(FAS 2018)**

Ans. **Conservative field:**

A field in which work done along a closed path is equ to zero.

Non conservative field:

The fields in which work done depends upon the pa followed.

27. How sunlight is directly converted into electricity by solar cells? **(RAW 2017)**

Ans. Solar cells are semi-conductor device, made fro silicon. Electrons in the silicon gain energy fro sunlight and create a voltage.

28. Define elastic P.E and gravitational P.E. **(RAW 2012)**

Ans. **Elastic P.E.:**

The energy stored in spring.

Gravitational P.E.:

The energy due to gravitational pull.

29. A person holds a bag of groceries while standing and talking to a friend. A car is stationary with its engine running. From the standpoint of work, how are these two situations similar? **(RAW 2016)**

Ans. In both cases, the displacement is zero i.e., $\vec{d} = 0$ and hence, no work is done because $W = \vec{F} \times \vec{d}$, $W = F \times 0 = 0$.

30. List the possible energy changes when a girl drops a cup from a certain height which breaks into pieces. **(SAG 2012)**

Ans. A girl drops a cup from a certain height, the potential energy is converted into kinetic energy. When the cup breaks into pieces, the kinetic energy is converted into heat and sound energy.

31. What is power? How it is related with velocity? Explain. **(SAG 2012)**

Ans. Time rate of doing work is known as power. i.e.

$P = \frac{W}{t}$

Instantaneous power $= \underset{\Delta t \to 0}{\text{Limit}} \frac{\Delta \omega}{\Delta t} = \underset{\Delta t \to 0}{\text{Limit}} \frac{Fd}{\Delta t}$

$\therefore W = Fd$

$P_{ins} = F \underset{\Delta t \to 0}{\text{Limit}} \frac{\Delta d}{\Delta t}$

$= F.V$

The dot product of force and velocity is equal to power.

32. Calculate the work done in kilo joule when 10kg crate is pushed through 4m across the floor with a force of 50 N. **(SAG 2012)**

Ans. $F = 50N$,

$S = 4m$,

$W = ?$

$W = Fd = 50 \times 4 = 200$ J

$W = \frac{200}{1000}$ KJ $= 0.2$ KJ

33. Define work, gravitational field. **(SAG 2013)**

Ans. When a body is moved or stopped through a certain distance by the action of applied force, work is said to be done.

Gravitational field: The space or region around the earth with in which gravitational force acts on a body is called the gravitational field.

34. What four conclusions can you draw from definition of work? **(BAH 2019 GI) (DGK 2011)**

Ans. From the above explanation of work, we conclude that.

(i) Work is a scalar quantity.

(ii) If angle '0' is less than 90° (θ > 90°), work done is said to be positive work. Its value is given with positive sign. If θ = 90°, no work is done, i.e. work done is equal to zero.

(iii) If angle '0' is greater than 90° (θ > 90°), the work done is said to be negative work. Its value is given with negative sign. This is because cosine of an angle greater than 90° is negative.

(iv) Under what condition work done will be +ve, –ve and zero. **(DGK 2017)**

Ans. From the definition of work we find the following important results.

(i) Work is a scalar quantity.

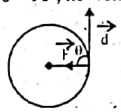
(ii) If θ < 90°, work is done and it is said to be positive work e.g., work is maximum when F is parallel to the direction of motion of the body i.e., θ = 0°.

$W = F d \cos 0°$

$W = Fd \times 1$

$W = F d$

(iii) If θ = 90°, no work is done.



$W = \vec{F} \cdot \vec{d}$

$W = F d \cos 90°$

$W = F d (0)$

$W = 0$

Example: Work done by the centripetal force is 0 and when a person holding a pail by force F is moving forward then θ = 90°.

$\therefore W = F d \cos 90°$

$W = Fd (0)$

$W = 0$

(iv) if θ > 90°, the work done is said to be negative.

Example

When a body moves against the force of friction on a horizontal plane i.e. θ = 180°

$\therefore W = F d \cos 180°$

$W = F d (-1)$

$W = -F d$

(v) SI unit of work is Nm known as joule (J).

$\boxed{1 J = 1 N \times 1m}$

36. How can you calculate work done by a force acting on an a object from force displacement graph? **(GUJ 2018)**

Ans. When a constant force acts through a displacement $\vec{d}$, then event can be plotted on a simple graph the displacement is plotted atoms the x-axis and the force along y-axis.

As the force the constant so the graph will be horizontal straight line hence area under a force displacement graph can be taken to represent the work done by the force. If $\vec{F}$ is not in the direction of the displacement the graph is plotted between F cos θ and d.

SECTION III

Long Questions

From Punjab Boards:-

1. A 1000 kg car at the top of an incline of 10 m 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? **(LHR 2011) (FAS 2014)**
2. Define conservative field. Prove that the work done in the earth's gravitational field is independent of the path followed. **(LHR 2012: GI, 2014: 2015: GI, 2017GII, 2017) (GUJ 2012) (MUL 2011, 2014) (FAS 2017) (SAG 2017, 2018 GI, 2019 GI) (SAW 2017) (BAH 2019 GI)**
3. What is absolute potential energy? Show that absolute P.E is $U = \frac{-G\,Mm}{r}$. **(LHR 2012: GII, 2018 GII, 2019 GI) (GUJ 2014) (RAW 2016, 2019 GI) (DGK 2013)**
4. A force (thrust) of 400 N is required to overcome road friction and air resistance in propelling an automobile at 80 km / hr. What power (kw) must the engine develop? **(LHR 2013: GI) (BAH 2011)**
5. Show that work done in gravitational field is independent of path followed. **(LHR 2014: GI, 2015: GII) (MUL 2019 GI)**
6. A car of mass 800 kg traveling at 54 kmh^{-1} is brought to rest in 60 meters. Find the average retarding force on the car. What has happened to original kinetic energy? **(LHR 2013: GII, 2017) (GUJ GI 2018) (FAS 2018 GI) (DGK 2019 GI) (SAW 2018 GI, 2019 GI)**
7. Describe work energy principle.**(GUJ 2013)(MUL 2012)**
8. A 70 kg man runs up a long flight of stairs in 4.0 s. The vertical height of stairs is 4.5 m. Calculate his power output in watts. **(GUJ 2014) (MUL 2016)**
9. A man pushes a lawn mower with 40 N force direction 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. **(GUJ 2015)**
10. How large a force is required to accelerate and electron ($m = 9.1 \times 10^{31}$ kg) from rest to a speed of 2.0×10^7 ms^{-1} through a distance of 5.0 cm. **(FAS 2012) (MUL 2011: Supply, 2012: Annual) (SAG 2017) (DGK 2012) (SAW 2013)**
11. What is a conservative force? Show that gravitational force is a conservative force. **(MUL 2017) (RAW 2017)**

12. A 10kg man runs up a long flight of stairs in 4.0 sec. The vertical height of the stairs is 4.5m. Calculate his power output in watts. (BAH 2014)
13. Define and determine the absolute potential energy of a body on the surface of earth. (FAS 2011)
14. Define work. Prove that work done in a gravitational field is independent of path followed. (FAS 2013)
15. Ten bricks, each 6.0cm thick and mass 1.5kg, lie flat on a table. How much work is required to stack them one on the top of another? (SAG 2012) (FAS 2016) (DGK 2017)
16. Explain the inter-conversion of potential energy and kinetic energy. (RAW 2014) (BAH 2013) (DGK 2014)
17. Define Escape velocity. Prove that Vesc = $\sqrt{2gR}$. (RAW 2014)
18. 100m^3 of water is pumped from a reservoir into a tank 10m higher than the reservoir in 20 minutes. If density of water is 1000kgm^{-3}, find the power delivered by the pump. (RAW GI 2018)
19. Derive a relation for the absolute gravitational potential energy of an object at a distance from the centre of the earth. (DGK 2011)
20. A body is falling from height "h". Discuss inter-conversion of potential energy into kinetic energy at different positions. (DGK 2017)
21. 100m^3 of water is pumped from a reservoir into a tank 10 m higher than the reservoir in 20 min. If density of water is 1000 Kgm^{-3}, find the power delivered by the pump. (SAW 2013)
22. State and explain work energy principle. (SAR GII 2018)
23. Define the absolute potential energy. Derive its mathematical expression. (DGK GI 2018)
24. Define absolute gravitational potential energy. Derive its relation for a distance 'r' for centre of earth. (SAG 2013)
25. What is escape velocity? Derive an expression for it and calculate its value on the surface of the earth? (LHR GI 2018) (BAH 2019 GI)
26. A brick of mass 2 kg is dropped from a rest position 5m above the ground. What is its velocity at height of 3 m above the ground. (SAG 2019)

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CHAPTER — 5

CIRCULAR MOTION

SECTION I

Multiple Choice Questions

From Punjab Boards:-

1) When a body moves in a circle, the angle between its linear velocity $\bar{v}$ and angular velocity $\bar{w}$ is: (LHR 2013 GI) (RAW 2017)
(a) 180° (b) 0°
(c) 90° (d) 45°

2) The linear velocity of disc moving down an inclined plane is: (LHR 2013 GI) (RAW 2011)
(a) $\sqrt{gh}$ (b) $\sqrt{\frac{4}{3}gh}$
(c) $\sqrt{\frac{2}{3}gh}$ (d) $\sqrt{\frac{gh}{2}}$

3) The apparent weight of a man in a lift moving down with an acceleration of 9.8 m / s^2 is: (LHR 2012)
(a) Zero (b) 9.8 N
(c) 19.6 N (d) Infinity

4) The force which can do no work on the body on which it acts is: (LHR 2013 GII)
(a) Elastic force (b) Frictional force
(c) Centripetal force (d) Gravitational force

5) One radian is equal to: (LHR 2013 GII) (GUJ 2016)
(a) 67.3° (b) 57.3°
(c) 87.3° (d) None

6) The apparent weight of a man in an ascending lift moving with acceleration "a". (LHR 2011)
(a) Increases (b) Decreases
(c) Remains constant (d) Becomes zero

7) The angular momentum L is given by: (LHR 2013 GII) (SAW 2018)
(a) $m\bar{w}$ (b) $\bar{w} \times \bar{r}$
(c) $\bar{r} \times \bar{F}$ (d) $\bar{r} \times \bar{P}$

8) The SI unit of angular acceleration is: (LHR 2012)
(a) rad/sec^2 (b) rad/sec
(c) rav/sec^2 (d) rev/sec

9) The rate of change of angular velocity is called (LHR 2016)
(a) Angular velocity
(b) Angular acceleration
(c) Angular displacement
(d) Angular speed

10) The S.I unit of angular displacement is (LHR 2016)
(a) Metre (b) Kilometre
(c) Radian (d) Centimetre

11) When an elevator is moving upward the apparent weight of a body in the elevator will be (LHR 2016)
(a) w = T (b) w = T + ma
(c) w = T – ma (d) w = – T – ma

12) Ratio of velocities of hoop and disc rolling down form an inclined plane of height h are $\left(\frac{V_h}{V_d}\right)$ (LHR 2016)
(a) 0.5 (b) 0.86
(c) 1.0 (d) 1.15

13) If a car moves with a uniform speed of 4ms^{-1} in a circle of radius 0.4m, its angular speed is (LHR 2016)
(a) 1 rad s^{-1} (b) 5 rad s^{-1}
(c) 10 rad s^{-1} (d) 20 rad s^{-1}

14) The time rate of change of angular displacement is called. (LHR 2017)
(a) Linear velocity (b) Linear speed
(c) Angular speed (d) Angular velocity

15) The ratio of moment of inertia of disc and hoop is. (LHR 2017)
(a) $\frac{1}{2}$ (b) $\frac{1}{4}$
(c) $\frac{3}{4}$ (d) $\frac{1}{3}$

16) S.I unit of angular displacement is (LHR 2017) (GUJ 2013)
(a) Radian (b) Degree
(c) Revolution (d) Minute

17) Direction of angular acceleration is always along. (LHR 2017)
(a) x-axis (b) y-axis
(c) z-axis (d) The axis of rotation

18) 2 radian = ... (LHR 2017)
(a) 114.6° (b) 57.3°
(c) 75.3° (d) 37.5°

19) A body rotating with angular velocity of 2 radian/s and linear velocity is also 2ms^{-1}, then radius of circle is. (LHR 2017)
(a) 1m (b) 0.5m
(c) 4m (d) 2m

20) The direction of angular momentum of a body moving inc circle is" (GUJ 2012)
(a) Along the tangent
(b) Perpendicular to the plane of the circle
(c) Radially outward (d) Radially inward

21) Which is larger for a hoop of mass M and radius R, that is rolling without slipping. Its translational or rotational kinetic energy? (GUJ 2011) (MUL 2011)
(a) Translational kinetic energy
(b) rotational kinetic energy
(c) Both are the same
(d) Answer depends upon the radius

22) Moment of inertia of sphere is (GUJ 2016) (MUL 2016) (SAG 2017)
(a) $\frac{1}{2}mr^2$ (b) $\frac{2}{5}mr^2$
(c) $\frac{2}{5}mr^3$ (d) $\frac{1}{3}mr^2$

23) The value of angular momentum is maximum when θ is (GUJ 2016)
(a) 90° (b) 60°
(c) 45° (d) 0°

24) One revolution is equal to (GUJ 2016) (FAS 2014)
(a) 57.3° = 1rad (b) 360°
(c) 2π rad (d) both B and C

25) One geostationary satellite covers longitudinal angle (GUJ 2016) (MUL 2012)
(a) 270° (b) 120°
(c) 90° (d) 60°

26) The minimum velocity necessary to put a satellite into orbit is (GUJ 2016) (FAS 2012)
(a) 7.1 kms^{-1} (b) 7.3 kms^{-1}
(c) 7.9 kms^{-1} (d) 8.9 kms^{-1}

27) 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: (MUL 2011) Supply
(a) F_c (b) $F_c / 2$
(c) 2 F_c (d) 4 F_c

28) A man in a lift is moving upward with constant velocity, will conclude that his weight has: (MUL 2014)
(a) Increased (b) Decreased
(c) Reduced to zero (d) Not changed

29) The direction of angular velocity is along the: (MUL 2011 annual)
(a) Radius of the circle towards the centre
(b) Radius of the circle away from the centre
(c) Tangent at a point
(d) Axis of rotation

30) The direction of angular velocity is determined by: (MUL 2012 Supply) (SAW 2013)
(a) Left hand rule (b) Head to tail rule
(c) Right hand rule (d) General rule

31) Rotational K.E of a hoop is: (MUL 2014) (FAS 2016)
(a) mv^2 (b) $\frac{1}{2}mv^2$
(c) $2mv^2$ (d) $\frac{1}{4}mv^2$

32) The angular displacement of one revolution is equal to: (MUL 2012 annual)
(a) 1 radian (b) π/2 radian
(c) π radian (d) 2π radian

33) The apparent weight of a man in a lift moving down with an acceleration of 9.8m/s^2 is: (MUL 2012 annual)
(a) Zero (b) 9.8N
(c) 19.6 N (d) Infinite

34) If angular velocity of a particle rotating in a circle is doubled than its moment of inertia: (MUL 2013)
(a) Remains the same (b) Become half
(c) Become doubled (d) Becomes 4 times

35) Moment of inertia of thin rod is given by relation: (MUL 2013)
(a) $\frac{1}{12}mL^2$ (b) $\frac{2}{5}mR^2$
(c) $12mL^2$ (d) $\frac{5}{7}mR^2$

36) The frequency of rotation of a spaceship about its own axis to create artificial gravity like that on earth is (MUL 2016)

(a) $f = 2\pi\sqrt{g/R}$ (b) $f = \frac{1}{2\pi}\sqrt{g/R}$

(c) $f = \frac{1}{2\pi}\sqrt{g/R^2}$ (d) $f = \frac{1}{2\pi}\sqrt{R/g}$

37) The centripetal fore is always directed (MUL 2016)

(a) Towards the centre (b) Away form centre

(c) Tangent to any point (d) In random direction

38) The correct relation between linear displacement and angular displacement is (MUL 2016)

(a) $S = r\theta$ (b) $S = r^2\theta$

(c) $S = r\theta^2$ (d) $S = r^2\theta^2$

39) A mass of 1 kg is free falling. The force of gravity is (MUL 2016)

(a) 1 N (b) 9.8 N

(c) 0.5 N (d) Zero

40) Orbital velocity near surface of earth is given by (MUL 2016)

(a) $\sqrt{2gR}$ (b) $\sqrt{gR}$

(c) $\sqrt{\frac{2g}{R}}$ (d) $\sqrt{\frac{g}{R}}$

41) The weight of the body at the centre of the earth is (MUL 2016)

(a) Slightly less (b) Slightly greater

(c) Zero (d) Infinite

42) The dimensions of Angular momentum are (MUL 2016)

(a) $[MLT^{-2}]$ (b) $[MLT^{-1}]$

(c) $[ML^2T^{-1}]$ (d) $[ML^{-2}T^{-2}]$

43) A 60kg man in an elevator is moving up ward with an acceleration of $9.8ms^{-2}$. The apparent weight of the man. (MUL 2017)

(a) Increases (b) Decreases

(c) Remains constant (d) Becomes zero

44) Moment of inertia of thin rod is given b the relation: (MUL 2017) (RAW 2016)

(a) $I = \frac{1}{12}mL^2$ (b) $I = \frac{2}{5}mR^2$

(c) $I = 12mL^2$ (d) $I = \frac{5}{7}mR^2$

45) If angular velocity of a particle rotating in a circle is doubled, then its moment of inertia: (MUL 2017)

(a) Remains same (b) Becomes half

(c) Becomes doubled (d) Becomes 4 times

54) In rotational motion the analogous of mass is: (MUL 2017)

(a) Angular momentum (b) Inertia

(c) Moment of inertia (d) Force

46) If a body of mass 1 kg is lifted vertically upward with an acceleration or $9.8ms^{-2}$. It apparent weight be observed as: (BAH 2011)

(a) Zero Newton (b) 9.8 Newton

(c) 19.6 Newton (d) 100 Newton

47) The time rate of change of angular velocity is called: (RAW 2013)

(a) Acceleration (b) Angular acceleration

(c) Impulse (d) Inertia

48) The angular version of F = ma is: (BAH 2014)

(a) L = Iw (b) $\tau = I\alpha$

(c) $L = \tau\alpha$ (d) $F = \frac{mv}{t}$

49) The angle through which a body moves is called: (BAH 2012)

(a) Angular velocity (b) Angular acceleration

(c) Angular displacement

(d) Angular momentum

50) A body of mass 7 kg moves along a circle of radius 4m with constant speed of $8ms^{-1}$, the centripetal force on the body is: (BAH 2013)

(a) 48 N (b) 8 N

(c) 112 N (d) 72 N

51) Minimum number of communication satellites required to over the whole earth is: (BAH 2013) (RAW 2011)

(a) 4 (b) 3

(c) 2 (d) 5

52) The expression for the orbital velocity of satellite is: - (BAH 2014)

(a) $v = \sqrt{GMr}$ (b) $v = \sqrt{GM}$

(c) $v = \sqrt{\frac{GM}{r}}$ (d) $v = \sqrt{r/Gm}$

53) Moment of inertia is measured in (BAH 2011)

(a) $Kg.m^2$ (b) $Kgm.^{-2}$

(c) rad– sec^{-1} (d) Joule . sec

54) Moment of inertia is equal to: (FAS 2012)

(a) m^2r (b) m^2r^2

(c) mr (d) mr^2

55) The dimension of angular acceleration is: (FAS 2013)

(a) $[T^{-1}]$ (b) $[T^{-2}]$

(c) $[LT^{-2}]$ (d) $[LT^{-3}]$

56) One radian is equal to: (FAS 2013)

(a) 360° (b) 57.3°

(c) 180° (d) 55.3°

57) The weight of a man in an elevator descending with an acceleration of $4.9ms^{-2}$ will become: (FAS 2011)

(a) Twice (b) Half

(c) Zero (d) Unchanged

58) An alternate unit to $Kgms^{-1}$ is: (FAS 2011)

(a) Js (b) Ns

(c) Nm (d) N

59) Rotational K.E of the disc is: (FAS 2013) (RAW 2013)

(a) $\frac{1}{4}mv^2$ (b) $\frac{1}{2}mv^2$

(c) $\frac{1}{2}mr^2$ (d) $\frac{1}{4}mr^2$

60) A body of mass 1 kg moves along a circle of radius 2m with constant speed $1ms^{-1}$. The centripetal force is (FAS2016)

(a) 0.5 N (b) 1 N

(c) 5 N (d) 10 N

61) Angular momentum of a rigid body is equal to (FAS 2016)

(a) $I\omega$ (b) $I\alpha$

(c) $I^2\omega$ (d) $I\omega^2$

62) Moment of inertia of a solid sphere is (FAS 2016)

(a) mr^2 (b) $\frac{1}{2}mr^2$

(c) $\frac{2}{5}mr^2$ (d) $\frac{1}{12}mr^2$

63) All points on a rigid body rotating about a fixed axis do not have same (FAS 2016)

(a) Speed (b) Angular speed

(c) Angular acceleration (d) Angular displacement

64) The angular velocity of the minute hand of a clock is: (FAS 2017)

(a) 2π rad s^{-1} (b) π rad s^{-1}

(c) $\frac{\pi}{60}$ rad s^{-1} (d) $\frac{\pi}{1800}$ rad s^{-1}

65) The ratio of velocity of disc to velocity of hoop is: (FAS 2017)

(a) $\frac{2}{\sqrt{3}}$ (b) $\frac{4}{\sqrt{3}}$

(c) $\frac{2}{3}$ (d) $\frac{4}{3}$

66) Relation between escape velocity "V_{esc}" and orbital velocity "V_o" is: (RAW 2014)

(a) $V_{esc} = \frac{1}{2}V_0$ (b) $V_{esc} = \sqrt{2}\,V_0$

(c) $V_{esc} = V_0$ (d) $V_{esc} = 2V_0$

67) The force and torque are analogous to: (RAW 2014)

(a) velocity (b) mass and weight

(c) moment of inertia (d) each other

68) The largest satellite system is managed by the countries: (RAW 2013)

(a) 126 (b) 136

(c) 120 (d) 3

69) Orbital speed of satellite can be determined by: (RAW 2012)

(a) $v = \frac{2\pi r}{t}$ (b) $v = \sqrt{\frac{GM}{r}}$

(c) $v = \sqrt{gR}$ (d) $v = \sqrt{\frac{2GM}{R}}$

70) The unit of angular momentum is (RAW 2016)

(a) N-S (b) J-S

(c) m.S (d) $KgmS^{-1}$

71) When a wheel turns throughan angle of 180° it lays out a tangential distance S is equal to (RAW 2016)

(a) $2\pi r$ (b) πr

(c) $2r$ (d) πr^2

72) Dimension of angular velocity is (RAW 2016)

(a) $[LT^{-1}]$ (b) [LT]

(c) $[L^2T]$ (d) $[T^{-1}]$

73) The pull of earth on a mass of 10 kg at the center of earth is (RAW 2016)

(a) 392N (b) 196N

(c) 9.8N (d) Zero

74) The SI unit of angular momentum is: (RAW 2017)

(a) kgm^2S^{-1} (b) kgm^2S^{-2}

(c) kg^2mS^{-1} (d) $kgmS^{-1}$

75) SI unit of moment of inertia is: (RAW 2017)

(a) kgm^{-1} (b) $kg.m^2$

(c) kgm^{-2} (d) kg.m

76) The diver spins faster when moment of inertia becomes: (RAW 2017)

(a) Smaller (b) Greater

(c) Constant (d) Zero

77) The rotational K.E. of a body is given by: (SAG 2012)

(a) $\frac{1}{2}IW^3$ (b) $\frac{1}{3}IW^2$

(c) W^2 (d) $\frac{1}{2}IW^2$

78) Angular speed for daily rotation of earth is: (SAG 2013)

(a) 2π (b) π

(c) 4π (d) 7.3×10^{-5} Red / Sec

79) Time rate of change of angular velocity is called: (SAG 2012)

(a) Angular momentum (b) Angular acceleration

(c) Angular displacement (d) Angular distance

80) Unit of angular velocity in SI unit is: (SAG 2013)

(a) Radian / sec (b) Meter sec^{-1}

(c) Degree / sec^{-1} (d) Revolution / sec

81) When torque acting on a system is zero which of the following will be constant. (SAG 2013)

(a) Linear momentum (b) Force

(c) Angular momentum (d) Impulse

82) The light from stars can be focused by their: (SAG 2017)

(a) Mass (b) Distance

(c) Radius (d) Gravity

83) Which of the following is not directed along the fixed axis of rotation? (SAG 2017)

(a) Angular displacement

(b) Angular momentum

(c) Centripetal acceleration

(d) Angular acceleration

84) Choose the quantity which plays the same role in angular motion as that of mass in linear motion: (SAG 2017)
(a) Angular acceleration
(b) Torque
(c) Moment of Inertia
(d) Angular momentum

85) The product of rotational inertia "I" and angular velocity "ω" is equal to: (SAG 2017)
(a) Torque (b) Linear momentum
(c) Angular momentum (d) Force

86) The rotational kinetic energy of a solid sphere is: (SAG 2017)
(a) $\frac{2}{5} mr^2\omega^2$ (b) $\frac{2}{5} mv^2$
(c) $\frac{1}{2} I\omega^2$ (d) $\frac{2}{5} I\omega^2$

87) The unit of rotational K.E is: (SAG 2017)
(a) rad sec (b) JS
(c) J (d) kg m²

88) In rotational motion, the torque is equal to rate of change of: (SAG 2017)
(a) Angular velocity (b) Linear momentum
(c) Angular momentum (d) Angular acceleration

89) An elevator is moving up with an acceleration equal to 'g'. An apparent weight of the body in an elevator is: (SAG 2017)
(a) Zero (b) Equal to real weight
(c) 2mg (d) 3mg

90) Angular momentum of a rigid body is given as: (SAG 2017)
(a) $I^2\omega^2$ (b) $I^2\omega$
(c) $I\omega^2$ (d) $I\omega$

91) The minimum velocity necessary to put a satellite into orbit is: (DGK 2013)
(a) 7.1 Kms⁻¹ (b) 7.3 Kms⁻¹
(c) 7.9 Kms⁻¹ (d) 8.9 Kms⁻¹

92) Moment of inertia is equal to: (DGK 2012 , 2013)
(a) m^2r (b) m^2r^2
(c) mr (d) mr^2

93) π Radian equal: (DGK 2012)
(a) 60° (b) 90°
(c) 180° (d) 360°

94) The S.I unit of angular displacement is: (DGK 2014)
(a) Degree (b) Revolution
(c) Radian (d) Rotation

95) The motion of a body moving along a circular path is called. (DGK 2014)
(a) Translational motion (b) Angular motion
(c) Linear motion (d) Vibratory motion

96) A wheel of radius 50 Cm having an angular speed of rad S⁻¹ have linear speed. (DGK 2015)
(a) 1.5 mS⁻¹ (b) 3.5 mS⁻¹
(c) 4.5 mS⁻¹ (d) 2.5 mS⁻¹

97) A ball tied to the end of a string is swung in a vertical circle under the action of gravity, the tension in the string when ball is at maximum height. (DGK 2011)
(a) equal to centripetal force (b) zero
(c) equal to weight of ball (d) Maximum

98) Rotational inertia of two equal masses cylinders, but one has larger diameter, will be. (DGK 2011)
(a) lesser (b) larger
(c) same (d) none of these

99) Moment of inertia of ring or hoop is: (SAW 2014)
(a) mr^2 (b) $\frac{2}{5} mr^2$
(c) $\frac{1}{2} mr^2$ (d) $\frac{1}{12} mr^2$

100) The angle subtended at the centre by circumference of circle is: (SAW 2015)
(a) $\frac{\pi}{4}$ rad (b) $\frac{\pi}{2}$ rad
(c) 2π rad (d) 4 π rad

101) The law of gravitation was introduced by: (SAW 2014)
(a) Huygen (b) Boyle
(c) Newton (d) Pascal

102) The Si unit of angular momentum is: (SAW 2013)
(a) JS (b) NS
(c) Joule (d) Newton

103) The apparent weight of object of mass m when the lift is moving upward with acceleration equal to "a" is given (SAR 2018)
(a) mg (b) 2mg
(c) Zero (d) $\frac{1}{2}$ mg

104) w = 60 rev min⁻¹ is equal to (I SAR 2018)
(a) π rads⁻¹ (b) 2π rads⁻¹
(c) $\frac{1}{\pi}$ rads⁻¹ (d) $\frac{2}{\pi}$ rads⁻¹

105) The moment of inertial of a thin rod is: (2010)
(a) $\frac{1}{2} mL^2$ (b) $\frac{1}{4} m^3L$
(c) $\frac{1}{12} mL$ (d) $\frac{1}{12} mL^2$

106) The expression for centripetal force is given by: (LHR 2019 GI)
(a) $\frac{mv^2}{r^2}$ (b) $\frac{m^2v^2}{r}$
(c) $\frac{m^2v^2}{r^2}$ (d) $mr\omega^2$

107) 2 revolutions are equal to: (LHR 2019 GI)
(a) π rad (b) $\frac{3\pi}{2}$ rad
(c) 2π rad (d) 4π rad

108) Relation between the speed of disc and hoop at the bottom of an incline is: (LHR 2019 GI)
(a) $V_{disc} = \sqrt{\frac{3}{4}} V_{hoop}$ (b) $V_{disc} = \sqrt{\frac{4}{3}} V_{hoop}$
(c) $V_{disc} = \sqrt{\frac{2}{5}} V_{hoop}$ (d) $V_{disc} = 2V_{hoop}$

109) Ratio of disk velocity to hoop velocity (in case of rotational kinetic energy) is: (LHR 2019 GI)
(a) $\sqrt{\frac{4}{3}}$ (b) $\frac{1}{2}$
(c) 2 (d) $\sqrt{\frac{3}{4}}$

110) 2° is equal to: (RAW 2019 GI)
(a) 0.035 rad (b) 0.30 rad
(c) 0.35 rad (d) 0.0035 rad

111) Centripetal force is directed along: (RAW 2019 GI)
(a) Tangent to circle (b) radius
(c) axis of rotation (d) x-axis

112) S.I unit of angular momentum is: (MUL 2019 GI)
(a) Kg m^2s^{-1} (b) Kg $m^{-2}s^{-1}$
(c) Kg $m^{-1}s$ (d) Kg m^2s^{-2}

113) Moment of inertia for a particle is given by: (MUL 2019 GI)
(a) m^2r^2 (b) mr^2
(c) m^2r (d) mr^{-2}

114) A man in a lift moving upward with constant velocity will conclude that his weight has: (DGK 2019 GI)
(a) Increased (b) Decreased
(c) Reduced to zero (d) Not changed

115) A body rotates with a constant angular velocity of 100 rad/sec about a vertical axis the required torque to sustain this motion will be: (SAG 2019 GI)
(a) Zero Nm (b) 100 Nm
(c) 200 Nm (d) 300 Nm

116) 20 N centripetal Force revolving a body along a circular path of a radius 1m, the work done by the centripetal Force is: (SAG 2019 GI)
(a) 20 Joule (b) 40 Joule
(c) 10 Joule (d) Zero Joule

117) Moment of inertia of 100 kg sphere having radius 50 cm will be: (SAG 2019 GI)
(a) 10 Kgm² (b) 5 Kgm²
(c) 500 Kgm² (d) 2.5 Kgm²

118) A body of mass 10 kg in free falling lift has weight: (SAG 2019 GI)
(a) 10 N (b) 9.8 N
(c) Zero N (d) 980 N

119) In one revolution the angular displacement covered is: (SAW 2019 GI)
(a) 60° (b) 360°
(c) 90° (d) 180°

120) The maximum velocity required of an object to go out from the gravitational field in heavenly body is: (SAW 2019 GI)
(a) moon (b) mercury
(c) mars (d) earth

121) When a body moves in a circular path, the angle between its Linear velocity and angular velocity is: (SAW 2019 GI)
(a) 180° (b) zero degree
(c) 90° (d) 45°

122) Angle 30° is equal to: (BAH 2019 GI)
(a) $\frac{\pi}{2}$ rad (b) $\frac{\pi}{3}$ rad
(c) $\frac{\pi}{4}$ rad (d) $\frac{\pi}{6}$ rad

123) The Rotational K.E. of Disc is equal to: (BAH 2019 GI)
(a) $\frac{1}{4} mv^2$ (b) $\frac{1}{2} mv^2$
(c) $\frac{1}{4} Iw^2$ (d) Iw^2

124) If External Torque on a body is zero, then which of these quantities is constant: (BAH 2019 GI)
(a) Force (b) Linear Momentum
(c) Linear Velocity (d) Angular Momentum

125) The correct S.I. Unit of Angular Momentum is: (BAH 2019 GI)
(a) Kgs m^{-2} (b) Kg ms^{-1}
(c) Kg m^2s^{-1} (d) Kg m^2s^{-2}

Entry Test MCQ's

1) The force required to bend the normally straight path of a prarticle into a circular path is called _____ force. (2008)
(a) Traveling (b) Bending
(c) Bending (d) Centripetal

2) The escape velocity corresponds to _____ energy gained by body, which carries it to an infinite distance from the surface of earth. (2008)
(a) Total (b) Potential
(c) Initial kinetic (d) None of these

3) The net magnetic field created by the electrons within an atoms is due to the field created by their _____ motion. (2008)
(a) Orbital (b) Spin
(c) Orbital & spin (d) Orbital x spin

4) When the spaceship rotates with _____ frequency, the artificial gravity like earth is produced to inhabitants of the ship: (2009)
(a) $2\pi\sqrt{\frac{R}{g}}$ (b) $2\pi\sqrt{\frac{\ell}{g}}$
(c) $\frac{1}{2\pi}\sqrt{\frac{R}{g}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{R}{g}}$

5) A wheel of radius 1 m covers an angular displacement of 180. Its linear displacement is: (2010)
(a) 3.14 m (b) π rad
(c) 6.28 m (d) 0.157 m

6) A 100 kg man is standing in an elevator, which accidentally falls freely. What will be the weight of the person in the freely falling elevator (take g = 10 m/s²) (2014)
(a) 1000N (b) 10N
(c) 5000N (d) Zero

7) 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: (2015)
(a) 196 N (b) 19.8 N
(c) 1.98 N (d) 2 N

8) A man in elevator ascending with an acceleration will conclude that his weight is: (2016)
(a) Increased (b) Decreased
(c) Reduced to zero (d) Remain Constant

SECTION II

Short Questions

From Punjab Boards:

1. **Show that orbital angular momentum Lo = mvr.**
(LHR 2011 : 2013 : GI, 2015 : GI, 2015 : GII) (GUJ 2012) (MUL 2013) (BAH 2011, 2014, 2019 GI) (FAS 2013) (RAW 2012) (SAG 2012, 2013, 2019 GI) (DGK 2013) (SAW 2013, 2017, 2019 GI)

Ans. Angular momentum is given by:

$$\vec{Lo} = \vec{r} \times \vec{p} \quad \text{——(i)}$$

Magnitude of angular momentum is:

$$Lo = rp \sin\theta \quad \text{—— (ii)}$$

Where θ is angle between r and p.

Linear momentum. $\vec{p} = m\vec{v}$

Magnitude of linear momentum = p = mv

$$Lo = mrv \sin\theta$$

Let $\theta = 90°$

$$Lo = mrv \sin 90°$$

$$Lo = mrv$$

2. **What is moment of inertia. Explain its significance.**
(LHR 2012 : 2014 : GII, 2017 GI) (BAH 2013) (FAS 2016, 2017) (MUL 2012, 2019 GI) (RAW 2017, 2019 GI) (SAG 2019 GI) (DGK 2019 GI) (SAW 2019 GI)

Ans. It is defined as the product of mass of particle and square of its distance from axis of rotation. It is denoted by I.

$$I = mr^2$$

The property of a body to oppose the accelerating torque is known as its moment of inertia.

Significance: For a body in linear motion, the acceleration is proportional to the force acting upon the body. i-e., the ratio of force to acceleration is constant. Mathematically.

$$F/a = m \text{ (constant)}. \quad (1)$$

Similarly for a body, rotation about any axis, the angular acceleration is proportional to the torque acting on the body i.e, the ratio of the torque to the angular acceleration is proportional to the torque to the angular acceleration is constant.

$$\tau/\alpha = I \ (\alpha \text{ constant}) \ (2).$$

By comparing (1) and (2), it can be seen that the moment of inertia of a rotating body is analogous to the mass of a body in linear motion. Hence, moment of inertia may be descried as rotation mass of a body. That is, moment of inertia plays the same role in angular motion as the mass in linear motion.

3. **Explain the difference between tangential velocity and angular velocity. (LHR 2012) (GUJ 2011, 2012) (MUL 2014, 2011) (FAS 2011, 2017) (RAW 2016) (DGK 2017)**

Ans. **Tangential velocity:**
It is the linear velocity of a particle moving along a circular path. Since, it is directed along the tangent to the curve, So it is called tangential velocity, and denoted by v.

Angular velocity:
It is rate of change of angular displacement of a particle moving along a circular path. It is denoted by ω. The rotation b/w tangential velocity and the angular velocity is written as.

$$V = r\omega.$$

4. **How we can find the direction of angular momentum and angular velocity: (LHR 2013 : GI, 2015 : GI) (DGK 2017, 2019 GI) (SAG 2019 GI)**

Ans. **(a) Angular momentum**

We know that the angular momentum is defined by $\vec{L} = \vec{r} \times \vec{p}$

The angular momentum is a vector quantity. The direction of angular momentum is perpendicular to the place containing $\vec{r}$ and $\vec{p}$. Its direction is determined by right hand rule.

(b) Angular velocity
Angular velocity is a vector quantity. Its direction also can be found by right hand rule curl the fingers of the right hand around the rotation axis in the direction of rotation, then thumb points towards the direction of angular velocity.

5. **What is meant by centripetal force. Write down it s formula. (LHR 2013 : GI) (MUL 2014) (BAH 2019 GI) (DGK 2017)**

Ans. **Centripetal force:**
"The force required to keep the body moving in the circular path directed towards the center of the circular path is called centripetal force. "It is denoted by $\vec{F_c}$.

Mathematically it can be written as:

$$F_c = \frac{mv^2}{r}$$

It is required formula for centripetal force.
The alternative form of centripetal force is

$$F_c = mr\omega^2 \qquad \because (v = r\omega)$$

6. **How we can find direction of angular displacement. (LHR 2013: GII)**

Ans. Curling of right hand fingers along the direction of circular motion of particle, then thumb points in the directions of angular displacement.

7. **Why bank tracks are needed for turns. (LHR 2013 : GII, 2014 : GII, 2015 : GI) (FAS 2012, 2013, 2016) (SAG 2012, 2013, 2017) (RAW 2016) (DGK 2014) (SAW 2014)**

Ans. Banked tacks are needed for turns that are taken so quickly that friction done cannot provide energy for centripetal force.

8. **Why mud flies off the tyre of a moving bicycle, in which direction does if fly? (LHR 2014 GI, 2017) (GUJ 2012) (BAH 2011) (MUL 2011, 2017) (SAG 2019 GI)**

Ans. When a bicycle is moving, each point of the tyre, including the mud has tangential velocity, as well as angular velocity. The mud flies off the tyre along the direction tangent to the surface of the tyre. It is due to its tangential velocity in the absence of the centripetal force.

9. **Why does a diver changes his body position before and after diving in the pool. (LHR 2014 : GII) (SAG 2017) (MUL 2019 GI) (BAH 2019 GI)**

Ans. A diver change his body position before diving in the pool because he wants to make somersaults, so he curled his body to spin himself faster.
When body is curled, the value of 'r' becomes small and moment of inertia ($I = mr^2$) is decreases, and the value of angular velocity '(ω)' increases.

10. **What is angular momentum? (LHR 2014 : GII) (MUL 2017) (BAH 2013) (FAS 2012) (RAW 2013)**

Ans. The momentum of a body due to its circular motion is called angular momentum. It is defined as, the cross product of position vector $\vec{r}$ of the particle and linear momentum $\vec{p}$.
Mathematically we can write,

Angular momentum $\vec{L} = \vec{r} \times \vec{p}$

11. **State practical use of rotational K.E. by fly wheel. (LHR 2017)**

Ans. Rotational K.E. is put to practical use by fly wheels which are essential part of many engine. A fly wheel store energy between. The power strokes of piston so that energy is distributed over the full rotation of the crankshaft and hence rotation remains smooth.

12. **What is radian? Calculate the number of degrees in one radian (or prove 1 radian = 57.3°). (LHR 2017) (FAS 2016) (RAW 2012, 2014, 2019 GI) (SAG 2013, 2019 GI) (DGK 2011)**

Ans. Radian is the angle subtended at the center of a circle by an arc of length equal to radius of the circle.
As we know that

$$2\pi \text{ radians} = 360°$$

$$1 \text{ radian} = \frac{360}{2\pi}$$

$$1 \text{ radian} = \frac{360}{2 \times \frac{22}{7}}$$

$$1 \text{ radian} = \frac{360° \times 7}{2 \times 22}$$

$$1 \text{ radian} = \frac{2520}{44}$$

$$1 \text{ radian} = 57.27°$$

$$1 \text{ radian} = 57.3°$$

Hence, 1 radian = 57.3°

13. **What is meant by INTEL SAT. At what frequency INTEL SAT VI operates. (LHR 2017, 2019 GI)**

Ans. The largest satellite system is managed by 126 countries, international Telecommunication satellite organization (INTELSAT). An INTELSAT VI satellite is shown in Fig. It operates at microwave frequency of 4, 6, 11 and 14 GHz and has capacity of 30,000 two way telephone circuits plus three T.V. channels.

14. **State law of conservation of angular momentum. (GUJ 2012)**

Ans. **Statement:**
It states that if no external torque acts on a system the total angular momentum of the system remains constant.
Mathematically;

$$L_{total} = L_1 L_2 + \ldots\ldots = \text{Constant}$$

15. **What are satellites and how they move around the earth? (GUJ 2013)**

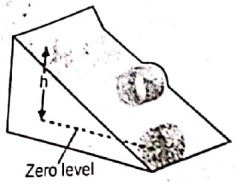
Ans. The object moves around the earth in an orbit is called satellite. Satellites are put into orbit by rockets and are held in orbitals by the gravitational pull of earth. satellites have acceleration 9.8 m/s² towards the centre of the earth. The satellite moving in a circle has an acceleration $a_c = \frac{v^2}{r}$. In a circular orbit around the earth the force of gravity produces centripetal acceleration $a_c = g = \frac{v^2}{r}$.

16. **A disc and hoop starts moving down form the top of inclined plane at the same time. Which one will moving faster on reaching the ground. (GUJ 2016) (MUL 2016, 2019 GI) (FAS 2016) (RAW 2012, 2016)**

Ans. When both (disc and hoop) start moving down as inclined plane of height h, their motion consists of both

rotational and transnational motions as shown in Fig. (5.15). If no energy is lost against friction, the total kinetic energy of the disc or hoop on reaching the bottom of the incline must be equal to its potential energy at the top.

P.E. = K.E. Transnational + K.E. rotational



or $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ .....(I)

For disc:

$P.E. = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$

or $mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$

or $mgh = \frac{2mv^2 + mv^2}{4}$

or $mgh = \frac{3mv^2}{4}$

or $\sqrt{v^2} = \sqrt{\frac{4gh}{3}}$

or $v = \sqrt{\frac{4gh}{3}}$ .....(II)

For hoop:

$P.E. = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$

or $mgh = mv^2 + mv^2$

or $mgh = \frac{2mv^2}{2}$

$mgh = mv^2$

$v = \sqrt{gh}$

From eq (i) & (ii) it is clear that disc will move faster as compared to hoop.

17. Differentiate between real weight and apparent weight. (MUL 2011: ANNUAL) (FAS 2014) (BAH 2014) (SAW 2013)

Ans. Real weight:

The gravitational pull of the earth on the object is called its real weight.

Apparent weight:

The weight of the object measured on a moving frame of reference (elevator) is called its apparent weight.

18. A disc and hoop start moving down from the top of an inclined place at the same time. Which one will be moving faster on reaching the bottom? (MUL 2011: ANNUAL, 2012: ANNUAL, 2012: SUPPLY)

Ans. The velocity of the disc on reaching the inclined plane is given by

$V = \sqrt{\frac{4gh}{3}}$ .....(i)

And the velocity of the hoop is

$V = \sqrt{gh}$ .....(ii)

From equation (i) and (ii) we see that velocity of disc is grater than that of the hop. Hence, the disc will move faster.

19. What do you mean by orbital velocity and artificial gravity? (MUL 2011: SUPPLY)

Ans. Orbital velocity:

Orbital velocity is the tangential velocity to put a satellite in orbit around the earth.

Artificial gravity:

Artificial gravity is the gravity like effect produced in an orbiting spaceship to overcome weightlessness by spinning the spaceship about its own axis.

20. Explain what is meant by centripetal force. How is it converted in terms of angular velocity? (MUL 2012: ANNUAL)

Ans. The force needed to bend the normally straight path of the particle into the curved path is called the centripetal force. It is written us.

$F_c = \frac{mv^2}{r}$

In terms of angular velocity, $v = r\omega$

So $Fc = mr\omega^2$.

21. Derive the relation between linear and angular velocity. (MUL 2012: ANNUAL) (BAH 2011, 2019 GI) (DGK 2013)

Ans. We know the relation for angular displacement

$\Delta S = r\Delta\theta$

Dividing both sides by Δt.

$\frac{\Delta S}{\Delta t} = \frac{r\Delta\theta}{\Delta t}$

Apply limit $\Delta t \to 0$

$\underset{\Delta t\to 0}{\text{Limit}} \frac{\Delta S}{\Delta t} = r \underset{\Delta t\to 0}{\text{Limit}} \frac{\Delta\theta}{\Delta t}$

We know that $\underset{\Delta t\to 0}{\text{Limit}} \frac{\Delta S}{\Delta t} = V$

$\underset{\Delta t\to 0}{\text{Limit}} \frac{\Delta\theta}{\Delta t} = w$

So $V = rw$.

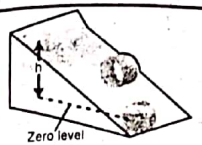
22. Explain rotational K.E. of a disc and a hoop. (MUL 2013) (RAW 2016) (SAG 2018 GI)

Ans. DISC:

The rotational K.E. of a disc is

$K.E_{rat} = \frac{1}{2}I\omega^2$

Since, moment of inertia of a disc is $I = \frac{1}{2}mr^2$



So

$K.E_{rat} = \frac{1}{2} \times \frac{1}{2}mr^2\omega^2$

$K.E_{rat} = \frac{1}{4}mr^2\omega^2$

But $r^2\omega^2 = v^2$

$\therefore K.E^{rat} = \frac{1}{4}mv^2$ .....(i)

HOOP

For a hoop

$I = mr^2$

So

$K.E_{rat} = \frac{1}{2}mr^2\omega^2$

$K.E_{rat} = \frac{1}{2}mv^2$ .....(ii)

23. Show that $S = r\theta$. (LHR 2016, 2019 GI) (MUL 2016, 2019 GI) (DGK 2014: GII) (SAW 2019 GI)

Ans. Proof:

In general arc length is directly proportional to angular displacement or:

$s \propto \theta$

$s = (\text{Constant})\,\theta$

or $\boxed{s = r\theta}$

Here 'r' is constant of proportionality which is radius of the circle in which body moves.

Note:

The relation ($s = r\theta$) is valid only when θ is measured is radian.

24. State law of conservation of angular momentum. (MUL 2016)

Ans. It states that total angular momentum of system remains constant if no external torque acts upon the system i-e.

$L(\text{total}) = L_1 + L_2 + L_3 + \text{——} = \text{Constant}$

25. 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. (MUL 2017)

Ans. Tangential Velocity: The tangential velocity V_T is the linear velocity of a particles moving along a curve or a circle directed along the tangent at any point on the curve.

Angular Velocity: The angular velocity ω is the rate of change of angular displacement moving along a curved path.

Relation: The tangential velocity V_T, angular velocity ω and the radius r of the wheel are related by the relation.

$V_T = r\omega$

If one of these is given for a wheel of known radius r then the other one can be find by using the above relation.

26. Why the micro waves are used in satellite communications. (BAH 2012)

Ans. Microwaves are used because they travel in a narrow beam in a straight line and pass easily through the atmosphere easily. The energy needed to amplify and re-transmit the signals is provided by large solar panels fitted on satellites.

27. Show that $L = mr^2\omega$. (FAS 2011)

Ans. $\vec{L} = \vec{r} \times \vec{P}$

$L = rP\sin\theta$

$P = mV$ and $\theta = 90°$

$L = rmV\sin 90°$

$V = r\omega$

$L = rmr\omega = mr^2\omega$

28. A hoop without shipping rolls down a hill of height 10m. If the hoop starts from rest at the hoop of hill. What is its velocity/speed at bottom? (FAS 2011)

Ans. $V = \sqrt{\frac{4gh}{3}}$

$h = 10m$, $g = 9.8\ m/sec^2$

$V = \sqrt{\frac{4 \times 9.8 \times 10}{3}} = 11.9 m/sec$

29. What is the relation between escape velocity and orbital velocity? (FAS 2013)

Ans. Escape velocity: The initial velocity of an object with which it goes out of earth's gravitational field is known as escape velocity.

Orbital velocity: The earth and some other planets revolve around the sun in nearly circular paths. The artificial satellite launched by men also adopt nearly circular course around the earth.

30. What is effect on the apparent weight of a body of mass "m" when an elevator is moving upward with uniform velocity? (RAW 2011)

Ans. When elevator is moving upward then.

$F = ma$

$T - w = ma$

$T = ma + w$

So weight is increased.

31. Define angular displacement. Write its units. (RAW 2016)

Ans. Angular displacement:

Definition:

It is defined as the angle subtended at the center of the circle by an arc along which it moves in a given time is known as angular displacement.

It SI unit is radian, but it is also measured in degree (deg) revolution (rev).

32. Why Einstein views of gravitation are preferred than Newton's view of gravitation explain. **(LHR 2019 GI) (RAW 2017)**

Ans. Einstein inferred that if gravity and acceleration are precisely equivalent, gravity must bend light, by a precisely amount that could be calculated. This was not entirely starling suggestions Newton's theory, based on the idea light beam would be deflected by gravity. But in Einstein's theory, the deflection of light is predicted to be exact twice as great as it is according to Newton's theory. Why the bending to straight caused by the gravity of the sun was measured during a solar eclipse in 1919, and found, match Einstein's prediction rather than Newton's, then Einstein's theory was hailed as a scientific triumph.

33. What is angular velocity? (DGK 2019 GI) (SAG 2017)

Ans. **Angular Velocity:** The angular velocity ω is the rate of change of angular displacement moving along a curved path.

Relation: The tangential velocity V_T, angular velocity ω and the radius r of the wheel are related by the relation.

$$V_T = r\omega$$

If one of these is given for a wheel of known radius r then the other one can be find by using the above relation.

34. Calculate the critical velocity of satellite orbiting near earth's surface. ($R = 6.4 \times 10^6$ m). **(LHR 2019 GI) (DGK 2014: GI)**

Ans. In a circular orbit around the Earth, the centripetal acceleration is supplied by gravity and we have.

$$g = \frac{V^2}{R} \quad \text{..... (1)}$$

where V is the orbital velocity and R is the radius of earth, which is 6400 km. From equation (1)

$$V_2 = gh$$
$$V = \sqrt{gR}$$
$$= \sqrt{9.8 \times 6.4 \times 10^6}$$
$$= \sqrt{62.72 \times 10^6}$$
$$= 7.9 \times 10^3 \text{ m/s}$$
$$V = 7.9 \text{ km/s}$$

35. 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? **(BAH 2012, 2019 GI) (SAW 2014, 2017)**

Ans. When a body moves in a circle with constant speed, the force which keeps the body moving in the circular path and always directed towards the centre of the circle is called centripetal force. The magnitude of the centripetal force is:

$$F_c = \frac{mv^2}{r} = mr\omega^2$$

Without this force, no body can move in a circular path. According to Newton's first law of motion, a body tends to move along a straight line with uniform velocity only if no net force acts on it. For uniform circular motion, a body must be under the continuous influence of some force that changes the direction of velocity of the body at every instant and thus produces the acceleration in the body. The centripetal force is always needed if the body is to be maintained in its circular path.

36. What is meant by angular momentum? Explain the law of conservation of angular momentum. **(SAW 201**

Ans. **Angular Momentum:**

The angular momentum of an object is defined as the cross product of position vector $\vec{r}$ with respect to the axis of rotation and the linear momentum $\vec{P}$. It is denoted by $\vec{L}$ mathematically.

It is written as $L = \vec{r} \times \vec{P}$.

Law of conservation of angular momentum.

Conservation of angular momentum:

The law of conservation of angular momentum states that if no external torque acts on a system, the total angular momentum of the system.

Constant i.e

$L_{total} = L_1 + L_2 + \_\_\_\_\_ = \text{constant}$

OR

$I_1w_1 = \text{constant}$

$I_2w_2 = \text{constant}$

$I_1w_1 = I_2w_2$

37. A disc without slipping rolling down a hill of height 10m. If the disc starts from rest at the top of the hill. What is the speed at the bottom. **(LHR 2019 GI)**

Ans. h = 10m

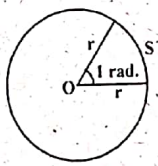
Speed of disc = V = ?

$$V = \sqrt{\frac{4gh}{3}}$$
$$V = \sqrt{\frac{4 \times 9.8 \times 10}{3}}$$
$$V = \sqrt{\frac{392}{3}}$$
$$V = \sqrt{133.66}$$
$$V = 11.4 \text{ms}^{-1}$$

38. Define radian and degree and what is the relation between them. **(LHR 2019 GI)**

Ans. **Radian:**

Radian is the plane angle between two radii of circle which cut off the circumference of circle by an are equal to length of the radius of the circle.



Degree:

When a rotating object complete one rotation, it makes an angle of 360° so whole circle is divided into 360 equal parts and each part is called degree.

The relation between radian and degree is:

$$1 \text{ rad} = 57.3°$$

39. Define geo – synchronous satellite and what is its height above the earth. **(LHR 2019 GI)**

Ans. A satellite whose orbital motion is synchronized with the rotation of earth is called geo stationary satellite. The height of such satellite above the equator comes to be 36000 Km.

40. Prove that a = rα or Establish a relationship between linear and angular acceleration. **(DGK 2019 GI)**

Ans. **Relation between linear and angular acceleration:**

We know that

$$v = r\omega \quad \text{.....(1)}$$

According to this relation if the reference, line op is rotating with n angular acceleration 'α' then point P will have linear or tangential acceleration i.e.

$$a_t = r\alpha \quad \text{.....(2)}$$

We know that

$$\Delta v = r\Delta\omega$$

Dividing both sides by Δt,

$$\frac{\Delta v}{\Delta t} = r\frac{\Delta\omega}{\Delta t} \quad \text{.....(3)}$$

Applying limit both sides

$$\text{Limit}\frac{\Delta v}{\Delta t} = r \lim_{\Delta t \to o}\frac{\Delta\omega}{\Delta t}$$

Now,

$$\lim_{\Delta t \to o}\frac{\Delta v}{\Delta t} = a \quad \text{and} \quad \lim_{\Delta t \to o}\frac{\Delta\omega}{\Delta t} = \alpha$$

∴ eq (3) becomes

$$\boxed{a = r\alpha}$$

In Vector Form:

$$\vec{a} = \vec{\alpha} \times \vec{r}$$

41. Define angular acceleration. Also give its formula. **(BAH 2019 GI)**

Ans. **ANGULAR ACCELERATION:**

When we switch on an electric fan, we see its velocity goes on increasing. We say it has an angular acceleration.

Definition:

"Rate of change of angular velocity is called angular acceleration."

Average Angular Acceleration:

If 'ω_i' and 'ω_f' are the values of instantaneous angular velocities of a body at time t_1 and t_2, then average acceleration is given by.

$$\alpha_{ave} = \frac{\omega_f - \omega_i}{t_2 - t_1}$$

or

$$\alpha_{ave} = \frac{\Delta\omega}{\Delta t}$$

Instantaneous Angular Acceleration:

The instantaneous angular acceleration is the limit of the ratio $\frac{\Delta\omega}{\Delta t}$ as Δt approaches to zero.

Thus, $\alpha = \lim_{\Delta t \to o}\frac{\Delta\omega}{\Delta t}$

Units:

Angular acceleration is generally expressed in three units. Degree/sec^2, revolution/sec^2 & radian/S^2. But SI unit of angular acceleration is rad/S^2.

42. Give one practical application of the rotational Kinetic Energy. **(BAH 2019 GI)**

Ans. **Use of Rotational K.E.**

Rotational K.E is put to practical use by fly wheels, which are essential parts of many engines. A fly wheel stores energy between the power strokes if the pistons so that energy is distributed over the full revolution of the crank shaft and hence, the rotations remain smooth.

SECTION III

Long Questions

From Punjab Boards:-

1. A 1000 kg car traveling with a speed of 144 kmh^{-1} round a curve of radius 100 m. Find the necessary centripetal force. **(LHR 2012 : GII , 2018 GI) (GUJ 2013) (MUL 2013) (RAW 2017)**
2. What is centripetal force? Derive relation for it in terms of angular velocity. **(LHR 2013: GII) (GUJ 2015) (SAG 2012) (DGK 2019 GI)**
3. A body of moment of inertia (I = .80 kgm^2) about a fixed axis rotates with constant angular velocity of 100 red/sec. Calculate its angular momentum "L" and torque to sustain this motion. **(LHR 2014: GI) (RAW 2014 , 2019 GI)**
4. A gramophone record turn table accelerate from rest to an angular velocity 45.0 rev/min 60 sec. What is its average angular acceleration. **(RAW 2016) (LHR 2017: GII, 2019 GI) (DGK 2016, 2017)**
5. Explain rotational kinetic energy. Find rotational kinetic energy of a disc and hoop. **(LHR 2013 GI, 2017) (MUL 2016) (DGK 2012) (RAW 2018 GI)**
6. Write difference between real and apparent weight. Explain how real and appeared weight are different in a lift moving with some acceleration. **(MUL 2012: Annual)**
7. Define and derive the expression for the centripetal force for a rotating body. **(MUL 2016)**
8. A 1000 Kg car is turning round a corner at 10ms^{-1} as it travels along an arc of a circle. If the radius of the circular path is 10m, how large a force must be exerted by the pavement on the tyres to hold the car in the circular path? **(MUL 2014)**
9. Define centripetal force. Derive an expression for it. **(BAH 2011) (SAW 2013)**

10. A disc with out slipping rolls down a hill of height of 10.0 m. If the disc starts from rest at the top of the hill, wheat is its speed at the bottom? (BAH 2013) (DGK 2012)
11. What is moment of inertia? Explain the moment of inertia of an irregular rigid body. (FAS 2012)
12. What is the least speed at which an aeroplane cm execute a vertical loop of 1 km radius so that there will be no tendency for the pilot to fall down at the highest point. (LHR 2015: GI) (GUJ GUJ 2012) (MUL 2019 GI) (FAS 2013)
13. What type of difficulties face by astronauts to stay in an artificial satellite for a long period and how to over come this difficulty? Derive an expression for frequency of an artificial gravity. (FAS 2014)
14. An electric fan rotating at 3 rev. s^{-1} is switched off. It comes to rest in 18 sec. Assuming deceleration to be uniform, find its value. How many revolutions did it turn before coming to rest? (SAG 2017) (BAH 2019 GI)
15. What is meant by centripetal force? Show by mathematical proof that $a_c = \frac{V^2}{r}$. (GUJ 2018 GI) (DGK 2017)
16. Calculate the angular momentum of a star of mass 2×10^{30} kg and radius 7×10^5 km. If it completes one complete rotation bout its axis once in 20 days. (BAH 2019 GI) (SAR GI 2018)
17. What is the difference between real and apparent weight? Discuss the apparent weight in different cases for an object suspended by a spring balance in a lift. (LHR 2019)

CHAPTER — 6

FLUID DYNAMICS

SECTION I

Multiple Choice Questions

From Punjab Boards:

1) The device used for the measurement of liquid flow is: (LHR 2011 , 2013 GII)
(a) Manometer (b) Barometer
(c) Hydrometer (d) Venturimeter

2) The maximum drag force on falling sphere is 9.8 N. Its weight is: (LHR 2013 GI)
(a) 1 N (b) 9.8 N
(c) 19.8 N (d) 4.9 N

3) The mathematical relation, $V_2 = \sqrt{2g(h_1 - h_2)}$ is known as: (LHR 2012)
(a) Equation of continuity (b) Bernoulli's equation
(c) Torricelli's theorem (d) Ventri relation

4) In the relation $F = 6\pi\eta rv$. Dimension of co-efficient of viscosity η is (LHR 2016)
(a) $[ML^{-1}T^{-1}]$ (b) $[MLT^{-1}]$
(c) $[ML^{-2}T^{-1}]$ (d) [MLT]

5) The fluid is said to be incompressible if its density is (LHR 2016)
(a) Very high (b) Very low
(c) Zero (d) Constant

6) Venturimeter is a device used to measure. (LHR 2017)
(a) Pressure of fluid (b) Speed of fluid
(c) Density of fluid (d) Viscosity of fluid

7) A horizontal pipe narrows from a diameter of 10cm to 5cm. For a fluid flowing larger diameter to smaller: (GUJ 2011) (MUL 2011)
(a) The velocity and pressure both increase
(b) The velocity increase and pressure decreases
(c) The velocity decreases and pressure both decrease
(d) The velocity and pressure both decrease

8) The venturi meter is used to find: (GUJ 2012)
(a) Speed of the fluid (b) Density of the fluid
(c) Pressure of the fluid (d) Viscosity of the fluid

9) SI unit of viscosity is (GUJ 2016)
(a) $Kg\ m^{-1}s^{-1}$ (b) $Kgm^{-1}5$
(c) $Kgm^{-1}5^{-2}$ (d) Kgms

10) Which of the following has maximum viscosity? (MUL 2012 , MUL ANNUAL 2014) (FAS 2016) , (SAW 2013)
(a) Air (b) Water
(c) Acetone (d) Glycerin

11) Venturi relation is given as: (MUL 2013)
(a) $P = \frac{1}{2}P^2V^2$ (b) $P_1 - P_2 = \frac{1}{2}PV_2^2$
(c) $P_1 - P_2 = \frac{1}{2}Sv_1^2 - \frac{1}{2}Iv_2^2$ (d) $V_2 = \sqrt{2g(h_1 - h_2)}$

12) When a body is falling under the action of gravity with terminal velocity, its accelerations is: (MUL 2012 ANNUAL)
(a) Constant (b) Zero
(c) Variable (d) $9.8m/s^2$

13) When body acquires termiaal velocity then its acceleration 'a' becomes (MUL 2016)
(a) $a = 0$ (b) $a = g$
(c) $a > g$ (d) $a < g$

14) 1 torr in Nm^{-2} is expressed as (MUL 2016)
(a) 130.5 Nm^{-2} (b) 133.3 Nm^{-2}
(c) 135.3 Nm^{-2} (d) 140.3 Nm^{-2}

15) An object moving through a fluid experience a retarding force called (MUL 2016) (BAH 2013) (SAG 2012)
(a) Drag force (b) Gravitational force
(c) Terminating force (d) Frictional force

16) The dimensions of volume flow rate of fluid are: (MUL 2017)
(a) $|LT^{-1}|$ (b) $|L^2T^{-2}|$
(c) $|L^3T^{-1}|$ (d) $|L^3T^{-2}|$

17) The frictional effect between different layers of a moving fluid is called: MUL (2017)
(a) Fluidity (b) Density
(c) Viscosity (d) Flow rate

18) The terminal velocity of a droplet falling down under gravity is directly proportional to the square of: (BAH 2014)
(a) Its density (b) Its radius
(c) Its viscosity (d) Its elasticity

19) Bernoulli's Theorem is applicable to: (BAH 2012)
(a) Solids (b) Plasma state
(c) Fluids (d) Liquids

20) Which material has maximum viscosity? (FAS 2013)
(a) Glycerin (b) Plasma
(c) Ethonal (d) Water

21) Venturi meter is a device used to measure: (FAS 2012)
(a) Density of fluid (b) Speed of fluid
(c) Pressure of fluid (d) Viscosity of fluid

22) The dimensions of kinetic energy per volume are same as that of (FAS 2016)
(a) Work (b) Power
(c) Momentum (d) Pressure

23) A fog droplet falls vertically through air with an acceleration: (FAS 2017)
(a) Equal to 'g' (b) Less than 'g'
(c) Zero (d) Greater than 'g'

24) A 6.0 metre high tank is full of water. A hole appears at its middle. What is the speed of efflux. (RAW 2014)
(a) $7.66ms^{-1}$ (b) $5.66ms^{-1}$
(c) $6.66ms^{-1}$ (d) $8.66ms^{-1}$

25) The term $\frac{1}{2}\delta v^2$ in Bernoulli's equation has same units are: (RAW 2013)
(a) Work (b) Volume
(c) Pressure (d) Force

26) The S.I unit of coefficient of viscosity is: (RAW 2011) (DGK 2012)
(a) $Kgm^{-1}S^{-1}$ (b) $Kgm^{-2}S^{-1}$
(c) $Kgm^{-2}S^{-2}$ (d) Kgm^2S

27) The low of conservation of mass gives (RAW 2016)
(a) Bernoulli's equation
(b) Venturi relation
(c) Torricelli's theorem
(d) Equation of continuity

28) Bunsen burner works on the principle of: (RAW 2017)
(a) Venturi effect (b) Terricilli's effect
(c) Bernoulli's effect (d) None of these

29) The pressure will be low when speed of fluid is: (RAW 2017)
(a) Low (b) Zero
(c) Constant (d) High

30) Velocity of efflux is measured by relation. (SAG 2013)
(a) $\sqrt{gh}$ (b) $\sqrt{\frac{gh}{2}}$
(c) $\sqrt{2gh}$ (d) $\sqrt{\frac{4}{3}gh}$

31) The frictional effect between difference layers of moving fluid is called. (DGK 2012)
(a) Fluidity (b) Density
(c) Viscosity (d) Flow rate

32) If the radius of droplet becomes half then its terminal velocity will be. (DGK 2011)
(a) double (b) one fourth
(c) half (d) four time

33) The terminal velocity of a drop is proportional to the square of its: (DGK 2013)
(a) Radius (b) Density
(c) Volume (d) Mass

34) Venturimeter is used to measure: (DGK 2017)
(a) Speed of fluid (b) Density of fluid
(c) Pressure of fluid (d) Viscosity of fluid

35) Opted unit to measure blood pressure is; (DGK 2017)
(a) N/m^2 (b) Pascal
(c) mm of Hg (d) $N.m^2$

36) Let A = area of cross-section of pipe V = speed of fluid then "AV" is called: (SAR 2018 GII)
(a) volume flow rate (b) energy flow rate
(c) mass flow rate (d) pressure flow rate

37) Equation of continuity gives the conservation of the: (LHR 2019 GI)
(a) Mass (b) Energy
(c) Speed (d) Volume

38) 1 torr is equal to: (LHR 2019 GI)
(a) 133.3 Nm^{-2} (b) 133.3 Nm^2
(c) 133.3 Nm (d) 133.3 N^2m

39) Terminal velocity V_t is related with the radius r of a spherical object as: (LHR 2019 GI)
(a) $v_t \propto r^2$ (b) $v_t \propto r$
(c) $v_t \propto \frac{1}{r}$ (d) $v_t \propto \frac{1}{r^2}$

40) The unit of $\frac{1}{2}pV^2$ in Bernoulli's equation is same as that of: (LHR 2019 GI)
(a) Energy (b) Pressure
(c) Work (d) Power

41) In the relation $F = 6\pi\eta rv$. Dimensions of coefficient of viscosity η is: (LHR 2019 GI)
(a) $[M^{-1}LT^{-1}]$ (b) $[ML^{-1}T]$
(c) $[M^{-1}L^{-1}T]$ (d) $[ML^{-1}T^{-1}]$

42) Terminal velocity of a particle in the fluid depends in: (RAW 2019 GI)
(a) Nature of fluid (b) Acceleration of particle
(c) Force on particle
(d) angular velocity of particle

43) Fluid dynamics is the study of the behaviour of: (MUL 2019 GI)
(a) Fluid at rest (b) Liquids at rest
(c) Liquids in motion
(d) Liquids and gasses in motion

44) If the radius of droplet becomes half, then terminal velocity will become: (DGK 2019 GI)
(a) Half (b) Four times
c) One third (d) One fourth

45) Stoke's Law hold for bodies when they have: (SAG 2019 GI)
(a) Spherical shape (b) Curved shape
(c) Rectangular shape (d) Oblong shape

46) Laminar flow occurs at: (SAG 2019 GI)
(a) High speed (b) Low speed
(c) Zero speed (d) Very high speed

47) One Torr is equal to: (SAG 2019 GI)
(a) 120 Pascals (b) 100 Pascals
(c) 133.3 Pascals (d) 80 Pascals

48) Formula one racing cars have a: (SAW 2019 GI)
(a) streamlined design (b) turbulented design
(c) rectangular design (d) elliptical design

49) The speed of efflux is equal to the velocity gained by the falling fluid under the action of gravity through a certain height is called: (SAW 2019 GI)
(a) Torricelli's theorem (b) Bernoulli's theorem
(c) Stoke's theorem (d) Venturi's theorem

50) Bernoulli's Equation based upon Law of Conservation of: (BAH 2019 GI)
(a) Mass (b) Linear Momentum
(c) Angular Momentum (d) Energy

51) A 10 meter high tank is full of water. A hole appears at its middle. The speed of efflux will be: (BAH 2019 GI)
(a) $5ms^{-1}$ (b) $10ms^{-1}$
(c) $100ms^{-1}$ (d) $5.11ms^{-1}$

52) The S.I. Unit of Flow Rate of a Fluid is: (BAH 2019 GI)
(a) m^2s^{-1} (b) ms^{-1}
(c) m^3s^{-1} (d) m^3s^{-2}

53) A 20 metre high tank is full of water. A hole appears at its middle. The speed of efflux will be: (BAH 2019 GI)
(a) $10ms^{-1}$ (b) $14ms^{-1}$
(c) $11.5ms^{-1}$ (d) $9.8ms^{-1}$

Entry Test MCQ's

1) The drag force decreases as the speed of an object moving through fluid _____. (2008)
(a) Increases. (b) Descreases
(c) Remains constant (d) Both B and C.

2) A tiny droplet of oil of density 'p' and radius 'r' falls through air under force of gravity. If viscosity of air is 'η', then terminal velocity acquired by the oil drop is given by: (2009)
(a) $v_t = \frac{4gr^2p}{9\eta}$ (b) $v_t = \frac{9\eta r^2p}{9\eta}$
(c) $v_t = \frac{2gr^2p}{9\eta}$ (d) $v_t = \frac{9\eta r^2p}{9\eta}$

3) The blood vessels collapse when: (2010)
(a) External pressure applied becomes greater than the systolic pressure
(b) External pressure applied is equal to systolic pressure
(c) External pressure applied is less than the systolic pressure
(d) External pressure applied is zero

4) 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? (2011)
(a) $6\pi\eta r^2$ (b) $6\pi\eta/r^2$
(c) $6\pi\eta r$ (d) $6\pi\eta/r$

5) When the drag force is equal to the weight of the droplet, the droplet will fall with: (2011)
(a) High speed (b) Low speed
(c) Certain acceleration (d) Constant speed

6) Stokes' Law for steady motion in a fluid of infinite extent is given by: (2012)
(a) $F = 6\pi\eta rv$ (b) $F = (4/3)\pi r^3pg$
(c) $F = 6\pi\eta r^2p$ (d) $F = 2gr^2p/9\eta$

7) Flow speed of the fluid through a non-uniform pipe increases from 1 m/sec to 3 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 = 1000 kg/m³) (2012)
(a) 1000 N/m² (b) 9000 N/m²
(c) 8000 N/m² (d) 4000 N/m²

8) 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}? (2013)
(a) 900 N (b) Zero
(c) 800 N (d) 700 N

9) Stokes' Law is given as: (2013)
(a) $F = 6\pi\eta r^2v$ (b) $F = 6\pi\eta rv$
(c) $F = 6\pi\eta rv^{-1}$ (d) $F = 6\pi^2\eta r^3v$

10) A small leak is developed in a large water storage tank. If the height of water above leakage is 10m, then find the speed of efflux through the leak: (2013)
(a) 14 m/sec (b) 10 m/sec
(c) 9.8 m/sec (d) 20 m/sec

11) For the horizontal pipe, the fluid inside it is flowing horizontally then Bernoulli's equation can be written as: (2014)
(a) $P + \rho v^2 = \text{constant}$ (b) $2P + \rho v^2 = \text{constant}$
(c) $P + 2\rho v^2 = \text{constant}$ (d) $2P + 2\rho v^2 = \text{constant}$

12) In fluid flow, for the equation of continuity $A_1v_1 = A_2v_2$. If velocity of the fluid at one end is doubled, then what will be the cross-sectional area at this end? (2015)
(a) Double (b) Half
(c) $(Half)^2$ (d) $(Double)^2$

13) Mass flow per second of the fluid is given by: (2015)
(a) ρAv (b) Av
(c) ρv (d) $\frac{Av}{\rho}$

14) The dimension of coefficient of viscosity is: (2015)
(a) $]M^{-2}L^{-1}T^{-1}]$ (b) $[ML^{-2}T^{-1}]$
(c) $[ML^{-2}T^{-1}]$ (d) $[ML^{-1}T^{-1}]$

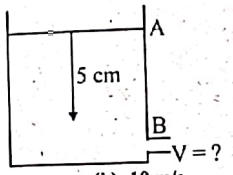
15) Potential energy per unit volume is given by: (2016)
(a) mgh (b) $\frac{mgh}{\rho}$
(c) gh (d) ρgh

16) When fluid is incompressible, the quantity is constant is: (2016)
(a) Mass (b) Density
(c) Pressure (d) Force

17) In Bernoulli's equation the term $\frac{1}{2}\rho v^2$ is called: (2016)
(a) K.E. per unit volume (b) K.E.
(c) K.E. per unit area (d) K.E. per unit length

18) The density of blood is: (2016)
(a) less than water (b) Greather than water
(c) Neavly equal wate (d) three times that of water

19) What is the speed of an incompressible non-viscous liquid flowing out from 'B' contained in a container as shown in the figure? Where AB = 5 m and g = 10/s². (2014)



(a) 5 m/s (b) 10 m/s
(c) 2 m/s (d) 50 m/s

SECTION II

SHORT QUESTIONS

From Punjab Boards:

1. State torricolli's theorem. (LHR 2011, 2012) (MUL 2011)

Ans. The speed of efflux is equal to the velocity gained by the fluid in falling through the distance $(h_1 - h_2)$ under the action of gravity.
Mathematically, we can express it as.

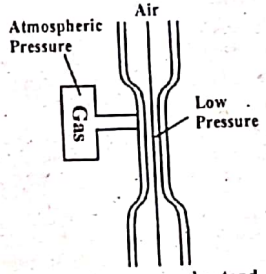
$$v_2 = \sqrt{2g(h_1 - h_2)}$$

2. Why fog droplets appear to be suspended in air? (LHR 2011, 2013: GII, 2014: GII) (MUL 2011) (MUL 2019 GI) (BAH 2011, 2013) (FAS 2011, 2013) (DGK 2011, 2012, 2017, 2019 GI) (SAW 2014, 2017)

Ans. As fog droplets are tiny drops with very small weight. When the drag force becomes equal to the weight of a droplet, then net force acting on the droplet is zero, and it attains terminal velocity and appear to be suspended in air.

3. Considering Bernoulli's principle, explain the working of a carburetor of a motor car. (LHR 2012) (MUL 2011, 2012) (SAG 2017) (DGK 2012)

Ans. The carburetor of a car uses a Ventury duct to feed the correct mixture of air and petrol to the cylinders. Air is drawn through duct along pipe to the cylinders. A tiny inlet at the side of the duct is fed with petrol. The air through the duct moves very fast, creating a low pressure in the decut which draws petrol vapours into the air-stream.



4. Explain what do you understand by the term viscosity? (LHR 2017) (MUL 2011) (BAH 2011) (FAS 2011, 2012) (SAG 2012, 2013, 2019 GI)

Ans. Viscosity: The frictional effect between different layers of a flowing fluid is described in terms of viscosity of the fluid. Viscosity measures, how much force is required to slide one layer of the liquid over another layer. It is denoted by η. The SI unit of viscosity is Ns/m^2.

5. Two row boats moving parallel in the same direction are pulled towards each other. Explain. (LHR 2017, 2019 GI) (GUJ 2011, 2015) (MUL 2012, 2016) (BAH 2019 GI) (FAS 2014) (SAG 2012, 2013, 2018)

Ans. We know that according to Bernoulli's principle "the pressure will be low where the speed of fluid is high and vice versa therefore when two row boats are moving parallel in the same direction then the speed of water between the boats will be fast and pressure will be low while on the opposite sides of the boats the speed of water will be small so pressure will be high, thus a force will act from high pressure to low pressure therefore two boats are pulled towards each other.

6. Explain the difference between laminar flow and turbulent flow. (LHR 2017) (BAH 2011, 2012) (FAS 2017) (SAG 2017) (DGK 2011) (MUL 2016)

Ans. Laminar Flow: The fluid, flow is said to laminar if every particle of the fluid that passes a point moves

along the same path as followed by particles which passed that point earlier.

Turbulent Flow: The irregular or unsteady flow of the fluid is called turbulent flow. In turbulent flow, there is a great disorder and constantly changing flow path.

7. Write values of systolic and diastolic blood pressure for a normal healthy man.(LHR 2019 GI) (GUJ 2016)

Ans. For a normal healthy man the value of

(i) Systolic blood pressure is 120 torr.

(ii) Diastole blood pressure is 75-80 torr.

8. What do you mean by drag force and venturi effect? (MUL 2011: SUPPLY)

Ans. Drag forces: As object moving through a fluid experiences a retarding force called drag force. The drag force acting on a small sphere of radius 'r', moving through a fluid is given by.

$$F = 6\pi \eta r v$$

Venturi's effect:

Where the speed of the fluid is high, the pressure will be low, this is known as venturi's effect.

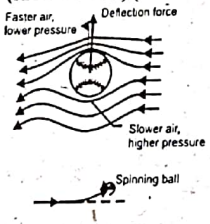
9. Briefly explain "viscous drag". (MUL 2012: ANNUAL)

Ans. An object moving through a fluid experiences a retarding force called drag force. The drag force acting on a small sphere of radius 'r' moving through a fluid is given by.

$$F = 6\pi \eta r v$$

10. Explain, how the swing is produced in a fast moving cricket ball? (LHR 2012, 2019 GI) (MUL 2016, 2017) (DGK 2013, 2017) (RAW 2019 GI) (SAG 2019 GI)

Ans. When a fast moving cricket ball moves in such a way that it spins as well as moves forward, the velocity of air on one side above the ball increases due to spin and air speed in the same direction below and ball and hence the pressure decreases.



According to Bernoulli's theorem, the pressure of the air below the ball s greater than that above the ball. The greater pressure on the other side below the tall deflects the path of ball and give an extra curvature to the ball know as swing which deceives the batsman.

We know that according to Bernoulli's principle "the pressure will be low where the speed of the fluid is high and vice versa". Therefore when a cricket ball is thrown by a fast bowler, the speed of air on the shining side will be fast and pressure will be low while on the rough side the speed of air is less and pressure is high. So a face will act from high pressure to the low pressure and the ball moves in a curved path called swing.

11. What is meant by drag force? What are the factors upon which drag force depends, on a spherical body moving down through a liquid? (BAH 2019 GI) (FAS 2011) (SAG 2019 GI) (DGK 2019)

Ans. An object moving through a fluid experience a retarding force called a drag force. The drag force increases as the speed of the object increases.

For a sphere it is given by stoke's law,

$$F = 6\pi\eta r v$$

So the drag force depends upon:

(i) η (viscosity of medium)

(ii) r (radius of sphere)

(iii) v (speed of sphere)

12. How a chimney works best? (LHR 2019 GI) (RAW 2012, 2014)

Ans. A chimney works best when it is tall and exposed to air currents, which reduces the pressure at the top and force the upward flow of smoke.

13. Differentiate between stream line and irregular flow of fluids. (SAG 2012)

Ans. Stream line flow: When every particle of fluid, during flow has constant velocity, constant pressure, constant density and have regularity is called stream line or laminar flow.

Irregular flow: An irregular and non-steady flow is called turbulent flow. In such flow, velocity, pressure and density are not uniform.

14. How an aeroplane is uplifted? (BAH 2019 GI) (DGK 2012)

Ans. Bernoulli's effect is applicable to the lift of an aeroplane. The wings of an aeroplane are designed to deflect the air so that the streamlines are close together above the wing than below it. Thus, the air is faster on the upper side of wing than on the lower. The pressure will be lower at the top of wing and so the wing will be forced upward. Hence , it will help in lifting an aeroplane upward.

15. Write the three characteristics of an ideal fluid. (DGK 2014 GI, 2019 GI)

Ans.

- The fluid is non-viscous, i-e, there is no internal frictional force between adjacent layers of the fluid.
- The fluid is incompressible.
- The fluid motion is steady.

16. What is stream line flow? (DGK 2012: GII)

Ans. Steam line flow:

The flow is said to be stream line, if every particle that passes a particular point, moves along exactly the same path, as followed by particles which passed that point earlier.

17. What is meant when we say fluid is non viscously. (GUJ 2018)

Ans. The frictional effect between different layers of a flowing fluid is called viscosity of the fluid. Viscosity measured how much force is required to slide one layer

of the liquid over another layer. It is divided by η. The unit of viscosity is Nsm^{-2}.

18. Define viscosity give its units. (RAW 2019 GI)

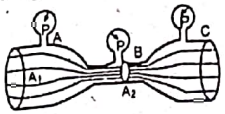
Ans. Frictional effects between different layers of fluid is called viscosity. Its unit is NSm^{-2}.

19. Establish a relation between pressure and speed of fluid. (MUL 2019 GI)

Ans. Relation betweep speed and pressure of fluid:

Where the speed is high, pressure will be low.

Proof: Suppose the water flows through a pipe system as shown in figure.



From figure it is clear that water will flow faster at 'B' than it does at 'A' or 'C'. Assume that the speed of water at 'A' is 0.20 ms^{-1}. And, at 'B' is 2.0ms^{-1}.

Let us compare the pressure at 'B' with that at 'A'. Applying Bernoulli's eq at A and B.

$$P_A + \frac{1}{2}\rho V^2{}_A + \rho g h_1 = P_B + \frac{1}{2}\rho V^2{}_B + \rho g h_2$$

Since the pipe is horizontal, therefore, $h_1 = h_2$. Thus average P.E is same at both place Thus eq (i) becomes.

$$P_A + \frac{1}{2}\rho V^2{}_A = P_B + \frac{1}{2}\rho V^2{}_B$$

$$P_A - P_B = \frac{1}{2}\rho V^2{}_B - \frac{1}{2}\rho V^2{}_A$$

$$P_A - P_B = \frac{1}{2}\rho(V^2{}_B - V^2{}_A)$$

Putting values in this equation.

$V_A = 0.20$ m/sec

$V_B = 2.0$ m/sec

$\rho = 1000$ kg/m^3

$$P_A - P_B = \frac{1}{2}(1000)[(2)^2 - (0.2)^2]$$

$$= 500\,(4 - 04)$$

$$= 1980\ Nm^{-2}$$

This shows that the pressure in the narrow pipe is much smaller than in wider pipe, thus. **"Where speed is high the pressure will be low."**

20. What is venturi relation explain briefly. (SAG 2019 GI, BAH 2019 GI)

Ans. Venturi Relation:

Venturi-meter:

"It is a device which is used to measure the speed of liquid flow using Venturi relation."

Explanation:

Consider two pipes, such that one of the pipes has a much smaller diameter than the other. Using Bernoulli's equation:

$$P1 + \rho g h1 + \frac{1}{2}\rho g h^2{}_1 = P2 + \rho g h_2 + \frac{1}{2}\rho V^2{}_2$$

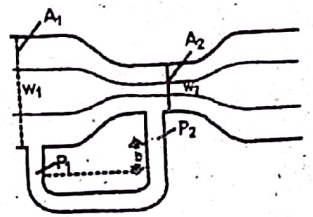
Suppose that the pipe is horizontal so that the term 'pgh' becomes equal and can, therefore, be dropped. So

$$P1 - P2 = \frac{1}{2}\rho(V^2{}_2 - V^2{}_1) \quad \text{.....(6.15)}$$

As the cross-sectional area A_2 is small as compared to the area A_1, i.e., $A_2 << A_1$, then according to the equation of continuity; $V_1 << V_2$

$$P_1 - P_2 = \frac{1}{2}\rho V^2{}_2$$

Which is the Venturi relation.



SECTION-III

Long Questions

From Punjab Boards:-

1. Water follows through a hose whose internal diameter is 1cm, at a speed 1ms^{-1}. What should be the diameter of the nozzle if the water is to average at 21ms^{-1}?**(LHR 2011, 2013: GII) (FAS 2012) (BAH 2012, 2013) (SAG 2018 GII)**

2. A tiny water droplet of radius 0.010 cm descends through air from a high building calculate its terminal velocity. Given that n for air = 19 × 10^{-6} kg $m^{-1}s^{-1}$ and density of water p = 1000 kg/m^3. **(LHR 2012: GII, 2017) (FAS 2016)**

3. State and explain Torricelli's theorem. **(LHR 2013; GI) (GUJ 2012) (MUL 2017)**

4. Define terminal velocity, show that terminal velocity is directly proportional to the square of radius of the droplet. **(LHR 2014: GII , 2015 : GI) (RAW 2016) (DGK 2018 GI) (SAW 2018 GI)**

5. State and prove the Bernoulli's equation in dynamic fluid, that relates pressure to fluid speed and height. **(LHR 2014 GI, 2015 GII) (GUJ 2012, 2018 GI) (FAS 2011) (RAW 201, 2013) (SAG 2017) (DGK 2012) (SAW 2013, 2014)**

6. State equation of continuity. Give its principle and also derive it. **(LHR 2017) (MUL 2014) (BAH 2014) (RAW 2014)**

7. Define Stoke's law and show that the terminal velocity is directly proportional to square of radius of the object. **(LHR 2017)**

8. What gauge pressure is required in the city main for a stream from a fire house connected to the mains to reach a vertical height of 15.0 m? (GUJ 2013, 2015) (MUL 2011 ANNUAL, 2012 ANNUAL) (DGK 2014) (SAG 2017, 2018 GI) (SAW 2017)
9. An air plane wing is designed so that the speed of the air across the top of the wing is 450 m/s, the speed of air below the wing is 410 m/s. What is the pressure difference between the top and bottom of the wings? Density of air = 1.29 kg/m^3. (GUJ 2014)
10. A water hose with an internal diameter of 20 mm at the outlet discharges 30kg of water in 60 seconds. Calculate the water speed at the outlet. Assume the density of water is 1000 kg/m^3 and its flow is steady. (MUL 2016)
11. What do you mean by stream line flow? Describe the equation of continuity. (MUL 2012: SUPPLY)
12. What is Equation of continuity? Derive a relation for it. Also discuss flow rate. (MUL 2016)
13. Water is flowing smoothly through a closed pipe system. At one point, the speed of water is 3ms^{-1}, while another point 3m higher, the speed is 4ms^{-1}. If the pressure is 80 KPa at the lower point what is the pressure at the upper point. (SAG 2017)
14. Define terminal velocity. Find the terminal velocity of a fog droplet of mass "m" having radius "r" moving through air of viscosity "η" also show that $vt \propto r^2$. (DGK 2011)
15. A tiny water droplet of radius 0.01cm descends through air from a height. Calculate its terminal velocity. Given that for air $\eta = 19\times10^{-6}$ kgm^{-1}S^{-1} and density of water ρ = 1000kgm^{-3}. (RWP GI 2018)

CHAPTER — 7

OSCILLATIONS

SECTION I

Multiple Choice Questions

From Punjab Boards:

1) Time period of simple pendulum only depends on: (LHR 2012)
(a) Mass of the bob
(b) Length of the pendulum
(c) Amplitude of vibration (d) Size of the bob

2) The frequency of second's pendulum is: LHR 2013 GI)
(a) 1 Hz (b) 2 Hz
(c) 0.5 Hz (d) 5 Hz

3) On increasing the tension, frequency of vibration of a string: (LHR 2013 GII)
(a) Increases (b) Decreases
(c) Remains constant
(d) First increases then decreases

4) The S.I units of spring constant are: (LHR 2011)
(a) m^{-1} (b) Nm^{-1}
(c) Nm^{-2} (d) Nm^2

5) The product of time period and frequency is: (LHR 2013) GII
(a) Zero (b) 1
(c) π (d) 2

6) The relation between time period and frequency is (LHR 2016)
(a) $f = 2\pi T$ (b) $f = \frac{1}{2\pi T}$
(c) $f = \frac{T}{2\pi}$ (d) $fT = 1$

7) The amplitude of vibrating body at resonance in vacuum is (LHR 2016)
(a) Maximum (b) Minimum
(c) Zero (d) Infinite

8) The profile of periodic waves generated by a source executing S.H.M is represented by a. (LHR 2017)
(a) Circle (b) Sine curve
(c) Tangent curve (d) Cosine curve

9) Total energy of a particle executing S.H.M is.(LHR 2017)
(a) $\frac{1}{2}kx^2$ (b) $\frac{1}{2}k(x_0^2 - x^2)$
(c) $\frac{1}{2}kx_0^2$ (d) $\frac{1}{2}k(x^2 - x_0^2)$

10) The distance covered during one vibration of an oscillating body in terms of amplitude 'A' is.(LHR 2017) (GUJ 2013) (SAW 2013)
(a) A/2 (b) A
(c) 2A (d) 4A

11) A body is executing SHM. What fraction of its total energy will be kinetic energy when its displacement from the mean position is half of its displacement? (GUJ 2011)
(a) $\frac{1}{2}$ (b) $\frac{3}{2}$
(c) $\frac{3}{4}$ (d) $\frac{1}{4}$

12) Which expression is correct for the time period of a simple pendulum? (GUJ 2012)
(a) $T \propto l$ (b) $T \propto n$
(c) $T \propto \sqrt{l}$ (d) $T \propto m$

13) The wave produced in microwave oven have a wave length of (GUJ 2016)
(a) 12 cm (b) 12 m
(c) 18 m (d) 18 cm

14) The length of simple pendulum of time period 1 sec is (GUJ 2016)
(a) 2 m (b) 1 m
(c) 0.5 m (d) 0.25 m

15) 10 waves passes through a point in 2 sec with a speed of 10 ms^{-1}, the frequency of wave will be (GUJ 2016)
(a) 1 Hz (b) 2 Hz
(c) 5 Hz (d) 10 Hz

16) The maximum K.E. of a mass attached to the end of a elastic spring is: (MUL 2012 SUPPLY)
(a) $\frac{1}{2}kx^2$ (b) $\frac{1}{2}kx_0^2$
(c) $\frac{1}{4}kx_0^2$ (d) kx_0^2

17) The process by which energy is dissipated from an oscillating system is called: (MUL 2011) ANNUAL)
(a) Resonance (b) Damping
(c) Forced vibrations (d) Harmonic oscillation

18) 10 cm extension is produced in a spring due to a force of 20N, the spring constant is: (MUL 2012 ANNUAL)
(a) 2Nm^{-1} (b) 20Nm^{-1}
(c) 200Nm^{-1} (d) 2000Nm^{-1}

19) In the mass of a simple pendulum is double, its time period will become/remain: (MUL 2011 SUPPLY)
(a) Unaffected (b) Double
(c) Helf (d) 1.41 as large

20) The acceleration of a body having SHM, depends upon its: (MUL 2014)
(a) Time period (b) Amplitude
(c) Frequency
(d) Displacement from mean position

21) Acceleration of projection of a particle moving around a circle is given by relation: (MUL 2013)
(a) $a = -\frac{gx}{l}$ (b) $a = -\omega^2 x$
(c) $a = \frac{-k}{m}x$ (d) $a = -g\sin\theta$

22) Frequency of second pendulum is (MUL 2016)
(a) 2 Hz (b) 0.5 Hz
(c) 10 Hz (d) 0.1 Hz

23) The frequency of waves produced in microwave oven is (MUL 2016) (RAW 2011) (DGK 2013) (SAW 2013)
(a) 2250 MHz (b) 2450 MHz
(c) 2650 MHz (d) 2850 MHz

24) If mass of the pendulum becomes double, its time period will become: (MUL 2017)
(a) Doubled (b) Half
(c) On fourth (d) Remains same

25) When one – fourth of the cycle of a vibrating body is completed then the phase change in it is: (MUL 2017)
(a) $\frac{\pi}{4}$ radian (b) $\frac{\pi}{2}$ radian
(c) $\frac{3\pi}{2}$ radian (d) π radian

26) Tuning a radio is best example of: (BAH 2012) (SAW 2013)
(a) Mechanical resonance (b) Light wave resonance
(c) Electrical resonance (d) Physical resonance

27) In case of Oscillating pendulum, its acceleration "a" is: (BAH 2011)
(a) $a \propto \theta$ (b) $a \propto$ time period
(c) $a \propto$ length of pendulum (d) $a \propto$ mass of bob

28) The length of second's pendulum is: (BAH 2013)
(a) 100 cm (b) 90 cm
(c) 99.2 cm (d) 98 cm

29) The mathematical expression for the restoring force is: (BAH 2014)
(a) F = kx (b) F = ma
(c) $F = \frac{dp}{dt}$ (d) F = – kx

30) The time period of a wave is 0.2s. Its frequency will be: (FAS 2012)
(a) 2Hz (b) 3Hz
(c) 4Hz (d) 5Hz

31) The wave from of S.H.M is: (FAS 2012)
(a) Cosine wave (b) Sine wave
(c) Square wave (d) Pulse wave

32) The product of time period and frequency is equal to: (FAS 2013) (DGK 2013)
(a) 3 (b) 2
(c) 1 (d) Zero

33) At mean position during SHM: (FAS 2011)
(a) PE is maximum and KE is minimum
(b) PE is minimum and KE is maximum
(c) Both KE and PE are maximum
(d) Both KE and PE are minimum

34) A quantity which indicates the sate and direction of a vibrating body is known as (FAS 2016)
(a) Time period (b) Amplitude
(c) Phase (d) Frequency

35) At which place the motion of a simple pendulum will be slowest: (FAS 2017)
(a) Karachi (b) K-2
(c) Murree (d) Lahore

36) Mass attached to spring is pulled slowly from mean position to X_0 Then work done will be: (RAW 2013)
(a) $\frac{1}{2}Kx_0$ (b) $\frac{1}{2}Kx_0^2$
(c) Kx_0 (d) W^2x_0

37) When a particle is moving along a circular path, its projection along the diameter executes: (RAW 2014)
(a) Linear motion (b) vibratory motion
(c) Rotatory motion (d) SHM

38) The correct relation between frequency and time period is (RAW 2016)
(a) $\frac{f}{T} = 1$ (b) $\frac{T}{f} = 1$
(c) fxT = 2 (d) fxT = 1

39) Shock absorber in automobiles is a practical form of: (RAW 2017)(SAG 2017)
(a) SHM (b) Damped oscillations
(c) Forced oscillations (d) None of these

40) The force responsible for the vibratory motion of simple pendulum is: (RAW 2017)
(a) mg cosθ (b) mg sinθ
(c) mg secθ (d) mg tanθ

41) The time required to complete one vibration is called: (SAG 2012)
(a) Time period (b) Frequency
(c) Vibration (d) Amplitude

42) Frequency of second pendulum is: (SAG 2013)
(a) 2.5 Hertz (b) 0.5 Hz
(c) 1.5 Hz (d) 2 Hz

43) By increasing the mass of a simple pendulum its period: (SAG 2017)
(a) Increases (b) Decreases
(c) Remains same (d) Become zero

44) In simple harmonic motion the velocity of a particle is maximum at: (DGK 2014)
(a) Extreme position
(b) Mean position
(c) In between extreme and mean position
(d) None of these

45) If mass of pendulum becomes double, then its time period will be: (DGK 2011)
(a) double (b) half
(c) four time (d) Remain same

46) If the time period of simple pendulum is 2 seconds its frequency will be: (GUJ 2018) (DGK 2012)
(a) 1.0 Hz (b) 0.5 Hz
(c) 1.5 Hz (d) 2 Hz

47) A phenomenon by which energy is dissipated from the oscillating system is called: (DGK 2017)
(a) Forced oscillations
(b) Free oscillations
(c) Simple harmonic oscillations
(d) Damping

48) When quarter of the cycle is completed of circular motion in SHM. The phase will be: (DGK 2017)
(a) 2π (b) $3\pi/2$
(c) π (d) $\pi/2$

49) The dimensions of spring constant 'K' are: (SAW 2014)
(a) $[MLT^{-1}]$ (b) $[MT^{-2}]$
(c) $[MLT^{-2}]$ (d) $[MT^{-1}]$

50) Base units of spring constant is: (LHR 2019 GI)
(a) $kg^{-1}s^{-2}$ (b) $kg^{-1}ms^{-2}$
(c) $kg\,ms^{-2}$ (d) kgs^{-2}

51) In order to double period of a simple pendulum the length of the pendulum should be increased by: (LHR 2019 GI)
(a) Four times (b) Three times
(c) Two times (d) Eight times

52) $\sqrt{\frac{\ell}{g}}$ and $\sqrt{\frac{m}{k}}$ has same: (RAW 2019 GI)
(a) numerical value (b) units
(c) damping (d) time period

53) Acceleration is S.H.M is proportional to the: (MUL 2019 GI)
(a) Velocity (b) Displacement
(c) Time period (d) Frequency

54) If the length of simple pendulum is doubled then its time period becomes: (DGK 2019 GI)
(a) Half (b) 2 times
(c) $\sqrt{2}$ times (d) 4 times

55) A simple pendulum is completing 20 vibration in 5 seconds, its frequency is: (SAG 2019 GI)
(a) 4 Hz (b) 20 Hz
(c) 200 Hz (d) 40 Hz

56) The Product of frequency and Time Period is: (SAG 2019 GI)
(a) 2 (b) 3
(c) 1 (d) 1 Hertz

57) The frequency of waves produced in microwave oven is: (SAW 2019 GI)
(a) 2850 MHz (b) 2450 MHz
(c) 2400 MHz (d) 2750 MHz

58) The distance covered by a body in one complete vibration is 20cm, what is the amplitude of the vibration: (BAH 2019 GI) (SAG 2019 GI)
(a) 10 cm (b) 80 cm
(c) 5 cm (d) 20 cm

59) If the Initial Phase is $\frac{\pi}{2}$ then displacement of SHM is: (BAH 2019 GI)
(a) $x = x^2_o \text{Sin wt}$ (b) $x = \text{Sin wt}$
(c) $x = x_o \text{ Cos wt}$ (d) Zero

Entry Test MCQ's

1) If the mass of the bob of a pendulum is doubled its time period is: (2008)
(a) Halved (b) Unchanged
(c) Doubled (d) Increases four times

2) The acceleration is proportional to the displacement and is directed towards mean position in _____ motion. (2008)
(a) Gravity (b) Simple haromine
(c) Uniform (d) Projectile

3) If the mass of the bob of a pendulum is doubled its time period is: (2008)
(a) Halved (b) Doubled
(c) Unchanged (d) Increases four times

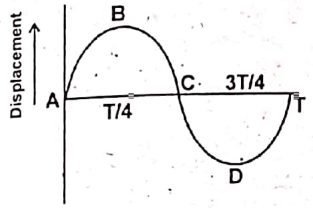
4) In a microwave oven, the wave produced has a wavelength of 12 cm at a frequency of: (2009)
(a) 2452 Hz (b) 2456 Hz
(c) 2455 Hz (d) 2450 Hz

5) If the mass attached with a spring becomes four times, the time period fo vibration becomes: (2009)
(a) One fourth (b) 3/4
(c) Half (d) Double

6) An oscillating body is at mean position at = 0 and t = T it wil be at: (2010)
(a) Extreme position (b) Mean position
(c) Between extreme and mean position
(d) Beyond extreme position

7) What is the period of mass spring system during SHM if the ratio of mass to spring constant is $\frac{1}{4}$? (2011)
(a) π (b) 2π
(c) $1/\pi$ (d) $\frac{1}{2}\pi$

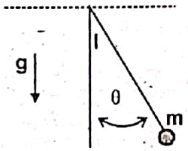
8) Waveform of SHM is given in figure. At what time/times displacement is equal to zero? (2011)



(a) T/4 only (b) 3T/4 only
(c) 0, T/4, 3T/4 and T (d) 0, T/2 and T

9) A wire is stretched by a force which causes an extension. The energy is stored in it only when: (2011)
(a) The extension of wire is proportional to force applied
(b) The cross-section area of the wire remains constant
(c) The wire is not stretched beyond its elastic limit
(d) The weight of wire is negligible

10) A simple pendulum length 'L' with bob of mass 'm' is slightly displaced from its mean position so that it string makes an angle 'θ' with vertical line as shown in the figure. Then bob of pendulum relased. What will be the expression of torque with which the bob starts to move towards the mean position? (2011)



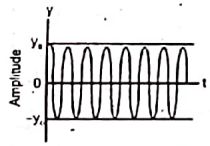
(a) mgL (b) mgL sin θ
(c) 0 (d) mgL cos θ

11) A simple harmonic oscillator has a time period of 10 seconds. Which equation rotates its acceleration 'a' and displacement 'x'? (2012)
(a) $a = -2 \times$ (b) $a = -2(20\pi) \times$
(c) $a = \left(\frac{2\pi}{10}\right)^2 \times$ (d) $a = -(20\pi)^2 \times$

12) When the length of a simple pendulum is doubled, find the ratio of the new frequency to the old frequency? (2012)
(a) 1/4 (b) 1/2
(c) $\sqrt{2}$ (d) $1/\sqrt{2}$

13) For vibrating mass-spring system, the expression of kinetic energy at any displacement 'x' is given by: (2013)
(a) $\frac{1}{2}kx_o^2\left(1-\frac{x^2}{x_o^2}\right)$ (b) $\frac{1}{2}kx_o^2$
(c) $\frac{1}{2}m\omega\left(1-\frac{x^2}{x_o^2}\right)$ (d) $\frac{1}{2}m\omega_2 x_o$

14) Variation of amplitude with respect ot time for an oscillation object is shown in figure. Identify the oscillation: (2013)



(a) Damped (b) Critical
(c) Undamped (d) Heavily damped

15) In a simple harmonic motion with a radius 'xo', the velocity of the particle at any point is: (2013)
(a) $v = \omega\sqrt{x_o^2 - x^2}$ (b) $v = \omega\sqrt{(x_o - x)}$
(c) $v = \omega(x^2 - x_o^2)$ (d) $v = \omega\sqrt{(x - x_o)}$

16) 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 '$\omega(rads^{-1})$'? (2014)
(a) $x_o = 0.03, \omega = 100$ (b) $x_o = 0.19, \omega = 16$
(c) $x_o = 5.3, \omega = 16$ (d) $x_o = 3.3, \omega = 100$

17) Frequency of simple pendulum of length 9.8 m will be: (2014)
(a) 2 πHertz (b) π/2 Hertz
(c) ½ πHertz (d) π/4 Hertz

18) Food being cooked in microwave oven is an example of: (2014)
(a) Beats (b) Overtones
(c) Resonance (d) Stationary waves

19) Mathematical formula of maximum velocity (v_o) for a body executing simple harmonic motion is: (2015)
(a) $v_o = \omega x_o$ (b) $v_o = \frac{k}{m}\sqrt{x_o^2 - x^2}$
(c) $v_o = v\sqrt{1-\frac{x^2}{x_o^2}}$ (d) $vo = m\sqrt{x_o^2 - x^2}$

20) What should be the length of simple pendulum whose period is 6.28 second at a place where $g = 10ms^{-2}$. (2015)

(a) 0.28 m (b) 10.8 m

(c) 6.28 m (d) 10 m

21) What should be the relation of kinetic energy to total energy for simple harmonic oscillator? (2015)

(a) $1 - \frac{x^2}{x_o^2}$ (b) 1

(c) $(x_o^2 - x^2)$ (d) $\frac{1}{2}x^2$

22) The time period 'T' of a simple pendulum depends on its length 'l' and acceleration due to gravity 'g' using unit dimension. The correct equation for time period is: (2016)

(a) $T = k\sqrt{\frac{g}{l}}$ where 'k' is constant

(b) $T = \frac{1}{k}\sqrt{\frac{g}{l}}$ where 'k' is constant

(c) $T = k\sqrt{\frac{l}{g}}$ where 'k' is constant

(d) $T = \frac{1}{k}\sqrt{\frac{l}{g}}$ where 'k' is constant

23) Resonance occurs when the driving frequency is: (2016)

(a) Greater than nature frequency

(b) unequal the natural frequency

(c) Less than natural frequency

(d) Equal to the natural frequency

24) Frequency audible range to human hearing lies in the range: (2016)

(a) 2–2000 kHz (b) 15–50000 kHz

(c) 20–20000 Hz (d) 20–20000 kHz

25) If the four of magnition 8N acids on a body in direction making angle 38, its x and y components will be:

(a) $Fx = 3\sqrt{3}$, $Fy = 4$ (b) $Fx = 4\sqrt{3}$, $Fy = 8$

(c) $Fx = 4\sqrt{3}$, $Fy = 4$ (d) $Fx = 8$, $Fy = 4\sqrt{3}$

26) Tuning radio is a best example of: (2016)

(a) Natural resonance (b) Mechanical resonance

(c) Free resonance (d) Electrical resonance

SECTION II

Short Questions

From Punjab Boards:

1. Why soldiers are advised to break their steps when marching on a bridge? (LHR 2011)

Ans. Because their rhythmic march might set up oscillations of dangerously large amplitude in the bridge structure and bridge may collapse due to violent resonance oscillations.

2. Define resonance and give an example of resonance. (LHR 2013: GI) (GUJ 2011, 2012, 2013, 2015, 2016) (MUL 2012, 2014) (RAW 2016) (SAG 2016, 2019 GI) (SAW 2013)

Ans. Resonance:

"A large-amplitude oscillation of a system is response to a small driving force (forced oscillation) in which frequency of applied force match with the natural frequency of applied force with natural frequency of an oscillator is called resonance".

For example:

Heating and cooking of food very efficiently and evenly by microwave oven is a good example of resonance. The waves produced in this type of oven have a wave length of 12 cm at a frequency of 2450 MHz. 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.

3. Give electrical examples of resonance. (LHR 2013: GII)

Ans. Tuning 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 the electric circuit of the receiver, to make it equal to the transmission frequency of the radio station. When the two frequencies coincide with each other, energy absorption is maximum programme of desired station.

4. Under what conditions does the addition of two simple harmonic motions produces a resultant, which is also simple harmonic motion? (LHR 2014: GI)

Ans. In order to produce resultant SHM by the addition of two simple harmonic motions, following conditions must be fulfilled.

Two SHMs must be parallel (i.e their phases must be in the same direction.

Two SHMs must have the same frequency (i.e. period) but different amplitudes.

These two harmonic motions must have constant phase differences.

If two SHMs are given as

$x_1 = A_1 \sin \omega t$ and $x_2 = A_2 \sin(\omega t + \phi)$

Resultant SHM will be written as

$x = x_1 + x_2 = A_1 \sin \omega t + A_2 \sin(\omega t + \phi)$

5. Describe some common phenomenon in which resonance plays an important role. (MUL 2012) (LHR 2014 GII, 2015 GI, 2017) (BAH 2011, 2012, 2019 GI) (RAW 2014, 2016, 2017) (SAW 2013)

Ans. Following are the common phenomena in which resonance plays an important role.

(i) Tuning of radio:

Tuning a radio is the best example of electrical resonance. By tuning a dial, the natural frequency of an alternating current in the receiving circuit is made equal to the frequency of the wave broadcast by the desired station. When the two frequencies match, energy absorptions is maximum and thus transmitted signal becomes large enough due to the resonance. This received signal enables us to hear the programme of desired station.

(ii) Swing:

A common phenomenon of resonance is provided by pushing a swing. If it is pushed after regular intervals of time (equal to the period of swing, its motion will increase with every push. If the pushes occur at irregular intervals, the swing will hardly vibrate.

(iii) Microwave oven:

The waves produced in this type of oven have a wave length of 12 cm at a frequency of 2450MHZ. At this frequency the waves are absorbed de to resonance by water and fat molecules in the food, heating them up and so cooking of food very efficiently and evenly.

6. Show that in simple harmonic motion, the acceleration is zero when the velocity is greatest and the velocity is zero when the acceleration is greatest. (LHR 2015: GI, 2015: GII) (GUJ 2015) (DGK 2012)

Ans. As the projection of particle moving in a circle executes SHM, the following relations for velocity and acceleration are given as

$a = -\omega^2 x$ $v = \omega\sqrt{x_o^2 - x^2}$

Where 'x' is the instantaneous displacement x_o is the maximum displacement and ω is the constant of SHM called angular frequency.

(i) At the mean position,

Where displacement $x = 0$

$\therefore a = -\omega^2 \times 0 = 0$

Hence $a = 0$ .....(i)

And $v = \omega\sqrt{x_o^2 - (0)^2} = \omega\sqrt{x_o^2}$

$\therefore v = \omega x_o$ .....(il)

Hence,

Equation (i) and (ii) show that velocity ($v = \omega x_o$) is maximum or greatest when acceleration 'a' is zero.

(ii) At the extreme positions

Where $x = x_o$

$\therefore a = -\omega^2 x_o$.....(iii)

and $v = \omega\sqrt{x_o^2 - x_o^2} = \omega\sqrt{0}$

or $v = 0$ .....(iv)

In this case, equations (iii) and (iv) show that velocity is zero when acceleration ($a = -\omega^2 x_o$) is maximum or greatest.

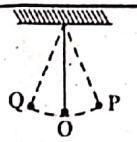
Conclusion: At the mean position, acceleration is zero but velocity is greatest. At the extreme positions, velocity is zero but acceleration is maximum.

7. What is the total distance traveled by an object moving with SHM in a time equal to its period, if its amplitude is A? (LHR 2015: GII) (GUJ 2011) (MUL 2011 Supply, 2014) (BAH 2014) (RAW 2012, 2014) (FAS 2016) (SAR 2018) (DGK 2017)

Ans. The total distance traveled by an object moving with SHM in its time period is 4A.

Where

A = amplitude of vibration



Explanation:

The time period of a body executing SHM is the time top complete to and for motion about the mean position. From the figure.

Distance $\overline{OP}$ = Amplitude = A (Given)

(Distance of half vibration from O to P and back from P to O) = A + A = 2A

Again

(Distance of half vibration from O to Q and back from Q to O) = A + A = 2A

(Total distacne covered by the body during one complete vibration) = 2A + 2A = 4A

As the time taken by one vibration is called time period. Hence, the object covers a total distance of 4A in a time equal to its time period.

8. Why waves of 2450 MHz frequency is necessary for heating and cooking food in microwave oven. (LHR 2017)

Ans. Cooking of Food by Microwave Oven:

Resonance is also used in microwave oven which heats and cooks food evenly and efficiently. Microwave oven uses microwaves of wavelength 12cm at a frequency of 2450MHz. At this frequency waves are absorbed due to resonance of water and fat molecules in the food. So they heat and cook the food. This is a very good example for heating and cooking the food in our homes.

9. Does the acceleration of a simple harmonic oscillator remain constant during its motion? Is the acceleration ever zero? Explain. (LHR 2017) (FAS 2016, 2017) (BAH 2019 GI) (SAG 2019 GI)

Ans. No, the acceleration of a simple harmonic oscillator does not remain constant. The acceleration of harmonic oscillator varies with displacement because.

$a = -\omega^2 x$

Where ω^2 is constant.

So, $a = -\text{constant} \times x$

$a \propto -x$

This shows that acceleration is directly proportional to displacement.

As displacement is changing during motion, therefore acceleration is also changing.

The acceleration will be zero at the mean position i.e., $x = 0$

So, $a = -\omega^2(0)$

$a = 0$

10. What happens to the period of simple pendulum if its length is doubled? What happens if the suspended mass is doubled?
(LHR 2012, 2013 GI, 2014 GII, 2017, 2018 GI, 2019 GI) (GUJ 2018) (MUL 2016, 2019 GI) (BAH 2014, 2016) (RAW 2011, 2016, 2019 GI) (DGK 2011, 2012, 2014)

Ans. We know that the time period of a simple pendulum is given by.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Let T be the time period of simple pendulum when length becomes double.

i.e., $l' = 2l$

Then, $T' = 2\pi\sqrt{\frac{2l}{g}}$

$$= 2\pi\sqrt{\frac{l}{g}} \times \sqrt{2}$$

$$T' = \sqrt{2}\,T$$

$$= 1.41T$$

If the length of pendulum is doubled then its time period increases by 1.41 times the original time period.

Mass: If mass of pendulum is doubled, there is no change in time period because it is independent of mass.

11. What will happen to the time-period of simple pendulum if its length is reduced to half and mass is doubled. (LHR 2017)

Ans. The time period of simple pendulum is given by.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Where l is length of simple pendulum.

If length 'l' is reduced to $l/2$.

Then above relation becomes.

$$T' = 2\pi\sqrt{\frac{l/2}{g}} = 2\pi\sqrt{\frac{l}{2g}}$$

or $$T' = (1/\sqrt{2})\,2\pi\sqrt{\frac{l}{g}}$$

$$T' = (1/\sqrt{2})\,T = \frac{T}{\sqrt{2}}$$

Hence, if its length is reduced to half, the time - period decreases by a factor $1/\sqrt{2}$ times the initial time period.

Mass: If mass of pendulum is doubled, then there is no change in time period because it is independent of mass.

12. What is meant by phase angle? Does it define angle between maximum displacement and driving force?
(LHR 2013 GII, 2014 GI) (GUJ 2014) (BAH 2011) (RAW 2013) (SAG 2019 GI) (SAW 2014, 2019 GI)

Ans. The angle which specifies the displacement as well as the direction of motion of the point executing SHM is known as phase. It is given by

$$\theta = \omega t$$

In other words, the phase determines the state of motion of the vibrating point.

The phase angle is not the angle between maximum displacement and the driving force.

13. If a mass spring system is hung vertically and set into oscillations, why does the motion eventually stop. (LHR 2017) (GUJ 2016) (MUL 2012, 2016) (FAS 2011, 2013) (BAH 2019 GI) (RAW 2012, 2017) (DGK 2013, 2014)

Ans. The motion of oscillation of mass spring system stops after some time due to damping forces which is directly proportional to the velocity of the oscillator in the medium.

14. Define restoring force and simple harmonic motion. (MUL 2011: ANNUAL)

Ans. **Restoring force:** The force which bring the body back to the mean position is called restoring force. It is equal and opposite to the applied force.

Simple harmonic motion: A vibratory motion in which acceleration is directly proportional to the displacement and always directed towards the mean position is called simple harmonic motion.

15. Explain the relation between total energy , potential energy and kinetic energy for a body oscillating with SHM? (MUL 2016)

Ans. For a body oscillating with SHM, the relation between potential energy , kinetic energy and total energy at ant instant t is

$$E_{total} = P.E. + K.E.$$

Since total energy of SHM remain constant, therefore any decrease in K.E. or P.E. results increase in P.E. or K.E. respectively.

During SHM, in the absence of frictional forces, the K.E. and P.E. are interchanged continuously from one form to another but the total energy remains constant. At mean position, the energy is totally kinetic i.e.; K.E. is maximum but P.E. is zero. At the extreme positions the K.E. is completely changed into P.E., i.e. P.E. becomes maximum but K.E. is zero.

16. What is the value of frequency and wavelength of waves produced in microwave oven. How it works. (MUL 2017)

Ans. Another good example of resonance is the heating and cooking of food very efficiently and evenly by microwave oven figure. The waves produced in this type of oven have a wavelength of 12cm at a frequency of 2450 MHz. 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.

17. What is resonance. Describe some common phenomenon in which resonance plays an important role. (FAS 2016)

Ans. The phenomenon of resonance occurs when the frequency of the applied force is equal to one of the natural frequencies of vibration of the forced (driven) harmonic oscillator.

Examples:

(1) Tuning of a radio is an example of electrical resonance.

(2) A swing is an example of mechanical resonance.

(3) Heating and cooking of food by microwave oven.

(4) The soldiers are ordered to break their steps while crossing a big bridge, because I the frequency of their steps coincides with the natural frequency of the bridge, the bridge may be set into vibration of large amplitude. Thus , the bridge may collapse due to resonance.

How cooking of food is possible in microwave oven? (RAW 2014)

18. Cooking of food is possible in microwave oven by the phenomenon, known as resonance.

Ans.

19. Does the acceleration of a simple harmonic oscillator remain constant during its motion? Is the acceleration ever zero? Explain. (RAW 2016)

Ans. The acceleration of a simple harmonic oscillator does not remain constant during its motion. It varies with displacement. The value of acceleration is zero at mean position.

20. Define vibrating motion, simple harmonic notion. (SAG 2013)

Ans. **Vibrating motion:** To and fro motion of a body about its mean position is called vibrating motion.

Simple harmonic motion: The acceleration at any instant of a body executing S.H.M is proportional to displacement and is always directed towards its mean position.

21. How does resonance play an important role in working of microwave oven. (MUL 2019 GI) (DGK 2017)

Ans. Heating and cooking of food very efficiently and evenly by microwave oven is a good example of resonance. The waves produced in this type of oven have a wavelength of 12 cm at a frequency of 2450 MHz. 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.

22. The equation for SHM of an object is given by $x = 0.25\cos\left(\frac{\pi}{8}\right)t$ what will be the displacement after two seconds. (DGK 2017)

Ans. For disp. After two seconds

$$x = 0.25\cos\left(\frac{\pi}{8}\right)t$$

$$x = 0.25\cos\frac{\pi}{8} \times 2$$

$$x = 0.25\cos\frac{\pi}{4}$$

$$x = 0.25\,(0.707)$$

$$\boxed{x = 0.18\ m}$$

23. Under what conditions does the addition of two simple harmonic motions produce resultant, which is also simple harmonic? (RAW 2013) (DGK 2017) (SAW 2019 GI)

Ans. In order to produce resultant SHM by the addition of two simple harmonic motions following conditions must be required.:

(i) Two SHMs are parallel i.e., in same direction.
(ii) Two SHMs are in phase.
(iii) Two SHMs vibrate with same frequency.

24. What will be the potential energy of mass attached to a spring at amplitude 5cm if its spring constant is 10Nm⁻¹. (SAW 2014)

Ans. As we know that.

$$P.E = \frac{1}{2}kx_0^2 \qquad x_0 = 5cm = 0.05m$$

$$= \frac{1}{2} \times 10 \times (.05)^2 \qquad k = 10Nm^{-1}$$

$$= 0.0125J$$

25. A mass spring system is vibrating with amplitude 10cm. Find its K.E and P.E at equilibrium position. When spring constant is 20Nm⁻¹. (LHR 2019 GI)

Ans. $x_o = 10cm = 0.1m$

$K = 20Nm^{-1}$

K.E = ? (at equilibrium position)

P.E = ? (at equilibrium position)

At equilibrium position K.E is maximum.

$$K.E = \frac{1}{2}Kx_o^2$$

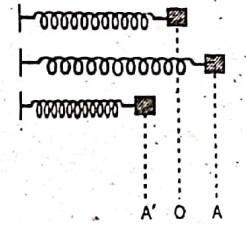
$$K.E = \frac{1}{2} \times 20\,(0.1)^2 = 0.1J$$

At equilibrium position P.E is zero because $x_o = 0$.

$$P.E = \frac{1}{2}K x_o^2 = \frac{1}{2}K(0) = 0$$

26. Derive Relation $\omega = \sqrt{\frac{k}{m}}$. (SAG 2019 GI)

Ans. Consider an oscillating mass 'm' attached to spring as shown in figure.



When mass is pulled with force $\vec{F}$ toward right through distance x from mean position then

$$F = -kx \qquad \text{.....(1)}$$

By, Newton's 2nd law of motion

$$F = ma \qquad \text{.....(2)}$$

Comparing (1) and (2), we get

$$ma = -kx$$

$$a = -\frac{K}{m}x \qquad \text{.....(3)}$$

In case of circular motion

$$a = -\omega^2 x \qquad \text{.....(4)}$$

Comparing (3) and (4), we get

$$-\omega^2 x = -\frac{K}{m}x$$

or $$\omega^2 = \frac{K}{m}$$

or $$\omega = \sqrt{\frac{k}{m}} \qquad \text{.....(5)}$$

27. What are the factors on which frequency mass spring system depends. (SAG 2019 GI)

Ans. As we know that frequency of mass spring system is

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

It is clear from this equation that frequency will depend on value of spring constant k and the mass attatched to the spring.

SECTION III

Long Questions

From Punjab Boards:-

1. Derive the relation (i) acceleration, (ii) instantaneous velocity, for the projection of a partical moving around a circle. (LHR 2013: GI)
2. Show that the motion of projection of a body moving in a circle with constant speed is simple harmonic motion. (LHR 2013: GII)
3. Define simple harmonic motion. Derive the relation for instantaneous velocity for the projection of partical "P" moving in a circle. (LHR 2011, 2014: GII)
4. Define and explain simple pendulum. (LHR 2012: GI)
5. What is simple pendulum. show that its motion is simple harmonic motion. Also derive expression for its time period. (LHR 2012: GII, 2015: GI, 2017, 2018 GII) (GUJ 2014, 2015, 2016) (MUL 2013) (RAW GI, GII 2018) (BAH 2011) (FAS 2012, 2017) (DGK 2011, 2014) (SAG 2017) (SAW 2013, 2019 GI)
6. A block of mass 4.0 kg is dropped from a height of 0.80 m onto a spring of spring constant K = 1960 N/m. Find the maximum distance through which the spring will be compressed. (LHR 2014: GI) (GUJ 2011) (BAH 2013) (FAS 2012) (SAG 2019 GI) (RAW 2013) (DGK 2012, 2013, 2019 GI)
7. A simple pendulum is 50 cm long, what will be its frequency of vibration at a place where the value of g = 9.8 m/s^2. (LHR 2015: GII, 2018 GI) (GUJ 2014) (RAW 2014, 2019 GI) (MUL 2012, 2017) (FAS 2013, 2014) (SAG 2018 GII)
8. A simple pendulum is 80 cm long. What will be its period and frequency of vibration at a place where g = 9.8 ms^{-2}? (LHR 2017) (SAG 2019 GI)
9. What is simple harmonic motion? Show that the total energy of the vibrating mass spring system is constant. (GUJ 2012)
10. Explain energy conservation in S.H.M. (BAH 2019 GI) (MUL 2012: ANNUAL)
11. Derive expressions for the K.E and P.E of the mass spring system executing S.H.M. Also prove that its total energy remains conserved. (MUL 2011: SUPPLY) (SAW 2014)
12. Explain phenomena of resonance. Also give examples where resonance plays an important role. (MUL 2016)
13. Define simple pendulum. Show that its motion is S.H.M. (BAH 2012)
14. What should be the length of simple pendulum whose period is 1.0 second at a place where g = 9.8 m/s^2. What is the frequency of such a pendulum? (GUJ 2018 GI) (BAH 2014) (SAG 2013)
15. What is S.H.M? By drawing suitable diagram of simple pendulum evaluate the relation for its acceleration and natural time period. (FAS 2011)
16. A spring, whose spring constant is 80Nm^{-1}, vertically supports a mass of 1kg in the rest position. Find the distance by which the mass must be pulled down, so that on bring released, it may pass the mean position with velocity of 1ms^{-1}. (FAS 2016)
17. Define SHM. Derive expression for the instantaneous velocity of the projection of a particle, along diameter, that is moving in a circle of radius X_o with constant angular velocity w. (RAW 2011)
18. What is a simple pendulum? Show that time period of simple pendulum is directly proportional to square root of its length. (RAW 2016)
19. What is simple harmonic motion. Show that motion of mass, m attached to a spring of spring constant K is SHM. System is considered to be friction less. (SAG 2012)
20. Show that the motion of the projection of a particle moving around a circle is SHM and derive the relation for its instantaneous velocity. (SAG 2017)
21. Define simple harmonic motion. Prove that projection is particle moving in a circle on vertical diameter is a SHM. (MUL 2019 GI) (DGK 2017)
22. A 100g body hang 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? (SAW 2017)
23. Define SHM.

    Prove that the total energy of the vibrating a spring system remains constant. (LHR 2019 GI) (DGK GI 2018) (BAH 2019 GI)
24. A 100 g body is hung on a spring elongate 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? (SAG 2018 GI) (SAW GI 2018)
25. A block weighting 4 kg extends a spring by 0.16 m from its unstretched position. The block is removed and a 0.50 kg body is hung from the same spring. If the spring is now stretched and then released, what is the period of vibration? (LHR 2019)

CHAPTER — 8

WAVES

SECTION I

Multiple Choice Questions

From Punjab Boards:-

1) The speed of sound in air depends upon: (LHR 2013 GI)
   (a) Temperature (b) Humidity (c) Density (d) All of these
2) 10 waves pass through the medium in one sec. with speed of 10 m / s the wavelength of waves is: (LHR 2012)
   (a) 1 m (b) 10 m (c) 20 m (d) 100 m
3) Beats are used to find: (LHR 2013 GI)
   (a) Frequency (b) Wavelength (c) Intensity (d) Speed
4) The speed of sound has maximum value in: (LHR 2013 GII)
   (a) Oxygen (b) Air (c) Hydrogen (d) Hellium
5) Distance between two consecutive nodes is: (LHR 2013 GI)
   (a) λ (b) $\frac{\lambda}{4}$ (c) $\frac{\lambda}{2}$ (d) 2λ
6) If 20 waves pass through a medium in 1 sec with a speed of 20ms^{-1}, then the wavelength is: (LHR 2011)
   (a) 20 m (b) 40m (c) 400m (d) 1m
7) The wavelength of the fundamental mode of vibration of a closed pipe of length "ℓ" is: (LHR 2013 GII) (SAG 2013)
   (a) $\frac{\ell}{2}$ (b) ℓ (c) 2ℓ (d) 4ℓ
8) Speed of sound in aluminum at 20°C is: (LHR 2016)
   (a) 3600 m/s (b) 5100 m/s (c) 5130 m/s (d) 5500 m/s
9) The velocity of sound is greatest in (LHR 2016)
   (a) Steel (b) Air (c) Iron (d) Water
10) The velocity of sound in vacuum is (LHR 2016)
   (a) Zero (b) 332 m/s (c) 280 m/s (d) 330 m/s
11) Speed of sound in air at 20°C is (LHR 2016)
   (a) 333.2 ms^{-1} (b) 332.2 ms^{-1} (c) 331.2 ms^{-1} (d) 334.2 ms^{-1}
12) If a transverse wave has a speed of 100 ms^{-1} and frequency 100 Hz, then its wavelength is (LHR 2016)
   (a) 1 m (b) 10 m (c) 100 m (d) 1000 m
13) Beats cannot be recognized if difference of frequencies of two sound is. (LHR 2017)
   (a) Less than 10 Hz (b) More than 10 Hz (c) Less than 5 Hz (d) Less than 7 Hz
14) At constant temperature and pressure, if volume of given mass of a gas is doubled, then density of the ages becomes. (LHR 2017)
   (a) Double (b) $\frac{1}{4}$ of original (c) $\frac{1}{2}$ of original (d) Unchanged
15) If the pressure of the gas is doubled, then the speed of sound. (LHR 2017)
   (a) Is also doubled (b) Becomes half (c) Is not affected (d) Increase by four times
16) A stationary wave is established in a string which vibrates in four segments at a frequency of 120 Hz. Its fundamental frequency is. (LHR 2017)
   (a) 15Hz (b) 30Hz (c) 60Hz (d) 480Hz
17) For each degree Celsius rise in temperature of gas, the speed of sound through it increase by: (GUJ 2012)
   (a) 0.6 ms^{-1} (b) 0.61 ms^{-1} (c) 61 ms^{-1} (d) 6.1 ms^{-1}
18) The error in the value of speed of sound calculated by Newton at S.T.P. is about: (GUJ 2013)
   (a) 14 % (b) 15 % (c) 16 % (d) 20 %
19) The louder the sound, the greater will be its: (GUJ 2012)
   (a) Amplitude (b) Wavelength (c) Speed (d) Frequency
20) Which of the following does not have any effect on the speed of sound in gases? (GUJ 2011)
   (a) Temperature (b) Density (c) The ratio $\gamma = \frac{C_p}{C_v}$ (d) Pressure
21) If the pressure of the gas is doubled, then the speed of sound. (GUJ 2013)
   (a) Is also doubled (b) Becomes half (c) Is not affected (d) Increases by four times
22) Speed of sound in copper is (GUJ 2016)
   (a) 38000 ms^{-1} (b) 3600 ms^{-1} (c) 3500 ms^{-1} (d) 3400 ms^{-1}

23) Velocity of sound is independent of (GUJ 2016)
(a) Temperature (b) Pressure
(c) Density (d) Medium

24) The error in speed of sound calculated by Newton at STP is about (GUJ 2016)
(a) 0% (b) 14%
(c) 15% (d) 16%

25) The increase in speed of sound in air per degree Celsius is: (MUL 2012 SUPPLY)
(a) 0.61 ms^{-1} (b) 61 ms^{-1}
(c) 0.612 cms^{-1} (d) 61 kms^{-1}

26) If a string of length ℓ vibrates in n loops, the wavelength of stationary wave produced will be: (MUL 2011 ANNUAL)
(a) $\frac{2l}{n}$ (b) $\frac{nl}{2}$
(c) $\frac{l}{2n}$ (d) $\frac{2n}{l}$

27) If the speed of sound in air at a given pressure is V, then by increasing the pressure to double, the new speed becomes: (MUL 2012 ANNUAL)
(a) 0.5V (b) V
(c) 2V (d) 4V

28) Electromagnetic wave can travel in free space with velocity equal to: (MUL 2012 SUPPLY)
(a) $3 \times 106 ms^{-1}$ (b) $3 \times 107\ ms^{-1}$
(c) $3 \times 10^8\ ms^{-1}$ (d) $3 \times 109\ ms^{-1}$

29) For each degree rise in temperature (in Celsius) the speed of sound in gases increases by: (BAH 2016) (MUL 2011 SUPPLY)
(a) 0.61 cms^{-1} (b) 61 cms^{-1}
(c) 6.1 cms^{-1} (d) 0.61 cms^{-1}

30) The velocity of sound at 0°C is $332ms^{-1}$, the velocity of sound at 10°C will be: (MUL 2014)
(a) 337.1 ms^{-1} (b) 338.1 ms^{-1}
(c) 342.1 ms^{-1} (d) 348.1 ms^{-1}

31) If the organ pipe is open at one end and closed at the other, then its frequency of fundamental harmonic is: (MUL 2014)
(a) $f_1 = \frac{V}{2\ell}$ (b) $f_1 = \frac{V}{4\ell}$
(c) $f_1 = \frac{2\ell}{V}$ (d) $f_1 = \frac{4\ell}{V}$

32) Appropriate range of audible frequencies for younger persons is: (MUL 2013)
(a) 20-200Hz (b) 20-2,000 Hz
(c) 20-20,000 Hz (d) 2,000-20,000 Hz

33) In stationary wave one mode of vibration of the string having length ℓ is equal to: (MUL 2012 SUPPLY)
(a) λ (b) $\lambda/2$
(c) $\lambda/4$ (d) 2λ

34) The time period of a wave is 0.2 sec. Its frequency WILL BE: (MUL 2011 SUPPLY)
(a) 2Hz (b) 0.4 Hz
(c) 0.5 Hz (d) 5 Hz

35) For same mass and length if tension of a vibrating string is increased four times then speed of wave increased by: (MUL 2013)
(a) 2 times (b) 4 times
(c) 6 times (d) $\sqrt{2}$ times

36) Density is inversely proportional to (MUL 2016)
(a) Temperature (b) Volume
(c) Pressure (d) Work

37) Apparent change in the frequency of sound was observed by (MUL 2016)
(a) C.S Lewis (b) Einstein
(c) John Doppler (d) Laplace

38) The sound waves are slower in gases because the gases have. (MUL 2016)
(a) Smaller density (b) Avogadro number
(c) Smaller elasticity (d) Greater volume

39) Speed of sound in air is independent of (MUL 2016)
(a) Pressure (b) Density
(c) Elasticity (d) Temperature

40) Speed of sound at 0°C is (MUL 2016)
(a) 332 ms^{-1} (b) 350 ms^{-1}
(c) 340 ms^{-1} (d) 390 ms^{-1}

41) The speed of sound in air does not depend upon (MUL 2016)
(a) Density (b) Humidity
(c) Temperature (d) Pressure

42) The basic principle of beats is: (MUL 2017)
(a) Interference (b) Diffraction
(c) Reflection (d) Refraction

43) The speed of sound in vacuum is: (MUL 2017)
(a) 280 ms^{-1} (b) 332 ms^{-1}
(c) 333 ms^{-1} (d) Zero

44) Phase angle of 180° is equivalent to a path difference: (MUL 2017)
(a) $\frac{\lambda}{2}$ (b) $\frac{\lambda}{4}$
(c) 2λ (d) λ

45) If 20 waves passes through the medium in 2 sec with a speed of $10ms^{-1}$ then the wavelength is: (MUL 2017)
(a) 200m (b) 2m
(c) 1m (d) 0.5m

46) Beats are produced due to: (MUL 2017)
(a) Diffraction of sound waves
(b) Superposition of sound waves
(c) Polarization of waves
(d) Bernoulli's effect

47) Newton's formula for velocity of sound in gas/air is related as under: (BAH 2011)
(a) $v = \frac{E}{\delta}$ (b) $v = \sqrt{\frac{E}{\delta}}$
(c) $v = \sqrt{\delta E}$ (d) $V = \delta E$

48) The Laplace's equation for speed of sound in gas: (BAH 2012) (SAG 2013)
(a) $\sqrt{\frac{rP}{\delta}}$ (b) $\sqrt{\frac{E}{\delta}}$
(c) $\sqrt{\frac{P}{\delta}}$ (d) $\sqrt{\frac{RS}{\delta}}$

49) If the speed of sound in air at given pressure is "V", then doubling the pressure the new speed becomes equal to: (BAH 2011)
(a) 2V (b) 1.44 V
(c) V (d) 4 V

50) What is the value of constant β in the expression $V_t = V_o(1 + \beta t)$: (BAH 2014)
(a) 273 (b) $\frac{1}{273}$
(c) 0.61 (d) 1.42

51) The apparent change in the pitch of sound due to relative motion is called: (BAH 2014)
(a) Carnot theorem (b) Interference
(c) Doppler effect (d) Beats

52) If 30 waves per second pass through a medium at a speed of $30ms^{-1}$ the wavelength is: (BAH 2013)
(a) 30m (b) 15 m
(c) 1 m (d) 280 m

53) In standing wave if $\lambda = \ell$ (length of string) the number of loops will be: (BAH 2013)
(a) 1 (b) 2
(c) 3 (d) 4

54) At the open end of an organ pipe: (FAS 2011)
(a) Nodes are formed (b) Antinodes are formed
(c) Nodes or antinodes my be formed
(d) Neither node nor antinode is formed

55) The periodic increase and decrease in loudness of sound is called: (FAS 2012)
(a) Resonance (b) Interference
(c) Beats (d) Polarization

56) Periodic alternations of sound between maximum and minimum loudness are called. (FAS 2011)
(a) Interferce (b) Resonance
(c) Doppler's effect (d) Beats

57) If the organ pipe is open at both ends the frequency of fundamental harmonic is: (FAS 2013)
(a) $f_1 = \frac{V}{2l}$ (b) $f_1 = \frac{V}{4l}$
(c) $f_1 = \frac{4l}{V}$ (d) $f_1 = \frac{2l}{V}$

58) If the string is made to vibrate in n loops then the wavelength of the stationary wave will: (FAS 2013)
(a) $\lambda n = \frac{n}{2} l$ (b) $\lambda n = \frac{2}{n} l$
(c) $\lambda n = \frac{2n}{l}$ (d) $\lambda n = \frac{l}{2n}$

59) Newton calculated the speed fo sound in air taking constant (FAS 2016)
(a) Heat (b) Temperature
(c) Pressure (d) Volume

60) Number of beats when $f_1 > f_2$ can be calculated by (FAS 2016) (DGK 2017)
(a) $f_1 + f_2$ (b) $f_1 - f_2$
(c) $\frac{f_1 - f_2}{2}$ (d) $\frac{f_1 + f_2}{2}$

61) The speed of sound is greater in solids due to their high. (FAS 2016)
(a) Density (b) Pressure
(c) Temperature (d) Elasticity

62) The distance between 1st node and 4th antinode is: (FAS 2017)
(a) $\frac{7}{4}\lambda$ (b) $5\frac{\lambda}{4}$
(c) $13\frac{\lambda}{4}$ (d) $11\frac{\lambda}{4}$

63) The periodic variations of sound between maximum and minimum loudness are called: (FAS 2017)
(a) Doppler's effect (b) Reflection
(c) Laplace correction (d) Beats

64) The velocity of sound in vacuum is: (FAS 2017)
(a) 332 ms^{-1} (b) 280 ms^{-1}
(c) Zero (d) 333 ms^{-1}

65) Laplace expression for the speed of sound in a gas is: (RAW 2011)
(a) $v = \sqrt{\frac{P}{\delta}}$ (b) $v = \frac{P}{\delta}$
(c) $v = \sqrt{\frac{rP}{\delta}}$ (d) $v = \sqrt{\frac{rP}{\delta}}$

66) Which one is correct relation for one end close pipe. (RAW 2013)
(a) $\lambda_n = 2l/n$ (b) $\lambda_n = 4l/n$
(c) $\lambda_n = nv/l$ (d) $\lambda_n = nv/4l$

67) Speed of sound at t °C is given as: (RAW 2013)
(a) $v_t = v_o + 0.61t$ (b) $v_t = v_o - 0.61t$
(c) $v_t = v_o + 61t$ (d) $v_t = v_o - 61t$

68) Beats can be heared when the difference of frequency is not more than: (RAW 2011)
(a) 8 (b) 4
(c) 10 (d) 6

69) With increase of temperature, speed of sound. (RAW 2014)
(a) remains constant (b) becomes zero
(c) decreases (d) increases

70) Two tuning forks of frequencies 240Hz and 243Hz are sounded together the number of beats per second is: (RAW 2014)
(a) zero (b) 4
(c) 3 (d) 2

71) Velocity of sound is independent of (RAW 2016)
(a) Temperature (b) Density
(c) Pressure (d) Medium

72) The correct relation is (RAW 2016)
(a) $V = \lambda T$ (b) $\lambda = \frac{V}{T}$
(c) $v = \frac{\lambda}{f}$ (d) $v = f\lambda$

73) Speed of sound in copper is (RAW 2016)
(a) $38000 mS^{-1}$ (b) $3600 mS^{-1}$
(c) $3500 mS^{-1}$ (d) $3400 mS^{-1}$

74) The speed of sound is greater in solids than in gases due to their high: (RAW 2017)
(a) Temperature (b) Pressure
(c) Density (d) Elasticity

75) Beats cannot be heard if the difference of frequencies is more than: (RAW 2017)
(a) 10Hz (b) 9Hz
(c) 6Hz (d) 4Hz

76) When sound waves enter in different medium, the quantity that remains unchanged is: (RAW 2017)
(a) Intensity (b) Speed
(c) Frequency (d) Wavelength

77) The velocity of sound in vacuum is: (RAW 2017)
(a) Zero m/sec (b) 280 mS^{-1}
(c) 332 mS^{-1} (d) 300 mS^{-1}

78) Sound waves can travel only through. (SAG 2013)
(a) Vacuum (b) Ether
(c) Material medium (d) None metals

79) When path difference in an integral multiple of wave lengths, the effect is called: (SAG 2012)
(a) Coherency (b) Distructive interference
(c) Constructive interference
(d) Phase lag

80) Beats can be hear difference of frequency is not more than: (SAG 2017)
(a) 8 Hz (b) 10 Hz
(c) 12 Hz (d) 16 Hz

81) Frequency range of hearing of cats is: (SAG 2017)
(a) 20 – 20000 Hz (b) 10 – 10000 Hz
(c) 60 – 20000 Hz (d) 60 – 70000 Hz

82) The distance between a compression and its adjacent rarefaction is: (SAG 2017)
(a) $\frac{\lambda}{2}$ (b) λ
(c) 2λ (d) $\frac{\lambda}{4}$

83) The wavelength of a transverse wave traveling with speed 'V' having frequency 'f': (SAG 2017)
(a) $\frac{f}{v}$ (b) vf
(c) $\frac{v}{f}$ (d) $\frac{f}{v^2}$

84) In a organ pipe which is open at one end and closed at other, the frequency of fundamental note is: (SAG 2017)
(a) $f_1 = \frac{v}{4l}$ (b) $f_1 = \frac{4l}{v}$
(c) $f_1 = \frac{v}{2l}$ (d) $f_1 = \frac{2l}{v}$

85) The waves used in radar speed trap are: (SAG 2017)
(a) Longitudinal (b) Sound waves
(c) Microwaves (d) Matter waves

86) The value of 'γ' for monatomic gas is: (DGK 2014)
(a) 1.67 (b) 1.40
(c) 1.29 (d) 1.45

87) According to Newton's formula the speed of sound in air it STP is: (DGK 2014)
(a) 332 mS^{-1} (b) 340 mS^{-1}
(c) 350 mS^{-1} (d) 280 mS^{-1}

88) The increase is sound in air per degree Celsius is: (DGK 2013)
(a) 0.61 ms^{-1} (b) 61 ms^{-1}
(c) 0.61 cms^{-1} (d) 61 kms^{-1}

89) Velocity of sound in space at 0°C. (DGK 2012)
(a) 332ms^{-1} (b) 224ms^{-1}
(c) 76ms^{-1} (d) 0

90) The pitch of sound depends upon: (DGK 2017)
(a) Intensity of sound (b) Wavelength of sound
(c) Frequency of sound (d) Loudness of sound

91) The velocity of sound in vacuum is: (DGK 2017)
(a) 280 mS^{-1} (b) 333 mS^{-1}
(c) 380 mS^{-1} (d) Zero mS^{-1}

92) If the pressure of the gas is doubled then speed of sound in such a gas: (DGK 2017)
(a) Doubled (b) 4 times
(c) Reduced to half (d) Remains same

93) With the rise of temperature, the velocity of sound. (SAW 2014)
(a) decreases (b) increases
(c) remains constant (d) becomes double

94) If a strentched string vibrate in three loops. Then relation between its length and wavelength of stationary wave is: (SAR GI 2018)
(a) $\frac{3\ell}{2}$ (b) $\lambda = 3\ell$
(c) $\lambda = \frac{2\ell}{3}$ (d) $\lambda = 3\ell$

95) Maximum velocity in SHM is: (MUL 2013)
(a) $x_o w^2$ (b) $x_o w$
(c) xw (d) $x_0^2 w$

96) Beats detectable easily upto frequency difference between two sounds is: (MUL 2013)
(a) 2 Hz (b) 6 Hz
(c) 10 Hz (d) 32 Hz

97) If stretching force "T" of a wire is increased then its frequency (BAH 2013)
(a) Decreases (b) Increases
(c) Remains the same (d) One half

98) If a stretched string 2m and it has 4 loops of stationary waves them wavelength is: GUJ 2018)
(a) 4m (b) 3m
(c) 2m (d) m

99) The value of "γ" for diatomic gas is: (LHR 2011)
(a) 1.67 (b) 1.40
(c) 1.29 (d) Infinity

100) Distance between adjacent node and antinode is: (LHR 2019 GI)
(a) λ (b) $\frac{\lambda}{2}$
(c) $\frac{\lambda}{4}$ (d) $\frac{\lambda}{3}$

101) Speed of sound at 0°C, in air is: (LHR 2019 GI)
(a) 332 ms^{-1} (b) 280 ms^{-1}
(c) 1400 ms^{-1} (d) 5500 ms^{-1}

102) On loading the prong of tuning forks with wax, the freqeuncy of sound. (RAW 2019 GI)
(a) Increase (b) Decreases
(c) Remain same
(d) Periodic increas and decrease

103) If speed of sound in air at a given pressure is "V" and now if pressure is doubled then new speed will be: (MUL 2019 GI)
(a) 2V (b) $\frac{V}{2}$
(c) V (d) 4V

104) It becomes difficult to recognize the beats when the difference between the frequencies of two sounds is more than: (DGK 2019 GI)
(a) 10 Hz (b) 20 Hz
(c) 30 Hz (d) 40 Hz

105) The speed of sound in vacuum is: (DGK 2019 GI)
(a) 330 ms^{-1} (b) 332 ms^{-1}
(c) 3×10^8 ms^{-1} (d) zero

106) Two tuning forks of frequencies 261 Hz and 258 Hz are sounded togather, the number of beats per second are: (SAG 2019 GI)
(a) 3 (b) 2
(c) 261 (d) 258

107) Speed of sound in Hydrogen is higher than in Oxygen by times: (SAG 2019 GI)
(a) 4 (b) 6
(c) 8 (d) 16

108) The number of beats produced per sec. in two tuning forks is equal to: (SAW 2019 GI)
(a) sum of two frequencies
(b) ratio of two frequencies
(c) the frequency of either of two tuning fork
(d) the difference of the frequencies of two tuning forks

109) Newton calculated speed of sound in air using the process: (BAH 2019 GI)
(a) Adiabatic (b) Isobaric
(c) Isochoric (d) Isothermal

110) In a stretched string, if speed of the wave is doubled, the tension in string will increase by: (BAH 2019 GI)
(a) 2 (b) 4
(c) 6 (d) 8

Entry Test MCQ's

1) A Standing wave pattern is formed when the length of string is an integral multiple of _____ wavelength. (2008)
(a) Triple (b) Full
(c) Hlaf (d) Double

2) Two waves of slightly different frequencies and tavelling in same direction produce_____. (2008)
(a) Interference (b) Polarization
(c) Stationary waves (d) Beats

3) A 2m long pipe is open at both ensds. What is tis harmonic frequency? (2008)
(a) 42.5 Hz (b) 85 Hz
(c) 220 Hz (d) None of these

4) If a particle of mass 5.0 mg moves with the speed of 8.0 m/sec, then the de-Broglie's wavelength will be: (2009)
(a) 1.68×10^{-27} m (b) 1.70×10^{-25} m
(c) 1.65×10^{-29} m (d) 1.66×10^{-29} m

5) Two waves of slightly different frequencies and travelling in the same direction lead to: (2009)
(a) Stationary Waves (b) Interference
(c) Beats (d) All of these

6) What is it that we use to calculate the speeds of distant stars and galaxies? (2009)
(a) Doppler Effect (b) Interference
(c) Beats (d) All of the above

7) Speed of the waves is equal to: (2009)
(a) $f\lambda$ (b) $\frac{\lambda}{T}$
(c) Both A and B (d) λT

8) In a simple pendulum, the tension of the string is: (2010)
(a) $g\cos\theta$ (b) $mg\sin\theta$
(c) $mg\cos\theta$ (d) mg

9) Two sound waves having the same amplitudes are moving in the same direction are out of phase. The amplitude of the resultant wave is: (2010)
(a) Zero amplitude
(b) The sum of amplitude of the two waves
(c) Diffeence of the amplitudes of the two waves
(d) Double the amplitude of either wave

10) 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: (2010)
(a) 244 Hz (b) 236 Hz
(c) 248 Hz (d) 246 Hz

11) 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: (2011)
(a) $\frac{v}{f}$ (b) vf
(c) $\frac{v-u_o}{f}$ (d) $(v-u_o)f$

12) When the source of sound moves towards the stationary observer, the value of apparent frequency 'f_o' is: (2012)
(a) $f_o=\left(\frac{v+u_i}{v}\right)f$ (b) $f_o=\left(\frac{v}{v-u_i}\right)f$
(c) $f_o=\left(\frac{v}{v+u_i}\right)f$ (d) $f_o=\left(\frac{v-u_i}{v}\right)f$

13) 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? (2012)
(a) $f=v\lambda$ (b) $f=\frac{\lambda}{v}$
(c) $f=\frac{v}{\lambda}$ (d) $f=v\lambda^{-2}$

14) An observer moves with velocity 'v_o' toward a stationary source, then the number of waves received in one second is: (2015)
(a) $f'=f\left(\frac{v}{v+v_o}\right)$ (b) $f'=f\left(\frac{v}{v-v_o}\right)$
(c) $f'=f\left(\frac{v+v_o}{v}\right)$ (d) $f'=f\left(\frac{v-v_o}{v}\right)$

SECTION II

SHORT QUESTIONS

From Punjab Boards

1. Explain why sound travels faster in warm air than in cold air?(LHR 2011, 2013: GI, 2013:GII, (LHR 2014: GI, 2014: GII 2015: GI) (MUL 2011, 2012, 2016) (SAG 2012, 2019 GI) (BAH 2011, 2019 GI) (FAS 2016) (RAW 2012) (DGK 2012, 2013, 2014, 2019 GI) (SAW 2013)

Ans. Due to rise in temperature volume of gas is increased due to which its density (p) decreased, then it is clear form the formula of velocity of sound in air, $\left(\text{i.e., } v=\sqrt{\frac{E}{p}}\right)$ when 'p' becomes small 'v' becomes large.

Hence sound travels faster in warm air then in cold air.

2. What is the velocity of sound in air, if temperature of air is 20°C? (LHR 2012)

Ans. Data $V_f = ?$, $T = 20°C$

Formula: $\frac{V_t}{V_o} = \sqrt{1+\frac{t}{273}}$

Solution:

$$\frac{V_t}{V_o} = \sqrt{1+\frac{t}{273}}$$

$$\frac{V_t}{V_o} = \sqrt{\frac{273+t}{273}}$$

Putting the values in eq., (i),

$$\frac{V_t}{332} = \sqrt{\frac{273+20}{273}}$$

$$\frac{V_t}{332} = \sqrt{\frac{293}{273}}$$

$$\frac{V_t}{332} = \sqrt{1.073}$$

$$\frac{V_t}{332} = 1.03$$

$$V_t = 1.03\times 332$$

$$= 343.9\ ms^{-1}$$

$$\cong 344 ms^{-1}$$

3. How are beats useful in tuning musical instruments? (LHR 2011, 2013, GII, 2014: GI, 2019 GI) (GUJ 2012, 2016) (MUL 2011, 2012, 2019 GI) (BAH 2014) (FAS 2011, 2014, 2016) (RAW 2012, 2013, 2015) (SAG 2012) (DGK 2012, 2014)

Ans. One can use beats note to tune a string instrument such as piano or violin. By beating a note against a note of known frequency by adjusting the tightening or loosing until no beats are heard.

4. What should be the path difference between two waves for destructive interference? (LHR 2016)

Ans. For destructive interference the path difference should be an odd integral multiple of half the wavelength, $\Delta s = (2n+1)\frac{\lambda}{2}$, where n = 0, 1, 2....

5. What are the conditions for constructive and destructive interference? (LHR 2014, 2019 GI) (GUJ 2012, 2016) (MUL 2016) (BAH 2012) (FAS 2012, 2017) (RAW 2014, 2016, 2017) (DGK 2012, 2014) (SAG 2013, 2017) (SAW 2013)

Ans. For constructive interference the path difference between the interfering waves must be equal to an integral multiple of wavelength, i.e.,

$$\boxed{\text{path difference} = n\lambda,\ n = 0, 1, \ldots.}$$

For destructive interference, the path difference must be equal to half an odd integral multiple of wavelength, i.e.,

$$\boxed{\text{path difference} = (2n+1)\frac{\lambda}{2},\ n = 0, 1, 2, \ldots.}$$

6. What do you observe in the collective effect of dots in the form of picture. (LHR 2017)

Ans. If we look back and white picture in a newspaper with magnifying glass, we observed the picture is made of many closed space dots. If we not use magnifying glass, we don't see the dots. So we can say that collective effects of dots appear in the form of picture.

7. Why sound travel faster in hydrogen than in oxygen. (LHR 2017)

Ans. As speed of sound is calculated as

$$V = \sqrt{\frac{rp}{\delta}}$$

At same temperature and pressure for the gases having same value of δ. So the velocity is inversely proportional to the square root of their densities. Thus the speed of sound in hydrogen is four times its speed in oxygen as density of oxygen is 16 times that of hydrogen.

8. Why does sound travels faster in solids than in gases? (MUL 2012: SUPPLY, 2019 GI) (GUJ 2011, 2013, 2014, 2015) (SAG 2013, 2019 GI) (FAS 2012, 2017) (BAH 2011, 2012, 2014) (RAW 2011, 2013, 2015, 2016, 2019 GI) (DGK 2011, 2014 GI) (SAW 2013, 2014)

Ans. The speed of sound in a medium of elasticity e and density ρ is given by.

$$V = \sqrt{\frac{E}{\delta}}$$

The density of solid is greater than density of a gas. But at the same time, the modulus of elasticity (E) of solid is far greater than that of a gas. So the ratio becomes greater for solid than in $\sqrt{\frac{E}{\delta}}$ a gas. Hence sound travel faster in slid than in gases.

9. Describe the effect of density on the speed of sound in gases. (LHR 2019 GI) (MUL 2012: SUPPLY) (BAH 2014) (DGK 2019 GI) (SAG 2018 GII)

Ans. The speed of sound is given by $v=\sqrt{\frac{\gamma p}{\rho}}$. At the same temperature and pressure for gases having the same value of γ, the speed is inversely proportional to the square root of their densities.

$$V \times \frac{1}{\sqrt{\rho}}$$

10. What is the effect of temperature on speed of sound in gas? (LHR 2019 GI) (MUL 2014) (FAS 2013)

Ans. The speed of sound in gas varies directly as the square root of its absolute temperature.

$V \times \sqrt{T}$

Or $V = \text{costant} \times \sqrt{T}$ – ①

Similarly for temperature T_1K and T_2k, we have.

$V = \text{constant}\sqrt{T_1}$ and $V_2 = \text{constant}\sqrt{T_2}$

And

$$\frac{V_2}{V_1} = \sqrt{\frac{T_2}{T_1}}$$

It shows that $V \propto \sqrt{T}$

11. Why does sound travel faster in solids than in gases. (MUL 2016)

Ans. As molecules in solids are very close to each other than in gases. So they give very quick response to any disturbance that is why speed of sound in solid is greater than that of gases.

12. How should a sound source move with respect to an observer so that frequency of its sound does not change. (MUL 2016) (GUJ 2011, 2015)

Ans. If sound source and observer move in such a way. That their relative velocity is zero, then, the apparent change of frequency of sound does not change.

13. Explain why sound travels faster in warm air than in cold air? (FAS 2012) (SAR 2018 II)

Ans. Due to rise in temperature volume of gas is increased due to which its density (ρ) decreased, then it is clear from the formula of velocity of sound in air, $\left(\text{i.e., } =\sqrt{\frac{E}{\rho}}\right)$ when 'ρ'. Hence sound travels faster in warm air then in cold air.

14. Speed of sound in air at 0°C is 332 m/s. Find its speed 20°C. (FAS 2013)

Ans. $v_t = V_0 + 0.61t$

$v_t = 33 + 0.61\ (20) = 332 + 12.2$

$v_t = 344.2$ m/ sec

15. What is the effect of pressure on the speed of sound? (FAS 2013) (BAH 2019 GI) (RAW 2011) (DGK 2013, 2014 GI)

Ans. Since density is proportional to the pressure, the speed of sound is not affected by a variation in the pressure of the gas.

16. Which is richer in harmonics? As open organ pipe or a closed organ pipe? (FAS 2014)

Ans. An open organ pipe is richer in harmonics as compared to closed organ pipe.

17. If wave length of wave is 0.02m and frequency is 0.5 Hz. Then find its velocity. (FAS 2016)

Ans. $\lambda = 0.02m$

$f = 0.5\ Hz$

$V = ?$

$V = f\lambda = 0.5 \times 0.02 = 0.01\ ms^{-1}$

18. How temperature of the medium effect the speed of sound. (FAS 2017)

Ans. Effect of Temperature:

As, $V_t = V_0 + 0.61t$

This shows that 1° degree Celsius rise in temperature produces approximately 0.61 ms^{-1} increase in speed of sound.

19. What are beats? (RAW 2016) (SAG 2018 GII)

Ans. When two tuning forks of slightly different frequencies are sounded together at the same time, the periodic alternations of sound between maximum and minimum loudness are called beats.

The number of beats produced per second is equal to the difference between the frequencies of the tuning forks. Beats are produced as a result o interference.

(i) They beats can be used to tune a string instrument.

(ii) They can be used to find the unknown frequencies.

37. What is effect of temperature on speed of sound. (LHR 2019 GI) (RAW 2017)

Ans. As we know that.

$V_t = V_0 + 0.61t$

This shows that 1° degree Celsius rise in temperature produces approximately 0.61 ms^{-1} increase in speed of sound.

20. Find the temperature of air if the velocity of sound is 340 ms^{-1} at that temperature. (SAG 2017)

Ans. As we know that.

$V_t = V_0 + 0.61t$ ..... (1)

Where, $V_t = 340\ ms^{-1}$, $V_0 = 332\ ms^{-1}$ at 20°C.

So from equation (1).

$V_t - V_0 = 0.61t$

$t = \frac{V_t - V_0}{0.61}$

$t = \frac{340 - 332}{0.61}$

$t = 13°C$

Thus the total temp of air is.

$t = 20°C + 13°C = 33°C$

21. Speed of sound in air at 0°C is 332 ms^{-1}. Find its speed at 15°C. (DGK 2017)

Ans. $v_t = v_0 + 0.61\ (t)$

$v_t = 332 + 0.61\ (15)$

$= 332 + 9.15$

$v_t = 341.15\ ms^{-1}$

So at 15°c. The speed of sound will be 341.5 ms^{-1}.

SECTION III

Long Questions

From Punjab Boards:-

1. Two tuning forks exhibit beat at a beat frequency of 3 Hz. The frequency of one of the fork is 256 Hz. Its frequency is then lowered by adding a bit of wax to one of its prongs. The two tuning forks then exhibit a beat frequency of 1 Hz. Determine the frequency of second tuning fork. (LHR 2013: GII) (BAH 2019 GI)
2. The frequency of note emitted by a stretched string is 300 Hz. What will be frequency of this note when the tension is increased by one third without changing the length of the wire? (LHR 2012: GII, 2013: GI, 2014: GII)
3. A stationary wave is established in a string which is 120 cm long and fixed at both ends. The string vibrated in four segments, at frequency of 120 Hz. Determine its wavelength and the fundamental frequency. (LHR 2012: GI , 2015: GI, 2019 GI) (MUL 2019 GI) (BAH 2012, 2016) (FAS 2017) (SAG 2019 GI)
4. A pipe has a length of 1 meter. Determine the frequencies of the fundamental and the first two harmonics if the pipe opens at both ends. (Speed of sound in air = 340 ms^{-1}) (LHR 2011) (SAG 2017)
5. Define and explain interference of sound waves. What are its kinds and condition. (LHR 2014: GI)
6. What are stationary waves? Describe the stationary waves produced in a stretched string and prove that their frequencies are quantized. (LHR 2017) (DGK 2019 GI)
7. A pipe has a length of 1 m. Determine the frequencies of fundamental and the first two harmonics: (i) if pipe is open at both ends, (ii) if pipe is closed at one end. (LHR 2017)
8. What is drawback of Newton's formula for speed of sound in air? How Laplace corrected it? (GUJ 2013) (FAS 2012)
9. The frequency of the note emitted by a stretched string is 300 Hz. What will be the frequency of this note. When the length of the sire is reduced by one-third with out changing the tension? (GUJ 2012)
10. A church organ consists of pipes each open at one end of different lengths. The minimum length is 30mm and the longest is 4m. Calculate the frequency range of the fundamental notes. (Speed of sound = 340 m/s) (GUJ 2014) (DGK 2011) (SAW 2013)

11. Find the temperature at which the velocity of sound in air is two times its velocity at 10°C. (BAH 2011) (MUL 2011: Supply , 2012: Annual) (FAS 2011) (RAW 2011) (DGK 2014) (SAG 2017) (SAW 2014)
12. Define fundamental frequency. Show that harmonics are the integral multiple fundamental frequency for stationary waves is the string. (MUL 2011: ANNUAL)
13. An organ pipe has a length of 50cm. Find the frequency of its fundamental note and the next harmonic when its is (a) open at both ends(b) closed one end. (GUJ2015) (MUL 2014) (BAH 2019 GI) (SAG 2012) (DGK 2017)
14. How the speed of sound was calculated by Newton and it was corrected by Laplace? (MUL 2017)
15. What is the effect of temperature on speed of sound. Derive mathematical expression for it as $v_t = v_o + 0.67$ t. (BAH 2014, 2016) (FAS 2013)
16. How Laplace correct the Newton's formula for velocity of sound. (DGK 2013)
17. An organ pipe ahs a length of 50cm. Find the frequency of its fundamental note and the next harmonic when is opened at both ends. Speed of sound = 350 ms^{-1}. (LHR GII 2018)
18. Speed of sound in air at 0°C is determined by Newton's formula $V = \sqrt{\frac{E}{\delta}}$. Why this formula could not give accurate velocity? Derive the correct formula by using Laplace correction. (GUJ GI 2018)
19. A pipe has length of one meter. Determine the frequencies of the fundamental and the first two harmonics. If the pipe is open at both ends. (Speed to sound in air = 340 ms^{-1}) (DGK GI 2018)
20. Describe Newton's formula for the speed of sound in air and explain how it was corrected by Laplace? (RAW 2019 GI) (SAR GI 2018) (SAW 2019 GI)

CHAPTER — 9

PHYSICAL OPTICS

SECTION I

Multiple Choice Questions

From Punjab Boards:-

1) The effective path difference between two reflected, in x-rays diffraction by crystals is: (LHR 2012)

(a) $d\sin\theta$ (b) $2d\sin\theta$

(c) $d\sin\left(\frac{\theta}{2}\right)$ (d) $d\sin(2\theta)$

2) The distance between two consecutive wave fronts is called: (LHR 2011)

(a) Time period (b) Frequency

(c) Wavelength (d) Displacement

3) The equation of Micheelson's interferometer is: (LHR 2013 GII) (GUJ 2016)

(a) $L = \frac{m\lambda}{2}$ (b) $L = \frac{m\lambda}{4}$

(c) $L = m\lambda$ (d) $L = 2m\lambda$

4) The distance between two adjacent bright or dark fringes is (LHR 2016)

(a) $\Delta y = \frac{L\lambda}{d}$ (b) $\Delta y = \frac{\lambda}{d}$

(c) $\Delta y = \frac{\lambda}{Ld}$ (d) $\Delta y = Ld\lambda$

5) According to Hygen's principle, each point on a wave front acts as a source of. (LHR 2017)

(a) Secondary wavelet (b) Primary wavelet

(c) New wave front (d) Sound

6) Newton's rings are formed as a result of. (LHR 2017)

(a) Interference (b) Dispersion

(c) Diffraction (d) Polarization

7) Bending of light around the edges of an obstacle is known as: (GUJ 2013) (MUL 2012)

(a) Refraction (b) Polarization

(c) Diffraction (d) Interference

8) The phase between two points on the same wave front is (GUJ 2016)

(a) 2π (b) π

(c) $\frac{\pi}{2}$ (d) 0

9) Number of colours used in the process of colour printing to produce the entire range of colours is: (MUL 2012 ANNUAL)

(a) Four (b) Five

(c) six (d) Seven

10) Optical rotation, a property of optically active substances can be used to determine their: (MUL 2012 ANNUAL)

(a) Density (b) Viscosity

(c) Concentration in solutions

(d) elasticity

11) The fringe spacing increases if we use: (MUL 2014)

(a) Red light (b) Blue light

(c) Green light (d) Yellow light

12) Brilliant and beautiful colours in soap bubbles are du to: (MUL 2011 ANNUAL) (DGK 2012

(a) Diffraction of light

(b) Polarization of light

(c) Interference of light

(d) Reflection of light

13) The distance between two adjacent dark fringes is given by: (MUL 2013) (RAW 2014) (DGK 2017)

(a) $\Delta y = \frac{\lambda L}{d}$ (b) $\Delta y = \frac{m\lambda L}{d}$

(c) $\Delta y = \left(m + \frac{1}{2}\right)$ (d) $\Delta y = \frac{\lambda d}{L}$

14) The Michel son's interferometer is used to find: (MUL 2011 SUPPLY)

(a) The refractive index of glass
(b) The kickness of glass plate
(c) The distance with very high precision
(d) Optical rotation

15) A surface on which all the points have same phase of vibration is known as: (MUL 2012)

(a) Crest (b) Trough
(c) Wave front (d) Wavelength

16) $2d \sin\theta = n\lambda$ is called (MUL 2016)

(a) Laplace's equation (b) Reflection equation
(c) Refraction equation (d) Bragg's equation

17) Diffraction is a special type of (MUL 2016)

(a) Reflection (b) Polarization
(c) Interference (d) Refraction

18) The fringe spacing in a double slit experiment can be increased by decreasing: (MUL 2017)

(a) Wavelength of light
(b) Width of slits
(c) Slit separation
(d) Distance between the slits and the screen

19) A typical diffraction grating has certain number of lines per centimeter whose range is: (BAH 2014)

(a) 40 to 50 (b) 4000 to 5000
(c) 400 to 500 (d) 400 to 5000

20) The center Newton's Rings is _____ due to destructive interference: (BAH 2012)

(a) Bright (b) Dark
(c) Colourless (d) Red

21) A diffraction grating has 5000 lines/cm. Its grating element will be: (BAH 2011)

(a) 2.0×10^{-6} m (b) 2.0×10^{-4} m
(c) 1.0×10^{-6} m (d) 1.0×10^{-4} m

22) The blue colour of the sky is due to: (BAH 2013)

(a) Diffraction (b) Reflection
(c) Polarization (d) Scattering

23) Light entering into glass prism from air does not give change in its: (BAH 2011)

(a) Frequency (b) Wave length
(c) Velocity (d) Direction

24) The center of Newton rings is dark due to: (FAS 2013)

(a) Constructive interference
(b) Destructive interference
(c) Diffraction (d) Polarization

25) The medium in which speed of light in the same in all directions is called: (FAS 2011)

(a) Homogenous (b) Heterogenous
(c) Non-homogeous (d) Free space

26) Light from sun reaches the earth in form of: (FAS 2013)

(a) Spherical wave front (b) Plane wave front
(c) Elliptical wave front
(d) Hyperbolic wave front

27) Soap film in sunlight appears coloured due to (FAS 2016)

(a) Diffraction (b) Scattering
(c) Interference (d) Dispersion

28) The fringe spacing increases if we use (FAS 2016)

(a) Red light (b) Blue light
(c) Yellow light (d) Green light

29) In Young's double slit experiment, the position for bright fringe is: (FAS 2017)

(a) $Ym = m\frac{\lambda d}{L}$ (b) $Ym = \frac{m\lambda}{Ld}$

(c) $Ym = \frac{m\lambda L}{d}$ (d) $Y_m = \frac{mLd}{\lambda}$

30) The distance between two adjacent bright fringes Δy is: (RAW 2011)

(a) $\frac{2\lambda L}{d}$ (b) $\frac{3\lambda L}{d}$

(c) $\frac{\lambda L}{2d}$ (d) $\frac{\lambda L}{d}$

31) The phase difference between two points on wave front is: (RAW 2013)

(a) Zero (b) $\pi/4$
(c) $\pi/2$ (d) π

32) The central point of Newton's Ring is (RAW 2016)

(a) Bright (b) Dark
(c) Blue (d) Red

33) Fring spacing is equal to (RAW 2016) (SAG 2017)

(a) $\frac{\lambda D}{L}$ (b) $\frac{\lambda L}{d}$

(c) $\frac{L}{\lambda D}$ (d) $\frac{dL}{\lambda}$

34) Michelson interferometer can be used to find the: (RAW 2017)

(a) Wavelength of light (b) Wavelength of sound
(c) Velocity of sound (d) Velocity of light

35) Diffraction is a special type of (SAG 2013)

(a) Polarization (b) Interference
(c) Reflection (d) Refraction

36) All waves fronts are concentric: (SAG 2012)

(a) Circles (b) Squares
(c) Spheres (d) Rectanglea

37) If 'N' is number of lines ruled on the grating having length 'L' then grating element 'd' is given by: (SAG 2017)

(a) $\frac{N}{L}$ (b) $\frac{2N}{L}$

(c) $\frac{L}{N}$ (d) $\frac{N}{2L}$

38) Bending off light around the edges of an obstacle is known as: (DGK 2013)

(a) Interference (b) Polarization
(c) Diffraction (d) Refraction

39) An oil film on water surface shown colour due to: (DGK 2014)

(a) Diffraction (b) Interference
(c) Polarization (d) Dispersion

40) The Micholson interferometer is used to find. (DGK 2012)

(a) The refractive index of glass
(b) The thickness of glass plate
(c) The distance with very high precision
(d) Optical rotation

41) Newton's rings are formed due to phenomenon of: (DGK 2017)

(a) Diffraction of light (b) Interference of light
(c) Polarization of light (d) Total internal reflection

42) Two light waves which are not coherent cannot produce. (SAW 2014)

(a) interference (b) diffraction
(c) polarization in same plane (d) return back

43) Wavelength of X-rays is of the order of: (SAW 2013)

(a) 10^{-10}m (b) 10^{-8}m
(c) 10^{-1}m (d) 10^{-4}m

44) If blue light is used at compared to red light then final spacing

(a) Increase (b) decrease
(c) remains same (d) becomes zero

45) The magnifying power of an astronomical isle scope is 10 if the focal length of objectives is 100cm the what is the focal length of eye piece?

(a) 10cm (b) minimum
(c) maximum (d) negative

46) Angle between a ray and wave front is: (SAR GII 2018)

(a) 180° (b) 0°
(c) 90° (d) 45°

47) $2d \sin\theta = n\lambda$ is called: (BAH 2012)

(a) Laplace's equation (b) Reflection equation
(c) Refraction equation (d) Bragg equation

48) Bragg's equation is: (LHR 2019 GI)

(a) $2d \sin\theta = \frac{\lambda}{2}$ (b) $d \sin\theta = n\lambda$

(c) $d \sin\theta = n\frac{\lambda}{2}$ (d) $d \sin\theta = 2\lambda$

49) Fringe spacing increases if we use: (LHR 2019 GI)

(a) Red light (b) Blue light
(c) Yellow light (d) Green light

50) Soap film shows colours due to: (RAW 2019 GI)

(a) Interference (b) Diffraction
(c) Polarization (d) Reflection

51) Fringe spacing increases if we use: (LHR 2019 GI)

(a) lowest order (b) highest order
(c) red light (d) blue light

52) In case of point source, shape of the wavefront is: (MUL 2019 GI)

(a) Plane (b) Spherical
(c) Circular (d) Ellipitical

53) Bending of light around the edges of an obstacle is called: (DGK 2019 GI)

(a) Refraction (b) Interference
(c) Polarization (d) Diffraction

54) Which of the following waves can not be polarized: (SAG 2019 GI)

(a) X-Rays (b) Light waves
(c) Sound waves (d) Infrared rays

55) When a mirror of Michelson interferometer is moved a distance of 0.5 mm, then 2000 frings are observed, the wavelength of light used is: (SAW 2019 GI)

(a) $5000 \times 10^{-10}m$ (b) $500 \times 10^{-9}m$
(c) $1000 \times 10^{-7}m$ (d) $5000 \times 10^{-7}m$

56) The locus of all points in the same phase of vibration is: (BAH 2019 GI)

(a) Wavefront (b) Wavelength
(c) Crest (d) Trough

Entry Test MCQ's

1) Speed of light, radio waves and microwaves in vacuum is: (2009)

(a) 3×10^5 ms^{-1} (b) 3×10^3 ms^{-1}
(c) 3×10^6 ms^{-1} (d) 3×10^8 ms^{-1}

2) In Young's Double Slit Experiment, if the distance between slits and screen is doubled, then frings spacing becomes: (2009)

(a) Zero (b) One
(c) Doubles of the original value
(d) Half of the original value

3) 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 quation $1 = m\frac{\lambda}{2}$ the wavelength of light used is: (2009)

(a) 588 nm (b) 620 nm
(c) 348 nm (d) 400 nm

4) The path difference 'BD' for destructive interference is: (2010)

(a) $(m+\frac{1}{2})$ (b) d sin θ

(c) mλ (d) 3 λ

5) In Newton ring apparatus, at the point of contact of the lens and glass plate, the additional path difference introduced is: (2010)

(a) λ /Δλ (b) λ /2

(c) λ (d) λ / 3

6) Wavelength of X-rays is the order of: (2011)

(a) 10^{-6}m (b) 10^{-10}m

(c) 10^{-13}m (d) 100 m

7) For interference of light waves to take place, the required condition is: (2011)

(a) The path difference of the light waves from the two sources must be large

(b) The interfering waves must be non-coherent

(c) The light waves may come from different soruces

(d) The light waves must come from two coherent sources

8) The property of bending of light around an obstacle and spreading of light waves into geometric shadow of an obstacle is called: (2011)

(a) Diffraction of light (b) Polarization of light

(c) Quantization of light (d) Interfernce of light

9) The property of bending of light around an obstacle and spreading of light waves into geometric shadow of an obstacle is called: (2011)

(a) Diffraction of light (b) Polarization of light

(c) Quantization of light (d) Interfernce of light

10) Polarization of light exhibited the nature of light as: (2012)

(a) Longitudinal wave (b) Compressional waves

(c) Transverse wave (d) Electromagnetic waves

11) The concentration of a sugar solution can be transmitted very safely and easily by: (2012)

(a) Un-polarized wire (b) Plane polarized light

(c) Interference of light (d) Diffraction of light

12) Two waves can interfere only if they have: (2012)

(a) Phase Coherence

(b) Same velocity

(c) Difference frequencies

(d) Different wavelengths

13) The wave nature of light was proposed by: (2012)

(a) Young (b) Gallileo

(c) Huygen (d) Newton

14) The phenomena which proves that the light is transverse wave is: (SAG 2012)

(a) Interference (b) Polarization

(c) Diffraction (d) Compton effect

15) The minimum distance from the eye at which an object can be seen clearly without strain is called: (2013)

(a) Focal point (b) Near point

(c) Yield point (d) Far point

16) In the diffraction of light around an obstacle, the angle of diffraction is increased then: (2013)

(a) The wavelength of incident light wave is increased

(b) The wavelength of incident light wave is decreased

(c) The amplitude of the incident light wave is increased

(d) The amplitude of the incident light wave is decreased

17) An oil film floating on water surface exhibits colour pattern due to the phenomenon of: (2014)

(a) Diffraction (b) Polarization

(c) Interference (d) Surface tension

18) The distance between two dark adjacent fringes is mathematically written as: (2015)

(a) $\Delta Y=\frac{\lambda L}{d}$ (b) $\Delta Y=\frac{\lambda}{dL}$

(c) $\Delta Y=\frac{\lambda d}{L}$ (d) $\Delta Y=\frac{d}{\lambda L}$

19) In Young's Double Slit Experiment, slit separation x= 0.05 cm, distance between screen and slit D = 200 cm, fringes separation x= 0.13cm, then the wavelength 'λ' of light is: (2015)

(a) $\lambda = 1.23 \times 10^{-2}$m (b) $\lambda = 3.25 \times 10^{-7}$m

(c) $\lambda = 4.55 \times 10^{-5}$m (d) $\lambda = 5.1 \times 10^{-7}$m

20) For bright fringe formation, the path difference is: (2016)

(a) $\left(n+\frac{1}{2}\right)\lambda$ (b) nλ where n = 0, 1, 2, ...

(c) $(2n+1)\frac{\lambda}{2}$ where n = 0, 1, 2, ...

(d) $\left(\frac{n+1}{2}\right)\lambda^2$ where n = 0, 1, 2, ...

21) Michel son Interferometer can be used to find: (2018)

(a) wavelength (b) wavelength of sound

(c) velocity of sound (d) velocity of light

SECTION II

SHORT QUESTIONS

From Punjab Boards:

1. **The center of Newton's rings are dark, why? (LHR 2011) (GUJ 2011) (SAG 2019 GI)**

Ans. The path difference between the rays reflected at the top and the bottom of the air gap at the point of contact is zero. Actually, the ray reflected from the top of the air film does not undergo any change in phase but the ray reflected form the bottom of air film (i.e. denser) suffers a phase change of 180° or an additional path difference of λ/2 is produced between two rays over this point of contact. Hence, instead of a bright spot, a dark spot is formed at the center.

2. **Under what conditions two or more sources of light behave as coherent sources? (LHR 2011, 2014: GI) (GUJ 2013, 2014, 2015, 2016) (BAH 2013) (RAW 2011, 2019 GI) (MUL 2012, 2013, 2016) (FAS 2012, 2016, 2017) (DGK 2011, 2012) (SAW 2012, 2013, 2017)**

Ans. Two or more sources of light behave as coherent sources when the light emitted continuously be the sources of the same period, same wavelength and having the constant phase difference.

3. **How can the distance between interference fringes affect by the separation between the slits of. Young's experiment? Can fringes disappear? (MUL 2019 GI) (LHR 2012, 2017) (FAS 2013) (DGK 2013)**

Ans. The formula for fring spacing is given by

$$\Delta y = \frac{\lambda L}{d}$$

It shows that fring spacing increase with the decrease of 'd' (the distance between slits), if 'd' is increased, the distance between the fringes decrease, they come closer so that these cannot be distinguished, here uniform intensity of light is seen and fringes disappear.

4. **How would you manage to get more orders spectra using a different grating? (LHR 2013: GI, 2019 GI) (MUL 2011, 2012, 2016) (GUJ 2012, 2013) (FAS 2011, 2014, 2016) (BAH 2019 GI) (RAW 2013, 2014, 2016, 2017, 2019 GI) (DGK 2012, 2014) (SAW 2013, 2017, 2019 GI)**

Ans. As we know from the formula

$$d \sin\theta = n\lambda$$

On increasing the value of 'θ' when θ becomes 90° then the maximum value of sinθ = 1, so it is ignored. Thus for a given value of λ, the order of spectrum 'n' is directly proportional to grating element 'd' i.e:

$$n \propto d$$

But $d = \frac{1}{N}$.

Thus, we conclude that in order to get more orders of spectra, we should increase the grating element 'd' i.e. spacing between the slite on the grating or decrease the number of lines per centimeter ruled on the grating. Hence. The best way is to reduce the no of lines on the grating.

5. **Can you obtain Newton's rings with transmitted light? If yes, would the pattern be different from that oriented with reflected light? (MUL 2011, 2012) (LHR 2013 GII, 2014 GII, 2017) (FAS 2016) (SAW 2013)**

Ans. Yes, Newton's rings can be observed with transmitted light. In case of transmitted light, the fring pattern is just opposite to the reflected pattern because of no phase change of 180°. It means that the central spot of Newton's rings in this case will be bright inside of dark due to transmitted light.

6. **What is Huygen's principle? (MUL 2013, 2016) (LHR 2014 GI, 2019 GI) (GUJ 2011, 2014) (BAH 2013, 2014, 2019 GI) (DGK 2012) (SAW 2013, 2017)**

Ans. This principle consists of two parts:

(i) Every point of a wavefront may be considered as a source of secondary wavelets which spread out in forward direction with a speed equal to the speed of propagation of the wave.

(ii) The new position of the wavefront after a certain interval of time can be found by constructing a surface that touches all secondary wavelets.

7. **What are coherent sources of light? (LHR 2014) (SAG 2019 GI)**

Ans. Two or more sources of light behave as coherent source if they have no phase difference or have a constant phase difference between waves emitted by them.

8. **Name the phenomenon which confirms transverse nature of light waves. (LHR 2016)**

Ans. Polarization.

9. **Do the frequency and wavelength change when light passes from a rarer to a denser medium.(LHR 2011)**

Ans. When light passes from one medium to another, wavelength changes but frequency does not change.

10. **What is monochromatic light? (LHR 2013)**

Ans. The light which consists of a single wavelength is called monochromatic light.

11. **What is the phase relationship between two points on a wavefront? (LHR 2014)**

Ans. The phase difference between two points on the same wavefront is always zero.

12. **Can white light produce interference? (LHR 2015) (GUJ 2011)**

Ans. Yes, while light can produce interference but it will not be clear as the fringes of different colours will overlap.

13. **What are the main differences between interference and diffraction? (LHR 2016) (MUL 2019 GI) (FAS 2012) (SAG 2017) (SAW 2012)**

Ans. Difference between interference and diffraction

Interference	Diffraction
1. Interference fringes are obtained due to the superposition of light coming from two different wavefronts originating from two coherent sources.	1. Diffraction fringes are obtained due to the superposition of light coming from different parts of the same wavelength.
2. The width of interference fringes is generally same.	2. The width of diffraction fringes is non same.
3. The intensity of all the bright fringes is same.	3. The intensity of all the bright fringes is not same. It is maximum for central fringe and decreases sharply for first, second etc. bright fringes.

14. On what factors does the fringe width depend? (LHR 2017)

Ans. The fringe width is given by $\Delta y = \frac{\lambda L}{d}$.

Thus the fringe width depends on:

(i) The distance between the slits and the screen (L).

(ii) The wavelength of the light and (λ).

(iii) The distance between the two slits (d).

15. Define diffraction grating and grating element. (LHR 2017)

Ans. Diffraction Grating:

A diffraction grating consists of a glass plate on which very fine equidistant parallel lines are drawn by means of a fine diamond point. The lines act as an opaque through which the light cannot pass, while the spacing between the lines on the glass plate act as slits through which light can pass. A typical diffraction grating has about 400 to 5000 lines per centimeter to produce diffraction of light.

Grating Element:

The distance between the centers of two adjacent lines or slits is called grating elements, which is denoted by d.

$$\text{Grating element} = d = \frac{L}{N}$$

16. What is the diffraction of light? (GUJ 2012)

Ans. The property of bending of light around obstacles and spreading of light waves into the geometrical shadow of an obstacle is called diffraction of light.

17. Define wave front and spherical wave front?(GUJ 2013) (SAG 2019 GI)

Ans. Wave front:

A surface at which all the waves have same phase of vibration is known as wave front.

Spherical wave front:

When the disturbance travels out in all direction from a point source of light the wave fronts are called spherical wave fronts.

18. Why does dark region not observe at the center of the pattern when diffraction of monochromatic light is studied due to narrow slit. (GUJ 2016)

Ans. The region b/w any two consecutive minima both above and below θ will be bright. A narrow slit therefore produces a series of bright and dark fringes with the first bright fringe at the center of the pattern.

19. Give the list of two substances which show optical rotation when they are in solution. (MUL 2011: ANNUAL)

Ans. Certain organic substance, such as sugar and tartaric acid, show optical rotation when they are in solution.

20. What are dependence factors of fringe spacing in young's double slit experiment?(MUL 2011: SUPPLY)

Ans. The fringe spacing in Young's double slit experiment is given by

$$\Delta y = \frac{\lambda L}{d}$$

This relation shows that the fringe spacing (or width) can be increased by.

(i) Increasing 'L' the distance between the slits and the screen.

(ii) Using a light of large wavelength 'λ'.

(iii)Decreasing 'd' the distance between the two slits.

21. Can visible light produce interference fringes? Explain. (MUL 2012 Annual, MUL 2012 Supply) (BAH 2019 GI) (FAS 2012, 2016) (RAW 2014, 2016, 2019 GI) (SAG 2019 GI) (DGK 2012, 2019 GI) (SAW 2017)

Ans. Yes the visible light or white light can produce interference fringes. As each component colour will produce interference fringes corresponding to its own wavelength.

22. Differentiate between constructive and destructive interference. (MUL 2012: Supply) (SAG 2019 GI)

Ans. Constructive interference:

The constructive interference will take place if the path difference between two waves is zero or integral multiple of waves length, that is:

Path different = d = 0,λ, 2λ, 3λ + ... mλ

Or in general:

$$\boxed{d = m\lambda}$$

Where m = 0, 1, 2, 3 + ... An integer

Destructive interference:

The destructive interference will take place if the path difference between two waves is odd integral multiple of half wave-length. That is:

Path difference = d = λ/2,3λ/2, 5λ,..... (m + 1/2)λ

Or d = (m + ½)λ

Where m = 0, 1, 2, 3; 4+ .....

23. Explain whether the young's experiment is an experiment for studying interference or diffraction effects of light. (LHR 2019 GI) (MUL 2014) (BAH 2011, 2014) (RAW 2017) (DGK 2011) (SAW 2017, 2019 GI)

Ans. Young's double slit experiment is basically used to study interference effect of light. However, spreading of light around the edges of the slite produces some diffraction effects but interference phenomenon plays a prominent role than the diffraction phenomenon. Since diffraction occurs along with the interference in the experiment, therefore the same experiment is also used to study diffraction effect. But diffraction is special type of interference, so interference phenomenon has an upper hand upon the diffraction phenomenon.

24. What is optical rotation. (LHR 2019 GI) (MUL 2016) (RAW 2011) (DGK 2013, 2014 GI)

Ans. Optical rotation:

When a plane polarized light is passed through certain crystal they rotate the plane of polarization Quartz and sodium chlorate are typical examples, which are termed as optically active crystals.

A few millimeter thickness of such crystals will rotate the plane of polarization by many degrees. Certain organic substances such as sugar and tartaric acid, show optical rotation when they are in solution. This property of optically active substances can be used to determine their concentration in the solution.

Write the conditions for detectable interference. (MUL 2016)

25. Conditions for detectable interference.

Ans. Interference of light waves is not easy to observe because of the random emission of light from a source. The following conditions must be met in order to observe the phenomenon.

(1) The interfering beams must be monochromatic, that is of a single wavelength.

(2) The interfering beams of light must be coherent.

Define wave front with its types. (MUL 2011) (SAW 2019 GI)

26.

Ans. Such a surface on which all the points have the same phase of vibration is known as wave front. There are two types.

(i) Spherical wave fronts (ii) Plane wave fronts

Spherical Wave Fronts:

The wave fronts in which the electromagnetic waves are propagated in spherical form with the source is called spherical wave front.

The spherical wave fronts transmitted energy equally in all directions and the direction in which the energy is travel is called a ray.

Plane Wave Fronts:

A small portion of spherical wave fronts which is far away from the source is called the plane wave fronts.

27. Find out fringe spacing between two consecutive bright fringe? (BAH 2011)

Ans. Each fringe have represented a wavelength, difference in height. The increasing or decrease in the existing consecutive height is calculated as $\Delta Y = \frac{\lambda L}{d}$.

28. Write the conditions for detectable interference of light. (FAS 2013)

Ans. i. The interfering beams must be monochromatic that is of single wavelength.

ii. The interfering beams of light must be coherent.

29. Why central spot of Newton's ring in dark?(FAS 2014) (RAW 2012)

Ans. The center of Newton's ring is dark due to destructive interference.

30. Write two applications of mechelson interferometer. (FAS 2016)

Ans. (i) It is used to measure distance with extremely high precision.

(ii) It is used to measure wave length of light used in experiment.

31. What do you mean by wave front and ray of light. (FAS 2017) (BAH 2019 GI)

Ans. Wave Front:

Such a surface on which all the points have the same phase of vibration is known as wave front.

A Ray of Light:

A line normal to the wave front, which gives the direction of motion of the wave is called a ray of light.

A ray is always perpendicular to the wave front.

32. State two conditions for detectable interference. (RAW 2012)

Ans. (i) The interfering beams must be monochromatic.

(ii) The interfering beams of light must be coherent.

33. In 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? (RAW 2013)

Ans. When one of the slits is covered with blue filter and other with red filter then blue and red lights come from the slits of young's experiment, having different wavelengths. But for interference the two sources of light should emit light of same wavelength (monochromatic). Hence we get mixture of the two colours on the screen of constant intensity.

34. Explain the interference in thin films. (RAW 2013)

Ans. A thin film is a transparent medium whose thickness is comparable with the wave length of light brilliant and beautiful colour in soap bubbles. And oil film on the surface of water are due to interference of light.

35. Write three factors on which interference in thin film depends. (RAW 2016)

Ans. The value of path difference between the rays reflected form upper and lower surfaces of a thin film depends upon the following factors.

(i) Thickness of the film.

(ii) Angle of incidence of rays on the thin film.

(iii) Nature of the film.

36. What do you understand by thin film. (RAW 2016)

Ans. A layer of extremely small thickness of certain transparent medium is called thin film. When light falls on a thin film, interference fringes are formed due to interference of light reflected form the two surfaces of the film.

(i) Surface of soap bubble.

(ii) A thin layer of oil film on the surface of water.

(iii) Cracks in glass plate.

37. Describe the principle and working of Michelson's interferometer. (DGK 2017)

Ans. Michelson's Interferometer:

Definition: A device which is used to measure distance accurately.

As wavelength of visible light is very small, optical interferometers can be used to measure distance with great precision. Albert A. Michelson devised this instrument in 1881 using the idea of interference of light rays.

Principle: It splits a light beam into two parts and then recombines them to form an interference pattern after they have traveled over different paths.

38. **What is the difference between interference fringes and diffraction fringes.** (SAW 2013)

Ans. **Interference fringes:** The super position of two waves having same frequency and travelling in the same direction results in a series of bright and dark fringes known as interference fringes.

Diffraction fringes: The formal fringes due to bending of light around the obstacles are called diffraction fringes.

39. **Define wave fronts, also give its types.** (SAW 2014)

Ans. **Wavefront:**

Such a surface on which all the points have the same phase of vibrations is known as wavefront. There are two types of wavefronts.

(i) Spherical wavefront

(ii) Plane wavefront

(i) Spherical wavefront:

The wavefront in which the light waves are propagated in spherical form with the source is called spherical wavefront.

(ii) Plane wavefront:

At very large distance i.e. infinity from the source, a small portion of a spherical wavefront will becomes very nearly plane. Such a wavefront is known as plane wavefront.

The direction of propagation of wave is along the line normal to the wavefront is called a ray of light.

40. **What is Braggs Law. Write down its equation.** (LHR 2019 GI)

Ans. When a beam of x – rays of wavelength λ enters a crystal. Then the maximum intensity of the reflected ray occurs is called Braggs law and is written as.

$$2d\sin\theta = n\lambda$$

41. **5000 lines per cm has been ruled on a diffraction grating. Find its grating element.** (LHR 2019 GI)

Ans. As grating element d is calculated as:

$$d = \frac{L}{N}$$

$$d = \frac{1}{500000}$$

$$d = 2 \times 10^{-6} \text{ Ans.}$$

Now it is given that

$$N = \frac{5000 \text{ line}}{\text{cm}}$$

$$N = \frac{500000 \text{ lines}}{\text{m}}$$

$$L = 1\text{m}$$

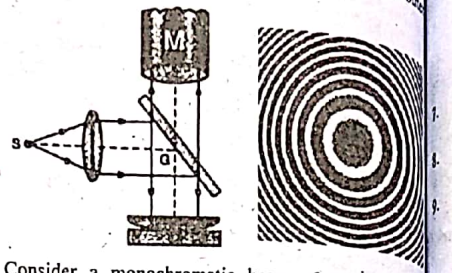
42. **What are Newton's Rings explain briefly.(DGK 2019 GI)**

Ans. **NEWTON'S RINGS:**

"The circular fringes formed due to the interference in a thin air film enclosed between a plano convex lens and a plane glass sheet is called Newton's Rings."

Explanation:

A plano convex lens of long focal length is placed in contact on plane glass plate. A thin air film in enclosed between these two. Its thickness is zero at point of contact 'O' and gradually increases towards the outer end.



Consider a monochromatic beam of light, which is made parallel by means of a lens. Using a glass sheet 'G', these rays are reflected towards the lens 'L'. Suppose a ray of light strikes the upper surface of the air film along normal. This ray is partly reflected and partly refracted. The refracted ray is again reflected from the lower surface of the film. These two rays reflected from the upper and lower surface of the film ere coherent. These rays will interfere constructively or destructively as observed through a microscope 'M' which is focused on the glass plate. So a series of dark and bright rings are seen with centre as 'O', called the Newton's Rings.

Central Ring is Dark:

At the point of contact 'O', the thickness of air film is zero. So due to the reflection from the denser medium, an additional path difference of $\lambda/2$ is introduced. As a result, the central ring is dark due to destructive interference.

SECTION III

Long Questions

From Punjab Boards:

1. Yellow sodium light of wavelength 589 nm, emitted by a single source passes through two narrow slits 1.00 mm apart. The interference pattern is observed on a screen 225 cm away. How far apart are two adjacent bright fringes? (LHR 2013: GII)
2. In a double slit experiment the second order maximum occures at $\theta = 0.25°$. The wavelength is 650 nm. Determine the slit separation. (GUJ 2013) (LHR 2012: GI, 2015: GII, 2019 GI) (MUL 2011, 2013) (FAS 2017) (RAW 2016) (DGK 2019 GI) (SAG 2019 GI)
3. Describe how michelson measured the speed of light. (LHR 2012: GI)
4. A light is incident normally on a grating which has 25×10^2 lines per centimeter. Compute the wavelength of a spectral lines for which the deviation in second order is 15°. (LHR 2012: GII , 2014: GII)

5. Define the construction and working of Michelson's interferometer. (LHR 2015 GI, 2017, 2019 GI) (FAS 2016) (SAW 2013)
6. Explain Young's Double Slit experiment to study interference of light. Derive relation for fringe thickness. (LHR 2011, 2013 GI, 2017) (MUL 2012, 2019 GI) (BAH 2012, 2019 GI) (FAS 2012, 2013, 2017) (RAW 2019 GI) (SAW 2019 GI) (DGK 2011)
7. What is interference of light waves? Describe Young's double slit experiment. (LHR 2017) (RAW 2011)
8. Describe the Michelson's experiment for calculation of speed of light. (GUJ 2013) (MUL 2014)
9. A light is incident normally on grating which has 2500 lines per centimeter. Compute the wave length of a spectral line for which the deviation in second order is 15.0°. (GUJ 2014) (MUL 2011 ANNUAL) (RAW 2014)
10. Define wave front. Derive an expression for fringe spacing in a young's double slit experiment. (BAH 2011)
11. X-rays of wavelength 0.150 nm are observed to undergo a first order reflection at a Bragg angle of 13.3° from a quartz (SiO_2) crystal. What is the inter-plane spacing of the reflecting planes in the crystal? (BAH 2013)
12. Discuss diffraction of x-rays by crystals. Also write down application of x-rays diffraction. (BAH 2014) (LHR 2014 GI) (GUJ 2012) (SAW 2018 GI)
13. Sodium light of wave length 589 nm is used to view an object under a microscope. If the aperture of the objective is 0.90 cm. Find the limiting angle of resolution. (BAH 2014)
14. Discuss the Young's double slit experiment and determine the positions where the dark and bright fringes will be observed? (FAS 2011)
15. What are thin films? Explain the construction and working of Michelson's interferometer. (SAG 2012)
16. Describe and explain the diffraction of x-rays by crystals and obtain Bragg's equation. (SAG 2017)
17. Explain young's double slit experiment and determine the relation for linear distance on the screen between adjacent bright fringes. (SAG 2017)
18. Write in detail interference in thin film. (DGK 2013)
19. How wavelength of monochromatic light is measured with the help of Miochelson's interferometer. (DGK 2014)
20. What is diffraction grating? Explain diffraction using diffracting grating. (DGK 2017) (SAW 2014)
21. X-ray of wavelength 0.150nm are observed to undergo a first order reflection at a Bragg angle of 13.3° from the quartz crystal. What is the interplaner spacing of the reflecting planes in the crystal? (RWP GI 2018)
22. A second order spectrum is formed at a an angle of 38.0° when light falls Normally on a diffraction grating having 5400 lins per centimeter. Determine wave length of the light used. (SAR GII 2018)(DGK 2018 GI)
23. Sodium light of wavelength $\lambda = 589$ nm, is incident normally on a grating having 3000 lines per centimeter. What is highest order of the spectrum obtained with this grating. (LHR GI 2018) (SAG 2019 GI)
24. Describe diffraction of X-rays by crystals and derive Bragg's equation and what are the uses of X-rays diffraction. (BAH 2019 GI) (SAR GI 2018)
25. Discuss in detail the Young's double slit experiment to study the interference of light. (LHR GII 2018)

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CHAPTER—10

OPTICAL INSTRUMENTS

SECTION I

Multiple Choice Questions

From Punjab Boards:

1) **The final image formed by simple microscope is:** (LHR 2011) (BAH 2011) (RAW 2013)
   (a) Virtual and inserted (b) Virtual and erect
   (c) Real and erect (d) Real and inverted
2) **The image formed by simple microscope is:** (LHR 2013 GII)
   (a) Real and inverted (b) Ercet
   (c) Real and erect (d) Inve
3) **The refractive index of water is 1.33. The speed of light in water is:** (LHR 2011)
   (a) $3 \times 10^8 ms^{-1}$ (b) $1.8 \times 10^8 ms^{-1}$
   (c) $2.3 \times 10^8 ms^{-1}$ (d) Zero
4) **If a single convex lens is placed close to eye, then it is being used as:** (LHR 2013 GI)
   (a) Telescope (b) Microscope
   (c) Magnifying glass (d) None of these
5) **The distance of near point form the eye is about** (LHR 2016)
   (a) 25 cm (b) 25 dm
   (c) 10 cm (d) 25 m
6) **The least distance of distinct vision for normal eye is** (LHR 2016)
   (a) 0.25 mm (b) 25 mm
   (c) 0.25 cm (d) 25 cm
7) **A layer over the central core of the jacket is called.** (LHR 2017)
   (a) Jacket (b) Plastic
   (c) Cladding (d) Rubber
8) **If the speed of light in vacuum is C, then its velocity in a medium of refractive index 1.3 is.** (LHR 2017)
   (a) 1.3C (b) $\frac{1.3}{C}$
   (c) $\frac{C}{1.3}$ (d) C

9) Which of the phenomena of light is used in propagation of light through optical fibers? (GUJ 2011) (GUJ 2011 SUPPLY)
(a) Total internal reflection (b) Polarization
(c) Interference (d) Diffraction

10) For normal adjustment, the length of astronomical telescope is: (GUJ 2013)
(a) $f_o - f_e$ (b) $f_o f_e$
(c) $f_o + f_e$ (d) $\frac{f_o}{f_e}$

11) Which combination can ensure less diffraction and more details to be seen by compound microscope? (GUJ 2012)
(a) A wider objective and red light
(b) A wider objective and blue light
(c) A wider eyepiece and red light
(d) A wider eyepiece and blue light

12) The minimum distance from the eye at which an object appears to be distinct is: (GUJ 2012 , 2016)
(a) 15 cm (b) 20 cm
(c) 25 cm (d) 30 cm

13) The least distance of distant vision is: (MUL 2014)
(a) 5 cm (b) 10 cm
(c) 25 cm (d) 50 cm

14) If N is the number of rulings on the grating than the resolving power in the mth order diffraction is equal to: (MUL 2011 ANNUAL)
(a) $R = Nm$ (b) $R = \frac{N}{m}$
(c) $R = \frac{1}{Nm}$ (d) $R = \frac{m}{N}$

15) The magnifying power of a teleschope in normal adjustment is equal to: (MUL 2012 SUPPLY)
(a) $\frac{f_o}{f_e}$ (b) $\frac{f_e}{f_o}$
(c) $f_o \times f_e$ (d) $\frac{1}{f_e f_o}$

16) In the focal length of objective and eye piece is 10cm m and 0.5 cm respectively, then magnifying power o telescope will be: (MUL 2013)
(a) 5 (b) 0.5
(c) 10 (d) 20

17) Infra red light used in optical communication has wave length. (MUL 2014)
(a) 1.11 μm (b) 1.3 μm
(c) 1.5 μm (d) 1.7 μm

18) The ratio of the size of image to the size of object is called: (MUL 2012 ANNUAL)
(a) Focal length (b) Visual angle
(c) Resolving power (d) Magnification

19) If "d" is the least distance of distnict vision, then magnification of a convex lens of focal length "R" be: (MUL 2011 SUPPLY)
(a) $1 + \frac{d}{f}$ (b) $1 - \frac{d}{f}$
(c) $1 + \frac{f}{d}$ (d) $1 - \frac{f}{d}$

20) For a lens of high angular magnification, the focal length should be (MUL 2016)
(a) Intermediate (b) Large
(c) Very small (d) Small

21) Magnifying power of astronomical telescope is (MUL 2016)
(a) f_e/f_o (b) f_o/f_e
(c) $f_e + f_o$ (d) $f_o - f_e$

22) The light emitted form light emitting diode (LED) has wave length (MUL 2016)
(a) 1.3 μm (b) 1.4 μm
(c) 1.5 μm (d) 1.6 μm

23) The formula $\alpha_{min} = 1.22 \frac{\lambda}{D}$ for resolving power of lens was given by: (MUL 2017)
(a) Newton (b) Michelson
(c) Young (d) Rayleigh

24) The magnifying power of a convex lens of focal length 10cm is: (MUL 2017)
(a) 3.5 (b) 7
(c) 9 (d) 11

25) Spectrometer is used to study the: (BAH 2013)
(a) Spectra (b) Interference
(c) Diffraction (d) None of these

26) It becomes possible to send light into inaccessible places due to: (BAH 2012)
(a) Coaxial cable (b) Fibre optic
(c) Copper wire (d) Glass wire

27) The collimator in a spectrometer is used to: (FAS 2011)
(a) Disperse the light beam
(b) Reflect the light beam
(c) Make the light beam parallel
(d) Coverage the light beam

28) The value of critical angle for glass-air boundary is: (FAS 2012)
(a) 41.8° (b) 41.5°
(c) 42.8° (d) 42

29) The magnifying power of a simple microscope is: (FAS 2013)
(a) $1 + \frac{d}{f}$ (b) $1 - \frac{d}{f}$
(c) $1 + \frac{d}{p}$ (d) $1 - \frac{d}{p}$

30) The magnification of a convex lens of focal length 5cm is: (FAS 2011)
(a) 3 (b) 5
(c) 6 (d) 20

31) Lenses of focal lengths 100cm and 5cm used as objective and eye piece of a telescope. Its length for normal adjustment is (FAS 2016)
(a) 95cm (b) 105cm
(c) 500cm (d) 1000cm

32) Which is not the essential component of a spectrometer? (FAS 2016)
(a) Collimator (b) Telescope
(c) Turntable (d) Microscope

33) In Michelson's experiment, the angle subtended by a side of the eight sided mirror is: (FAS 2017)
(a) $\frac{\pi}{8}$ rad (b) $\frac{\pi}{4}$ rad
(c) $\frac{\pi}{2}$ rad (d) $\frac{\pi}{6}$ rad

34) At some angle of incidence when the angle of refraction become 90°, this angle is called. (RAW 2011)
(a) Phase angle (b) Incident angle
(c) Refractive angle (d) Critical angle

35) The final image seen through eye-piece in telescope is: (RAW 2014)
(a) Real, enlarge and inverted
(b) Virtual, enlarge and erect
(c) virtual, enlarge and inverted
(d) Real, enlarge and erect

36) The light emitted from LED has a wavelength in optical Fiber. (RAW 2011)
(a) 1.3 pm (b) 1.3 μm
(c) 1.3 mm (d) 1.3 m

37) The magnification of a convex lens of focal length 10cm is (RAW 2016)
(a) 2.5 (b) 3.5
(c) 4.5 (d) 5

38) The final image obtained by astronomical telescope is: (RAW 2017)
(a) Erect (b) Virtual
(c) Magnified (d) All of these

39) The light emitted from LED (Light emitting diode) has wavelength: (RAW 2017)
(a) 1.3μm (b) 1.2μm
(c) 1.4μm (d) 1.5μm

40) A device used for viewing distant objects is called: (SAG 2012)
(a) Telescope (b) Spectrometer
(c) Microscope (d) Magnifying glass

41) Least distance of distinct vision. (SAG 2013)
(a) Increases with age (b) Decreases with age
(c) Remain const with age
(d) Becomes infinite after 60 years

42) The units of magnifying power of microscope or telescope are: (SAG 2017)
(a) Metre (b) m^{-1}
(c) Dioplre (d) No unit

43) Magnifying power of telescope is: (DGK 2014)
(a) $\frac{f_e}{f_o}$ (b) $f_o + f_e$
(c) $\frac{f_o}{f_e}$ (d) $f_o - f_e$

44) The least distance of distant vision is: (DGK 2012)
(a) 5 C.m (b) 10 C.m
(c) 25 C.m (d) 50 C.m

45) If the object is placed with in the focal length of a convex lens its image will be: (DGK 2011)
(a) magnified (b) erect
(c) virtual (d) all of these

46) If the object is at 5cm from the lens of simple microscope than its magnifying power will be: (DGK 2017)
(a) 5 (b) 10
(c) 15 (d) 25

47) In Michelson's experiment; the relation used to find the speed of light is: (DGK 2017)
(a) $C = 16\frac{f}{d}$ (b) $C = 16fd$
(c) $C = \frac{fd}{16}$ (d) $C = \frac{16d}{f}$

48) The minimum distance from the eye at which an object appears to be distinct is: (SAW 2013)
(a) 15 cm (b) 20 cm
(c) 25 cm (d) 30 cm

49) When Newton's Ring are seem through the transmitted light, then the central spot is: (SAR GII 2018)
(a) Dark (b) Blue
(c) Bright (d) Red

50) Product of number of rulings "N" and the order of diffraction "m" is equal to: (LHR 2019 GI)
(a) Resolving power (b) Magnification
(c) Near point (d) Magnifying power

51) If $f_o = 100cm$; $f_e = 5$ cm length and magnifying power of an astronomical telescope is: (LHR 2019 GI)
(a) 0.05 cm ; 20 (b) 95 cm ; 20
(c) 20 cm ; 500 (d) 105 cm ; 20

52) Magnifying power of the lens is 6 then its focal length will be: (LHR 2019 GI)
(a) 4 (b) 6
(c) 5 (d) 4.5

53) Magnifying power of telescope is: (MUL 2019 GI)
(a) $f_o + f_e$ (b) $f_o - f_e$
(c) $\frac{f_o}{f_e}$ (d) $\frac{f_e}{f_o}$

54) If a convex Lenz of focal length "f" is cut into tw identical halves along the Lens diameter, the foc length of each half is: (SAG 2019 GI
(a) $\frac{3}{2}f$ (b) $2f$
(c) $\frac{f}{2}$ (d) f

55) The image formed by eyepiece of compound microscope is: (SAG 2019 GI)
(a) Real and magnified (b) Real and diminished
(c) Virtual and enlarge (d)Virtual and diminished

56) Microphone converts: (SAW 2019 GI)
(a) electrical signal into sound signal
(b) electrical signal into light signal
(c) light signal into electrical signal
(d) sound signal into electrical signal

57) The magnifying power of a magnifying glass is: (BAH 2019 GI)
(a) $1-\frac{d}{f}$ (b) $1-\frac{f}{d}$
(c) $\frac{f}{d}$ (d) $\frac{d}{f}+1$

58) When light ray travels from one medium to another, the characteristic which does not change is: (BAH 2019 GI)
(a) Velocity (b) Wavelength
(c) Amplitude (d) Frequency

Entry Test MCQ's

1) The centre of Newton rings is dark due to: (2008)
(a) Polarization
(b) Destructive interference
(c) Constructive Interference
(d) Relflection.

2) Which of the following lights travels the fastest in optical fibres? (2008)
(a) Visible light. (b) Invisible infra-rad
(c) Ultra-violet (d) Ordinary light

3) The ratio of the _____ is called magnification:(2008)
(a) Image size to object size
(b) Object size to image size
(c) Eyepiece size to object size
(d) None of these

4) In Michelson's Experiment, the formula to calculate the speed of light is: (2009)
(a) c = 2 fd (b) $\frac{2\pi f}{d}$
(c) $c=\frac{16 f}{d}$ (d) c = 16 fd

5) In the case of a gratting the resolving power 'R' of the grating is defined as: (2010)
(a) $\lambda/\Delta\lambda$ (b) λ/D
(c) λ/λ_1 (d) N × m

6) Which one of the following lights travels fastest in optical fibers? (2010)
(a) Visible light (b) Ultraviolet light
(c) Ordinary light (d) Invisisble infrared light

7) The normal human eye can focus a sharp image of an object on the eye if the object is located at certain distance called: (2011)
(a) Least Point (b) Near Point
(c) Far Point (d) Distinck Point

8) The normal human eye can focus a sharp image of an object on the eye if the object is located at certain distance called: (2011)
(a) Least Point (b) Near Point
(c) Far Point (d) Distinck Point

9) The image of an object placed inside the focal length of a convex lens will be largest and clearest when it is at the: (2012)
(a) Less than 25 cm (b) Near point
(c) Greater than 25 cm (d) Infinity

10) What is the formula for critical angle in case of light through two mediums having refractive indexes n_1 and n_2 such that $n_1 > n_2$? (2013)
(a) $\sin^{-1}\left(\frac{n_1}{n_2}\right)$ (b) $\cos^{-1}\left(\frac{n_1}{n_2}\right)$
(c) $\cos^{-1}\left(\frac{n_2}{n_1}\right)$ (d) $\sin^{-1}\left(\frac{n_2}{n_1}\right)$

11) An object 15 cm from a lens produces a real image 30 cm from the lens. What is the focal length of the lens? (2013)
(a) + 15 cm (b) + 20 cm
(c) + 10 cm (d) + 25 cm

12) The value of the least distance of distinct vision or near point is _____ for a normal human eye. (2014)
(a) 20 cm (b) 25 cm
(c) 10 cm (d) 15 cm

13) In a compound microscope, the magnification by objective = 20, magnification by eyepiece = 11 cm. (2014)
(a) M = -220 (b) M = –0.19
(c) M = -0.05 (d) M = 220

14) The value of least distance vision for normal eye is: (2015)
(a) 20 cm (b) 30 cm
(c) 25 cm (d) 40 cm

15) In normal adjustment of compound microscope, the eye piece is positioned so that the final image is formed at: (2015)
(a) Optical Center (b) Infinity
(c) Principle Focus (d) Near Point

16) The minimum distance from the eye at which an object appears to be distant is: (2016)
(a) 25 cm (b) 22 cm
(c) 35 cm (d) 20 cm

17) Using the relation for the magnifying power L_e, M = 1 + d/f, if f = 5 cm and d = 25 cm then M will be: (2016)
(a) 5 (b) 7
(c) 6 (d) 8

SECTION II

Short Questions

From Punjab Boards:

1. What is the function of collimator in a spectrometer? (LHR 2011) (MUL 2017)(RAW 2017)

Ans. It is used to make the light rays parallel. It consists of a fixed metallic tube with a convex lens at one end and adjustable slit (which can slide in and out) at the other end. When the slit is adjusted at the principle focus of the convex lens the ray of light coming out of the lens becomes parallel after passing through the lens.

2. Explain the difference between angular magnification and resolving power of optical instrument. (LHR 2011, 2014: GII)

Ans. The magnifying power or angular magnification is defined as, the ratio of he angles subtended by the image as seen through the optical device to that subtended by the object at the unaided eye. The resolving power of an instrument is its ability to reveal the minor details of the object under examination. The limit of magnification is that due to enlargement of image its details must not be lost. Lens defects mainly spherical and chromatic aberrations limit the magnification of an optical instrument.

3. One can buy a cheap microscope for use of the children. The image seen in such a microscope have coloured edge. Why is this so? (GUJ 2012, 2013) (LHR 2012) (MUL 2011) (FAS 2012, 2016) (RAW 2016) (DGK 2014)

Ans. The image seen in a cheap microscope have coloured edges due to defect of the lenses. Such a defect is known as chromatic aberration. A lens acts like two prisms placed end to end. This give rise to dispersion of light. When rays of white light parallel to principle axis pass through a convex lens present inside the microscope, they are dispersed into seven colours. As blue light bends more than red light, so the focal length for blue light is smaller. So such a lens cannot bring all rays of while light form a point on the object to a single point on the object to a single point on the image. Consequently, the image is not sharp and is coloured at edges.

4. If a person was looking through a telescope at ... full moon, how would the appearance of the moon be changed by covering half of the objective lens? (LHR 2012, 2017) (GUJ 2015) (MUL 2011, 2014) (FAS 2011, 2013, 2016) (BAH 2019 GI) (RAW 2011, 2014, 2015, 2016) (DGK 2019 GI) (SAW 2013)

Ans. Still he will observe the full image of the moon but its brightness is reduced. As the intensity of light depends upon the diameter of the objective lens, therefore, the intensity of light received form the moon will decrease.

5. Why would it be advantageous to use blue light with a compound microscope? (LHR 2013: GI, 2014: GI, 2015: GI, 2015: GII) (GUJ 2012, 2013, 2014) (MUL 2012, 2016, 2019 GI) (BAH 2019 GI) (FAS 2011, 2013, 2017) (RAW 2013, 2014,2016, 2017, 2019 GI) (DGK 2011, 2012, 2013, 2014 GII) (SAW 2019 GI)

Ans. An objective lens of large aperture and use of blue light of short focal length produces less diffraction and increase its resolving power. Thus more details of the object can be seen by the eye. As by using the formula.

$$R=\frac{d}{1.22\lambda}$$

6. Find the magnifying power of a convex lens of 10 cm focal length. (LHR 2013: GI)

Ans. f = 10 cm
d = 25 cm (near point)
M = ?

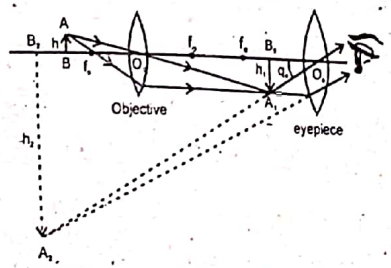
$$M = 1+\frac{d}{f}$$

$$M = 1+\frac{25cm}{10cm}$$

$$= 1 + 2{:}5 = 3.5$$

7. Sketch ray diagram of compound microscope. (LHR 2014: GII)

Ans.



8. Write down uses of spectrometer. (LHR 2015: GI) (BAH 2011)

Ans.
(i) It is used to study the spectra from different sources of light.
(ii) It is used to determine the refractive index of transparent materials.
iii) By using diffraction grating the spectrometer can be used to measure the wavelength of light.
(iv) The deviation of light by a glass prism can be measure by it very accurately.
(v) It is also used for the determination of wavelength of different light colours.

9. How do the frequency and wavelength change when light passes from a rarer to a denser medium? (LHR 2014)

Ans. The frequency remains unchanged, but the wavelength decreases.

10. Define refractive index of a medium. (LHR 2013)

Ans. Refractive index of a medium is defined as the ratio of the speed of light in vacuum to the speed for light in that medium.

$$\mu=\frac{c(\text{Speed of light in vaccum})}{c_m(\text{Speed of light in medium})}$$

11. Name two factors on which the refractive index of a medium depends. (LHR 2014)

Ans. (i) Nature of he medium.
(ii) Wavelength of the light used.

12. Can the absolute refractive index of a medium be less than unity? (LHR 2011)

Ans. No, we know that $\mu = \frac{c}{c_m}$ and c_m cannot be grater than c.

13. What is the cause of refraction of light? (LHR 2016)

Ans. The change in the speed of light on entering from one medium to another causes refraction of light.

14. How can a real image be distinguished form a virtual image? (LHR 2017)

Ans. Real image is always inverted and can be taken on a screen. Virtual image is erect and cannot be taken on a screen.

15. State Snell's law of refraction. (LHR 2016)

Ans. **Snell's law of refraction:** For any two media and for light of given wave-length, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant.

If i is angle of incidence and r is angle of refraction, then $\frac{\sin < i}{\sin < r} = \text{constant}$.

16. Define critical angle. (LHR 2014) (RAW 2017) (SAW 2019 GI)

Ans. When a ray of light passes from a denser to a rarer medium, it bends away from the normal. The angle or incidence in the denser medium for which angle of refraction in the rare medium is 90° is called critical angle.

17. What is a total internal reflection? (LHR 2013 GI) (GUJ 2012) (RAW 2016, 2017)

Ans. When the angle of incidence in the denser medium is grater than the critical angle, then the ray of light is reflected back into the same medium following the laws of reflection. This phenomenon is called total internal reflection.

18. What is the value of the critical angle for a material of refractive index $\sqrt{2}$. (LHR 2014, 2016)

Ans. $\sin < c$

$$\frac{n}{1} = \frac{1}{\sin < c}$$

$$\sin < c = \frac{1}{n}$$

$$\sin < c = \frac{1}{\sqrt{2}}$$

$$< c = \sin^{-1} 0.707 = 45°$$

19. State two conditions for producing total internal reflection. (LHR 2017) (SAG 2019 GI)(BAH 2014)

Ans. (a) The ray of light should travel from a denser to a rarer medium.

(b) The angle of incidence should be greater than the critical angle for the given pair of media.

20. What are optical fibres? Give their one use. (LHR 2016)

Ans. Optical fibres consist of thousands of long fine quality glass or quartz fibres, coated with a thin layer of a material of lower refractive indeed. When light is incident on one end of a fibre, it goes inside and suffers repeated total internal reflections to finally come out. The angle of incidence here is always larger than the critical angle of the fibre material with respect to the coating. Light can pass along the fibre even if it is bent. These are used for optical signal transmission and also as a 'light pipe', in medical diagnosis.

21. What is dispersion of light? (LHR 2016)

Ans. The phenomenon of splitting up of white light into its constituent colours is called dispersion of light.

22. What is spectrometer. Write down its three main parts. (LHR 2014 GII, 2017) (GUJ 2011) (MUL 2011 ANNUAL) (RAW 2012, 2013, 2014) (DGK 2017)

Ans. **Spectrometer:**

Definition: An optical device used to study the spectra from different sources of light is known as spectrometer.

Construction: A spectrometer has the following essential components:

(i) Collimator (ii) Turntable (iii) Telescope

23. A telescope is made of an objective of focal length 20cm, and eyepiece of 5 cm, both convex lenses. Find the magnifying power of telescope. (GUJ 2011)

Ans. Solution:

Focal length of objective = f_0 = 20 cm

Focal length of eyepiece = fe = 5.0 cm

Angular Magnification = M = ?

Calculations:

As we known that

$$M = \frac{f_0}{f_e}$$

Putting values we get

$$M = \frac{20cm}{5cm}$$

$\boxed{M = 4}$ Ans.

24. What do you understand by linear and angular magnification. (GUJ 2016) (BAH 2011, 2013) (FAS 2016) (SAG 2013, 2014)

Ans. Linear magnification = $\frac{\text{Size of image}}{\text{Size of object}}$

Angular magnification =

$$\frac{\text{Angle subterded by image as seen through optical device}}{\text{Angle subtanded by the object at the unaidedey}}$$

25. Differentiate between angular magnification and resolving power of an instrument. (DGK 2019 GI) (MUL 2011: ANNUAL, 2012: ANNUAL)

Ans. (i) Angular magnification of an optical instrument shows that how much larger is the size of image to the size of object.

(ii) Resolving power of an optical instrument is its ability to form two separate images of very closely placed objects which appear as a single object to the naked eye.

26. In simple microscope, the focal length of its lens is 1/5d, where d is least distinct vision. Find its magnifying power. (MUL 2011: ANNUAL)

Ans. Magnifying power of simple microscope is

$$M = 1 + \frac{d}{f} \quad \text{—①}$$

$$P = \frac{1}{5}d, \text{ put in ①}$$

$$M = 1 + \frac{d}{\frac{1}{5}d} = 1+5=6 \quad \boxed{M = 6}$$

27. What is the near point? Given its numerical value. (MUL 2012: SUPPLY) (FAS 2011) (SAW 2019 GI)

Ans. The minimum distance from the eye at which an object appear to distinct is called least distance of distinct vision or near point.

i-e d = 25cm

28. When object lie within principle focus of convex lens, what is the nature of image and where is it formed. (MUL 2013)

Ans. When object lie within principle focus of convex lens, then image formed is virtual, erect and magnified.

29. What is resolving power of optical instrument? (BAH 2012, 2019 GI)

Ans. The resolving power of an instrument is its ability to reveal the minor details of the object under examination.

$$R = \frac{\lambda}{\lambda_2 - \lambda_1} = \frac{\lambda}{\Delta\lambda}$$

30. Find magnifying power of a convex lens of 25cm focal length act as a magnifying glass. When F_e=5.(FAS 2012) (RAW 2012)

Ans. $M = \frac{F_o}{F_e} = \frac{25}{5} = 5 \Rightarrow M = 5$

31. Explain Convex Lens as a magnifier. (DGK 2012)

Ans. A convex lens of sorter focal length can be used as a magnifier when the object is placed very close to focus. The image thus formed is virtual, erect and magnified. For detail, see theory art 10.3

32. What is compound microscope? (RAW 2016)

Ans. Compound microscope is an optical instrument which is used for higher magnification of a near small object.

33. What is telescope? (RAW 2016)

Ans. An optical instrument used for viewing distant objects is known as telescope.

34. What do you understand by linear magnification? Explain how a convex lens is used as a magnifier? (MUL 2016) (SAG 2012)

Ans. Linear magnification = $\frac{\text{Size of image}}{\text{Size of object}}$

When an object is placed within focal length of a convex lens, then magnified and erect image is formed. The size of the image is now much larger than of without the lens. Thus a convex lens is used as a magnifier. The used convex lens is known as magnifying glass or simple microscope.

35. Define angular magnification. (SAG 2012, 2018)

Ans. 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 is called angular magnification.

$$M = \frac{\beta}{\alpha}$$

36. Explain the difference between angular magnification and resolving power of an optical instrument. What limits the magnification of an optical instrument? (LHR 2019 GI) (SAG 2017)

Ans. **Angular Magnification:**

Angular magnification simply increases the apparent size of the object when seen through an optical device.

Resolving Power:

The resolving power of an instrument is its ability to reveal the minor details of object under examination.

Limitation:

Magnification of an optical instrument is limited due to defect of lenses such as spherical and chromatic aberrations.

37. Define resolving power and least distance of distinct vision. (DGK 2011)

Ans. **Resolving power:** The power of the instrument to show the mirror details of the given object. It is denoted by 'R'.

Least distance of distinct vision: The minimum distance of the object from eye where object appear clear and distinct is called the least distance of distinct vision.

38. What do you mean by normal adjustment of telescope. (DGK 2017)

Ans. When the image A'B' is formed at the focus of the eye-piece, the final image is formed at infinity. In this case, the telescope is said to be a normal adjustment or focused at infinity. The distance between objective and eye-piece which is equal to the length 'L' of the telescope in normal adjustment. That is,

$$L = f_o + f_e$$

Where f_o and f_e are focal lengths of objective and eye-piece respectively

39. Explain, how a convex lens is used as magnifier? (LHR 2019 GI) (BAH 2019 GI) (RAW 2012) (SAW 2014)

Ans. We know that the magnifying power of a magnifying glass or simple microscope is given by.

$$M = 1 + d/f$$

This relation shows that smaller the focal length, greater will be the magnification (i.e $M \propto 1/f$)

Therefore, a lens of smaller focal length is used to increases the magnifying power of magnifying glass.

40. What are the problems, having a high magnifying power in astronomical telescope? (SAW 2016)

Ans. Size of telescope must be very large due to uses of big lenses and thus its handling create problem.

41. Define diffraction of light. (SAR 2018)

Ans. The property of bending of light around obstacles and spreading of light wave into the geometrical shadow of an obstacle is called diffraction.

42. What is resolving powr of an instrument.(GUJ 2018)

Ans. The resolving power of an instrument is its ability to reveal the minor details of the object under examination.

SECTION III

Long Questions

From Punjab Boards:

1. Define and explain simple microscope. **(LHR 2013: GII) (MUL 2013) (FAS 2014) (SAG 2013)**
2. Explain the construction and magnification of a compound microscope with ray diagram. **(LHR 2012: GII) (SAG 2019 GI)**
3. A telescope is made of an objective of focal length 20cm and an eye piece of 5.0 cm, both convex lenses. Find the angular magnification. **(LHR 2014: GI) (RAW 2012, 2019 GI) (SAG 2012) (SAW 2013, 2019 GI)**
4. Define microscope. Derive relation for magnifying power of compound microscope. **(LHR 2014 GII, 2019 GI) (GUJ 2014) (RAW 2017) (BAH 2013) (SAG 2018 GII)**
5. What is compound microscope? Derive mathematical expression for its magnification. **(LHR 2015: GII)**
6. An Astronomical telescope having magnifying power of 5 consist of two thin lenses 24 cm apart. Find the focal lengths of the lenses. **(GUJ 2012) (LHR 2011, 2013 GI, 2015 GI, 2017) (MUL 2012) (BAH 2012) (FAS 2011, 2013, 2016, 2017) (RAW 2011, 2017) (DGK 2013) (SAW 2014)**
7. A compound microscope has lenses of focal length 1 cm and 3 cm. An object is placed 1.2 cm from the objective lens. If virtual image is formed at 25 cm from the eye, calculate the separation of lenses? **(LHR 2017) (SAG 2016) (BAH 2019 GI)**
8. Write down the construction and working of a compound microscope. Derive a relation for its angular magnification. **(GUJ 2011)**
9. What is "Astronomical telescope"? Give its construction and working. Also find its magnifying power.(GUJ 2015)
10. Describe the construction and working of a compound microscope. Derive expression its magnification. **(MUL 2011: Annual , 2014)**
11. How the light signal is transmitted through optical fiber? Discuss in detail. **(MUL 2011: SUPPLY)**
12. Explain Simple Microscope. Calculate its magnification. What si magnifying glass. How it is used s microscope. Derive a relation for its magnifying power. **(MUL 2016) (SAG 2019 GI)**
13. Calculate the magnification of simple microscope by using ray diagram. **(MUL 2017)**
14. A converging lens of focal length 5.0 cm is used as a magnifying glass. If the near point of the observer is 25cm and the lens is help close to the eye. Calculate the angular magnifications. What is the angular magnification when the final image is formed at infinity? (FAS 2017)
15. Explain the principle, construction and magnifying power of a compound the help of a ray diagram. (RAW 2018)
16. Describe McChelson's rotational mirror method for the measurement of speed of light. (RAW 2016)
17. A glass light pipe in air totally internally reflect a light ray, If its angle of incidence is at least 39°. What is the minimum angle for total internal reflection if pipe is in water? (Refractive index of water = 1.33)(MUL 2019 GI, (LHR 2018 GII, 2019 GI, (BAH 2011) (RAW 2016) (DGK 2017)
18. A simple astronomical telescope is normal adjustment has an object of focal length 10 cm and eye piece of focal length 5cm. Find the position of the final image and its angular magnification. (DGK 2011)
19. Define magnification. Describe the construction and working of a compound microscope. Derive expression for its magnification. (DGK 2012)
20. Calculate the critical angle and angle of entry for an optical fibre having core of refractive index 1.50 and cladding of refractive index 1.48. (SAG 2018 GI)
21. What is spectrometer? Describe its construction and working. Also write down its two uses. (DGK 2014) (DGK 2017)
22. Explain a simple microscope. Derive formula for its magnification. (SAW 2017) (LHR-GI-2018) (DGK 2019 GI)
23. What is astronomical telescope? Using ray diagram, calculate magnification power of astronomical telescope. (RWP GI 2018)
24. What is astronomical telescope? Draw its ray diagram and derive relation for its magnification. (GUJ GI 2018)
25. What is telescope? Discuss its construction and magnification with ray diagram. (DGK GI 2018)

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CHAPTER—11

HEAT & THERMODYNAMICS

SECTION I

Multiple Choice Questions

From Punjab Boards:

1) The efficiency of cornot engine depends upon: (LHR 2013 GI)
   (a) Sink temperature (b) Source temperature
   (c) **Both source and sink temperature**
   (d) The working substance

2) Boltzmann's constant 'k' is equal to: (LHR 2013 GII) (GUJ 2013)
   (a) $\frac{R}{N_A}$ (b) $\frac{1}{RN_A}$
   (c) $\frac{N_A}{R}$ (d) RN_A

3) The pressure exerted by a column of mercury 76 cm high and at 0°C is called. (LHR 2013 GI)
   (a) 1 atmp (b) $1Nm^{-2}$
   (c) 1 Pascal (d) None of these

4) Isothermal process is carried out at constant: (LHR 2013 GII)
   (a) Volume (b) Pressure
   (c) Energy (d) Temperature

5) The value of Boltzman's constant is (LHR 2016) (RAW 2016) (SAG 2017)
   (a) 1.38×10^{-23} J / K (b) $1.38 \times 10^{+23}$ J / K
   (c) 1.38×10^{-23} J/mole – K (d) 1.38×10^{-23} J/K mole – K

6) In adiabatic process (LHR 2016) (BAH 2013) (FAS 2013) (SAG 2016)
   (a) $Q = \Delta U + W$ (b) $Q = \Delta U$
   (c) $Q = 0$ (d) $Q = W$

7) Gas law PV^{γ} = constant, is for the process of (LHR 2016)
   (a) Isothermal (b) Adiabatic
   (c) Isobaric (d) Isochoric

8) The change in internal energy is defined as. (LHR 2017)
   (a) Q – W (b) Q – T
   (c) Q + P (d) Q – P

9) For an ideal gas, the potential energy associated with its molecules is. (LHR 2017)
   (a) Maximum (b) Zero
   (c) $\frac{1}{2}kx_0^2$ (d) $\frac{1}{2}kx_0$

10) Which is called internal energy of an ideal gas? (GUJ 2012)
   (a) Potential energy
   (b) Translational energy
   (c) Vonratopma, lometcle energy
   (d) Vibrational kinetic energy

11) The most important factor regarding the significance of the cornot engine is that: (GUJ 2011)
   (a) It is practically possible
   (b) Its efficiency is 100 %
   (c) Its efficiency is possible maximum
   (d) Its efficiency is minimum

12) The most important factor regarding the significance of the cornot engine is that: (GUJ 2012)
   (a) It is practically possible
   (b) Its efficiency is 100 %
   (c) It sets an upper limit on the efficiency
   (d) It sets a lower limit on the efficiency

13) Which is not the example of adiabatic process? (GUJ 2013)
   (a) Rapid escape of air from burst tyre
   (b) Rapid expansion of air
   (c) Conversion of water into ice in a refrigerator
   (d) Cloud formation is the atmosphere

14) The form of the first law of thermodynamics for adiabatic process will be: (GUJ 2011)
   (a) Q = W (b) Q = –W
   (c) W = – ΔU (d) W = ΔU

15) Cloud formation in atmosphere is an example of _____ process (GUJ 2016)
   (a) Isothermal (b) Isochoric
   (c) Adiabatic (d) Isobaric

16) Which one is rule for an isothermal process(GUJ 2016) (FAS 2012 , 2014)
   (a) Q = 0 (b) W = 0
   (c) Q = W (d) W = ΔU

17) The efficiency of carnot engine depends on the: (MUL 2011 ANNUAL)
   (a) Nature of working substance
   (b) Size of engine
   (c) Construction of the engine
   (d) **Temperature of hot and cold reservoir**

18) An ideal heat engine can only be 100% efficient if its cold temperature reservoir is at: (MUL 2014)
   (a) 0 K (b) 0°C
   (c) 100 K (d) 100°C

19) An adiabatic process is that which has constant: (MUL 2011 ANNUAL)
   (a) Entropy (b) Volume
   (c) Pressure (d) Temperature

20) Boyle's Law is applicable to: (MUL 2012 ANNUAL)
   (a) Isobaric Process (b) Isochoric Process
   (c) **Isothermal process** (d) Adiabatic process

21) Which one of the following is practically reversible. (MUL 2011 ANNUAL)
   (a) Explosion (b) human metabolism
   (c) **Evaporation of substance**
   (d) Cloud formation

22) An ideal gas is one whose molecules have: (MUL 2011 SUPPLY)
   (a) **Kinetic energy only** (b) Potential energy only
   (c) Rotational K.E only (d) Vibrational K.E only

23) A graph between "T" and "V" of a gas at constant pressure is: (MUL 2012 SUPPLY)
   (a) Hyperbola (b) Parabola
   (c) **Straight line** (d) Exponential wave

24) How much energy, petrol engine converts into works. (MUL 2012 SUPPLY)
   (a) 100% (b) 75% (c) 50% (d) 25%

25) Average translational K.E of molecules for an ideal gas is given by relation: (MUL 2013)
   (a) $\frac{2}{3}KT$ (b) $\frac{3}{2}KT$
   (c) $\frac{2}{3K}T$ (d) $\frac{3}{2K}T$

26) Cloud formation in the atmosphere is an example of (MUL 2016) (DGK 2011)
   (a) Adiabatic process (b) Isothermal process
   (c) Isochoric process (d) Isobaric process

27) When we heat a substance, then its internal energy is (MUL 2016)
   (a) Decreased (b) Remains the same
   (c) **Increased** (d) Never changed

28) In _____ case the work done is zero (MUL 2016)
(a) Constant pressure (b) Constant volume
(c) Constant temperature (d) Constant mass

29) A heat engine operates between he temperature 1000 K and 400 K. Its efficiency is (MUL 2016)
(a) 100 % (b) 70 %
(c) 60 % (d) 50 %

30) For an ideal gas system, the internal energy is directly proportional to: (MUL 2017)
(a) Pressure (b) Volume
(c) Mass (d) Temperature

31) $kgm^{-1}s^{-2}$ is the unit of: (MUL 2017)
(a) Force (b) Work
(c) Pressure (d) Momentum

32) Cloud formation in the atmosphere is examples of: (BAH 2012)
(a) Adiabatic process (b) Isothermal process
(c) Isochoric process (d) Isobaric process

33) An ideal reversible heat engine has: (BAH 2014)
(a) 100 % efficiency (b) 80 %
(c) Highest efficiency
(d) an efficiency which depends on the nature of working substance

34) When the temperature of source and sink are the equal then efficiency of carnot's engine is: (BAH 2013)
(a) Maximum (b) One
(c) Zero (d) None of these

35) A heat engine operate between temperatures 1000 K and 400 K. Its efficiency can be equal to: (BAH 2011)
(a) 50 % (b) 60 %
(c) 70 % (d) 100 %

36) Heat is a form of: (FAS 2011)
(a) Power (b) Work
(c) Energy (d) Motion

37) The sum of all type of energies of all molecules of a substance is called (FAS 2016)
(a) Heat energy (b) Efficiency
(c) Power (d) Internal energy

38) Which is an example of irreversible process? (FAS 2016)
(a) Explosion (b) Evaporation
(c) Slow compression (d) Liquefaction

39) Unit of thermodynamic scale of temperature is: (FAS 2017)
(a) Centigrade (b) Fahrenheit
(c) Kelvin (d) Celsius

40) First law of thermodynamics for an adiabatic process is: (FAS 2017)
(a) $Q = \Delta U$ (b) $Q = W$
(c) $W = Q + U$ (d) $W = -\Delta U$

41) The curve representing an adiabatic process is called. (RAW 2014)
(a) An adiabat (b) An isotherm
(c) both of these (d) None of these

42) For working of heat engine, there must be; (RAW 2014)
(a) a source (b) a sink
(c) either of these (d) both a, b

43) A process in which no heat enters or leaves the system is called. (RAW 2011)
(a) Isothermal process (b) Adiabatic process
(c) Isochoric Process (d) Isobaric process

44) Absolute zero temperature means (RAW 2016)
(a) 0°C (b) 0°F
(c) 0K (d) 273K

45) The unit of ρgh is same as that of
(a) Pressure (b) Energy
(c) Power (d) Force

46) Efficiency of steam locomotive is (RAW 2016)
(a) 10% (b) 9%
(c) 8% (d) 7%

47) Cloud formation in atmosphere is an example of (RAW 2016)
(a) Isothermal process (b) Adiabatic process
(c) Isobaric process (d) Isochoric process

48) The ratio of $\frac{C_p}{c_v} = r$ for diatomic gas like air is: (RAW 2017)
(a) 1.40 (b) 1.30
(c) 1.29 (d) 1.67

49) S.I unit of pressure of gas is: (RAW 2017)
(a) Nm^{-2} (b) N.m
(c) N^2/m (d) $N^2.m$

50) The process in which no heat enters or leaves the system is known as: (SAG 2012)
(a) Adiabatic (b) Isothermal
(c) Isochroic (d) Isobasic

51) By increasing temperature, the kinetic energy is: (SAG 2012)
(a) Decreased (b) Increased
(c) remains same (d) Never changed

52) Unit of thermodynamic scale of temp is: (SAG 2013)
(a) Kelvin (b) Centigrade
(c) Fahrenheit (d) Celsius

53) In adiabatic process first law of thermodynamics reduces to: (SAG 2017)
(a) $Q = W$ (b) $Q = \Delta U$
(c) $W = -\Delta U$ (d) $W = 0$

54) For an isothermal process 1st law of thermodynamics is: (DGK 2014)
(a) $Q = W$ (b) $Q = P$ ~~const~~
(c) $Q = -W$ (d) $Q = \Delta u + \Delta W$

55) For an ideal gas the internal energy is directly proportional to: (DGK 2014) (SAW 2014)
(a) Pressure (b) Volume
(c) Mass (d) Temperature

56) The number of steps in carnot engine are: (DGK 2013)
(a) Two (b) Three
(c) Four (d) Five

57) For an adiabatic process, First law of thermodynamics becomes. (DGK 2012)
(a) $Q = \Delta U + W$ (b) $Q = \Delta U$
(c) $Q = W$ (d) $\Delta U = -W$

58) The difference between Cp and Cv is equal to: (DGK 2012)
(a) Avogdro's constant (b) Plank's constant
(c) Universal gas constant
(d) Boltzmann constant

59) First law of thermodynamics for isothermal process is: (DGK 2013, 2014)
(a) $Q = 0$ (b) $Q = W$
(c) $QW = -\Delta U$ (d) $W = \Delta u$

60) The temperature scale which is independent of nature of substance is: (DGK 2017)
(a) Thermodynamic scale (b) Centigrade scale
(c) Fahrenheit scale (d) Renault scale

61) For a diatomic gas $C_v = \frac{5}{2}R$, then the value of γ for this gas will be: (DGK 2017)
(a) 1.4 (b) 1.67
(c) 1.29 (d) 1.74

62) Temperature of a gas is increased from 27°C to 127°C. The ratio of its mean K.E will be: (DGK 2017)
(a) 3/4 (b) 9/16
(c) 4/3 (d) 10/9

63) If heat engine absorbs 400J and rejects 200J heat energy. Its efficiency will be: (DGK 2017)
(a) 25% (b) 50%
(c) 70% (d) 100%

64) Which one of the following processes is irreversible
(a) slow comperssion of an elastic spring
(b) slow evaportaion of a substance in an isolated vessel
(c) slow compression of a gas
(d) a chemical explasion

65) Which one of the following processes is irreversible: (GUJ 2018)
(a) slow compression of an elastic spring
(b) slow evaporation of a substance in an isolated vessel
(c) slow compression of a gas
(d) a chemical explosion

66) Difference between C_p and C_v is equal to: (LHR 2019 GI)
(a) Avogardro's number (b) Planck's constant
(c) Universal gas constant (d) Boltzman's constant

67) If P = Pressure ; V = Volume of a gas $P \Delta V$ represents: (LHR 2019 GI)
(a) Work (b) Density
(c) Power (d) Temperature

68) Root mean square velocity is related to the absolute temperature of an ideal gas as: (LHR 2019 GI)
(a) $V_{rms} \propto T$ (b) $V_{rms} \propto T^2$
(c) $V_{rms} \propto \sqrt{T}$ (d) $V_{rms} \propto \frac{1}{\sqrt{T}}$

69) Carnot engine cycle consists of: (RAW 2019 GI)
(a) Four steps (b) Three steps
(c) Single step (d) Two steps

70) If temperature of sink is decreased, the efficiency of Carnot engine. (MUL 2019 GI)
(a) Decreases (b) Increases
(c) Remain same
(d) First increases then decreases

71) In case of adiabatic process, the 1st law of thermodynamic is written as: (MUL 2019 GI)
(a) $W = \Delta U$ (b) $W = Q$
(c) $W = Q - \Delta U$ (d) $W = -\Delta U$

72) For an ideal gas, the P.E. associated with its molecules is equal to: (DGK 2019 GI)
(a) $\frac{1}{2}KX$ (b) $\frac{1}{2}KX_0^2$
(c) $2KX_0$ (d) Zero

73) The approximate efficiency of dry cell battery is: (DGK 2019 GI)
(a) 70 % (b) 80 %
(c) 90 % (d) 93 %

74) The Sum of all the energies of molecules is known as: (SAG 2019 GI)
(a) Elastic potential energy
(b) Kinetic energy
(c) Internal energy
(d) Gravitational potential energy

75) Solid Ice, Liquid water and water vapours consist in thermal equilibrium at Temperature: (SAG 2019 GI)
(a) 273 K (b) 273.16 K
(c) 273 °C (d) 100 °C

76) A carnot engine has an efficiency of 50% when its sink temperature is 27 °C. The temperature of source is: (SAG 2019 GI)
(a) 300 °C (b) 327 °C
(c) 373 °C (d) 273 °C

77) The direction of flow of heat between two bodies in thermal contact is determined by: (SAG 2019 GI)
(a) Internal energies (b) Kinetic energies
(c) Potential energies (d) Atmospheric pressure

78) A system does 700 Joules of work and at the same time its internal energy increases to 400 Joules, heat supplied by the source is: (SAW 2019 GI)
(a) 700 Joules (b) 400 Joules
(c) 1100 Joules (d) 300 Joules

79) If C_p for a gas is $\frac{7R}{2}$ then the value of C_v will be: (BAH 2019 GI)
(a) $\frac{3R}{2}$ (b) $\frac{5R}{2}$ (c) $\frac{9R}{2}$ (d) R

80) If the temperature of sink is equal to absolute zero, the efficiency of heat engine should be: (BAH 2019 GI)
(a) 100 % (b) 50 %
(c) Zero (d) Infinity

81) At constant temperature, if pressure is halved, then its volume: (BAH 2019 GI)
(a) Constant (b) Halved
(c) Doubled (d) Four Times

82) The Average Kinetic Energy of Gas is zero at: (BAH 2019 GI)
(a) 0°C (b) −273°C
(c) 100°C (d) 100 K

Entry Test MCQ's

1) For adiabatic process, the First Law of Thermodynamics is: (2009)
(a) $W = \Delta U + Q$ (b) $Q = -W$
(c) $Q = W$ (d) $W = -\Delta U$

2) The entropy of the universe always: (2009)
(a) Decreases (b) Increases
(c) Remains the same (d) Both A and B

3) The value of universal; Gas Constnat 'R' is: (2009)
(a) 8.314 $Jmol^{-2}k^{-1}$ (b) 1.39 $Jmol^{-1}k^{-2}$
(c) 1.38 $Jmol^{-1}k^{-1}$ (d) 8.314 $Jmol^{-1}K^{-1}$

4) The value of universal gas constant is: (2010)
(a) 8.314 $Jmol^{-1}k^{-1}$ (b) 8.324 $Jmol^{-1}k^{-1}$
(c) 7.23 $Joml^{-1}k^{-1}$ (d) 1.00 $Jmol^{-1}k^{-1}$

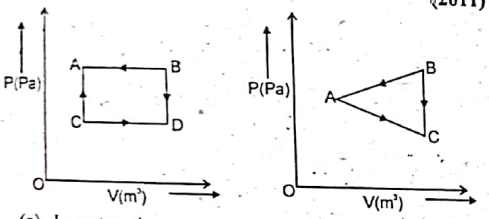
5) Which one is not an irreversible process? (2010)
(a) Slow compression of a gas into a cylinder
(b) Chanes due to friction
(c) Explosion (d) Disspiation of energy

6) The turbine in a steam power plant takes steam for a boiler at 427 °C and exhausts into a low temperature reservoir at 77 °C. What is the maximum possible efficiency? (2010)
(a) 50 % (b) 40 %
(c) 60 % (d) 70 &

7) Which of the following is the expression of root mean square speed of a gas having n number of molecules contained in the container? (2011)
(a) $\sqrt{\frac{v_1^2 + v_2^2 + \ldots + vx^2}{N}}$ (b) $\frac{v_1^2 + v_2^2 + \ldots + vx^2}{N}$
(c) $\sqrt{\frac{v_1^2 + v_2^2 + \ldots + vx}{N}}$ (d) $\frac{v_1 + v_2 + \ldots + vx}{N}$

8) 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: (2011)
(a) Collisions between gas molecules occur
(b) Collisions between gas molecules occur linearly
(c) Collisions must be elastic
(d) Collision must be inelastic

9) In which of the following, the change in internal energy is more? (2011)



(a) In system A
(b) In system B
(c) Cannot be predicted
(d) Change is zero in both. (both are cyclic)

10) Which of the following is expression of mean square speed of 'N' gas molecules contained in a cylinder? (2012)
(a) $\frac{v_1 + v_2 + \ldots + v_x}{N}$ (b) $\frac{v_1^2 + v_2^2 + \ldots + v_x^2}{N}$
(c) $\sqrt{\frac{v_1 + v_2 + \ldots + v_x}{N}}$ (d) $\sqrt{\frac{v_1^2 + v_2^2 + \ldots + v_x^2}{N}}$

11) 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: (2012)
(a) Q/W (b) Q - W
(c) W/Q (d) 1 + Q/W

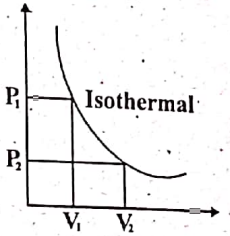
12) A heat engine operating according to second law of thermodynamics rejects one fouth of the heat taken from high temperature reservoir. What is the percentage efficiency of heat engine? (2012)
(a) 100% (b) 25 %
(c) 50% (d) 75 %

13) First law of thermodynamics under adiabatic conditions can be mathematically written as: (2012)
(a) Q = W (b) Q = ΔU
(c) Q = U + W (d) W = − Δ U

14) Speed of sound through a gas is measured as 340 m/s at pressure P_1 and temperature T_1. What will be the speed of sound if pressure of gas is doubled but temperature is kept constant? (2013)
(a) 342 m/s (b) 340 m/s
(c) 170 m/s (d) 680 m/s

15) What is the factor upon which change in internal energy of an ideal gas depends? (2013)
(a) Change in volume
(b) Change in temperature and volume
(c) Change in temperature
(d) Path followed to change internal energy

16) What will be the mathematical form of first law of thermodynamics for a system whose variation of volume by pressure is shown? (2013)



(a) Q = U (b) U = W
(c) Q = U/W (d) Q = W

17) For a heat engine 'A' ratio of Q_1 to Q_2 is 2/3 while that of heat engine 'B', ratio of Q_2 to Q_1 is 1/3. (2013)
(a) 1:3 (b) 1:2
(c) 2:3 (d) 2:1

18) In 'General Gas Equation PV= nRT' 'n' represents the number of moles of gas. Which of the following represents the relation of 'n'? (2014)
(a) $n = NN_A$ (b) $n = N/N_A$
(c) $n = N_A/N$ (d) $n = N + N_A$

19) At triple point of water, the pressure of gas is 2680 Pa, by changing 'T' the pressure increases to 4870 Pa. Then 'T' is: (2014)
(a) 496.38 K (b) 438.96 K
(c) Zero (d) 496.38 °F

20) 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? (2014)
(a) 27 °C (b) 127 °C
(c) 300 °C (d) 600°C

21) 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? (2015)
(a) 3:2 (b) $\sqrt{2}:\sqrt{3}$
(c) 4:9 (d) 2:3

22) When the rate of gas changes without change in temperature, the gas is said to undergo: (2015)
(a) Isothermal Process (b) Adiabatic Process
(c) Isochoric Process (d) Isobaric Process

23) Root mean square velocity of a gas having pressure 'P' and density 'ρ' is given by: (2015)
(a) $\sqrt{\frac{3P}{\rho}}$ (b) $\frac{3P}{\rho}$
(c) $\sqrt{\frac{3\rho}{P}}$ (d) $\frac{3\rho}{P}$

24) What is the 273 k on the Celsius scale of temperature? (2015)
(a) 0.15 °C (b) 273.15°C
(c) −0.15 °C (d) −273.15°C

25) If head 'Q_1' is absorbed ay temperature 'T' and heat 'Q_2' is absorbed at temperature of triple point of water, then unknown temperature of system (in K) is: (2015)
(a) 273.16 (b) 273.16 Q_2/Q_1
(c) 273.16 Q (d) 273.16 Q_1/Q_2

26) The relation 'PV = nRT' shows which law of physics: (2016)
(a) Charles Law (b) Avogadro's Law
(c) Newton's Constant (d) Ideal Gas Law

27) Which relation exactly described the isothermal process? (2016)
(a) Q = W (b) W = − ΔU
(c) Q = − ΔU Q = ΔU + W

SECTION II

Short Questions

From Punjab Boards:

1. Why is the average velocity of the molecules in a gas is zero but the average of the square of the velocities is not zero? (LHR 2012, 2015: GI, 2015: GII) (GUJ 2014, 2016) (MUL 2013, 2014) (FAS 2014) (BAH 2011) (RAW 2011) (SAG 2012, 2013) (DGK 2011, 2012) (SAW 2013)

Ans. As molecules are moving randomly so they have equal chances to move in every direction. The velocity of molecules moving towards left is same and equal in magnitude of the velocity of molecules moving towards the right. Hence their vector sum is zero due to −ve sign.

$$\langle V^2 \rangle = \frac{\langle v \rangle + \langle -v \rangle}{2} = 0$$

But average of the square of velocities cannot be zero.

Because $\langle V^2 \rangle = \frac{\langle vx^2 \rangle + \langle -vx^2 \rangle}{2}$

2. Specific heat of a gas at constant pressure is greater than specific heat at constant volume. Why? (LHR 2012, 2084: GI, 2017) (GUJ 2012, 2014, 2015,2018) (MUL 2016, 2019 GI) (BAH 2014, 2019 GI) (RAW 2019 GI) (SAG 2013, 2019 GI) (DGK 2014, 2017) (SAW 2017, 2019 GI)

Ans. As we know that:

$$C_p - C_v = R$$

or $$C_p = C_v + R$$

as 'R' has + ve value and is called molar gas constant, thus.

$$C_p > C_v$$

i.e., specific heat of a gas at constant pressure is greater than specific heat at constant volume, because when heating a gas at constant pressure, heat is required to increase the internal energy and temperature and also do work to expand the gas against constant pressure, but in the case of constant volume no work is done to expand the gas, the heat is required only to increase the internal energy and temperature.

This shows that more heat is required to heat a gas at constant pressure than at constant volume.

3. Can the mechanical energy be converted heat energy? If so, give an example. (LHR 2012) (BAH 2014, 2019 GI) (FAS 2016) (RAW 2014, 2017, 2019 GI) (SAG 2019 GI)

Ans. Yes, the mechanical energy can be converted completely into heat energy.

e.g., When work is done in compressing the gas by adiabatic process, the increase in the internal energy of the gas is equal to the work done (mechanical energy).

4. Derive Boyle's law form kinetic theory of gases. (LHR 2013: GI) (GUJ 2011, 2013, 2015) (MUL 2016) (BAH 2013)

Ans. We know the formula for the pressure of gas on the kinetic theory of gas is,

$$P = \frac{2}{3}\frac{N}{V}\left\langle \frac{1}{2}mv^2 \right\rangle$$

or $$PV = \frac{2}{3}N\left\langle \frac{1}{2}mv^2 \right\rangle$$

If we keep the temperature constant, average K.E. $\left(\left\langle \frac{1}{2}mv^2 \right\rangle\right)$ remains constant, so the right hand side of the above equations becomes

$$PV = \text{Constant}$$

or $$\boxed{P \propto \frac{1}{V}}$$

Thus pressure P is inversely proportional to volume 'V' at constant temperature of the gas, which is Boyle's law.

5. State Carnot's theorem: (LHR 2013: GI)

Ans. No practical heat engine can be perfectly reversible and also energy dissipation is inevitable. This fact led to the statement of Carnot's theorem as follows.

Statement:
No heat engine can be more efficient than a cannot engine operating between the same two temperatures.

6. **Why does the pressure of a gas in a tyre increases when it is driven through some distance?**
(LHR 2013: GI, 2014: GI, 2017) (GUJ 2013, 2015) (MUL 2011, 2012, 2016) (BAH 2017) (RAW 2016) (SAG 2017) (DGK 2013, 2014)

Ans. When a car is driven through some distance, work done by the car is partly used in overcoming the frictional force between the road and the car tyre. Some part of work done against friction is converted into heat which raises the temperature of the gas in a car tyre. As we know that pressure is directly proportional to absolute temperature at constant volume, therefore, the pressure must increase because the heat energy increases the velocity and collisions of gas molecules. As a result, molecular collisions against the walls of a tyre increase the pressure of air inside the tyre.

7. **Why adiabat is steeper than isotherm? Explain.**
(LHR 2013: GII) (SAG 2019 GI)

Ans. Adiabat is steeper than isotherm, since slope of isotherm $= \frac{-P}{V}$ and slope of adiabat $= \frac{-rP}{V}$

but $r > 1$.

8. **What happens to the room temperature, when an air-conditioner is left running on a table in the middle of a room? (LHR 2013: GII, 2017, 2019 GI) (RAW 2016) (BAH 2013, 2019 GI) (DGK 2013) (SAR 2018GII)**

Ans. The temperature of the room will increase, because air conditioner placed in the middle of room absorbs as well as rejects heat in the room. Here rejected heat is greater than the absorbed heat because the electric energy consume by the air conditioner is also converted into heat during the working of air conditioner.

9. **Derive Charle's law from kinetic theory of gases.**
(LHR 2013: GII, 2014: GI: 2014: GII, 2019 GI) (GUJ 2012) (BAH 2013, 2014) (RAW 2013) (SAG 2017)

Ans. The formula of pressure is given by,

$$P = \frac{2}{3}\frac{N}{V}\left\langle\frac{1}{2}mv^2\right\rangle$$

$$\Rightarrow \quad V = \frac{2}{3}\frac{N}{P}\left\langle\frac{1}{2}mv^2\right\rangle$$

If pressure is kept constant, then

$$V \propto \left\langle\frac{1}{2}mv^2\right\rangle \quad \text{.....(iii)}$$

As we have proved that, $\left\langle\frac{1}{2}mv^2\right\rangle \propto T$ so equation becomes,

$$\boxed{V \propto T}$$

Thus volume is directly proportional to absolute temperature of the gas provided pressure is kept constant. This is known as Charle's law.

10. **Is it possible to convert internal energy into mechanical energy? Explain with example.**
(LHR 2014: GII) (GUJ 2011, 2013, 2014) (MUL 2013) (BAH 3013) (RAW 2015) (SAG 2012, 2016, GI)

Ans. Applying the first law of thermodynamics

$$\Delta Q = \Delta U + \Delta W$$

For an adiabatic process

$$\Delta Q = 0,$$

So $0 = \Delta U + \Delta W$

$\therefore \Delta U = -\Delta W$

If work done 'ΔW' is negative, the work is done at the ex of internal energy. This means, if a gas (system) is allowe to expand adiabatically, some work is done at the exp internal energy. Thus internal energy decreases becaus some quantity of internal energy has been converted to mechanical work.

Examples:
(i) Gases can be liquefied by this process.
(ii) In case of heat engines (e.g. petrol engine) the gas expand and the piston moves backward. In this way its internal energy is converted into work (.e: mechanical work).

11 **Is it possible to construct a heat engine that will not expel heat into the atmosphere? (GUJ 2018) (LHR 2015: GI: 2015: GII) (MUL 2012: ANNUAL, 2014) (BAH 2012, 2013, 2014, 2019 GI) (FAS 2018) (RAW 2011, 2013, 2016, 2019 GI) (SAG 2013, 2019 GI) (DGK 2011, 2012, 2014, 2019 GI)**

Ans. No, it not possible to construct a heat engine that will not expedient into the atmosphere.
Because second law of thermodynamics states that, it is impossible to construct a heat engine, operating continuously in a cycle can exert heat form a heat reservoir and convert it completely into work.

12. **State second law of thermodynamics in terms of entropy. (LHR 2015: GII, 2017, 2019 GI) (MUL 2014, 2016) (FAS 2014) (SAG 2017) (BAH 2019 GI)**

Ans. If a system undergoes a natural process, it will go in the direction that causes the entropy of the system plus the environment to increase.
It has been found that natural process tends to proceed towards a state of greater disorder. Thus, there is a relation between entropy and molecular disorder.

13. **Define reversible and irreversible process. Give one example of each. (GUJ 2011, 2013) (MUL 2016) (BAH 2011) (FAS 2011, 2016)**

Ans.
- A successive of events which bring the system back to its initial condition is called a cycle. A reversible cycle is the one in which all the changes are reversible.
- If a process cannot be retraced in the backward direction by reversing the controlling factors, it is an irreversible process.

14. **State first law of thermodynamic and give its mathematical form. (GUJ 2014) (RAW 2016) (SAW 2019 GI)**

Ans. In any thermodynamic process, when heat 'Q' is added to a system, this energy appears as an increases in the internal energy 'Δu' stored in the system plus the work 'w' done by the system on its surroundings. This is called first law of thermodynamics.
Mathematically, it can be written as

$$Q = \Delta U + W$$

(i) 'Q' is positive when heat enters, the system and negative when it leaves the system.
(ii) 'W' is positive when work is done by the system and negative when work is done one the system.
(iii) ΔU is positive when temperature of the system rises and negative when temperature of system falls.

Why Cp > Cv? (MUL 2011: ANNUAL)

15. **Ans.** When a gas is heated at constant volume, all the heat supplied in used to increase the temperature of a gas. But if the same gas is heated at constant pressure, a part of heat is used to do work on surrounding and a part of heat is used to increase temperature. Hence more heat is required at constant pressure than at constant volume for the same rise in temperature. That is why specific heat of a gas at constant pressure is greater than specific heat at constant volume.

16. **Prove that $v^2 = \frac{3P}{\delta}$. (MUL 2011: SUPPLY)**

Ans. According to kinetic theory of gases.

$$P = \frac{2N}{3V}\left\langle\frac{1}{2}mv^2\right\rangle$$

$$P = \frac{mN}{3V}\langle v^2\rangle \text{—①}$$

Here "m" is mass of single molecule of a gas, the mass of N molecules will be mN since.

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\delta = \frac{mN}{V}$$

$$P = \frac{1}{3}\delta\langle v^2\rangle$$

Or $\langle v^2\rangle = \frac{3P}{\delta}$

17. **Given two examples of adiabatic process. (MUL 2012: ANNUAL) (DGK 2019 GI)**

Ans. (i) Cloud formation in the atmosphere.
(ii) The rapid escape of air from a burst tyre.

18. **Define first law of threnody namics and 2nd law of threnody namics. (MUL 2016)**

Ans. **First Law of Thermodynamics:**
It states that, in any thermodynamic process, the heat energy supplied to a system is equal to the increase in the internal energy of the system plus the work done by the system on its surroundings.
Mathematical form of first law of thermodynamics is:

$$\boxed{Q = \Delta U + W}$$

Where Q = Heat energy
And ΔU = Increase in the internal energy

Second Law of Thermondynamics:
The second law is concerned with the circumstances in which heat can be converted into work and direction of flow of heat.
There are two statements of the second law of thermodynamics, by the two scientists Lord Kelvin and Clausius.

Lord Kelvin's Statement:
"This states that, it is impossible to construct a heat engine, operating continuously in a cycle can extract heat from a heat reservoir and convert is completely into work".

Clausius Statement:
This states that it is impossible to have a flow of heat from a cold body to a hot body without the expenditure of energy.

19. **Define the term internal energy. (MUL 2016)**

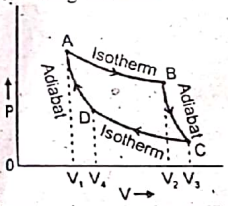
Ans. The sum of all forms of molecular energy (K.E + P.E) of a substance is termed as internal energy.

20. **What are the basic assumption of kinetic molecular theory of gases? (MUL 2016)(GUJ 2018) (RAW 2012, 2016) (SAG 2012)**

Ans. Matter is composed of tiny molecules which are not in the state of rest. These molecules move in different direction and make collision with each other as well as with the walls of the container. The molecular kinetic theory of gases based on the following postulates.
(i) A finite volume of gas consists of a very large number of molecules.
(ii) The size of the molecule is much smaller than the separation between molecules.
(iii) The gas molecules are in random motion and may change their direction of motion after every collision.
(iv) Collision between gas molecules themselves and with walls of container are assumed to be perfectly elastic.
(v) Molecules do not exert force on each other except during a collision.

21. **What is Carnot's theorem? (MUL 2014) (FAS 2012) (SAR 2018 GII)**

Ans. No heat engine can be more efficient than a Carnot engine operating between the same two temperature.
The Carnot's theorem can be extended to state that all Carnot's engines operating between the same two temperatures have the same efficiency, irrespective of the nature of working substance.



All real heat engines are less efficient than Carnot engine due to friction and other heat losses.

22. Describe the isothermal process and also draw P-V diagram. (MUL 2015)

Ans. The process, in which temperature of the system remains constant is called an isothermal process.

Consider a system consisting of an ideal gas, in a cylinder having conducting base and non-conducting walls and piston. The piston is frictionless and moveable.

The cylinder is placed on heat reservoir. In order to keep the temperature of the gas constant, the expansion or compression must take place slowly because transfer of heat requires time. In case of an ideal gas potential energy associated with its molecules is zero. Hence the internal energy of an ideal gas depends only on its temperature, which is constant.

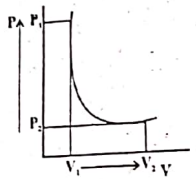
$\therefore \Delta U = 0$

Hence 1st law of thermodynamics becomes.

$Q = \Delta U + W$

$Q = 0 + W$

$Q = W$



This shows that if the gas expands and does an external work 'W', then an amount of heat 'Q', has to be supplied to keep the temperature constant. Conversely, if the gas is compressed i.e., work is done on the system, then heat 'Q' should leave the system to keep the temperature constant.

The curve representing an isothermal process is called an isotherm.

The relation for isothermal process is.

$PV =$ Constant

23. Define C_p and C_v. (BAH 2012)

Ans. (i) The molar specific heat at constant volume is the amount of heat transfer required to raise the temperature of one mole of the gas through 1k at constant volume and it symbolized C_v.

(ii) The molar specific at constant pressure is the amount of heat transfer required to raise the temperature of one mole of the gas through 1k at constant pressure and is represented by symbol C_p.

24. Find the relation for work done by heat at constant pressure. (FAS 2013)

Ans. $W = F\Delta Y$

$F = PA$

$W = PA\Delta Y$

$A\Delta Y = \Delta V$

$W = P\Delta V$ ——— (i)

Equation (i) is the relation for work done by heat at constant pressure.

25. Write Kelvin statement of second law of thermodynamics. (FAS 2019)

Ans. Lord Kelvin's Statement:

It is impossible to devise a process which may convert heat, extracted from a single reservoir, entirely into work without leaving any change in the working system (heat engine).

OR

"No heat engine, working continuously in a cycle, can extract heat from a heat reservoir (source) and convert it completely into work".

26. A heat engine is working between two temperatures 500k and 300k. Find its percentage efficiency. (RAW 2019)

Ans. $T_1 = 500k$, $T_2 = 300k$

Percentage efficiency $= \left[1 - \frac{T_2}{T_1}\right] \times 100 \Rightarrow \left[\frac{200}{800}\right]^{\text{above}}$

$\Rightarrow$ Percentage efficiency = 40%

27. State two postulates of kinetic theory of gases. (RAW 2012) (SAG 2019)

Ans. (i) A finite volume of gas consists of very large number of molecules.

(ii) The size of molecules in much smaller than the separation between molecules.

28. What is thermodynamic scale? Give its unit? (SAG 2019)

Ans. A scale of temperature which starts form zero Kelvin or –273°C. At this temperature all the gases are liquefied. Hence it is attainable.

Its unit is Kelvin.

29. What is the difference between isothermal process and adiabatic process? (RAW 2019 GI) (SAG 2019 GI) (DGK 2011, 2013)

Ans. Isothermal process: The process in which the temperature of the system remains constant

$T =$ constant

$\Delta B = 0$

so $Q = \Delta U + W = 0 + W \Rightarrow \boxed{Q = W}$

Adiabatic Process: The process in which no heat enters or leaves the system is called adiabatic process.

$Q = 0$

and $Q = \Delta U + W$

so $Q = 0 \Rightarrow 0 = \Delta U + W \Rightarrow \boxed{-\Delta U = W}$

30. Prove that $W = P\Delta V$. (2014: GI)

Ans. We assume that the gas expands through ΔV very slowly, so that it remains in equilibrium. As the piston moves up through a small distance ΔY, the work done by the gas is.

$W = F\Delta y = PA\Delta y$

$A\Delta Y = \Delta V$

$W = P\Delta V$

31. State Boyle's law and Charle's law. (2014: GII)

Ans. Boyle's law: The pressure "P" is inversely proportional to volume "V" at constant temperature of gas i.e.,

$P \propto \frac{1}{V}$

Charle's law: Volume is directly proportional to absolute temperature of gas, provided pressure is kept constant i.e.,

$V \propto T$

32. State Lord Kelvin's statement of second law of thermodynamics. (2017)

Ans. It is impossible to construct a heat engine working continuously in a cycle, takes heat from a hot reservoir (source) and converts it completely into work.

33. Describe adiabatic process under what conditions this process occur. (2017)

Ans. Adiabatic Process:

"An adiabatic process is the one, in which no heat enters or leaves, the system".

i.e. $Q = 0$

This prevention of heat may be achieved either by surrounding the system with a layer of insulting material or by performing expansion or compression process quickly, because heat flow require finite time and any process performed quickly is practically adiabatic. e.g.

(i) The rapid escape of air from a burst tyre.

(ii) The rapid expansion and compression of air through, which a sound wave is passing.

(iii) Cloud formation in the atmosphere.

34. What is the average translational kinetic energy of the molecules in a gas at 28°C? (SAW 2013)

Ans. $T = 28°C = 28 + 273 = 301K$

$K = 1.38 \times 10^{-23}\ JK^{-1}$

$\langle K.E \rangle = ?$

As we know that

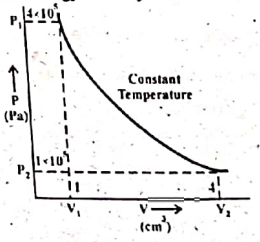
$T = \frac{2}{3K} \langle K.E \rangle$

$\Rightarrow \langle K.E \rangle = \frac{3KT}{2} = \frac{3 \times 1.38 \times 10^{-23} \times 301}{2}$

$\langle K.E \rangle = 6.23 \times 10^{-21}\ J$

35. A system under goes from state P_1V_1 to P_2V_2. What will be the change in internal energy? (SAW 2014)

Ans. The temperature of a gas is directly proportional to the average K.E. of its molecules, which is the internal energy of the system (gas). As temperature remains constant, internal energy remains the same; hence there is no change in the internal energy of the system.



36. What are defects in first law of thermodynamics and how they can be removed in second law of thermodynamics? (SAW 2014)

Ans. First law of thermodynamics tells us that heat energy can be converted into work but it is silent about the condition under which this conversion takes place.

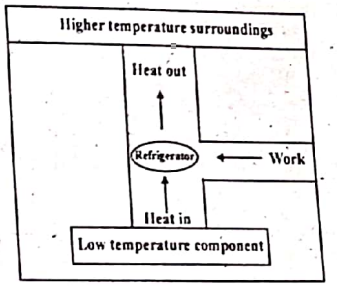
But 2nd law tells us the circumstances in which heat can be converted into work and direction of flow of heat.

37. Give an example of a natural process that involves an increases in entropy. (SAW 2017)

Ans. When ice is melted due to high temperature of surroundings. The heat transferred to ice from surroundings is positive. Since $\Delta S = \frac{\Delta Q}{T}$. As ΔS is positive thus the entropy of this natural process increases.

38. Draw the schematic diagram of refrigerator. (GUJ 2018)

Ans.



39. Write two limitations of first law of thermodynamics. (DGK 2017)

Ans. First law of thermodynamics tells us that heat energy can be converted into equivalent amount of work. But it does not tell us that:

(i) Under what conditions and

(ii) In what direction this transformation can take place.

40. Justify work and heat are similar. (LHR 2019 GI)

Ans. When energy is exchanged between thermodynamic system by thermal interaction. Then the transfer of energy is called heat and is converted into work. So we can say that both are similar.

So net change in entropy is positive.

41. What is metabolism. How first law of thermodynamic explain it. (LHR 2019 GI)

Ans. Energy transforming process in an organism is called Human metabolism which is also good example of energy conservation.

Human beings and animal do work when they walk, run, move or light heavy objects. Work always require energy. Energy is also required for growth and in making new cells and to replace the old dead cells.

We can apply first law of thermodynamics as:

$\Delta U = Q - w$

To an organism of human body therefore it is clear that work done w will result in decrease in enternal energy

of the body. Hence the body temperature or internal energy is maintained by the food we eat.

42. An engine absorbs heat of 10J and rejects 5J heat. What is the heat being used by the engine. **(LHR 2019 GI)**

Ans. Heat absorb = Q1 = 10J
Heat rejected = Q = 5J
Heat being used by engine = W = ?
W = Q1 – Q2
W = 10J – 5J
W = 5J Ans.

43. Find the average speed of oxygen molecule in the air at S.T.P. SOLUTION:- **(SAG 2019 GI)**

Ans. **DATA:-**
AT S.T.P we have
Temperature = T = 0°C
= 0 + 273 = 273 k
Pressure = P = 1.01×10^5 N–m^{-2}
Avogadro's number = $N_A = 6.022 \times 10^{-23}$
Molecular mass of oxygen = m = 32 g
Boltzman constant = k = $1.38 \times 10^{-23} jk^{-1}$
TO FIND:-
Average speed of oxygen molecules = <V> = ?
FORMULA:-

$$T = \frac{2}{3k} < \tfrac{1}{2} mv^2 >$$

CALCULATIONS:-
The above formula can be written as

$$\langle v^2 \rangle = \frac{3kT}{m} \quad \text{.....(1)}$$

Using Avogadro's number $N_A = 6.022 \times 10^{23}$, the mass m of one molecule of oxygen is given as:

$$m = \frac{\text{molecular mass}}{N_A} = \frac{32g}{6.022 \times 10^{23}} = \frac{32g \times 10^3}{6.022 \times 10^{23} \times 10^3}$$

or

$$m = \frac{32\ kg}{6.022 \times 10^{26}}$$

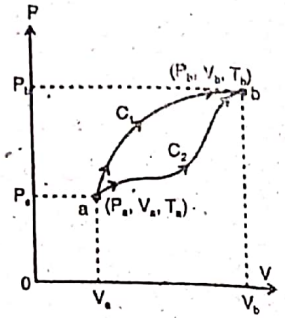
Putting the values in equation (1) we have

$$\text{or } \langle v^2 \rangle = \frac{3 \times 1.38 \times 10^{-23} \times 273 \times 6.022 \times 10^{26}}{32}$$

or $\langle v \rangle = \sqrt{212693}\ ms^{-1}$
Hence, $\langle v \rangle = 461 ms^{-1}$ Ans.
RESULT:
The average speed of oxygen molecule at S.T.P. is 461 ms^{-1}.

44. Internal energy is a state function. Explain.(DGK 2019 GI)

Ans. **Internal Energy:**
The sum of all form of molecular energies (K.E and P.E.) of a substance is called internal energy.
Independence on Path:
In thermodynamics, internal energy is a function of state. Internal energy does not depend on path it depends on initial and final states of the system.
Suppose a system is changed from initial state 'a' to final state 'b'. Let its initial pressure and volume is P_a and V_a respectively. It changes to P_b and V_b. By experiment it has been seen that change in internal energy is the same and independent of paths C_1 and C_2 as shown in fig.



Thus internal energy is similar to the gravitational P.E. Therefore we can not take its absolute value. We take change in internal energy i.e.

$$\Delta U = U_b - U_a$$

Where,
U_b = internal energy at state b.
U_a = internal energy at state a.

45. As we know that PV^r = Constant. What do you know about r. **(SAW 2019 GI)**

Ans. Here r is the ratio of molar specific heat of the gas at constant pressure to molar specific heat at constant volume and is written as

$$r = \frac{C_p}{C_v}$$

46. Give an example of a process in which on heat is transferred to or from the system but the temperature of the system changes. **(BAH 2019 GI)**

Ans. An Adiabatic process is the one in which no heat enters or leaves the system but the temperature of the system changes.
In Adiabatic Expansion, the temperature of the system falls at the cost of its own internal energy. Whereas, in Adiabatic Compression, the temperature of the system increases without the transfer of heat to the system.
Examples: 1. Cloud formation.
2. Rapid escape of air from a burst tyre.
3. Passing of sound wave from air.

47. Carnot cycle provides the basis to define a temperature scale that is independent of material properties. Explain. **(BAH 2019 GI)**

Ans. According to carnot. cycle, the ratio, the ratio $\frac{Q_2}{Q_1}$ depends only on temperature of two heat reservoirs.
Therefore, the ratio of the two temperatures $\frac{T_2}{T_1}$ can be found by operating a reversible carnot cycle between these two temperatures and measuring the heat transfers Q_2 and Q_1.
Thus the relation.

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1} \quad \text{.....(1)}$$

Equation (1)
Can be used define thermodynamic scale of temperature.
The thermodynamic scale of temperature is defined by choosing 273. 16K as the absolute temperature of the triple point of water as one fixed point and absolute zero, as the other.
The unit of thermodynamic scale is Kelvin.
Kelvin:
1 Kelvin is defined as $\frac{1}{273.16}$ of the thermodynamic temperature of the triple point of water.

SECTION III

Long Questions

From Punjab Boards:-

1. Define molar specific heat and prove the relation $C_P - C_V = R$. **(LHR 2012: GI , 2013: GII) (FAS 2013, 2017) (SAG 2017, 2018 GII) (BAH 2019 GI)**
2. Prove that the absolute temperature of an ideal gas is directly proportional to the average translation kinetic energy of gas molecules: **(LHR 2011)**
3. A heat engine performs 100 J of work and at the same time ejects 400 J of heat energy to cold reservoir. What is efficiency of the engine? **(LHR 2014 GI, 2018 GII) (RAW 2013) (DGK 2012)**
4. Estimate the average speed of nitrogen molecules in air understand conditions of pressure and temperature. **(LHR 2014: GII)**
5. 336J of energy is required to melt 1 g of ice at 0°C. What is the change in entropy of 30 g of water at 0°C, as it is changed to ice at 0°C by a refrigerator? **(GUJ 2011) (LHR 2015: GI, 2017) (FAS 2016) (RAW 2011)**
6. A mechanical engineer develops an engine, working between 327°C and 27°C and claims to have an efficiency of 52%. Does he claim correctly? Explain. **(FAS 2011) (LHR 2015: GII) (SAW 2013)**
7. Define pressure of a gas. Prove that **(LHR 2017)**

$$P = \frac{2}{3} N_o < \tfrac{1}{2} mv^2 >.$$

8. Explain isothermal process and adiabatic process. **(GUJ 2013) (MUL 2013)**
9. 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? **(GUJ 2012) (BAH 2014) (RAW 2014)**
10. Define pressure of a gas. Derive its expression $\frac{1}{3} \rho \langle V^2 \rangle$. **(GUJ 2014)**
11. A thermodynamics system undergoes a process in which its internal energy decreases by 300j. If at the same time, 120 J of work is done on the system. Find the heat lost by the system. **(MUL 2012 : SUPPLY)**
12. Define a Carnot engine. Describe its working and calculate its efficiency. **(MUL 2011:ANNUAL)**
13. What is the average translational kinetic energy of molecules in a gas at temperature 27°C? (The value of "K" Boltzman constant is 1.38×10^{-23} JK^{-1}) **(RAW 2019 GI) (MUL 2014, 2017)**
14. Explain CARNOT engine and state Carnot's Theorem. **(BAH 2013)**
15. Define molar specific heats of gas. Show that difference of molar specific heat a constant pressure and at constant volume is equal to universal gas constant. **(LHR 2019 GI) (GUJ 2015) (BAH 2012) (RAW 2018 GI) (DGK 2019 GI)**
16. Write down the four steps of cornot cycle and derive relation for the efficiency of carnot heat engine. **(BAH 2011)**
17. Show that $C_P - C_V = R$, where C_P , C_V and R are molar specific heat at constant pressure, molar specific heat at constant volume and universal gas constant respectively. **(FAS 2012)**
18. State and explain first law of thermodynamics. Also write its applications.
(i) isothermal process (ii) adiabatic process
(BAH 2019 GI) (FAS 2016) (DGK 2014, 2017
19. Describe Carnot engine and show that its efficiency only depends on the temperature of hot can cold reservoirs.
20. What is carnot engine? Give its four processes and derive the relation for its efficiency. **(LHR 2019 GI) (RAW 2017) (SAG 2012, 2013, 2018 GI, 2019 G**
21. Define pressure of Gas. Drive an expression for pressure is directly proportional average translational K.E of the gas molecules. **(DGK 2013) (SAG 2017) (SAW 2019 G**
22. A cornot engine utilises an ideal gas. The source temperature is 227°C and since temperate is 127°C. Find the efficiency of the engine. **(DGK 201**
23. Estimate the average speed of nitrogen molecules in understanding conditions of pressure and temperature. **(SAW 2**
24. 336 J of energy is required to melt 1 gm of ice at 0°C. What is the change in entropy of 30 gm of water at 0°C as changed to ice at 0°C by a refrigerator. **(LHR GI 2**
25. Find the average speed of oxygen molecule in the STP. **(RAW 2016) (DGK GI**

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