BOARD OF INTERMEDIATE EDUCATION, KARACHI

INTERMEDIATE EXAMINATION, 2024 (ANNUAL)

Date: 08.06.2024
11:40 a.m. to 12:00 p.m.

PHYSICS PAPER – I

(Science Pre-Engineering & Pre-Medical Groups)
(For Fresh Candidates)

Max. Marks : 17
Time: 20 Minutes

According to New Book

SECTION 'A'
(MULTIPLE CHOICE QUESTIONS) – (M.C.Qs.) (Marks : 17)

Note:
i) This section consists of 17 part questions and all are to be answered. Each question carries 1 mark.
ii) Do not copy the part questions in your answerbook. Write only the answer in full against the proper number of the question and its part.
iii) The use of scientific calculator is allowed. All notation are used in their usual meanings.

1. Select the correct answer for each from the given options:

i) A point charge $q_1 = 2\mu C$ is located at a distance 'd' away from another point charge $q_2 = 6\mu C$. The ratio $\frac{F_{12}}{F_{21}}$ will be:
- 1
- 3
- $\frac{1}{2}$
- $\frac{1}{3}$

ii) The work done by a centripetal force is always:
- Maximum
- Half of maximum value
- Quarter of maximum value
- Zero

iii) If the cross-sectional area of a pipe decreases, then the velocity of fluid:
- Increases
- Decreases
- Depends on the fluid density
- Remains the same

iv) The process of superimposing signal frequency on carrier wave is:
- Transmission
- Detection
- Reception
- Modulation

v) A heat sensitive device whose resistivity changes with the change in temperature is called:
- Conductor
- Thermistor
- Resistor
- Thermometer

vi) A ray of light enters obliquely from air into water then these two or three quantities of the following change:
a) wavelength b) frequency c) speed d) direction:
- (a), (c) and (d)
- (a) and (b)
- (b) and (d)
- (b) and (c)

vii) The dot product and cross product of two vectors are equal at this angle:
- 65°
- 45°
- 76°
- 30°

viii) The rate of change of linear momentum is :
- Force
- Impulse
- Torque
- Power

ix) One Degree (1°) is equal to:
- π *radians*
- $\left(180/\pi\right)$ *radians*
- $\left(\pi/180\right)$ *radians*
- 2π *radians*

x) Dimensions of kinetic energy are the same as those of:
- Force
- Work
- Momentum
- Power

xi) A completely submerged object always displaces fluid equal to its:
- Weight
- Volume
- Density
- Mass

xii) In Young's double slit experiment when the distance between slits and screen is doubled, while separation of slits is halved, then fringe spacing will be:
- 4 times
- $\frac{1}{4}$ times
- doubled
- unchanged

xiii) A wire of uniform area of cross-section 'A' length 'L' and resistance 'R' is cut into two equal parts. The resistivity of each part:
- Becomes zero
- Is halved
- Is doubled
- Remains same

xiv) A child is swinging on a swing in sitting position. If he stands up, then the time period of the swing will :
- Increase
- Decrease
- Remains the same
- First increase and then decrease

xv) The charging of a capacitor through a resistance follows:
- Linear law
- Exponential law
- Inverse square law
- Power law

xvi) The physical quantity which remains constant during simple harmonic motion is:
- Velocity
- Acceleration
- Energy
- Momentum

xvii) If V_a, V_h and V_m are the speed of sound in air, hydrogen and a metal at same temperature, then:
- $V_a > V_h > V_m$
- $V_m > V_h > V_a$
- $V_h > V_m > V_a$
- $V_m > V_a > V_h$

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INTERMEDIATE EXAMINATION, 2024 (ANNUAL)

PHYSICS PAPER – I

(Science Pre-Engineering & Pre-Medical Groups)

(For Fresh Candidates)

Date: 08.06.2024
09:00 a.m. to 11:40 a.m.

Max. Marks : 68
Time: 2 hours 40 Minutes

According to New Book

SECTION 'B'

(SHORT-ANSWER QUESTIONS) (36 Marks)

NOTE: Answer any Nine part questions from this section. All questions carry equal marks. Draw diagrams where necessary. Use of scientific calculator is allowed.

2. i) With the help of diagram show the forces acting on a car moving on a banked curve and derive the mathematical expression for banking angle. $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$

ii) How far apart must two protons be if the magnitude of the electrostatic force acting on either one due to the other is equal to the magnitude of the weight of a proton on earth's surface $(m = 1.67\times10^{-27}\,kg, q = 1.6\times10^{-19}\,C)$

iii) State Kirchoff's first and second law. Draw diagram for both the laws.

iv) A marter shell is fired at a ground level target $500m$ distance with an initial velocity of $90\,ms^{-1}$. What is the launch angle?

v) How energy is stored in a capacitor? Derive mathematical expression for the energy stored in a capacitor.

vi) Define escape velocity. Derive the relation $v_{es} = \sqrt{2gR}$ for escape velocity on earth's surface.

vii) The small piston of a hydraulic press has an area of 10 cm^2. If the applied force is 50 N, what must the area of the large piston to exert a pressing force of 4800 N.

viii) A block is kept on a horizontal table. The table is undergoing simple harmonic motion of frequency 3 Hz in a horizontal plane. The coefficient of static friction between the block and the table is 0.72. Find the maximum amplitude of the table at which the block does not slip on the table.

ix) Derive Bragg's equation for X-ray diffraction.

x) Calculate the viscous drag on a drop of oil of 0.1mm radius falling through air at its terminal velocity. $(\text{viscosity of air} = 1.8\times10^{-5}\,Pa\cdot s;\ \text{density of oil} = 850\,kg/m^3)$.

xi) A 20 meter long wire has a cross sectional area of $1\,mm^2$ and having a resistance of 5Ω. Calculate the conductivity of the wire.

xii) State the law of conservation of linear momentum. By using the law, calculate the speed of recoil of the gun, when a $100\,g$ bullet is fired from a $10\,kg$ gun with a speed of $1000\,m/s$.

xiii) Prove that following equations are dimensionally correct:

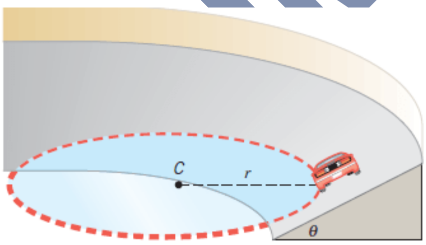
- $T = 2\pi\sqrt{\frac{l}{g}}$
- $x = m\frac{\lambda}{2}$

xiv) Write Newton's formula for the speed of sound in air. What correction did Laplace made in it? Also give the corrected formula.

(i)- With the help of a diagram show the force acting on a car moving on a banked curve and derive the mathematical expression for the banking angle $\theta = \tan^{-1}\left(\frac{v^2}{r\,g}\right)$

Ans **FORCES ACTING ON BANKED CURVE**

A banked curve is a curve that has its surface at an angle to the ground on which the curve is positioned as shown in the figure. The reason for banking curves is to decrease the moving object depends on the force of friction.



On a banked curve, however, the normal force acting on the object such as a car, will act at an angle with the horizontal and that will create a component normal force that acts along the x-axis. This component's normal force will now be responsible for creating the centripetal acceleration required to move the car along the curve.

BANKING DEPENDENCE ON ANGLE AND SPEED OF VEHICLE.

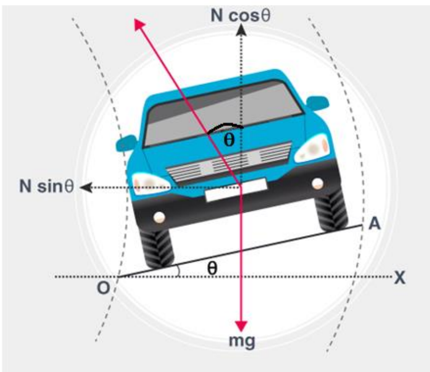
Consider a car on a frictionless banked curve. If the angle θ is ideal for the speed and radius r, then the net external force equals the necessary centripetal force. The only two external forces acting on the car are its weight and the normal force of the road N. The normal force horizontal component must equal the centripetal force, that is.

$$N\sin\theta = \frac{mV^2}{r} \quad \ldots\ldots\ldots\ldots\ldots (i)$$

The vertical component of the normal force is Ncosθ, and the only other vertical force is the car's weight. These must be of equal magnitude; thus,

$N\cos\theta = mg$ ………..(ii)

Dividing equation (i) by (ii)



$$\frac{N\sin\theta}{N\cos\theta} = \frac{\frac{mV^2}{r}}{mg}$$

$$\frac{\sin\theta}{\cos\theta} = \frac{mV^2}{rmg}$$

$$\tan\theta = \frac{V^2}{rg}$$

$$\theta = \tan^{-1}\left(\frac{V^2}{r\,g}\right)$$

This expression can be understood by considering how θ depends on v and r. A large θ is obtained for a large v and a small r.

(ii) How far apart must two protons be if the magnitude of the electrostatic force acting on either one due to the other is equal to the magnitude of the gravitational force on a proton at Earth's surface? (Mass of proton = $1.67 \text{ X } 10^{-27}$ kg, charge of proton = $1.6 \text{ x } 10^{-19}$ C)

Data: (a) $q_1 = 1.6 \text{ x } 10^{-19}\ C$ $q_2 = 1.6 \text{ x } 10^{-19}\ \text{C}$ $m = 1.67 \text{ X } 10^{-27}\ \text{kg}$ $r = ?$ **SOLUTION:** **Electric force = weight of the object** $F_e = W$ $\frac{k\ q_1\ q_2}{r^2} = m\ g$	$\frac{k\ q_1\ q_2}{m\ g} = r^2$ $\frac{9 \times 10^9 \times 1.6 \text{ x } 10^{-19} \times 1.6 \text{ x } 10^{-19}}{1.67 \text{ X } 10^{27} \times 9.8}$ $= r^2$ $\frac{2.304 \times 10^{-28}}{1.6366 \text{ X } 10^{-26}} = r^2$ $0.01407 = r^2$ $\sqrt{0.01407} = \sqrt{r^2}$ $0.118\ m = r$

(iii) State Kirchoff's first and second law. Draw a diagram for both the laws

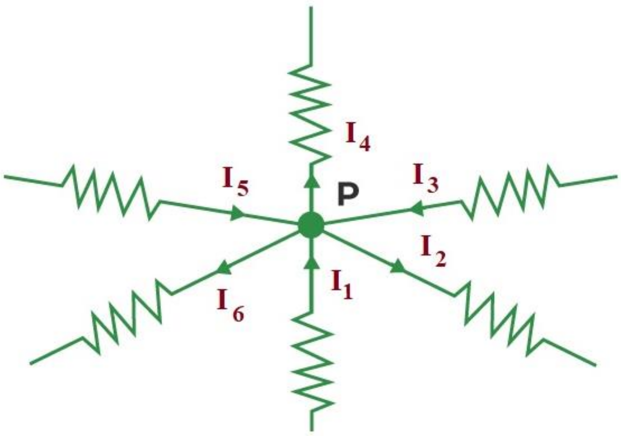
KIRCHHOFF'S FIRST LAW OR KIRCHHOFF'S CURRENT LAW(KCL)

Kirchhoff's Current Law,

STATEMENT

The sum of the currents entering a junction always equals the sum of the currents out of the junction

According to Kirchhoff's Current Law



sum of the currents entering a junction = sum of the currents out of the junction

$$I_1 + I_3 + I_5 = I_2 + I_4 + I_6$$

KIRCHHOFF'S SECOND LAW OR KIRCHHOFF'S VOLTAGE LAW(KVL)

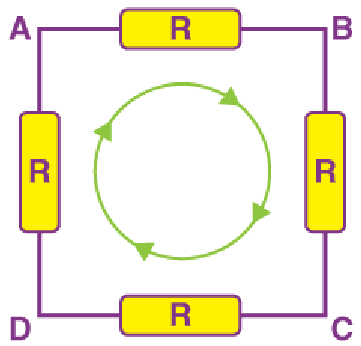
Kirchhoff's Voltage Law,

STATEMENT

The net electromotive force around a closed-circuit loop is equal to the sum of potential drops around the loop

The sum of all the voltage drops around the loop is equal to zero

$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$



(iv) A marter shell is fired at a ground-level target 500 m distance with an initial velocity of 90 m. What is the launch angle?

Data:

R = 500m

V_o = 90 m/s

θ = ?

g = 9.8 m / s^2

SOLUTION:

$$R = \frac{V_o^2}{g} \text{Sin}2\theta$$

$$500 = \frac{(90)^2}{9.8} \text{Sin}2\theta$$

$$500 = \frac{8100}{9.8} \text{Sin}2\theta$$

$$\frac{500 \times 9.8}{8100} = Sin2\theta$$

Sin 2θ = 0.6049

2θ = Sin^{-1} (0.6049)

2θ = 37.22°

θ = 18.61°

And another possible angle will be,

α = 90° - 18.61°

α = 71.39°

(v) How is energy stored in a capacitor? Derive the mathematical expression for the energy stored in a capacitor

Ans Energy stored in a capacitor is electrical potential energy, and it is thus related to the charge ***Q*** and voltage ***V*** on the capacitor. Initially, when the capacitor is uncharged, no work is required to move the first bit of charge over. As more charge is transferred, work is needed to move the charge against the increasing voltage V. The work needed to add a small amount of charge Δq when a potential difference V is across the plates is the total work W = VΔq needed to move total charge Q is equivalent to moving all the charge Q across a voltage equal to the average voltage during the process. The average voltage is $\frac{V_f - 0}{2} = \frac{V_f}{2} = \frac{V}{2}$, where V is the final voltage; so the work to move the total charge *Q* from one plate to the other is

$$U = Q\,\frac{V}{2}$$

$$U = \frac{1}{2} Q\,V \ldots\ldots\ldots (i)$$

Energy stored in terms of V and C

We know that

$$Q = CV$$

Substituting the value of Q = C V in the equation (i), we get

$$U = \frac{1}{2}(C\,V)\,V$$

$$U = \frac{1}{2} C\,V^2$$

(vi) Define escape velocity. Derive the relation $v_{es} = \sqrt{2\,g\,R}$ for escape velocity of the earth's surface

Escape velocity

Escape velocity on Earth or any other planet is defined as the minimum velocity with which the body has to be projected vertically upwards from the surface of the Earth or any other planet so that it just crosses the gravitational field of Earth or of that planet and never return on its own.

Work is done at the cost of kinetic energy given to the body at the surface of the earth. If V_{es} is the escape velocity of the body projected from the surface of the earth. Then kinetic energy of the body will escape out of the gravitational field.

$$\frac{1}{2}\,m\,v_{es}^2 = \frac{G\,m\,M_e}{R}$$

$$v_{es}^2 = \frac{2\,G\,M_e}{R}$$

$$v_{es} = \sqrt{\frac{2\,G\,M_e}{R}} \ldots\ldots\ldots (i)$$

The gravitational acceleration at the surface of the earth is given by

$$g = \frac{G\ M_e}{R^2}$$

$$G\ M_e = g\ R^2 \quad \ldots\ldots(ii)$$

Substituting the expression $G\ M_e$ in equation (i)

$$v_{es} = \sqrt{\frac{2\ g\ R^2}{R}}$$

$$v_{es} = \sqrt{2\ g\ R}$$

ESCAPE VELOCITY OF EARTH

$$v_{es} = \sqrt{2\ g\ R}$$

$$v_{es} = \sqrt{2\ \times 9.8\ \times\ 6.38\ \times 10^6}$$

$$v_{es} = \sqrt{1.25\ \times 10^8}$$

$$v_{es} = 11.2\ \times 10^3\ m/s$$

$$v_{es} = 11.2\ \times K\ m\ s^{-1}$$

(vii) The small piston of the hydraulic press has an area of 10 cm^2. If the applied force is 50 N, what must the area of the large piston to exert a pressing force of 4800N?

Data:

$A_1 = 10\ cm^2 = 10\ \times\ 10^{-4}\ m^2$

$F_1 = 50\ N$

$A_2 = ?$

$F_1 = 4800\ N$

SOLUTION:

$$\frac{F_1}{F_2} = \frac{A_1}{A_2}$$

$$\frac{50}{4800} = \frac{10 \times 10^{-4}}{A_2}$$

$$A_2 \times 50 = 10\ \times\ 10^{-4} \times 4800$$

$$A_2 = \frac{10\ \times\ 10^{-4} \times 4800}{50}$$

$$A_2 = 0.096\ m = 960\ \times\ 10^{-4}\ m$$

$$A_2 = 960\ cm^2$$

(viii) A block is kept on a horizontal table. The table is undergoing simple harmonic motion of frequency 3 Hz in a horizontal plane. The coefficient of static friction between the block and the table surface is 0.72. Find the maximum amplitude of the table at which the block does not slip on the surface.

DATA

f = 3 Hz

$\mu = 0.72$

T = 2.41 s

$x_0 = ?$

SOLUTIONS

The maximum force of static friction is given as

$$f = \mu R$$

$$f = \mu mg$$

In case the body does not slip

$$\boldsymbol{newton's force = friction\ force}$$

$$ma = \mu mg \qquad (a = x_0\,\omega^2)$$

$$m(x_0\,\omega^2) = \mu mg$$

$$x_0\,\omega^2 = \mu g \qquad (\omega = 2\pi f)$$

$$x_0\,(2\pi f)^2 = \mu g$$

$$x_0 \times 4\pi^2 f^2 = \mu g$$

$$x_0 \times 4\,(3.142)^2\,(3)^2 = (0.72)\,(9.8)$$

$$x_0 \times 355.305 = 7.056$$

$$x_0 = \frac{7.056}{355.305}$$

$$x_0 = 0.021\,m$$

$$x_0 = 2.1\,cm$$

(ix) Derive Bragg's equation for diffraction grating.

Ans **DERIVATION OF BRAGG'S LAW**

Consider two x-rays 1 and 2, of wavelength λ which are incident on the crystal salt. These x-rays are reflected from atoms A and D of a crystal with a separation distance (d) between its atomic planes.

Let θ be the angle made by x-rays with the layers, as shown in figure. It can be seen in the figure that the second x-ray covers more distance as compared to the first x-ray, the total path difference will be

Path difference = BD + DC ………(i)

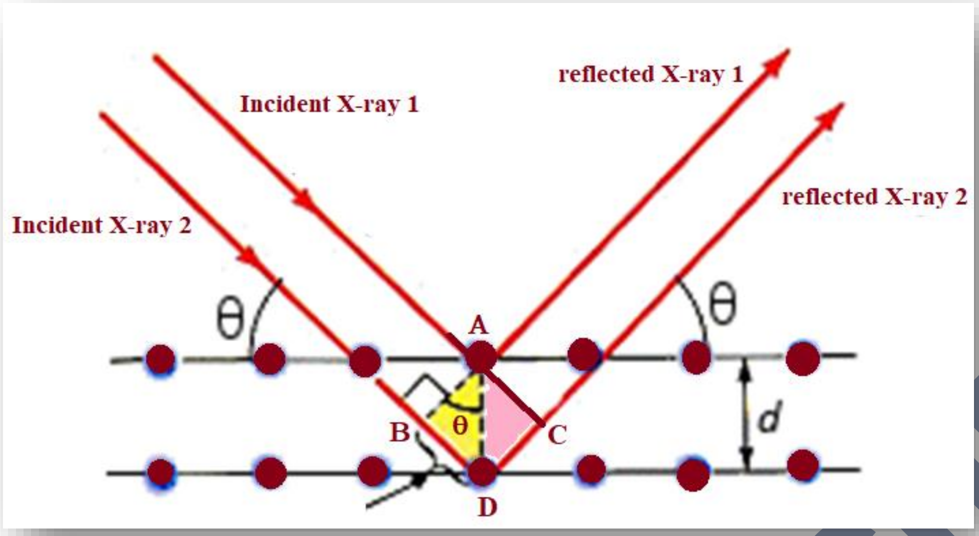
Consider a triangle DAB,

$$Sin\theta = \frac{perp}{hyp}$$

$$Sin\theta = \frac{BD}{AD}$$

$$Sin\theta = \frac{BD}{d}$$

$$BD = d\,Sin\theta$$



Similarly, Consider another triangle DAC,

$$Sin\theta = \frac{perp}{hyp}$$

$$Sin\theta = \frac{BC}{AD}$$

$$Sin\theta = \frac{BC}{d}$$

$$BC = d\ Sin\theta$$

Substituting the expression for BD and BC in equation(i), we get

Path difference $= d\ Sin\theta + d\ Sin\theta$

Path difference $= 2\ d\ Sin\theta \quad \dots\dots\dots\dots.(ii)$

We know that the condition for constructive interference

Path difference $= m\lambda$ ……………(iii)

Comparing equations (ii) and (iii)

$$\boldsymbol{2\ d\ Sin\theta = m\ \lambda}$$

(x) Calculate the viscous drag on a drop of oil of 0.1 mm radius falling through air at this terminal velocity. (Viscosity of air = 1.8×10^{-5} Pa. s ; density of oil = 850 kg/m³)

Data.

$r = 0.1\ mm = 0.1 \times 10^{-3}\ m$

$\eta = 1.8 \times 10^{-5}\ Pa.\ s$

$\rho = 850\ kg / m^3$

$F_d = ?$

$v_t = ?$

SOLUTION.

For v_t
We know that

$$v_t = \frac{2r^2 \rho g}{9\eta}$$

$$v_t = \frac{2(0.1\,x\,10^{-3})^2(850)(9.8)}{9(1.8\,x\,10^{-5})}$$

$$v_t = \frac{2(1\,x\,10^{-8})(850)(9.8)}{1.62\,x\,10^{-4}}$$

$$v_t = \frac{1.66\,x\,10^{-4}}{1.62\,x\,10^{-4}}$$

$$v_t = 1.024\,m/s$$

For F_d
By Stoke`s law

$$F_d = 6\,\pi\,\eta\,r\,v_t$$

$$F_d = 6\,(3.142)(1.8\,x\,10^{-5})(0.1\,x\,10^{-3})(1.024)$$

$$F_d = 3.48\,x\,10^{-8}\,N$$

(xi) A 20-meter length of cable has a cross-sectional area of 1mm^2 and a resistance of 5 Ω. Calculate the conductivity of the cable.

Data:	**SOLUTION:**
$L = 200\text{ m}$ $A = 1\text{ mm}^2 = 1 \times 10^{-6}\ m$ $R = 5\ \Omega$ $\rho = ?$	Conductivity is given by $\sigma = \frac{L}{R\ \ A}$ $\sigma = \frac{200}{(5)\ \ (1\,x\,10^{-6})}$ $\sigma = 4 \times 10^7\ S/m$

(xii) State the law of conservation of linear momentum. By using the law, Calculate the speed of recoil of the gun, when a 100 g bullet is fired from a 10 kg gun with a speed of 1000 m/s

STATEMENT

The momentum of a system of two interacting bodies remains constant if the net external force acting on the system is zero".

Data:	**SOLUTION:**
$m_1 = 100\ g = \frac{100}{1000} = 0.1\ kg$	Applying the Law of conservation of momentum
$m_2 = 10\ kg$	$m_1U_1 + m_2U_2 = m_1V_1 + m_2V_2$
Initially the bullet is at rest $U_1 = 0$	$0.1(0) + 10(0) = 0.1(1000) + 10V_2$
Initially the gun is at rest $U_2 = 0$	$0 = 100 + 10V_2$
$V_1 = 1000\ m/s$	$-100 = 10V_2$
$V_2 = ?$	$-\frac{100}{10} = V_2$
	$V_2 = -10ms^{-1}$

(XIII) Prove that the following equations are dimensionally correct.

(i) $T = 2\pi\sqrt{\frac{l}{g}}$ (ii) $x = m\ \frac{\lambda}{2}$

(i) $T = 2\pi\sqrt{\frac{l}{g}}$

SOLUTION

$L.H.S = [T]$

$L.H.S = [\mathrm{T}]$

$R.H.S = 2\pi\sqrt{\frac{[l]}{[g]}}$

$R.H.S = 2\pi\sqrt{\frac{[L]}{[L\,T^{-2}]}}$

$R.H.S = 2\pi\sqrt{\frac{1}{[\,T^{-2}]}}$

$R.H.S = 2\pi\sqrt{T^2}$

$R.H.S = 2\pi\,T$

$\{\,2\pi\ \ has\ no\ dimension\,\}$

$R.H.S = T$

we have [L.H.S] = [R.H.S]
Hence, the given equation is dimensionally correct.

(ii) $x = m\ \frac{\lambda}{2}$

SOLUTION

$L.H.S = [x]$

$L.H.S = [\mathrm{L}]$

$R.H.S = m\ \frac{\lambda}{2}$

$R.H.S = \frac{m}{2}\ [\lambda]$

$R.H.S = \frac{m}{2}\ [L]$

$\left\{\frac{m}{2}\ has\ no\ dimension\right\}$

$R.H.S = [L]$

we have [L.H.S] = [R.H.S]
Hence, the given equation is dimensionally correct

(xiv) Write Newton's formula for the speed of sound in air. What correction did Laplace make it? also, give the corrected formula.

NEWTON'S FORMULA FOR THE SPEED OF SOUND

The speed of the sound waves in a medium solid, liquid, or gas depends on the elasticity and density of the medium.

$$v = \sqrt{\frac{\text{Elastic property of the medium}}{\text{density of the medium}}}$$

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

If the elastic property of the medium is equal to bulk modulus B of the medium, the speed of the sound wave in that medium is

$$v = \sqrt{\frac{B}{\rho}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(i)$$

Where B = bulk modulus of medium.

LAPLACE'S CORRECTION

In 1816 a French mathematician "Laplace" put forward a correction to Newton's formula. He explained that sound travels through the air as a combination of compression and rarefactions. At compression, the temperature of air rises, and at rarefaction temperature falls. Because of the very rapid occurrence of compressions and rarefactions and bad conductivity of air, there is not sufficient time for heat to be conducted from hot compression to cold rarefaction. Hence the temperature of air does not remain constant and the isothermal form of Boyle's law cannot be applied.

Laplace proposed the adiabatic propagation of sound in which no exchange of heat takes place. In this condition

$$P\,V^{\gamma} = \text{constant}$$

Laplace's correction formula

$$v = \sqrt{\frac{\gamma\,P}{\rho}}$$

Where

'γ' $\text{is the ratio of molar specific heat of gases.}$

P is the pressure

ρ $\text{is th density of a medium}$