BOARD OF INTERMEDIATE EDUCATION, KARACHI

INTERMEDIATE EXAMINATION, 2025 (ANNUAL)

PHYSICS PAPER – I

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

Date: 17.05.2025
11:40 a.m. to 12:00 p.m.

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 part 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) This property of light does not change with the nature of medium:
- Velocity • Amplitude • Wavelength • Frequency

ii) The process of superimposing signal frequency on the carrier wave is known as:
- Resonance • Modulation • Damping • Diffraction

iii) The maximum value of static friction is called:
- Kinetic friction • Sliding friction • Rolling friction • Limiting friction

iv) The speed of sound in air at STP is $332\,m/s$. If the air pressure becomes half at the same temperature, the speed of sound becomes:
- $332\,cm/s$ • $664\,cm/s$ • $332\,m/s$ • $166\,m/s$

v) One revolution per minute (RPM) is equal to:
- $\frac{2\pi}{30}rad/s$ • $\frac{\pi}{60}rad/s$ • $\frac{2\pi}{60}rad/s$ • $\frac{60}{2\pi}rad/s$

vi) If 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:
- become zero • is halved • is doubled • remain same

vii) If the cross-sectional area of a pipe decreases, the fluid velocity:
- increases • remains the same
- decreases • first increase then decrease

viii) If one joule of work is performed on a body in one second, the power will be:
- One watt • One joule • One newton • One pascal

ix) The acceleration of projectile at highest point of its trajectory will be:
- zero • $980\,m/s^2$ • $9.8\,m/s^2$ • $19.8\,m/s^2$

x) $(\hat{i}\cdot\hat{i}) =$:
- 0 • 1 • $\hat{j}$ • $\hat{k}$

xi) LT^{-2} are dimensions of:
- acceleration due to gravity • moment of inertia
- moment of force • angular momentum

xii) The dot product of force and velocity, is called:
- Work • Power • Energy • Torque

xiii) 'An object completely submerged in a fluid, displaces fluid equal to its own volume', this is:
- Pascal's Law • Boyle's Law
- Archimedes Principle • Charle's Law

xiv) $1.6\times10^{-19}\,J =$
- Charge of electron • 1 volt
- 1 watt • 1 electron volt (eV)

xv) With the presence of dielectric between plates of a parallel plate capacitor, the capacitance of the capacitor:
- decreases • remains same • increases • become zero

xvi) By increasing temperature of a metallic conductor, resistance will:
- decrease • increase • remain same • become zero

xvii) Oscillations in which the amplitude gradually decreases over time due to energy loss are called:
- Free oscillations • Forced oscillations
- Damped oscillation • Resonance

----------xxxxxxxxx----------

SECTION B

SHORT QUESTION AND ANSWER (SOLUTIONS)

(i) A 100 g bullet is fired into a 12 kg block that is suspended by a long cord so that it can swing as a pendulum. If the block is displaced, its centre of gravity rises by 10cm. What was the speed of the bullet?

Data:

$$m_1 = 100\text{ g} = \frac{100}{1000} = 0.01\ kg$$

$$m_2 = 12\text{ kg}$$

Initial velocity of the bullet $U_1 = ?$

initial velocity of the gun $U_2 = 0$

final velocity of the bullet $V_1 = V$

final velocity of the gun $V_2 = V$

centre of gravity rise $h = 10\text{ cm}$

$$h = 0.1\text{ m}$$

SOLUTION:

Applying the Law of conservation of momentum

$$m_1U_1 + m_2U_2 = m_1V_1 + m_2V_2$$

$$0.1\,U_1 + 12(0) = 0.1\,V + 12V$$

$$0.1\,U_1 = 12.1\,V \quad \ldots\ldots\ldots..(i)$$

After the collision block-bullet system moves like a pendulum so their K.E is converted into P.E as they rise,

∴ loss of K.E = P.E gained

$$\frac{1}{2}\cancel{(m_1+m_2)}V^2 = \cancel{(m_1+m_2)}gh$$

$$\frac{1}{2}V^2 = g\,h$$

$$V = \sqrt{2g\,h} = \sqrt{2 \times 9.8 \times 0.1}$$

$$V = \sqrt{1.96} = 1.4\ m/s$$

Putting the value of v = 1.4 m/s in eq (i)

$$0.1\,U_1 = 12.1 \times 1.4$$

$$U_1 = \frac{12.1 \times 1.4}{0.1}$$

$$U_1 = 169.4\ \ m/s$$

(ii) **A tank 4 m long, 3 m wide, and 2 m deep is filled to the brim with paraffin (density 800 kg/m³). Calculate the pressure on the base? What is the thrust on the base?**

Data:
L = 4 m
w = 3 m
d = h = 2 m
P = ?
F = ?

Solution:
For "P".
By the pressure of fluid.

P = ρ g h
P = 800 x 9.8 x 2
P = 15680 Pa

For "F".
By the definition of pressure.

P = F / A
F = P A = P (l x w)
F = 15680 (4 x 3)
F = 188160 N

(iii) **An electron of charge 1.6 x 10⁻¹⁹ C is situated in a uniform electric field of intensity 1200-volt /m. Find the force on it.**

Data:	SOLUTION:
$q = 1.6 \times 10^{-19}\ C$ $E = 1200 \frac{volt}{m}$ $F = ?$	$F_e = q\,E$ $F_e = 1.6 \times 10^{-19} \times 1200$ $F_e = 1.92 \times 10^{-16}\ N$

(iv) **A satellite is orbiting the Earth with an orbital velocity of 3200 m/s. What is the orbital radius?**

DATA $v = 3200\ m/s$ $r = ?$ **SOLUTION:** (a) Centripetal acceleration $v = \sqrt{\frac{G\,M}{R}}$ Squaring both the side $(v)^2 = \left(\sqrt{\frac{G\,M}{R}}\right)^2$	$v^2 = \frac{G\,M}{R}$ $R = \frac{G\,M}{v^2}$ $R = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(3200)^2}$ $R = \frac{3.988 \times 10^{14}}{1.024 \times 10^{7}}$ $R = 3.894 \times 10^{7}\ m$

(v) When an object is thrown upwards. It rises to a height 'h'. How high is the object in terms? of h, when it has lost one-third of its original kinetic energy?

DATA

Height = h ; H = ? for which

K.E Lost = $\frac{1}{3} \times initial \ \ K.E$

SOLUTION:

Initial K.E at the ground = $\frac{1}{2} mv^2$

but P.E = 0

At max height 'h' i.e. at point P.

Final K.E = 0

P.E. = mgh

$\Rightarrow$ Loss in K.E = Gain in P.E ………. (i)

or $\frac{1}{2} mv^2 = mgh$

Let 's' be the height of an object when it has lost $\frac{1}{3}$ of its K.E then Eq. (i) $\Rightarrow$

$\frac{1}{3}$ loss in K.E = $\frac{1}{3}$(Gain in P.E)

$$\frac{1}{3}\left(\frac{1}{2}mv^2\right) = mgH$$

$$\frac{1}{3}(mgh) = mgH$$

$\Rightarrow$ $H = \frac{1}{3}$ h

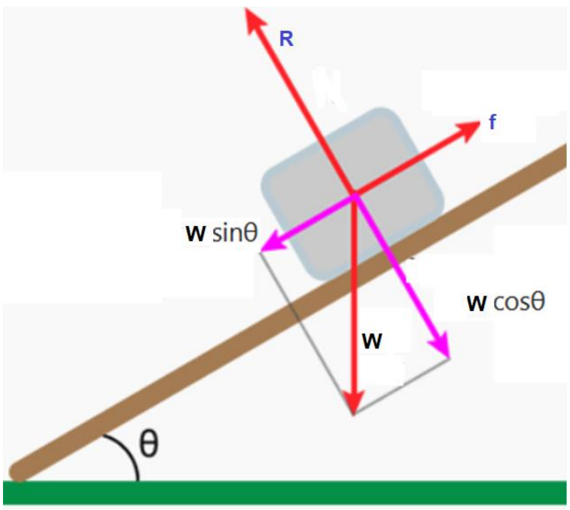
(vi) For an inclined plane, derive the relation between the angle of friction and the angle of repose

RELATION BETWEEN ANGLE OF FRICTION AND ANGLE OF REPOSE

The angle of repose is defined as the minimum angle made by an inclined plane with the horizontal such that an object placed on the inclined surface just begins to slide.

Consider the plane makes an angle θ with the horizontal, the body just begins to move. Let '**R**' be the normal reaction of the body, and '**f**' be the frictional force. As shown in the figure

Here



W sinθ = f

mg sinθ = f ………………(i)

W cosθ = R

mg cosθ = R ……………(ii)

Dividing equation (i) by (ii)

$$\frac{mg \sin\theta}{mg \cos\theta} = \frac{f}{R}$$

$$\frac{\sin\theta}{\cos\theta} = \frac{f}{R} \quad \{\mu = \frac{f}{R}\}$$

$$\tan\theta = \mu \quad \ldots\ldots\ldots (i)$$

The angle of repose is given by

$$\tan\alpha = \mu \ \ldots\ldots\ldots (ii)$$

comparing equatin (i) *and* (*ii*)

$$\tan\theta = \tan\alpha$$

$$\theta = \alpha$$

The angle of repose is equal to the angle of friction

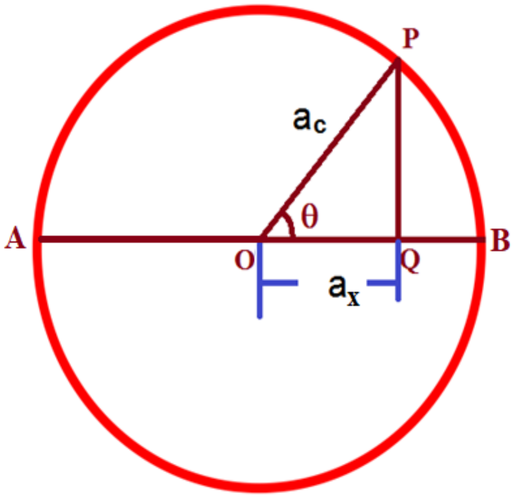
(vii) What capacitance is required to store energy of 3.6 x 10^7 J at a potential difference of 1000 V?

Data:	SOLUTION:
$U = 3600000\ J = 3.6 \times 10^7 J$ $V = 1000\ V$	$U = \frac{1}{2} C V^2$ $3.6 \times 10^7 = \frac{1}{2} C (1000)^2$ $2 \times 3.6 \times 10^7 = C \times 1 \times 10^6$ $\frac{7.2 \times 10^7}{1 \times 10^6} = C$ $72\ Farad = C$

(viii) Prove that the motion of the projection of a particle describing circular motion with constant angular speed ω is simple harmonic motion on one of the diameters of the circle.

Ans **<u>PROJECTION OF UNIFORM CIRCULAR MOTION ALONG A DIAMETER OF THE CIRCLE.</u>**

Consider a particle of mass **m** rotating in a circle of radius **r** with a speed of **v,** then the projection '*Q*' of the particle moves back and forth along the diameter of the circle.



The centripetal acceleration of particle 'P' a_c into its rectangular components

$$a_x = a_c \cos\theta$$

$$a_x = x_0\,\omega^2 \cos\theta$$

And

$$a_y = a_c \sin\theta$$

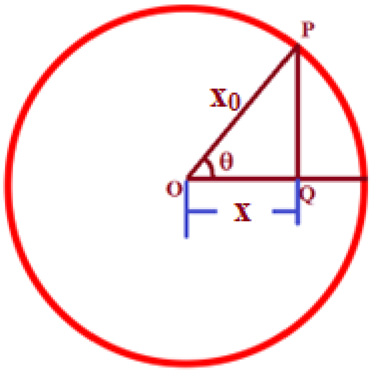
$$a_y = x_0\,\omega^2 \sin\theta$$

Since a_x is the component along the diameter AOB and always directed towards the equilibrium position '0'. At any instant t the direction of the acceleration vector is opposite to the direction of the displacement vector. Therefore;

$$a_x = -\,x_0\,\omega^2 \cos\theta \quad \dots\dots\dots\dots..(i)$$

Consider the right-angle triangle OQP

$$Cos\theta = \frac{x}{x_0}\dots\dots\dots\dots\dots\dots(ii)$$



Substituting cosθ expression in equation (i)

$$a_x = -\,x_0\,\omega^2 \left(\frac{x}{x_0}\right)$$

$$a_x = -\,\omega^2\,x$$

$$a_x = -\,(constant)\,x$$

$$a_x \propto -\,x$$

This is an equation representing simple harmonic motion, which indicates that the acceleration of 'Q' is directly proportional to its displacement and is directed towards mean position. Hence the motion of projection 'Q' along the diameter of the circle is simple harmonic motion.

(ix) **Define electric field intensity and electric potential, and prove $E = -\frac{\Delta V}{\Delta r}$**

ELECTRIC FIELD INTENSITY

DEFINITION:

Electric field intensity is defined as the force exerted on a unit positive charge placed at a specific point in an electric field. it's a vector quantity

$$E = \frac{F}{q_o}$$

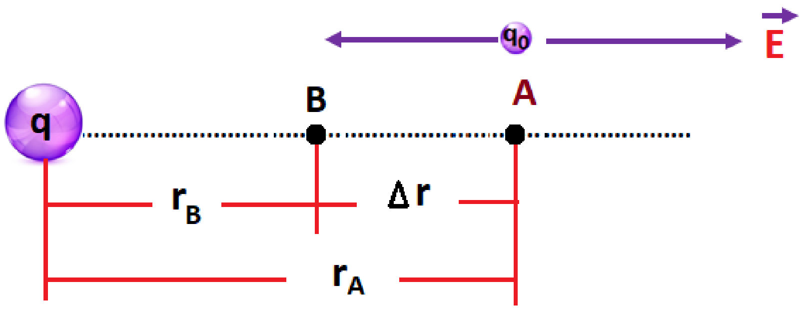
ELECTRIC POTENTIAL

DEFINITION:

Electric potential is the amount of work needed to move a unit charge from a reference point to a specific point against an electric field.

CALCULATING ELECTRIC FIELD FROM ELECTRIC POTENTIAL

Suppose that a positive test charge q_0 moves from one point A to another point B against the electric field. As shown in the figure



The work done in moving a test through a distance Δr
Work done on q_o against the field = $-F\ \Delta r$

$$W = -q_o E\ \Delta S$$

potential difference between the points

$$\Delta V = \frac{\Delta W}{q_o}$$

$$\Delta V = -\frac{q_0 E \Delta S}{q_o}$$

$$\Delta V = -E\ \Delta S$$

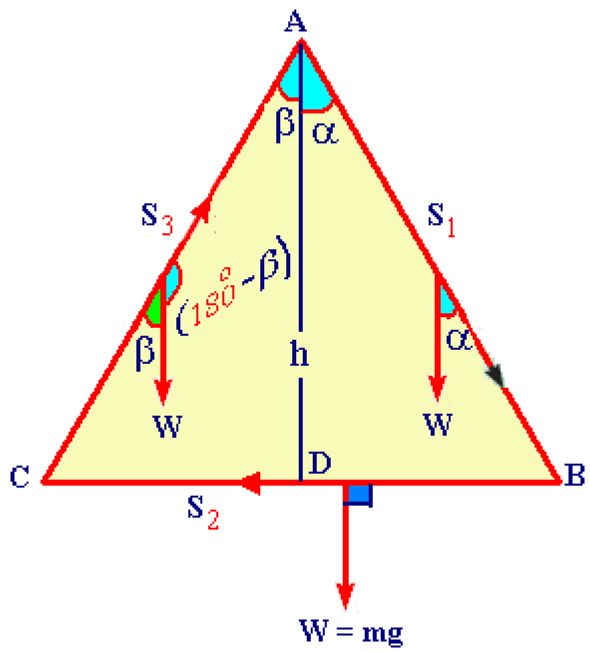
or $$E = -\frac{\Delta V}{\Delta S}$$

$\left(\frac{\Delta V}{\Delta S}\right)$ is the ratio of change of potential with respect to the distance known as potential gradient.

(x) Prove that the work done by the gravitational force in moving a body around a closed path is zero.

Ans **In a gravitational field, the net work done by the force on an object moving around a closed path is zero , therefore gravitational field is a conservative field.**

To prove this statement, consider a closed triangular path ABCA as shown. Let us calculate the work done around a closed path of mass 'm' in the gravitational field of Earth.



work done along AB = $W_{A\to B}$

$$W_{A\to B} = \vec{F}.\vec{S_1}$$

$$W_{A\to B} = F\,S_1\,Cos\alpha$$

$$W_{A\to B} = W\,S_1\,Cos\alpha \quad ....(i)$$

From the triangle ACD

$$Cos\alpha = \frac{AD}{AC}$$

$$Cos\alpha = \frac{h}{S_1}$$

$$h = S_3 Cos\alpha \ ....\ (ii)$$

Substituting the value of h from equation (ii) in equation (i), we get

$$W_{A\to B} = mgh \quad ....(iii)$$

work done from B to C

$$W_{B\to C} = \vec{F}g\vec{S_2}$$

$$W_{B\to C} = F\,S_2\,Cos90^0 \qquad \alpha = 90^0$$

$$W_{B\to C} = W\,S_2\,Cos90^0 \qquad W = mg \quad Cos90^0 = 0$$

$$W_{A\to B} = mg\,S_2\,(0) \quad ....(iv)$$

work done along CA = $W_{C\to A}$

$$W_{C\to A} = \vec{F}g\vec{S_3}$$

$$W_{C\to A} = F\,S_3\,Cos\theta$$

$$W_{C\to A} = W\,S_3\,Cos(180-\beta) \qquad \theta = 180-\beta$$

$$W_{C\to A} = W\,S_3\,(-Cos\beta) \qquad Cos(180-\beta) = -Cos\beta$$

$$W_{C\to A} = -mg\,S_3\,Cos\beta$$

$$W_{C\to A} = -mg\,h \qquad (h = S_3 Cos\beta)$$

$$\text{Total work} = W_{A\to B} + W_{B\to C} + W_{C\to A}$$

$$\text{Total work} = mgh + 0 + (-mgh)$$

$$\text{Total work} = 0$$

Thus, the gravitational field is conservative

(xi) Prove the following equation is dimensionally correct

* $S = v_i t + \frac{1}{2} a t^2$ * $T = 2\pi\sqrt{\frac{\ell}{g}}$

(ii) $S = v_i t + \frac{1}{2} a t^2$

SOLUTION

$L.H.S = [S]$

$L.H.S = [L]$

$R.H.S = [v_i][t] + \frac{1}{2}[a][t^2]$

$R.H.S = [L T^{-1}][T] + \frac{1}{2}[L T^{-2}][T^2]$

$R.H.S = [L T^{-1} T] + \frac{1}{2}[L T^{-2} T^2]$

$\left\{\frac{1}{2} \text{ has no dimension}\right\}$

$R.H.S = [L] + \frac{1}{2}[L] = [L] + [L]$

$R.H.S = 2[L]$ $\{2 \text{ has no dimension}\}$

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

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

SOLUTION

$L.H.S = [T]$

$L.H.S = [T]$

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

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

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

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

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

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

$R.H.S = T$

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

(xii) Define resistivity and derive its mathematical expression

RESISTIVITY

DEFINITION:

Resistivity is defined as the resistance offered by the material per unit length per unit cross-section of the material

Unit:

The SI unit of resistivity is ohm-meter. Which is written in symbols as **Ω m**.

Formula:

It is found experimentally that the resistance **R** of a metal wire is directly proportional to its length **"L"**

$$R \ \alpha \ L \quad \dots\dots..(i)$$

It is found experimentally that the resistance **R** of a metal wire is inversely proportional to its area of cross-section **"A",** that is

$$\mathrm{R} \ \alpha \ \frac{1}{\mathrm{A}} \quad \dots\dots..(\mathrm{ii})$$

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

$$\mathrm{R} \ \alpha \ \frac{\mathrm{L}}{\mathrm{A}}$$

$$\mathrm{R} = \text{constant} \ \frac{\mathrm{L}}{\mathrm{A}}$$

$$\mathrm{R} = \rho \ \frac{\mathrm{L}}{\mathrm{A}}$$

$$A \times \mathrm{R} = \rho \times \mathrm{L}$$

$$\frac{A \times \mathrm{R}}{\mathrm{L}} = \rho$$

$$\rho = \frac{A \times \mathrm{R}}{\mathrm{L}}$$

Where ρ (Greek Letter Rho) is a constant of proportionality, it is called resistivity and depends on the material used.

(xiii) What is projectile motion? Derive the mathematical expression for its range

PROJECTILE MOTION

The motion of a body is said to be projectile motion if its velocity has two components, where one component remains constant and the other changes continuously throughout the motion. It is a two-dimensional motion under gravitational force and negligible frictional resistance of air; this motion follows a parabolic path

HORIZONTAL RANGE:-

The distance between the point of projection and the point where it hits the level from which it was launched is known as its horizontal range.

DERIVATION

Let R be the range of the projectile, then it can be found by using the formula

$$x = v_{ix}\ t + \frac{1}{2} a_x\, t^2 \ldots\ldots (i)$$

Where $X = R$ $\quad V_{ix} = V_{ox} = V_o \cos\theta$

$a_y = -g$ $\quad t = T = \frac{2V_o \sin\theta}{g}$

substituting these values in equation (i)

$$R = V_0 \cos\theta \times \frac{2V_o \sin\theta}{g} + \frac{1}{2}(0)\, t^2$$

$$R = (V_o \cos\theta)\left(\frac{2V_o \sin\theta}{g}\right)$$

$$R = \frac{V_o{}^2\ 2\sin\theta\ \cos\theta}{g} \qquad \because 2\sin\theta \cos\theta = \sin 2\theta$$

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

(xiv) A train sounds its whistle with a frequency of 200 Hz. A stationary observer measures this frequency of 219 Hz. Find the speed of the train (speed of sound is 340 m/s)

DATA	
f = 200 Hz f' = 219 Hz V_s = ? V = 340 m/s **SOLUTION:** $f' = \left(\frac{V}{V - V_s}\right) f$	$219 = \left(\frac{340}{340 - V_s}\right) 200$ $219(340 - V_s) = 340 \times 200$ $74460 - 219 \times V_s = 68000$ $74460 - 68000 = 219 \times V_s$ $6460 = 219 \times V_s$ $V_s = \frac{6460}{219} = 29.5\ m/s$