# FINAL JEE–MAIN EXAMINATION – JULY, 2021

**(Held On Tuesday 27th July, 2021)** **TIME : 3 : 00 PM to 6 : 00 PM**

## PHYSICS | TEST PAPER WITH SOLUTION

### SECTION-A

**1.** An electron and proton are separated by a large distance. The electron starts approaching the proton with energy 3 eV. The proton captures the electrons and forms a hydrogen atom in second excited state. The resulting photon is incident on a photosensitive metal of threshold wavelength 4000 Å. What is the maximum kinetic energy of the emitted photoelectron?

(1) 7.61 eV
(2) 1.41 eV
(3) 3.3 eV
(4) No photoelectron would be emitted

**Official Ans. by NTA (2)**

**Sol.** Initially, energy of electron = +3eV

finally, in $2^{nd}$ excited state,

$$\text{energy of electron} = -\frac{(13.6\text{eV})}{3^2}$$

$$= -1.51\text{eV}$$

Loss in energy is emitted as photon,

So, photon energy $\frac{hc}{\lambda} = 4.51$ eV

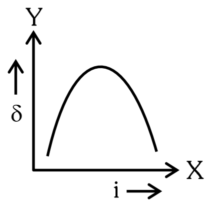
Now, photoelectric effect equation

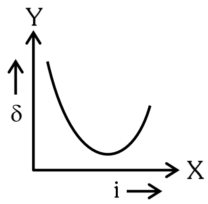
$$KE_{max} = \frac{hc}{\lambda} - \phi = 4.51 - \left(\frac{hc}{\lambda_{th}}\right)$$

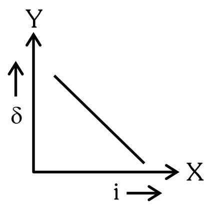
$$= 4.51\text{ eV} - \frac{12400\text{ eVÅ}}{4000\text{ Å}}$$

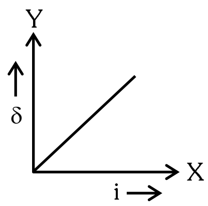
$$= 1.41\text{ eV}$$

**2.** The expected graphical representation of the variation of angle of deviation 'δ' with angle of incidence 'i' in a prism is :

(1) 


(2) 


(3) 


(4) 


**Official Ans. by NTA (2)**

**Sol.** Standard graph between angle of deviation and incident angle.

**3.** A raindrop with radius R = 0.2 mm falls from a cloud at a height h = 2000 m above the ground. Assume that the drop is spherical throughout its fall and the force of buoyance may be neglected, then the terminal speed attained by the raindrop is :

[Density of water $f_w = 1000$ kg m$^{-3}$ and Density of air $f_a = 1.2$ kg m$^{-3}$, g = 10 m/s$^2$

Coefficient of viscosity of air = $1.8 \times 10^{-5}$ Nsm$^{-2}$]

(1) 250.6 ms$^{-1}$
(2) 43.56 ms$^{-1}$
(3) 4.94 ms$^{-1}$
(4) 14.4 ms$^{-1}$

**Official Ans. by NTA (3)**

**Sol.** At terminal speed

$$a = 0$$

$$F_{net} = 0$$

$$mg = F_v = 6\pi\eta Rv$$

$$v = \frac{mg}{6\pi\eta Rv}$$

$$v = \frac{\rho_w \frac{4\pi}{3} R^3 g}{6\pi\eta R}$$

$$= \frac{2\rho_w R^2 g}{9\eta}$$

$$= \frac{400}{81}\text{ m/s}$$

$$= 4.94\text{ m/s}$$

**4.** One mole of an ideal gas is taken through an adiabatic process where the temperature rises from 27°C to 37°C. If the ideal gas is composed of polyatomic molecule that has 4 vibrational modes, which of the following is true?

[$R = 8.314\ J\ mol^{-1}\ k^{-1}$]

(1) work done by the gas is close to 332 J

(2) work done on the gas is close to 582 J

(3) work done by the gas is close to 582 J

(4) work done on the gas is close to 332 J

**Official Ans. by NTA (2)**

**Sol.** Since, each vibrational mode, corresponds to two degrees of freedom, hence, f = 3 (trans.) + 3(rot.) + 8 (vib.) = 14

& $\gamma = 1+\frac{2}{f}$

$\gamma = 1+\frac{2}{14} = \frac{8}{7}$

$W = \frac{nR\Delta T}{\gamma - 1} = -582$

As W < 0. work is done on the gas.

**5.** An object of mass 0.5 kg is executing simple harmonic motion. It amplitude is 5 cm and time period (T) is 0.2 s. What will be the potential energy of the object at an instant $t = \frac{T}{4}$ s starting from mean position. Assume that the initial phase of the oscillation is zero.

(1) 0.62 J (2) $6.2 \times 10^{-3}$ J

(3) $1.2 \times 10^{3}$ J (4) $6.2 \times 10^{3}$ J

**Official Ans. by NTA (1)**

**Sol.** $T = 2\pi\sqrt{\frac{m}{k}}$

$0.2 = 2\pi\sqrt{\frac{0.5}{k}}$

$k = 50\pi^2$

$\approx 500$

$x = A \sin(\omega t + \phi)$

$= 5\text{ cm} \sin\left(\frac{\omega T}{4} + 0\right)$

$= 5\text{ cm} \sin\left(\frac{\pi}{2}\right)$

$= 5$ cm

$PE = \frac{1}{2}kx^2$

$= \frac{1}{2}(500)\left(\frac{5}{100}\right)^2$

$= 0.6255$

**6.** Match **List I** with **List II**.

| **List-I** | **List-II** |
|---|---|
| (a) Capacitance, C | (i) $M^1L^1T^{-3}A^{-1}$ |
| (b) Permittivity of free space, $\varepsilon_0$ | (ii) $M^{-1}L^{-3}T^4A^2$ |
| (c) Permeability of free space, $\mu_0$ | (iii) $M^{-1}L^{-2}T^4A^2$ |
| (d) Electric field, E | (iv) $M^1L^1T^{-2}A^{-2}$ |

Choose the correct answer from the options given below

(1) (a) → (iii), (b) → (ii), (c) → (iv), (d) → (i)

(2) (a) → (iii), (b) → (iv), (c) → (ii), (d) → (i)

(3) (a) → (iv), (b) → (ii), (c) → (iii), (d) → (i)

(4) (a) → (iv), (b) → (iii), (c) → (ii), (d) → (i)

**Official Ans. by NTA (1)**

**Sol.** $q = CV$

$[C] = \left[\frac{q}{V}\right] = \frac{(A\times T)^2}{ML^2T^{-2}}$

$= M^{-1}L^{-2}\,T^4A^2$

$[E] = \left[\frac{F}{q}\right] = \frac{MLT^{-2}}{AT}$

$= MLT^{-3}\,A^{-1}$

$F = \frac{q_1q_2}{4\pi\epsilon_o r^2}$

$[\epsilon_o] = M^{-1}L^{-3}T^4A^2$

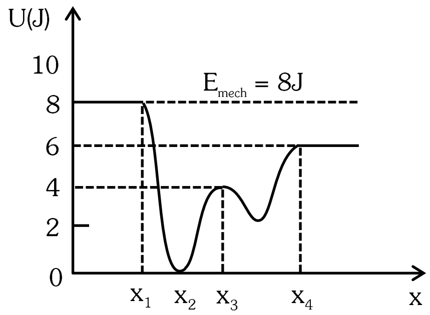
Speed of light $c = \frac{1}{\sqrt{\mu_o\epsilon_o}}$

$\mu_o = \frac{1}{\epsilon_o c^2}$

$[\mu_o] = \frac{1}{[M^{-1}L^{-3}T^4A^2][LT^{-1}]^2}$

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

**7.** Given below is the plot of a potential energy function U(x) for a system, in which a particle is in one dimensional motion, while a conservative force F(x) acts on it. Suppose that $E_{mech}$ = 8 J, the incorrect statement for this system is :




[where K.E. = kinetic energy]

(1) at $x > x_4$, K.E. is constant throughout the region.

(2) at $x < x_1$, K.E. is smallest and the particle is moving at the slowest speed.

(3) at $x = x_2$, K.E. is greatest and the particle is moving at the fastest speed.

(4) at $x = x_3$, K.E. = 4 J.

**Official Ans. by NTA (2)**

**Sol.** $E_{mech.} = 8J$

(A) at $x > x_4$, $U$ = constant = 6J

$K = E_{mech.} - U = 2J$ = constant

(B) at $x < x_1$, $U$ = constant = 8J

$K = E_{mech.} - U = 8 - 8 = 0$ J

Particle is at rest.

(C) At $x = x_2$, $U = 0 \Rightarrow E_{mech.} = K = 8$ J

KE is greatest, and particle is moving at fastest speed.

(D) At $x = x_3$, $U = 4$ J

$U + K = 8$ J

$K = 4$ J

**8.** A 100 Ω resistance, a 0.1 μF capacitor and an inductor are connected in series across a 250 V supply at variable frequency. Calculate the value of inductance of inductor at which resonance will occur. Given that the resonant frequency is 60 Hz.

(1) 0.70 H (2) 70.3 mH

(3) $7.03 \times 10^{-5}$ H (4) 70.3 H

**Official Ans. by NTA (4)**

**Sol.** $C = 0.1\ \mu F = 10^{-7}$ F

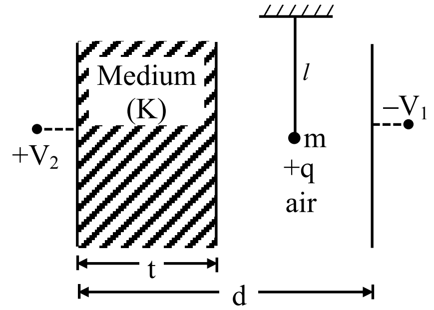
Resonant frequency = 60 Hz

$$\omega_o = \frac{1}{\sqrt{LC}}$$

$$2\pi f_o = \frac{1}{\sqrt{LC}} \Rightarrow L = \frac{1}{4\pi^2 f_o^2 C}$$

by putting values $L \simeq 70.3$ Hz.

**9.** A simple pendulum of mass 'm', length '$l$' and charge '+q' suspended in the electric field produced by two conducting parallel plates as shown. The value of deflection of pendulum in equilibrium position will be




(1) $\tan^{-1}\left[\frac{q}{mg} \times \frac{C_1(V_2 - V_1)}{(C_1 + C_2)(d - t)}\right]$

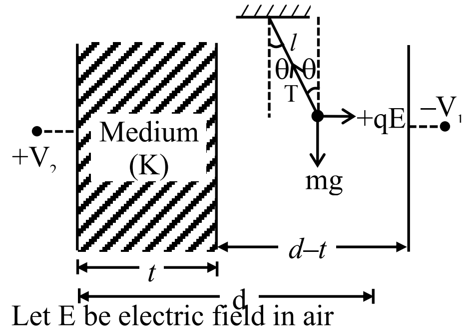
(2) $\tan^{-1}\left[\frac{q}{mg} \times \frac{C_2(V_2 - V_1)}{(C_1 + C_2)(d - t)}\right]$

(3) $\tan^{-1}\left[\frac{q}{mg} \times \frac{C_2(V_1 + V_2)}{(C_1 + C_2)(d - t)}\right]$

(4) $\tan^{-1}\left[\frac{q}{mg} \times \frac{C_1(V_1 + V_2)}{(C_1 + C_2)(d - t)}\right]$

**Official Ans. by NTA (3)**

**Sol.**

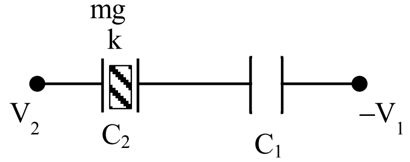



Let E be electric field in air

$T \sin\theta = qE$

$T \cos\theta = mg$

$$\tan\theta = \frac{qE}{mg}$$




$$Q = \left[\frac{C_1 C_2}{C_1 + C_2}\right][V_1 + V_2]$$

$$E = \frac{Q}{A\epsilon_o} = \left[\frac{C_1 C_2}{C_1 + C_2}\right]\frac{[V_1 + V_2]}{A\epsilon_o}$$

$$C_1 = \frac{\epsilon_o A}{d - t} \Rightarrow E = \frac{C_2[V_1 + V_2]}{(C_1 + C_2)(d - t)}$$

$$\text{Now } \theta = \tan^{-1}\left[\frac{q.E}{mg}\right]$$

$$\theta = \tan^{-1}\left[\frac{q}{mg} \times \frac{C_2(V_1 + V_2)}{(C_1 + C_2)(d - t)}\right]$$

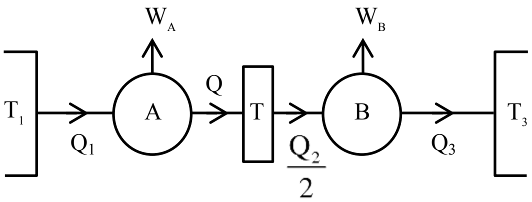
**10.** Two Carnot engines A and B operate in series such that engine A absorbs heat at $T_1$ and rejects heat to a sink at temperature T. Engine B absorbs half of the heat rejected by Engine A and rejects heat to the sink at $T_3$. When workdone in both the cases is equal, to value of T is :

(1) $\frac{2}{3}T_1 + \frac{3}{2}T_3$ (2) $\frac{1}{3}T_1 + \frac{2}{3}T_3$

(3) $\frac{3}{2}T_1 + \frac{1}{3}T_3$ (4) $\frac{2}{3}T_1 + \frac{1}{3}T_3$

**Official Ans. by NTA (4)**

**Sol.**




$$W_A = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T}{T_1} \Rightarrow \frac{Q_2}{Q_1} = \frac{T}{T_1}$$

$$W_B = 1 - \frac{Q_3}{(Q_2/2)} = 1 - \frac{T_3}{T} \Rightarrow \frac{2Q_3}{Q_2} = \frac{T_3}{T}$$

Now, $W_A = W_B$

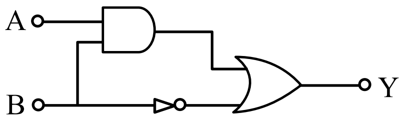
$$Q_1 - Q_2 = \frac{Q_2}{2} - Q_3$$

$$\Rightarrow \frac{2Q_1}{Q_2} + \frac{2Q_3}{Q_2} = 3$$

$$\Rightarrow \frac{2T_1}{T} + \frac{T_3}{T} = 3$$

$$\frac{2T_1}{3} + \frac{T_3}{3} = T$$

**11.** Find the truth table for the function Y of A and B represented in the following figure.




(1)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

(2)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

(3)

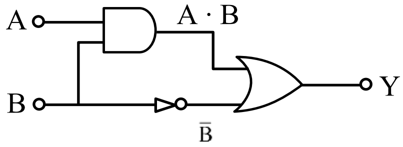
| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

(4)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

**Official Ans. by NTA (2)**

**Sol.**




$$Y = A \cdot B + \bar{B}$$

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

**12.** Figure A and B shown two long straight wires of circular cross-section (a and b with a < b), carrying current I which is uniformly distributed across the cross-section. The magnitude of magnetic field B varies with radius r and can be represented as :

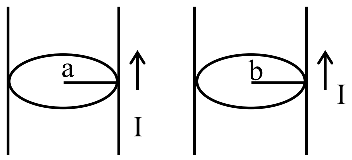
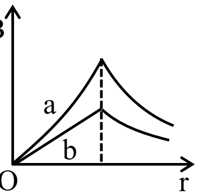
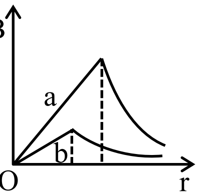



Fig. A Fig. B

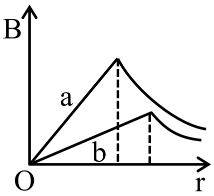
(1)



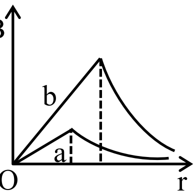

(2)




(3)

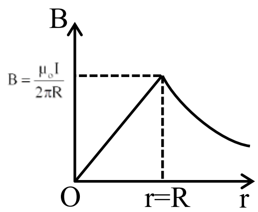



(4)




**Official Ans. by NTA (3)**

**Sol.** Graph for wire of radius R :




As b > a

$B_a > B_b$

$$B_a = \frac{\mu_0 i}{2\pi a}$$

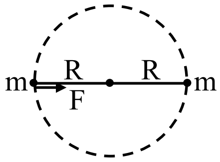
$$B_b = \frac{\mu_0 i}{2\pi b}$$

**13.** Two identical particles of mass 1 kg each go round a circle of radius R, under the action of their mutual gravitational attraction. The angular speed of each particle is :

(1) $\sqrt{\frac{G}{2R^3}}$ (2) $\frac{1}{2}\sqrt{\frac{G}{R^3}}$ (3) $\frac{1}{2R}\sqrt{\frac{1}{G}}$ (4) $\sqrt{\frac{2G}{R^3}}$

**Official Ans. by NTA (2)**

**Sol.**




$$F = \frac{Gm^2}{(2R)^2} = mR\omega^2$$

$$\omega = \frac{1}{2}\sqrt{\frac{G}{R^3}}$$

**14.** Consider the following statements :

A. Atoms of each element emit characteristics spectrum.

B. According to Bohr's Postulate, an electron in a hydrogen atom, revolves in a certain stationary orbit.

C. The density of nuclear matter depends on the size of the nucleus.

D. A free neutron is stable but a free proton decay is possible.

E. Radioactivity is an indication of the instability of nuclei.

Choose the correct answer from the options given below :

(1) A, B, C, D and E

(2) A, B and E only

(3) B and D only

(4) A, C and E only

**Official Ans. by NTA (2)**

**Sol.** (A) True, atom of each element emits characteristic spectrum.

(B) True, according to Bohr's postulates

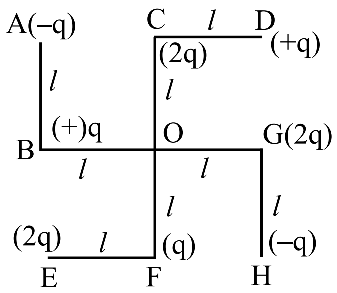
$mvr = \frac{nh}{2\pi}$ and hence electron resides into orbits of specific radius called stationary orbits.

(C) False, density of nucleus is constant

(D) False, A free neutron is unstable decays into proton and electron and antineutrino.

(E) True unstable nucleus show radioactivity.

**15.** What will be the magnitude of electric field at point O as shown in figure? Each side of the figure is $l$ and perpendicular to each other?




(1) $\frac{1}{4\pi\varepsilon_0}\frac{q}{l^2}$ (2) $\frac{1}{4\pi\varepsilon_0}\frac{q}{(2l^2)}\left(2\sqrt{2}-1\right)$

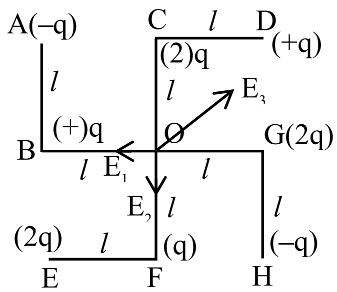
(3) $\frac{q}{4\pi\varepsilon_0(2l)^2}$ (4) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{2l^2}\left(\sqrt{2}\right)$

**Official Ans. by NTA (2)**

**Sol.** $E_1 = \frac{kq}{\ell^2} = E_2$

$$E_3 = \frac{kq}{(\sqrt{2}\ell)^2} = \frac{kq}{2\ell^2}$$

$$E = \frac{\sqrt{2}kq}{\ell^2} - \frac{kq}{2\ell^2} = \frac{kq}{2\ell^2}\left(2\sqrt{2}-1\right)$$




**16.** A physical quantity 'y' is represented by the formula $y = m^2 r^{-4} g^x l^{-\frac{3}{2}}$

If the percentage errors found in y, m, r, $l$ and g are 18, 1, 0.5, 4 and p respectively, then find the value of x and p.

(1) 5 and ± 2 (2) 4 and ± 3

(3) $\frac{16}{3}$ and $\pm\frac{3}{2}$ (4) 8 and ± 2

**Official Ans. by NTA (3)**

**Sol.** $\frac{\Delta y}{y} = \frac{2\Delta m}{m} + \frac{4\Delta r}{r} + \frac{x\Delta g}{g} + \frac{3}{2}\frac{\Delta \ell}{\ell}$

$$18 = 2(1) + 4(0.5) + xp + \frac{3}{2}(4)$$

$8 = xp$

By checking from options.

$$x = \frac{16}{3},\ p = \pm\frac{3}{2}$$

**17.** An automobile of mass 'm' accelerates starting from origin and initially at rest, while the engine supplies constant power P. The position is given as a function of time by :

(1) $\left(\frac{9P}{8m}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$ (2) $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{2}{3}}$

(3) $\left(\frac{9m}{8P}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$ (4) $\left(\frac{8P}{9m}\right)^{\frac{1}{2}} t^{\frac{3}{2}}$

**Official Ans. by NTA (4)**

**Sol.** P = const.

$$P = Fv = \frac{mv^2dv}{dx}$$

$$\int_0^x \frac{P}{m}dx = \int_0^v v^2dv$$

$$\frac{Px}{m} = \frac{v^3}{3}$$

$$\left(\frac{3Px}{m}\right)^{1/3} = v = \frac{dx}{dt}$$

$$\left(\frac{3P}{m}\right)^{1/3}\int_0^t dt = \int_0^x x^{-1/3}dx$$

$$\Rightarrow x = \left(\frac{8P}{9m}\right)^{1/2} t^{3/2}$$

**18.** The planet Mars has two moons, if one of them has a period 7 hours, 30 minutes and an orbital radius of $9.0 \times 10^3$ km. Find the mass of Mars.

$$\left\{\text{Given } \frac{4\pi^2}{G} = 6\times10^{11}\ N^{-1}\ m^{-2}\ kg^2\right\}$$

(1) $5.96 \times 10^{19}$ kg (2) $3.25 \times 10^{21}$ kg

(3) $7.02 \times 10^{25}$ kg (4) $6.00 \times 10^{23}$ kg

**Official Ans. by NTA (4)**

**Sol.** Option D is correct

$$T^2 = \frac{4\pi^2}{GM}\cdot r^3$$

$$M = \frac{4\pi^2}{G}\cdot\frac{r^3}{T^2}$$

by putting values

$M = 6 \times 10^{23}$

**19.** A particle of mass M originally at rest is subjected to a force whose direction is constant but magnitude varies with time according to the relation

$$F = F_0\left[1 - \left(\frac{t-T}{T}\right)^2\right]$$

Where $F_0$ and T are constants. The force acts only for the time interval 2T. The velocity v of the particle after time 2T is :

(1) $2F_0T / M$

(2) $F_0T / 2M$

(3) $4F_0T / 3M$

(4) $F_0T / 3M$

**Official Ans. by NTA (3)**

**Sol.** t = 0, u = 0

$$a = \frac{F_o}{M} - \frac{F_o}{MT^2}(t-T)^2 = \frac{dv}{dt}$$

$$\int_0^v dv = \int_{t=0}^{2T}\left(\frac{F_o}{M} - \frac{F_o}{MT^2}(t-T)^2\right)dt$$

$$V = \left[\frac{F_o}{M}t\right]_o^{2T} - \frac{F_o}{MT^2}\left[\frac{t^3}{3} - t^2T + T^2t\right]_0^{2T}$$

$$V = \frac{4F_oT}{3M}$$

**20.** The resistance of a conductor at 15°C is 16 Ω and at 100°C is 20Ω. What will be the temperature coefficient of resistance of the conductor?

(1) $0.010°C^{-1}$

(2) $0.033°C^{-1}$

(3) $0.003°C^{-1}$

(4) $0.042°C^{-1}$

**Official Ans. by NTA (3)**

**Sol.** $16 = R_o\,[1 + \alpha\,(15 - T_o)\,]$

$20 = R_o\,[1 + \alpha\,(100 - T_o)\,]$

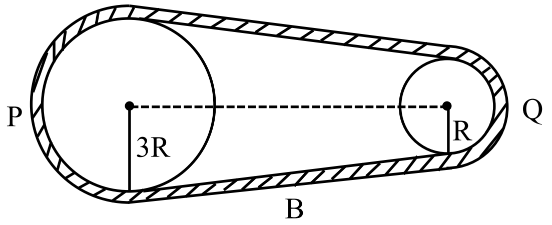
Assuming $T_o = 0°C$, as a general convention.

$$\Rightarrow \frac{16}{20} = \frac{1+\alpha\times15}{1+\alpha\times100}$$

$\Rightarrow \alpha = 0.003\ °C^{-1}$

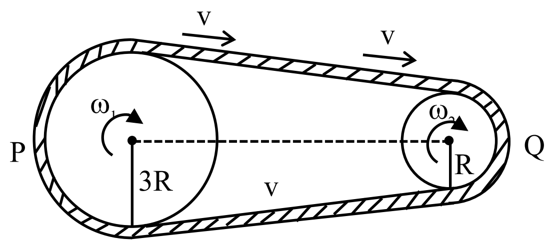
## SECTION-B

**1.** In the given figure, two wheels P and Q are connected by a belt B. The radius of P is three times as that of Q. In case of same rotational kinetic energy, the ratio of rotational inertias $\left(\frac{I_1}{I_2}\right)$ will be x : 1. The value of x will be _____.




**Official Ans. by NTA (9)**

**Sol.**




$$\frac{1}{2}I_1(\omega_1)^2 = \frac{1}{2}I_2(\omega_2)^2$$

$$I_1\left(\frac{v}{3R}\right)^2 = I_2\left(\frac{v}{R}\right)^2$$

$$\frac{I_1}{I_2} = \frac{9}{1}$$

**2.** The difference in the number of waves when yellow light propagates through air and vacuum columns of the same thickness is one. The thickness of the air column is ______ mm. [Refractive index of air = 1.0003, wavelength of yellow light in vacuum = 6000 Å]

**Official Ans. by NTA (2)**

**Sol.** Thickness $t = n\lambda$

So, $n\,\lambda_{vac} = (n+1)\,\lambda_{air}$

$$n\,\lambda = (n+1)\,\frac{\lambda}{\mu_{air}}$$

$$n = \frac{1}{\mu_{air}-1} = \frac{10^4}{3}$$

$t = n\lambda$

$$= \frac{10^4}{3}\times 6000\text{Å}$$

$= 2$ mm

**3.** The maximum amplitude for an amplitude modulated wave is found to be 12V while the minimum amplitude is found to be 3V. The modulation index is 0.6x where x is ______.

**Official Ans. by NTA (1)**

**Sol.** $A_{max} = A_c + A_m = 12$

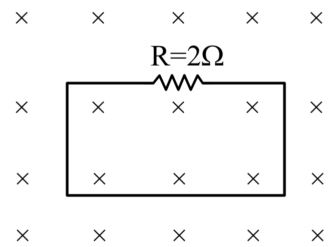
$A_{min} = A_c - A_m = 3$

$$\Rightarrow A_c = \frac{15}{2} \;\&\; A_m = \frac{9}{2}$$

$$\text{modulation index} = \frac{A_m}{A_c} = \frac{9/2}{15/2} = 0.6$$

$\Rightarrow x = 1$

**4.** In the given figure the magnetic flux through the loop increases according to the relation $\phi_B(t) = 10t^2 + 20t$, where $\phi_B$ is in milliwebers and t is in seconds.
The magnitude of current through R = 2Ω resistor at t = 5 s is ______ mA.




**Official Ans. by NTA (60)**

**Sol.** $$|\epsilon| = \frac{d\phi}{dt} = 20t + 20 \text{ mV}$$

$$|i| = \frac{|\epsilon|}{R} = 10t + 10 \text{ mA}$$

at t = 5

$|i| = 60$ mA

**5.** A particle executes simple harmonic motion represented by displacement function as

$$x(t) = A\sin(\omega t + \phi)$$

If the position and velocity of the particle at t = 0 s are 2 cm and 2ω cm $s^{-1}$ respectively, then its amplitude is $x\sqrt{2}$ cm where the value of x is ____.

**Official Ans. by NTA (2)**

**Sol.** $x(t) = A\sin(\omega t + \phi)$

$v(t) = A\omega\cos(\omega t + \phi)$

$2 \quad = A\sin\phi$ ......(1)

$2\omega \quad = A\omega\cos\phi$ ......(2)

From (1) and (2)

$\tan\phi = 1$

$\phi = 45°$

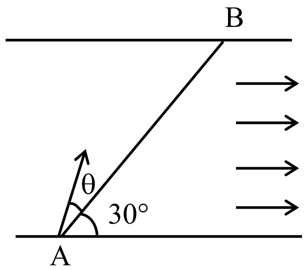
Putting value of $\phi$ in equation (1)

$$2 = A\left\{\frac{1}{\sqrt{2}}\right\}$$

$A = 2\sqrt{2}$

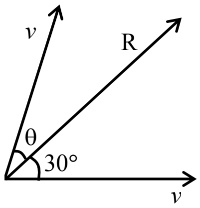
$x = 2$

**6.** A swimmer wants to cross a river from point A to point B. Line AB makes an angle of 30° with the flow of river. Magnitude of velocity of the swimmer is same as that of the river. The angle $\theta$ with the line AB should be ____°, so that the swimmer reaches point B.




**Official Ans. by NTA (30)**

**Sol.**




Both velocity vectors are of same magnitude therefore resultant would pass exactly midway through them

$\theta = 30°$

**7.** For the circuit shown, the value of current at time t = 3.2 s will be ______ A.

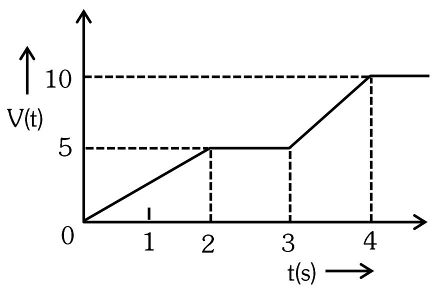



Figure 1

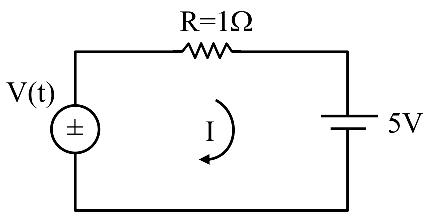
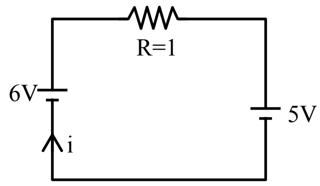



Figure-2

[Voltage distribution V(t) is shown by Fig. (1) and the circuit is shown in Fig. (2)]

**Official Ans. by NTA (1)**

**Sol.** From graph voltage at t = 3.2 sec is 6 volt.

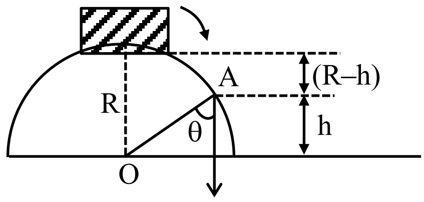



$$i = \frac{6-5}{1}$$

$$i = 1\text{ A}$$

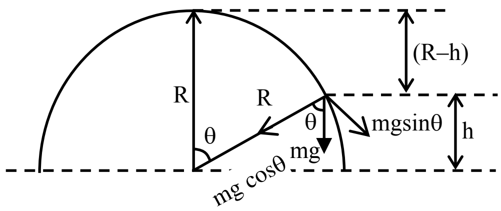
**8.** A small block slides down from the top of hemisphere of radius R = 3 m as shown in the figure. The height 'h' at which the block will lose contact with the surface of the sphere is ____m.

(Assume there is no friction between the block and the hemisphere)




**Official Ans. by NTA (2)**

**Sol.**




$$mg\cos\theta = \frac{mv^2}{R} \qquad ....(1)$$

$$\cos\theta = \frac{h}{R}$$

Energy conservation

$$mg\{R-h\} = \frac{1}{2}mv^2 \qquad ....(2)$$

$$\text{from (1) \& (2)} \Rightarrow mg\left\{\frac{h}{R}\right\} = \frac{2mg\{R-h\}}{R}$$

$$h = \frac{2R}{3} = 2\text{m}$$

**9.** The $K_\alpha$ X-ray of molybdenum has wavelength 0.071 nm. If the energy of a molybdenum atoms with a K electron knocked out is 27.5 keV, the energy of this atom when an L electron is knocked out will be ______ keV. (Round off to the nearest integer)

[$h = 4.14 \times 10^{-15}$ eVs, $c = 3 \times 10^{8}$ ms$^{-1}$]

**Official Ans. by NTA (10)**

**Sol.** $E_{k_\alpha} = E_k - E_L$

$$\frac{hc}{\lambda_{k_\alpha}} = E_k - E_L$$

$$E_L = E_k - \frac{hc}{\lambda_{k_\alpha}}$$

$$= 27.5\text{ KeV} - \frac{12.42 \times 10^{-7}\text{ eVm}}{0.071 \times 10^{-9}\text{ m}}$$

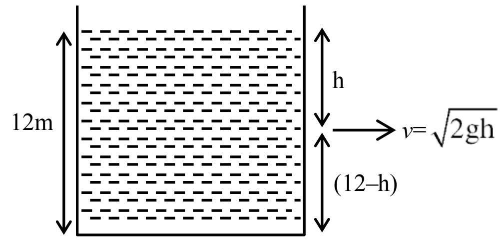
$E_L = (27.5 - 17.5)$ keV

$= 10$ keV

**10.** The water is filled upto height of 12 m in a tank having vertical sidewalls. A hole is made in one of the walls at a depth 'h' below the water level. The value of 'h' for which the emerging stream of water strikes the ground at the maximum range is ___ m.

**Official Ans. by NTA (6)**

**Sol.**




$$R = \sqrt{2gh} \times \sqrt{\frac{(12-h)\times 2}{g}}$$

$$\sqrt{4h(12-h)} = R$$

For maximum R

$$\frac{dR}{dh} = 0$$

$\Rightarrow h = 6$m