JEE Main February 2021

Question Paper With Text Solution

26 Feb.| Shift-2

PHYSICS

MATRIX

JEE Main & Advanced | XI-XII Foundation| VI-X Pre-Foundation

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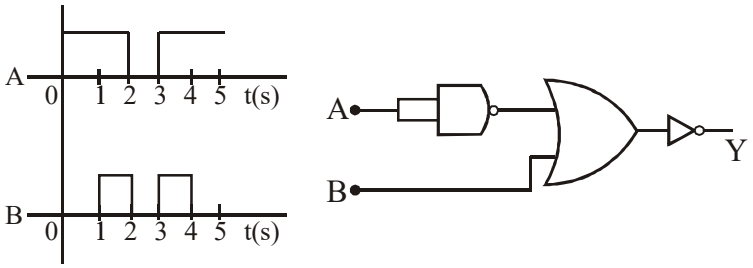
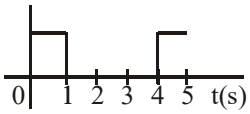
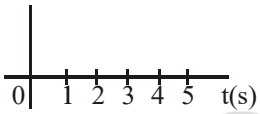
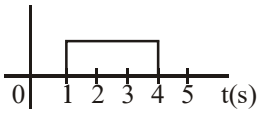
JEE MAIN FEB 2021 | 26TH FEB SHIFT-II

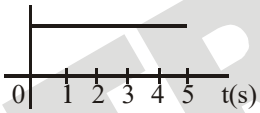
1. Draw the output signal Y in the given combination of gates.



(1) 

(2) 

(3) 

(4) 

Ans. **Official Answer NTA :** (1)

Sol.

2. An aeroplane, with its wings spread 10 m, is flying at a speed of 180 km/h in a horizontal direction. The total intensity of earth's field at that part is 2.5×10^{-4} Wb/m^2 and the angle of dip is 60º. The emf induced between the tips of the plane wings will be _____.

(1) 54.125 mV (2) 88.37 mV (3) 108.25 mV (4) 62.50 mV

Ans. **Official Answer NTA :** (3)

Sol. $B_V = B\sin 60^\circ$

$EMF = B_V lV$

$= 2.5 \times 10^{-4} \times \frac{\sqrt{3}}{2} \times 10 \times 50$

$= 108.25$ mV

3. Given below are two statements :

Statement I : A second's pendulum has a time period of 1 second.

Statement II : It takes precisely one second to move between the two extreme positions.

(1) Both Statement I and Statement II are false

(2) Statement I is true but Statement II is false

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are true

Ans. **Official Answer NTA :** (3)

Sol. Statement I is false because second's pendulum has time period 2 sec

4. A particle executes S.H.M., the graph of velocity as a function of displacement is :

(1) A parabola (2) An ellipse (3) A circle (4) A helix

Ans. **Official Answer NTA :** (2)

Sol. For SHM :

$$v = \omega\sqrt{A^2 - x^2}$$

$$\frac{V^2}{A^2\omega^2} + \frac{x^2}{A^2} = 1 \quad \text{Ellipse}$$

5. Given below are two statements : one is labeled as Assertion A and the other is labeled as Reason R.

Assertion A : For a simple microscope, the angular size of the object equals the angular size of the image.

Reason R : Magnification is achieved as the small object can be kept much closer to the eye than 25 cm and hence it subtends a large angle.

In the ligtht of the above statements, choose the most appropriate answer from the options given below:

(1) Both A and R are true and R is the correct explanation of A

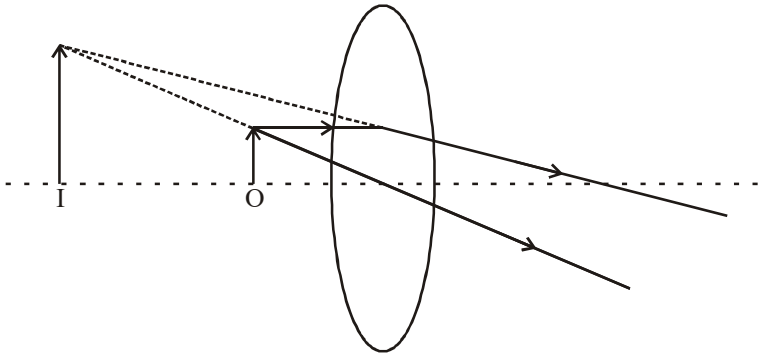
(2) A is false but R is true

(3) Both A and R are true but R is NOT the correct explanation of A

(4) A is true but R is false

Ans. **Official Answer NTA :** (1)

Sol.



6. Two masses A and B, each of mass M are fixed together by a massless spring. A force acts on the mass B as shown in figure. If the mass A starts moving away from mass B with accelertion 'a', then the acceleration of mass B will be :

(1) $\frac{Ma - F}{M}$ (2) $\frac{MF}{F + Ma}$ (3) $\frac{F + Ma}{M}$ (4) $\frac{F - Ma}{M}$

Ans. **Official Answer NTA :** (4)

Sol.

$a_A = \frac{Kx}{M} = a, \quad a_B = \frac{F - Kx}{M} = \frac{F - Ma_A}{M} = \frac{F - Ma}{M}$

7. A cord is wound round the circumference of wheel of radius r. The axis of the wheel is horizontal and the moment of inertia about it is I. A weight 'mg' is attached to the cord at the end. The weight falls from rest. After falling through a distance 'h', the square of angular velocity of wheel will be :

(1) $\frac{2gh}{I + mr^2}$ (2) $\frac{2mgh}{I + 2mr^2}$ (3) $2gh$ (4) $\frac{2mgh}{I + mr^2}$

Ans. **Official Answer NTA :** (4)

Sol. Using Energy Conservation

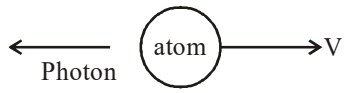
$mgh = \frac{1}{2} m v^2 + \frac{1}{2} I\omega^2$ [also $v = r\omega$]

$w^2 = \frac{2gh}{(mr^2 + I)}$

8. The recoil speed of a hydrogen atom after it emits a photon in going from n = 5 state to n = 1 state will be :

(1) 2.19 m/s (2) 4.34 m/s (3) 4.17 m/s (4) 4.25 m/s

Ans. **Official Answer NTA :** (3)

Sol. 

Momentum Conservation : $|\overline{P}_{photon}| = |\overline{P}_{Atom}|$

for Photon : $P = \frac{h}{\lambda}$ also $\frac{1}{\lambda} = R\left(1 - \frac{1}{25}\right)$, $\lambda = \frac{25}{24R}$

$\frac{h}{\lambda} = mv$, $v = \frac{h}{m\lambda} = 4.17 m/sec$

9. The trajectory of a projectile in a vertical plaen is $y = \alpha x - \beta x^2$, where α and β are constants and x & y are respectively the horizontal and vertical distances of the projectile from the point of projection. The angle of projection θ and the maximum height attained H are respectively given by :

(1) $\tan^{-1}\left(\frac{\beta}{\alpha}\right), \frac{\alpha^2}{\beta}$ (2) $\tan^{-1}\beta, \frac{\alpha^2}{2\beta}$ (3) $\tan^{-1}\alpha, \frac{\alpha^2}{4\beta}$ (4) $\tan^{-1}\alpha, \frac{4\alpha^2}{\beta}$

Status : Answered

Ans. **Official Answer NTA :** (3)

Sol. $y = \alpha x - \beta x^2$

$y = \alpha x\left(1 - \frac{x}{\alpha/\beta}\right)$

Compare with $y = x \tan\theta\left(1 - \frac{x}{R}\right)$

$\tan\theta = \alpha$ and $R = \frac{\alpha}{\beta}$

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

also $\frac{R}{H} = \frac{4}{\tan\theta}$

$H = R\frac{\tan\theta}{4} = \frac{\alpha}{\beta}\frac{(\alpha)}{4} = \frac{\alpha^2}{4\beta}$

10. A wire of 1 Ω has a length of 1 m. It is stretched till its length increases by 25%. The percentage change in resistance to the nearest integer is :

(1) 76% (2) 56% (3) 12.55% (4) 25%

Ans. **Official Answer NTA :** (2)

Sol. $\ell' = \ell + \frac{\ell}{4} = \frac{5\ell}{4}$ (New length)

Also $Al = A'l'$ (as volume is constant)

$$A' = \frac{4A}{5}$$

$$R' = \frac{\rho l'}{A'} = \frac{25}{16}\left(\frac{\rho L}{A}\right)$$

$$R^1 = \frac{25}{16}R$$

$$\% \text{ change} = \frac{R^1 - R}{R} = 56.25\%$$

Ans: 56%

11. A tuning fork A of unknown frequency produces 5 beats/s with a fork of known frequency 340 Hz. When fork A is filed, the beat frequency decreases to 2 beats/s. What is the frequency of fork A ?

(1) 335 Hz (2) 342 Hz (3) 345 Hz (4) 338 Hz

Ans. **Official Answer NTA :** (1)

Sol. Beat frequency

$|f_2 - f_1| = 5$ so f_2 = 335 Hz or 345 Hz

Due to filling of second fork, f_2 increases and beat frequency decreases so f_2 = 335 Hz

12. The incident ray, reflected ray and the outward drawn normal are denoted by the unit vectors $\vec{a}, \vec{b}$ and $\vec{c}$ respectively. Then choose the correct relation for these vectors.

(1) $\vec{b} = \vec{a} - \vec{c}$ (2) $\vec{b} = \vec{a} - 2\left(\vec{a}.\vec{c}\right)\vec{c}$ (3) $\vec{b} = \vec{a} + 2\vec{c}$ (4) $\vec{b} = 2\vec{a} + \vec{c}$

Ans. **Official Answer NTA :** (2)

Sol. As we know

$\hat{r} = \hat{i} - 2(\hat{i}.\hat{n})\hat{n}$

$\hat{r}$ = unit vector along reflected ray

$\hat{i}$ = unit vector along incident ray

$\hat{n}$ = unit vector along normal

13. If 'C' and 'V' represent capacity and voltate respectively then what are the dimensions of λ where C/V = λ ?

(1) $[M^{-1} L^{-3} I^{-2} T^{-7}]$ (2) $[M^{-3} L^{-4} I^{3} T^{7}]$ (3) $[M^{-2} L^{-4} I^{3} T^{7}]$ (4) $[M^{-2} L^{-3} I^{2} T^{6}]$

Ans. **Official Answer NTA :** (3)

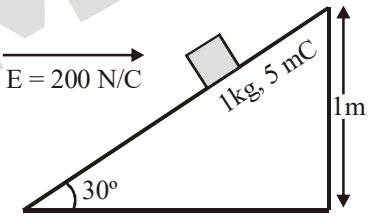
Sol. $\lambda = \frac{C}{V} = \frac{Q}{V^2} = \frac{Q^3}{W^2}$

$[\lambda] = \frac{(IT)^3}{(M^1L^2T^{-2})^2}$

$= M^{-2} L^{-4} I^{3} T^{7}$

14. An inclined plane making an angle of 30º with the horizontal is placed in a uniform horizontal electric field 200 $\frac{N}{C}$ as shown in the figure. A body of mass 1 kg and charge 5 mC is allowed to slide down from rest at a height of 1 m. If the coefficient of friction is 0.2, find the time taken by the body to reach the bottom.

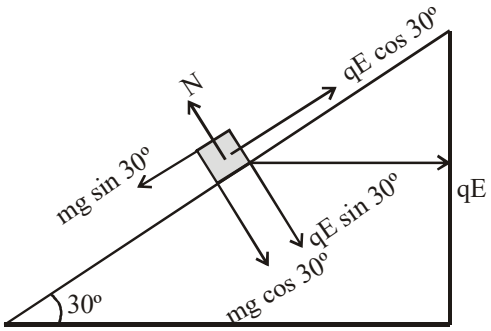
[g = 9.8 m/s²; sin 30º $\frac{1}{2}$; cos 30º = $\frac{\sqrt{3}}{2}$]



(1) 0.46 s (2) 2.3 s (3) 0.92 s (4) 1.3 s

Ans. **Official Answer NTA :** (4)

Sol.



$N = mg\cos 30^\circ + qE\sin 30^\circ$

$W = 9.16\ N$

$$a = \frac{mg\sin 30^\circ - qE\cos 30^\circ - \mu N}{m}$$

$a = 2.302$

Now $S = 0 + \frac{1}{2}at^2$

$t = 1.31$ sec

15. A radioactive sample is undergoing a decay. At any time t_1, its activity is A and another time t_2, the activity is $\frac{A}{5}$ What is the average life time for the sample ?

(1) $\frac{ln5}{t_2 - t_1}$ (2) $\frac{t_1 - t_2}{ln5}$ (3) $\frac{ln(t_2 + t_1)}{2}$ (4) $\frac{t_2 - t_1}{ln5}$

Ans. **Official Answer NTA :** (4)

Sol. $A = A_O e^{-\lambda t}$

$A = A_O e^{-\lambda t_1}$ (1)

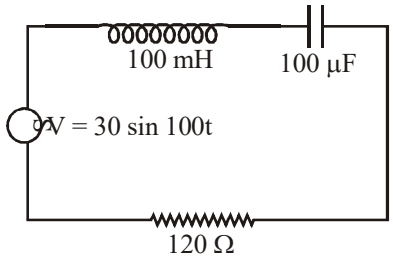
$\frac{A}{5} = A_O e^{-\lambda t_2}$ (2)

From (1) & (2)

$5 = e^{\lambda(t_1 - t_2)}$

$\lambda = \frac{\ell n5}{t_2 - t_1}$, half life $= \frac{t_2 - t_1}{\ell n5}$

16. Find the peak current and resonant frequency of the following circuit (as shown in figure).



(1) 0.2 A and 50 Hz (2) A and 100 Hz (3) 2 A and 50 Hz (4) 0.2 A and 100 Hz

Ans. **Official Answer NTA :** (1)

Sol. $I = \frac{V}{Z}$

$$I = \frac{30}{\sqrt{(120)^2 \times \left[\frac{1}{100\times100\times10^{-6}} - 100\times100\times10^{-3}\right]^2}}$$

$$I = \frac{30}{\sqrt{(120)^2 \times (90)^2}}$$

$$I = \frac{30}{150} = 0.2A$$

also $\omega = \frac{1}{\sqrt{LC}} = \sqrt{10^5} = 100\pi$ $(\sqrt{10} = \pi)$

$f = 50$ Hz

17. Given below are statement :

Statement I : An electric dipole is placed at the centre of a hollow sphere. The flux of electric field through the sphere is zero but the electric field is not zero anywhere in the sphere.

Statement II : If R is the radius of a solid metallic sphere and Q be the total charge on it. the electric field at any point on the spherical surface of radius r (< R) is zero but the electric flux passing through his closed spherical surface of radius r is not zero.

In the light of the above statements, choose the correct answer from the options given below :

(1) Statement I is false but Statement II is true

(2) Statement I is true but Statement II is false

(3) Both Statement I and Statement II are false

(4) Both Statement I and Statement II are true

Ans. **Official Answer NTA :** (2)

Sol. Statement I is correct since electric flux will be zero because total charge enclosed will be zero

Statement II is wrong because electric flux through the given spherical surface (r < R) will be zero because total enclosed charge will be zero

18. The internal energy (U), pressure (P) and volume (V) of an ideal gas are related as U = 3 PV + 4 The gas is :

(1) Diatomic only (2) Either monoatomic

(3) Monotomic only (4) Polyatomic only

Ans. **Official Answer NTA :** (4)

Sol. $U = 3PV + 4$, $dU = \frac{f}{2}nRdT$ (2)

$U = 3nRT + 4$

$dU = 3nRdT$ (1)

From (1) & (2), $\frac{f}{2} = 3$

$F = 6 \rightarrow$ triatomic

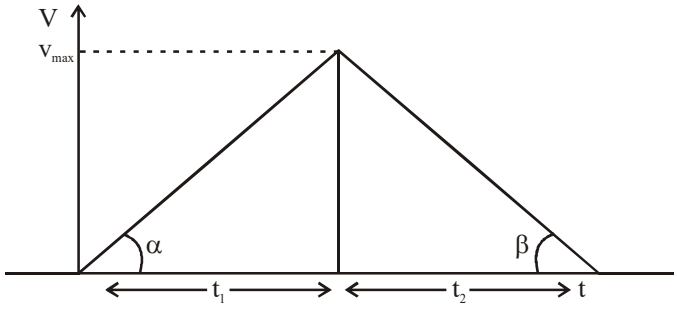
19. A scooter acceleratres from rest for time t_1 at constant rate a_1 and then retards at constant rate a_2 for time t_2 and comes to rest. The correct value of $\frac{t_1}{t_2}$ will be :

(1) $\frac{a_1 + a_2}{a_1}$ (2) $\frac{a_2}{a_1}$ (3) $\frac{a_1 + a_2}{a_2}$ (4) $\frac{a_1}{a_2}$

Question Type : MCQ

Ans. **Official Answer NTA :** (2)

Sol.



$$\tan\alpha = \frac{V_{max}}{t_1} = a_1 \qquad (1)$$

$$\tan\beta = \frac{V_{max}}{t_2} = a_2 \qquad (2)$$

from (1) & (2), $\frac{a_1}{a_2} = \frac{t_2}{t_1}$

$$\frac{t_1}{t_2} = \frac{a_2}{a_1}$$

20. The length of metallic wire is l_1 when tension in it is T_1. It is l_2 when the tension is T_2. The original length of the wire will be :

(1) $\frac{T_2 l_1 + T_1 l_2}{T_1 + T_2}$ (2) $\frac{T_1 l_1 - T_2 l_2}{T_2 - T_1}$ (3) $\frac{l_1 + l_2}{2}$ (4) $\frac{T_2 l_1 - T_1 l_2}{T_2 - T_1}$

Ans. **Official Answer NTA :** (4)

Sol. From Hooke's law :

so $\Delta\ell = \frac{F\ell}{YA}$

$$\ell_1 - \ell = \frac{T_1\ell}{YA} \qquad \text{- (1)}$$

$$\ell_2 - \ell = \frac{T_2\ell}{YA} \qquad \text{- (2)}$$

From (1) & (2) = $\frac{\ell_1 - \ell}{\ell_2 - \ell} = \frac{T_1}{T_2}$

$$\ell = \frac{T_1\ell_2 - T_2\ell_1}{T_1 - T_2}$$

Section - B

1. If the highest frequency modulating a carrier is 5 kHz, then the number of AM broadcast stations accommodated in a 90 kHz bandwidth are _____.

Ans. **Official Answer NTA :** (9)

Sol. Band width = 2f = 10 KHz

Number of AM broadcast Station = $\frac{90}{10} = 9$

2. 27 similar drops of mercury are maintained at 10 V each. All these spherical drops combine into a single big drop. The potential energy of the bigger drop is _____ times that of a smaller drop.

Ans. **Official Answer NTA :** (243)

Sol. R = radius of bigger drop

r = radius of smaller drop

$V_i = V_f$

$\Rightarrow 27\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

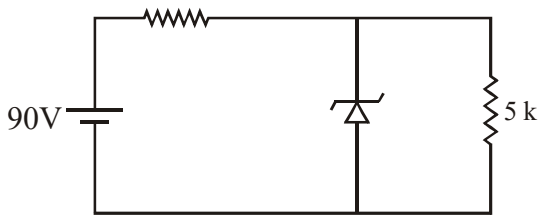
R = 3r

$U_{bigger} = \frac{3}{5}\frac{KQ^2}{R}$ (Q = 27q)

$= 243\frac{kq^2}{r}$

$= 243\ U_{Smaller}$

3. The zener diode has a V_z = 30 V. The current passing through the diode for the following circuit is _____ mA.



Ans. **Official Answer NTA :** (9)

Sol. Current through $5K\Omega = \frac{30}{5000} = 6mA$

Current through $4K\Omega = \frac{60}{4000} = 15mA$

Current through zener diode = 15 – 6

= 9mA

4. The volume V of a given mass of monoatomic gas changes with temperature T according to the relation $V = KT^{\frac{2}{3}}$. The workdone when temperature changes by 90 K will be xR. The value of *x* is _____.

[R = universal gas constant]

Ans. **Official Answer NTA :** (60)

Sol. $V = KT^{2/3}$

$$V = K\left[\frac{PV}{nR}\right]^{2/3}$$

$\Rightarrow P^{2/3} V^{-1/3} = const$

$\Rightarrow PV^{-1/2} = constant$

$$W = \frac{nR\Delta T}{(1-x)} \qquad \text{(for } PV^x = \text{ const)}$$

$$= \frac{90R}{\left(1+\frac{1}{2}\right)} = 60R$$

5. A particle executes S.H.M. with amplitude 'a' and time period 'T'. The displacement of the particle when its speed is half of maximum speed is $\frac{\sqrt{x}a}{2}$ The value of *x* is _____.

Ans. **Official Answer NTA :** (3)

Sol. $V = \omega\sqrt{A^2 - x^2}$

$$\frac{\omega A}{2} = \omega\sqrt{A^2 - x^2}$$

$$= x = \pm\frac{\sqrt{3}}{2}A$$

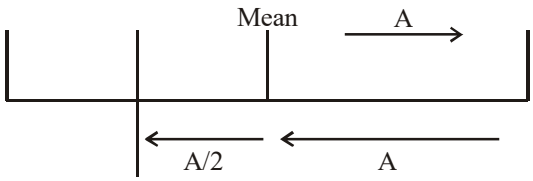
6. Time period of a simple pendulum is T. The time taken to complete $\frac{5}{8}$ oscillations starting from mean position is $\frac{\alpha}{\beta}$T. The value of α is _____.

Ans. **Official Answer NTA :** (7)

Sol. Total distance in one Oscillation = 4 A

Distance Covered in $\left(\frac{5}{8}\right)$ oscillation = $\frac{5}{2}$A

Now time to cover $\frac{5}{2}$A = 2A + $\frac{A}{2}$



Time = $\frac{T}{4}+\frac{T}{4}+\frac{T}{12}=\frac{7}{12}T$

$\alpha = 7$

7. 1 mole of rigid diatomic gas performs a work of $\frac{Q}{5}$ when heat Q is supplied to it. The molar heat capacity of the gas during this transformation is $\frac{xR}{8}$. The value of x is _____.

[R = universal gas constant]

Ans. **Official Answer NTA :** (25)

Sol. $\Delta U = Q - W$

$= Q - \frac{Q}{5} = \frac{4Q}{5}$

$\Delta T = \frac{\Delta U}{nC_v} = \frac{4Q}{5\times1\times\frac{5R}{2}} = \frac{8Q}{25R}$

$C = \frac{\Delta Q}{n\Delta T} = \frac{25R}{8} \Rightarrow x = 25$

8. Two stream of photons, possessing energies equal to twice and ten times the work function of metal are incident on the metal surface successively. The value of ratio of maximum velocities of the photoelectrons emitted in the two respective cases is *x* : y. The value of *x* is _____.

Ans. **Official Answer NTA :** (1)

Sol. $E = \phi + \frac{1}{2}mV_{max}^2$

$E_1 = 2\phi = \phi + \frac{1}{2}mV_1^2 \quad \Rightarrow mV_1^2 = 2\phi$

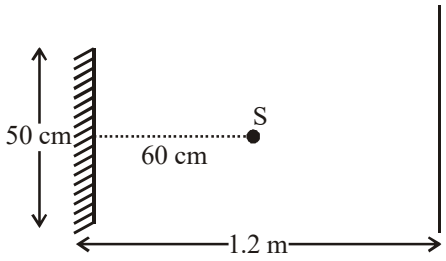
$E_2 = 10\phi = \phi + \frac{1}{2}mV_2^2 \quad \Rightarrow mV_2^2 = 18\phi$

$\frac{V_1^2}{V_2^2} = \frac{1}{9}$

$= \frac{V_1}{V_2} = \frac{1}{3}$

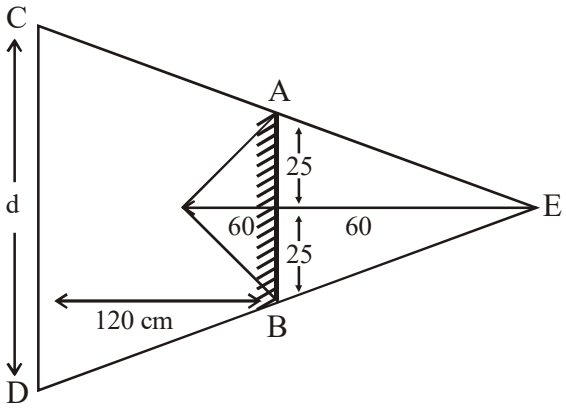
$\alpha = 1$

9. A point source of light S, placed at a distance 60 cm infront of the centre of a plane mirror of width 50 cm, hangs vertically on a wall. A man walks infront of the mirror along a line parallel to the mirror at a distance 1.2 m from it (see in the figure). The distance between the extreme points where he can see the image of the light source in the mirror is _____ cm.



Ans. **Official Answer NTA :** (150)

Sol.



ΔABE & ΔCDE

$$\frac{60}{180}=\frac{50}{d}$$

d = 150 cm

30. In the reported figure of earth, the value of acceleration due to gravity is same at point A and C but it is smaller than that of its value at point B (surface of the earth). The value of OA : AB will be *x* : y. The value of *x* is _____.

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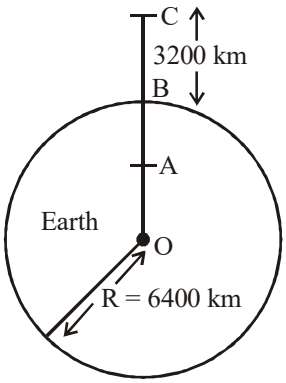
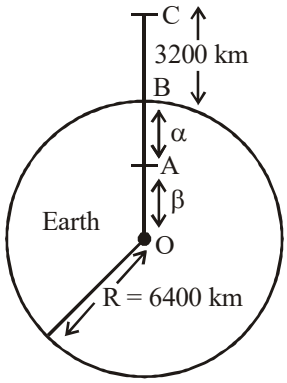


Ans. **Official Answer NTA :** (4)

Sol.



$$E_A = E_C$$

$$\frac{GM}{(6400+3200)^2} = \frac{GM}{(6400)^3}\beta$$

$$\Rightarrow \beta = \frac{8}{9}\times 3200$$

$$\Rightarrow \alpha = R - \beta = \frac{10}{9}\times 3200$$

$$\Rightarrow \frac{\alpha}{\beta} = \frac{5}{4} \Rightarrow \frac{OA}{AB} = \frac{\beta}{\alpha} = \frac{4}{5}$$

$$\Rightarrow x = 4$$