FINAL NATIONAL STANDARD EXAMINATION - 2019

(Held On Sunday 24th November, 2019)

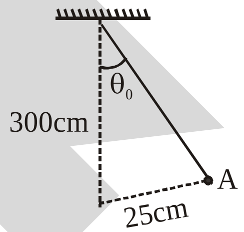
PHYSICS — TEST PAPER WITH SOLUTION

1. A pendulum is made by using a thread of length 300 cm and a small spherical bob of mass 100 g. It is suspended from a point S. The bob is pulled from its position of rest at O to the point A so that the linear amplitude is 25 cm. The angular amplitude in radian and the potential energy of the bob in joule at A are respectively

(a) 0.10 and 0.10 (b) 0.083 and 0.01 (c) 0.251 and 2.94 (d) 0.083 and 0.24

Ans. (b)

Sol. Angular amplitude , $\theta_0 = \frac{25}{300}$



$\theta_0 = .083$ rad

potential energy, $U = mg\ell(1 - \cos\theta)$

$U = 2mg\ell \sin^2(\theta/2)$

$\Rightarrow U \simeq mg\ell\frac{\theta^2}{2}$

$= 0.1 \times 10 \times 3 \times \left(\frac{1}{12}\right)^2 \times \frac{1}{2}$

$= 0.01$ J

2. Consider the following physical expressions

(I) ρv^2 (ρ : density, v : velocity)

(II) $\frac{Y\Delta L}{L}$ (Y : Young's modulus, L : length)

(III) $\frac{\sigma^2}{\varepsilon_0}$ (σ : surface density of charge)

(IV) $h\rho r g$ (h : rise of a liquid in a capillary tube of radius r)

(a) I and II only (b) II and III only (c) II, III and IV only (d) I, II and III only

Ans. (d)

Sol. $[\rho v^2] = [ML^{-3}][L^2T^{-2}]$

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

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

$$\left[\frac{\sigma^2}{\epsilon_0}\right] = [\text{Pressure}] = ML^{-1}T^{-2}$$

$[h\rho r g] = [ML^{-1}T^{-2}][L] = MT^{-2}$

3. Two simple pendulums of lengths 1.44 m and 1.0 m start swinging together in the same phase. The two will be in phase again after a time of

(a) 6 second (b) 9 second (c) 12 second (d) 25 second

Ans. (c)

Sol. $T_1 = 2\pi\sqrt{\frac{1.44}{10}}$ $T_2 = 2\pi\sqrt{\frac{1}{10}}$

$T_1 = 1.2\ T_0$, $T_2 = T_0$

Let after minimum time t, both will again be in phase,

$n_1T_1 = n_2T_2 = t$

$\Rightarrow n_1 \times 1.2 = n_2 \Rightarrow \frac{n_2}{n_1} = \frac{6}{5}$

minimum value of $n_1 = 5$ & $n_2 = 6$

$\therefore\ t = 6 \times \frac{2\pi}{10} \simeq 12$ second

4. A home aquarium partly filled with water slides down an inclined plane of inclination angle θ with respect to the horizontal. The surface of water in the aquarium

(a) remains horizontal

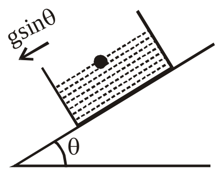
(b) remains parallel to the plane of the incline

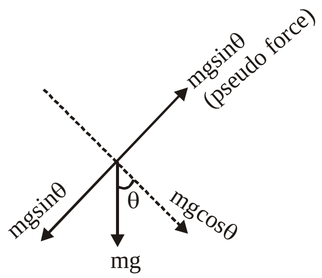
(c) forms an angle α with the horizon where $0 < \alpha < \theta$

(d) forms an angle α with the horizon, where $\theta < \alpha < 90$

Ans. (b or c)

Sol. Considering friction is absent





F.B.D. of a particle in frame of aquarium.

From FBD it can be said that net force (including pseudo force)

act perpendicular to inclined plane therefore liquid surface will be parallel to incline plane

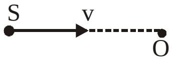
If friction is present then pseudo force will be less than mgsinθ, therefore $0 < \alpha < \theta$.

5. A sound source of constant frequency travels with a constant velocity past an observer. When it crosses the observer the sound frequency sensed by the observer changes from 449 Hz to 422 Hz. If the velocity of sound in 340 m/s, the velocity of the source of sound is

(a) 8.5 m/s (b) 10.5 m/s (c) 12.5 m/s (d) 14.5 m/s

Ans. (b)

Sol.



frequency heard by observer when source is approaching observer

$$f_1 = \left[\frac{v}{v - v_s}\right] f_0 = 449 \qquad ....(1)$$

frequency heard by observer when source is receding from observer

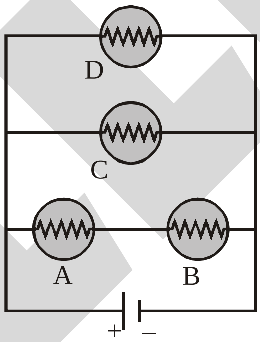
$$f_2 = \left[\frac{v}{v + v_s}\right] f_0 = 422 \qquad ...(2)$$

from eq. (1) & (2)

$$\frac{v - v_s}{v + v_s} = \frac{422}{449} \Rightarrow \frac{v_s}{v} = \frac{27}{871}$$

$$\Rightarrow v_s = \frac{27}{871} \times 340 = 10.5 \text{m / s}$$

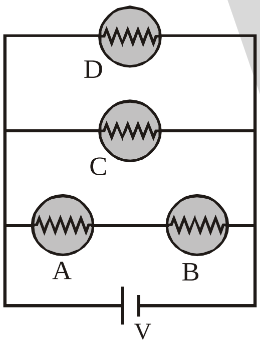
6. Identify the rank in order from the dimmest to the brightest when all the identical bulbs are connected in the circuit as shown below .



(a) A = B > C = D (b) A = B = C = D (c) A > C > B > D (d) A = B < C = D

Ans. (d)

Sol.



$$P_A = \frac{V^2}{4R}, \quad P_B = \frac{V^2}{4R}$$

$$P_D = \frac{V^2}{R}, \quad P_C = \frac{V^2}{R}$$

$\therefore P_A = P_B < P_D = P_C$

7. The unit of magnetizing field is

(a) tesla (b) newton (c) ampere (d) ampere turn/meter

Ans. (d)

8. A star undergoes a supernova explosion. Just after the explosion, the material left behind forms a uniform sphere of radius 8000 km with a rotation period of 15 hours. This remaining material eventually collapses into a neutron star of radius 4 km with a period of rotation.

(a) 14 s (b) 3.8 h (c) 0.021 s (d) 0.0135 s

Ans. (d)

Sol. According to angular momentum conservation

$I_1\omega_1 = I_2\omega_2$

$$\Rightarrow \frac{2}{5}mR_1^2\left(\frac{2\pi}{T_1}\right) = \frac{2}{5}mR_2^2\left(\frac{2\pi}{T_2}\right)$$

$$\Rightarrow \frac{(8000)^2}{15} = \frac{(4)^2}{T_2} \Rightarrow T_2 = 15\left(\frac{1}{2000}\right)^2 \text{hr}$$

$\Rightarrow T_2 = 0.0135$ sec

9. A number of identical absorbing plates are arranged in between a source of light and a photo cell. When there is no plate in between, the photo current is maximum. Under the circumstances let us focus on the two statements -

(1) The photo current decreases with the increase in number of absorbing plates.

(2) The stopping potential increases with the increase in number of absorbing plates.

(a) Statement (1) and (2) are both true and (1) is the cause of (2)

(b) Statement (1) and (2) are both true but (1) and (2) are independent

(c) Statement (1) is true while (2) is not true and (1) and (2) are independent

(d) Statement (1) is true while (2) is not true and (2) is the effect of (1)

Ans. (c)

Sol. due to absorbing plates, intensity of light decreases, but frequency remain same
therefore photo current decreases but stopping potential remain same

10. In a nuclear reaction, two photons each of energy 0.51 MeV are produced by electron-positron annihilation. The wavelength associated with each photon is

(a) 2.44×10^{-12} m (b) 2.44×10^{-8} m
(c) 1.46×10^{-12} m (d) 3.44×10^{-10} m

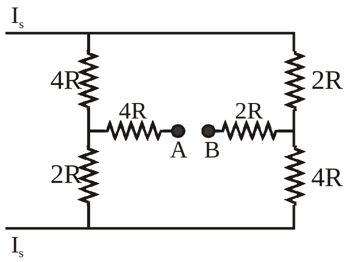
Ans. (a)

Sol. $\frac{hc}{\lambda} = 0.51$ MeV $= 0.51 \times 10^6$ eV

$$\lambda = \frac{hC}{5.1\times10^5} = \frac{1242}{5.1\times10^5}\text{nm}$$

$\lambda = 2.44 \times 10^{-12}$ m

11. In the circuit shown if an ideal ammeter is connected between A and B then the direction of current and the current reading would be (assume I_s remains unchanged)



(a) B to A and $I_s/2$

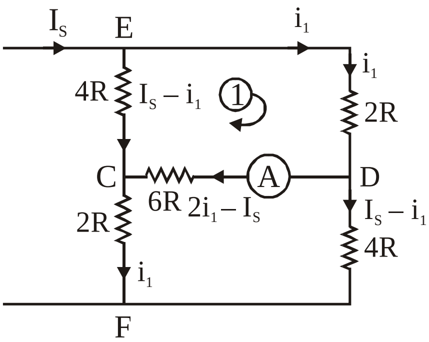
(b) A to B and $I_s/4$

(c) B to A and $I_s/9$

(d) B to A and $I_s/3$

Ans. (c)

Sol.



On applying Kirchhoff's law

in 1 loop

$-2i_1R - 6R(2i_1 - I_S)$

$+ 4R(I_S - i_1) = 0$

$-2i_1 - 12i_1 + 6I_S + 4I_S - 4i_1 = 0$

$-18i_1 + 10I_S = 0$

$$i_1 = \frac{5}{9}I_S$$

current through ammeter $= 2i_1 - I_S$

$$= \left(\frac{10}{9} - 1\right)I_S$$

$$= \frac{I_S}{9} \text{ from B to A}$$

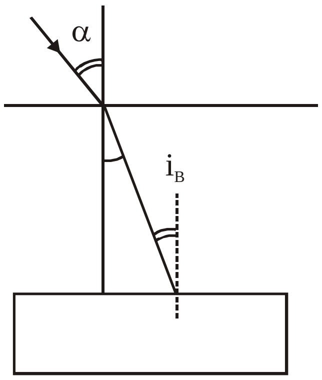
ALLEN

12. A rectangular slab of glass of refractive index 1.5 immersed in water of refractive index 1.33 such that the top surface of the slab remains parallel to water level. Light from a point source in air is incident on the surface of water at an angle α such that the light reflected from the glass slab is plane polarised, the angle α is :-

(a) 84.4º (b) 48.4º (c) 56.3º (d) 53.1º

Ans. (a)

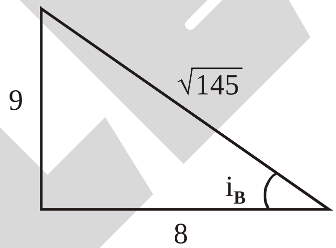
Sol.



i_B = Brewster angle

$$\therefore \quad \frac{4}{3}\sin i_B = \frac{3}{2}\sin(90 - i_B)$$

$$\therefore \quad \tan i_B = \frac{9}{8} \Rightarrow \sin\alpha = \frac{4}{3}\sin i_B$$



$$\Rightarrow \sin\alpha = \frac{4}{3}\times\frac{9}{\sqrt{145}} = \frac{12}{\sqrt{145}}$$

13. In a spectrometer the smallest main scale division is $\frac{1}{3}$ of a degree. The total number of divisions on the vernier scale attached to the main scale is 60 which coincide with the 59 divisions of the main circular scale. The least count of the spectrometer is :-

(a) 20' (b) 20" (c) 30" (d) 30'

Ans. (b)

Sol. $\therefore$ 60 VSD = 59 MSD

$\therefore$ 1 VSD = $\frac{59}{60}$ MSD

$\therefore$ 1 least count

= 1 MSD – 1 VSD

= $\frac{1}{60}$ MSD

$$= \frac{1}{60}\left(\frac{1^\circ}{3}\right) = 20''$$

14. White light is used to illuminate two slits in Young's double slit experiment. Separation between the two slits is b and the screen is at a distance D(>>b) from the plane of slits. The wavelength missing at a point on the screen directly in front of one of the slits is :-

(a) $\frac{2b^2}{3D}$ (b) $\frac{2b^2}{D}$ (c) $\frac{b^2}{3D}$ (d) $\frac{b^2}{2D}$

Ans. (c)

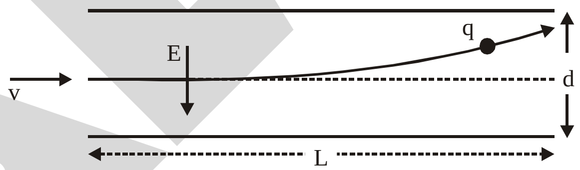
Sol. Path difference in front of one slit = $\frac{b^2}{2D}$

Let λ is the wavelength, whose minima coincides with this point, then

$$(2n+1)\frac{\lambda}{2}=\frac{b^2}{2D}$$

$$\lambda=\frac{b^2}{D(2n+1)}$$

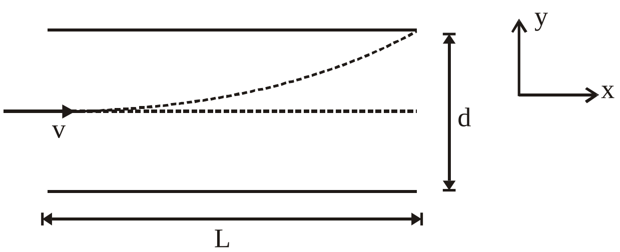
15. In an ink-jet printer, an droplet of mass m is given a negative charge q by a computer-controlled charging unit. The charged droplet then enters the region between two deflecting parallel plates of length L separated by distance d (see figure below) with a speed v. All over this region there exists a unifrom downward electric field E (in the plane of paper). Neglecting the gravitational force on the droplet, the maximum charge that can be given to this droplet, so that it does not hit any of the plates, is



(a) $\frac{mv^2L}{Ed^2}$ (b) $\frac{mv^2d}{EL^2}$ (c) $\frac{md}{Ev^2L^2}$ (d) $\frac{mv^2L^2}{Ed}$

Ans. (b)

Sol.



In limiting case drop will travel L distance along x axis while $\frac{d}{2}$ along y axis.

$\therefore \frac{1}{2}\left(\frac{qE}{m}\right)t^2 = \frac{d}{2}$ ... (i)

& L = vt ... (ii)

$\therefore \frac{qE}{m} \cdot \frac{L^2}{v^2} = d$

$q = \frac{dmv^2}{EL^2}$

16. A converging beam of light is pointing to P. Two observations are made with (i) a convex lens of focal length 20 cm and, (ii) a concave lens of focal length 16 cm placed in the path of the convergent beam at a distance 12 cm before the point P. It is observed that

(a) in both cases the images are real

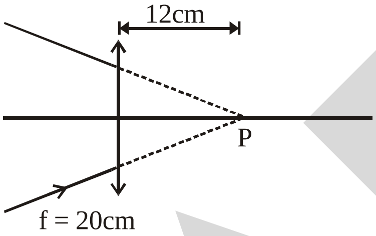
(b) in both cases the images are virtual

(c) for (i) the image is real and for (ii) the image is virtual

(d) for (i) the image is virtual and for (ii) the image is real

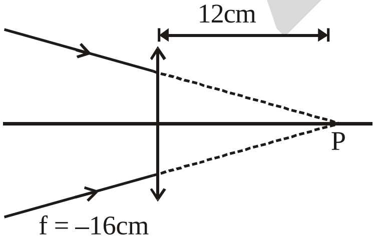
Ans. (a)

Sol.



(i) $\frac{1}{v} - \frac{1}{12} = \frac{1}{20}$

v > 0

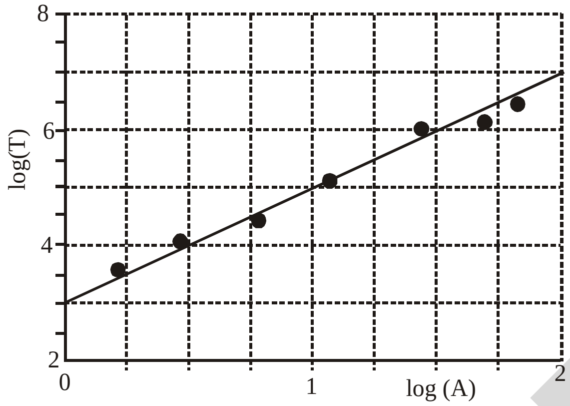


(ii) $\frac{1}{v} - \frac{1}{12} = -\frac{1}{16}$

v> 0

$\therefore$ both images are real

17. The log-log graph for a non-linear oscillator is shown below. Assuming the constants to have appropriate dimensions the relationship between time period (T) and the amplitude (A) can be expressed as :-



(a) $T = 1000\ A^2$ (b) $T = 4A^{1/2}$ (c) $T = 4A^2 + B$ (d) $T = 8A^3$

Ans. (a)

Sol. According to graph

$$\log(T) = \left(\frac{7-3}{2}\right)\log(A) + 3$$

$$\log(T) = 2\log A + 3$$

$$\log(T) = \log A^2 + \log 1000$$

$T = (1000\ A^2)$

18. In many situations the point source emitting a wave strats moving, through the medium, with velocity V greater than the wave velocity in that medium. In such a case when source velocity (V) > wave velocity (v), the wave front changes

(a) from spherical to plane (b) from spherical to conical

(c) from plane to spherical (d) from cylindrical to spherical

Ans. (b)

Sol. Theoretical

19. If the average mass of a smoke particle in an Indian kitchen is 3×10^{-17}kg, the rms speed of the smoke particles at 27ºC is approximately :

(a) 2 cm/sec (b) 2 m/sec (c) 2 km/sec (d) none of these

Ans. (a)

Sol. $v_{rms} = \sqrt{\frac{3RT}{M}} = 2$ cm/s

20. Two wires, made of same material, one thick and the other thin are joined to form one composite wire. The composite wire is subjected to the same tension throughout. A wave travels along the wire and passes the point where the two wires are joined. The quantity which changes at the joint are

(a) frequency only
(b) propagation speed only
(c) wavelength only
(d) both propagation speed and wavelength

Ans. (d)

Sol. Frequency is the property of material.

21. The frequency of the third overtone of a closed end organ pipe equals the frequency of the fifth harmonic of an open end organ pipe. Ignoring end correction, the ratio of their lengths $l_{open} : l_{close}$ is

(a) 10 : 7 (b) 10 : 9 (c) 2 : 1 (d) 7 : 10

Ans. (a)

Sol. $\dfrac{7v}{4\ell_{close}} = \dfrac{5v}{2\ell_{open}}$

$\dfrac{\ell_{open}}{\ell_{close}} = \dfrac{10}{7}$

22. Light of wavelength 640 nm falls on a plane diffraction grating with 12000 lines per inch. In the diffraction pattern on a screen kept at a distance of 12 cm from the grating, the distance of the second order maximum from the central maximum is

(a) 1.81 cm (b) 2.41 cm (c) 3.62 cm (d) 7.25 cm

Ans. (d)

Sol. $\lambda = 640, d = \dfrac{1\text{ inch}}{12000} = \dfrac{2.54\text{cm}}{12000}$

for 2^{nd} order maxima

d sin θ = 2λ

$d\dfrac{y}{D} = 2\lambda \Rightarrow y = \dfrac{2D\lambda}{d}$

$y = \dfrac{2\times12\times10^{-2}\times640\times10^{-9}\times12000}{2.54\times10^{-2}}$

= 7.25 cm

23. If the force acting on a body is inversely proportional to its speed, the kinetic energy of the body varies with time t as

(a) t^0 (b) t^1 (c) t^2 (d) t^{-1}

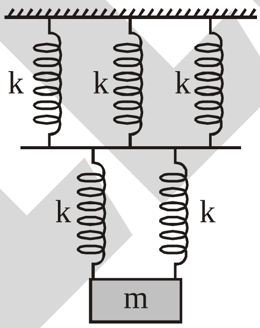
Ans. (b)

Sol. $F \propto \frac{1}{v} \Rightarrow F = \frac{k}{v} = \frac{k\partial t}{\partial x}$

$\int F dx \Rightarrow \int k dt \Rightarrow W = kt$

$KE \propto t$

24. As shown in the figure, a block of mass m is hung from the ceiling by the system of springs consisting of two layers. The force constant of each of the springs is k. The frequency of vertical oscillations of the block is



(a) $\frac{1}{2\pi}\sqrt{\frac{k}{5m}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{4k}{5m}}$ (c) $\frac{1}{2\pi}\sqrt{\frac{5k}{6m}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{6k}{5m}}$

Ans. (d)

Sol. $\frac{1}{K_{eq}} = \frac{1}{3k} + \frac{1}{2k} \Rightarrow k_{eq} = \frac{6}{5}k$

$T = 2\pi\sqrt{\frac{5m}{6k}} \Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{6k}{5m}}$

25. Two simple harmonic motions are given by x_1 = a sin ωt + a cos ωt and $x_2 = a \sin \omega t + \frac{a}{\sqrt{3}} \cos \omega t$.

The ratio of the amplitudes of the first to the second and the phase difference between them respectively are

(a) $\sqrt{\frac{3}{2}}$ and $\frac{\pi}{12}$ (b) $\frac{\sqrt{3}}{2}$ and $\frac{\pi}{12}$ (c) $\frac{2}{\sqrt{3}}$ and $\frac{\pi}{12}$ (d) $\sqrt{\frac{3}{2}}$ and $\frac{\pi}{6}$

Ans. (a)

Sol. $x_1 = a \sin \omega t + a \cos \omega t$

$$= \sqrt{2}a\left(\frac{1}{\sqrt{2}}\sin \omega t + \cos \omega t \frac{1}{\sqrt{2}}\right)$$

$$= \sqrt{2}a \sin(\omega t + \pi/4)$$

$$x_2 = a \sin \omega t + \frac{a}{\sqrt{3}} \cos \omega t$$

$$= \frac{2a}{\sqrt{3}}\left(\frac{\sqrt{3}}{2}\sin \omega t + \frac{1}{2}\cos \omega t\right)$$

$$= \frac{2a}{\sqrt{3}}\sin\left(\omega t + \frac{\pi}{6}\right)$$

$$\frac{A_1}{A_2} = \frac{\sqrt{2}a\sqrt{3}}{2a} = \sqrt{\frac{3}{2}}$$

and $\phi_1 - \phi_2 = \frac{\pi}{12}$

26. A particle is projected from the ground with a velocity $\vec{v} = (3\hat{i} + 10\hat{j})ms^{-1}$. The maximum height attained and the range of the particle are respectively given by (use g = 10 m/s^2)

(a) 5m and 6m (b) 3m and 10m (c) 6m and 5m (d) 3m and 5m

Ans. (a)

Sol. $\mu_m = \frac{u_y^2}{2g} = -\frac{20^2}{20} = 5m$

$$R = u_x \frac{2u_y}{g} = 3 \times \frac{2 \times 10}{10} = 6m$$

27. A 20 cm long capillary tube stands vertically with lower end just in water. Water rises up to 5 cm. If the entire system is now kept on a freely falling platform, the length of the water column in the capillary tube will be

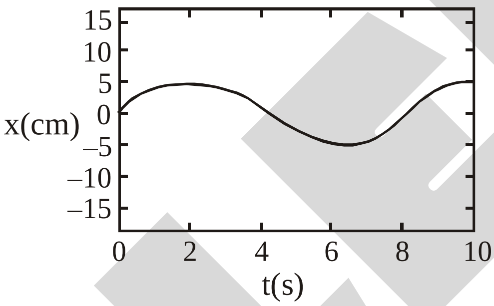
(a) 5 cm (b) 10 cm (c) Zero (d) 20 cm

Ans. (d)

Sol. $h = \dfrac{2T\cos\theta}{\rho g_{eff} r}$

$g_{off} = 0$ so $h \to \infty$ but water can't come out of tube, so h = length of tube = 20 cm

28. Position-time graph of a particle moving in a potential field is shown beside. If the mass of the particle is 1 kg its total energy is approximately



(a) 15.45×10^{-4} J (b) 30.78×10^{-4} J (c) 7.71×10^{-4} J (d) 3.85×10^{-4} J

Ans. (c)

Sol. $x = (5\text{cm}) \sin\left(\dfrac{2\pi}{8}t\right)$

$TE = \dfrac{1}{2}kA^2 = \dfrac{1}{2}m\omega^2A^2$

$= \dfrac{1}{2} \times 1 \times \dfrac{\pi^2}{16} \times 25 \times 10^{-4}$

$= 7.71 \times 10^{-4}$ J

29. An observer stands on the platform at the front edge of the first bogie of a stationary train. The train starts moving with uniform acceleration and the first bogie takes 5 seconds to cross the observer. If all the bogies of the train are of equal length and the gap between them is negligible, the time taken by the tenth bogie to cross the observer is

(a) 1.07 s (b) 0.98 s (c) 0.91 s (d) 0.81 s

Ans. (d)