PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 20

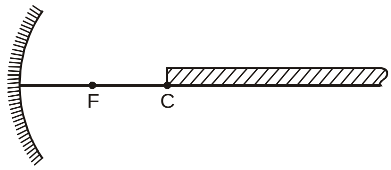
Total Marks : 33

Max. Time : 35 min.

Topics : Geometrical Optics , Kinetic Theory of Gases, Rigid Body Dynamics, String Wave, Electrostatics, Center of Mass

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.4	(3 marks, 3 min.)	[12, 12]
Multiple choice objective ('–1' negative marking) Q.5	(4 marks, 4 min.)	[4, 4]
Subjective Questions ('–1' negative marking) Q.6 to Q.7	(4 marks, 5 min.)	[8, 10]
Comprehension ('–1' negative marking) Q.8 to Q.10	(3 marks, 3 min.)	[9, 9]

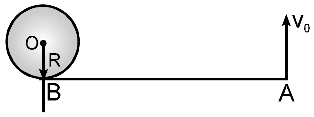
1. An infinitely long rectangular strip is placed on principal axis of a concave mirror as shown in figure. One end of the strip coincides with centre of curvature as shown. The height of rectangular strip is very small in comparison to focal length of the mirror. Then the shape of image of strip formed by concave mirror is



(A) Rectangle (B) Trapezium (C) Triangle (D) Square

2. N(< 100) molecules of a gas have velocities 1, 2, 3........ N km/s respectively. Then
(A) rms speed and average speed of molecules is same.
(B) ratio of rms speed to average speed is $\sqrt{(2N+1)(N+1)/6N}$
(C) ratio of rms speed to average speed is $\sqrt{(2N+1)(N+1)/6}$
(D) ratio of rms speed to average speed of molecules is $2\sqrt{(2N+1)/6(N+1)}$

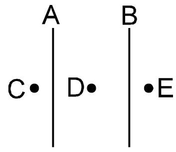
3. A horizontal plane supports a fixed vertical cylinder of radius R and a particle is attached to the cylinder by a horizontal thread AB as shown in Fig. A horizontal velocity v_o is imparted to the particle, normal to the thread, then during subsequent motion



(A) Angular momentum of particle about O remains constant
(B) Angular momentum about B remains constant
(C) Momentum and kinetic energy both remain constant
(D) Kinetic energy remain constant.

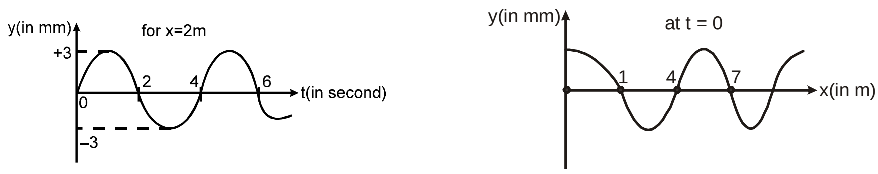
4. The equation of a string wave is given by (all quantity expressed in S.I. units) $Y = 5 \sin 10\pi (t - 0.01x)$ along the x-axis. The magnitude of phase difference between the points separated by a distance of 10 m along x-axis is
(A) $\pi/2$ (B) π (C) 2π (D) $\pi/4$.

5. Two infinite plane sheets A and B are shown in the figure. The surface charge densities on A and B are $(2/\pi) \times 10^{-9}$ C/m^2 and $(-1/\pi) \times 10^{-9}$ C/m^2 respectively. C, D, E are three points where electric fields (in N/C) are E_C, E_D and E_E respectively.



(A) E_C = 18, towards right (B) E_D = 54, towards right
(C) E_D = 18, towards right (D) E_E = 18, towards right

6. A sinusoidal wave propagates along a string. In figure (a) and (b) 'y' represents displacement of particle from the mean position. 'x' and 't' have usual meanings. Find:



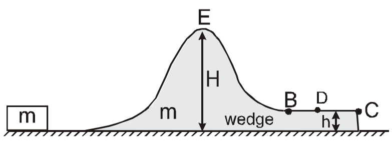
(a) wavelength, frequency and speed of the wave.
(b) maximum velocity and maximum acceleration of the particles
(c) the magnitude of slope of the string at x = 2 at t = 4 sec.

7. A point charge Q is located at centre of a fixed thin ring of radius R with uniformly distributed charge-Q. The magnitude of the electric field strength at the point lying on the axis of the ring at a distance x from the centre is (x >> R) _______________.

COMPREHENSION

Figure shows an irregular wedge of mass m placed on a smooth horizontal surface. Horizontal part BC is rough.The other part of the wedge is smooth.

8. What minimum velocity should be imparted to a small block of same mass m so that it may reach point B :



(A) $2\sqrt{gH}$ (B) $\sqrt{2gH}$ (C) $2\sqrt{g(H-h)}$ (D) $\sqrt{gh}$

9. The magnitude of velocity of wedge when the block comes to rest (w.r.t. wedge) on part BC is :

(A) $\sqrt{gH}$ (B) $\sqrt{g(H-h}$ (C) $2\sqrt{gH}$ (D) none of these

10. If the coefficient of friction between the block and wedge is μ, and the block comes to rest with respect to wedge at a point D on the rough surface then BD will be

(A) $\frac{H}{\mu}$ (B) $\frac{H-h}{\mu}$ (C) $\frac{h}{\mu}$ (D) none of these

Answers Key

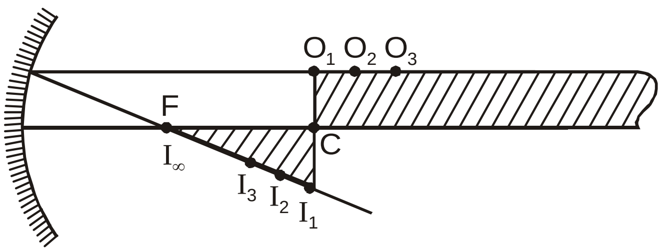
1. (C) **2.** (D) **3.** (D)
4. (B) **5.** (B), (D)
6. (a) 6m, 0.25 Hz, 1.5m/s
(b) 1.5π mm/s, $0.75\pi^2$ mm/s (c) $\pi \times 10^{-3}$

7. $\dfrac{3QR^2}{8\pi \in_0 x^4}$

8. (A) **9.** (A) **10.** (B)

Hints & Solutions

1. **(Moderate)** Draw an incident ray along the top side of rectangular strip, which happens to be parallel to the principal axis. After reflection this ray passes through focus. Hence image of all points (for e.g. O_1, O_2, O_3, ...) on top side of the strip lie on this reflected ray (at I_1, I_2, I_3, ...) in between focus and centre of curvature. Thus the image of this strip is a triangle as shown in figure



2. $V_{rms} = \sqrt{\dfrac{V_1^2 + V_2^2 + ...V_N^2}{N}}$

$= \sqrt{\dfrac{1^2 + 2^2 + ... + N^2}{N}}$

$= \sqrt{\dfrac{N(N+1)\ (2N+1)}{6N}}$

$\Rightarrow\ V_{rms} = \sqrt{\dfrac{(N+1)\ (2N+1)}{6}}$

$V_{avg} = \dfrac{V_1 + V_2 + ... + V_N}{N} = \dfrac{1 + 2 + ... + N}{N}$

$= \dfrac{N\ (N+1)}{2N} = \dfrac{N+1}{2}$

$$\frac{V_{rms}}{V_{avg}} = 2\sqrt{\frac{(2N+1)}{6(N+1)}}$$

4. The magnitude of phase difference between the points separated by distance 10 metres

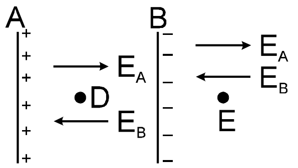
$= k \times 10 = [10\pi \times 0.01] \times 10 = \pi$

5. At E,

$E_E = E_A - E_B$

$$= \frac{2/\pi \times 10^{-9}}{2.\in_0} - \frac{1/\pi \times 10^{-9}}{2.\in_0}$$

= 18, towards right.



At D

$E_O = E_A + E_B$

$$= \frac{(2/\pi)\times 10^{-9}}{2\in_0} + \frac{(1/\pi)\times 10^{-9}}{2\in_0} = 54,$$

towards right.

6. (a) from y – x graph

wavelength = λ = 6m

from y – t graph

Time period = T = 4 sec

$\Rightarrow$ frequency = f = $\frac{1}{4}$ = 0.25 Hz

wave speed = $f\lambda$ = 0.25 × 6 = 1.50 m/s

(b) maximum velocity = 3mm × $\frac{\pi}{2}$ rad/sec

= 1.5 π mm/sec

maximum accelesation = $w^2A = \frac{\pi^2}{4} \times 3\,mm$

= 0.75 π^2 mm/sec^2.

(c) $k = \frac{2\pi}{\lambda} = \frac{\pi}{3}$ m^{-1}

$\Rightarrow$ $w = \frac{2\pi}{T} = \frac{\pi}{2}$ rad/sec

$$y = 3 \sin\left(\frac{\pi}{3}x - \frac{\pi}{2}t + \theta_o\right)$$

y(x = 2, t = 0) = 0

$\Rightarrow \sin\left(\frac{2\pi}{3} + \theta_0\right) = 0$

$\Rightarrow \theta_0 = -\frac{2\pi}{3}$ or $\frac{\pi}{3}$

and $\frac{\partial y}{\partial t}$ (t = 0 , x = 2) > 0

$\Rightarrow \frac{-3\pi}{2} \cos\left(\frac{\pi}{3}x - \frac{\pi t}{2} + \theta_0\right) > 0$

(For x = 2, t = 0)

$\Rightarrow \cos\left(\frac{2\pi}{3} + \theta_0\right) < 0 \qquad \Rightarrow \theta_0 = \frac{\pi}{3}$

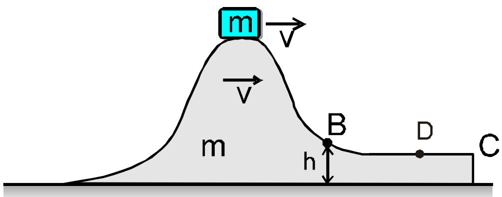
$y = (x,t) = 3 \sin\left(\frac{\pi x}{3} - \frac{\pi t}{2} + \frac{\pi}{3}\right)$

$\frac{\partial y}{\partial x} = \pi \cos\left(\frac{\pi x}{3} - \frac{\pi t}{2} + \frac{\pi}{3}\right)$

$\Rightarrow$ at x = 2 and t = 4 sec ; $\frac{\partial y}{\partial x}\ \pi \times 10^{-3}$

7. **Ans.** $\frac{3QR^2}{8\pi \in_0 x^4}$

8. Let ‘u’ be the required minimum velocity. By momentum conservation :
mu = (m + m)v $\Rightarrow$ v = u/2.



(At highest point)

Energy equation :

$$\frac{1}{2} mu^2 = \frac{1}{2}(2m)v^2 + mgH.$$

Substituting v = u/2 : $\qquad u = 2\sqrt{gH}$

9. When the block comes to rest, the wedge continues to move at $V = \frac{u}{2} = \sqrt{gH}$ on the smooth surface.

(since, momentum of wedge-block system remains conserved).

10. By work-energy theorem of the block :

$-(\mu mg)(BD) - mg(H-h) = 0$

$BD = \frac{H-h}{\mu}$