PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 30

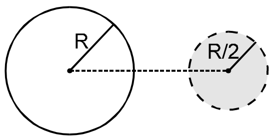
Total Marks : 27

Max. Time : 29 min.

Topics : Electrostatics, Calorimetry & Thermal Expansion, Rectilinear Motion, Fluid, Center of Mass, String Wave

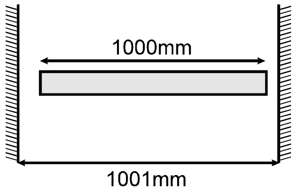
Type of Questions		**M.M., Min.**
Single choice Objective ('–1' negative marking) Q.1 to Q.2	**(3 marks, 3 min.)**	**[6, 6]**
Multiple choice objective ('–1' negative marking) Q.3	**(4 marks, 4 min.)**	**[4, 4]**
Subjective Questions ('–1' negative marking) Q.4 to Q.5	**(4 marks, 5 min.)**	**[8, 10]**
Comprehension ('–1' negative marking) Q.6 to Q.8	**(3 marks, 3 min.)**	**[9, 9]**

1. A ring of radius R having a linear charge density λ moves towards a solid imaginary sphere of radius $\frac{R}{2}$, so that the centre of ring passes through the centre of sphere. The axis of the ring is perpendicular to the line joining the centres of the ring and the sphere. The maximum flux through the sphere in this process is :



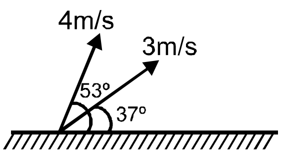
(A) $\frac{\lambda R}{\epsilon_0}$ (B) $\frac{\lambda R}{2 \epsilon_0}$ (C) $\frac{\lambda \pi R}{4 \epsilon_0}$ (D) $\frac{\lambda \pi R}{3 \epsilon_0}$

2. A rod of length 1000 mm and co-efficient of linear expansion $\alpha = 10^{-4}$ per degree is placed symmetrically between fixed walls separated by 1001 mm. The Young's modulus of the rod is 10^{11} N/m^2. If the temperature is increased by 20 ºC, then the stress developed in the rod is (in N/m^2):



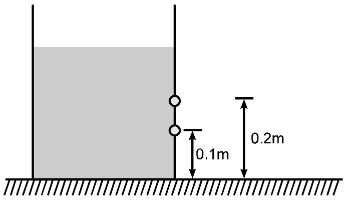
(A) 10
(B) 10^8
(C) 2×10^8
(D) cannot be calculated

3. Two particles are projected under gravity with speed 4m/s and 3m/s simultaneously from same point and at angles 53º and 37º with the horizontal surface respectively as shown in figure. Then :

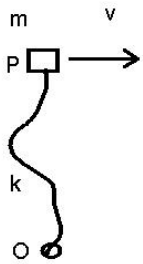


(A) Their relative velocity is along vertical direction.
(B) Their relative acceleration is non-zero and it is along vertical direction.
(C) They will hit the surface simultaneously
(D) Their relative velocity (for time interval 0 < t < 0.36s) is constant and has magnitude 1.4 m/s.

4. A long cyclindrical drum is filled with water. Two small holes are made on the side of the drum as shown in the fig. Find the depth of the liquid in the drum if the ranges of water from the holes are equal.



5. A 500 g block P rests on a frictionless horizontal table at a distance of 400 mm from a fixed pin O . The block is attached to pin O by an elastic cord of constant k = 100N/m and of undeformed length 900 mm . If the block is set in motion perpendicularly as shown in figure, (assume there is no loss in energy due to jerk) determine :



(a) the speed in the begining for which the distance from O to the block P will reach the maximum value of 1.2 m.

(b) the speed when OP = 1.2 m

(c) the radius of curvature of the path of the block when OP = 1.2 m .

COMPREHENSION

A sinusoidal wave travels along a taut string of linear mass density 0.1 g/cm. The particles oscillate along y-direction and wave moves in the positive x-direction. The amplitude and frequency of oscillation are 2mm and 50 Hz respectively. The minimum distance between two particles oscillating in the same phase is 4m.

6. The tension in the string is (in newton)

(A) 4000 (B) 400 (C) 25 (D) 250

7. The amount of energy transferred (in Joules) through any point of the string in 5 seconds is

(A) $\frac{\pi^2}{10}$ (B) $\frac{\pi^2}{50}$ (C) $\frac{\pi^2}{5}$

(D) Cannot be calculated because area of cross-section of string is not given.

8. If at x = 2m and t = 2s, the particle is at y = 1mm and its velocity is in positive y-direction, then the equation of this travelling wave is : (y is in mm, t is in seconds and x is in metres)

(A) $y = 2 \sin (\frac{\pi x}{2} - 100\pi t + 30°)$ (B) $y = 2 \sin (\frac{\pi x}{2} - 100\pi t + 120°)$

(C) $y = 2 \sin (\frac{\pi x}{2} - 100\pi t + 150°)$ (D) None of these

Answers Key

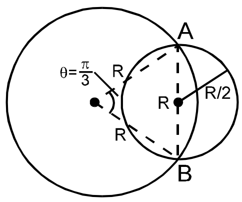
1. (D) **2.** (B) **3.** (A), (D) **4.** 0.3 m

5. (a) 4.5 m/s (b) 1.5 m/s (c) 3.75 cm

6. (B) **7.** (C) **8.** (D)

Hints & Solutions

1. Flux will be maximum when maximum length of ring is inside the sphere.



This will occur when the chord AB is maximum. Now maximum length of chord AB = diameter of sphere. In this case the arc of ring inside the sphere subtends an angle of $\frac{\pi}{3}$ at the centre of ring.

$\therefore$ charge on this arc = $\frac{R\pi}{3}.\lambda$

$$\therefore \quad \phi = \frac{\frac{R\pi}{3}\lambda}{\epsilon_0} = \frac{R\pi\lambda}{3\,\epsilon_0}$$

2. The change in length of rod due to increase in temperature in absence of walls is

$\Delta\ell = \ell\,\alpha\,\Delta T = 1000 \times 10^{-4} \times 20$ mm = 2 mm

But the rod can expand upto 1001 mm only.

At that temperature its natural length is

= 1002 mm.

$\therefore$ compression = 1mm

$$\therefore \quad \text{mechanical stress} = Y\,\frac{\Delta\ell}{\ell} = 10^{11} \times \frac{1}{1000}$$

$$= 10^{8}\ \text{N/m}^2$$

3. $v_1 = 4\cos 53^\circ\ \hat{i} + 4\sin 53^\circ\ \hat{j} = \frac{12}{5}\hat{i} + \frac{16}{5}\hat{j}$

$v_2 = 3\cos 37^\circ\ \hat{i} + 3\sin 37^\circ\,\hat{j} = \frac{12}{5}\hat{i} + \frac{9}{5}\hat{j}$

$v_{12} = \frac{7}{5}\hat{j} = 1.4\ \hat{j}$

Relative velocity in horizontal direction is zero.

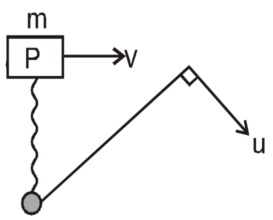
4. 0.3 m

$(\text{Range})_1 = (\text{Range})_2$

$$\sqrt{2g(\ell - 0.1)}\sqrt{\frac{2\times 0.1}{g}} = \sqrt{2g(\ell - 0.2)}\sqrt{\frac{2\times 0.2}{g}}$$

$\ell = 0.3$

5. **(a)** 4.5 m/s **(b)** 1.5 m/s **(c)** 3.75 cm



By conservation of angular momentum

$0.5 \times V \times 0.4 = 0.5 \times 4 \times 1.2$

$v = 3u$

also by energy conservation

$$\frac{1}{2}\times 0.5 \times v^2 = \frac{1}{2}\times 100 \times (0.3)^2 + \frac{1}{2}\times 0.5 \times u^2$$

$$\Rightarrow \frac{v^2}{4} = \frac{9}{2} + \frac{u^2}{4}$$

$$\Rightarrow \frac{9u^2}{4} = \frac{9}{2} + \frac{u^2}{4}$$

$$\Rightarrow \frac{8u^2}{4} = \frac{9}{2}$$

$$\Rightarrow u = \sqrt{\frac{9}{4}} = \frac{3}{2}$$

So $v = 3u$

$= 3 \times 1.5$

$= 4.5$

(c) $a_n = \dfrac{u^2}{r}$

$\Rightarrow$ $r = \dfrac{u^2}{a_n}$ $\left(a_n = \dfrac{K_h}{m} = \dfrac{100 \times 0.3}{0.5} = 60 m/s^2\right)$

$\Rightarrow$ $r = \dfrac{(1.5)^2}{(60)} = \dfrac{2.25}{60} = 0.0375$ m

= 3.75 cm

6. λ = 4m and f = 50 Hz.

$\therefore$ V = fλ = 200 m/s

$\because$ $V = \sqrt{\dfrac{T}{\mu}}$

$\therefore$ $T = \mu v^2 = (0.1) \times (200)^2$

= 400 N

7. Since integral number of waves shall cross a point is 5 seconds, therefore power transmitted in 5 seconds is

$= \langle P \rangle \times 5 = 2\pi^2 f^2 A^2 \mu v \times 5$

$= 2 \times \pi^2 \times (50)^2 \times (2 \times 10^{-3})^2 \times (0.01) \times 200 \times 5$

$= \dfrac{\pi^2}{5}$

8. The equation of waves is

$y = A \sin(kx - \omega t + \phi_0)$

$\therefore$ where $K = \dfrac{2\pi}{\lambda} = \dfrac{\pi}{2}$, $\omega = 2\pi f = 100\pi$ and A = 2

at x = 2 and t = 2 y = 1 mm

$\therefore$ $1 = 2 \sin(\pi - 200\pi + \phi_0)$

solving $\phi_0 = -30°$

$\therefore$ $y = 2 \sin\left(\dfrac{\pi x}{2} - 100\pi t - 30°\right)$