# PHYSICS

**DPP**

DAILY PRACTICE PROBLEMS

# DPP No. 31

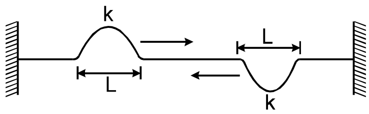
**Total Marks : 32**

**Max. Time : 37 min.**

**Topics : String Wave, Newton's Law of Motion, Electrostatics, Projectile Motion, Circular Motion, Center of Mass**

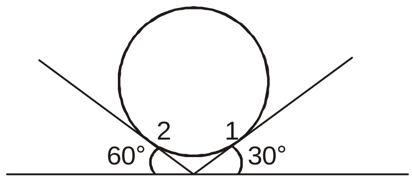
| **Type of Questions** | | **M.M., Min.** |
|---|---|---|
| **Single choice Objective ('–1' negative marking) Q.1** | **(3 marks, 3 min.)** | **[3, 3]** |
| **Subjective Questions ('–1' negative marking) Q.2 to Q.4** | **(4 marks, 5 min.)** | **[12, 15]** |
| **Comprehension ('–1' negative marking) Q.5 to Q.7** | **(3 marks, 3 min.)** | **[9, 9]** |
| **Match the Following (no negative marking) (2 × 4)Q.8** | **(8 marks, 10 min.)** | **[8, 10]** |

**1.** Two identical pulses move in opposite directions with same uniform speeds on a stretched string. The width and kinetic energy of each pulse is L and k respectively. At the instant they completely overlap, the kinetic energy of the width L of the string where they overlap is :

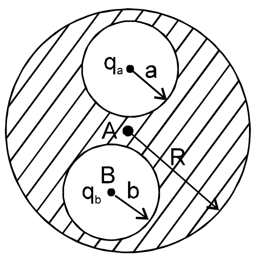



(A) k (B) 2k (C) 4k (D) 8 k

**2.** A solid sphere of mass 10 kg is placed over two smooth inclined planes as shown in figure. The normal reactions at 2 is 10x N. Find x ($g = 10\ m/s^2$)




**3.** A conducting sphere of radius R has two spherical cavities of radius a and b. The cavities have charges $q_a$ and $q_b$ respectively at their centres. 'A' is the centre of the sphere and 'B' is the centre of the cavity of radius 'b'. Find:




(i) electric field and electrical potential at
  (a) r (distance from A)> R,
  (b) r (distance from B)< b

(ii) surface charge densities on the surface of radius R, radius a and radius b.

(iii) What is the force on $q_a$ and $q_b$?

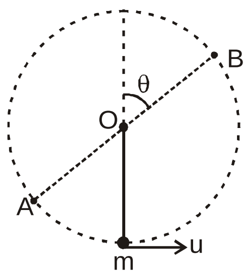
**4.** A particle moves along the plane trajectory y = f(x) with velocity v whose modulus is constant. Find the acceleration of the particle at the point x = 0 and the curvature radius of the trajectory at that point if the trajectory has the form

(a) of a parabola $y = ax^2$.

(b) of an ellipse $(x/a)^2 + (y/b)^2 = 1$; a and b are constants here.

**COMPREHENSION**

A ball is hanging vertically by a light inextensible string of length L from fixed point O. The ball of mass m is given a speed u at the lowest position such that it completes a vertical circle with centre at O as shown. Let AB be a diameter of circular path of ball making an angle $\theta$ with vertical as shown. (g is acceleration due to gravity)




**5.** Let $T_A$ and $T_B$ be the magnitude of tension in string when ball is at A and B respectively, then $T_A - T_B$ is equal to

(A) $6\ mg\ \cos\theta$ (B) 6 mg (C) $12\,mg\ \cos\theta$ (D) None of these

**6.** Let $\vec{a}_A$ and $\vec{a}_B$ be acceleration of ball when it is at A and B respectively, then $|\vec{a}_A + \vec{a}_B|$ is equal to

(A) $2\,g\ \sin\theta$ (B) $g\sqrt{12\cos^2\theta + 4}$ (C) $4\,g\ \cos\theta$ (D) None of these

**7.** Let $K_A$ and $K_B$ be kinetic energy of ball when it is at A and B respectively, then $K_A - K_B$ is equal to

(A) $mgL\ \cos\theta$ (B) $2mgL\ \cos\theta$ (C) $4mgL\ \cos\theta$ (D) None of these

**8.** Two identical uniform solid smooth spheres each of mass m each approach each other with constant velocities such that net momentum of system of both spheres is zero. The speed of each sphere before collision is u. Both the spheres then collide. The condition of collision is given for each situation of column-I. In each situation of column-II information regarding speed of sphere(s) is given after the collision is over. Match the condition of collision in column-I with statements in column-II.

| **Column-I** | **Column-II** |
|---|---|
| (A) Collision is perfectly elastic and head on | (p) speed of both spheres after collision is u |
| (B) Collision is perfectly elastic and oblique | (q) velocity of both spheres after collision is different |
| (C) Coefficient of restitution is $e = \frac{1}{2}$ and collision is head on | (r) speed of both spheres after collision is same but less than u. |
| (D) Coefficient of restitution is $e = \frac{1}{2}$ and collision is oblique | (s) speed of one sphere may be more than u. |

# Answers Key

**1.** (C) **2.** 5

**3.** (i) (a) **v =** $\frac{K(q_a + q_b)}{r}$ ; **E =** $\frac{K(q_a + q_b)}{r^2}$

(b) **E =** $\frac{Kq_b}{r^2}$ (ii) $\sigma_b = \frac{-q_b}{4\pi b^2}$ (iii) 0

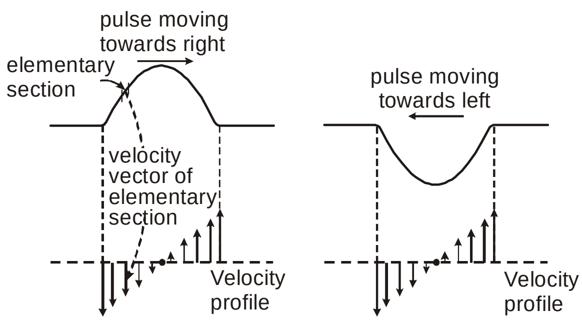
**4.** (a) $\omega = 2av^2$, $R = \frac{1}{2a}$ (b) $\omega = \pm\ bv^2 / a^2$, $R = a^2 / b$

**5.** (A) **6.** (B) **7.** (B)

**8.** (A) p,q (B) p,q (C) q,r (D) q,r

# Hints & Solutions

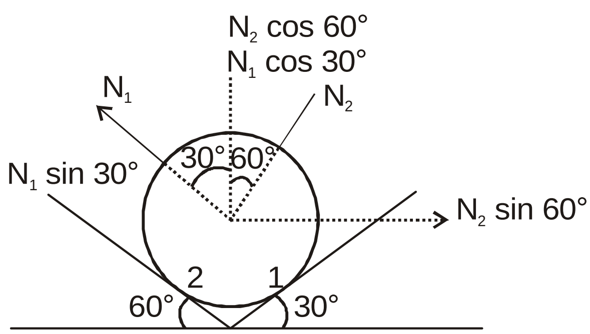
**1.** The velocity of profile of each elementary section of the pulse is shown in figure 1 and figure 2.




(Figure-1) (Figure-2)

When both the pulses completely overlaps, the velocity profiles of both the pulses in overlap region are identical. By superposition, velocity of each elementary section doubles. Therefore K.E. of each section becomes four times. Hence the K.E. in the complete width of overlap becomes four times, i.e., 4k.

**2.**



$N_1 \sin 30° = N_2 \sin 60°$

$N_1 \cos 30° + N_2 \cos 60° = mg$

Solving above equation

$$N_2 = \frac{mg}{2} = \frac{10 \times 10}{2} = 50$$

**3.** (i) (a) The charge on the outer most surface will be $(q_a + q_b)$ and it will be uniformly distributed

$\therefore$ **v =** $\frac{K(q_a + q_b)}{r}$ **Ans.** ;

**E =** $\frac{K(q_a + q_b)}{r^2}$ **Ans.**

where $K = \frac{1}{4\pi \in_0}$

(b) At a point inside the cavity of radius 'b' the potential will be due to $q_b, - q_b$ induced on its inner surface and due to $(q_a + q_b)$ on the outer surface of the sphere.

**v =** $\frac{Kq_b}{r} - \frac{Kq_b}{b} + \frac{K(q_a + q_b)}{R}$ **Ans.**

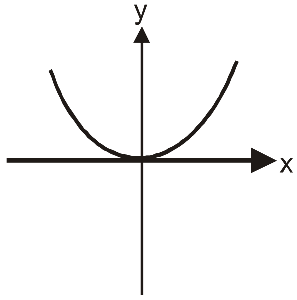
and E at that point will be only due to $q_b$ (which is placed at B)

**E =** $\frac{Kq_b}{r^2}$ **Ans.**

(ii) $\sigma_R = \frac{q_a + q_b}{4\pi R^2}$, $\sigma_a = \frac{-q_a}{4\pi a^2}$, $\sigma_b = \frac{-q_b}{4\pi b^2}$ **Ans.**

(iii) **0** **Ans.**

4. (a) Parabola $y = ax^2$ is shown. It is clear from diagram that at x = 0 velocity is along x-axis and constant $a_N$ is along y-axis. So,




$$a_N = \frac{d^2y}{dt^2}$$

$$\frac{dy}{dt} = 2a \times \frac{dx}{dt} = 2aVx$$

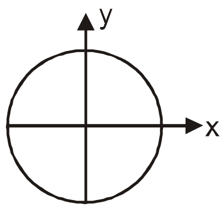
$$\frac{d^2y}{dt^2} = 2av\frac{dx}{dt} = 2av^2 \quad (\because \frac{d^2x}{dt^2} = 0)$$

$a_N = 2av^2$

$$R = \frac{v^2}{2av^2} = \frac{1}{2a}.$$

(b) $\left(\frac{x}{a}\right)^2 + \left(\frac{y}{b^2}\right)^2 = 1$

Here again at x = 0 particle is at (0, ± b) moving along positive or negative x-axis hence $a_N$ is along y-axis only.




$$a_N = \frac{d^2y}{dt^2}$$

$$\frac{2x}{a^2}\frac{dx}{dt} + \frac{2y}{b^2}\frac{dy}{dt} = 0$$

$$\frac{2vx}{a^2} + \frac{2y}{b^2}\left(\frac{dy}{dt}\right) = 0$$

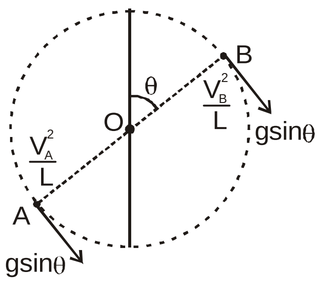
$$\frac{2v}{a^2}\frac{dx}{dt} + \frac{2}{b^2}\left(\frac{dy}{dt}\right)^2 + \frac{2y}{b^2}\left(\frac{d^2y}{dt^2}\right) = 0$$

[$\because$ v = const. along x-axis only $\frac{dy}{dt}$ = 0]

$$\frac{2v^2}{a^2} = -\frac{2(b)}{b^2}\left(\frac{d^2y}{dt^2}\right) \quad \Rightarrow \quad a_N = -\frac{bv^2}{a^2}$$

$$R = -\frac{v^2}{a_N} = \frac{a^2}{b}$$

**7.** The difference in K.E. at positions A and B is




$K_A - K_B = \frac{1}{2}mv_A^2 - \frac{1}{2}mv_B^2$ = mg (2L cosθ)

= 2mgLcosθ .... (1) **Ans.**

$T_A = \frac{mv_A^2}{L}$ + mg cosθ

$T_B = \frac{mv_B^2}{L}$ – mg cosθ

$\therefore T_A - T_B = \frac{mv_A^2 - mv_B^2}{L}$ + 2 mg cosθ .... (2)

from equation (1) and (2)

$T_A - T_B = 6\ mg\cos\theta$ **Ans.**

The component of accelerations of ball at A and B are as shown in figure.

$$\therefore\ |\vec{a}_A + \vec{a}_B| = \sqrt{(2g\sin\theta)^2 + \left(\frac{v_A^2}{L} - \frac{v_B^2}{L}\right)^2}$$

$$= \sqrt{4g\sin^2\theta + 16g^2\cos^2\theta} = g\sqrt{4 + 12\cos^2\theta}$$ **Ans.**

**8.** (A) p,q (B) p,q (C) q,r (D) q,r

**Sol.** In all cases speed of balls after collision will be same.
In case of elastic collision speed of both balls after collision will be u, otherwise it will be less than u.