# PHYSICS

# DPP

DAILY PRACTICE PROBLEMS

# DPP No. 27

**Total Marks : 37**

**Max. Time : 40 min.**

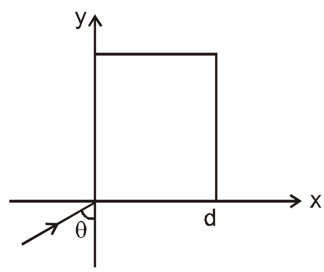
**Topics : Kinetic Theory of Gases, Geometrical Optics, Electrostatics, Center of Mass, Relative Motion, Rigid Body Dynamics, String Wave**

| 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 | (4 marks, 5 min.) | [4, 5] |
| Comprehension ('–1' negative marking) Q.7 to Q.9 | (3 marks, 3 min.) | [9, 9] |
| Match the Following (no negative marking) (2 × 4) Q.10 | (8 marks, 10 min.) | [8, 10] |

**1.** At pressure P and absolute temperature T a mass M of an ideal gas fills a closed container of volume V. An additional mass 2M of the same gas is added into the container and the volume is then reduced to $\frac{V}{3}$ and the temperature to $\frac{T}{3}$. The pressure of the gas will now be:

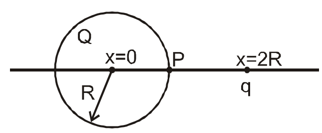
(A) $\frac{P}{3}$ (B) P (C) 3 P (D) 9 P

**2.** A ray hits the y-axis making an angle $\theta$ with y-axis as shown in the figure. The variation of refractive index with x-coordinate is $\mu = \mu_0\left(1-\frac{x}{d}\right)$ for $0 \le x \le d\left(1-\frac{1}{\mu_0}\right)$ and $\mu = \mu_0$ for $x < 0$, where d is a positive constant. The maximum x-coordinate of the path traced by the ray is




(A) $d(1 - \sin\theta)$ (B) $d(1 - \cos\theta)$ (C) $d \sin\theta$ (D) $d \cos\theta$

**3.** A sphere of radius R contains a total charge +Q which is uniformly distributed throughout its volume. At a distance 2R from the centre of sphere, a particle having charge +q is fixed. P is a point on surface of sphere and lying on line joining the centre of sphere and point charge. For what value of q will the electric field at P be zero.




(A) $\frac{Q}{2}$ (B) Q (C) $\frac{3}{2}$Q (D) 2Q

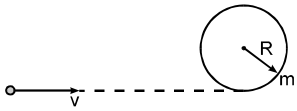
**4.** A particle 'A' of mass m collides head on with another stationary particle 'B' of the same mass 'm'.The kinetic energy lost by the colliding particle 'A' will be maximum if the coefficient of the restituition is

(A) 1 (B) 0 (C) 0.5 (D) none

**5.** An open elevator is ascending with zero acceleration and speed 10 m/s. A ball is thrown vertically up by a boy when he is at a height 10 m from the ground, the velocity of projection is 30m/s with respect to elevator. Choose correct option, assuming height of the boy very small : ($g = 10\ m/s^2$)

(A) Maximum height attained by the ball from ground is 90 m.
(B) Maximum height attained by the ball with respect to lift from the point of projection is 45 m.
(C) Time taken by the ball to meet the elevator again is 6 sec
(D) The speed of the ball when it comes back to the boy is 20 m/s with respect to ground.

**6.** A circular ring of mass m and radius R rests flat on a frictionless surface. A bullet also of mass m and moving with a velocity v, strikes the ring and gets embedded in it. The thickness of the ring is much smaller than R. Find the angular velocity with which the system rotates after the bullet strikes the ring.




**COMPREHENSION**

One end of massless inextensible string of length $\ell$ is fixed and other end is tied to a small ball of mass m. The ball is performing a circular motion in vertical plane. At the lowest position, speed of ball is $\sqrt{20 g \ell}$. Neglect any other forces on the ball except tension and gravitational force. Acceleration due to gravity is g.

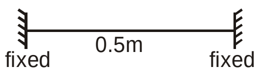
**7.** Motion of ball is in nature of
(A) circular motion with constant speed
(B) circular motion with variable speed
(C) circular motion with constant angular acceleration about centre of the circle.
(D) none of these

**8.** At the highest position of ball, tangential acceleration of ball is -
(A) 0 (B) g (C) 5 g (D) 16 g

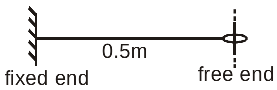
**9.** During circular motion, minimum value of tension in the string -
(A) zero (B) mg (C) 10 mg (D) 15 mg

**10.** In each of the four situations of column -I , a stretched string or an organ pipe is given along with the required data. In case of strings the tension in string is T = 102.4 N and the mass per unit length of string is 1 g/m. Speed of sound in air is 320 m/s. Neglect end corrections. The frequencies of resonance are given in column -II. Match each situation in column-I with the possible resonance frequencies given in Column -II.

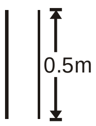
**Column-I** **Column-II**

(A) String fixed at both ends


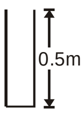
(p) 320 Hz

(B) String fixed at one end and free at other end


(q) 480 Hz

(C) Open organ pipe


(r) 640 Hz

(D) Closed organ pipe


(s) 800 Hz

# Answers Key

**1.** (C) **2.** (B) **3.** (B) **4.** (A)

**5.** (A, B, C, D) **6.** $\omega = v/3R$

**7.** (B) **8.** (A) **9.** (D)

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

# Hints & Solutions

**1.** If $M_0$ is molecular mass of the gas then for initial

condition $PV = \frac{M}{M_0} . RT$ ...(1)

After 2M mass has been added

$P' . \frac{V}{3} = \frac{3M}{M_0} . R . \frac{T}{3}$ ...(2)

By dividing (2) by (1)

$P' = 3P$

**2.** Snell's law = $\mu_0 \sin(90° - \theta) = \mu_0 \left(1 - \frac{x}{d}\right) \sin 90°$

$\Rightarrow \left(1 - \frac{x}{d}\right) = \cos\theta$

$\Rightarrow x = d(1 - \cos\theta)$

**3.** The electric field at P shall be zero if q = Q.

**4.** All energy is transfered to other particles.

**5.** (A) Absolute velocity of ball = 40 m/s (upwards)

$h_{max} = h_i = f_f$

$= 10 + \frac{(40)^2}{2 \times 10}$

h = 90 m

(B) Maximum height from left = $\frac{(30)^2}{2 \times 10} = 45$ m

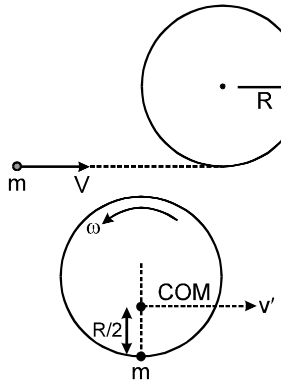
(C) The ball unless meet the elevator again when displacement of ball = displacement of lift

$40\,t - \frac{1}{2} \times 10 \times t^2 = 10 \times t \Rightarrow t = 6s.$

(D) Let $t_0$ be the total time taken by the ball to reach the ground then – 10 = 40 × to – $\frac{1}{2}$ × 10 × $to^2$

$\Rightarrow$ $t_0$ = 8.24 s.

$\therefore$ time taken by the ball for each the ground after crossing the elevator = $t_0 - t$ = 2.24 s.

**6.** 


Let velocity of COM after collision is v′ & angular velocity is ω.

conserving linear momentum

$$mv = 2mv' \Rightarrow v' = \frac{v}{2} \qquad \text{...........(1)}$$

conserving angular momentum about COM

$$mv.\frac{R}{2} = I.\omega$$

$$= (I_{\text{Ring COM}} + I_{\text{mass}})$$

$$\omega = \left[\left(MR^2 + \frac{MR^2}{4}\right) + \frac{MR^2}{2}\right]\omega$$

$$= \left(MR^2 + \frac{MR^2}{4}\right)\omega = mv.\frac{R}{2} = \frac{3}{2}MR^2\omega$$

$$\omega = \frac{v}{3R}$$

**7.** As speed of ball is variable, so motion is non uniform circular motion.

**8.** At the highest position of ball, net tangential force is zero, hence tangential acceleration of ball is zero,

**9.** Tension in the string is minimum when ball is at the highest position. By conservation of energy

$$\frac{1}{2}mv^2 + mg(2\ell) = \frac{1}{2}m(20g\ell)$$

$v^2 = 16g\ell$ where v is the velocity of ball at the highest point.

$$\text{So } T + mg = \frac{mv^2}{\ell}$$

$$T = \frac{m16g\ell}{\ell} - mg = 15\,mg$$

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

(A) The fundamental frequency in the string,

$$f_0 = \frac{\sqrt{T/\mu}}{2\ell} = \sqrt{\frac{102.4}{1\times10^{-3}}}\times\frac{1}{2\times0.5}\text{ Hz} = 320\text{ Hz.}$$

Other possible resonance frequencies are $f_A$ and $f_0$ = 320 Hz, 640 Hz, 960 Hz.

(B) The fundamental frequency in the string.

$$f_0 = \frac{\sqrt{T/\mu}}{4\ell} = \frac{320}{4\times0.5} = 160\text{ Hz.}$$

Other possible resonance frequencies are

$f_B$ = 160 Hz, 480 Hz, 800 Hz.

(C) The fundamental frequency in both ends open organ pipe is

$$f_0 = \frac{v}{2\ell} = \frac{320}{2\times0.5} = 320\text{ Hz.}$$

Other possible resonance frequencies are

$f_c$ = 320 Hz, 640 Hz, 960 Hz

(D) The fundamental frequency in one end open organ pipe is

$$f_0 = \frac{v}{4\ell} = \frac{320}{4\times0.5} = 160\text{ Hz.}$$

Other possible resonance frequencies are

$f_D$ = 160 Hz, 480 Hz, 800 Hz.