PHYSICS

DPP

DAILY PRACTICE PROBLEMS

DPP No. 42

Total Marks : 27

Max. Time : 30 min.

Topics : Gravitation, Elasticity & Viscosity, Geometrical Optics, Sound Wave, Rigid Body Dynamics, Current Electricity

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.2	(12 marks, 12 min.)	[6, 6]
Subjective Questions ('–1' negative marking) Q.3 to Q.5	(4 marks, 5 min.)	[12, 15]
Comprehension ('–1' negative marking) Q.6 to Q.8	(3 marks, 3 min.)	[9, 9]

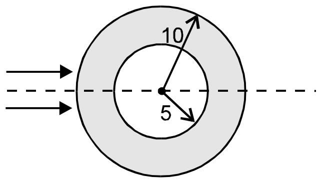
1. In a binary star system one star has thrice the mass of other. The stars rotate about their common centre of mass then:

(A) Both stars have same angular momentum about common centre of mass.
(B) Both stars have angular momentum of same magnitude about common centre of mass.
(C) Both stars have same angular speeds.
(D) Both stars have same linear speeds.

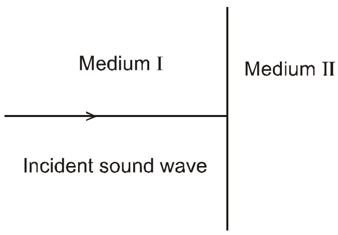
2. A thin rod of negligible mass and area of cross-section 2×10^{-6} m^2, suspended vertically from one end, has a length of 0.5 m at 200^{0}C. The rod is cooled to 0^{0}C, but prevented from contracting by attaching a mass at the lower end. The value of this mass is : (Young's modulus = 10^{11} N/m^2, Coefficient of linear expansion 10^{-5} K^{-1} and g = 10 m/s^2):

(A) 20 kg (B) 30 kg (C) 40 kg (D) 50 kg

3. A glass sphere with 10 cm radius has a 5 cm radius concentric spherical hole. A narrow beam of parallel light from outside is incident on the sphere . Find the final image position with respect to the last surface.The refractive index of the glass is 1.5 .



4. A sound wave propagating along x-axis, in medium I of density ρ_1 = 1.5 kg/m^3 is transmitted to a medium II of density ρ_2 = 3kg/m^3 as shown. The equation of excess pressure developed by wave in medium I and that in medium II respectively are

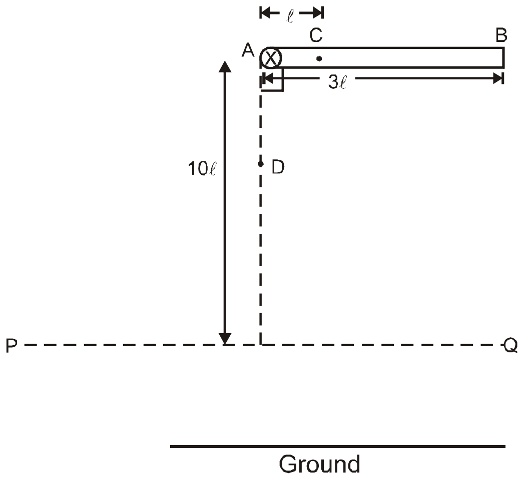


$p_1 = 4 \times 10^{-2} \cos \omega\left(t - \dfrac{x}{400}\right)$ (in SI units)

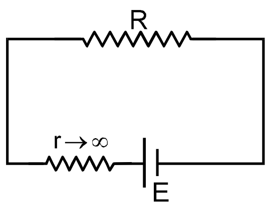
$p_2 = 3 \times 10^{-2} \cos \omega\left(t - \dfrac{x}{1200}\right)$ (in SI units)

If the intensity of transmitted wave is I_2 (wave in medium II) and intensity of incident wave is I_1 (wave in medium I), then find the value of $\dfrac{6I_1}{I_2}$.

5. A uniform thin rod of mass 'm' and length '3ℓ' is released from rest from horizontal position as shown. When it passes through the vertical line AD, it gets broken at point 'C' due to some reason. Find the angle (in radian) rotated by rod BC till its centre of mass passes through the horizontal line PQ from the instant of breakage. ($g = 10\ m/s^2$) (hinge is smooth)



COMPREHENSION

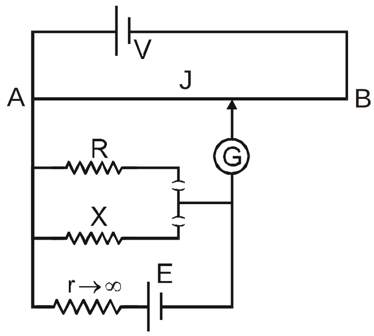


Consider a battery with a large internal resistance ($r \to \infty$) ≈ 10 kΩ. If we connect a light resistance R (R << r) across it, current will be

$\frac{E}{r+R} \approx \frac{E}{r}$ = constant (Independent from external resistance R)

So if we put any light resistance across it, current in it would not change, and will be constant ($\approx \frac{E}{r}$)

So a battery with a large internal resistance is equivalent to a constant current source (A source providing a constant current)



This concept is used in potentiometer circuit for comparing two resistances R and X, as shown in figure.

Here a battery with large internal resistance supply a cosntant current (i) to either R or X. If it is connected to R = 10 Ω potential drop across it will be iR, and the balance length is found to be 58.3 cm. If it is connected to X (unknown), Potential drop across it will be iX and the balance length is coming = 68.5 cm.

6. Estimate the unknown resistance X

(A) 11.25 (B) 11.75 (C) 12.25 (D) 12.50

7. If you fail to find any balanced point, as we slide the jocky along A B. What may be the reason.

(A) Resistance of potentiometer wire may be large.
(B) Emf of the primary cell (V) may be very high
(C) potential drop across R or X may exceed V
(D) Emf of the source (E), may be very large.

8. In the previous question, what can we do to get the balance point

(A) Increase V
(B) Reduce E
(C) Increase the internal resistance (r) connected with E
(D) Use a longer potentiometer wire

Answers Key

1. (C) **2.** (C)
3. $v_1 = 30$, $v_2 = -25$, $v_3 = -35/3$, $v_4 = -25$ cm
4. 64 **5.** 4 radians **6.** (B)
7. (C) (D) **8.** (A)(B) (C)

Hints & Solutions

1. In a binary star system

$\omega_1 = \omega_2$

2. Strain (ε) = $\frac{\Delta\ell}{\ell} = \propto \Delta T = (10^{-5})(200)$

$= 2 \times 10^{-3}$

Stress = Y (strain)

Stress = $10^{11} \times 2 \times 10^{-3} = 2 \times 10^{8}$ N/m^2

$\Rightarrow$ Required force = stress × Area

$= (2 \times 10^{8})(2 \times 10^{-6}) = 4 \times 10^{2} = 400$ N

$\therefore$ Mass to be attached = $\frac{400}{g}$ = 40 kg

3. [Ans. v_1 **=30,** v_2 **= – 25,** v_3 **= -35/3,** v_4 **= -25 cm]**

4. **Ans. 64**

$$I = \frac{p^2}{\rho v}$$

$$\frac{I_2}{I_1} = \frac{p_2^{\,2}}{p_1^{\,2}} \times \frac{\rho_1}{\rho_2}\,\frac{v_1}{v_2}$$

$$= \frac{9}{16} \times \frac{1.5}{3} \times \frac{400}{1200} = \frac{9}{16 \times 3 \times 2} = \frac{3}{32}$$

$$6\,\frac{I_1}{I_2} = \frac{6 \times 32}{3} = 64$$

5. By energy conservation,

$$mg.\frac{3\ell}{2} = \frac{1}{2}.\frac{m(3\ell)^2}{3}.\omega^2$$

$$\omega = \sqrt{\frac{g}{\ell}}$$

and velocity of centre of mass of rod BC

$$V_{cm} = \sqrt{\frac{g}{\ell}}.2\ell$$

$$V_{cm} = 2\sqrt{g\ell}$$

If time taken by centre of mass of rod BC from breaking position to line PQ is t.

$$8\ell = \frac{1}{2} \times g \times t^2$$

$$t = 4\sqrt{\frac{\ell}{g}}$$

$\theta = \omega.t \quad = \quad 4$ radian.

6. $iR = \phi\,(58.3)$

& $iX = \phi\ (68.5)$

where ϕ is the potential gradient of the potentiometer

$$\therefore \frac{R}{X} = \frac{58.3}{68.5}$$

$$\frac{10}{X} = \frac{58.3}{68.5} \Rightarrow X = \mathbf{11.75\ \Omega}$$

7. The maximum P.D. which we can measure by this potentiometer is V

8. Any change can be done which assures p.d. across R or X less then or equal to V