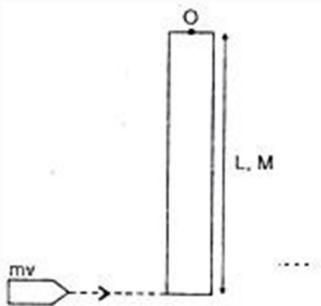


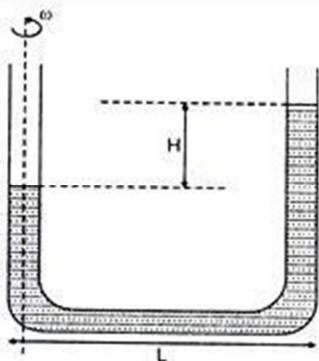
IIT-JEE-Physics-Mains-2005

MAINS

1. A rod of length L and mass M is hinged at point O. A small bullet of mass m hits the rod as shown in the figure. The bullet gets embedded in the rod. Find angular velocity of the system just after impact.



2. An observer standing on a railway crossing receives frequencies of 2.2 kHz and 1.8 kHz when the train approaches and recedes from the observer. Find the velocity of the train. [the speed of the sound in air is 300 m/s].



3. A U-shaped tube contains a liquid of density ρ and it is rotated about the line as shown in the figure. Find the difference in the levels of liquid column.

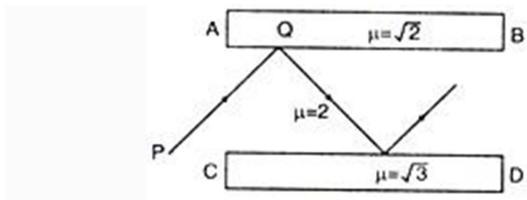
4. A conducting bubble of radius a , thickness t ($t \ll a$) has potential V . Now the bubble collapses into a droplet. Find the potential of the droplet.

5. The potential energy of a particle varies as

$$\begin{aligned}U(x) &= E_0 \quad 0 < x < 1 \\&= 0 \quad x > 1\end{aligned}$$

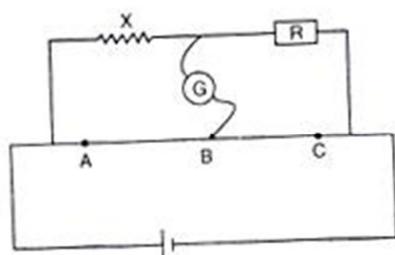
For $0 < x < 1$, de Broglie wavelength is λ_1 and for $x > 1$ the de Broglie wavelength is λ_2 . Total energy of the particle is $2E_0$. Find λ_1/λ_2 .

6. AB and CD are two slabs. The medium between the slabs has refractive index 2. Find the minimum angle of incidence at Q so that the ray is totally reflected by both the slabs.



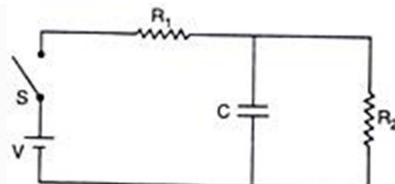
7. The edge of a cube is measured using a vernier caliper. [9 divisions of the main scale is equal to 10 divisions of vernier scale and 1 main scale division is 1 mm]. The main scale division reading is 10 and 1 division of vernier scale was found to be coinciding with the main scale. The mass of the cube is 2.736 g. Calculate the density in g/cm³ upto correct significant figures.

8. R₁, R₂, R₃ are different values of R. A, B, C are the null points obtained corresponding to R₁, R₂ and R₃ respectively. For which resistor, the value of X will be the most accurate and why?

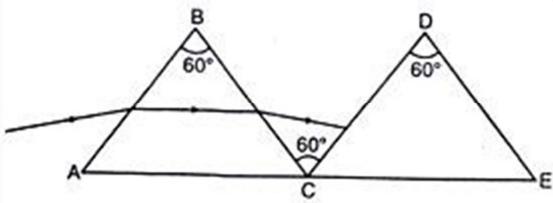


9. A solid cylinder rolls without slipping on an inclined plane inclined at an angle θ . Find the linear acceleration of the cylinder. Mass of the cylinder is M.

10. At $t = 0$, switch S is closed. The charge on the capacitor is varying with time as $Q = Q_0 (1 - e^{-at})$. Obtain the value of Q_0 and a in the given circuit parameters.



11. A ray of light is incident on a prism ABC of refractive index $\sqrt{3}$ as shown in figure.



(a) Find the angle of incidence for which the deviation of light ray by the prism ABC is minimum.

(b) By what angle the second prism must be rotated, so that the final ray suffer net minimum deviation.

12. A harmonically moving transverse wave on a string has a maximum particle velocity and acceleration of 3 m/s and 90 m/s² respectively. Velocity of the wave is 20 m/s. Find the waveform.

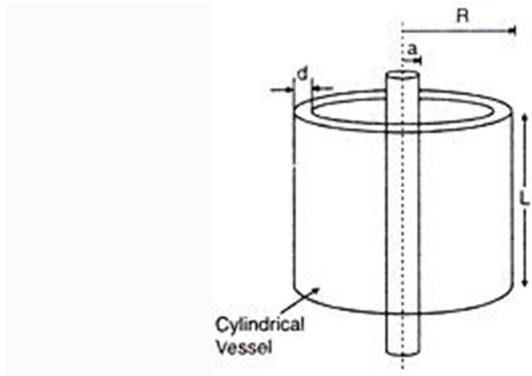
13. X-rays are incident on a target metal atom having 30 neutrons. The ratio of atomic radius of the target atom and ²⁴He is (14)1/3.

(a) Find the atomic number of target atom.

(b) Find the frequency of Ka line emitted by this metal.

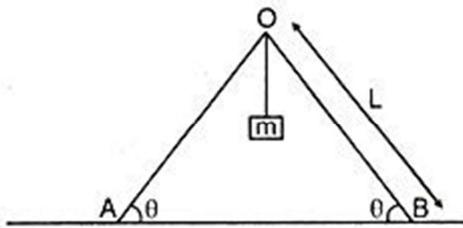
$$R = 1.1 \times 10^7 \text{ m}^{-1}, c = 3 \times 10^8 \text{ m/s}$$

14. A long solenoid has n turns per unit length and radius a . A current $I = I_0 \sin \omega t$ flows through it. A cylindrical vessel of radius R , length L , thickness d ($d \ll R$) and resistivity r is kept coaxially as shown in the figure. Find the induced current in the outer cylindrical vessel.

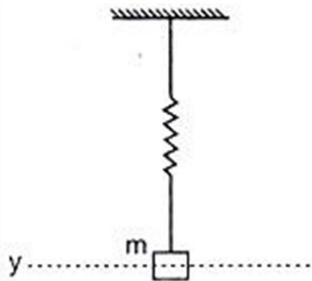


15. Two identical ladders are arranged as shown in the figure. Mass of each ladder is M and length L . The system is in equilibrium. Find direction and magnitude of frictional force acting

at A or B.



16. A mass m is undergoing SHM in the vertical direction about the mean position y_0 with amplitude A and angular frequency ω . At a distance y from the mean position, the mass detaches from the spring. Assume that the spring contracts and does not obstruct y (measured from the mean position) such that the height h attained by the block is maximum. ($\omega^2 > g$).



17. A metal of mass 1 kg at constant atmospheric pressure and at initial temperature 20°C is given a heat of 20,000 J. Find the following :

- (a) Change in temperature
- (b) Work done
- (c) Change in internal energy

(**Given :** Specific heat $400 \text{ J/kg/}^\circ\text{C}$, coefficient of cubical expansion, $\alpha = 9 \times 10^{-5}/^\circ\text{C}$, density $\rho = 9000 \text{ kg/m}^3$, atmospheric pressure = 105 N/m^2)

18. A moving coil galvanometer experiences torque = ki where i is current. If N coils of area A each and moment of inertia I is kept in magnetic field B .

- (a) find k in terms of given parameters
- (b) if for current i deflection is $\pi/2$, find out torsional constant of spring,
- (c) if a charge Q is passed suddenly through the galvanometer find out maximum angle of deflection.