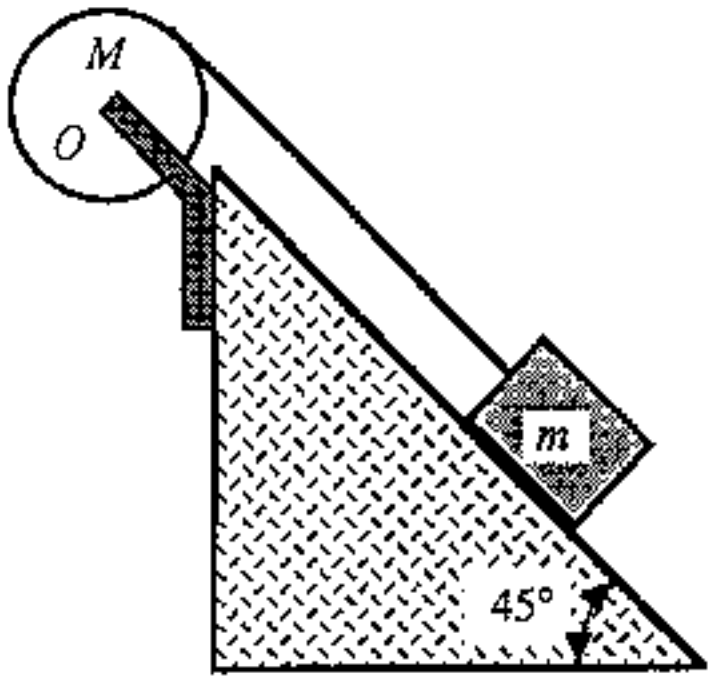
Problem #1

Describe a feasible method to measure the moment of inertia of your body. State in detail the procedures and physical theorems employed in your measurement. (10%)

Problem #2

A block of mass m = 5 kg slides down a surface inclined 45° to the horizontal, as shown in the figure below. The coefficient of sliding friction is 0.25. A string attached to the block is wrapped around a flywheel on a fixed axis at O. The flywheel has a mass M = 20 kg, an outer radius R = 0.2 m, and a moment of inertia with respect to the axis of 0.2 $kg \cdot m^2$.

(a) What is the acceleration of the block down the plane? (5%)
(b) What is the tension in the string? (5%)



Problem #3

Assume there is an ideally spherical drop of liquid resting on a clean surface, and its radius is r.

(a) Prove that the free energy change $\Delta\mu$ due to the addition of infinitesimal number of material dn can be expressed as follows:

$$\Delta\mu = \frac{2\sigma\Omega}{r}$$

where σ is the surface energy of the liquid phase and Ω is the atomic volume of the liquid phase. (5%)

(b) Using the above equation, derive the following relationship of the equilibrium vapor pressure (P) and the surface radius (r) of a liquid phase

$$\ln\left(\frac{P_1}{P_2}\right) = \frac{2\sigma\Omega}{kT}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

where k is the Boltzmann constant and T is the temperature. (5%)

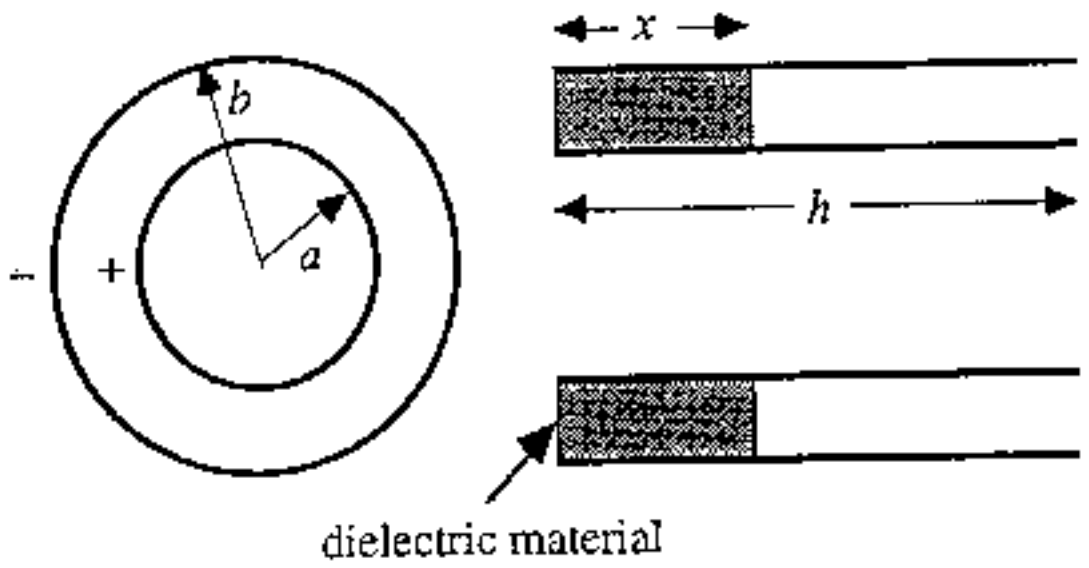
Problem #4

Describe the Gauss' law and apply it to calculate : (a) the electric field of a charged cylinder conductor; (b) the electric field between oppositely charged parallel conducting plates; (c) the electrical field just outside any charged conductor. (12%)

Problem #5

(a) A cylindrical capacitor consists of two coaxial cylinders of radii a and b and length h, as shown in the figure below. Find out the capacitance C_o of this device. (5%)

(b) This capacitor is charged to a potential difference V_o. The charging battery is then removed, and a dielectric material (dielectric constant κ) is introduced to fill the capacitor up to a length of x. Find out the final potential difference of the capacitor. (10%)



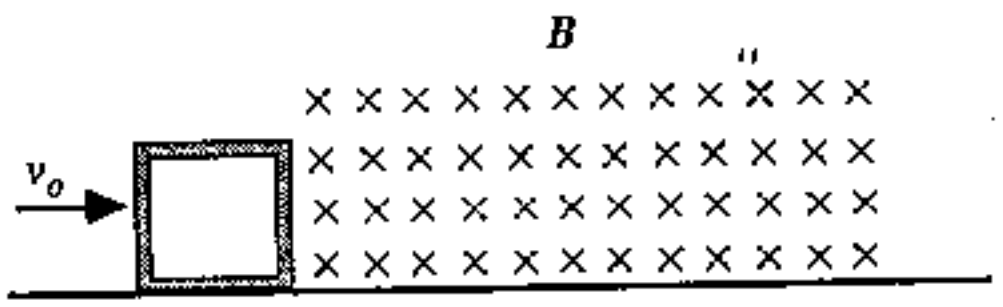
Problem #6

A square metallic frame of edge length l, mass m, and total resistance R was sliding on a frictionless plane, into a region of uniform magnetic induction $\boldsymbol{B}$ at time $t = 0$, as shown in the figure below. The initial velocity of the frame is v_o.

Find out

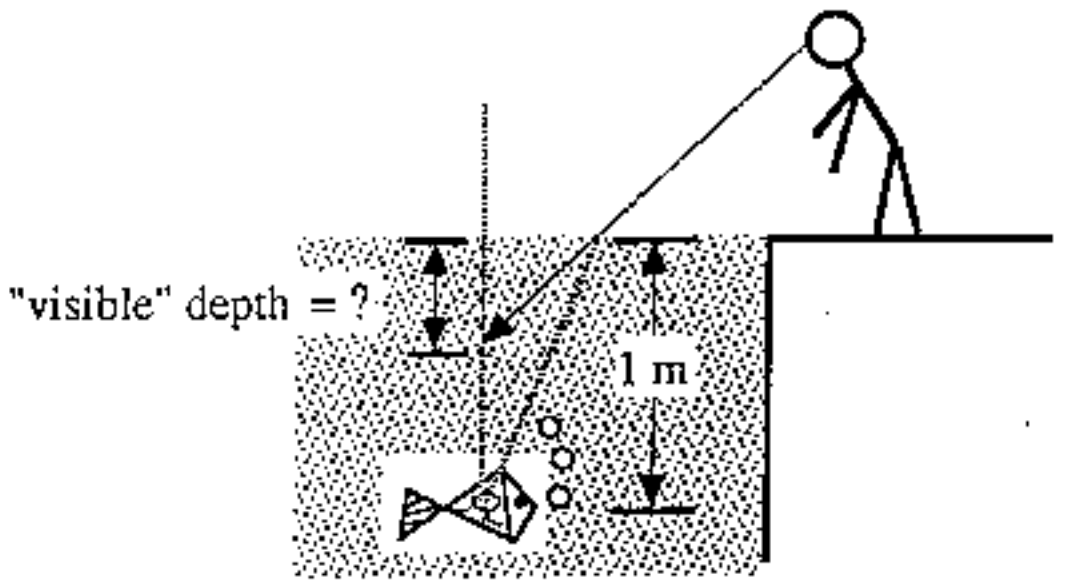
(a) the final velocity of the frame (7%)

(b) the time at which it just completely slid into the region. (8%)



Problem #7

Determine the "visible" depth of a fish if it is actually at a depth of 1 m beneath the surface of a lake. (Refraction index of air ≈ 1; refraction index of water = 1.33.)



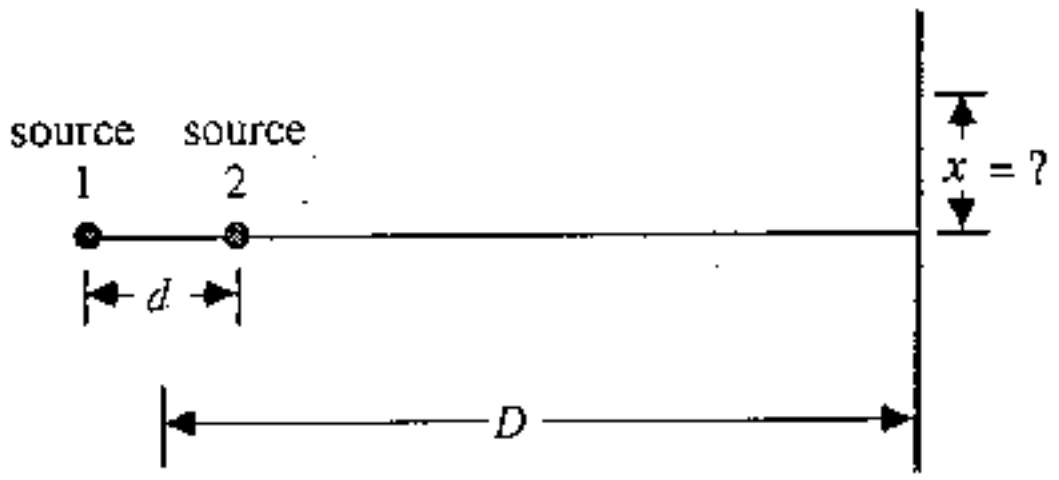
(6%)

Problem #8

Two coherent sound sources of 500 Hz are positioned as shown below.

(a) Calculate the distance x where the first maximum sound intensity will be detected. (D = 100 m; d = 1 m; speed of sound wave = 330 $^{m}/_{sec}$.) (8%)

(b) If the frequency of sound wave can be altered, determine the minimum sound frequency above which the constructive sound interference in (a) can be detected. (8%)



Problem #9

Describe the physical significance involved in the following principles of modern physics:

(a) The correspondence principle, and (3%)

(b) The uncertainty principle. (3%)