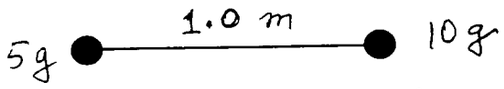
(1) Two small metal spheres of mass 5 g and 10 g carry a positive charge of 5 μC each. The spheres are connected by a massless string of length 1.0 m (much greater than the diameter of the spheres)



USE $(4\pi\varepsilon_0)^{-1} = 9 \times 10^9 \frac{Nm^2}{C^2}$

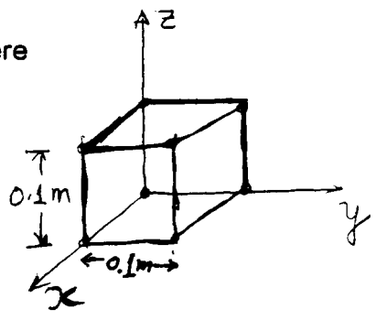
(a) What is the electrostatic potential energy of the system ? (8 points).

(b) The string is now cut. Find the velocity of the lighter sphere a long time after the string has been cut. Ignore the effects of gravity completely (12 points).

(c) Similarly what is the velocity of the other sphere ? (5 points)

(2) In a certain region in space the electric potential due to a charge distribution varies only with z as $V = a_0 + a_1 z^2$, where $a_0 = 12$ V and $a_1 = -10$ V/m^2. A cube is placed such that it sits on the x-y plane with one of the corners coinciding with the origin (see figure).

(a) Find the electric field magnitude and direction everywhere in this region (5points).

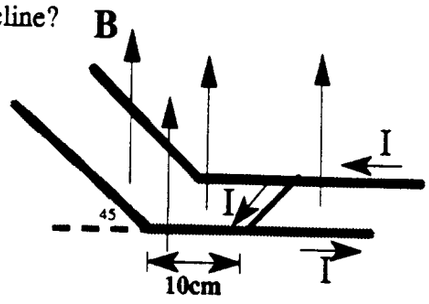


(b) Calculate the electric flux coming out of the cube (15 points)

(c) What is the charge enclosed inside the cube ? (5 points)

3. A metal wire with mass **m=50 g** can slide on two horizontal conducting rails spaced a distance **d=1 cm** apart. As shown, the track lies in a vertical uniform magnetic field, **B=0.5 T**, and a constant current, **I=2 A,** flows through the system. The metal wire is initially at rest, **10 cm** from the beginning of the incline.

a) [7 points] How long does it take the wire to reach the base of the incline?



b) [8 points] What is the velocity of the wire at the time you found in part (a)?

c) [10 points] The wire is now picked up and placed at rest on the incline. How much current is required to keep the wire at rest on the slope?

(4) A parallel-plate 15nF-capacitor is connected to a battery which maintains a potential difference of 20V across the plates. The separation, d, between the plates is reduced to d/2 :

(a) [6 points] What is the new capacitance ?

(b) [7 points] What is the change in potential energy stored in the capacitor [you must specify the sign of potential energy change] ? Identify the source (?) or drain (?) of this energy.

(c) [6 points] What is the change in the charge stored on the capacitor ?

(d) [6 points] If a dielectric with κ=3 and thickness d/4 is inserted into the capacitor as shown, what is the new capacitance ?