Potential Energy and Potential

1. Three charges of +122mC each are placed on the corner of an equilateral triangle, 1.72 m on a side. If energy supplied at the rate of 831W, how many days would required to move one of the charges onto the mid point of the line joining the other two. (t = 2.17 day)

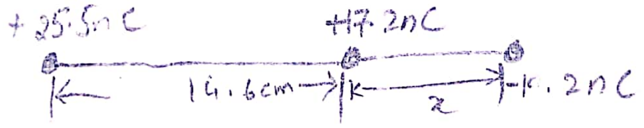
2. Two parallel, flat, conducting surface of spacing d = 1cm have a potential difference ΔV of 10.3 kV. An electron is projected from one plate directly toward the second. What is the initial velocity of the electron if it comes to rest just at the surface of the second plate? Ignore the relativistic effects. (Me = 9.11×10^{-31} kg) ($V = 6.01 \times 10^4$ m/s)

3. The charges shown in figure 1 are fixed in space. Find the value of the distance x so that the electric potential energy of the system is zero. (x = 20.5 cm)

4. An infinite sheet of charge has a charge density $\sigma = 0.12 \mu C/m^2$. How far apart are the equipotential surfaces whose potentials differ by 48V? (L = 7.1 mm)

5. Two large, parallel, conducting plates are 12cm apart and carry equal but opposite charge on their facing surfaces. An electron placed midway between the two plates experiences a force of 3.9 x 10^{-15} N. (a) Find the electric field at the position of the electron. (b) what is the potential difference between the plates? ((a) 24.4 kV/m (b) V = 2.925 kV)

fig-1



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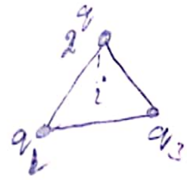
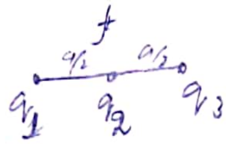
$$U_i = \frac{k q_1 q_2}{r_{12}} + \frac{k q_2 q_3}{r_{23}} + \frac{k q_3 q_1}{r_{31}} = \frac{3kq^2}{a}$$



$$U_f = \frac{k q_1 q_2}{a/2} + \frac{k q_2 q_3}{a/2} + \frac{k q_1 q_3}{a}$$

$$U_f = \frac{5kq^2}{a}$$



$$\frac{\Delta U}{t} = P \Rightarrow t = \frac{\Delta U}{P} = \frac{2kq^2/a}{831} = 217\,day$$

Q.2

$$W = \Delta U = q\Delta V = k_f - k_i \quad \therefore W = \Delta K$$

$$q\Delta V = 0 - \frac{1}{2} m v_i^2$$

$$v_i = \sqrt{\frac{2 q \Delta V}{m}} = \sqrt{\frac{2(1.6\times10^{-19})(10.3\times10^{3})}{9.11\times10^{-31}}} = 60,149.8$$

Q.3

$$\frac{k q_1 q_2}{r_{12}} + \frac{k q_2 q_3}{r_{23}} + \frac{k q_1 q_3}{r_{13}} = 0$$

$$\frac{(25.5n)(17.2n)}{14.6} + \frac{(25.5n)(-19.2)}{14.6+x} + \frac{(17.2n)(-19.2)}{x} = 0$$

$$30.04x^2 - 381.24x - 4821.5 = 0 \qquad x = 20.5\,cm$$

Q.4

$$E = \frac{\sigma}{2\epsilon_0} = \frac{0.12\times10^{-6}}{2(8.85\times10^{-12})} = 6780\ V/m$$

$$V_b - V_a = EL$$

$$V_b - V_a = 48 = EL \Rightarrow L = \frac{48}{E} = \frac{48}{6780} = 7.1\ mm$$

Q.5

$$E = \frac{F}{q} = \frac{3.9\times10^{-15}}{1.6\times10^{-19}} = 24.4\ kV/m$$

$$V = EL = 24.4 \times 0.12 = 2.925\ kV$$

Magnetic Field

Q1. An electron that has velocity v = (2.0*10^6 m/s) + (3.0*10^6 m/s) moves with the uniform magnetic field (b =0.030t)I – (0.15t)j (a)Find the force on the electron due to magnetic field.(b)Repeat your calculation for proton having same velocity.

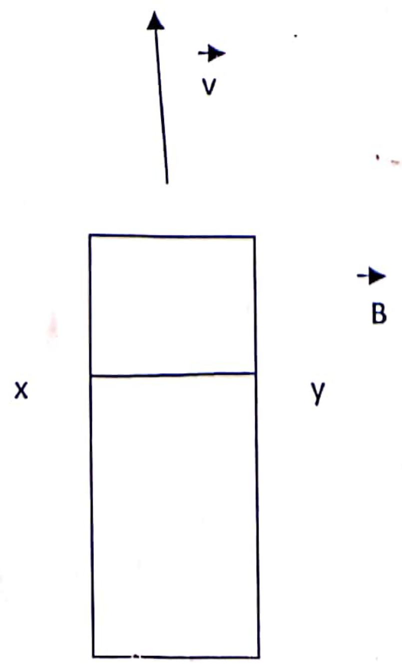
Q2. An alpha particle travel at velocity of magnitude 550m/s through uniform magnetic field of magnitude 0.045t (an alpha particle has the charge of + 3.2 * 10^-19C and mass of 6.6*10^-27 kg). the angle between v and B is 52 degree. What is the magnitude of (a)Force F b acting on the particle due to filed(b)Acceleration of particle due to Fb(c)Does the speed of particle increase, decrease or remain same.

Q3) a particle of mass 10 g and charge 80µC move through uniform magnetic field in a region where the free fall acceleration is -9.8j m/s^2.the velocity of particle is constant 20i km/s which is perpendicular to magnetic field. what then, is magnetic field?

Q4) an electron moves through uniform magnetic field given by B= Bxi + (3.0Bx)j. At a particular instant, the electron has velocity v = (2.0i + 4.0j)m/s and the magnetic force acting on it is (6.4 * 10^-19N)k. find Bx.

Q5) an electron has initial velocity of (12.0j + 15.0k) km/s and the constant acceleration of (2.00*10^12 m/s^2)i in a region in which uniform electric and magnetic field are present. If B = (400µT)i. find the electric field E

Q6). A metal strip 6.50 cm long, 0.850 cm wide and 0.760 mm thick moves with constant velocity through a uniform magnetic field B = 1.20 mT directed perpendicular to strip as figure. A potential difference of 3.90µv is measured between points x and y across the strip. Calculate the speed v.



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Q.1

(a) $F_B = q v \times B = q(v_x \hat{i} + v_y \hat{j}) \times (B_x \hat{i} + B_y \hat{j})$

$= q(v_x B_y - v_y B_x)\hat{k}$

$= -1.6\times10^{-19}\cdot[2\times10^{6}(-0.15) - (3\times10^{6})(0.030)]\hat{k}$

$F_B = (6.2\times10^{-14}\,N)\hat{k}$

Magnetude of F_B is 6.2×10^{-14} & point in (+ve) z-direction.

(b) For proton

Same magnitud but opposit direction

$F_B = -(6.2\times10^{-14}N)\hat{k}$

Q.2

(a) $F_B = |q| v B \sin\phi = (+3.2\times10^{-19}C)(550)(0.045)(\sin 52) = 6.2\times10^{-18}N$

(b) $a = \frac{F_B}{m} = 9.5\times10^{8}\,m/s^2$

(c) Since it is perpendicular to $\bar{v}$, $\bar{F}_B$ does not any work on the particle. Thus from the work-energy theorem both K.E & speed of particle remain same.

Q.3

$F = qvB\sin\theta \qquad \theta = 90$

$B = \frac{F}{qv} = \frac{ma}{qv} \quad (F = ma) = \frac{10\times10^{-3}(-9.8)}{2\times10^{4}\times80\times10^{-16}} = 6.125\times10^{-2}T$

Q.4

$F = q(v_x B_y - v_y B_x)\hat{k} = q[v_x(3B_x) - v_y B_x]\hat{k} \qquad B_y = 3B_x$

Since $F = F_n\hat{k} \Rightarrow F_z = 6.4\times10^{-19}N$

So

$q(3v_x - v_y)B_x = F_z \Rightarrow B_x = \frac{F_z}{q(3v_x - v_y)} = -2\,T$

$\because v_x = 2\,m/s$

$v_y = 4\,m/s$

$q = -1.6\times10^{-19}$

Q.5 $F = q(E + \bar{v}\times\bar{B}) = m_e\bar{a} \Rightarrow E = \frac{m\bar{a}}{q} + \bar{B}\times\bar{v}$

$= \frac{9.11\times10^{-31}kg\,(2\times10^{12})}{-1.6\times10^{-19}} + 400\times10^{-6}\,\hat{i}\times[12\,km/s\,\hat{j} + 15\,km/s\,\hat{k}]$

$E = (-11.4\,\hat{i} - 6\hat{j} + 4.8\hat{k})\,V/m$