Tan Zhi Yong 03S6H Charge & Field

Subject: Date:

1) Point Charge / Charged spheres

a) Force between 2 point charges

Coulomb's Law : $F = \frac{Q_1 Q_2}{4\pi \varepsilon_0 r^2}$

$F = qE$

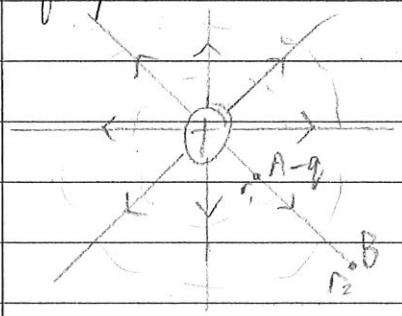
b) E field strength due to source charge Q_1 : $E = \frac{Q_1}{4\pi \varepsilon_0 r^2}$

c) Potential due to source charge Q $V = \frac{+Q}{4\pi\varepsilon_0 r}$ (Q is +ve)

$V = \frac{-Q}{4\pi\varepsilon_0 r}$ (if Q is -ve)

d) Relation between |E| and V $|E| = \left|\frac{dV}{dr}\right|$

e) Equipotential lines



$V = \frac{Q}{4\pi\varepsilon_0 r}$

$= \frac{k}{r}$

$U_A = -qV$

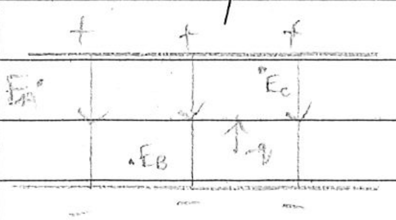
$= -q\left(\frac{Q}{4\pi\varepsilon_0 r_1}\right)$

$U_B = -q\left(\frac{Q}{4\pi\varepsilon_0 r_2}\right)$

$W_{A\to B} = U_B - U_A$

$W_{B\to A} = U_A - U_B$

2) Parallel plates (uniform field) E is constant in magnitude & direction



$|E_A| = |E_B| = |E_C|$

Force experienced by a charge $-q$ in a uniform E field

$|F| = q|E|$

E field strength between parallel plates

$|E| = \left|\frac{V_1 - V_2}{d}\right|$

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Potential at different points between the plates

$$\frac{V_1 - V_2}{x} = |E|$$

$$V = |E|x + V_2$$

Point Charges (sphere)

$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$

$E = \frac{Q}{4\pi\varepsilon_0 r^2}$

$F = qE$

$V(+) = \frac{+Q}{4\pi\varepsilon_0 r}$

$V(-) = \frac{-Q}{4\pi\varepsilon_0 r}$

* $E_p = qV$
* $|E| = \left|\frac{dV}{dr}\right|$

Parallel plates (uniform field)

$E = \frac{V_1 - V_2}{d}$

$F = qE$

$V = \left(\frac{V_1 - V_2}{d}\right)x + V_2 = Ex + V$

$U = qV$

Tan Zhi Yong 03SG4 Charge & Field Tutorial

Subject: Date: 14-2-04

1) For (a), Force along x-axis $= -3q + 2q$
$= -q$
Force along y-axis $= -5q$
Magnitude of F_R $= \sqrt{(q)^2 + (5q)^2}$
$= \sqrt{26q^2}$
$= 5.10q$ (3 s.f)

For (b), Force along x-axis $= 3q - 2q$
$= q$
Force along y-axis $= -5q$
$|F_R|$ $= \sqrt{q^2 + (-5q)^2}$
$= 5.10q$ (3 s.f)

For (c), Force along x-axis $= 4q - q$
$= 3q$
Force along y-axis $= -5q$
$|F_R|$ $= \sqrt{(3q)^2 + (-5q)^2}$
$= 5.83q$ (3 s.f)

For (d), Force along x-axis $= -4q + q$
$= -3q$
Force along y-axis $= -q - 4q$
$= -5q$

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2a) $V_x = \left(\frac{2\times10^{-6}}{6} + \frac{-1\times10^{-6}}{2}\right)\left(\frac{1}{4\pi(8.85\times10^{-12})}\right)$

$= \cancel{-14}\ -1500\ V\ (3s.f)$

$V_y = \left(\frac{2\times10^{-6}}{3} + \frac{-1\times10^{-6}}{1}\right)\left(\frac{1}{4\pi(8.85\times10^{-12})}\right)$

$= -3000\ V\ (3s.f)$

2b) Yes.

$V_x + V_y = 0$

$V_x = V_y$

Let distance from pt to $+2\times10^{-6}$ C charge be r

$\frac{2\times10^{-6}}{4\pi\varepsilon_0 r} = \frac{1\times10^{-6}}{4\pi\varepsilon_0(4-r)}$

$(4-r)(2\times10^{-6}) = 1\times10^{-6} r$

$8\times10^{-6} - 2\times10^{-6} r = 1\times10^{-6} r$

$3\times10^{-6} r = 8\times10^{-6}$

$r = 2.67\ m\ (3s.f)$

No. $\varepsilon \neq 0$

3a)

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4b) $F = qE$

$= 1.6\times10^{-19} \times 3.5 \times 10^{4}$

$= 5.6 \times 10^{-15}$ N downwards

4c) $V_x = 3.2 \times 10^{7}\ ms^{-1}$

4d) $t = \frac{\cancel{5.0\times10^{-3}}\ 5\times10^{-2}}{3.2\times10^{7}}$

$= 1.56 \times 10^{-9}$ s (3s.f)

4e) $\cancel{V_y = U_y + at}$ $\quad a = \frac{F}{m}$

$\cancel{= at}$ $\quad = \frac{5.6\times10^{-15}}{9.1\times10^{-31}}$

$\cancel{= 6.1\times10^{15}}$ $\quad = 6.15 \times 10^{15}\ ms^{-2}$ (3s.f)

4f) $V_y = U_y + at$

$= 0 + (6.154\times10^{15})(1.56\times10^{-9})$

$= 9.6 \times 10^{6}\ ms^{-1}$ ~~downwards~~

4g) $V_f = \sqrt{(3.2\times10^{7})^2 + (9.6\times10^{6})^2}$

$= 3.34 \times 10^{7}\ ms^{-1}$

$\tan\theta = \frac{9.6\times10^{6}}{3.2\times10^{7}}$

$\theta = 16.7°$ (3s.f) clockwise from horizontal

5a) $E = \frac{V}{d}$

$= \frac{4.2}{30\times10^{-3}}$

$= 140$ V

5b) $\Delta U = q\Delta V$

$= 1.6\times10^{-19} \times 4.2$

$= 6.7 \times 10^{-19}$ J

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5c) $\frac{1}{2}$

No charge ~~x~~ as
plates.

6a) True. Electro
balance

6b) False. Charge
6c) True. Electros
upward.
6d) False. Electroste
depending
polarity.
6e) False. Termin
radius of

7)

For 1st e, my
For 2nd e, 2my
(2)÷(1): 2
∴ N

8a)

Tan Zhi Yong 0356H Charge & Field Discussion

Subject: Date: 17-2-04.

1a) Right of B. $|E| \propto \frac{Q}{r^2}$ $\longrightarrow E_A$ $\longrightarrow E_B$

2a) Equilibrium of forces $\Sigma F_x = 0$

$\Sigma F_y = 0$

Vert $\Sigma F_y = 0 \Rightarrow T\cos 30° = mg$ —— (1)

Hor $\Sigma F_x = 0 \Rightarrow T\sin 30° = F_E$ —— (2)

$\frac{(2)}{(1)}$: $\cancel{T}\tan 30° = \frac{F_E}{mg}$

$= \frac{F_E}{1.5\times10^{-5}\times 9.81}$

$F_E =$

2b) $r = 2\times 0.1\sin 30°$

or $r = 0.1\,m$ (equilateral $\triangle$)

2c) Coulomb's law

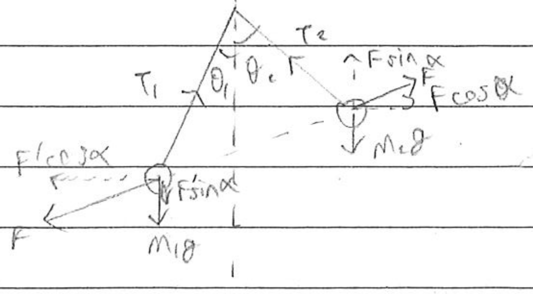
2d) Forces ~~of~~ on P:

Vert: $m_1 g + F'\sin\alpha = T_1\cos\theta_1$

Hor: $F'\cos\alpha = T_1\sin\theta_1$

$\tan\theta_1 = \frac{F'\cos\alpha}{m_1 g + F'\sin\alpha}$

$\tan\theta_2 = \frac{F\cos\theta}{m_2 g + F\sin\alpha}$



4ai) An external force needs to be applied to overcome the mutual repulsion. Work is done by the external force in bringing the 2 spheres together.

4aii) When work is done, energy is converted from one form to another. Energy from work is converted to energy.

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stored in the field. This is electric ~~potential~~ as the forces are electric in nature, and it is potential energy as it is capable of doing work.

4bi) $E = \frac{8.9 \times 10^{9} \times (1.6 \times 10^{-19})^2 3}{1.2 \times 10^{-15} + 2.3 \times 10^{-15}}$

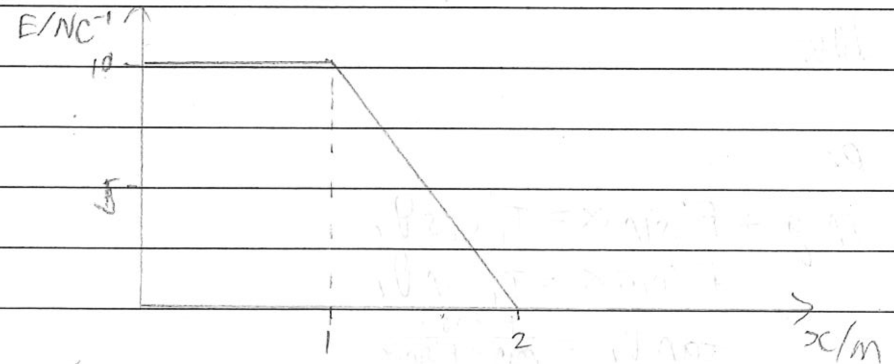
$= 1.95 \times 10^{-13}$ J

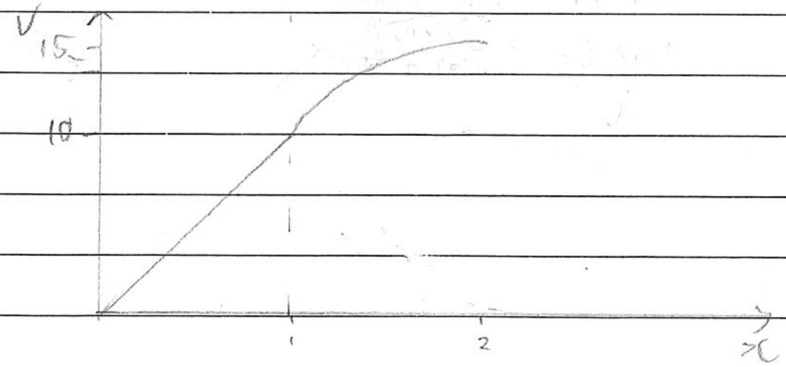
4bii) $\frac{1}{2} m u^2 + 0 = 0 + 1.95 \times 10^{-13}$

$u = \sqrt{\frac{1.953 \times 10^{-13} \times 2}{3 \times 1.67 \times 10^{-27}}}$

$= 8.83 \times 10^{6}\ ms^{-1}$ (3s.f)

5a) $|E| = \left|\frac{dV}{dx}\right|$





Graph goes up as $\left|\frac{dV}{dx}\right| > 0$ since $|E| > 0$ at all times

~~5b~~ $E = \frac{dV}{dx}$

$\int_{V_1}^{V_2} dV = \int_0^2 E\, dx$

$V_2 - V_1 =$ Area under graph

$= \frac{1}{2}(1)(10) + 10$

$= 15$ V

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5bi) $P.d. = 15 - \cancel{3}0$

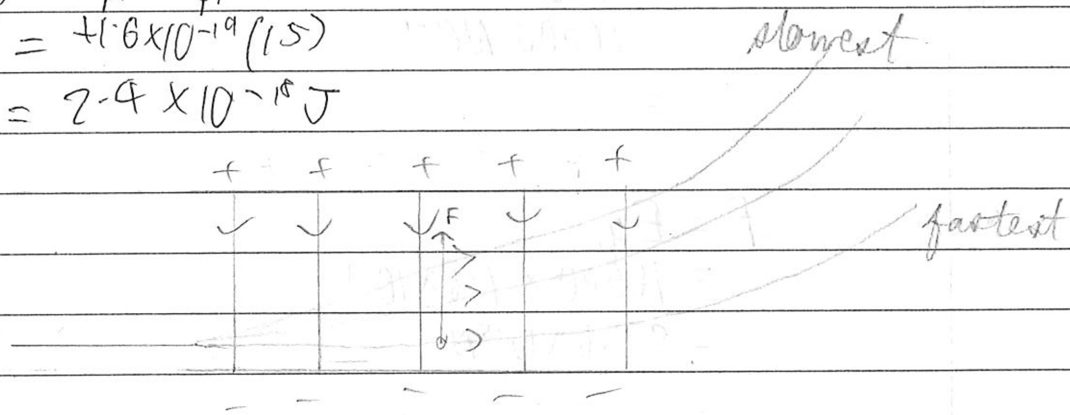
$= 15\ V$

5bii) $\Delta E_p = E_{pf} - E_{pi}$

$= +1.6 \times 10^{-19}(15)$

$= 2.4 \times 10^{-18}\ J$

6a)



$F = qE = q\frac{\Delta V}{d}$

$ma = q\frac{\Delta V}{d}$

$a = \frac{q\Delta V}{md}$

$V_y = U_y + at$

$= 0 + at$

$= \frac{q\Delta V t}{md}$

$V_y \propto$ deflection

U_x determines t

6bi) $E = \frac{\Delta V}{d}$

$d\downarrow$, $V_y\uparrow$ $\therefore$ deflection is less

6bii) Deflection is less $\Delta V\downarrow$, $F\downarrow$ $\therefore$ deflection is less.

6biii) Deflected in opposite direction as force exerted is in opposite direction.

6biv) Deflected in opposite direction.

6bv) No change.

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7ai)

7aii)

$$E = \frac{80}{0.005}$$
$$= 16000\ NC^{-1}$$
$$=$$

7aiii)

$$F = Eq$$
$$= 16000 \times 1.6 \times 10^{-9}$$
$$= 2.56 \times 10^{-5} N$$

7aiv)

$$F = ma$$
$$a = \frac{F}{m}$$
$$= \frac{2.56 \times 10^{-5}}{a}$$
$$= 2.8 \times 10^{15}\ ms^{-2}$$

7av)

$$V_y = at$$
$$=$$
$$= 1.8 \times 10^{6}\ ms^{-1}$$

7b)

$$y = \cancel{14 \tan\theta} \quad y_1 + y_2$$
$$= \cancel{14\left(\frac{1.8 \times 10^{6}}{3.1 \times 10^{7}}\right)} \quad 14 \tan\theta + \frac{1}{2} at^2$$
$$= \cancel{0.88\ cm} \quad 14\left(\frac{1.8 \times 10^{6}}{3.1 \times 10^{7}}\right) + \frac{1}{2}(2.8 \times 10^{15})(6.5 \times 10^{-10})^2$$
$$= 0.88\ cm$$

9a ~~7c)~~

$$f = Bqv \sin\theta$$
$$F = Bqv$$
$$r = \frac{mv}{Bq}$$

~~↑r~~ e. since v↓, r↓