Exam Review - Problem Set 2

①

$$\frac{T_e^2}{R_e^3} = \frac{T_s^2}{R_s^3}$$

$$\frac{1^2}{1^3} = \frac{(29.46)^2}{R_s^3}$$

$$R_s = \sqrt[3]{(29.46)^2}$$

$$\boxed{R_s = 9.54 \text{ AU}} \quad \text{or } 1.42 \times 10^{12} \text{ m}$$

②

Note: since the satellite stays above the same point on the equator, it is geosynchronous.

$\therefore T_s = 1$ day

$$\frac{T_s^2}{R_s^3} = \frac{T_m^2}{R_m^3}$$

$$\frac{1^2}{R_s^3} = \frac{(27.3)^2}{(3.84 \times 10^8)^3}$$

$$R_s = \sqrt[3]{\frac{(3.84 \times 10^8)^3}{(27.3)^2}}$$

$$\boxed{R_s = 42\,353\,515 \text{ m}}$$

③ $19.2\ AU \times 1.49\times10^{11}\ \frac{m}{AU} = 2.86\times10^{12}\ m$

$$F_g = \frac{GMm}{r^2}$$

$$= \frac{(6.67\times10^{-11})(1.99\times10^{30})(8.69\times10^{25})}{(2.86\times10^{12})^2}$$

$$F_g = \boxed{1.41\times10^{21}\ N}$$

④ $r = 4.22\times10^{8}\ m$

$T = 42.5\times3600 = 153\,000\ s$

$$v = \frac{2\pi r}{T}$$

$$= \frac{2\pi(4.22\times10^{8})}{153\,000}$$

$v = 17\,330.1\ m/s$

$$\Sigma F = F_g$$

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$M = \frac{rv^2}{G}$$

$$= \frac{(4.22\times10^{8})(17330.1)^2}{(6.67\times10^{-11})}$$

$$M = \boxed{1.90\times10^{27}\ Kg}$$

(5)

$$\Sigma F = F_g$$

$$\frac{\cancel{m} v^2}{\cancel{r}} = \frac{GM\cancel{m}}{r^{\cancel{2}}}$$

$$v = \sqrt{\frac{GM}{r}}$$

$$= \sqrt{\frac{(6.67\times10^{-11})(1.99\times10^{30})}{(1.08\times10^{11})}}$$

$$v = 35\,057.2 \text{ m/s}$$

$$v = \frac{2\pi r}{T}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi(1.08\times10^{11})}{35\,057.2} = 19\,356\,465 \text{ s}$$

or $\boxed{224 \text{ days}}$

(6)

$$v = \frac{2\pi r}{T}$$

$$= \frac{2\pi(1.5\times10^{11})}{(31536000)}$$

$$v = 29\,885.8 \text{ m/s}$$

$$\Sigma F = F_g$$

$$\frac{\cancel{m} v^2}{\cancel{r}} = \frac{GM\cancel{m}}{r^{\cancel{2}}}$$

$$M = \frac{r \cdot v^2}{G}$$

$$= \frac{(1.5\times10^{11})(29885.8)^2}{(6.67\times10^{-11})}$$

$$M = \boxed{2.0\times10^{30} \text{ kg}}$$

⑦ a) $F_g = \frac{GMm}{r^2}$

$$= \frac{(6.67\times10^{-11})(5.98\times10^{24})(7.34\times10^{22})}{(3.84\times10^{8})^2}$$

$$F_g = \boxed{1.99\times10^{20}\ N}$$

b) $\Sigma F = F_g$

$$\frac{mv^2}{r} = F_g$$

$$\frac{(7.34\times10^{22})\,v^2}{(3.84\times10^{8})} = 1.99\times10^{20}$$

$$v = \sqrt{\frac{(1.99\times10^{20})(3.84\times10^{8})}{(7.34\times10^{22})}}$$

$$v = \boxed{1019.2\ m/s}$$

⑧ Earth

$F_g = mg$

$700 = m(9.8)$

$m = 71.4\ kg$

Mars

$$F_g = \frac{GMm}{r^2}$$

$$= \frac{(6.67\times10^{-11})(6.4\times10^{23})(71.4)}{(3.38\times10^{6})^2}$$

$$F_g = \boxed{266.9\ N}$$

(9) $F_e = \frac{kQq}{r^2}$

$= \frac{(9\times10^9)(6.3\times10^{-6})(4.8\times10^{-6})}{(0.15)^2}$

$F_e = \boxed{12.1\ N\ [\text{Towards the other charge}]}$

(10) $F_e = \frac{kQq}{r^2}$

$r = \sqrt{\frac{kQq}{F_e}}$

$= \sqrt{\frac{(9\times10^9)(2\times10^{-6})(2\times10^{-6})}{(4\times10^{-4})}}$

$r = \boxed{9.49\ m}$

(11) $F_e \propto \frac{1}{r^2}$

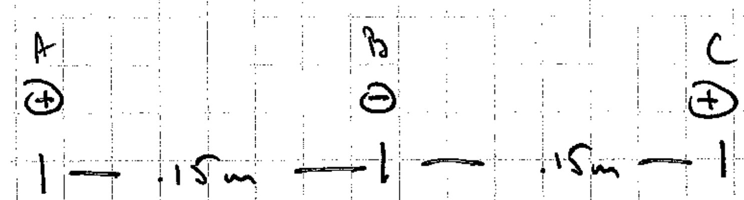
$\frac{1}{r^2} = 12$

$r = \sqrt{\frac{1}{12}}$

$r = \boxed{0.29}$

The new separation is 0.29 times the original separation.

(12)



a) The two outside charges will have equal forces, but in opposite directions.

Charge A

$$F_B = \frac{k Q_A Q_B}{r^2}$$

$$= \frac{(9\times10^{9})(9\times10^{-6})(9\times10^{-6})}{(.15)^2}$$

$$F_B = 32.4\ N\ [\text{Right}]$$

$$F_c = \frac{k Q_A Q_c}{r^2}$$

$$= \frac{(9\times10^{9})(9\times10^{-6})(9\times10^{-6})}{(.30)^2}$$

$$F_c = 8.1\ N\ [\text{Left}]$$

$$F_{total} = 32.4 - 8.1 = \boxed{24.3\ N\ [\text{Right}]}$$

Charge C

$$F_{total} = \boxed{24.3\ N\ [\text{Left}]}$$

(12) b) Charge B

$F_A = \frac{kQ_AQ_B}{r^2}$ (see work for Charge A)

$= 32.4\ N$ [Left]

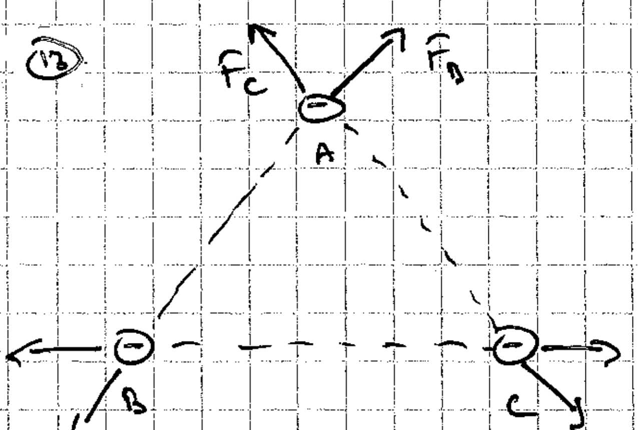
$F_c = \frac{kQ_BQ_c}{r^2}$

$= \frac{(9\times10^9)(9\times10^{-6})(9\times10^{-6})}{.15^2}$

$F_c = 32.4\ N$ [Right]

$F_{total} = 32.4 - 32.4 = \boxed{0}$

(13)



$F_B = \frac{kQ_AQ_b}{r^2}$

$= \frac{(9\times10^9)(3.7\times10^{-9})(3.7\times10^{-9})}{(0.5)^2}$

$F_B = 4.9284\times10^{-7}\ N$ [60° N of E]

$F_c = 4.9284\times10^{-7}\ N$ [60° N of W]

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(13) continued

	N	E
F_B	$4.9\times10^{-7}\sin60$	$4.9\times10^{-7}\cos60$
F_C	$4.9\times10^{-7}\sin60$	$-4.9\times10^{-7}\cos60$
F_{total}	8.5×10^{-7}	0

$$F_{total} = 8.5\times10^{-7}\ N\ [North]$$

The force on the other 2 charges will have the same magnitude, but different directions. Each direction is 150° from the triangles sides.

∴ Charge B: $F_{total} = 8.5\times10^{-7} N$ [30° S of W]

Charge C: $F_{total} = 8.5\times10^{-7} N$ [30° S of E]

(14) $$E = \frac{kq}{r^2} = \frac{(9\times10^9)(1.75\times10^{-6})}{(0.2)^2}$$

$$E = \boxed{393\,750\ N/C}$$

(15) $F_e = qE$

$= (1.6 \times 10^{-19})(1.46 \times 10^{5})$

$F_e = \boxed{2.3 \times 10^{-14}\ N}$

(16) $v_f = v_i + at$

$3 \times 10^{6} = 0 + a(1 \times 10^{-6})$

$a = \frac{3 \times 10^{6}}{1 \times 10^{-6}} = 3 \times 10^{12}\ m/s^2$

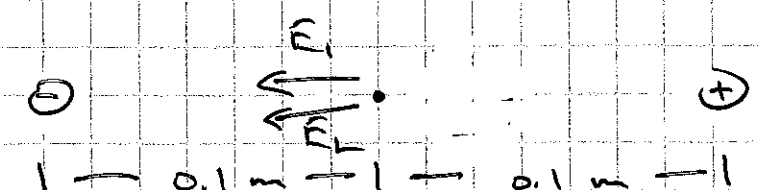
$\Sigma F = F_e$

$ma = qE$

$(1.67 \times 10^{-27})(3 \times 10^{12}) = (1.6 \times 10^{-19})E$

$E = \boxed{31\,312.5\ N/C}$

(17) a)



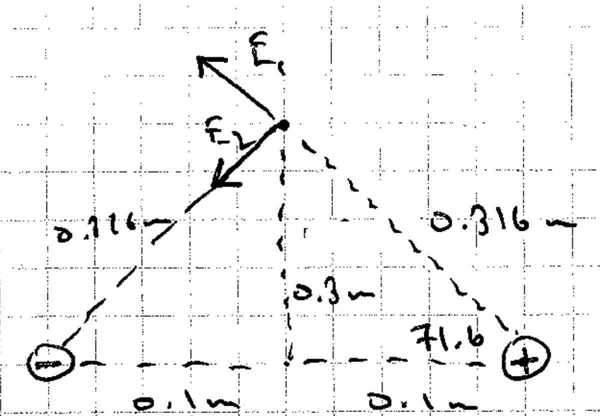
$E_1 = \frac{kq}{r^2} = \frac{(9 \times 10^{9})(3 \times 10^{-6})}{(0.1)^2} = 2\,700\,000\ N/C$ [Left]

$E_2 = \frac{kq}{r^2} = \frac{(9 \times 10^{9})(3 \times 10^{-6})}{(0.1)^2} = 2\,700\,000\ N/C$ [Left]

$E_{total} = 2\,700\,000 + 2\,700\,000$

$= 5\,400\,000\ N/C$ [Left]

(17) b)



$$E_1 = \frac{kQ}{r^2} = \frac{(9\times10^9)(3\times10^{-6})}{(0.316)^2} = 270\,000\ N/C\ [72^\circ\ N\ of\ W]$$

$$E_2 = \frac{kQ}{r^2} = \frac{(9\times10^9)(3\times10^{-6})}{(0.316)^2} = 270\,000\ N/C\ [72^\circ\ S\ of\ W]$$

	N	E
E_1	270000 sin 72	−270 000 cos 72
E_2	−270000 sin 72	−270 000 cos 72
E_{total}	0	−170 763

$$E_{total} = \boxed{170\,763\ N/C\ [West]}$$

(18) $$V = \frac{kQ}{r} = \frac{(9\times10^9)(2.5\times10^{-3})}{(0.45)}$$

$$V = \boxed{50\,000\,000\ V}$$

(19) $W = q\Delta V$

$3.75 \times 10^{-4} = (13.7 \times 10^{-6})\,\Delta V$

$\Delta V = \boxed{27.4\ V}$

(20) $W = q\Delta V$ $\qquad W = \Delta E_k$

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

$(1.6 \times 10^{-19})(300\,000) = \frac{1}{2}(1.67 \times 10^{-27})\, v_f^2 - 0$

$4.8 \times 10^{-14} = 8.35 \times 10^{-28}\, v_f^2$

$v_f = \sqrt{\frac{4.8 \times 10^{-14}}{8.35 \times 10^{-28}}}$

$v_f = \boxed{7\,581\,888\ m/s}$

(21) $W = q\Delta V$ $\qquad E = \frac{\Delta V}{d}$

$\Delta V = E \cdot d$

$W = qEd$

$= (1.6 \times 10^{-19})(7.65)(0.015)$

$W = \boxed{1.84 \times 10^{-20}\ J}$

(22)

$$\Sigma F = F_B$$

$$\frac{mv^2}{r} = qvB$$

$$B = \frac{mv}{qr}$$

$$= \frac{(6.64\times10^{-27})(1.85\times10^{7})}{(3.2\times10^{-19})(0.58)}$$

$$B = \boxed{0.66\ T}$$

(23)

$$\Sigma F = F_B$$

$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB}$$

$$= \frac{(1.67\times10^{-27})(1.25\times10^{6})}{(1.6\times10^{-19})(1.15)}$$

$$r = \boxed{0.011\ m}$$

(24) $v = \frac{E}{B} = \frac{2.48 \times 10^4}{0.75} = 33\,066.7 \text{ m/s}$

Boron 10

$r = \frac{mv}{qB} = \frac{(10)(1.67 \times 10^{-27})(33\,066.7)}{(1.6 \times 10^{-19})(0.75)}$

$r = 0.0046 \text{ m}$

Boron 11

$r = \frac{mv}{qB} = \frac{(11)(1.67 \times 10^{-27})(33\,066.7)}{(1.6 \times 10^{-19})(0.75)}$

$r = 0.0051 \text{ m}$

$0.0051 - 0.0046 = \boxed{0.0005 \text{ m}}$