PR 9 E force & field

MC 1) (d) $F = \frac{kqQ}{r^2}$ ✓

2) (c) ✓

3) $\frac{k(2q)(q)}{x^2} = \frac{k(3q)(q)}{y^2}$

$\frac{y^2}{x^2} = \frac{3}{2}$

$\frac{y}{x} = \sqrt{\frac{3}{2}}$ (c) ✓

4)

$E = \frac{kQ}{r} - \frac{kQ}{r} = 0$ (A)

(e)

5) $F = \frac{kQq}{r^2} = ma$

as $r\uparrow$, $a\downarrow$

$v\uparrow$ (d) ✓

6) $\vec{F} = qE$

$F = -2qE = -2F$ (b) ✓

7) (d) ✓

8) (b) ✓

9) $\int E \cdot dA = \frac{Q_{enc}}{\varepsilon_0}$

$Q \cdot \frac{r}{R}$

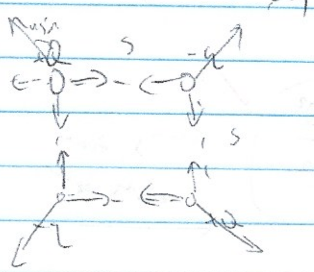
$E \cdot 4\pi \left(\frac{r}{R}\right)^2 = \frac{Q_{in}}{\varepsilon_0}$

(A) ✓

$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{R \cdot r}$

10) $q_{total} = 0$ (A) ✓

FR 1) a)



$\frac{kQq}{s^2} = \frac{kQQ}{(\sqrt{2}s)^2} \cdot \frac{\sqrt{2}}{2}$

$\frac{\cancel{Q}q}{\cancel{s^2}} = \cancel{kQQ}\ \frac{Q^2}{2\cancel{s^2}} \cdot \frac{\sqrt{2}}{2}$

$q = \boxed{\frac{\sqrt{2}}{4}Q}$ $\frac{\sqrt{2}}{4} = \frac{\sqrt{2}\cdot\sqrt{2}}{4\sqrt{2}} = \frac{1}{2\sqrt{2}}$ ✓

b) yes, it must cancel out ~

c) $E = \frac{kQ}{s} = \frac{kQ}{\sqrt{2}s}$ ~

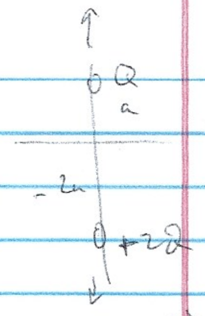
$\frac{kQ}{\sqrt{2}s} + \frac{kQ}{\sqrt{2}s} - \frac{kq}{\sqrt{2}s} - \frac{kq}{\sqrt{2}s}$

$= \frac{2}{\sqrt{2}}\frac{kQ}{s} - \frac{2}{\cancel{\sqrt{2}}} \cdot \frac{\cancel{\sqrt{2}}Q}{4s}$

$= \frac{kQ}{s}\left(\frac{2}{\sqrt{2}} - \frac{1}{2}\right)$

$= \frac{kQ}{s}\left(\frac{2\sqrt{2}}{2} - \frac{1}{2}\right)$

$= \boxed{\frac{kQ}{s}\left(\sqrt{2} - \frac{1}{2}\right)}$

2) 

a) $F = \frac{kQ(2Q)}{(3a)^2} = \boxed{\frac{2kQ^2}{9a^2}}$ away from each other

b) $E_1 = \frac{kQ}{r^2} = \frac{kQ}{a^2}(-\hat{j})$

$E_2 = \frac{k2Q}{4a^2} = \frac{kQ}{2a^2}(\hat{j})$

$E_{Total} = \frac{kQ}{a^2}\left(\frac{1}{2} - 1\right)$

$= \boxed{-\frac{kQ}{2a^2}\hat{j}}$

c) No, since the field from the charges is radially outwards & they're both the same sign.

d) ~~[illegible]~~ Yes.

$\frac{k2Q}{r_2^2} - \frac{kQ}{r_1^2} = 0$

$r_1 + r_2 = 3a$

$\frac{2}{r_2^2} = \frac{1}{r_1^2}$

$\frac{r_1^2}{r_2^2} = \frac{1}{2}$

$r_1 = r_2 + 3a$

$\frac{r_1}{r_2} = \frac{1}{\sqrt{2}}$

$\frac{3a}{r_2} - \frac{r_2}{r_2} = \frac{1}{\sqrt{2}}$

$\frac{3a}{r_2} = \frac{\sqrt{2}+1}{\sqrt{2}}$

$\frac{r_2}{3a} = \frac{\sqrt{2}}{\sqrt{2}+1}$

$r_2 = \left(\frac{\sqrt{2}}{\sqrt{2}+1}\right)3a$

$r_1 = 3a\left(1 - \frac{\sqrt{2}}{\sqrt{2}+1}\right)$?

~~$r_1 = 3a\left(\frac{\sqrt{2}}{\sqrt{2}+1}\right)$~~

e) it would accelerate towards ~~the~~ Q

$F = qE = ma$

$a = \frac{qE}{m} = \frac{q}{m}\left(-\frac{kQ}{a^2}\right)\hat{j}$

$\boxed{\frac{kQq}{ma^2}\hat{j}}$

3) 

a, b, c, d

both conductors

charges want to get as far away as possible

b) inner sphere - charge goes to the ~~outside~~ inside

~~A)~~ outer sphere - charge goes to the outside

a) i) $Q_{enc} = 0$; $E = 0$

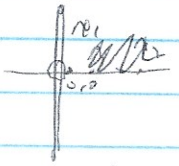
ii) $a < r < b$ $Q_{en} = 2q$

$E = \frac{2kq}{r^2}$

iii) $E = \frac{2kq}{r^2}$

iv) $E = \frac{2kq}{r^2}$

v) $r > d$ $E = \frac{5kq}{r^2}$

4) 

$\lambda = \frac{Q}{l}$

$\cdot\, x_2$

A) $x << l$

$\int E \cdot dA = \frac{Q_{enc}}{\varepsilon_0}$

$E \cdot 4\pi x_1^2 = \frac{Q_{enc}}{\varepsilon_0}$

$E = \frac{k \cdot Q_{enc}}{x_1^2}$ $\quad Q_{enc} = 2x_1\lambda$

$= \frac{2k x_1 \lambda}{x_1^2} = \boxed{\frac{2k\lambda}{x_1}}$

B) $Q = \lambda l$

C) $x_2 >> l$

$E = \frac{k\lambda l}{x_2^2}$

5) $\rho(r) = \frac{\rho_0}{a} r$ $\quad$ radius = a

A) ρ is in $\frac{C}{m^3}$

B) $Q = \rho V = \frac{\rho_0\, dr}{a} \cdot \frac{4}{3}\pi r^3$

$= \int \frac{\rho_0}{a} \cdot \frac{4}{3}\pi r^3 dr$

$= \frac{4\rho_0\pi}{3a} \int r^3 dr = \boxed{\frac{\rho_0 \pi}{3a} r^4}$ $\quad \frac{\rho_0 \cdot 0}{a} = 0 \quad C = 0$

where $r = a$;

$Q = \frac{\rho_0 \pi a^3}{3}$

c) i) $E = \frac{k\, Q_{enc}}{r^2}$ Gauss' law

~~$Q_{enc} = \int \frac{\rho_0}{a} dr$~~

$Q_{enc} = \frac{\rho_0 \pi}{3a} r^4$

$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{1}{r^2} \cdot \frac{\rho_0 \pi}{3a} \cdot r^4$

$= \boxed{\frac{\rho_0 r^2}{12 a \varepsilon_0}}$

ii) $E = \frac{k}{r^2} \cdot \frac{\rho_0 \pi a^3}{3} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{1}{r^2} \cdot \frac{\rho_0 \pi a^3}{3}$

$= \boxed{\frac{\rho_0 a^3}{12 \varepsilon_0 r^2}}$

D)