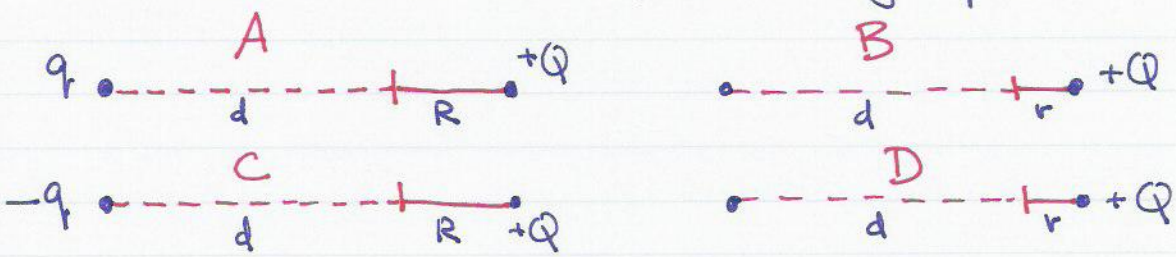
Solutions to Test 2

1. A) T $\because E = 0 \Rightarrow \vec{F} = q\vec{E} = 0$
   B) F
   C) F electron is negatively charged, so the direction of the force is <u>opposite</u> to $\vec{E}$ field
   D) T like projectile motion
   E) F there is still an electric force acting on it (just as in projectile motion, there's gravity)
   F) T $q = 0$ in "meat"

2. A) F Q_1 is positive & Q_2 is negative
   B) F tangent at b is not pointing toward Q_2
   C) T "density" of lines is higher at a than at c.
   D) T $\vec{F} = q\vec{E}$
   E) F E is small here, not zero.
   F) T $|Q_1| > |Q_2| \Rightarrow$ net charge is positive

3. $\vec{F} = q\vec{E} \Rightarrow$ out of the page, toward the reader.

4. The shells can be replaced by point charges.



$r \rightarrow$ radius of smaller shell
$R \rightarrow$ radius of bigger shell

So:

most attractive : D
next (attractive) : C
next (repulsive) : A
most repulsive : B

So answer : C

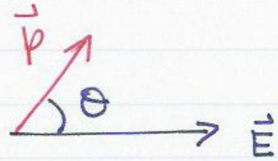
5. The charge on the shaded strip is $\sigma W dy$.

No horizontal component, so we need to integrate the z-component from $-L/2$ to $L/2$

answer: B

6. If there's no enclosed charge then the electric flux is zero. $\vec{E}$-field can be non-zero!

the incorrect statement: E

7. 

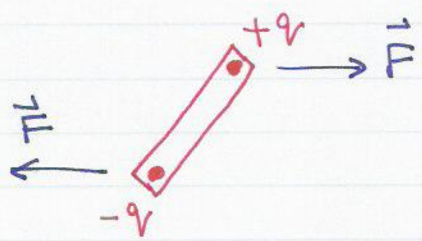
$$\tau = |\vec{p} \times \vec{E}|$$

$$= |\vec{p}||\vec{E}| \sin\theta = (q)(d)(E)\sin\theta$$

$$= (0.01)(0.015)(7)(\sin 24^\circ)$$

$$= 0.0042707 \text{ Nm}$$

E

8. 

net force $= 0$! A

9. A) T right hand rule
B) F clockwise, i.e., $\vec{p}$ will try to line up along $\vec{E}$
C) T Work is done by the field ($W > 0$)
D) T
E) F when field is orthogonal to $\vec{p}$, $\vec{p} \cdot \vec{E} = 0$!

10.

$$U = -\vec{p} \cdot \vec{E} = -(0.01)(0.015)(7)(\cos 34^\circ)$$

$$= -0.00087049 \text{ J}$$

answer: A

11) $\vec{V}_0 = V_{0x}\,\hat{i} + V_{0y}\,\hat{j}$ $\qquad \vec{E} = E_y\,\hat{j}$

election $\Rightarrow$ $q = -e$

$F = qE = ma \Rightarrow a_y = \frac{-eE_y}{m}$

$a_x = 0$

$x - x_0 = V_{0x}t + \frac{1}{2}\cancel{a_x}t^2 \Rightarrow t = \frac{x - x_0}{V_{0x}}$

$\therefore\; y - y_0 = V_{0y}t + \frac{1}{2}a_y t^2$

$V_{0x} = 46.0 \times 10^4$ m/s $\qquad V_{0y} = 2.8 \times 10^4$ m/s

$\vec{E} = 22\hat{j}$ N/C $\qquad a_y = \frac{-(1.6 \times 10^{-19})(22)}{(9.11 \times 10^{-31})}$

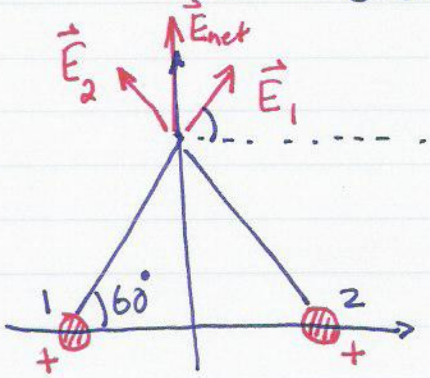
$t = \frac{x - x_0}{V_{0x}} = \frac{0.027}{46 \times 10^4}$

$= 5.8696 \times 10^{-8}$ s

$y - y_0 = (2.8 \times 10^4)(5.8696 \times 10^{-8}) - \frac{(1.6 \times 10^{-19})(22)(5.8696 \times 10^{-8})^2}{(2)(9.11 \times 10^{-31})}$

$= -5.01248 \times 10^{-3}$ cm. A

12.



$E_1 = E_2 = \frac{q}{4\pi\epsilon_0 r^2}$

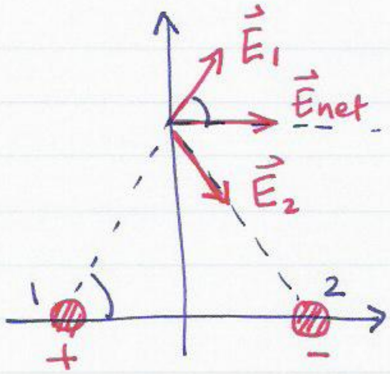
$E_{net} = 2E_1 \sin 60°$

$E_1 = \frac{(30.5 \times 10^{-6})}{(4\pi\epsilon_0)(1.2)^2}$

$= 190413.1944$ N/C B

$\Rightarrow E_{net} = (2)(190413.1944)\sin 60° = 329805.32\ \frac{N}{C}$

13.



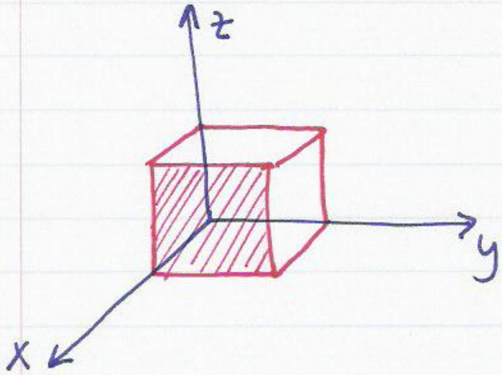
this time

$$E_{net} = 2E_1 \cos 60^\circ$$

$$= (2)(190413.1944) \cos 60^\circ$$

$$= 190413 \text{ N/C}$$ D

14. $\vec{E} = (1\hat{i} - 6\hat{j} + 5z\hat{k})$ N/C



$a = 0.6$ m

for the face at $x = a$

$$A = (0.6)^2 \hat{i}$$

$$\Phi = \vec{E} \cdot \vec{A} = (1\hat{i} - 6\hat{j} + 5z\hat{k}) \cdot (0.6)^2 \hat{i}$$

$$= 0.36 \ \frac{\text{Nm}^2}{\text{C}}$$ H

15. Total flux through cube? The flux through the left face cancels out that through right face. Likewise, Φ front & back cancel each other. flux through bottom face is zero since $\vec{E} = 0$ here. only top face:

$$\Phi = (1\hat{i} - 6\hat{j} + 5z\hat{k}) \cdot (0.6)^2 \hat{k}$$ F

$$= (5)(0.6)(0.6)^2 = 1.08 \ \frac{\text{Nm}^2}{\text{C}}$$

16. charge on solid sphere $= (\rho)\left(\frac{4}{3}\pi a^3\right)$

$$= (-10.8)\ \frac{4}{3}\pi (0.42)^3 = -3.35 \ \mu\text{C}$$ C

$$\therefore \ \sigma_{inner} = \frac{+3.35\,\mu\text{C}}{4\pi b^2} = \frac{3.35\,\mu\text{C}}{4\pi (0.58)^2} = 0.792856 \ \frac{\mu\text{C}}{\text{m}^2}$$

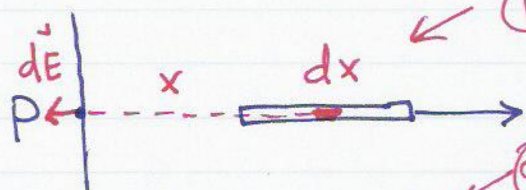
17. $q_{inner} + q_{outer} = q_{net}$

$$\Rightarrow \quad q_{outer} = q_{net} - q_{inner}$$
$$= -3.7\mu C - 3.35\mu C$$
$$= -7.05\mu C$$

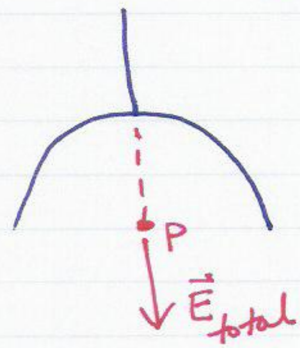
$$\therefore \quad \sigma_{outer} = \frac{q_{outer}}{4\pi c^2} = \frac{-7.05}{4\pi (0.75)^2} = -0.997606 \ \frac{C}{m^2}$$

A

18. straight section:



1 figure

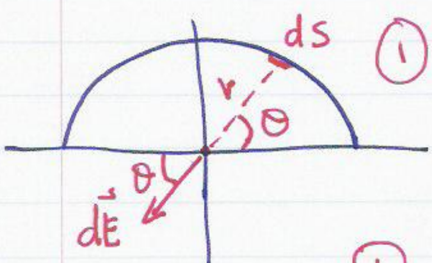


$$dE = \frac{dq}{4\pi\epsilon_0 r^2} = \frac{\lambda dx}{4\pi\epsilon_0 x^2}$$ 0.5 2

$$E = \int_d^{2d} \frac{\lambda dx}{4\pi\epsilon_0 x^2} = \frac{\lambda}{4\pi\epsilon_0}\left[\frac{-1}{x}\right]_d^{2d} = \frac{-\lambda}{4\pi\epsilon_0}\left[\frac{1}{2d} - \frac{1}{d}\right]$$ 1 2

$$= \frac{\lambda}{8\pi\epsilon_0 d}$$

curved section:



1 fig.

0.5

$$dq = \lambda ds = \lambda d(d\theta)$$

1 (no horizontal component)

$$dE = \frac{\lambda ds}{4\pi\epsilon_0 r^2}$$

1

$$dE_y = \frac{\lambda ds}{4\pi\epsilon_0 d^2} \sin\theta$$

1

So: $$E_y = \frac{\lambda}{4\pi\epsilon_0 d}\int_0^{\pi} \sin\theta \, d\theta$$

2

$$= \frac{-\lambda}{4\pi\epsilon_0 d} \cos\theta \Big|_0^{\pi}$$
$$= \frac{\lambda}{2\pi\epsilon_0 d}$$

direction 1

$$E_{total} = \frac{\lambda}{8\pi\epsilon_0 d} + \frac{\lambda}{2\pi\epsilon_0 d}$$
$$= \frac{5\lambda}{8\pi\epsilon_0 d}$$ 1

$$\vec{E} = \frac{-5\lambda}{8\pi\epsilon_0 d}\hat{j}$$