PHY 212 HOMEWORK 2 SOLUTIONS

1. 21.27 a) $|q|E = mg \Rightarrow |q| = \dfrac{(0.00145\,kg)(9.8\,m/s^2)}{650\,N/C}$

$= 2.19 \times 10^{-5} C$, sign is negative

b) $qE = mg \Rightarrow E = \dfrac{(1.67\times 10^{-27}\,kg)(9.8\,m/s^2)}{(1.6\times 10^{-19} C)} = 1.02\times 10^{-7}\,N/C$ upward.

2. 21.48 For a long straight wire,

$E = \dfrac{\lambda}{2\pi\epsilon_0 r} \Rightarrow r = \dfrac{1.5\times 10^{-10}\,C/m}{2\pi\epsilon_0 (2.5 N/C)} = 1.08\,m$

3. 21.50 For a ring of charge, electric field is

a) $\bar{E} = \dfrac{1}{4\pi\epsilon_0}\dfrac{Qx}{(x^2+a^2)^{3/2}}\,\hat{\imath}$

$\bar{E} = \dfrac{1}{4\pi\epsilon_0}\dfrac{(0.125\times 10^{-9} C)(0.4\,m)}{(0.4^2+0.025^2)^{3/2}}\,\hat{\imath} = 7\,\hat{\imath}\,N/C$

b) $\bar{F}_{on\ ring} = -\bar{F}_{on\ q} = -q\bar{E} = -(-2.5\times 10^{-6} C)(7\,\hat{\imath}\,N/C)$

$= 1.75\times 10^{-5}\,\hat{\imath}\,N$

4. 21.59 a) $p = qd \Rightarrow (4.5\times 10^{-9} C)(0.0031\,m) = 1.4\times 10^{-11}\,C\cdot m$ in the direction from q_1 towards q_2.

b) If $\bar{E}$ is at $36.9°$, and torque $\tau = pE\sin\phi$, then

$E = \dfrac{\tau}{p\sin\phi} = \dfrac{7.2\times 10^{-9}\,Nm}{(1.4\times 10^{-11}\,Cm)\sin 36.9} = 856.5\,N/C$

5. 21.90 a) On the axis,

$|\bar{E}| = \dfrac{\sigma}{2\epsilon_0}\left[1 - \left(\dfrac{R^2}{x^2}+1\right)^{-1/2}\right] = \dfrac{4\,pC/\pi\,(0.025\,m)^2}{2\epsilon_0}\left[1 - \left(\dfrac{(0.025)^2}{(0.002)^2}+1\right)^{-1/2}\right]$

$\Rightarrow E = 106\,N/C$ in the $+x$ direction.

b) The electric field is less than that of an infinite sheet $E_\infty = \frac{\sigma}{2\epsilon_0} = 115\ N/C$

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6. 21.94 The electric field in the x-direction cancels from the left and right halves of the semicircle. The remaining y-component points in the negative y-direction. The charge per unit length of the semicircle is

$$\lambda = \frac{Q}{\pi a} \quad \text{and} \quad dE = \frac{k\lambda\, dl}{a^2} = \frac{k\lambda\, d\theta}{a}$$

but $dE_y = dE \sin\theta = \frac{k\lambda \sin\theta\, d\theta}{a}$

$$\text{So, } E_y = \frac{2k\lambda}{a}\int_0^{\pi/2} \sin\theta\, d\theta = \frac{2k\lambda}{a}\left[-\cos\theta\right]_0^{\pi/2}$$

$$= \frac{2k\lambda}{a} = \frac{2kQ}{\pi a^2} \quad \text{downward.}$$