Physics 1B
HW #2 Solutions
Chap 15 Conceptual Questions: 22
Chap 16 Conceptual Questions: 2, 5
For Questions or Errors please email Morgan at mjbrown@ucsd.edu

22. As the electron moves through the electric field, it experiences a constant force. This will cause it to accelerate downward ($F = ma$). Thus, the path will look very similar to an object that has rolled off the edge of a table. It will fall in a parabolic path.

2. We know $Q = CV$ for any capacitor and C = _ A / d for a parallel plate capacitor. Putting this together we have V = Q/C = Q d / _ A . Thus, if we want to increase the voltage (assuming Q and d are fixed) we have two options. First, we can decrease the plate area. Conceptually, this is going to crowd the charge closer together on the plate and thus increase the voltage across the plates. Another idea is that perhaps we can introduce a dielectric material to increase the value of _. This allows the breakdown voltage to increase because with a material between the plates, it takes a higher electrical force (and thus higher voltage) to ionize a pathway between the plates.

5. Once the cable is on your car you had better stay inside. This is because since you are in contact with the cable, you are at 20-kV. If you get out of the car and contact the ground (zero volts) there will be a potential drop across your body of 20-kV and current will run from the power line, through your body, and into the ground. As long as you stay in the car, you remain at 20-kV and the potential drop across your body is zero. Note here, it is only the potential difference across your body that determines whether you get hurt.

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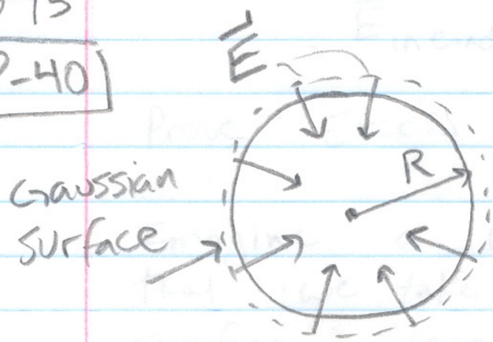
HW 2 Chap 15 : C-22
P - 40, 41, 44, 59

Chap 16 : C - 2, 5
P - 3, 4, 9

Chap 15

P-40



$E = 890\ N/C$ radially inward

$R = .750\ m$

$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$

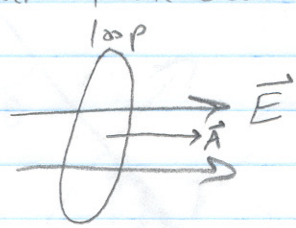
(a) net charge? $\Phi = \frac{Q_{enclosed}}{\varepsilon_0} = EA = E(4\pi R^2)$

$Q = E(4\pi R^2)\varepsilon_0 = \boxed{5.57 \times 10^{-8}\ C = |Q|}$ (negative)

(b) We know the charge is evenly spread out on the surface of the sphere because the $\vec{E}$ field is radially everywhere. Since the field points inward, we know the charge must be negative.

P-41

Max Flux occurs when loop is perpendicular ($\theta = 0$, $\cos\theta = 1$)



$\Phi = EA \Rightarrow E = \frac{\Phi}{A} = \frac{\Phi}{\pi R^2}$

$\Phi = 5.2 \times 10^5\ Nm^2/C$

$R = \frac{1}{2}d = 0.20\,m$

$E = \left(5.2 \times 10^5 \frac{Nm^2}{C}\right) \frac{1}{\pi (0.20\,m)^2} = 4138030\ N/C$ Round sig figs

$= \boxed{4.1 \times 10^6\ N/C = E}$

Physics 1B

HW2

P-44 Given: Gauss's Law $EA = \Phi = Q_{enclosed}/\varepsilon_0$

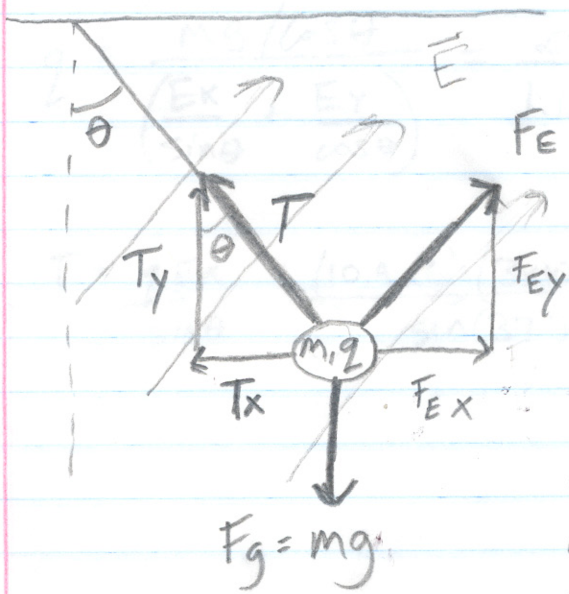
$\vec{E}_{in\,conductor} = 0$

Prove: Excess charge is on surface

Imagine a volume inside the conductor that we take to be the gaussian surface. Since $E=0$ on this surface, the relation $Q_{enclosed} = \varepsilon_0 EA$ shows that $Q_{enclosed}$ also is zero. Now imagine the volume inside is expanded until it completely fills the conductor except the surface of the conductor. Now, we still have $E=0 \Rightarrow Q=0$. Thus no charge is in the conductor. Therefore, all the charge is on the surface.

P-59 To be in equilibrium, we have $a=0$ so $F_{NET}=0$

There are 3 forces acting on the ball, T, F_g, F_E



From diagram we see

(1) $|T_x| = |F_{EX}|$ (horizontal)

(2) $|mg| = |T_y| + |F_{Ey}|$ (vertical)

$E_x = 3\times10^5\,N/C$

$E_y = 5\times10^5\,N/C$

$m = 1g = .001\,kg$

$\theta = 37°$

59) continued: we solve for T and q.

We need to get equations in terms of variables that we have:

$F_{Ex} = qE_x$

$F_{Ey} = qE_y$

$T_x = T\sin\theta$

$T_y = T\cos\theta$

plug into the 2 equations we have on the previous page.

(1) $T\sin\theta = qE_x$

(2) $mg = T\cos\theta + qE_y$

2 equations and 2 unknowns $\therefore$ solve for T & q

(1) $T = qE_x/\sin\theta$ (2) $T = (mg - qE_y)/\cos\theta$

$$\therefore \frac{qE_x}{\sin\theta} = \frac{mg - qE_y}{\cos\theta} \Rightarrow q\left(\frac{E_x}{\sin\theta} + \frac{E_y}{\cos\theta}\right) = \frac{mg}{\cos\theta}$$

$$q = \frac{mg/\cos\theta}{\left(\frac{E_x}{\sin\theta} + \frac{E_y}{\cos\theta}\right)} = \frac{.0123\text{N}}{1.125\times10^{6}\text{ N/C}} = \boxed{10.9\text{ nC} = q}$$

Recall
$m = .001$ kg
$E_x = 3\times10^5$ N/C
$E_y = 5\times10^5$ N/C
$\theta = 37°$

$$T = \frac{qE_x}{\sin\theta} = \frac{(10.9\text{ nC})(3\times10^5\text{ N/C})}{\sin(37°)} = \boxed{T = 5.44\times10^{-3}\text{ N}}$$

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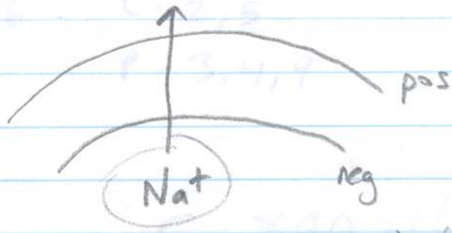
HW 2

$\boxed{16-3}$ $\Delta V = 90\,mV$



$W = q\Delta V = (+e)\Delta V = (1.6\times10^{-19}\,C)(90\times10^{-3}\,V) = \boxed{1.4\times10^{-20}\,J}$

$\boxed{16-4}$ $\Delta V = 60.0\,V$

$\Delta PE = \Delta U = -1.92\times10^{-17}\,J$, find q

Since potential energy decreased, it is a ~~positive~~ negative charge.

$W = -\Delta PE = q\Delta V \rightarrow q = \dfrac{+\Delta PE}{\Delta V} = \dfrac{-1.92\times10^{-17}\,J}{60.0\,V} = -3.2\times10^{-19}\,C$

Note, divide by $e \rightarrow \dfrac{-3.2\times10^{-19}\,C}{1.6\times10^{-19}\,C} = \boxed{\text{2 electrons worth of charge}}$

$\boxed{16-9}$ ⓐ For a spring, the $PE = \frac{1}{2}kx^2$

Since it starts at rest and ends at rest, $\Delta KE = 0$
For the charged block, $\Delta PE = q\Delta V = q(Ed) = qE\Delta x$

Thus, conservation of total energy tells us the
$|\Delta PE_{spring}| = |\Delta PE_{block}| \Rightarrow \frac{1}{2}k(\Delta x)^2 = qE\Delta x \Rightarrow \Delta x = \dfrac{2qE}{k}$

$\Delta x = \dfrac{2qE}{k} = \dfrac{2(50\,\mu C)(5\times10^{5}\,V/m)}{100\,N/m} = \boxed{0.50\,m = \Delta x_m}$

ⓑ Use hooke's Law $F = -kx$; $F = F_E = qE \Rightarrow kx = qE$
→ b/c restoring force (kx) = applied force (qE) @ equilibrium

$x = qE/k = \boxed{.25\,m = x_{eq}}$