Haley Kivett

PHYSICS 135B: MIDTERM #1

Unit ⊘: Electrostatics I + II

①

$2.00\,\mu C * \frac{1C}{10^6\,\mu C} * \frac{1P}{1.6\times10^{-19}C} = \boxed{1.25\times10^{13} \text{ excess protons}}$

$50g * \frac{1\,mol}{63.5g} * \frac{6.02\times10^{23}}{1\,mol} = \boxed{4.74\times10^{23} \text{ atoms of copper}}$

$4.74\times10^{23} \times \frac{29p}{1\,atom\,cu} = \boxed{1.37\times10^{25} \text{ protons}}$

$\frac{1.25\times10^{13}}{1.37\times10^{25}} = \boxed{\frac{9.09\times10^{-13}}{1}}$

②

10 cm

1 · 2 · 3 ·

+6μC +2μC +4μC

$F_{12} = \frac{K|q_1q_2|}{r^2}$

$F_{12} = 8.99\times10^9 \frac{|6\times10^{-6}\times2\times10^{-6}|}{(0.05)^2}$

$\boxed{F_{12} = 43.152\,N}$

$F_{23} = K\frac{|q_2q_3|}{r^2}$

$F_{23} = 8.99\times10^9 \frac{|2\times10^{-6}\times4\times10^{-6}|}{(0.05)^2}$

$\boxed{F_{23} = 28.76\,FN}$

$\Sigma F_1 = F_{12} - F_{23}$

$\Sigma F = 43.152 - 28.76$

$\boxed{\Sigma F = 14.384\,N}$ ← away!

$\Sigma F_3 = ?$

③ $F_{23} - F_{13} = ?$

$\frac{K|q_2q_3|}{r_{23}^2} - \frac{K|q_1q_3|}{r_{13}^2} = ?$

$\frac{8.99\times10^9|1\times10^{-6}\times2\times10^{-6}|}{(0.03)^2}$

$- \frac{8.99\times10^9|1\times10^{-6}\times2\times10^{-6}|}{(0.05)^2}$

positive so point to right!

$\boxed{F_3 = 12.8\,N}$

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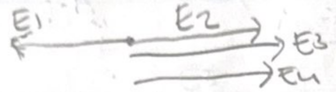
(4)

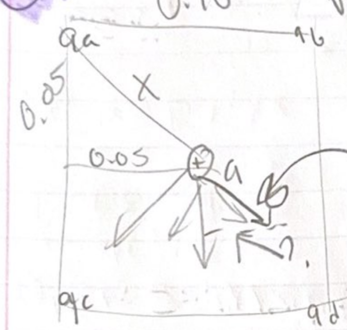


$K\left[\frac{5\times10^{-9}}{(0.06)^2}+\frac{1.5\times10^{-6}}{(0.03)^2}+\frac{5\times10^{-9}}{(0.03)^2}-\frac{1\times10^{-8}}{(0.1)^2}\right]=E_{TOT}$

$E_2+E_3+E_4-E_1=E_{TOT}$

$\boxed{E_{TOT}=2.03\times10^{5}\ N/C}$

(5)



$\sqrt{0.05^2+0.05^2}=\sqrt{c^2}$

$\boxed{c=0.0707\ m}$

$F=\frac{kq_1q_2}{r^2}$

$F=8.99\times10^9\frac{(7.5\times10^{-6}\times2\times10^{-6})}{(0.0707)^2}$

$\boxed{F=26.97\ N}$

$F_{ay}=26.97\cos(45)$ $\boxed{F_{ay}=19.07\ N}$

$\boxed{F_T=76.3\ N}$

(6)

e^-

$\Delta V=40kV$

$\Delta V=40{,}000\ kV$

$\Delta V=\frac{\Delta PE}{q}$

$40{,}000=\frac{\Delta PE}{1.6\times10^{-19}}$

$\boxed{\Delta PE=6.4\times10^{-15}\ J}$

$KE=6.4\times10^{-15}\ J$

$KE=\frac{1}{2}mv^2$

$\sqrt{\frac{2KE}{m}}=v$

$v=\sqrt{\frac{2(6.4\times10^{-15})}{9.11\times10^{-31}}}$

$\boxed{v=1.18\times10^{8}\ m/s}$

(7)

0.04

A B

$E=7.5\times10^{4}\ V/m$

$V_{AB}=?$

$V_{AB}=Ed$

$V_{AB}=7.5\times10^{4}(0.04)$

$\boxed{V_{AB}=3{,}000\ V}$

$\frac{1}{4}(3{,}000)=\boxed{750V}$

$V_{AB}=Ed$

$E=V/d$

$E=\frac{0.08}{9\times10^{-9}}$

$\boxed{E=8.89\times10^{6}\ V/m}$

(8) $q = 2(1.6\times10^{-19}\,C) = \boxed{3.2\times10^{-19}\,C}$

ΔPE

$E = 32.0\,keV \times \frac{1000\,\cancel{eV}}{1\,\cancel{keV}} \times \frac{1.6\times10^{-19}\,J}{1\,\cancel{eV}} = \boxed{5.12\times10^{-15}\,J}$

$\boxed{1eV = 1.6\times10^{-19}\,J}$

$\Delta V = \frac{\Delta PE}{q} = \frac{5.12\times10^{-15}}{3.2\times10^{-19}} = \boxed{1.6\times10^{4}\,V}$

$V_{AB} = Ed \quad E = V/d = \frac{1.6\times10^{4}}{0.02} = \boxed{8.0\times10^{5}\,V/m}$

(9) $\overset{+2}{\cdot}$ $E = 5\,meV$

79+

$q = 3.2\times10^{-19}\,C$ $\quad 1.26\times10^{-17}\,C$

$E = 5\,MeV \times \frac{10^6\,eV}{1\,meV} \times \frac{1.6\times10^{-19}\,J}{1\,eV} = \boxed{8\times10^{-13}\,J}$

$\Delta V = \frac{\Delta PE}{q} = \frac{8\times10^{-13}}{3.2\times10^{-19}} = \boxed{\Delta V = 2.5\times10^{6}\,V}$

$r = \frac{kq}{V} = r = \frac{9\times10^{9}(1.264\times10^{-17})}{2.5\times10^{6}}$ $\boxed{r = 4.55\times10^{-14}\,m}$

Unit 1: Capacitors, Currents, and DC Circuits

(1) $C = ?$
$q = 3\times10^{-6}\,C$
$V = 120V$

$C = q/V$
$C = \frac{3\times10^{-6}}{120}$
$\boxed{C = 2.50\times10^{-8}\,F}$

(2) $E_{cap} = ?$
$C = 10\times10^{-6}\,F$
$V = 9\times10^{3}\,V$

$C = q/V$
$q = C \cdot V$
$q = 10\times10^{-6}(9\times10^{3})$ $\boxed{0.09000C}$

$E = \frac{CV^2}{2}$
$E = \frac{10\times10^{-6}(9\times10^{3})^2}{2}$
$\boxed{E = 405\,J}$

$V = ?$
$C = 8\times10^{-6}\,F$
$E = 40\,J$

$E_{cap} = \frac{CV^2}{2}$
$V = \sqrt{\frac{2E}{C}}$
$V = \sqrt{\frac{2(40)}{8\times10^{-6}}}$
$\boxed{V = 3.16\times10^{3}\,V}$

$C = q/V$
$q = CV$
$q = (8\times10^{-6})(3.16\times10^{3})$
$\boxed{q = 0.0253\,C}$

3 $C = \frac{Q}{V}$ $C = \frac{Q}{4V} \rightarrow C = \frac{3.00 \times 10^{-3} C}{4(9.00 \times 10^{3} V)}$

$V = 9.00 \times 10^{3} V$ $= \frac{3.00 \times 10^{-3} C}{36 \times 10^{3} V}$

$Q = 3.00 \times 10^{-3} C$

$C = 1/12 \times 10^{-6} F$

$\boxed{C = 8.33 \times 10^{-8} F}$

connect capacitors ↑ total voltage and faster shock!

4 $R = p \times L/A$ $r = d/2 = \frac{1 \times 10^{-3} m}{2} = \boxed{5 \times 10^{-4} m}$

$P = 1.68 \times 10^{-8}$ $A = \pi (5 \times 10^{-4})^2$

$A = \pi r^2$ $= \pi 25 \times 10^{-8} m^2$

$R = 2.0 \Omega$ $= \boxed{7.85 \times 10^{-8} m^2}$

$d = 1mm = 1 \times 10^{-3} m$

$L = \frac{R \times A}{P}$ $L = \frac{2 \Omega * 7.85 \times 10^{-8} m^2}{1.68 \times 10^{-8} \Omega m} = \frac{15.7 \times 10^{-8} m^2}{1.68 \times 10^{-8} \Omega m}$

$\boxed{L = 9.345 m}$

max length = 1.0mm
resistance = 2 Ω @ 20°C
approx = 9.35m

5 $V_{bat} = 3.0V$ $I = \frac{V_{bat}}{R_{tot}} = \frac{3.0V}{1003 \Omega}$ $\boxed{I \approx 2.99 mA}$

$R_{resist} = 1 k\Omega = 1000 \Omega$

$R_{LED} = 3 \Omega$

$Q = I \times t$

$P = I * V$ $I = 2.99 \times 10^{-3} A$

$P = 2.99 \times 10^{-3} A \times 3.0V$ $t = 10 \times 60s = 600s$

$\boxed{P \approx 8.97 mW}$

$Q = 2.99 \times 10^{-3} A \times 600s$

$\boxed{Q = 1.794 C}$

Unit 2: DC Circuits w/ Resistors in Series + parallel, RC circuits

① $R_1 = 10k\Omega$
$R_2 = 5k\Omega$
$R_{TOT} = 2k\Omega$
$\Delta V = 12V$

$\frac{1}{R_{TOT}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{2000} = \frac{1}{10000} + \frac{1}{5000} + \frac{1}{R_3}$

$\frac{1}{2000} = \frac{1}{10000} + \frac{2}{10000} + \frac{1}{R_3}$

$\frac{1}{2000} = \frac{3}{10000} + \frac{1}{R_3}$

$\frac{1}{R_3} = \frac{1}{2000} - \frac{3}{10000}$

$\frac{1}{R_3} = \frac{5}{10000} \rightarrow R_3 = \frac{10000}{5}\Omega = \boxed{2000\Omega}$

$\Delta V = I \times R_{Total}$

$I = \frac{\Delta V}{R_{TOT}}$

$I = \frac{12V}{2000\Omega}$

$\boxed{I = 6\times10^{-3} A} \rightarrow \boxed{6mA}$

$I_1 = \frac{\Delta V}{R_1} = \frac{12V}{10\times10^3\Omega} = \boxed{1.2mA}$

$I_3 = \frac{\Delta V}{R_3} = \frac{12V}{2000\Omega} = \boxed{6mA}$

$I_2 = \frac{\Delta V}{R_2} = \frac{12V}{5\times10^3\Omega} = \boxed{2.4mA}$

② $V_{total} = V_{bat\#1} + V_{bat\#2}$ . . . - etc.

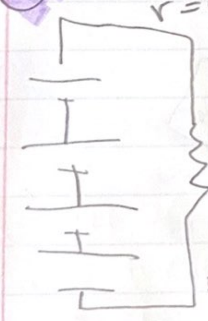
$V_{tot} = n \times 1.5V$

$I = \frac{V_{tot}}{R}$ → $I = \frac{n * 1.5V}{R}$

$V_{total} = \boxed{3V}$

? kinda stuck on this one

③



$r = 0.02\Omega$
$EMF = 1.5V$
$R_L = 10.0\Omega$
$I_L = 0.617A$
$EMF = 1.53V$
$r = 0.1\ \Omega$

$I_T = \frac{V_T}{R_T} \rightarrow I_T = \frac{3(1.58)+1.53}{3(0.02)+0.1+10}$

$\boxed{I_T = 0.617A}$

$P_L = I_L^2 R_L$

$P_L = (0.617)^2\ (10)$

$\boxed{P_L = 3.81W}$

$P_L = I_L^2 R_L$

$0.5 = I_L^2(10)$

$I_L = 0.224\ A$

$I_T = \frac{V_T}{R_T}$

$0.224 = \frac{3(1.58)+1.53}{3(0.02)+r+10}$ § $\frac{6.27}{10.06+r} - 10.06$

$\boxed{r = 18.0\Omega}$

(4) $\frac{72 \text{ times}}{1 \text{ min}} \rightarrow \frac{1 \text{ min}}{72 \text{ beats}} = 0.0139 \frac{\text{min}}{\text{beat}} * \frac{60 \text{ sec}}{1 \text{ min}} = \boxed{0.833 \text{ s/beat}}$

$\tau = R \cdot C \rightarrow 0.833 = R(25 \times 10^{-7}) \rightarrow \boxed{R = 3.33 \times 10^{7}\ \Omega}$

(5)

$T = 1 \times 10^{-4}$ sec

$R = 1 \times 10^{3}\ \Omega$

$C = ?$

$\frac{T}{R} = C$

$\frac{1 \times 10^{-4}}{1 \times 10^{3}} = C$

$\boxed{C = 1 \times 10^{-7} F}$

$\boxed{C < 1 \times 10^{-7} F}$

$T = RC$

$1 \times 10^{-4} = \cancel{R}$

$1 \times 10^{-5} = L$

Unit 3: Magnetism I

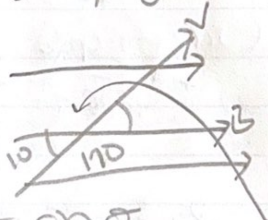
(1) $F_L = q(v \times B)$

CASE	v direc.	b direc.	f direc.
A	Ĵ	↑	towards out of page
B	↑	Ĵ	towards out of page
C	↑	R	towards up (+) j direction
D	Ĵ	R	towards Left (-) î direc

(2)

$F = qvB\sin\theta$

$\sin\theta = \frac{F}{qvB}$



$\frac{1.4 \times 10^{-16}}{(1.6 \times 10^{-19})(4 \times 10^{3})(1.25)} = \sin\theta$

$\boxed{169.9° = \theta}$

$\sin^{-1}(0.175) = (\sin\theta)\sin^{-1}$

$\boxed{10.1° = \theta}$

(3) $r = \frac{mv_T}{|q|B} \rightarrow q = \frac{mv_T}{rB} \rightarrow q = \frac{2.66 \times 10^{-26}\,(5\times10^{6})}{0.231\,(1.20)}$

$\frac{4.80\times10^{-19}\,C}{1.6\times10^{-19}\,C} = \boxed{3}$ $\boxed{q = 4.80 \times 10^{-19}\ C}$

$\frac{m}{z} = \frac{B \cdot r}{q} \rightarrow \frac{m_{16}}{z} = \frac{m_{18}}{z} \rightarrow m_{16} = {}^{16}/_{18}\, m_{18}$

$\frac{m_{18}}{m_{16}} = \frac{m_{18}}{{}^{16}/_{18}\, m_{18}} = \frac{18}{16} = \boxed{\frac{9}{8}}$ ← mass of O2-18 ion is 9/8 times mass of O2-16 ion

$\frac{m_{18}}{z} = \frac{B \cdot r}{q} = \frac{9}{8} = \frac{Br_{18}}{z} \rightarrow 9/8 = \frac{Br_{16}}{z}$

$r_{16} = r_{18} = r \rightarrow 9/8 = \frac{Br}{z} \rightarrow \boxed{r = 9/8 * \frac{z}{B}}$ ← circular arc

(4) $F = I\ell B\sin\theta$

$F = 100(0.25)(2)\sin(90)$

$\boxed{F = 50\ N}$

(5) $\tau = NIAB\sin\theta \rightarrow \frac{\tau}{NIA\sin\theta} = B$

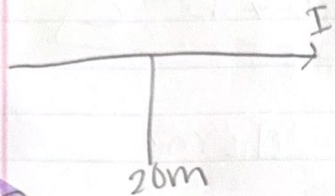
$\frac{300}{200(25)(0.2^2)\sin(90)} = B \rightarrow \boxed{1.50T = B}$

(6)

Case	B direction
a	$\hat{k}$
b	$\hat{\imath}$
c	$-\hat{\imath}$

(7)

$B = \frac{\mu_0 I}{2\pi r}$ $\quad P = \frac{F}{V}$ $\quad \frac{450\times10^6}{300{,}000} = I$



$B = \frac{4\pi\times10^{-7}(1500)}{2\pi(20)}$ $\quad \boxed{B = 1.50\times10^{-5}T}$

(8) $B = 1.0$ Tesla

$r = 5\,m$

$\mu_0 = 4\pi\times10^{-7}$

$B = \frac{\mu_0 N I}{2\pi r} \rightarrow N = \frac{2\pi r B}{\mu_0 I}$ $\quad \boxed{\approx 3}$

$N = \frac{2\pi\times5\times1}{4\pi\times10^{-7}\times I} \rightarrow \frac{10}{4\times10^{-7}\times I} \rightarrow \frac{25\times10^6}{I} \rightarrow \frac{25\times10^6}{10\times10^6} = \boxed{2.5}$

$I = \frac{2\pi\times5\times1}{3\times4\pi\times10^{-7}} = \frac{10}{3\times10^{-7}} \approx 3.33\times10^{7}\,A$

$f = \frac{qB}{2\pi m} \rightarrow \frac{(1.602\times10^{-19}C)(1.0T)}{2\pi(1.673\times10^{-27}kg)} = \frac{1.602\times1}{2\pi\times1.673}\times10^8$

$= \frac{1.602}{10.511}\times10^8 = 15.24\times10^6 \approx \boxed{15.24\,MHz}$