# Work for Midterm Answers:

Amber Tec

$\frac{19.5}{20}$

yay!

## 2. Electric Charge & Electric field

#1

a) $E_c = 2.00 \times 10^{-3}$ V/m

$r = 1\text{mm} \rightarrow \text{m} \rightarrow 1\times10^{-3}$ m

? $E_c$ @ 5mm produced by same charge

$\downarrow$ m

$5\times10^{-3}$ m

**For 1mm**

$\vec{F} = q\vec{E} \rightarrow E = \frac{q}{F}$

$\vec{E_c} = \left(\frac{1}{4\pi\epsilon_0}\right)\left(\frac{Q}{r^2}\cancel{x}\right)$

$2.00\times10^{-3}\ \text{V}/\cancel{m} = \left(\frac{1}{4\pi\epsilon_0}\right)\left(\frac{q}{(1\times10^{-3}\cancel{m})^2}\right)$

$(1\times10^{-6})2.00\times10^{-3} = \left(\frac{1}{4\pi\epsilon_0}\right)\left(\frac{q}{\cancel{1\times10^{-6}}}\right)\cancel{(1\times10^{-6})}$

$2\times10^{-9}\ \text{V} = \frac{q}{4\pi\epsilon_0}$

**For 5mm**

$E_c = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$

just a scaling problem

$E_c = \frac{1}{4\pi\epsilon_0}\frac{q}{(5\times10^{-3})^2}\ \text{m}^2$

$(2.5\times10^{-5})E_c = \frac{1}{4\pi\epsilon_0}\frac{q}{2.5\times\cancel{10^{-5}}} \cdot 2.5\times10^{-5}\ \text{m}$

$(2.5\times10^{-5}\ \text{m})(E_c) = \frac{q}{4\pi\epsilon_0}$

$\rightarrow (2\times10^{-9})(2.5\times10^{-5})$

$-\frac{1}{2}$ $8\times10^{-5}$ V/m

$E_c = \frac{2\times10^{-9}\ \text{V}}{2.5\times10^{-5}\ \text{m}} = \boxed{8\times10^{-15}\ \text{V/m}}$ answer

b) $q = 1\mu C = 1\times10^{-6}$ C

$E = 8.00\times10^{-3}$ V/m

$r =$ same distance

? = value of $E_c$ @ same distance if $q = 3\mu C = 3\times10^{-6}$ C

$E_c = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$

**For 1μC**

$8.00\times10^{-3}\ \text{V/m} = \left(\frac{1}{4\pi\epsilon_0}\right)\left(\frac{1\times10^{-6}\text{C}}{r^2}\right)$

$\frac{1}{1\times10^{-6}\text{C}} \cdot 8\times10^{-3}\ \text{V/m} = \frac{\cancel{1\times10^{-6}\text{C}}}{4\pi\epsilon_0 r^2} \cdot \frac{1}{\cancel{1\times10^{-6}\text{C}}}$

$8\times10^{3}\ \text{C}\ \frac{\text{V}}{\text{m}} = \frac{1}{4\pi\epsilon_0 r^2}$

**For 3μC**

$E_c = \left(\frac{1}{4\pi\epsilon_0}\right)\left(\frac{3\times10^{-6}\text{C}}{r^2}\right)$

$E_c = \frac{\cancel{3\times10^{-6}\text{C}}}{4\pi\epsilon_0 r^2} \cdot \frac{1}{\cancel{3\times10^{-6}\text{C}}}$

$3\times10^{-6}\text{C} \cdot \frac{E}{3\times10^{-6}\text{C}} = (8\times10^{3}\ \cancel{C}\ \frac{\text{V}}{\text{m}})(3\times10^{-6}\cancel{C})$

$\boxed{0.024 \text{ or } 2.4\times10^{-2}\ \text{V/m}}$ answer

#2

a) mass = $4\times10^{-16}$ kg

$E = 6131.25$ N/C

$g\downarrow = 9.81\ m/s^2$

$F_e = F_g$

$\frac{qE}{E} = \frac{mg}{E}$

$q = \frac{mg}{E}$

$q_e = 1.6\times10^{-19}$

$q = \frac{(4\times10^{-16})(9.81)}{6131.25}$

$q = 6.4\times10^{-19}C$

# of electrons in drops $= \frac{q}{q_e}$ $\quad \frac{6.4\times10^{-19}C}{1.6\times10^{-19}} = \boxed{4 \text{ electrons}}$ answer

b) mass = $4\times10^{-16}$ kg

$E = 6131.25$ N/C

$g\downarrow = 9.81\ m/s^2$

$4e - 1e = (3e)(1.6\times10^{-19}c)$

$q = 4.8\times10^{-19}C$

$F = ma$

$a = \frac{F}{m}$

$F = mg$

$F = qE$

$a = mg - qE$

$\frac{F}{m} \rightarrow \frac{(4\times10^{-16}\times9.81) - (4.8\times10^{-19}\times6131.25)}{4\times10^{-16}}$

$\boxed{= 2.45\ m/s^2}$ answer

3. Potential Energy & Voltage

#1 a) $\Delta V = 4kV \rightarrow 4\times10^3 v$

$U = q\Delta V$ $\quad q_e = 1.6\times10^{-19}$ C

$H\ q = +1q_e = 1.6\times10^{-19}$

$He\ q = +2q_e = 3.2\times10^{-19}$

$H_q = 1.6\times10^{-19}(4\times10^3 v) = \boxed{6.4\times10^{-16} J\ H}$

$He_q = 3.2\times10^{-19}(4\times10^3 v) = \boxed{1.28\times10^{-15} J\ He}$ answers

easier to use eV, though

b) $\Delta x = 5cm \rightarrow 5\times10^{-2}m$

E-field value?

$E = -\frac{\Delta V}{\Delta x} \rightarrow -\frac{4\times10^3 v}{5\times10^{-2}m} = \boxed{-80{,}000}$ answer

volts

#2

$E = 1\times10^3\ v/m$

$r = 2mm \rightarrow 2\times10^{-3}$ m

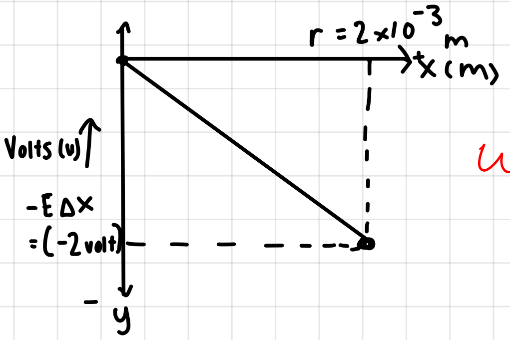
$E = \frac{-\Delta v}{\Delta x}$ or $\Delta V = -E\Delta x$

$(\Delta x)$ $\quad \Delta v = (-1\times10^3)(2\times10^{-3})$

$\Delta v = -2$

Slope $= \frac{-2}{2\times10^{-3}}$

Slope = $-1000$ v/ m




Well done!

Answer: The y-intercept is zero

#3 a) area = $1\,cm^2 = 1\times10^{-4}\,m^2$
$d = 2\times10^{-3}\,m$
Capacitance? $\epsilon_0 = 8.85\times10^{-12}$ F/m

$$C = \frac{\epsilon_0 A}{d} = \frac{(8.85\times10^{-12}\ F/\cancel{m})(1\times10^{-4}\ \cancel{m^2})}{2\times10^{-3}\ \cancel{m}} \rightarrow C = \boxed{4.425\times10^{-13}\ F}$$ answer

b) $U = 1/2\, CV^2$

$$U = \frac{1}{2}(4.425\times10^{-13} F)(5v)^2$$

$U = \boxed{5.53\times10^{-12}\ J}$ answer

#4 If we need a system that can store more energy for the same voltage the identical capacitor should be connected to the first in parallel since series woud decrease the energy since $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C2}$, a parallel system, however would increase the energy since $C_p = C_1 + C_2$.

## 4. Current, Resistance, & DC Circuits

#1 $r_1 = r_2 = 2\Omega$
emfs → $\epsilon_1 = \epsilon_2 = 1.5\,v$
$R = 50\,\Omega$
$R$ = 1.5 v or 3 V device

a) Using kirchhoff's rules, find current through R for serial case 3v & parallel

**Series:**

$\epsilon_1 + \epsilon_2 =$
$1.5v + 1.5v = 3v$
$R_{tot} = 2\Omega + 2\Omega = 4\Omega$
$R_{tot} = 4\Omega + 50\Omega = 54\Omega$
$I = \frac{3}{54} \rightarrow I = \boxed{0.06\ A}$ answer (6.055 A)

**parallel:**

$$R_{Tot} = \frac{R_1 \times R_2}{R_1 + R_2} \frac{(2\Omega)(2\Omega)}{2\Omega + 2\Omega} = \frac{4\Omega}{4\Omega} = 1\Omega$$

$$\frac{\epsilon_1 r_2 + \epsilon_2 r_1}{r_1 + r_2} \rightarrow \frac{(1.5)(2\Omega) + (1.5)(2\Omega)}{2\Omega + 2\Omega}$$

$R_{Tot} = 1\Omega + 50\Omega$
$R_{Tot} = 51\Omega$

$$\boxed{I = \frac{1.5v}{51\Omega} = 0.03\ A}$$ answer

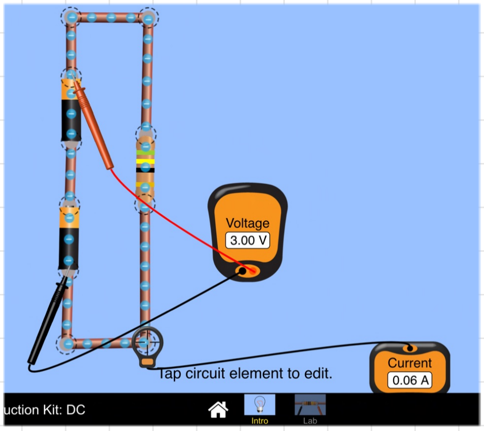
$$\frac{3+3}{4} = \frac{6}{4} = 1.5v$$

B) $P = I \cdot v$

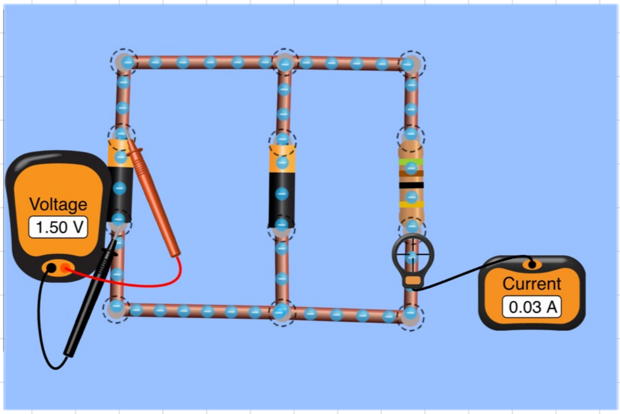
**series:** $(0.06\ A)(3v) = \boxed{0.18\ w}$ answer (165 mW)

**parallel:** $(0.03\ A)(1.5v) = \boxed{0.044\ w}$ answer (45 mW)

c) Series:

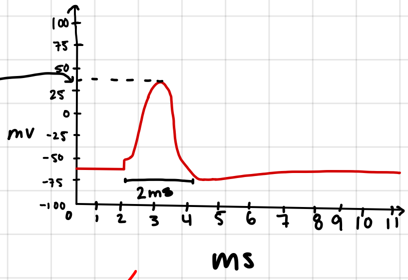


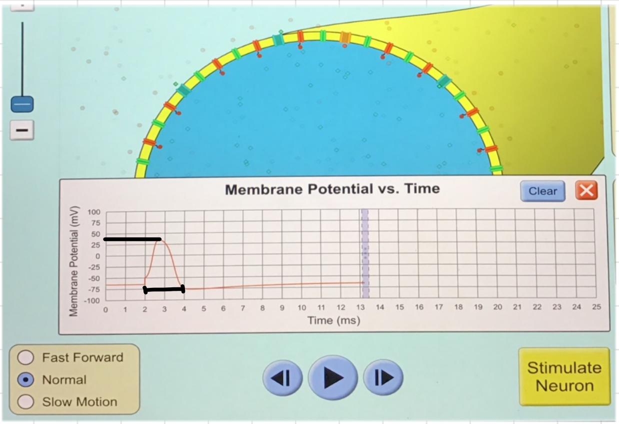

Parallel:




#2 a) If the nerve is stimulated the pulse width would be $\boxed{2\ ms}$ answer

25+50/2 = 37.5




b) (37.5) - (-75) $\boxed{= 112.5 \text{ mv} \approx 113 \text{ mv}}$ answer

peak to peak

excellent!