Electric Charge & Electric Fields

2. 1. a) $E_L = 2.00 \times 10^{-3}$ V/m

$\frac{2.00 \times 10^{-3}}{25} = 8 \times 10^{-5}$ V/m

18.5/20

Well done

$q = 1\mu C$ b) $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2}$

$1\mu C = 1 \cdot 10^{-6} C$ $\quad 8 \cdot 10^{-3} = \frac{1}{4\pi\epsilon_0} \cdot \frac{1 \times 10^{-6}}{r^2}$

$\left(\frac{1}{1\times10^{-6}}\right)\left(8\times10^{-3}\right) = \frac{1\times10^{-6}}{4\pi\epsilon_0 r^2} \cdot \left(\frac{1}{1\times10^{-6}}\right)$

$8 \cdot 10^{3} = \frac{1}{4\pi\epsilon_0 r^2}$

$q = 3\mu C = 3 \cdot 10^{-6}$ C

$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2}$

$E = \frac{1}{4\pi\epsilon_0} \cdot \frac{3\times10^{-6}}{r^2}$

$E = \frac{3 \cdot 10^{-6}}{4\pi\epsilon_0 r^2}$

$E = \frac{1}{4\pi\epsilon_0 r^2} \cdot \frac{3\times10^{-6}}{1}$ ★ Substitution for $\frac{1}{4\pi\epsilon_0 r^2}$

$E = (8\times10^{3})(3\times10^{-6})$

$E = 2.4 \times 10^{-2}$

Electric Charge & Electric Fields

2 :2 a) $q = \frac{mg}{E}$

$= \frac{(4\times10^{-15})(9.8)}{6131.25}$

$q = 6.39\times10^{-19}$,

Correct value, so how many e^-?

b) $q' = q - e$

$(6.39\times10^{-19}) - (1.6\times10^{-19})$

$q' = 4.79\times10^{-19}$

solve for Fe

$F_e = q' \cdot E$

$= (4.79\times10^{-19})(6131.25)$

$F_e = 2.94\times10^{-15}\ N$

solve for oil drop mass

$m' = m - m_e$ (mass of oil) − (mass of e^-)

$m' = (4\times10^{-15}) - (9.1\times10^{-31})$

$m' \approx 4\times10^{-15}$

I never thought about this, interesting. but it's a tiny effect

solve for Fg

$F_g = m'g$

$= (4\times10^{-15})(9.8)$

$F_g = 3.92\times10^{-15}\ N$

Finally, solve for a

$a = \frac{F_g - F_e}{m} = \frac{(3.92\times10^{-15}) - (2.94\times10^{-15})}{(4\times10^{-15})}$

$a = 2.45\ m/s^2$ ✓ ✓ 2

Potential Energy & Voltage, Capacitors

3 1. a) $KE = qV$

$= (1.6\times10^{-19})(4 \text{ ~~kV~~})$

$= 6.4\times10^{-19}$ eV Hydrogen

Hydrogen: $+1q_e = 1(1.6\times10^{-19}) = 1.6\times10^{-19}$

Helium: $+2q_e = 2(1.6\times10^{-19}) = 3.2\times10^{-19}$

~~ΔV = 4 kV = 4000 = 4×10³ V~~

eV = kV

$2(1.6\times10^{-19})(4)$

$= 1.28\times10^{-18}$ eV

(-1) almost, the eV goes like: $q\Delta V$

4 keV ← $1e^+$ (4000V)

8 keV ← $2e^+$ (4000V)

b) $E = \frac{\Delta V}{\Delta x^2}$ $\Delta x = 5$ cm

5 cm $= 5\times10^{-2}$ m

$E = \frac{4\times10^3}{5\times10^{-2}}$

$E = 8\times10^4$ V/m ✓

2, $E = 1$ kV/m $= 1000$ V/m

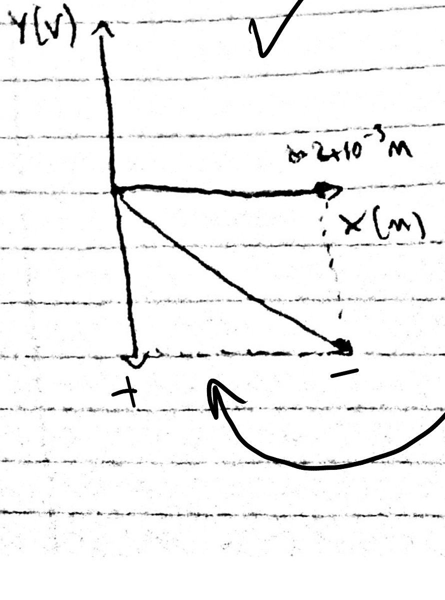
- B/C question deals w/ parallel plate capacitor, E-field is constant
- E-field ~~is~~ also slope of voltage function
- This makes the function linear due to the constant slope
- function will also point downward since E-field relative to potential

✓

1000 V/m ~~2~~ mm $= 2\times10^{-3}$ m

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

neg. slope



~~[illegible]~~

$y = mx + b$

$y = 1000x + ~~b~~$

- y-intercept is 0 due to function beginning at (0,0)

Potential Energy of Voltage, Capacitors

3 3. a) $C = \frac{E_0 A}{d}$ $1cm^2 = (1\cdot10^{-2} m)^2$ $d = 2mm = 2\cdot10^{-3} m$

$C = \frac{(8.85\cdot10^{-12})(1\cdot10^{-2})^2}{(2\cdot10^{-3})}$

$C = 4.43\cdot10^{-13}$ F

b) $W = \frac{1}{2}CV^2$ $V=5$

$W = \frac{1}{2}(4.43\cdot10^{-13})(5^2)$

$W = 5.54\cdot10^{-12}$ J

4. The identical capacitors should be connected in parallel in order to achieve more energy

A parallel combination allows for the sum of all capacitances

$C_{tot} = C_1 + C_2 ...$ $\uparrow C$

A series combination adds the reciprocals of all capacitors, which results in the equivalent capacitance being smaller than the smallest individual capacitance & results in less energy

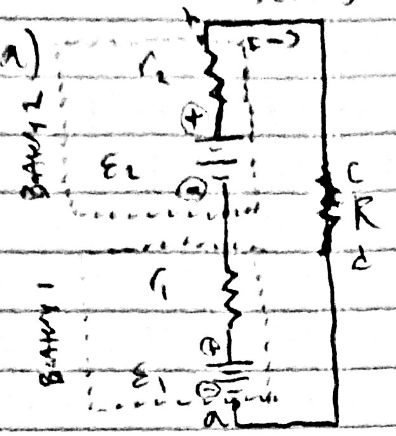
$C_{tot}^{-1} = C_1^{-1} + C_2^{-1}$ $\downarrow C$

Current, Resistance, & DC Circuits

4 1.

Series

a)



$E_1 - Ir_1 + E_2 - Ir_2 = 0$

$I = \dfrac{E_1 + E_2}{r_1 + r_2 + R}$ ✓

$I = \dfrac{1.5 + 1.5}{2+2+50} \approx 55.6\,mA$

b) $P_{tot} = P_{r_1} + P_{r_2} + P_R$

$= I^2 r_1 + I^2 r_2 + I^2 R$

$= (55.6)^2 2 + (55.6)^2 2 + (55.6)^2 50$

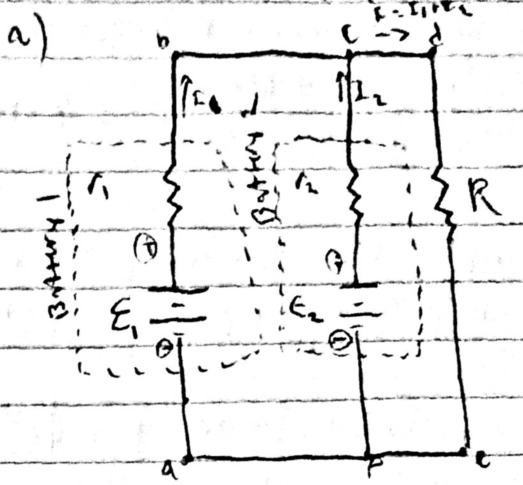
=

$\approx 166\,mW$ ✓

but something seems odd bc I don't see the unit conversions o.o

Parallel

a)



$\dfrac{1}{R_{tot}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

$0 = \dfrac{1}{r_1} + \dfrac{1}{r_2} + \dfrac{1}{R}$

$0 = \dfrac{V_x - 1.5}{2} + \dfrac{V_x - 1.5}{2} + \dfrac{V_x}{50}$

obtain common denominator

$0 = \left(\dfrac{25}{25}\right)\left(\dfrac{V_x - 1.5}{2}\right) + \left(\dfrac{25}{25}\right)\left(\dfrac{V_x - 1.5}{2}\right) + \dfrac{V_x}{50}$

$0 = \dfrac{25V_x - 37.5 + 25V_x - 37.5 + V_x}{50}$

$0 = 75 + 51V_x$

$V_x = 1.47V$

$V = IR \to I = \dfrac{V}{R}$

$I_1 = \dfrac{1.5 - 1.47}{2} = 15\,mA$

$I_2 = \dfrac{1.5 - 1.47}{2} = 15\,mA$ +

$I = 30\,mA$ ✓

b) $P_{tot} = P_{r_1} + P_{r_2} + P_R$

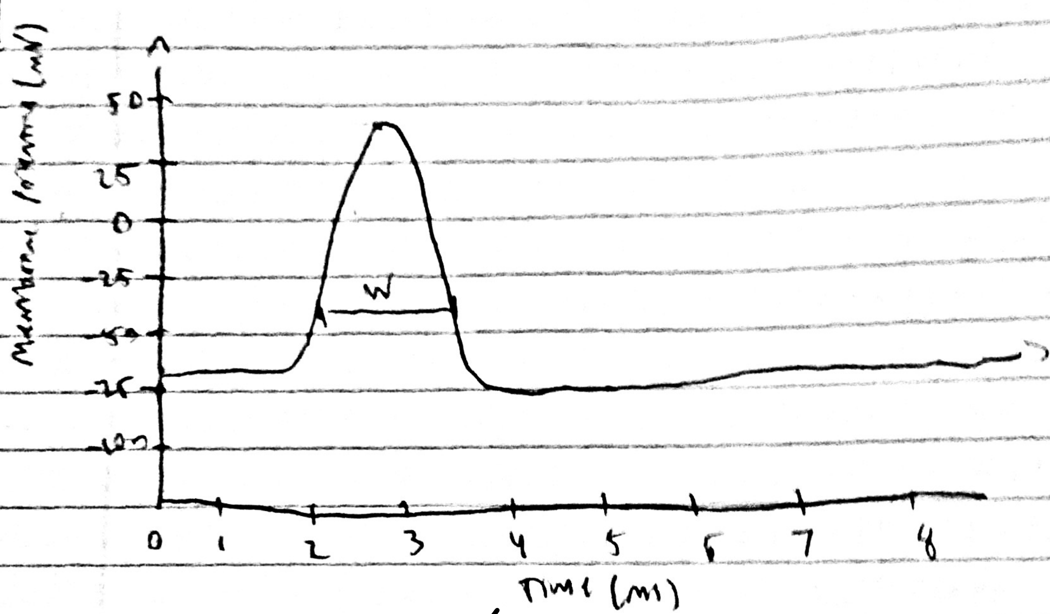
$= I^2 r_1 + I^2 r_2 + I^2 R$

$= (15)^2 2 + (15)^2 2 + (30)^2 50$

$\approx 45.9\,mW$ ✓

Current, Resistance, & DC circuits

4 2 a) After stimulating nerve, I then graphed membrane potential vs time



4 - 2
= 2ms ✓

b) greatest voltage - least
40 - (-75)
= 45V (mV)

-1/2