

Mid-term

Electric Charge and Electric Fields

1) a)  $E_c = 2.00 \times 10^3 \text{ V/m}$  at 1mm or 0.001m

$E_c$  at 5mm (0.005m) is ?

$$E_c = \frac{kq}{r^2}$$

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at 5mm

$$E_c = \frac{kq}{r^2} = \frac{(9 \times 10^9)(2.22 \times 10^{-19})}{(0.005)^2} = 8 \times 10^{-5} \text{ V/m}$$

$$q = 2.22 \times 10^{-19} \quad q = 5.55 \times 10^{-18}$$

b)  $E_c = 8.00 \times 10^3 \text{ V/m}$   $q = 1 \mu\text{C}$   $E_c = ?$  when  $q = 3 \mu\text{C}$

$$E_c = \frac{kq}{r^2} \rightarrow E_c = \frac{k \cdot 3q}{r^2}$$

charges 3 times greater so  $E_c$  is 3 times greater

$$(8 \times 10^3) \times 3 = 24.0 \times 10^3 \text{ V/m}$$

2) Given: mass =  $4 \times 10^{-16} \text{ kg}$   $E = 6131.25 \text{ N/C}$

a)  $F = qE$   $F = \text{mg (weight)} \rightarrow \text{mg} = qE$   $q = \frac{F}{E}$   $q = \frac{mg}{E}$   $q = \frac{(4 \times 10^{-16})(9.8)}{6131.25}$

$q = \text{\# of electrons} \times \text{charge of electron}(e)$   $q = ne$   $e = 1.6 \times 10^{-19}$

$$\frac{q}{e} = n = \frac{6.39 \times 10^{-19}}{1.6 \times 10^{-19}}$$

$$n = 3.996$$

$n = 4 \text{ electrons}$

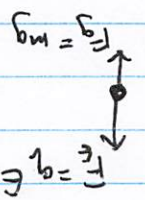
b) one  $e^-$  removed

$$q - e = q_2 = 6.39 \times 10^{-19} - 1.6 \times 10^{-19} = 4.79 \times 10^{-19}$$

$$F_{\text{net}} = F_g - F_e = ma \quad a = \frac{F_g - F_e}{m} \quad a = \frac{mg - qE}{m}$$

$$q = \frac{(4 \times 10^{-16})(9.8) - (4.79 \times 10^{-19})(6131.25)}{4 \times 10^{-16}}$$

$$a = 2.45 \text{ m/s}^2$$



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Electric Charge and Electric Fields

1) a)  $E = 2.00 \times 10^3 \text{ V/m}$  at  $1 \text{ mm}$  or  $0.001 \text{ m}$

b) at  $2 \text{ mm}$  ( $0.002 \text{ m}$ ) is?

$E = \frac{kQ}{r^2} = \frac{(9.0 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)(0.0001 \text{ C})}{(0.001 \text{ m})^2} = 9.0 \times 10^5 \text{ V/m}$

$E = \frac{kQ}{r^2} = \frac{(9.0 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)(0.0001 \text{ C})}{(0.002 \text{ m})^2} = 2.25 \times 10^5 \text{ V/m}$

d)  $E = 8.00 \times 10^3 \text{ V/m}$  at  $1 \text{ mm}$   $E = ?$  when  $d = 3 \text{ cm}$

$E = \frac{kQ}{r^2} \Rightarrow E_2 = E_1 \left( \frac{r_1}{r_2} \right)^2$  charges & distance so  $E_1 = 8 \times 10^3$

$(8 \times 10^3) \times 3 = 2.4 \times 10^4 \text{ V/m}$

2) Given: mass =  $4.10 \times 10^{-10} \text{ kg}$   $E = 6.18152 \text{ N/C}$

a)  $F = qE$   $F = \text{weight} \Rightarrow \text{weight} = qE$   $q = \frac{F}{E} = \frac{mg}{E} = \frac{(4.10 \times 10^{-10} \text{ kg})(9.8 \text{ m/s}^2)}{6.18152 \text{ N/C}} = 6.48 \times 10^{-10} \text{ C}$

b)  $q = \text{# of electrons} \times \text{charge of electron}(e)$   $q = n e$   $n = \frac{q}{e} = \frac{6.48 \times 10^{-10} \text{ C}}{1.6 \times 10^{-19} \text{ C}} = 4.05 \times 10^9$

$n = 4.05 \times 10^9$

d) one removed

$q = e = 1.6 \times 10^{-19} \text{ C}$   $q = 1.6 \times 10^{-19} \text{ C}$



$F_{\text{net}} = F_1 + F_2 = ma$  or  $\frac{kqQ}{r^2} + \frac{kqQ}{r^2} = ma$   $\frac{2kqQ}{r^2} = ma$

$Q = 5.2 \times 10^{-12} \text{ C}$

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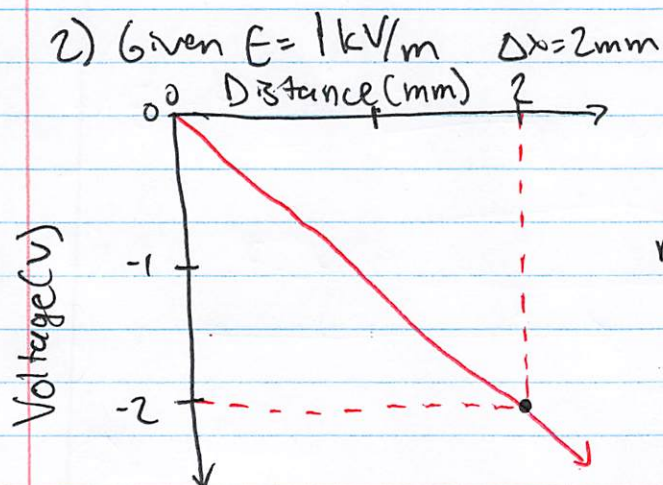
## Potential Energy and Voltage, Capacitance

1) Given:  $\Delta V = 4 \text{ kV}$   $H = +1q_e$   $He = +2q_e$   $1 \text{ J} = 6.242 \times 10^{18} \text{ eV}$

a)  $U = qV$   $U_{\text{tot}} = KE_{\text{tot}} \rightarrow KE = qV$

hydrogen  $KE = (1.6 \times 10^{-19})(4 \times 10^3) = 6.4 \times 10^{-16} \text{ J} \times \frac{6.242 \times 10^{18} \text{ eV}}{1 \text{ J}} = 3995 \text{ eV}$

helium  $KE = 2(1.6 \times 10^{-19})(4 \times 10^3) = 12.8 \times 10^{-16} \text{ J} \times \frac{6.242 \times 10^{18} \text{ eV}}{1 \text{ J}} = 7990 \text{ eV}$



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

$m(\text{slope}) = -1000 \text{ V/m}$   
or  
 $-1 \text{ V/mm}$

y-intercept is zero. when distance is zero, voltage is zero ( $V = E\Delta x$ )

b)  $E = \frac{\Delta V}{\Delta x} = \frac{(4 \times 10^3)}{(5 \times 10^{-2})}$

$E = 8 \times 10^4 \text{ V/m}$   
negative  $\nabla$

3) a)  $C = \frac{\epsilon_0 A}{d}$   $\epsilon_0 = 8.85 \times 10^{-12}$   $A = 1 \text{ cm}^2 \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 1 \times 10^{-4} \text{ m}^2$

$$C = \frac{(8.85 \times 10^{-12})(1 \times 10^{-4})}{2 \times 10^{-3}} = 4.425 \times 10^{-13} \text{ F}$$

b) Energy =  $\frac{1}{2} CV^2 = \frac{1}{2} (4.425 \times 10^{-13}) (5^2) = 5.53 \times 10^{-12} \text{ J}$

4)  $C_{\text{tot}} = C_1 + C_2$  in parallel  $\frac{1}{C_{\text{tot}}} = \frac{1}{C_1} + \frac{1}{C_2}$  in series

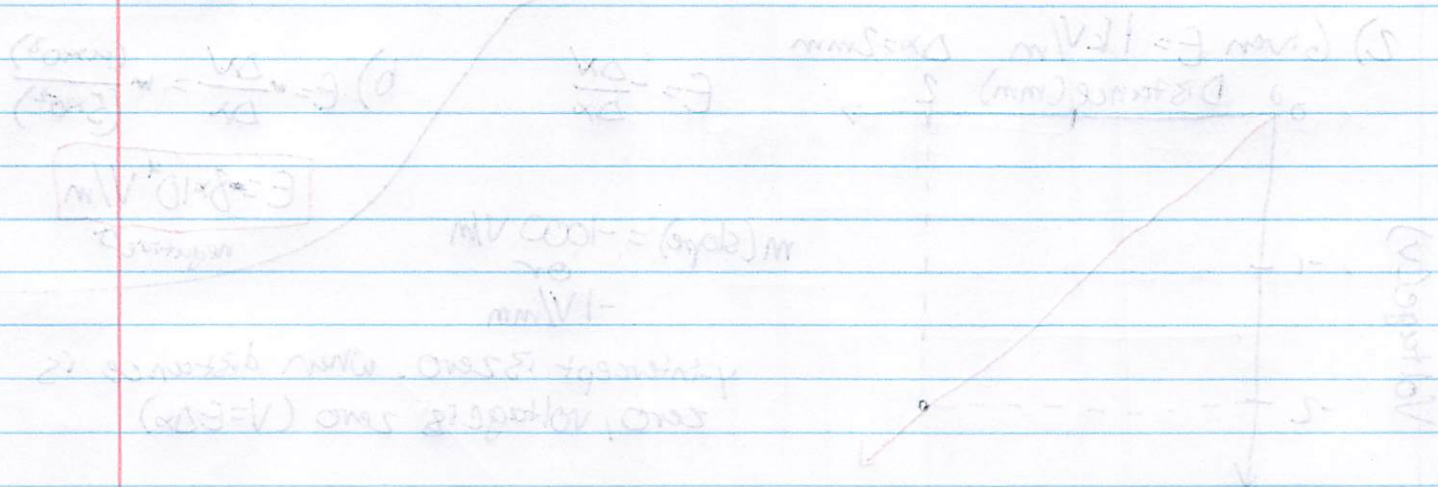
to store more energy we should add the other capacitor in parallel.

parallel

Potential Energy and Voltage (capacitance)  
 1) Given:  $V = 1.5 \text{ V}$ ,  $H = 1 \text{ cm}$ ,  $W = 2.5 \times 10^{-8} \text{ m}$

Hydrogen  $KE = (1.6 \times 10^{-19} \text{ C})(1.5 \text{ V}) = 2.4 \times 10^{-19} \text{ J}$   
 $KE = \frac{1}{2}mv^2 \rightarrow v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(2.4 \times 10^{-19} \text{ J})}{1.67 \times 10^{-27} \text{ kg}}} = 1.7 \times 10^5 \text{ m/s}$

Helium  $KE = 2.1 \times 10^{-18} \text{ J}$   
 $KE = \frac{1}{2}mv^2 \rightarrow v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(2.1 \times 10^{-18} \text{ J})}{6.64 \times 10^{-27} \text{ kg}}} = 2.5 \times 10^5 \text{ m/s}$



2)  $A = \frac{1}{4\pi\epsilon_0} \frac{Q^2}{r^2}$   
 $100 \text{ N} = \frac{1}{4\pi(8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2)} \frac{Q^2}{(1 \text{ m})^2}$   
 $Q = 1 \text{ C}$

$E = \frac{1}{2}QV = \frac{1}{2}(1 \text{ C})(1 \text{ V}) = 0.5 \text{ J}$

3) Energy  $= \frac{1}{2}CV = \frac{1}{2}(1 \text{ F})(1 \text{ V}) = 0.5 \text{ J}$

4)  $C_{\text{total}} = C_1 + C_2 = 1 \text{ F} + 1 \text{ F} = 2 \text{ F}$

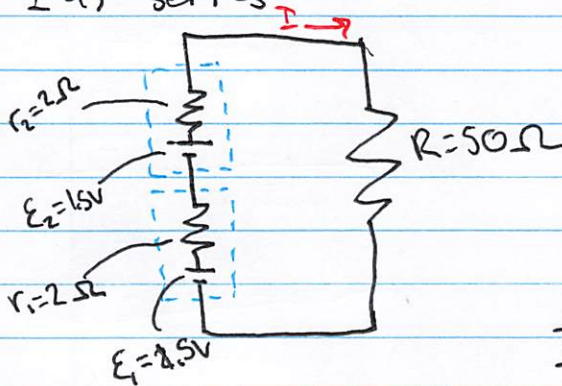
To store more energy we should add the other capacitor in parallel.

parallel



# Current, Resistance, and DC circuits

1 a) series



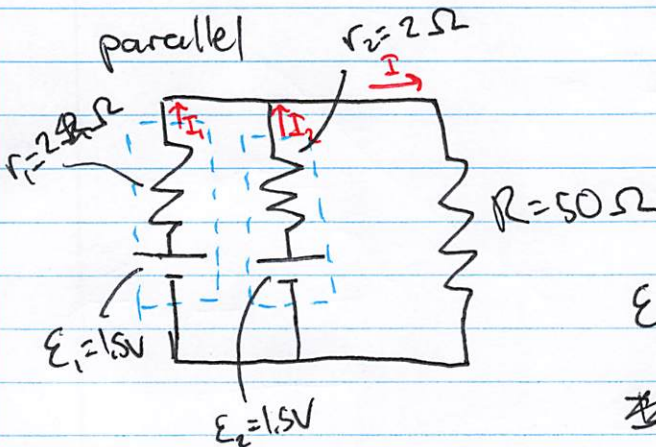
$$\mathcal{E}_1 + \mathcal{E}_2 + \dots = 0$$

$$\mathcal{E}_1 - I r_1 - I r_2 - I R + \mathcal{E}_2 = 0$$

$$\mathcal{E}_1 + \mathcal{E}_2 = I r_1 + I r_2 + I R$$

$$\mathcal{E}_1 + \mathcal{E}_2 = I (r_1 + r_2 + R)$$

$$I = \frac{\mathcal{E}_1 + \mathcal{E}_2}{r_1 + r_2 + R} = \frac{1.5 + 1.5}{2 + 2 + 50} = 55.6 \text{ mA series}$$



$$I_1 + I_2 = I$$

$$I_1 + I_2 = I$$

$\mathcal{E} = 1.5 \text{ V}$  because batteries are in parallel

$$I = \frac{\mathcal{E}}{R} = \frac{1.5}{50} = 30 \text{ mA}$$

b) series  $P = IV$   $P = (55.6 \times 10^{-3})(3) = 166.8 \text{ mW}$

$$V_{\text{tot}} = V_1 + V_2$$

parallel  $P = IV$   $P = (30 \times 10^{-3})(1.5) = 45 \text{ mW}$

$$V_{\text{tot}} = 1.5 \text{ V}$$

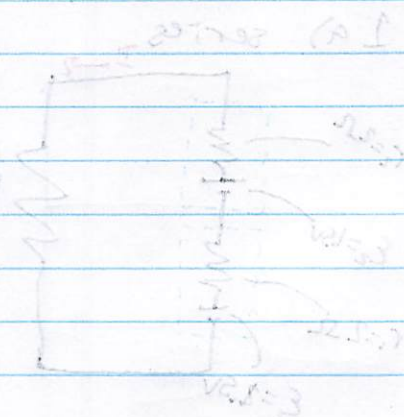
# Current Resistance and DC circuit

$$0 = 3 + 9I - 7I - 3$$

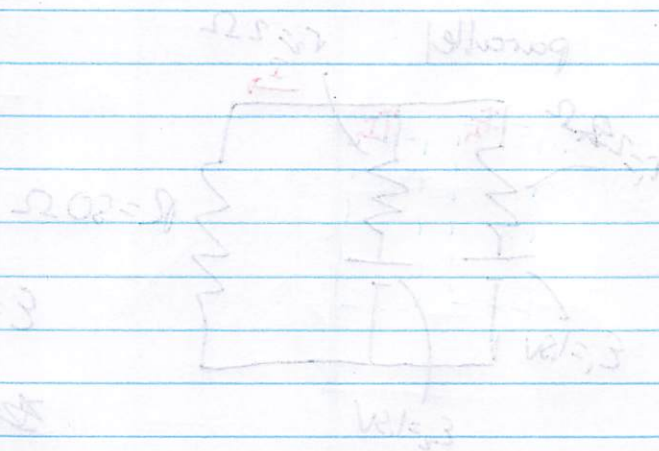
$$9I + 7I = 3 + 3$$

$$(9 + 7)I = 3 + 3$$

$$I = \frac{3 + 3}{9 + 7} = \frac{6}{16} = 0.375 \text{ A}$$



$$I = I + I$$



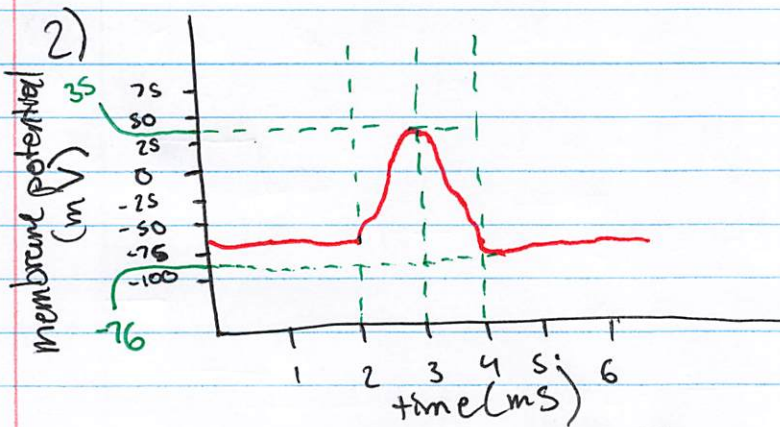
parallel in one resistor and in parallel

$$I = \frac{V}{R} = \frac{20}{2} = 10 \text{ A}$$

$$W_{max} = P = (I^2 R) = (10^2 \times 2) = 200 \text{ W}$$

$$W_{max} = P = (I^2 R) = (10^2 \times 2) = 200 \text{ W}$$





a) pulse width  $\approx 2 \text{ ms}$  2 ms

b) top peak = 35 mV  
bottom peak = -76 mV

$$35 - (-76) = 35 + 76 = \boxed{111 \text{ mV}}$$

$V_{m25} = 2.5 \text{ V}$  (d)  $V_{m25} = 2.5 \text{ V}$  (d)  
 $V_{m25} = 2.5 \text{ V}$  (d)  $V_{m25} = 2.5 \text{ V}$  (d)

$$V_{m11} = 11 \text{ V}$$

$$2 \text{ mV}$$

(cmV/mV)

(mV)  
 (cmV/mV)

