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Physics Midterm

1. a) at r = 1mm $\quad \mathcal{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

E = 2×10^{-3}

$2\times10^{3} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(1\times10^{-3})^2}$

$(2\times10^{-3})(1\times10^{-6}) = \frac{q}{4\pi\varepsilon_0}$

Value at r = 5 mm

$\mathcal{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(5\times10^{-3})^2}$

$\mathcal{E} = 2\times10^{-3}\times10^{-6}\cdot\frac{1}{25\times10^{-6}}$

$\mathcal{E} = 0.08\times10^{-3} \Rightarrow$ **8×10^{-5} V/m**

b) 1μC charge $\mathcal{E}_c = 8.00\times10^{-5}$ V/m

In this the electric field is 3X bigger so we need to multiply $(8\times10^{-5}$ V/m$)$ 3 times 3 because it is a scaling problem

↳ **$= 24\times10^{-3}$ V/m**

2. a) mass = 4×10^{-16} kg $\quad$ Electric field = 6131.25 N/C

let Charge = q

$qE = mg$

$q = \frac{mg}{E} \rightarrow q = \frac{4\times10^{-16}\times9.8}{6131.25} \Rightarrow q = 6.39\times10^{-19}$

We know $q = ne$

$\frac{q}{e} = n \rightarrow n = \frac{6.39\times10^{-19}}{1.6\times10^{-19}} \approx 3.99 \Rightarrow$ **n = 4 electrons**

b) If one electron removed...

$q' = q - e = 4.793\times10^{-19}$

*Find the Forces with an electron removed, find the mass with an electron removed, then find acceleration

Electrostatic Force = qE (Fe)

$F_e = q'E \rightarrow F_e = (4.7934\times10^{-19})(6131.25) = 29\times10^{-5}$

mass of drop is

$m' = m - m_e \approx 4.0\times10^{-16}$ kg

Gravitational Force

$F_g = m'g$

$= 4.0\times10^{-16}\times9.8 \Rightarrow$ **$F_g = 3.92\times10^{-15}$ N**

Acceleration

$a = \frac{F_g - F_e}{m} \rightarrow \frac{3.92\times10^{-15} - 2.939\times10^{-15}}{4\times10^{-16}}$

$a = 2.45$ m/s²

Potential Energy & Voltage, Capacitors

1. a) $KE = qV$

KE hydrogens $= (1.6 \times 10^{-19})(4 \times 10^3)$

$= 6.4 \times 10^{-16}$ J $\Rightarrow$ 3995 electron-volts

$1\text{J} = 6.242 \times 10^{18}(6.4 \times 10^{-16})(6.242 \times 10^{18}) = 3994.88$

Total : 11985 electron-volts

KE Helium $= (2 \times 10^{-19})(4 \times 10^3)$

$= 12.8 \times 10^{-16}$ J $\Rightarrow$ 7990 electron-volts

$1\text{J} = 6.242 \times 10^{18}(12.8 \times 10^{-16})(6.242 \times 10^{18}) = 7989.76$

b) $E = -\frac{\Delta V}{\Delta x} \rightarrow -\frac{4 \times 10^3}{5 \times 10^{-2}}$ $= -8 \times 10^4$ V/m

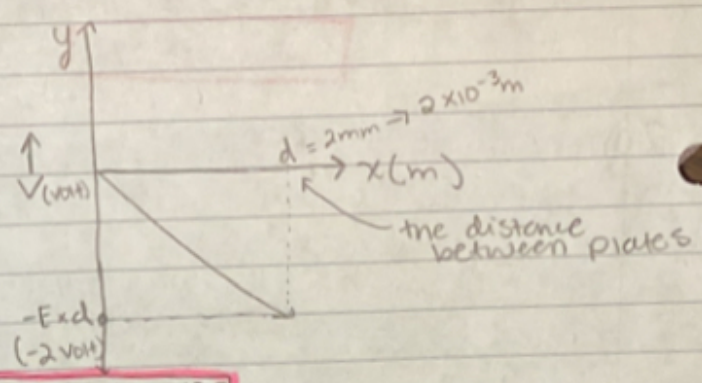
5 cm $\rightarrow 5 \times 10^{-2}$ m

2. $\mathcal{E} = 1000$ V/m

$\rightarrow \mathcal{E} = -\frac{dV}{dx}$ or $V = -\mathcal{E} \times x$

Slope $= -1000$ V/m

+ y intercept is zero



*graph is between V & x is straight line w/ -ve slope

3. a) $C = \frac{\varepsilon_0 A}{d} = \frac{8.85 \times 10^{-12} \times 10^{-4}}{2 \times 10^{-3}}$ $= 4.425 \times 10^{-13}$ F

b) Energy $= \frac{1}{2}CV^2$

$= \frac{1}{2}(4.425 \times 10^{-13})(5)^2$

$= 5.5 \times 10^{-12}$ J

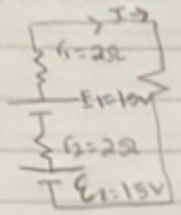
4. To get a system with more capacitance, we should connect the identical capacitors in parallel because in parallel combination capacitance gets added up in parallel combination

$C_{net} = C_1 + C_2 = 2C$

but in series C_{net} becomes $C/2$ so the inverse

Current, Resistance, and DC circuits

1. a) Serial case (3V)



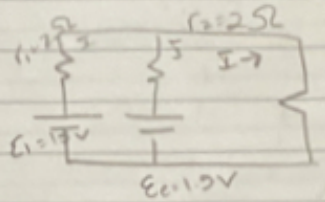
Kirchoff's rule

$-\mathcal{E}_2 + Ir_2 + Ir_1 - E_1 + IR = 0$

$I = \frac{3V}{r_1+r_2+R} = \frac{3}{2+2+50} = \frac{3}{54}$

$= 0.0555\,A \Rightarrow$ 55.6mA

Parallel case



$I = I_1 + I_2$

$\mathcal{E} = 1.5V$ the system is in Parallel

$I = \frac{V}{R}$

$I = \frac{1.5}{50} \rightarrow 0.03 \Rightarrow$ 30mA

b) Power consumption series

$P = IV$

$V_{tot} = V_1 + V_2$

$P = (55.6\times10^{-3})(3) = 0.1668W$

$= 166.8mW$

Power consumption Parallel

$P = IV$

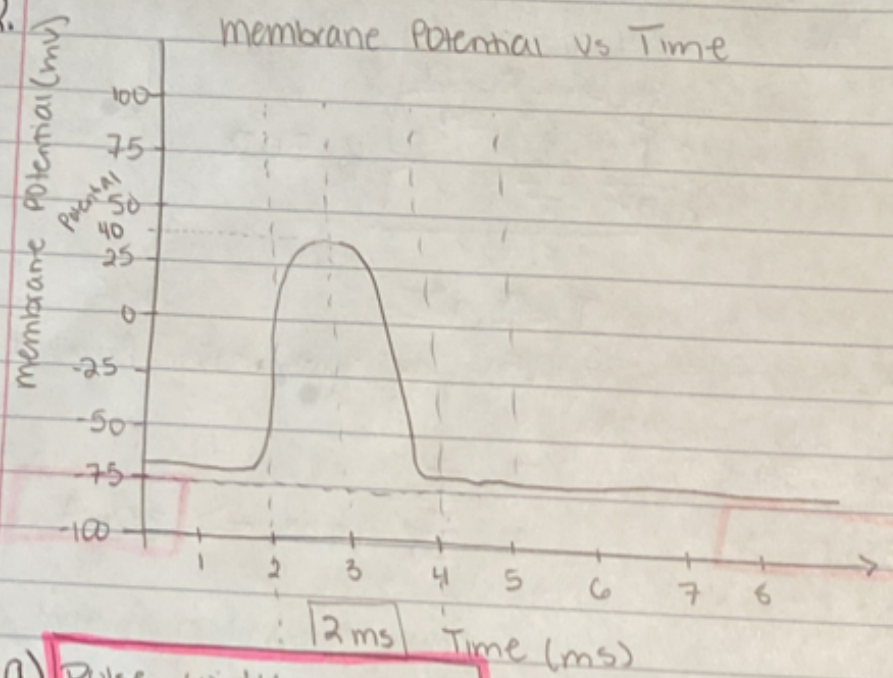
$V_{tot} = 1.5V$

$P = (30\times10^{-3})(1.5) = 0.045$

$= 45mW$

c) Checked on PhET ✓ correct

2.



a) Pulse width is 2ms

b) Peak to Peak voltage

$= 40 - (-75)$

$= 40 + 75$

$V_{peak\,peak} = 115\,mV$