19/20

Midterm

2. Electric Charge and Electric Fields

① a) $E = \frac{1}{4\pi \varepsilon_0} \cdot \frac{q_1}{r^2}$

$2.00\times10^{-3} = \frac{1}{4\pi \varepsilon_0} \cdot \frac{q_1}{(1\times10^{-3})^2}$

$2.00\times10^{-3} \times 1\times10^{-6} = \frac{q}{4\pi \varepsilon_0}$

$E = \frac{1}{4\pi \varepsilon_0} \cdot \frac{q_1}{(5\times10^{-3})^2}$

$E = 2.00\times10^{-3}\times10^{-6} \cdot \frac{1}{25\times10^{-6}}$

$\boxed{E = 0.08\times10^{-3} \text{ or } 8\times10^{-5}\ V/C}$ ✓

b) $E = \frac{1}{4\pi \varepsilon_0} \cdot \frac{q}{r^2}$

$8.00\times10^{-3} = \frac{1}{4\pi \varepsilon_0} \cdot \frac{1\times10^{-6}}{r^2}$

$8.00\times10^{3} = \frac{1}{4\pi \varepsilon_0 r^2}$

$E = \frac{1}{4\pi \varepsilon_0} \cdot \frac{3\times10^{-6}}{r^2}$

$= 8.00\times10^{3} \cdot 3\times10^{-6}$ ✓

$\boxed{E = 24\times10^{-3}\ N/C}$

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

$= \frac{(4\times10^{-16})(9.8)}{6131.25}$

$q = 6.39348\times10^{-19}$

$q = ne \Rightarrow n = \frac{q}{e}$

$= \frac{(6.39348\times10^{-19})}{(1.6\times10^{-19})}$

$\boxed{n = 3.99 \simeq 4}$ ✓

b) $q = q - e$

$= 6.39348\times10^{-19}\,C - 1.60\times10^{-19}\,C$

$q = 4.79348\times10^{-19}\,C$

$F_e = q'E$

$= (4.79348\times10^{-19}\,C)(6131.25\,N/C)$

$F_e = 2.939\times10^{-15}\,N$

$F_g = (4\times10^{-16}\,kg)(9.81\,m/s^2)$

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

$a = \frac{F_g - F_e}{m}$

$= \frac{(3.92\times10^{-15}N) - (2.939\times10^{-15}N)}{4\times10^{-16}\,kg}$

$\boxed{a = 2.4525\ m/s^2}$ ✓

3. Potential Energy and Voltage. Capacitors

① a) $KE = qV$

$KE_{HYD} = (1.6\times10^{-19}\,C)(4\times10^{3}\,V)$ ✓

$\boxed{KE_{HYD} = 6.4\times10^{-16}\,J}$

$KE_{HE} = 2(1.6\times10^{-19}\,C)(4\times10^{3}\,V)$ ✓

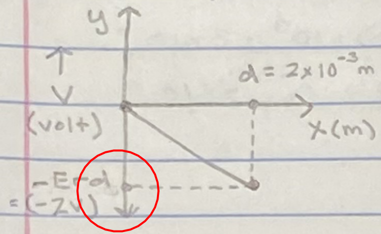
$\boxed{KE_{HE} = 12.8\times10^{-16}\,J}$

b) $E = \frac{\Delta V}{\Delta x}$

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

$\boxed{E = 8\times10^{4}\ V/m}$

(2) $E = 1000\ V/m$



$m = -1000\ V/m$

$\boxed{y = (0,0)}$

(3) a) $C = \frac{\varepsilon_0 A}{d}$

$= \frac{(8.85\times10^{-12} F/m)(1\times10^{-4} m)}{2\times10^{-3} m}$

$\boxed{C = 4.425\times10^{-13} F}$

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

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

$\boxed{Energy = 55.31\times10^{-13} J}$

(4) We should connect the identical capacitor to the first in parallel because capacitance adds up in parallel combination, $C_{net} = C_1 + C_2 = 2C$.

4. Current, Resistance, and DC Circuits

(1) a) $-E_2 + IR_2 + IR_1 - E_1 + IR = 0$

$-1.5V + I(2\Omega + 2\Omega + 50\Omega) - 1.5V = 0$

$\boxed{I = \frac{3V}{54\Omega} = 55.56\ mA}$

$\frac{V_R - 1.5}{2} + \frac{V_R - 1.5}{2} + \frac{V_R}{50} = 0$

$\frac{25V_R - 37.5 + 25V_R - 37.5 + V_R}{50} = 0$

$51V_R = 75$

$V_R = 1.47\ V$

$I_1 = \frac{1.5 - 1.47}{2\Omega} = 15\ mA$

$I_2 = \frac{1.5 - 1.47}{2\Omega} = 15\ mA$

$\boxed{I = 30\ mA}$

b) $P_{TOT} = P_{R_1} + P_{R_2} + P_R$

$= I^2R_1 + I^2R_2 + I^2R$

$= (55.56\,mA)^2 \times 2 + 2(55.56\,mA)^2 + 50(55.56\,mA)^2$

$= 6.17\,mW + 6.17\,mW + 154.34\,mW$

$\boxed{P_{TOT} = 777.51\,mW}$ -1

$mA^2\Omega \neq mW$ because of the squaring

$mA \cdot V = mW$

$P_{TOT} = P_{R_1} + P_{R_2} + P_R$

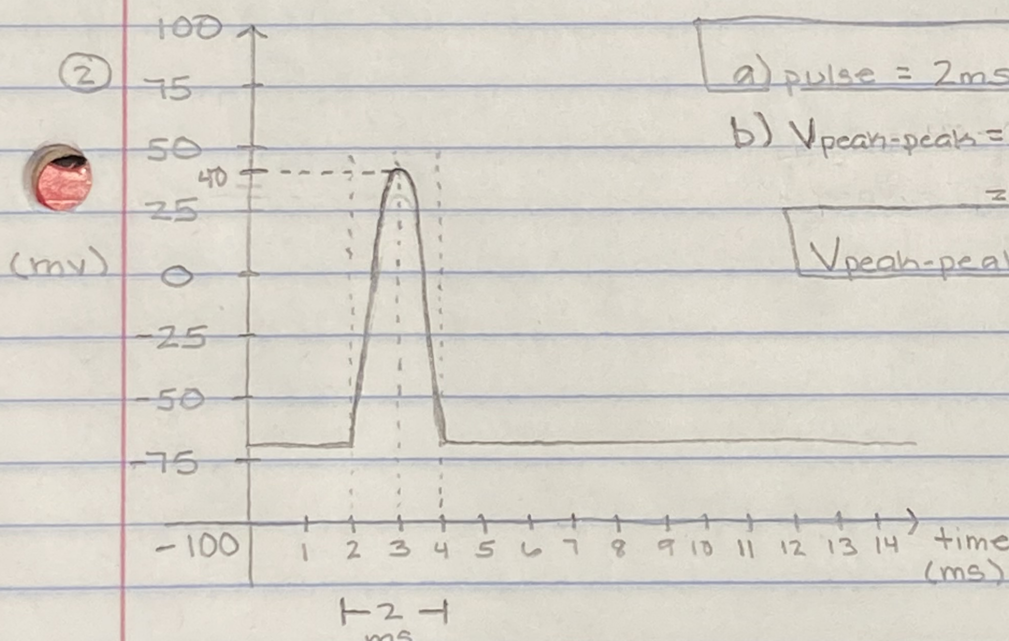
$= I_1^2R_1 + I_2^2R_2 + I^2R$

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

$= 0.45\,mW + 0.45\,mW + 45\,mW$

$\boxed{P_{TOT} = 45.9\,mW}$ ✓

(2)



$\boxed{\text{a) pulse} = 2\,ms}$ ✓

b) $V_{peak\text{-}peak} = 40\,mV - (-75\,mV)$

$= 40\,mV + 75\,mV$

$\boxed{V_{peak\text{-}peak} = 115\,mV}$ ✓