Physics 30 - Lesson 18H
Resistors and Capacitors
Part A

1) / 5

$A = (0.9m) \times (0.025m)$

$A = 0.0225m^2$ ✓

$d = 0.5 \times 10^{-3} m$

$V = 9.0V$

$$C = \varepsilon_o \frac{A}{d} = \left(8.85 \times 10^{-12} C/Nm\right)\left(\frac{0.0225m^2}{0.5 \times 10^{-3} m}\right) ✓$$

$C = 3.98 \times 10^{-10} F$

$\boxed{C = 398\,pF}$ ✓

$Q = CV$ ✓

$Q = (3.98 \times 10^{-10} F)(9.0V)$

$\boxed{Q = 3.58 \times 10^{-9} C}$ ✓

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2) / 3

$V = 9.0V$

$C = 40uF$

$E = ?$

$E = \frac{1}{2} CV^2$ ✓

$E = \frac{1}{2}(40 \times 10^{-6} F)(9.0V)^2$ ✓

$\boxed{E = 1.62 \times 10^{-3} J}$ ✓

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3) / 3

$Q = ?$

$V = 12.0V$

$C = 2.50 \times 10^{-6} F$

$Q = CV$ ✓

$Q = (2.50 \times 10^{-6} F)(12.0V)$ ✓

$\boxed{Q = 3.0 \times 10^{-5} C}$ ✓

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4) / 3

$V = 388V$

$Q = 1500 \mu C$

$C = ?$

$$C = \frac{Q}{V} ✓ = \frac{1500 \times 10^{-6} C}{388V} ✓ = 3.87 \times 10^{-6} C ✓$$

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5) / 6

$E = ?$

$V = ?$

$C = 20 \mu F$

$Q = 300 \mu C$

$d = 2.0 \times 10^{-3} m$

$$V = \frac{Q}{C} ✓ = \frac{300 \mu C}{20 \mu F} ✓ = 15V ✓$$

$$E = \frac{V}{d} ✓ = \frac{15V}{2.0 \times 10^{-3} m} ✓ = 7500V/m ✓$$

$\boxed{E = 7.5 \times 10^3 V/m}$

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6) / 5

$E = ?$

$A = (0.1m)(0.1m)$

$\quad = 0.01m^2$

$d = 3.0\times10^{-3}m$

$Q = 3.00\times10^{-6}C$

$$C = \varepsilon_o \frac{A}{d} = \left(8.85\times10^{-12}C/Nm\right)\left(\frac{0.01m^2}{3.0\times10^{-3}m}\right)$$ ✓

$C = 2.95\times10^{-11}F$ ✓

$$E = \frac{(1/2)Q^2}{2C} = \frac{(1/2)(3.00\times10^{-6}C)^2}{2(2.95\times10^{-11}F)}$$ ✓ ✓

↖ Two plates, equal and opposite

$\boxed{E = 0.31J}$ ✓

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7) / 3

Q

$d' = 2d$

$E' = ?$

$$C = \varepsilon_o \frac{A}{d}$$ ✓

$$E = \frac{(1/2)Q^2}{C} = \frac{(1/2)Q^2}{\left(\varepsilon_o \frac{A}{d}\right)}$$ ✓

$$E \;\alpha\; \frac{1}{\frac{1}{d}}$$ ✓

$E \;\alpha\; d$ so if d↑(2), E↑(2)

If the separation between the plates doubles, then the energy stored should also double (Keeping all else the same!)

Part B

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1) / 4

$If\;\; C_1 = C_2 = C_3 = C$

$Then\;\; C_A = C_2 + C_3 = C + C = 2C$ ✓

$$\frac{1}{C_B} = \frac{1}{C_A} + \frac{1}{C_1}$$ ✓

$$\frac{1}{C_B} = \frac{1}{2C} + \frac{1}{C} = \frac{1}{2C} + \frac{2}{2C} = \frac{3}{2C}$$ ✓

$\therefore \boxed{C_B = \tfrac{2}{3}C}$ ✓

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2) / 3

$t = ?$

$R = 200\times10^3$

$t = ?$

$R = 200\times10^3\Omega$

$C = 3.0\times10^{-6}F$

$t = RC$ ✓

$t = (200\times10^3\Omega)(3.00\times10^{-6}F)$ ✓

$t = 0.6s$ ✓

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3) / 6

A) $C = 1.5\mu F$

$C = C_1 + +C_2 + C_3 + C_4 + C_5 + C_6$ ✓

$$\frac{1}{C} = 1.5\mu F + 1.5\mu F + 1.5\mu F + 1.5\mu F + 1.5\mu F + 1.5\mu F$$ ✓

$\boxed{C = 9\mu F}$ ✓

B) $C = 1.5\mu F$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4} + \frac{1}{C_5} + \frac{1}{C_6} \checkmark$$

$$\frac{1}{C} = \frac{1}{1.5\mu F} + \frac{1}{1.5\mu F} + \frac{1}{1.5\mu F} + \frac{1}{1.5\mu F} + \frac{1}{1.5\mu F} + \frac{1}{1.5\mu F} \checkmark$$

$$\boxed{C = 0.25\mu F} \checkmark$$

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4) By adding a $1\mu F$ capacitor in parallel to the circuit, the new capacitance will be $4\mu F$ ✓

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5) To accomplish this, you would have to add a capacitor in series such that:

$$\frac{1}{x} + \frac{1}{3600\,pF} = \frac{1}{1000\,pF} \checkmark$$

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$$\therefore \frac{1}{x} = \frac{1}{1000\,pF} - \frac{1}{3600\,pF} \checkmark$$

$x = 1384.6\,pF$ (added in series to the circuit) ✓

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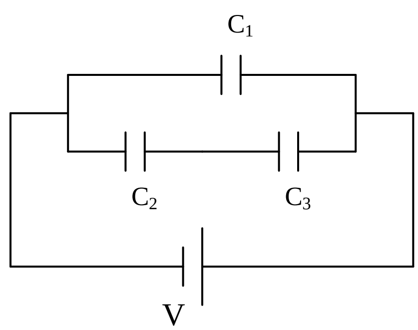
6)



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$$\frac{1}{C_A} = \frac{1}{C_2} + \frac{1}{C_3} \checkmark$$

$$\frac{1}{C_A} = \frac{1}{4.0\mu F} + \frac{1}{4.0\mu F} \checkmark$$

$$C_A = 2.0\mu F \checkmark$$

$$C_B = C_1 + C_A = 2.0\mu F + 4.0\mu F$$

$C_B = 6.0\mu F$ (Total Capacitance) ✓

$$C_1 = C_2 = C_3 = 4\mu F$$

$$V = 50V$$

$$Q = CV$$

$$Q_1 = C_1 V$$
$$Q_1 = (4.0\mu F)(50V)$$
$$Q_1 = 2.0\times10^{-4} C$$
$$\boxed{Q_1 = 20mC} \checkmark$$

$$Q_2 = C_2 V$$
$$Q_1 = (2.0\mu F)(50V)$$
$$Q_1 = 1.0\times10^{-4} C$$
$$\boxed{Q_1 = 10mC} \checkmark$$

$$Q_3 = C_3 V$$
$$Q_1 = (2.0\mu F)(50V)$$
$$Q_1 = 1.0\times10^{-4} C$$
$$\boxed{Q_1 = 10mC} \checkmark$$

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7) <u>Maximum</u>

Hook all the capacitors in parallel

$C_T = C_1 + C_2 + C_3 = 2000\times10^{-12}F + 5000\times10^{-12} + 0.1\times10^{-6}F$ ✓

$\boxed{C_T = 1.07\times10^{-7}F}$ ✓

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<u>Minimum</u>

Hook all the capacitors in series

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{2000\,pF} + \frac{1}{5000\,pF} + \frac{1}{0.1pF}$ ✓

$\boxed{C_T = 1.4\times10^{-9}F}$ ✓

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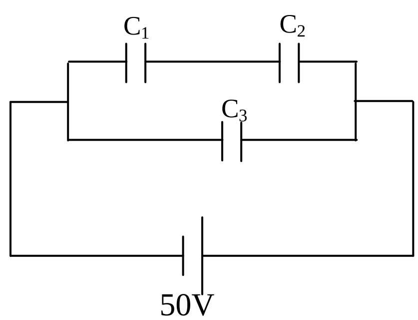
8)



$C_1 = 3.0\mu F$

$C_2 = 4.0\mu F$

$C_3 = 2.0\mu F$

A) $\frac{1}{C_A} = \frac{1}{3.0\mu F} + \frac{1}{4.0\mu F}$

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$C_A = 1.71\mu F$ ✓

$C_T = C_A + C_3 = 1.71\mu F + 2.0\mu F = \boxed{3.7\mu F}$ ✓

B) $Q = CV$

$Q_A = C_A V$

$Q_A = (1.71\mu F)(50V)$ ✓

$Q_A = 8.55\times10^{-5}C$

$Q_3 = C_3 V$

$Q_3 = 2.0\mu F(50V)$ ✓

$Q_3 = 1.0\times10^{-4}C$

$V_1 = \frac{Q_A}{C_1} = \frac{8.55\times10^{-5}C}{3.0\mu F}$

$\boxed{V_1 = 28.5V}$ ✓

$V_2 = \frac{Q_A}{C_2} = \frac{8.55\times10^{-5}C}{4.0\mu F}$

$\boxed{V_2 = 21.4V}$ ✓

$V_3 = \frac{Q_A}{C_3} = \frac{8.55\times10^{-5}C}{2.0\times10^{-6}F}$

$\boxed{V_3 = 50V}$ ✓

9) $f = 70b/\min = 1.17b/\sec$ ✓

$T = \frac{1}{f} = \frac{1}{1.17b/\sec} = 0.857\sec/b$

$C = 7.0\mu F$ ✓

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$t = RC \therefore R = \frac{t}{c} = \frac{0.857\sec/b}{7.0uF}$ ✓

$\boxed{R = 0.122M\Omega}$ ✓