Problem 1, 25 points total. $E = 100\, \text{V}$ and all capacitors are $20\, \mu\text{F}$.

(a) [13 points] How much energy is stored in the capacitor network?

\[ W = \frac{1}{2} C \cdot E^2 = \frac{1}{2} \cdot 20 \mu\text{F} \cdot (100\, \text{V})^2 = 50\, \text{mJ} \, \checkmark \]

\[ \frac{V_1}{C_1} = \frac{60\, \text{V}}{20\, \mu\text{F}} = \frac{3\, \text{V}}{\mu\text{F}} \, \checkmark \]

\[ V_2 = V_3 = \frac{V_4}{C_3} = \frac{3\, \text{V}}{20\, \mu\text{F}} = 0.15\, \text{V} \, \checkmark \]

\[ V_4 = V_5 = E - V_1 - V_2 = 94.85\, \text{V} \, \checkmark \]
Problem 2, 27 points total.

E₂ = 10 V. The current through R₅ is 0.020 A.
R₁ = 100 Ω, R₂ = 200 Ω, R₃ = 300 Ω,
R₄ = 400 Ω, R₅ = 500 Ω, R₆ = 600 Ω.

(a) [7 points] What is E₁?
(b) [7 points] What is the voltage across R₆?
(c) [7 points] How much power is supplied by E₁?

\[ E₁ = \mathcal{L}_{235} \mathcal{R}_{235} \]
\[ = (0.020 A)(1000 Ω) \]
\[ = 20 V \square \]

\[ V₆ = \mathcal{L}_6 \mathcal{R}_6 = \mathcal{L}_{146} \mathcal{R}_6 \]
\[ E₁ + E₂ - \mathcal{L}_{146} \mathcal{R}_{146} = 0 \]
\[ \mathcal{L}_{146} = 27.2 mA \]
\[ V₆ = 16.4 V \square \]

\[ \mathcal{L}_{E₁} = \mathcal{L}_{235} + \mathcal{L}_{146} = 47.2 mA \]
\[ P_{E₁} = \mathcal{L}_{E₁} E₁ = 944 mW \square \]

(d) [6 points] Suppose R₅ was in the shape of a cylinder with radius r and length L.
(i) If the radius was doubled the resistance would (circle one):
\[ \text{decrease} \quad \text{remain the same} \quad \text{increase} \]
(ii) If the length was doubled the current through R₆ would (circle one):
\[ \text{decrease} \quad \text{remain the same} \quad \text{increase} \]
Problem 3, 24 points total. \( E = 10 \text{V}, R_1 = 10 \ \Omega, R_2 = 20 \ \Omega, R_3 = 30 \ \Omega, C = 2 \ \mu\text{F}. \) The switch is initially open and the capacitor is initially uncharged. The switch is then closed.

(a) [12 points] Immediately after the switch is closed, find:
- \( V_1 \), the voltage across resistor \( R_1 \).
- \( i_c \) = the current through \( C \).
- \( P \) = the battery power.

\[ i = \frac{E}{R_1 + R_3} = 0.75 \text{A} \]

\[ V_1 = i R_1 = 2.5 \text{V} \checkmark \]

\[ i_c = i = 0.75 \text{A} \checkmark \]

\[ P = i E = 2.5 \text{W} \checkmark \]

(b) [8 points] A long time after the switch is closed, find:
- \( V_2 \) = voltage across resistor \( R_2 \).
- \( U \) = the energy stored by \( C \).

\[ i = \frac{E}{R_1 + R_2 + R_3} = 0.17 \text{A} \]

\[ V_2 = i R_2 = 3.3 \text{V} \checkmark \]

\[ U = \frac{1}{2} C V_2^2 = \frac{1}{2} C V_c^2 = 11 \ \mu\text{J} \checkmark \]

(c) [4 points] If the switch was opened again, what would be the time constant for the capacitor discharge?

\[ \tau = R_2 C = 40 \ \mu\text{s} \checkmark \]
Problem 4, 24 points total. Following are several unrelated questions.

(A) [9 points] For each circuit below: Circle every capacitor that is in parallel with at least one other capacitor; Draw an “X” through every capacitor that is in series with at least one other capacitor.

(B) [15 points] A solid conducting sphere, radius 1.0 cm, is at a potential of 300 V. (Assume a potential reference of \( V = 0 \) at infinity.)

(i) What is the potential at the center of the sphere?

\[ V = 300 \text{ V} \]  
\( \because \text{the sphere is an equipotential.} \)  

(ii) What is the potential at a distance of 2.0 cm from the center of the sphere?

\[ V(r) = \frac{k \Phi}{r} \]  
\( \text{so} \)  
\[ V(2.0 \text{ cm}) = \frac{1}{2} V(1.0 \text{ cm}) = 150 \text{ V} \)  

(iii) What is the net charge on the sphere? (Reminder: \( k = \frac{1}{4\pi \varepsilon_0} = 8.99 \times 10^9 \frac{Nm^2}{C^2} \))

\[ \Phi = \frac{V(r)}{k} \]  
\[ = \frac{(300 \text{ V})(0.01 \text{ cm})}{k} \approx 0.33 \text{ nC} \)  