Permittivity of free space: $\varepsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$

1) (25 pts) In this figure a 20 V battery is connected across capacitors of capacitances $C_1=2\mu\text{F}$, $C_2=4\mu\text{F}$, $C_3=2\mu\text{F}$, $C_4=12\mu\text{F}$, $C_5=8\mu\text{F}$, and $C_6=8\mu\text{F}$.

a) What is the equivalent capacitance, $C_{eq}$? $C_{eq} =$

b) What is the charge stored by $C_{eq}$? $Q_{eq} =$

c) $V_1 =$

d) $Q_2 =$ (not $Q_1$)

e) $V_4 =$

f) $Q_4 =$

g) $V_5 =$

h) $Q_5 =$
2) (15 pts) In this figure, how much charge is stored on the parallel-plate capacitors by the 30 V battery? On is filled with air, and the other is filled with a dielectric for which \( \kappa = 1.50 \); both capacitors have a plate area of \( 2.0 \times 10^{-3} \text{ m}^2 \) and a plate separation of 10.00 mm.

\[ Q_1 = \underline{\quad} \text{C} \]

\[ Q_2 = \underline{\quad} \text{C} \]
3) (15 pts) A wire 3 m long and 5.00 mm in diameter has a resistance of 10.0 mΩ. A potential difference of 34.0 V is applied between the ends.

a) What is the current in the wire?

b) What is the magnitude of the current density?

c) What is the resistivity of the wire material?
4) (30 pts) In this figure, the resistances are $R_1=1.0 \, \Omega$ and $R_2=2.0 \, \Omega$, and the ideal batteries have emfs $E_1=3.0 \, \text{V}$, $E_2=4.0 \, \text{V}$, and $E_3=5.0 \, \text{V}$. What are

a. size and direction (up or down) of current in battery 1

b. size and direction of current in battery 2

c. size and direction of current in battery 3

d. the potential difference $V_a-V_b$
5) (15 pts) A capacitor with an initial potential difference of 100 V is discharged through a resistor when a switch between them is closed at \( t=0 \). At \( t=5.0 \) s, the potential difference across the capacitor is 2 V. (a) What is the time constant of the circuit? (b) What is the potential difference across the capacitor at \( t=20 \) seconds?

a) time constant= _______________

b) \( V(t=20s) = \) _______________