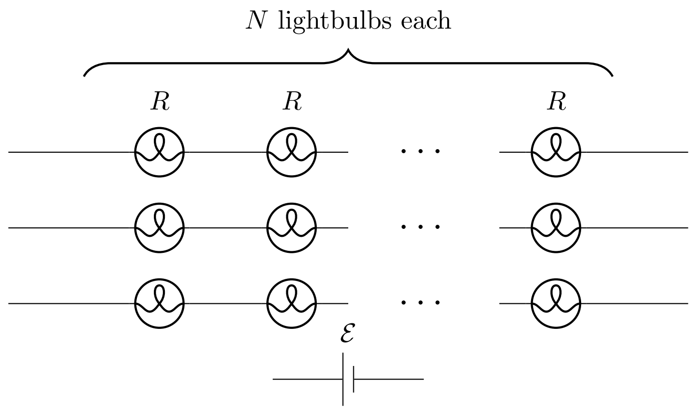
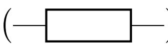
Quiz 2 (compiled : 2026/04/26 at 22:04; version 1)

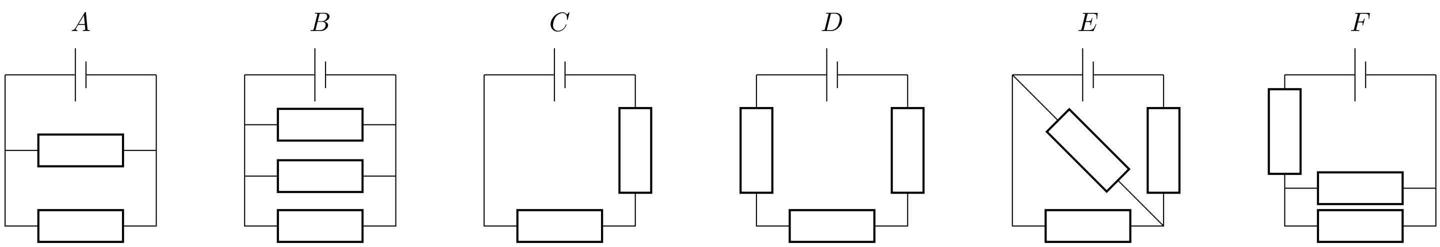
Name:

Student ID:

Problem 1: A set of light strips is sold with three strips and one battery to power them. Each light strip consists of N identical light bulbs, each lightbulb having resistance R, attached one after another on a wire as shown in the figure below. The battery supplies a voltage $\mathcal{E}$. The ends of the light strips can be connected to each other, or to either end of the battery. A designer is thinking of the different ways the strips can be wired together.



Using () to represent each of the strips, the designer considers the following designs, some of which don't use all three strips:



(a) For each of the following pairs of designs, compare the total power of the lightbulbs involved. *(Hint: The power for a group of components can be computed using equivalent resistance, $P = (\Delta V)^2/R_{eq} = I^2 R_{eq}$)*

- A and B : ○ $P_A > P_B$ ○ $P_A < P_B$ ○ $P_A = P_B$ ○ Cannot be determined
- C and D : ○ $P_C > P_D$ ○ $P_C < P_D$ ○ $P_C = P_D$ ○ Cannot be determined
- B and E : ○ $P_B > P_E$ ○ $P_B < P_E$ ○ $P_B = P_E$ ○ Cannot be determined
- E and F : ○ $P_E > P_F$ ○ $P_E < P_F$ ○ $P_E = P_F$ ○ Cannot be determined

(b) Suppose $\mathcal{E} = 120$ V, $R = 10\ \Omega$, and $N = 10$, determine the magnitude of the current through the battery in design E. (Round to 2 decimal places)

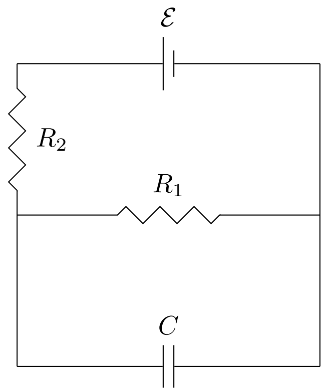
$|I_{E,\text{bat}}| =$ ______ A

(c) Select all expressions that could be a magnitude of the voltage difference across an individual lightbulb in one of the designs above:

☐ $\frac{2\mathcal{E}}{N}$ ☐ $\frac{\mathcal{E}}{N}$ ☐ $\frac{\mathcal{E}}{2N}$ ☐ $\mathcal{E}$ ☐ $\frac{\mathcal{E}}{2}$ ☐ $\frac{\mathcal{E}}{3}$ ☐ $\frac{\mathcal{E}}{3N}$ ☐ $\frac{2\mathcal{E}}{3N}$ ☐ $\frac{\mathcal{E}}{4N}$ ☐ $\frac{\mathcal{E}}{4}$

General Circuits	**Equivalent Resistance**	**Exponential Decay**
$\Delta V_{\text{loop}} = 0,\ I_{\text{in}} = I_{\text{out}},\ \Delta V_{\text{battery}} = \mathcal{E}$ $\Delta V_{\text{resistor}} = -IR,\ \Delta V_{\text{capacitor}} = Q/C$ $P = \lvert I\Delta V\rvert = (\Delta V)^2/R = I^2 R$	$R_{\text{series}} = R_1 + R_2 + \cdots$ $R_{\text{parallel}} = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\cdots}$	$\frac{dy}{dt} = \lambda(y_{\text{eq}} - y)$ $\implies y = (y_0 - y_{\text{eq}})e^{-\lambda t} + y_{\text{eq}}$ $\tau = t_{1/e} = 1/\lambda = RC,\ t_{1/2} = \ln(2)t_{1/e}$

Problem 2: A capacitor with capacitance C is wired 'in parallel' with a resistor R_1. If the capacitor starts discharged, then the battery with voltage difference $\mathcal{E}$ would charge it.



(a) At the moment when the capacitor is still discharged, what is the current through each of the components? *(Hint: Capacitor discharged means $Q = 0$.)*

- Battery : ○ 0 ○ $\mathcal{E}\frac{R_1R_2}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_1+R_2}{R_1R_2}$ ○ $\frac{\mathcal{E}}{R_1}$ ○ $\frac{\mathcal{E}}{R_2}$ ○ $\frac{\mathcal{E}}{R_1+R_2}$
- Resistor 1 : ○ 0 ○ $\mathcal{E}\frac{R_1R_2}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_1+R_2}{R_1R_2}$ ○ $\frac{\mathcal{E}}{R_1}$ ○ $\frac{\mathcal{E}}{R_2}$ ○ $\frac{\mathcal{E}}{R_1+R_2}$
- Resistor 2 : ○ 0 ○ $\mathcal{E}\frac{R_1R_2}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_1+R_2}{R_1R_2}$ ○ $\frac{\mathcal{E}}{R_1}$ ○ $\frac{\mathcal{E}}{R_2}$ ○ $\frac{\mathcal{E}}{R_1+R_2}$
- Capacitor : ○ 0 ○ $\mathcal{E}\frac{R_1R_2}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_1+R_2}{R_1R_2}$ ○ $\frac{\mathcal{E}}{R_1}$ ○ $\frac{\mathcal{E}}{R_2}$ ○ $\frac{\mathcal{E}}{R_1+R_2}$

(b) After a long time, when the capacitor is fully charged, what is the magnitude of the voltage difference across each component? *(Hint: Capacitor fully charged means $I_{capacitor} = 0$)*

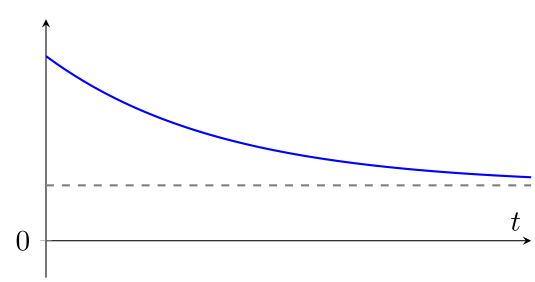
- Battery : ○ 0 ○ $\mathcal{E}$ ○ $\mathcal{E}\frac{R_1}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_2}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_1}{R_2}$ ○ $\mathcal{E}\frac{R_2}{R_1}$
- Resistor 1 : ○ 0 ○ $\mathcal{E}$ ○ $\mathcal{E}\frac{R_1}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_2}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_1}{R_2}$ ○ $\mathcal{E}\frac{R_2}{R_1}$
- Resistor 2 : ○ 0 ○ $\mathcal{E}$ ○ $\mathcal{E}\frac{R_1}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_2}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_1}{R_2}$ ○ $\mathcal{E}\frac{R_2}{R_1}$
- Capacitor : ○ 0 ○ $\mathcal{E}$ ○ $\mathcal{E}\frac{R_1}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_2}{R_1+R_2}$ ○ $\mathcal{E}\frac{R_1}{R_2}$ ○ $\mathcal{E}\frac{R_2}{R_1}$

(c) Suppose $\mathcal{E} = 120$ V, $R_1 = 10\ \Omega$, $R_2 = 10\ \Omega$, and $C = 5$ F.
What is the half-life corresponding to the charging process? (Round to two decimal places)

$t_{1/2} =$ [ ] s

(d) For the graph below, the horizontal axis denotes time, with the capacitor discharged at $t = 0$. Which of the following quantities could be the ones plotted on the vertical axis?

- ☐ $|\Delta V_{\text{battery}}|$ ☐ $|I_{\text{battery}}|$
- ☐ $|\Delta V_{R_1}|$ ☐ $|I_{R_1}|$
- ☐ $|\Delta V_{R_2}|$ ☐ $|I_{R_2}|$
- ☐ $|\Delta V_{\text{capacitor}}|$ ☐ $|I_{\text{capacitor}}|$



General Circuits	**Equivalent Resistance**	**Exponential Decay**
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