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# Series and Parallel Combinations of Resistors and Capacitors

## Given

- Resistances:
  - $R_1 = 1 \, \Omega$
  - $R_2 = 2 \, \Omega$
  - $R_3 = 1 \, \Omega$
  - $R_4 = 2 \, \Omega$
  - $R_5 = 1 \, \Omega$
  - $R_6 = 2 \, \Omega$
- Capacitances:
  - $C_1 = 1 \, \text{F}$
  - $C_2 = 2 \, \text{F}$
  - $C_3 = 2 \, \text{F}$
  - $C_4 = 2 \, \text{F}$
  - $C_5 = 1 \, \text{F}$

## Finding Equivalent Resistance

### Step 1: Combine $R_1$, $R_2$, and $R_3$ in Series

The combined resistance of resistors in series:

$$R_{\text{series}} = R_1 + R_2 + R_3$$

$$R_{\text{series}} = 1\, \Omega + 2\, \Omega + 1\, \Omega = 4\, \Omega$$

**Explanation:** When resistors are in series, their resistances add up.

### Step 2: Combine $R_4$ and $R_5$ in Parallel

The combined resistance of resistors in parallel:

$$\frac{1}{R_{\text{parallel}}} = \frac{1}{R_4} + \frac{1}{R_5}$$

$$\frac{1}{R_{\text{parallel}}} = \frac{1}{2\, \Omega} + \frac{1}{1\, \Omega}$$

$$\frac{1}{R_{\text{parallel}}} = 0.5 + 1$$

$$\frac{1}{R_{\text{parallel}}} = 1.5$$

$$R_{\text{parallel}} = \frac{1}{1.5} = \frac{2}{3} \, \Omega$$

**Explanation:** When resistors are in parallel, the reciprocal of their combined resistance is equal to the sum of the reciprocals of their individual resistances.

### Step 3: Combine the Result from Step 2 with $R_6$ in Series

The combined resistance of resistors in series:

$$R_{\text{total}} = R_{\text{parallel}} + R_6$$

$$R_{\text{total}} = \frac{2}{3} \, \Omega + 2 \, \Omega$$

$$R_{\text{total}} = \frac{2}{3} + 2 = \frac{2}{3} + \frac{6}{3} = \frac{8}{3} \, \Omega$$

$$R_{\text{total}} = 2.67 \, \Omega$$

**Explanation:** Adding resistances in series results in the sum of the resistances.

### Step 4: Combine the Result from Step 1 and Step 3 in Parallel

$$\frac{1}{R_{\text{eq}}} = \frac{1}{R_{\text{series}}} + \frac{1}{R_{\text{total}}}$$

$$\frac{1}{R_{\text{eq}}} = \frac{1}{4\, \Omega} + \frac{1}{2.67\, \Omega}$$

$$\frac{1}{R_{\text{eq}}} = 0.25 + 0.375$$

$$\frac{1}{R_{\text{eq}}} = 0.625$$

$$R_{\text{eq}} = \frac{1}{0.625} = 1.6 \, \Omega$$
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Explanation: The reciprocal of the total resistance of parallel resistors is the sum of the reciprocals of each resistor's resistance.

Finding Equivalent Capacitance

Step 1: Combine C_1 and C_2 in Series

The combined capacitance of capacitors in series:

$$\frac{1}{C_{\text{series}}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_{\text{series}}} = \frac{1}{1 \, \text{F}} + \frac{1}{2 \, \text{F}}$$

$$\frac{1}{C_{\text{series}}} = 1 + 0.5$$

$$\frac{1}{C_{\text{series}}} = 1.5$$

$$C_{\text{series}} = \frac{1}{1.5} = \frac{2}{3} \, \text{F}$$

Explanation: Adding the reciprocals of the capacitances when in series results in the reciprocal of the total capacitance.

Step 2: Combine C_{series} with C_3, C_4 and C_5 in Parallel

The combined capacitance of capacitors in parallel:

$$C_{\text{parallel}} = C_{\text{series}} + C_3 + C_4 + C_5$$

$$C_{\text{parallel}} = \frac{2}{3} \, \text{F} + 2 \, \text{F} + 2 \, \text{F} + 1 \, \text{F}$$

$$C_{\text{parallel}} = \frac{2}{3} + 5$$

$$C_{\text{parallel}} = \frac{2}{3} + \frac{15}{3}$$

$$C_{\text{parallel}} = \frac{17}{3} \, \text{F}$$

$$C_{\text{parallel}} = 5.67 \, \text{F}$$

Explanation: When capacitors are in parallel, their capacitances add up directly.

Final Solutions

Equivalent Resistance: $R_{\text{eq}} = 1.6 \, \Omega$

Equivalent Capacitance: $C_{\text{eq}} = 5.67 \, \text{F}$

These values represent the overall resistance and capacitance of the given circuit.

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