

# Fundamentals and mixed circuits

Solutions · step by step

- 01**
1. Outside the source: positive to negative.
  2. Divide voltage by resistance.
  3.  $I = 20 \text{ mA}$ .

$$I = \frac{6 \text{ V}}{300 \Omega} = 0.020 \text{ A}$$

- 02**
1. Milli means one thousandth:  $4 \text{ mA}$ .
  2. Kilo means one thousand:  $4700 \Omega$ .
  3. Convert units before substitution.

$$0.004 \text{ A} = 4 \text{ mA}; \quad 4.7 \text{ k}\Omega = 4700 \Omega$$

- 03**
1.  $I = 9/470 = 19.15 \text{ mA}$ .
  2.  $P = 81/470 = 0.172 \text{ W}$ .
  3.  $0.125 \text{ W}$  is insufficient; choose a rating with margin.

$$P = \frac{U^2}{R} = \frac{81}{470} \text{ W} \approx 0.172 \text{ W}$$

- 04**
1. Add series resistors:  $550 \Omega$ .
  2. Both carry the same current.
  3.  $11 \text{ V} / 550 \Omega = 20 \text{ mA}$ .

$$R_{\Sigma} = 220 + 330 = 550 \Omega$$

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- 05**
1.  $I = 20 \text{ mA}$ .
  2.  $U_1 = 0.02 \cdot 220 = 4.4 \text{ V}$ ;  $U_2 = 6.6 \text{ V}$ .
  3.  $4.4 \text{ V} + 6.6 \text{ V} = 11 \text{ V}$ .

$$U_1 + U_2 = 4.4 \text{ V} + 6.6 \text{ V} = 11 \text{ V}$$

- 06**
1. Both branches share voltage.
  2. Equal parallel resistors halve the resistance.
  3. Result:  $500 \Omega$ .

$$R_p = \frac{1000 \cdot 1000}{1000 + 1000} = 500 \Omega$$

- 07**
1.  $I_1 = 20 \text{ mA}$ ;  $I_2 = 10 \text{ mA}$ .
  2. Currents add at the node.
  3. Total current:  $30 \text{ mA}$ .

$$I_\Sigma = \frac{6}{300} + \frac{6}{600} = 0.030 \text{ A}$$

- 08**
1. No.
  2. The extra branch allows more current at the same voltage.
  3. Equivalent resistance is below the smallest branch resistance.

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- 09**
1. First replace the parallel group:  $200\ \Omega$ .
  2. Then add  $R_1$ .
  3. Total  $R = 300\ \Omega$ .

$$R_{\Sigma} = 100 + \frac{300 \cdot 600}{300 + 600} = 300\ \Omega$$

- 10**
1. Total  $I = 12/300 = 40\text{ mA}$ .
  2.  $U_1 = 0.04 \cdot 100 = 4\text{ V}$ .
  3.  $R_2$  and  $R_3$  each have  $8\text{ V}$  across them.

$$U_p = 12\text{ V} - 4\text{ V} = 8\text{ V}$$

- 11**
1.  $I_2 = 8/300 = 26.67\text{ mA}$ .
  2.  $I_3 = 8/600 = 13.33\text{ mA}$ .
  3. Sum =  $40\text{ mA}$  = source current.

$$I_2 + I_3 = 26.67 + 13.33 = 40\text{ mA}$$

- 12**
1. Only  $R_1$  and  $R_2$  remain as a current path.
  2. Total  $R = 100 + 300 = 400\ \Omega$ .
  3. Total  $I = 30\text{ mA}$ ; current decreases.

$$I = \frac{12}{400} = 0.030\text{ A}$$

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- 13**
1. The parallel group is bypassed.
  2.  $U_2 = 0 \text{ V}$  and  $I_2 = 0 \text{ A}$ .
  3. Only  $R_1$  limits current: total  $I = 120 \text{ mA}$ .

$$I_{\Sigma} = \frac{12}{100} = 0.120 \text{ A}$$

- 14**
1. Total resistance:  $5 \text{ k}\Omega$ .
  2. Current:  $2 \text{ mA}$ .
  3. Voltage across  $R_2$ :  $6 \text{ V}$ .

$$U_o = 10 \frac{3}{2+3} = 6 \text{ V}$$

- 15**
1.  $R_2$  parallel load =  $1.5 \text{ k}\Omega$ .
  2. Total resistance:  $3.5 \text{ k}\Omega$ .
  3. Output =  $10 \cdot 1.5/3.5 = 4.286 \text{ V}$ .

$$U_o = 10 \frac{1.5}{2+1.5} \approx 4.286 \text{ V}$$

- 16**
1. Output is one quarter of input.
  2. Total resistance must be four times  $R_2$ .
  3.  $R_1 = 4 \text{ k}\Omega - 1 \text{ k}\Omega = 3 \text{ k}\Omega$ .

$$R_1 = R_2 \left( \frac{U_i}{U_o} - 1 \right) = 3 \text{ k}\Omega$$

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- 17**
1. At 4 V:  $P = 16/8 = 2 \text{ W}$ .
  2. At 8 V:  $P = 64/8 = 8 \text{ W}$ .
  3. Double voltage means four times the power.

$$P = \frac{U^2}{R}$$

- 18**
1.  $R_{\min} = 950 \Omega$ ,  $R_{\max} = 1050 \Omega$ .
  2. Minimum I uses maximum R: 4.762 mA.
  3. Maximum I uses minimum R: 5.263 mA.

$$I_{\min} = \frac{5}{1050}; \quad I_{\max} = \frac{5}{950}$$

- 19**
1. Ammeter in series with the current path.
  2. Voltmeter in parallel across the resistor.
  3. An ammeter across the source nearly shorts it.

- 20**
1. Source:  $12 \cdot 0.04 = 0.48 \text{ W}$ .
  2.  $R_1$ : 0.16 W;  $R_2$ :  $64/300 = 0.2133 \text{ W}$ ;  $R_3$ :  $64/600 = 0.1067 \text{ W}$ .
  3. Sum = 0.48 W.

$$P_Q = P_1 + P_2 + P_3 = 0.48 \text{ W}$$