ID Resources: Topic 5– Current and Resistance

1. In a certain circuit, the current as a function of time is given as:

$$i(t) = 3t^2 - 2t$$

where i is measured in milliamps and t is measured in seconds. How much charge passes through this circuit during the interval $0 < t < 5.00\ s$?

A. 28.0 mC

B. 65.0 mC

√ C. 100 mC

D. 150 mC

2. Which of the following statements are true regarding current density?

I. It is the current flowing per unit area
II. It is a vector quantity with a direction opposite to that of the negative charges
III. Its SI unit is Am^{-1}

A. I only

B. II only

C. I and II only

√ D. I, II and III

3. A conductor carries a current of 50 μA. If the area of cross-section of the conductor is 50 mm², then value of the current density is ____.

√ A. $10^{-6}\ Am^{-2}$

B. $10^{-3}\ Am^{-2}$

C. $0.5\ Am^{-2}$

D. $1.0\ Am^{-2}$

4. Ohm's Law states that the potential difference across a device is equal to ____.

√ A. the current flowing through the device times the resistance of the device

B. the current flowing through the device divided by the resistance of the device

C. the resistance of the device divided by the current flowing through the device

D. the current flowing through the device times the cross-sectional area of the device

5. Which of the following are the correct units for conductance and conductivity?

	Conductance	Conductivity
√ A.	Siemens (S)	$(\Omega\text{m})^{-1}$
B.	Ohms (Ω)	Ωm
C.	Ωm	Ohms (Ω)
D.	$(\Omega\text{m})^{-1}$	Siemens (S)

6. A potential difference of 2.0 V is applied across a wire of cross sectional area 2.5 mm^2. The current which passes through the wire is $3.2 \times 10^{-3}\ A$. What is the resistance of the wire?

A. $2.8 \times 10^2\ \Omega$

B. $3.6 \times 10^2\ \Omega$

C. $4.2 \times 10^2\ \Omega$

√ D. $6.3 \times 10^2\ \Omega$

7. Two cylindrical wires, 1 and 2, made of the same material, have the same resistance. If the length of wire 2 is twice that of wire 1, what is the ratio of their cross-sectional areas, A_1 and A_2?

A. $\frac{A_1}{A_2} = 2$

B. $\frac{A_1}{A_2} = 4$

√ C. $\frac{A_1}{A_2} = 0.5$

D. $\frac{A_1}{A_2} = 0.25$

8. Which of the following wires has the largest current flowing through it?

A. a 1 m long copper wire of diameter 1 mm connected to a 10 V battery

B. a 0.5 m long copper wire of diameter 0.5 mm connected to a 5 V battery

√ C. a 2 m long copper wire of diameter 2 mm connected to a 20 V battery

D. a 1 m long copper wire of diameter 0.5 mm connected to a 5 V battery

9. A particular wire has a diameter of 1.7 mm and length of 1.3 m. If its resistance is 15 mΩ, what is the resistivity of the metal from which it is made?

A. 1.0×10^{-7} Ωm

√ B. 2.6×10^{-8} Ωm

C. 4.4×10^{-6} Ωm

D. 1.8×10^{-5} Ωm

10. A 20 cm long and 1.0 mm diameter thick copper wire of resistivity 1.7×10^{-8} Ωm is connected across a 3.0 V battery. The current through the wire is ___.

A. 7.00 A

B. 125 A

√ C. 693 A

D. 789 A

11. A copper wire of diameter 2.0 mm carries 12 A of current for an electric stove. Assuming the resistivity of copper of 1.7×10^{-8} Ω.m, the power dissipated in 2.0 m length of the wire is ___.

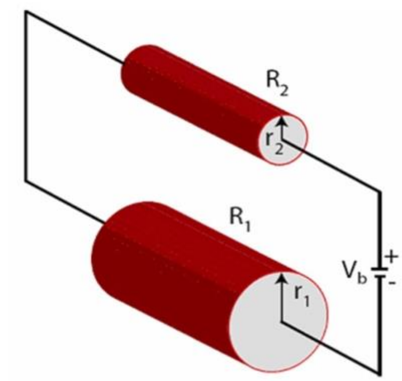
A. 0. 72 W

B. 0. 98 W

C. 1.44 W

√ D. 1.56 W

12. Two cylinders are made out of the same material and are of equal length as shown. The cylinders are connected to a battery with voltage V_b. If the voltage drop across resistor R_2 is $0.810 \times V_b$, what is the ratio of the radii r_1/r_2 of the two cylinders?



A. 1.10

B. 1.51

√ C. 2.06

D. 3.31

13. The emf (electromotive force) is an ______.

A. electric force vector

B. electric field vector

√ C. electric potential produced by a source

D. electric current

14. A resistor with R = 10.0 Ω is connected across a source of emf with potential difference V_{emf} = 1.50 V. What is the current flowing though the circuit?

√ A. 0.15 A

B. 0.23 A

C. 6.67 A

D. 150 A

15. N identical resistors are connected in series. The resistance of one of them is equal to R. What is the equivalent resistance of all N resistors?

A. R/N

B. N/R

C. R

√ D. NR

16. You make a series combination using a resistor A having a very large resistance and a resistor B having a very small resistance. The equivalent resistance of this combination will be

√ A. slightly greater than the resistance of the resistor A

B. slightly less than the resistance of the resistor A

C. slightly greater than the resistance of the resistor B

D. slightly less than the resistance of the resistor B

17. In the diagram below the current in the 3.0 Ω resistor is 4.0 A. The potential difference between points A and B must be _____.

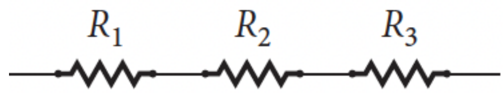
A. 0.80 V

B. 1.25 V

C. 12 V

√ D. 20 V

18. Three identical resistors, R_1, R_2, and R_3, are wired together as shown in the figure. An electric current is flowing through the three resistors. The current through R_2 _____.



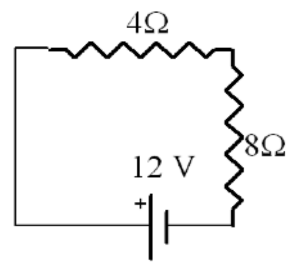
√ A. is the same as the current through R_1 and R_3

B. is a third of the current through R_1 and R_3

C. is twice the sum of the current through R_1 and R_3

D. is three times the current through R_1 and R_3

19. What is voltage across the 8 Ω resistor?



A. ¼ V

B. 4 V

√ C. 8 V

D. 12 V

20. A battery has an unloaded terminal voltage of 48 V. When a load of 15 Ω is connected to the battery, the terminal voltage drops to 45.4 V. What is the internal resistance of the battery?

√ A. 0.86 Ω

B. 1.0 Ω

C. 1.2 Ω

D. 1.3 Ω

21. A battery has an internal resistance of 1.3 Ω and a voltage of 48 V. What is the load resistance which causes the voltage to drop to 45.4 V?

A. 0.587 Ω

B. 1.37 Ω

C. 2.63 Ω

√ D. 22.7 Ω

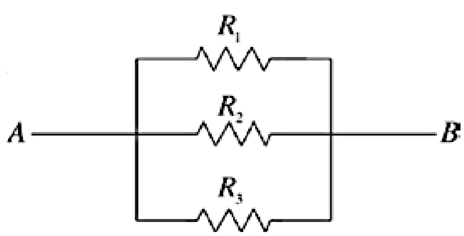
22. A battery has an internal resistance of 1.3 Ω and a voltage of 48.0 V. If a load of 15.0 Ω is connected to the battery, what is the voltage across the terminals of the battery?

A. 39.6 V
√ B. 44.2 V
C. 45.4 V
D. 48.0 V

23. N identical resistors are connected in parallel. The resistance of one of them is equal to R. What is the equivalent resistance of all N resistors?

√ A. R/N
B. N/R
C. R
D. NR

24. What is the equivalent resistance of the circuit shown if $R_1 = 24\ \Omega$, $R_2 = 40\ \Omega$, $R_3 = 16\ \Omega$?



√ A. 7.7 Ω
B. 10 Ω
C. 56 Ω
D. 61 Ω

25. You make a parallel combination using a resistor A having a very large resistance and a resistor B having a very small resistance. The equivalent resistance of this combination will be

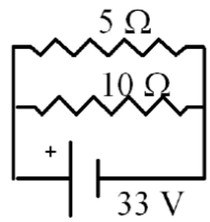
A. slightly greater than the resistance of the resistor A
B. slightly less than the resistance of the resistor A
C. slightly greater than the resistance of the resistor B
√ D. slightly less than the resistance of the resistor B

26. Two identical light bulbs are connected to a battery. Will the light bulbs be brighter if they are connected to the battery in series or in parallel?

A. in series
√ B. in parallel
C. The brightness will be the same in series and in parallel
D. There is not enough information to determine an answer

Questions 27 to 29

Two resistors are connected to a battery as shown in the figure below.



27. What is the current in the 5 Ω resistor?

A. 2.2 A
B. 3.3 A
√ C. 6.6 A
D. 9.9 A

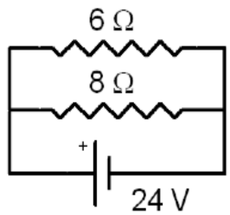
28. What is the current in the 10 Ω resistor?

A. 2.2 A
√ B. 3.3 A
C. 6.6 A
D. 9.9 A

29. What is the current supplied by the battery?

A. 2.2 A
B. 3.3 A
C. 6.6 A
√ D. 9.9 A

30. What is the total power dissipated in both resistors?



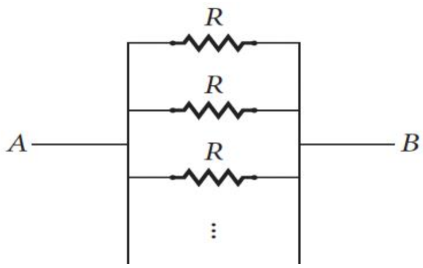
A. 0.68 W

B. 5.2 W

C. 12.3 W

√ D. 168 W

31. As more identical resistors, R, are added to the circuit shown in the figure, the resistance between points A and B will ___.



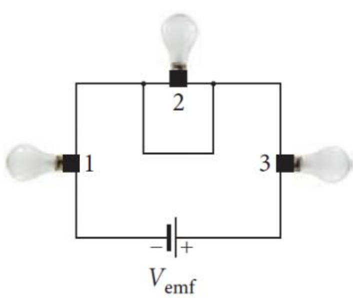
A. increase

√ B. decrease

C. stay the same

D. Change in an unpredictable manner

32. Three light bulbs are connected in series with a battery that delivers a constant potential difference, V_{emf}. When a wire is connected across light bulb 2 as shown in the figure, light bulbs 1 and 3 ___.



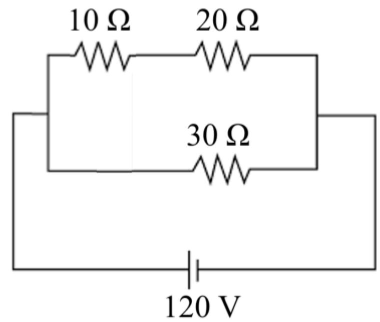
A. burn just as brightly as they did before the wire was connected.

√ B. burn more brightly than they did before the wire was connected

C. burn less brightly than they did before the wire was connected

D. go out

33. A 10 ohm resistor is attached to a 20 ohm resistor in series. This combination is then attached to a 30 ohm resistor in parallel. This is then connected to a 120 V battery. What is the current flow through the 20 ohm resistor?



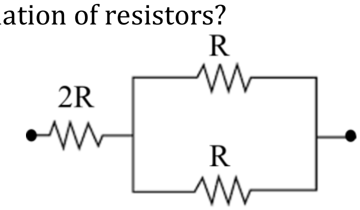
√ A. 4.0 A

B. 6.0 A

C. 8.0 A

D. 16 A

34. Two resistors of resistance R are connected in parallel. The combination is connected in series to a resistor of resistance $2R$. What is the resistance of this combination of resistors?



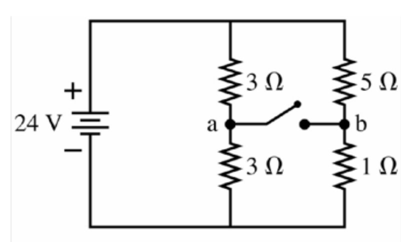
A. 0.5 R

B. R

C. 1.0 R

√ D. 2.5 R

35. What is the battery current I_{bat} when the switch in the figure is closed?



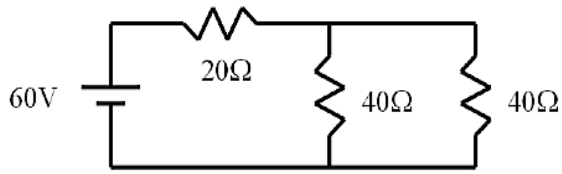
A. 1.09 A

B. 8.00 A

√ C. 9.14 A

D. 12.5 A

36. What is the current in the 20 Ω resistor in the circuit in the figure?



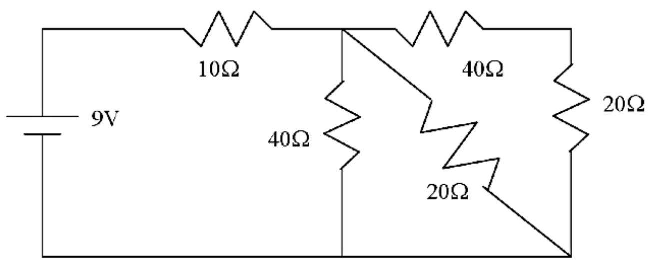
A. 0.33 A

B. 0.60 A

C. 1.0 A

√ D. 1.5 A

37. What is the current that flows out of the ideal 9.0 V battery in the circuit in the figure?



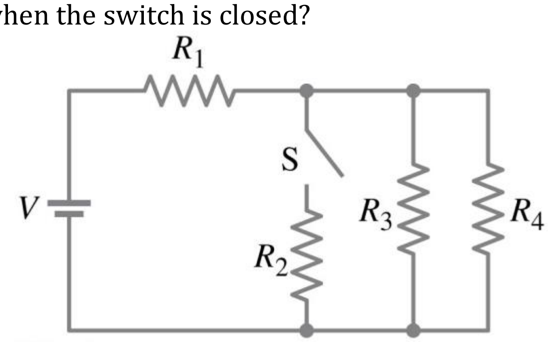
A. 0.07 A

√ B. 0.43 A

C. 0.54 A

D. 0.90 A

38. What happens to the voltage across the resistor R_4 when the switch is closed?



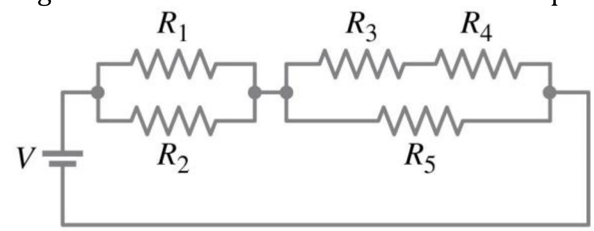
A. Increases

√ B. Decreases

C. Stays the same

D. Increases and then decreases

39. Which resistor has the greatest current going through it? Assume that all the resistors are equal.



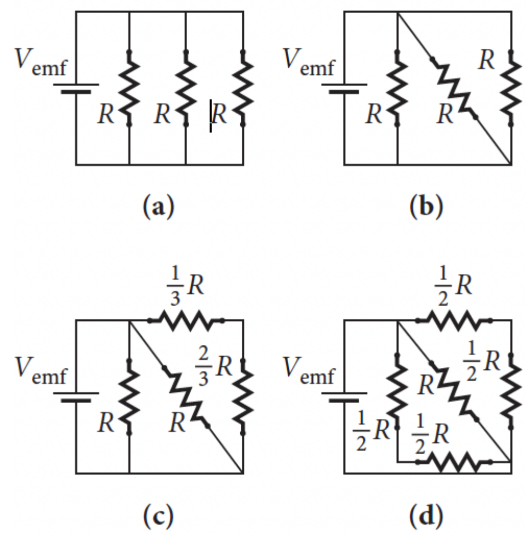
A. R_1

√ B. R_5

C. R_3 and R_4

D. R_1 and R_2

40. Which combination of resistors has the highest equivalent resistance?



√ A. Combination (a)

B. Combination (b)

C. Combination (c)

D. Combination (d)

E. The equivalent resistance is the same for all the four circuits

41. How much energy is used by a 15 W electric motor if it operates for half an hour?

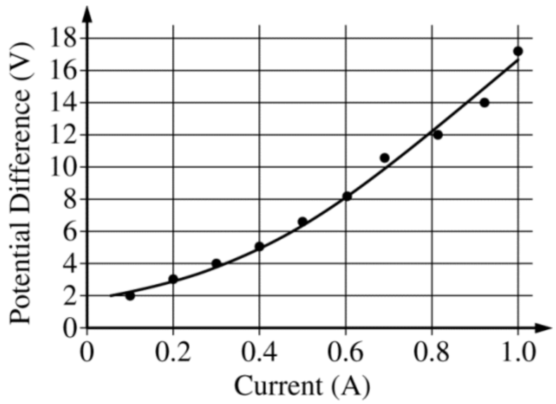
A. 127 J

B. 450 J

C. 9000 J

√ D. 27000 J

42. The graph below shows experimental data for the potential difference across a lightbulb as a function of the current through the light bulb. The power dissipated by the lightbulb when the potential difference across the bulb is 12 V is most nearly ____.



A. 0.067 *W*

B. 7.7 *W*

√ C. 9.6 *W*

D. 12 *W*

43. If the current through a resistor is increased by a factor of 4, how does this affect the power dissipated?

A. It decreases by a factor of 4

B. It increases by a factor of 4

C. It decreases by a factor of 8

√ D. It increases by a factor of 16

44. If the electric [potential across a resistor is increased by a factor of 4, how does this affect the power dissipated?

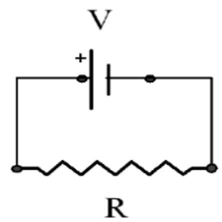
A. It decreases by a factor of 4

B. It increases by a factor of 4

C. It decreases by a factor of 8

√ D. It increases by a factor of 16

45. In order to double the power dissipated in the resistor R, _____.



A. double the resistance R

B. double the voltage V

√ C. increase the voltage V by about 40%.

D. decrease the resistance R by a factor of four

46. Two lightbulbs operate at 120 V, but one has a power rating of 25 W while the other has a power rating of 100 W. Which one has the greater resistance?

A. The 25 W bulb

√ B. The 100 W bulb

C. Both have the same resistance

D. Resistance is independent of power

47. A fixed voltage is applied across the length of a tungsten wire. An increase in the power dissipated by the wire would result if which of the following could be increased?

A. The resistivity of the tungsten

√ B. The cross-sectional area of the wire

C. The length of the wire

D. The temperature of the wire

48. Copper wire *A* has twice the length and half the diameter of copper wire *B*, but carries the same current *I*. If *P* is the rate at which energy is dissipated in wire *B*, what is the rate at which energy is dissipated in wire *A*?

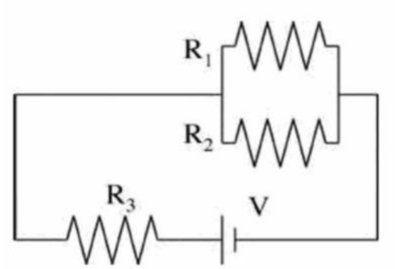
A. P/8

B. P/4

C. 4P

√ D. 8P

49. In the circuit shown, $R_1 = 9.00\ \Omega$, $R_2 = 14.0\ \Omega$, $R_3 = 2.50\ \Omega$, and $V = 16.0\ V$. Find the total power dissipated in the circuit in W.



A. 2.00 W

B. 10.1 W

C. 22.1 W

√ D. 32.1 W

50. A 12.0 V battery is connected to a 7.54 ohm resistor and a current of 0.999A is measured to flow through the resistor. How much power is dissipated as heat inside the battery?

√ A. 4.47 W

B. 7.10 W

C. 12.0 W

D. 19.1 W

Free Response:

1. True or False.

a. Two wires made of different materials, but of same length and area of cross section, have the same resistivity. (False)

b. Conductors of the same material with different geometries have different resistances. (True)

c. Conductors of the same material with different geometries have the same resistivity. (True)

d. The resistance of a copper wire of constant cross-sectional area is directly proportional to its length. (True)

e. The resistance of a copper wire of constant length is directly proportional to its cross-sectional area. (False)

2. A copper wire 3.2 mm in diameter carries a 5.0 A current. Determine the current density in the wire.

$$j = \frac{I}{A} = \frac{I}{\pi r^2}$$

$$j = \frac{5.0\ A}{\pi(1.6 \times 10^{-3}\ m)^2} = 6.2 \times 10^5\ Am^{-2}$$

3. What is the resistance of a copper wire of length $l = 10.9\ m$ and diameter $d = 1.30\ mm$? The resistivity of copper is $1.72 \times 10^{-8}\ \Omega m$.

$$R = \frac{\rho L}{A} = (1.72 \times 10^{-8}\ \Omega m)\left(\frac{10.9\ m}{\pi(0.65 \times 10^{-3}\ m)^2}\right) = 0.141\ \Omega$$

4. A potential difference of 12.0 V is applied across a wire of cross-sectional area 4.50 mm² and length 1000 km. The current passing through the wire is $3.20 \times 10^{-3} A$.

a. What is the resistance of the wire?

$$R = \frac{V}{I} = \frac{12.0\ V}{3.20 \times 10^{-3} A} = 3750\ \Omega$$

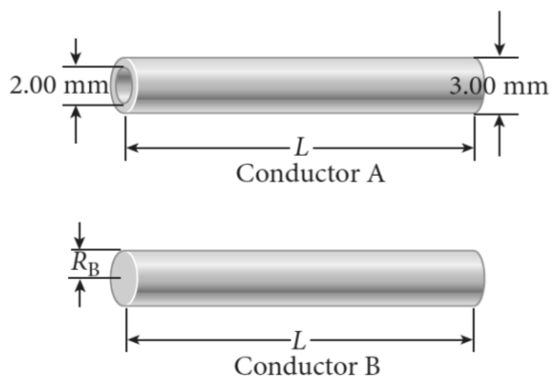
b. What is the resistivity of the wire?

$$\rho = \frac{RA}{l} = \frac{(3750\ \Omega)(4.50 \times 10^{-6}\ \text{m}^2)}{1000\ 000\ m} = 1.69 \times 10^{-8}\ \Omega m$$

c. What is the conductivity of the wire?

$$\sigma = \frac{1}{\rho} = \frac{1}{1.69 \times 10^{-8}\ \Omega m} = 5.92 \times 10^{7} (\Omega m)^{-1}$$

5. Two conductors are made of the same material and have the same length L. Conductor A is a hollow tube with inside diameter 2.00 mm and outside diameter 3.00 mm; conductor B is a solid wire with radius R_B. What value of R_B is required for the two conductors to have the same resistance measured between their ends?

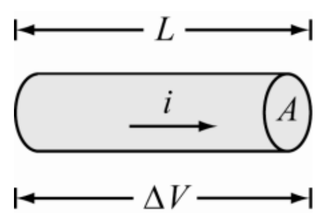


The resistance will be the same when their cross-sectional areas are the same.

$$\pi {R_B}^2 = \pi \left(\frac{d_o}{2}\right)^2 - \pi \left(\frac{d_i}{2}\right)^2 \Rightarrow R_B = \frac{1}{2}\sqrt{{d_0}^2 - {d_i}^2}$$

$$R_B = \frac{1}{2}\sqrt{(3.00\ mm)^2 - (2.00\ mm)^2} = 1.12\ mm$$

6. A potential difference of 12.0 V is applied across a wire of cross-sectional area 4.50 mm^2 and length 1000 km. The current passing through the wire is $3.20 \times 10^{-3}\ A$.



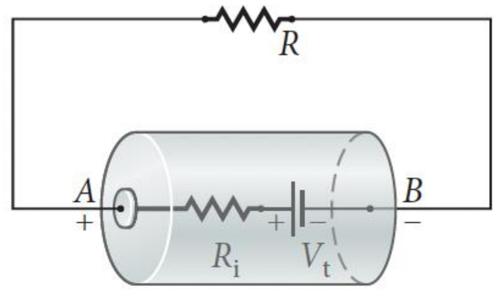
a. What is the resistance of the wire?

$$R = \frac{\Delta V}{I} = \frac{12.0\ V}{3.20 \times 10^{-3}\ A} = 3750\ \Omega$$

b. What is the resistivity of the wire?

$$\rho = \frac{RA}{l} = \frac{(3750\ \Omega)(4.50 \times 10^{-6}\ m^2)}{1000 \times 10^3\ m} = 1.69 \times 10^{-8}\ \Omega m$$

7. Consider a battery that has V_t = 15.0 V when it is not connected to a circuit. When a 10.0 Ω resistor is connected with the battery, the potential difference across the battery's terminals drops to 12.5 V. What is the internal resistance of the battery?



The current flowing through the resistor:

$$I = \frac{V}{R} = \frac{12.5\ V}{10.0\ \Omega} = 1.25\ A$$

$V_t = IR_{eq} = I(R + R_i)$

$15.0\ V = (1.25\ A)(10\ \Omega + R_i)$

R_i =2.0 Ω

8. A battery with an emf of $\mathcal{E} = 12.0\ V$ has a terminal voltage of 11.5 V when the current is $I = 3.0\ A$.

a. Calculate the battery's internal resistance r.

$\mathcal{E} = IR + Ir$

$12.0\ V = 11.5\ V + (3.0\ A)r$

$$r = \frac{0.5\ V}{3.0\ A} = 0.17\ \Omega$$

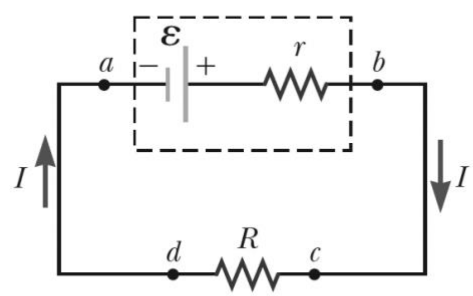
b. Find the load resistance R .

$$R = \frac{V}{I} = \frac{11.5\ V}{3.0\ A} = 3.8\ \Omega$$

9. The figure shows a battery of emf $\mathcal{E}$ and internal resistance $r = 0.15\ \Omega$ connected to an external resistor $R = 8.00\ \Omega$.

a. Find the current in an 8.00 Ω resistor if the voltage across the battery (the terminal voltage) is 9.00 V.

$$I = \frac{V}{R} = \frac{9.00\ V}{8.00\ \Omega} = 1.13\ A$$



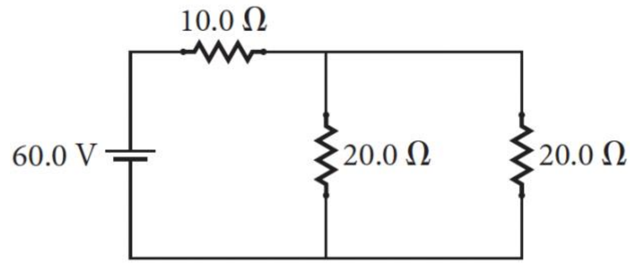
b. What is the emf of the battery?

$\mathcal{E} = IR + Ir$

$\mathcal{E} = 9.00\ V + (1.13\ A)(0.15\ \Omega)$

$\mathcal{E} = 9.17\ V$

10. The figure below shows three resistors connected in a circuit.



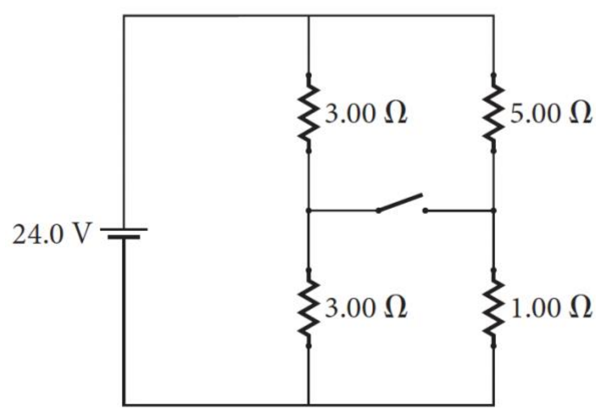
a. What is the equivalent resistance of the circuit?
The two 20 Ω resistors are in parallel with each other.
$$\frac{1}{R_P} = \frac{1}{20\ \Omega} + \frac{1}{20\ \Omega} = \frac{1}{10\ \Omega}$$
$$R_P = 10\ \Omega$$

$$R_{eq} = 10\ \Omega + R_P = 10\ \Omega + 10\ \Omega = 20\ \Omega$$

b. What is the current through the 10 Ω resistor?
$$I = \frac{V}{R_{eq}} = \frac{60.0\ V}{20\ \Omega} = 3.0\ A$$

c. What is the voltage across the 20 Ω resistors?
$$V = IR_P = (3.0\ A)(10\ \Omega) = 30\ V$$

11. The figure below shows a circuit with four resistors.



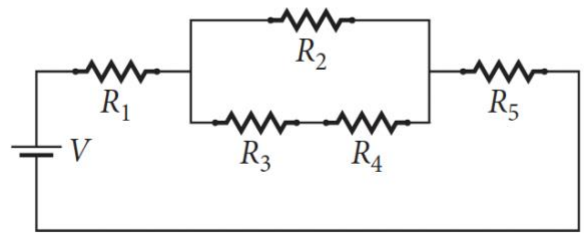
a. What is the equivalent resistance of the circuit when the switch is open?
$$R_{eq} = \left(\frac{1}{R_1 + R_2} + \frac{1}{R_3 + R_4}\right)^{-1}$$
$$R_{eq} = \left(\frac{1}{3.00\ \Omega + 3.00\ \Omega} + \frac{1}{5.00\ \Omega + 1.00\ \Omega}\right)^{-1}$$
$$R_{eq} = 3.00\ \Omega$$

b. What is the current in the circuit when the switch is open?
$$I = \frac{V}{R_{eq}} = \frac{24.0\ V}{3.00\ \Omega} = 8.00\ A$$

c. What is the equivalent resistance of the circuit when the switch is closed?
$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_3}\right)^{-1} + \left(\frac{1}{R_2} + \frac{1}{R_4}\right)^{-1}$$
$$R_{eq} = \left(\frac{1}{3.00\ \Omega} + \frac{1}{5.00\ \Omega}\right)^{-1} + \left(\frac{1}{3.00\ \Omega} + \frac{1}{1.00\ \Omega}\right)^{-1}$$
$$R_{eq} = 1.88\ \Omega + 0.75\ \Omega = 2.63\ \Omega$$

d. What is the current in the circuit when the switch is closed?
$$I = \frac{V}{R_{eq}} = \frac{24.0\ V}{2.63\ \Omega} = 9.14\ A$$

12. For the circuit shown in the figure, $R_1 = 6.00\ \Omega$, $R_2 = 6.00\ \Omega$, $R_3 = 2.00\ \Omega$, $R_4 = 4.00\ \Omega$, $R_5 = 3.00\ \Omega$, and the potential difference is 12.0 V.



a. What is the equivalent resistance for the circuit?

$$R_{eq} = R_1 + \left(\frac{1}{R_2} + \frac{1}{R_3 + R_4}\right)^{-1} + R_5$$

$$R_{eq} = 6.00\ \Omega + \left(\frac{1}{6.00\ \Omega} + \frac{1}{2.00\ \Omega + 4.00\ \Omega}\right)^{-1} + 3.00\ \Omega$$

$$R_{eq} = 6.00\ \Omega + 3.00\ \Omega + 3.00\ \Omega = 12.0\ \Omega$$

b. What is the current through R_5?

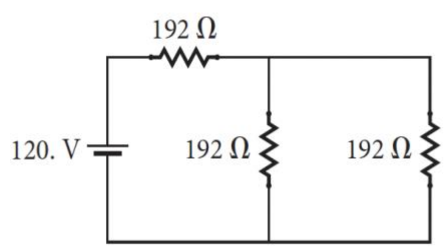
$$I = \frac{V}{R_{eq}} = \frac{12.0\ V}{12.0\ \Omega} = 1.00\ A$$

c. What is the potential drop across R_3?

The current through each branch is $I/2$, so potential across R_3:

$$V_3 = \frac{IR_3}{2} = \frac{(1.00\ A)(2.00\ \Omega)}{2} = 1.00\ V$$

13. Three resistors are connected across a battery as shown in the figure.



a. What is the equivalent resistance of the circuit?

$$R_{eq} = 192\ \Omega + \left(\frac{1}{192\ \Omega} + \frac{1}{192\ \Omega}\right)^{-1}$$

$$R_{eq} = 192\ \Omega + 96\ \Omega = 288\ \Omega$$

b. How much power is dissipated across the three resistors?

$$P = \frac{V^2}{R_{eq}} = \frac{(120\ V)^2}{288\ \Omega} = 50\ W$$

c. Determine the potential drop across each resistor.

Current from the supply:

$$I = \frac{V}{R_{eq}} = \frac{120\ V}{288\ \Omega} = 0.417\ A$$

$$V_1 = IR_1 = (0.417\ A)(192\ \Omega) = 80\ V$$

$$V_2 = V_3 = IR_P = (0.417\ A)(96\ \Omega) = 40\ V$$