Chapter Problems

Electric Current

Classwork

1. If 560 C of electric charge passed through a light bulb in 8 min; what was the magnitude of the average electric current passing through the bulb?

2. If the current through a resister were 0.5 A; how much electric charge would flow through it in 2 min?

3. How long would it take for 300 C of electric charge to pass through an aluminum wire if the current through it is 0.6 A?

Homework

4. What is the magnitude of the electric current passing through the heating coil of a hot plate if 25 C of charge passes through it in 8 s?

5. An average current of 4 A flows through a pair of automotive headlights: how much electric charge flows through them in 5 h?

6. How long will it take for 400 C of electric charge to pass through a copper wire if the current through it is 1.5 A?

Ohm's Law

Classwork

7. An electric iron with a resistance of 49 Ω is connected to an electrical line with 120 V of voltage. What is the current in the iron?

8. How much voltage must be applied across a 0.35 Ω wire in order to create a 30 A current?

9. A 0.5 A current flows through a light bulb when 120 V is applied across it: what is the resistance of the light bulb?

Homework

10. Calculate the electric current in a wire, whose resistance is 0.45 Ω, if the applied voltage is 9 V.

11. How much voltage is needed in order to produce a 0.25 A current through a 360 Ω resistor?

12. What is the resistance of a rheostat coil, if 0.05 A of current flows through it when 6 V is applied across it?

Resistivity

Classwork (Resistivities for materials can be found in Appemdix A)

Be sure to convert areas expressed in mm^2 to m^2. Remember 1 m^2 = 10^6 mm^2

13. What is the resistance of a 2 m long tungsten wire whose cross-sectional area of 0.15 mm^2?

14. An aluminum wire with a length of 9.43 x 10^5 m and cross-sectional area of 10 mm^2 has a resistance of 2.5 Ω. What is the resistivity of the wire?

15. What is the length of a 10 Ω copper wire whose diameter is 3.2 mm?

16. What diameter of 100 m long copper wire would have a resistance of 0.10 Ω?

Homework

17. What is the resistance of a 150 m long nichrome wire with a cross-sectional area 0.4 mm^2?

18. A metal wire is 7.2 cm long and 3.25 mm in diameter. What is the resistivity of the wire if its resistance is 1.75 Ω?

19. What length of 2.6 mm diameter aluminum wire would have a resistance of 40 Ω?

20. If a long iron wire has a resistance of 12 Ω and a length of 7 m, what is its diameter?

Electric Power

Classwork

21. What is the power consumption of a light bulb that draws a current of 0.5 A when connected across 120 V?

22. A toy car's electric motor has a resistance of 17 Ω; find the power delivered to it by a 6-V battery.

23. A 9.6 A electric current flows through an electric oven with a resistance of 25 Ω. What is the power dissipated in the oven?

24. When 12 V is applied across a resistor it generates 350 W of heat: what is the magnitude of its resistance?

25. A 30 Ω toaster consumes 560 W of power: how much current is flowing through the toaster?

26. How much voltage must be applied across a 45 Ω light bulb filament in order for it to consume 75 W of power?

Homework

27. What is the power consumption of a flash light bulb that draws a current of 0.28 A when connected to a 6 V battery?

28. A hair dryer's electric motor has a resistance of 24 Ω: how much power is delivered to it by a 120-V power supply?

29. What power does a toaster with 15 A of current and 20 Ω of resistance consume?

30. A mobile phone consumes 3.5 W of power when connected to a 9-V battery. What is the resistance of the player?

31. A 40 Ω electric motor consumes 350 W of power. How much current flows through the motor?

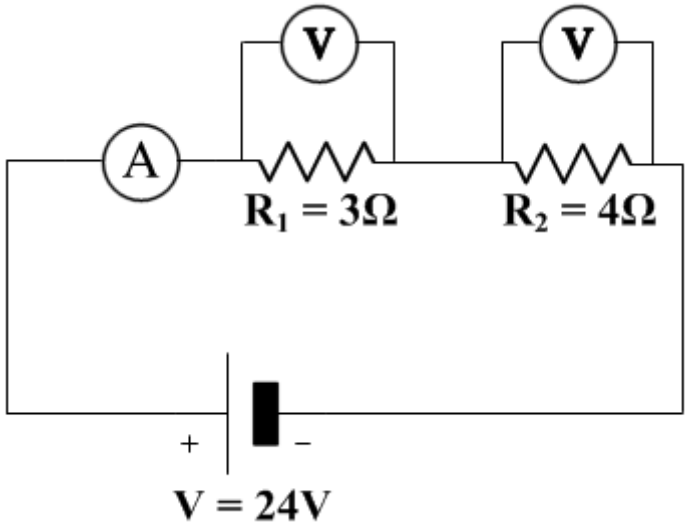
32. How much voltage must be applied across a 450 Ω resistor in order for it to consume 120 W of power?

Resistors in Series

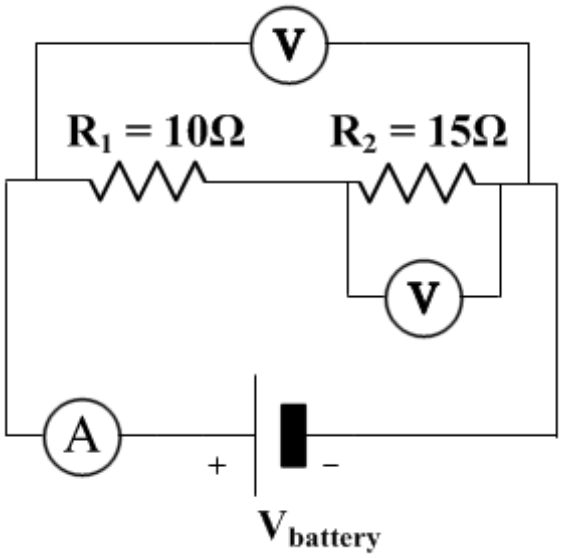
Classwork

33. A 3 Ω resistor is connected in series to a 6 Ω resistor and a 12-V battery. What is the current in each of the resistors? What is the voltage drop across each resistor?

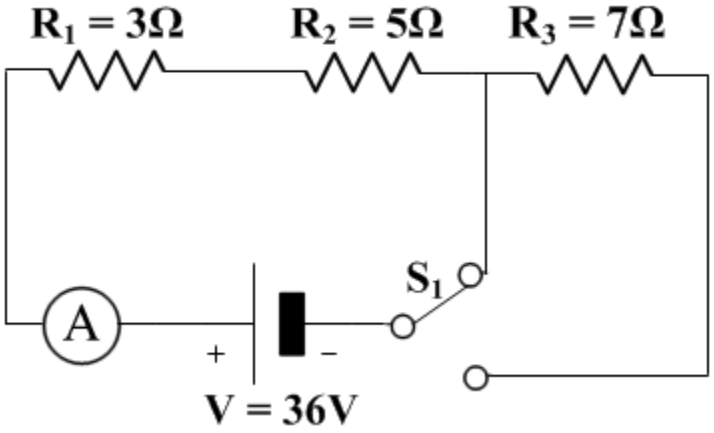
34. A 480 Ω resistor is connected in series to a 360 Ω resistor and a 120-V power supply. What is the current in each of the resistors? What is the voltage drop across each resistor?



35. Two resistors with values of 3 Ω and 4 Ω are connected to a 24 V battery as shown above. Determine the readings on all three devices.



36. Two resistors with values of 10 Ω and 15 Ω are connected in series, as shown above. A voltmeter connected across R_2 reads 30 V. Determine the current passing through the circuit. What is the voltage of the battery and across R_2.

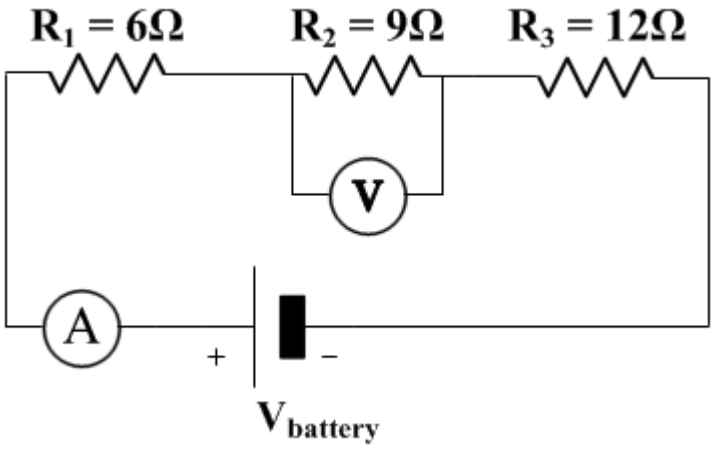


37. Three resistors with values of 3 Ω, 5 Ω and 7 Ω are connected in a circuit, as shown above. When the switch S_1 is in the position shown on the diagram only two resistors, R_1 and R_2, are connected to the 36 V battery and the current is I_1. If the switch is moved to it's down position the third resistor R_3 is connected in series to R_1, R_2, and the battery, producing a current I_2. Find the current reading of the ammeter, I_1 and I_2, for the two different switch positions.

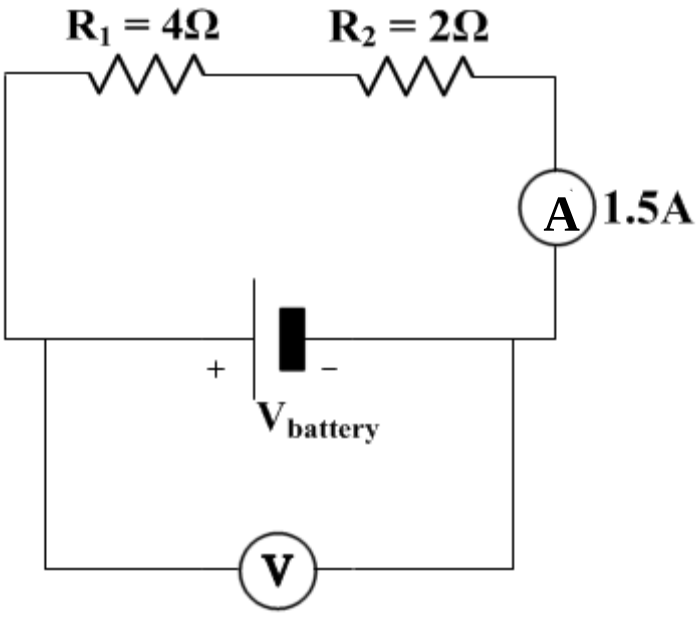
Homework

38. Three resistors with values of 12 Ω, 24 Ω and 6 Ω are connected in series to one another and a 24 V power supply. Find the current through each resistor. Find the voltage drop across each resistor. What is the total voltage drop across all the resistors?

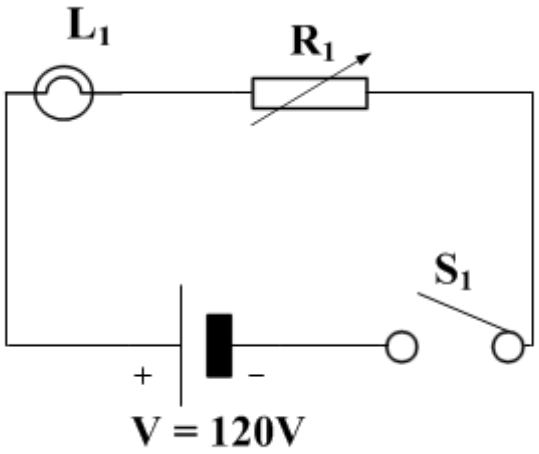
39. Four resistors with values of 5 Ω; 2.5 Ω; 7.5 Ω; and 10 Ω are connected in series to each other and a 50 V power supply. Find the current through each resistor. Find the voltage drop across each resistor. What is the total voltage drop across all the resistors?



40. Three resistors with values of 6 Ω, 9 Ω, and 12 Ω are connected in series to each other and to a battery, as shown above. The voltmeter in the circuit reads 18 V. Determine the reading of the ammeter and the voltage of the battery.



41. Two resistors with values of 4 Ω and 2 Ω are connected in series, as shown above. The ammeter reads 1.5 A. What is the reading of the voltmeter?



42. In the above diagram, a 6 W, 12 V light bulb is used in series with a 120 V power supply. To what resistance would you need to set the adjustable resistor, R1, so that the light bulb operates properly?

Resistors in Parallel

Classwork

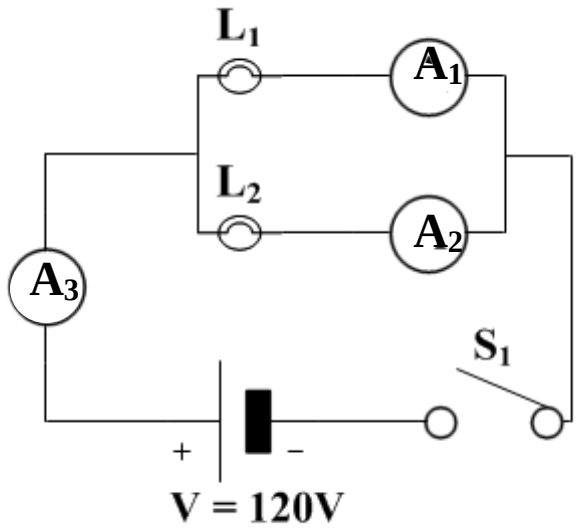
43. Resistors with values of 4 Ω and 6 Ω are connected in parallel to one another and the combination is connected in series to a 36 V battery. Find the current through each resistor and the power dissipated by each resistor.

44. Four resistors with values of 3 Ω; 6 Ω; 9 Ω; and 12 Ω are connected in parallel to one another and the combination is connected in series to a 24 V battery. What is the current through each resistor? What amount of power is dissipated by each resistor?

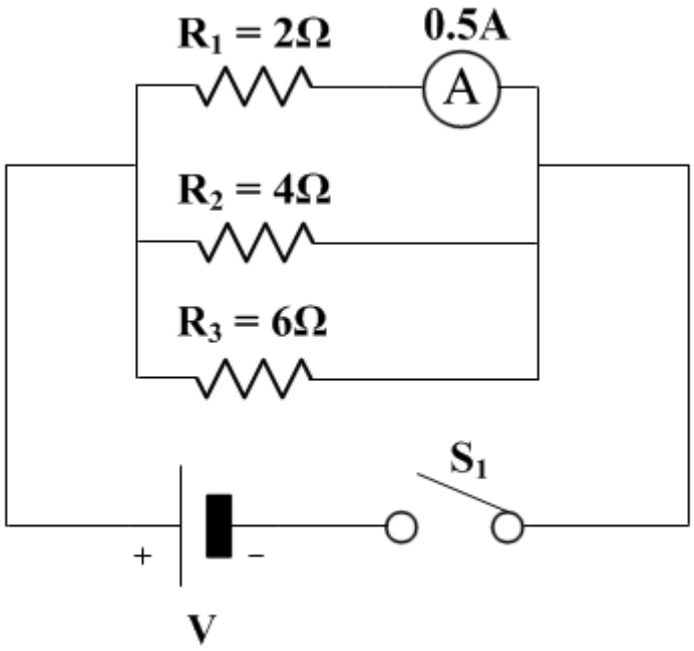
Homework

45. Three resistors with values of 5 Ω, 15 Ω and 25 Ω are connected in parallel to each other and the combination is connected in series to a 120 V power supply. Find the current through the circuit as well as its total power consumption.

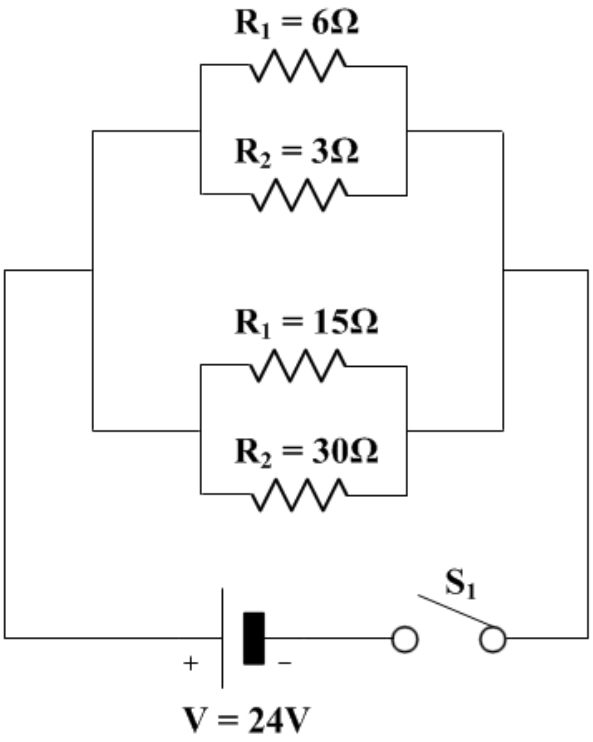
46. A 5 Ω resistor is connected in parallel to an 8 Ω resistor and the combination is connected in series to a DC power supply. A 0.25A current passes through the 5 Ω resistor: what is the current passing through the 8- Ω resistor? How much current flows through the power supply?



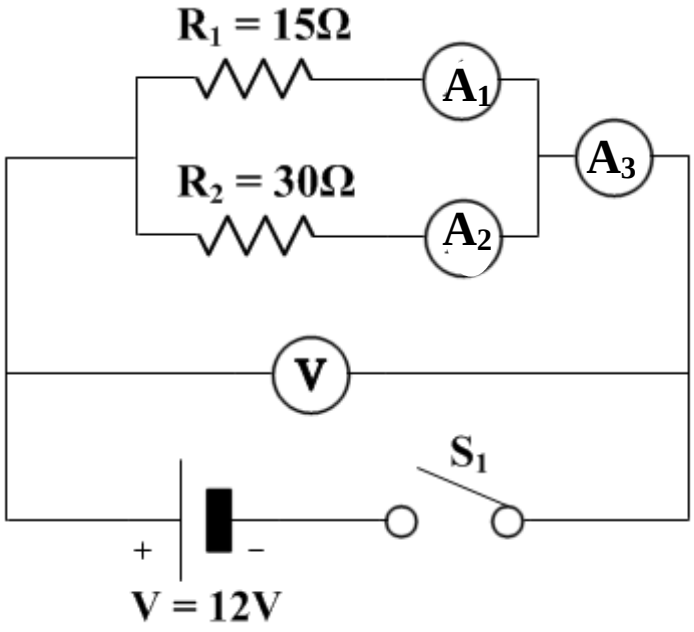
47. In the above circuit, two light bulbs, L_1 and L_2, are connected in parallel to one another and the combination is connected in series to a 120 V power supply. The resistances of the light bulbs are 480 Ω and 360 Ω respectively. Find the reading of each ammeter shown in the circuit.



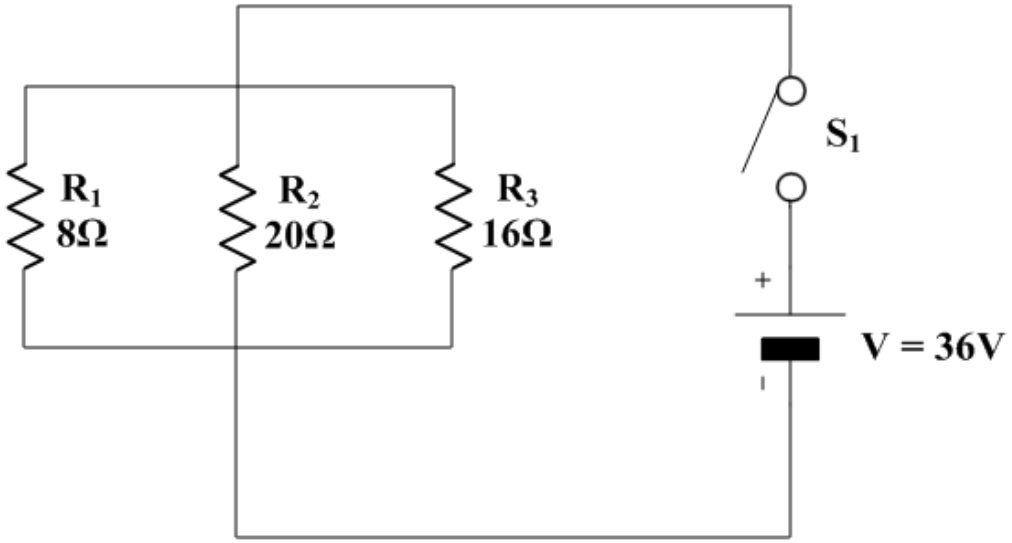
48. Three resistors with values of 2 Ω, 4 Ω and 6 Ω are connected in parallel with each other and the combination is connected in series with the battery. The ammeter in the circuit reads 0.5 A. Find the current through each resistor and through the battery.



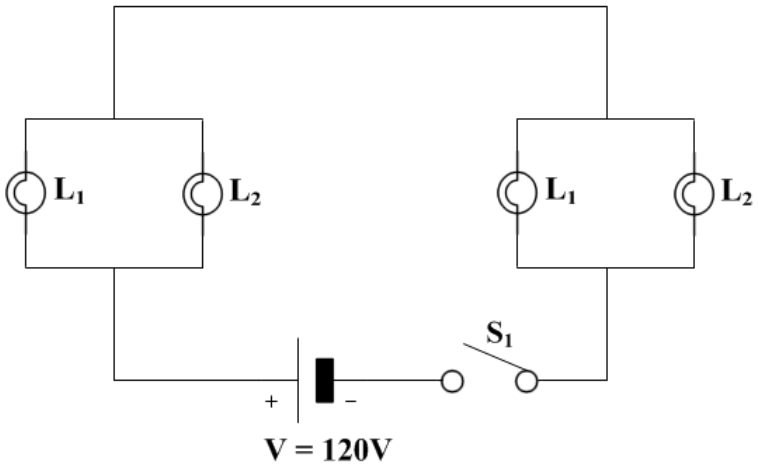
49. In the above diagram, four resistors with values of 6 Ω; 3 Ω; 15 Ω; and 30 Ω are connected in parallel with one another and the combination is connected in series to a 24 V battery. Find the total resistance of the circuit and the current through the battery.



50. In the above circuit, two resistors with values of 15 Ω and 30 Ω are connected in parallel to each other and the combination is connected in series to a 12 V battery. Find the readings of each meter when the switch is closed.



51. Three resistors with values of 8 Ω, 20 Ω and 16 Ω are connected in parallel to each other and the combination is connected in series to a 36 V battery. Find the total resistance of the circuit and the current passing through each resistor. How much current flows through the battery?



52. Four light bulbs, L_1; L_2; L_3; and L_4 are connected together in a circuit as shown in the above diagram. They are dissipating the following amounts of power: 50 W; 25 W; 100 W; and 75 W. Find the total resistance of the circuit and the current through the power supply.

EMF and Terminal Voltage

Classwork

53. A battery with an emf of 12 V and an internal resistance of 0.5 Ω is connected in series to a 15 Ω resistor. What is the current in the circuit? What is the terminal voltage of the battery?

54. A wire is connected across the terminals of a 120 V generator. The internal resistance of the generator is 0.2 Ω and the terminal voltage of the generator is measured to be 110 V. What is the resistance of the wire?

55. Two 1.5 V battery cells are connected in series to each other and to a 28 Ω light bulb. What is the current in the light bulb given that the internal resistance of each of the cells is 0.1 Ω?

56. A 6 Ω rheostat is connected in series to a 4.5 V battery, whose internal resistance of 1 Ω. Find the maximum and minimum current that can flow through this circuit.

57. When a 39.6 Ω resistor is connected in series with a battery, the electric current through it is 0.25 A; when that resistor is replaced by a 7.6 Ω resistor, the current becomes 1.25 A. Find the emf and the internal resistance of the battery.

58. Two light bulbs are rated to consume 30 W and 60 W of power when connected across a standard US 120 V electric outlet. They are connected to a 120 V generator whose internal resistance is 0.5 Ω. What is the current through the generator if the light bulbs are connected in series? In parallel?

Homework

59. A 6 volt battery, whose internal resistance 1.5 Ω, is connected in series to a light bulb with a resistance of 6.8 Ω. What is the current in the circuit? What is the terminal voltage of the battery?

60. A 25 Ω resistor is connected across the terminals of a battery whose internal resistance is 0.6 Ω. What is the emf of the battery if the current in the circuit is 0.75 A?

61. Two 4.5 V battery cells are connected in series to each other and to a 15 Ω electromagnet. What is the current through the electromagnet if the internal resistance of each cell is 0.5 Ω?

62. An adjustable resistor, with a resistance that can range from 0 Ω to 12 Ω, is connected across a 9 V battery, whose internal resistance is 0.8 Ω. Find the range of electric current that can flow through this circuit.

63. When a 5.5 Ω resistor is connected to a battery, the electric current is 2 A; when a 1 Ω resistor is connected to the same battery, the current is 8 A. Find the emf and internal resistance of the battery.

64. Two light bulbs are rated to consume 45 W and 75 W of power when connected across a standard US 120 V electric outlet. They are connected to a 120 V generator whose internal resistance is 0.2 Ω. What is the current through the generator if the light bulbs are connected in series? In parallel?

General Problems
Classwork

1. A copper wire with a length of 5m and a 2 mm diameter is connected to a 120V power supply. ($\rho_{CU} = 1.68 \times 10^{-8}\ \Omega \cdot m$)
    a. What is the resistance of the wire?
    b. What is the magnitude of the current running though the wire?
    c. How much power is dissipated in the wire?
    d. If that wire were used as part of the electrical wiring of a house; how much energy would be consumed during 30 days (assume that it is used for 5 h each day)?
    e. How much will that energy cost; if you pay 10 cents per kWh?

2. A 75 W lightbulb is design to be used in Europe; where electrical outlets deliver 220V.
    a. What is the resistance of the light bulb?
    b. How much current flows through the light bulb when it is connected to a 220 V outlet?
    c. How much current would flow through that same light bulb if you used it in the United States (120V)?
    d. How much power would the bulb use in the US?
    e. How would the brightness of the bulb compare in the US versus in Europe?

Homework

3. A tungsten wire with a length of 10 m and a 1.5 mm diameter is used to make the heating element of an oven. ($\rho = 5.6*10^{-8}\ \Omega \cdot m$)
    a. What is the resistance of the wire?
    b. What is the magnitude of the current through the wire when it is connected to a 120 V power supply?
    c. How much power would be dissipated in the wire?
    d. If the oven were turned on for 5 h; how much energy would be dissipated by the tungsten wire?
    e. How much would this cost at 10 cents per kWh?

4. A 550 W toaster is design to operate from a 120 V electrical line.
    a. What is the resistance of the toaster?
    b. How much electrical current flows through the toaster when it's being used?

c. What would the current become if the line voltage were to drop to 110V?

d. How much power would the toaster consume when operating at 110V?

e. How would that affect the length of time it would take to toast a slice of bread?

Classwork

5. A 20,000 kg train travels at a constant speed of 15 m/s. The electric motor driving the train uses 50A of electric current at a voltage of 550V: the efficiency of the motor is 85%.

    a. What is the resistance of the motor?

    b. How much electrical power is produced by the motor?

    c. What is the maximum mechanical power that can be produced by the motor?

    d. What must be the total force of resistance (friction, air resistance, etc.) acting on the train?

6. An elevator delivers 5 passengers to the fifth floor of a building in 10s. The total mass of the elevator and passengers is 500 kg and the fifth floor is located 15 m above ground level. The elevator is powered by an electric motor whose resistance is 25 Ω and which operates at 440V.

    a. How much work is done to deliver passengers to the fifth floor?

    b. How much mechanical power is necessary to do that in 10s?

    c. How much current would be running through the motor?

    d. How much electrical power would be used by the motor?

    e. What is the efficiency of the motor?

Homework

7. A 1200 kg hybrid car travels at a constant speed of 50 km/h on a horizontal road. The coefficient of kinetic friction (acting to slow the car down) is 0.02. The speed of the car is maintained by an electric motor that operates at a voltage of 250 V and a current of 15 A.

    a. What is the resistance force on the car?

    b. How much mechanical power must the motor generate to keep the car moving at 50 km/h?

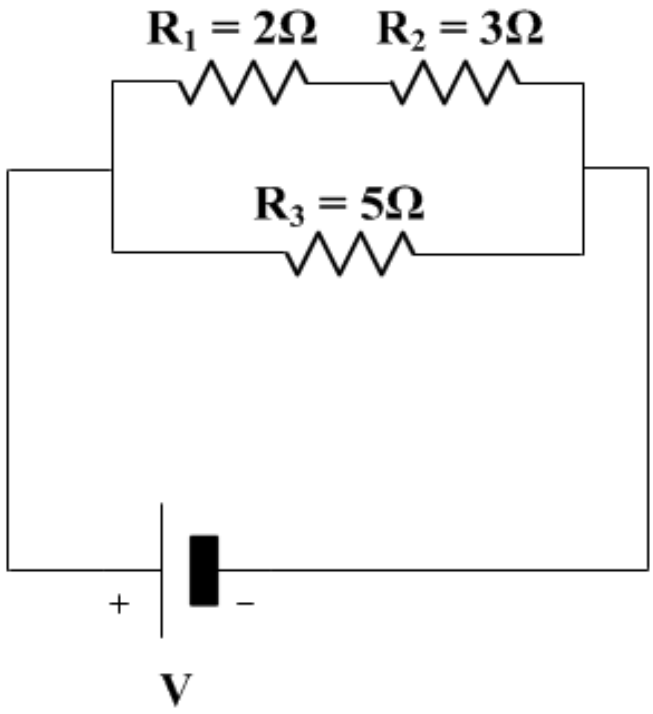
    c. What is the resistance of the motor coil?

    d. How much electrical power is used by the motor?

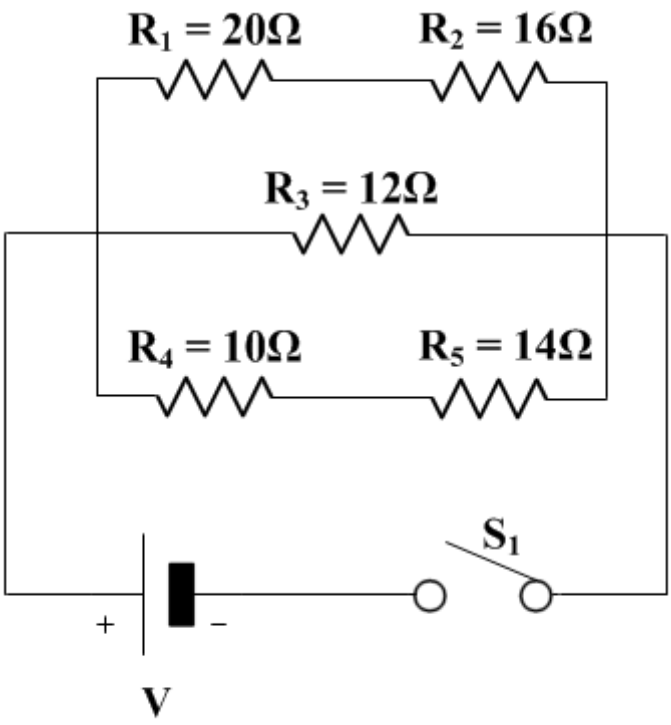
    e. What is the efficiency of the motor?

    f. How could the efficiency of the car be improved?

Classwork

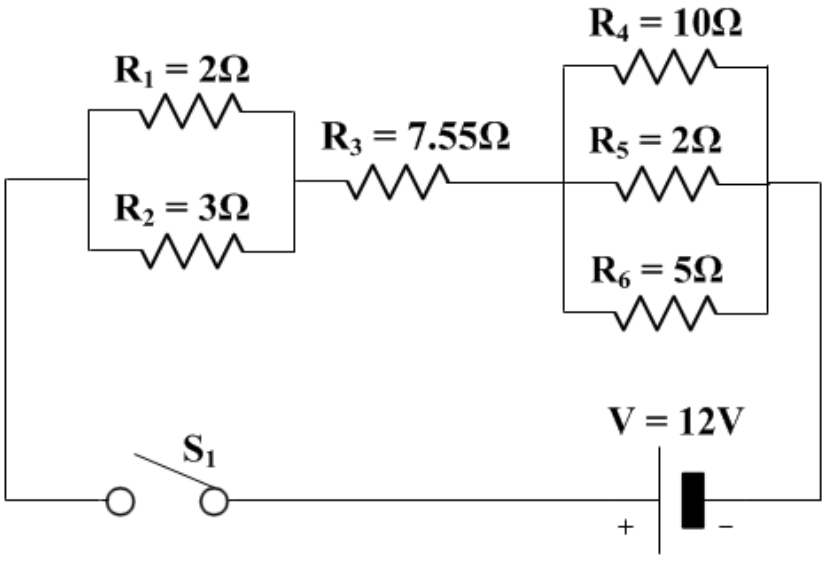


8. Find the net resistance of the above circuit.



9. Find the net resistance of the above circuit.

Homework



10. Determine the following for the above circuit:
    a. The equivalent resistance of R_1 and R_2.
    b. The equivalent resistance of R_4, R_5 and R_6.
    c. The equivalent resistance of all six resistors.

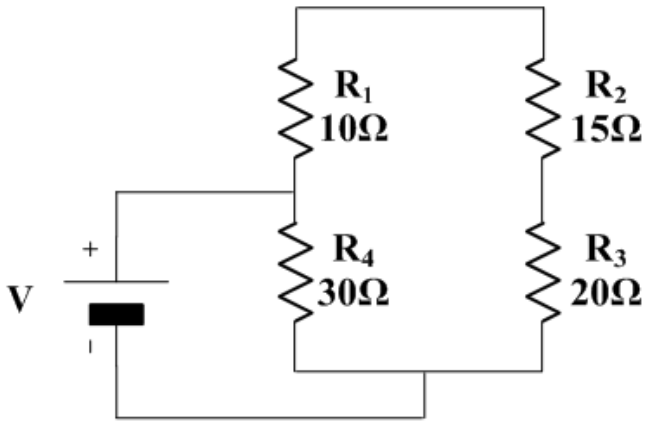
d. The current through the battery.

e. The voltage drop across R_1 and R_2?

f. The voltage drop across R_3?

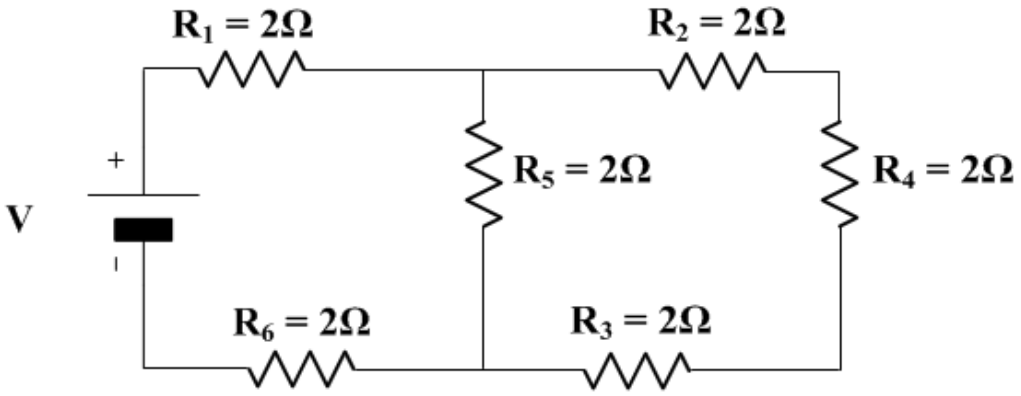
g. The voltage drop across R_4, R_5 and R_6?

h. The current through each resistor?

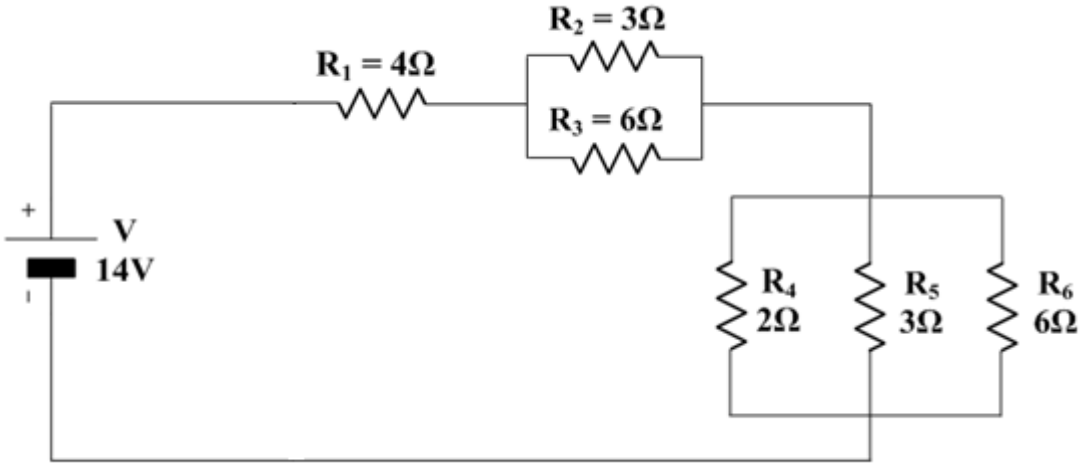


11. Find the net resistance of the above circuit.

Classwork

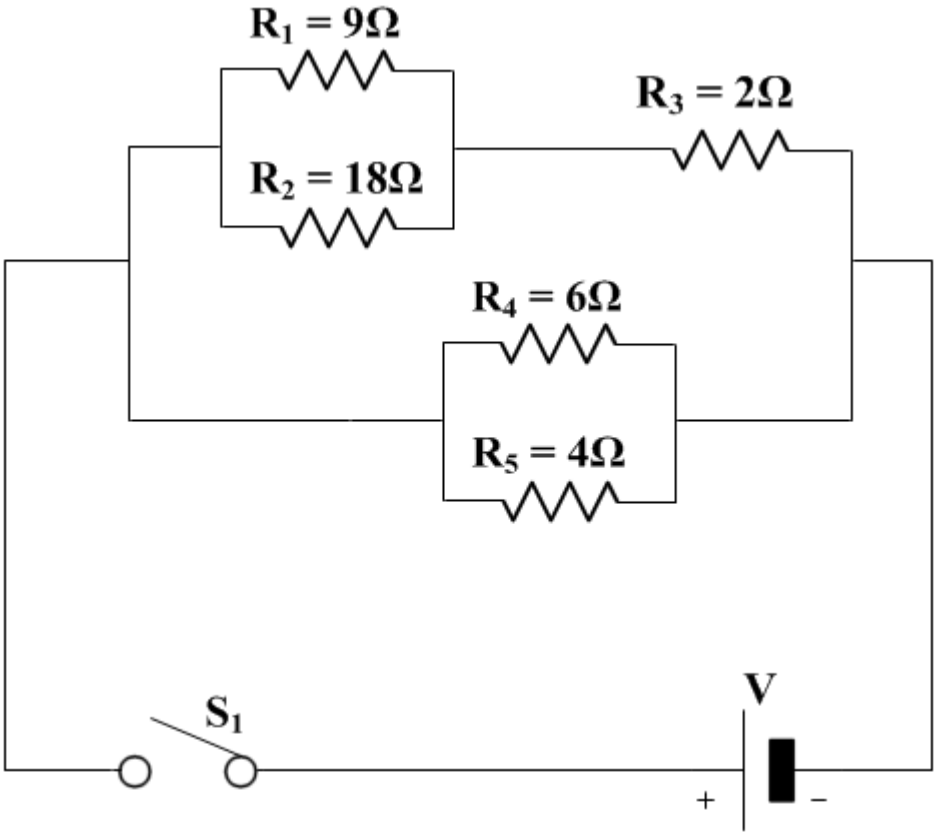


12. Find the net resistance of the above circuit.

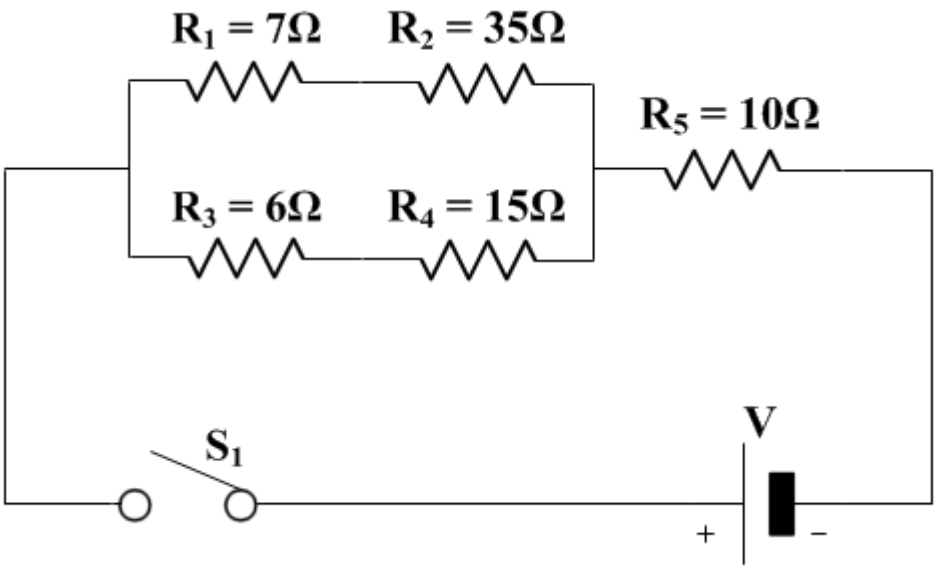


13. Determine the following for the above circuit:
    a. The equivalent resistance to R_2 and R_3.
    b. The equivalent resistance to R_4, R_5 and R_6.
    c. The net resistance of the circuit.
    d. The current through the battery.
    e. The current through R_1.
    f. The power dissipated in R_1.

Homework



14. In the above circuit, the current through the 9- Ω resistor is 1 A. Determine:
    a. The voltage across the 9 - Ω resistor.
    b. The current through the 18- Ω resistor.
    c. The current through the 2- Ω resistor.
    d. The voltage across the 2- Ω resistor.
    e. The current through the 6- Ω resistor.
    f. The current through the 4- Ω resistor.
    g. The terminal voltage of the battery.
    h. The power dissipated in the 6- Ω resistor.



15. In the above circuit, the current through the 7- Ω resistor is 5 A. Determine:
    a. The voltage across the 7 Ω resistor.
    b. The voltage across the 35 Ω resistor.
    c. The current through the 6 Ω resistor.
    d. The voltage across the 15 Ω resistor.
    e. The current through the 10 Ω resistor.
    f. The terminal voltage of the battery.
    g. The total power dissipated in the circuit.

1) 1.17 A
2) 60 C
3) 500 s
4) 3.125 A
5) 72000 C
6) 267 s
7) 2.45 A
8) 10.5 V
9) 240 Ω
10) 20 A
11) 90 V
12) 120 Ω
13) .75 Ω
14) 2.65×10^{-10} Ω·m
15) 4787 m
16) 0.0046 m
17) 375 Ω
18) 2.02×10^{-4} Ω·m
19) 8.010×10^{-3} m
20) 2.69×10^{-4} m
21) 60 W
22) 2.12 W
23) 2304 W
24) 0.41 Ω
25) 4.32 A
26) 58.1 V
27) 1.68 W
28) 600 W
29) 4500 W
30) 23.1 Ω
31) 2.96 A
32) 232.4 V
33) 1.3 A
V_3 = 4V
V_6 = 8V
34) 0.14 A
V_{R480} = 68.6 V
V_{R360} = 51.4 V
35) 3.43 A
V_{R1} = 10.29 V
V_{R2} = 13.71 V
36) 2 A
V_{R1+R2} = 50 V
V_{R2} = 30 V
37) I_1 = 4.5 A
I_2 = 2.4 A
38) 0.57 A
V_{R12} = 6.9 V
V_{R24} = 13.7 V
V_{R6} = 3.4 V
39) 2 A
V_{R5} = 10 V
$V_{R2.5}$ = 5 V
V_{R7} = 15 V
V_{R10} = 20 V
40) 2 A
54 V
41) 9 V
42) 216 Ω
43) I_{R4} = 9 A
P_{R4} = 324 W
I_{R6} = 6 A
P_{R6} = 216 W
44) R_3: 8 A, 192 W
R_6: 4 A, 96 W
R_9: 2.7 A, 64 W
R_{12}: 2 A, 48 W
45) 36.8 A
4416 W
46) I_{R8} = 0.155 A
I_{net} = 0.406 A
47) I_1 = 0.33 A
I_2 = 0.25 A
I_3 = 0.58 A
48) I_{R1} = 0.25 A
I_{R3} = 0.17 A
I_{net} = 0.92 A
49) 1.67 Ω
14.4 A
50) I_1 = 0.8 A
I_2 = 0.4 A
I_3 = 1.2 A
51) 4.21 Ω
I_{R1} = 4.5 A
I_{R2} = 1.8 A
I_{R3} = 2.25 A
I_{net} = 8.55 A
52) 58 Ω
2.06 A
53) 0.77 A
11.6 V
54) 2.4 Ω
55) 0.106 A
56) 4.5 A
0.64 A
57) 10 V
.4 Ω
58) 0.17 A
0.75 A
59) 0.72 A
4.92 V
60) 19.2 V
61) 0.56 A
62) 11.25 A
0.703 A
63) 12 V
0.5 Ω
64) Parallel: 1 A
Series: .23 A

Question 1
a) 2.6 Ω
b) 44 A
c) 5000 W
d) 2.7×10^9 J
e) $75

Question 2
a) 645.3 Ω
b) 0.341 A
c) 0.186 A
d) 22.3 W
e) Less bright in US

Question 3
a) 0.32 Ω
b) 375 A
c) 45000 W
d) 8.1×10^8 J
e) $22.50

Question 4
a) 26.2 Ω
b) 4.58 A
c) 4.20 A
d) 462 W
e) Longer to toast

Question 5
a) 11 Ω
b) 27500 W
c) 23375 W
d) 275 N

Question 6
a) 73500 J
b) 7350 W
c) 17.6 A
d) 7744 W
e) 95%

Question 7
a) 235.2 N
b) 3267 W
c) 16.7 Ω
d) 3750 W
e) 87%
f) Less friction

Question 8
2.5 Ω

Question 9
6.55 Ω

Question 10
a) 1.2 Ω
b) 1.25 Ω
c) 10 Ω
d) 1.2 A
e) 1.44 V
f) 9.06 V
g) 1.5 V
h) I_{R1}= 0.72 A
I_{R2} = .48 A
I_{R3} = 1.2 A
I_{R4} = 0.15 A
I_{R5} = 0.75 A
I_{R6} = 0.3 A

Question 11
18.7 Ω

Question 12
5.5 Ω

Question 13
a) 2 Ω
b) 1 Ω
c) 7 Ω
d) 2 A
e) 2 A
f) 16 W

Question 14
a) 9 V
b) 0.5 A
c) 1.5 A
d) 3 V
e) 2 A
f) 3 A
g) 12 V
h) 24 W

Question 15
a) 35 V
b) 175 V
c) 10 A
d) 150 V
e) 15 A
f) 360 V
g) 5400 W

Resistivities of Common Conductors

Material	Resistivity ($10^{-8}\ \Omega m$)
Silver	1.59
Copper	1.68
Gold	2.44
Aluminum	2.65
Tungsten	5.60
Iron	9.71
Platinum	10.6
Mercury	98
Nichrome	100

