

Answers to Activity 1:

Use Ohm's Law to solve problems



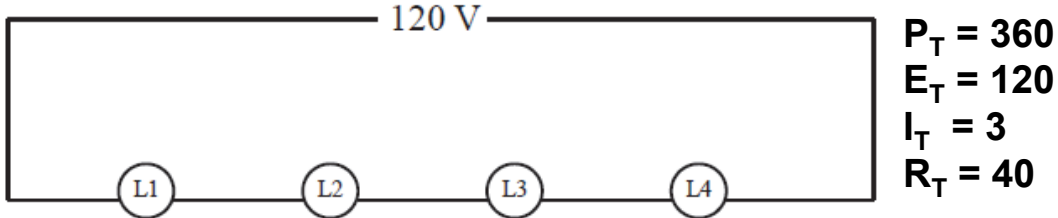
1.	P = 1,200	E = 120	I = 10	R = 12
2.	P = 11,520	E = 480	I = 24	R = 20
3.	P = 576	E = 24	I = 24	R = 1
4.	P = 4,500	E = 240	I = 18.75	R = 12.8
5.	P = 9,152	E = 208	I = 44	R = 4.7
6.	P = 15,000	E = 500	I = 30	R = 16.6
7.	P = 748,800	E = 12,480	I = 60	R = 208
8.	P = 95	E = 15.41	I = 6.16	R = 2.5

Activity 1

Use the resistive (not the inductive) power wheel to apply the principles of Ohm's law to these problems.

1.	P = <u>1,200</u>	E = <u>120</u>	I = 10	R = 12
2.	P = <u>11,520</u>	E = 480	I = 24	R = <u>20</u>
3.	P = <u>576</u>	E = 24	I = 24	R = <u>1</u>
4.	P = 4,500	E = 240	I = <u>18.75</u>	R = <u>12.8</u>
5.	P = <u>9152</u>	E = 208	I = 44	R = <u>4.7</u>
6.	P = 15,000	E = <u>500</u>	I = 30	R = <u>16.6</u>
7.	P = <u>95</u>	E = 12,480	I = 60	R = <u>208</u>
8.	P = 95	E = <u>15.42</u>	I = <u>6.16</u>	R = 2.5

Answers to Activity 2: Solve series circuit problem



	Totals	L1	L2	L3	L4
1.	$P_T = 360$	$P_1 = 90$	$P_2 = 90$	$P_3 = 90$	$P_4 = 90$
2.	$E_T = 120$	$E_1 = 30$	$E_2 = 30$	$E_3 = 30$	$E_4 = 30$
3.	$I_T = 3$	$I_1 = 3$	$I_2 = 3$	$I_3 = 3$	$I_4 = 3$
4.	$R_T = 40$	$R_1 = 10$	$R_2 = 10$	$R_3 = 10$	$R_4 = 10$

Activity 2

Apply the principles of Ohm's law for series circuits to this exercise. Your instructor will lead the discussion. Write in the answers below.

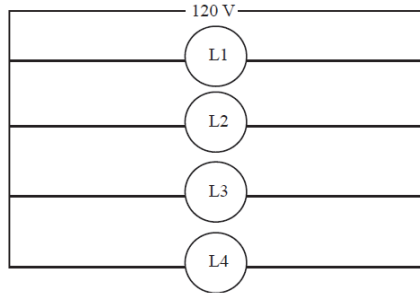
Assumptions:

All loads are equal.

Amps remain the same in a series circuit.

	Totals	L1	L2	L3	L4
1.	$P_T = 360$	$P_1 = 90$	$P_2 = 90$	$P_3 = 90$	$P_4 = 90$
2.	$E_T = 120$	$E_1 = 30$	$E_2 = 30$	$E_3 = 30$	$E_4 = 30$
3.	$I_T = 3$	$I_1 = 3$	$I_2 = 3$	$I_3 = 3$	$I_4 = 3$
4.	$R_T = 40$	$R_1 = 10$	$R_2 = 10$	$R_3 = 10$	$R_4 = 10$

Answers to Activity 3: Parallel Circuit Problems



$$P_T = 2880$$

$$E_T = 120$$

$$I_T = 24$$

$$R_T = 5$$

	Totals	L1	L2	L3	L4
1.	$P_T = 2880$	$P_1 = 720$	$P_2 = 720$	$P_3 = 720$	$P_4 = 720$
2.	$E_T = 120$	$E_1 = 120$	$E_2 = 120$	$E_3 = 120$	$E_4 = 120$
3.	$I_T = 24$	$I_1 = 6$	$I_2 = 6$	$I_3 = 6$	$I_4 = 6$
4.	$R_T = 5$	$R_1 = 20$	$R_2 = 20$	$R_3 = 20$	$R_4 = 20$

Activity 3

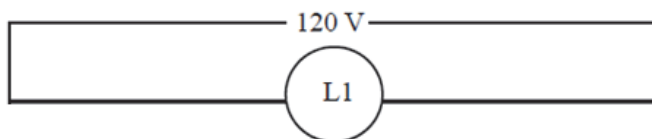
Apply the principles of Ohm's Law for parallel circuits to this exercise.
Assumptions: All loads are equal.

	Totals	L1	L2	L3	L4
1.	$P_T = 2880$	$P_1 = 720$	$P_2 = 720$	$P_3 = 720$	$P_4 = 720$
2.	$E_T = 120$	$E_1 = 120$	$E_2 = 120$	$E_3 = 120$	$E_4 = 120$
3.	$I_T = 24$	$I_1 = 6$	$I_2 = 6$	$I_3 = 6$	$I_4 = 6$
4.	$R_T = 5$	$R_1 = 20$	$R_2 = 20$	$R_3 = 20$	$R_4 = 20$

Answers to Activity 4: Portable Space Heater



One (1) electric 1500 watt portable heater
connected to a power strip



$$P_T = 1,500$$

$$E_T = 120$$

$$I_T = 12.5$$

$$R_T = 9.6$$

	Totals	L1
1.	$P_T = 1,500$	$P_1 = 1,500$
2.	$E_T = 120$	$E_1 = 120$
3.	$I_T = 12.5$	$I_1 = 12.5$
4.	$R_T = 9.6$	$R_1 = 9.6$

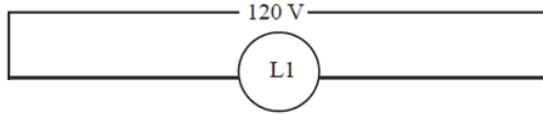
Activity 4

Apply the principles of Ohm's Law for parallel circuits to this exercise with a portable space heater.

Assumptions: All loads are equal.

	Totals	L1
1.	$P_T = 1500$	$P_1 = 1,500$
2.	$E_T = 120$	$E_1 = 120$
3.	$I_T = 12.5$	$I_1 = 12.5$
4.	$R_T = 9.6$	$R_1 = 9.6$

Practice Exercise 1: Calculate Space Heater Electricity Costs



$P_T = 1.5 \text{ kW}$
 $E_T = 120 \text{ Vac}$
 $I_T = 12.5 \text{ amps}$
 $R_T = 9.6 \text{ ohms}$

Totals	Cost @ \$.10/hr
Cost per hour	\$ _____
Cost per month	\$ _____
Cost per year	\$ _____

Activity - Calculate space heater electricity costs

Use the assumptions to calculate the electricity cost of operating one (1) electric 1.5 kW portable heater connected to a power strip.

Assumptions: Electricity costs \$.10/kWh

Calculation Formula: kW x hours x \$/kWh

Answer these questions:

1. What is the hourly operating cost? _____

2. Assume that the space heater operates on average 4 hours total per workday during the heating season (assume 20 workdays/month).

What is the monthly operating cost? _____

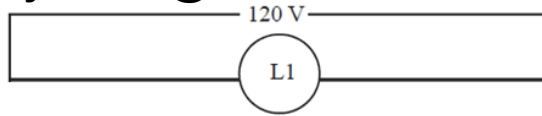
3. What is the annual operating cost if the heating season is 4 months per year?

Practice Exercise 1 Answer:

Calculate Space Heater Electricity Costs



What is the monthly and annual cost of operating one (1) electric 1.5 kW portable heater connected to a power strip if electricity costs @ .10/kWh?



$$P_T = 1.5 \text{ kW}$$

$$E_T = 120 \text{ Vac}$$

$$I_T = 12.5 \text{ amps}$$

$$R_T = 9.6 \text{ ohms}$$

Totals	Cost @ \$.10/hr
Cost per hour	\$ <u>.15</u>
Cost per month	\$ <u>12</u>
Cost per year	\$ <u>48</u>

Activity - Calculate space heater electricity costs

Use the assumptions to calculate the electricity cost of operating one (1) electric 1.5 kW portable heater connected to a power strip.

Assumptions: Electricity costs \$.10/kWh

Calculation Formula: kW x hours x \$/kWh

Answer these questions:

1. What is the hourly operating cost?

$$1.5 \text{ kW} \times 1 \times \$0.15 = \$0.15$$

2. Assume that the space heater operates on average 4 hours total per workday during the heating season (assume 20 workdays/month).

What is the monthly operating cost?

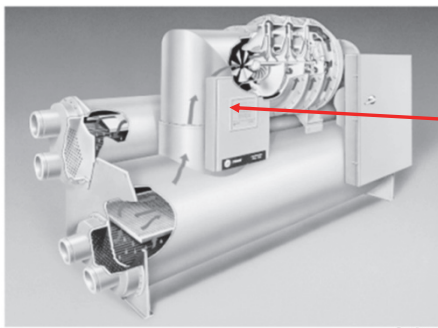
$$\$0.15 \times 4 \text{ hrs/day} \times 20 \text{ days/month} = \$12$$

3. What is the annual operating cost if the heating season is 4 months per year?

$$\$12/\text{month} \times 4 \text{ month/yr} = \$48$$

Practice Exercise 2:

Using Ohms Law to Determine kW, kWh, and Cost of Operation for a Chiller



Compressor Operating
VAC = 480, 200 amps, .85 PF

Formula for kW (3 phase) = [Volts x Amps x 1.732 x PF] / 1000

$$\text{kW} = \frac{\text{Volts} \times \text{Amps} \times 1.732 \times \text{PF}}{1000} = \underline{\hspace{2cm}}$$

$$\underline{\hspace{2cm}} \text{ kW} \times 24 \text{ hours} = \underline{\hspace{2cm}} \text{ kWh/day}$$

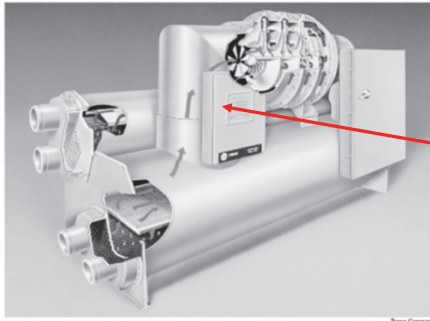
$$\text{Cost of electricity/day: } \underline{\hspace{2cm}} \text{ kWh/day} \times \$0.10/\text{kWh} = \$\underline{\hspace{2cm}}/\text{day}$$

$$\text{Cost of electricity/month: } \$/\text{day} \times 30 \text{ days} = \$\underline{\hspace{2cm}}/\text{month}$$

This slide illustrates the formulas and steps to calculate kW, kWh, and cost of operation of a chiller. The same principles apply to most equipment within your building. However, the cost of electrical power will vary across the country and your region.

Practice Exercise 2 Answers:

Using Ohms Law to Determine kW, kWh, and
Cost of Operation for a Chiller



Compressor Operating
VAC = 480, 200 amps, .85 PF

$$\text{Formula for kW (3 phase)} = [\text{Volts} \times \text{Amps} \times 1.732 \times \text{PF}] / 1000$$
$$\text{kW} = \frac{480\text{Volts} \times 200\text{Amps} \times 1.732 \times .85 \text{ PF}}{1000} = \underline{\underline{141.3 \text{ kW}}}$$

$$\underline{\underline{141.3 \text{ kW}}} \times 24 \text{ hours} = \underline{\underline{3391 \text{ kWh/day}}}$$

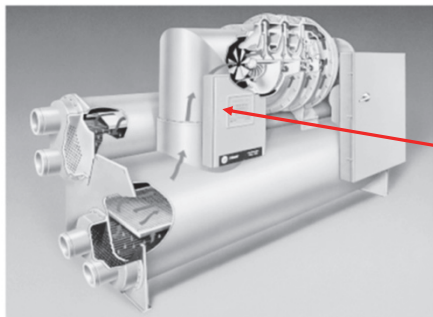
$$\text{Cost of electricity/day: kWh/day} \times \$.10/\text{kWh} = \underline{\underline{\$339/\text{day}}}$$

$$\text{Cost of electricity/month: \$/day} \times 30 \text{ days} = \underline{\underline{\$10,170/\text{month}}}$$

This slide illustrates the formulas and steps to calculate kW, kWh, and cost of operation of a chiller. The same principles apply to most equipment within your building. However, the cost of electrical power will vary across the country and your region.

Practice Exercise 3:

Using Ohms Law to Determine kW, kWh, and Cost of Operation



Compressor Operating
VAC = 480, 300 amps, .88 PF

Formula for kW (3 phase) = [Volts x Amps x 1.732 x PF] / 1000

$$\text{kW} = \frac{\text{Volts} \times \text{Amps} \times 1.732 \times \text{PF}}{1000}$$

___ kW x 24 hours = _____ kWh/day

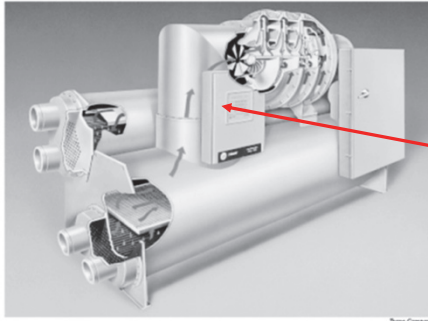
Cost of electricity/day: ___ kWh/day x \$.10/kWh = \$ ___/day

Cost of electricity/month: \$/day x 30 days = \$ ___/month

This slide illustrates the formulas and steps to calculate kW, kWh, and cost of operation of a chiller. The same principles apply to most equipment within your building. However, the cost of electrical power will vary across the country and your region.

Practice Exercise 3 Answers:

Using Ohms Law to Determine kW, kWh, and
Cost of Operation



Compressor Operating
VAC = 480, 300 amps, .88 PF

$$\text{Formula for kW (3 phase)} = [\text{Volts} \times \text{Amps} \times 1.732 \times \text{PF}] / 1000$$
$$\text{kW} = \frac{480 \text{ Volts} \times 300 \text{ Amps} \times 1.732 \times .88 \text{ PF}}{1000} = \underline{\underline{219.5 \text{ kW}}}$$

$$\underline{\underline{219.5 \text{ kW}}} \times 24 \text{ hours} = \underline{\underline{5268 \text{ kWh/day}}}$$

$$\text{Cost of electricity/day: } \underline{\underline{5268 \text{ kWh/day}}} \times \$0.10/\text{kWh} = \underline{\underline{\$527/\text{day}}}$$

$$\text{Cost of electricity/month: } \underline{\underline{\$/day}} \times 30 \text{ days} = \underline{\underline{\$15,810/\text{month}}}$$

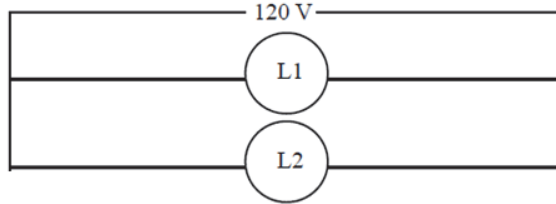
This slide illustrates the formulas and steps to calculate kW, kWh, and cost of operation of a chiller. The same principles apply to most equipment within your building. However, the cost of electrical power will vary across the country and your region.

Practice Exercise 4: Complete the Parallel Circuit Answers

Assume all loads are equal



Exercise with two (2) electric 1.5 kW portable heaters connected to same power strip



$P_T =$
 $E_T = 120$
 $I_T =$
 $R_T =$

	Totals	L1	L2
1.	$P_T =$	$P_1 =$	$P_2 =$
2.	$E_T = 120$	$E_1 =$	$E_2 =$
3.	$I_T =$	$I_1 =$	$I_2 =$
4.	$R_T =$	$R_1 =$	$R_2 =$

Instructions for this exercise. Work in small groups to solve these problems. Apply the principles of Ohm's law for parallel circuits to this exercise. Your instructor will help you to solve the first couple of problems. Notice, volts remain the same in a parallel circuit. Thus, both heaters have the same voltage.

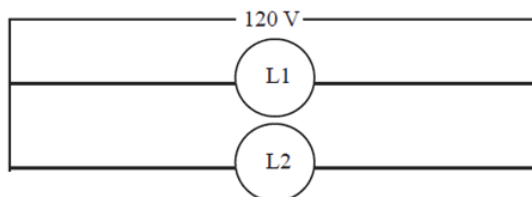
Remember, Power = Volts x Amps

Practice Exercise 4 Answers: Complete the Parallel Circuit



Assume all loads are equal

Exercise with two (2) electric 1.5 kW portable heaters connected to same power strip



$P_T = 3000$
 $E_T = 120\text{ V}$
 $I_T = 25$
 $R_T = 4.8$

	Totals	L1	L2
1.	$P_T = 3,000$	$P_1 = 1,500$	$P_2 = 1,500$
2.	$E_T = 120$	$E_1 = 120$	$E_2 = 120$
3.	$I_T = 25$	$I_1 = 12.5$	$I_2 = 12.5$
4.	$R_T = 4.8$	$R_1 = 9.6$	$R_2 = 9.6$

Answers to Test Your Knowledge Questions 1-4

Q1. Using Ohm's Law, calculate the amps used by 4500 watt electric heater if the voltage is 240 VAC at the power outlet or at the power strip.

1. 15.0 amps
2. **18.75 amps**
3. 24.0 amps
4. 12.5 amps

Q2. What can happen if too many appliances or portable electric heaters are plugged into the same outlet on the same circuit?

1. Increased load in the circuit will increase voltage and cause the breaker to trip.
2. **Increased load in the circuit will increase amperage in the circuit, and cause the breaker to trip.**
3. A decrease in voltage will cause an increase in current and cause the breaker to trip.
4. Decreased load will increase the resistance and cause the breaker to trip.

Q3. Which of the following is a characteristic of a parallel circuit?

1. **There is more than one pathway or branch through the whole circuit.**
2. A light switch and the light it controls are connected in parallel.
3. An opening anywhere in the circuit de-energizes the whole circuit.
4. The current is constant and the voltage and resistance is additive.

Q4. What are the basic components of an electrical circuit?

1. A wire, a switch, and a battery
2. A wire, a lamp and a fuse
3. **A voltage source, a pathway and a load**
4. A transformer, a circuit breaker, and a load.

Answers to “Test Your Knowledge” Questions 5-7

Q5. What does a transformer do?

1. Raises or lowers AC voltages
2. Maintains stable voltages on branch circuits
3. Transforms voltage wave signatures
4. Dampens voltage surges.

Q6. What is the safest method to test a fuse?

1. With fuse still in the panel with power on.
2. With fuse still in the panel with power off
3. With fuse pulled from the panel on a bench
4. With a voltmeter and power on.

Q7. During a routine PM inspection, an operator observed that a motor serving a chiller was vibrating more than normal. Upon further inspection, it was noticed that the motor was running hotter than normal. These symptoms could indicate possible motor inefficiencies related to:

1. low-quality electrical power
2. adverse environmental conditions
3. ineffective or insufficient maintenance
4. all of the above