

### *Unit Summary...*

Now that we have covered the basic principles behind the movement of energy, let's look at the specifics of how heat moves. Because we all like to live in homes that are the "right" temperature, understanding how heat moves is very important to Building Performance professionals.



Understanding how heat moves through a home lets you make the right decisions

#### LEARNING OBJECTIVES

- Be able to define conduction, , and radiation and give examples of each*
- Be able to list substances that are very efficient at transferring heat and some that are very inefficient at transferring heat*



**TIME:** 60 minutes

**MATERIALS:**

1. GETS Participant Handbooks
2. Copies of the unit “Check Your Learning” for the test at the end of the section
3. Cup of warm coffee
4. Candle and candleholder
5. Matches
6. Towel
7. Glass beaker
8. Heat source: Bunsen burner or candle
9. Stand to hold the beaker above the heat source
10. Food coloring
11. Power source
12. Radiating space heater
13. Extension cord
14. Water
15. Rubbing alcohol
16. Plastic bottle
17. Clear plastic drinking straw
18. Modeling clay
19. Tub of cool water

As you move into the specifics of heat movement, use this opportunity to bring in props and use many hands-on experiments and demonstrations. This Instructor Manual will give you some ideas and examples but use the materials that are available to you and that you think will connect with your participants. Remember to look in the Appendices for great ideas.

Today's section is large compared to the other sections and it is best if you are able to get through all of it in one session. Make sure you have enough time to get through this section in one shot.

Consider other strategies to help your participants follow today's materials:

- Paraphrase the material to the participants
- Ask the participants to close their manuals and ask a series of simple questions that lead them to a point you are trying to make – encourage them to realize the greatest “tool” they have at their disposal is what's between their ears, not some book or manual.
- Have the participants break into groups, prepare a presentation on a small section of the Unit and present their section to the class. This is particularly effective because it gets the participants to work on their teamwork

## TEACHING STRATEGIES

Remember to ask your participants leading questions that take them from the big, abstract concepts to the specific, concrete examples. Using this teaching strategy is a great way to get the participants talking and tying ideas and concepts together.

Now that you are immersed in the GETS curriculum, begin encouraging participants to read their manuals outside of class and do their own research on-line. Make sure each student understands they are ultimately responsible for their own learning. Reward those that demonstrate initiative. Find a way to reward for your participants that works for them: healthy treats, pencils, pens, etc.

Also take advantage of the power of showing appreciation to individual participants in a less public forum. If you see a participant making an improvement, however small, take the opportunity to pull the participant aside during a break or after class and tell him. This can be an incredibly powerful incentive and motivator for an individual who has felt unappreciated. Remember the words of the American philosopher William James:

*“The deepest principle of human nature is the craving to be appreciated.”*

As an instructor, you are in a position to wield great influence. Let your participants know when you are impressed by them and they will work harder to impress you.



# ANSWER AS YOU GO...

Answer these questions as you go through today's lesson.

## HEAT ON THE MOVE: QUESTIONS

1. "Cold" is actually the \_\_\_\_\_ .

**ANSWER:** *Cold is actually the absence of heat .*

2. What does BTU stand for?

\_\_\_\_\_ .

**ANSWER:** *British Thermal Unit*

3. When you burn one \_\_\_\_\_ , approximately one BTU is released.

**ANSWER:** *When you burn one wooden kitchen match , approximately one BTU is released.*

4. Name the 3 ways heat moved and give an example of each:

1. \_\_\_\_\_ Example: \_\_\_\_\_

2. \_\_\_\_\_ Example: \_\_\_\_\_

3. \_\_\_\_\_ Example: \_\_\_\_\_

**ANSWERS:**

1. Conduction of a hot skillet

2. Convection of a radiator in a cold room

3. Radiation of the sun

# HEAT TRANSFER

A big part of being a Building Performance professional is gaining an understanding of how heat moves into, around and out of a home. To do that, we first need to understand the fundamentals of heat movement.

You might be asking yourself:

“Why are we so concerned about heat? What about cold?” That’s a great question. Let’s talk about cold briefly.

*Brrrrr...I can feel the absence of heat!*

Ever feel a cold breeze and think, “Wow, I can really feel the cold!” That’s not an entirely accurate statement. What you are experiencing is an **absence of heat**, not the presence of cold. Likewise, when a thermometer registers a level of cold, it is really indicating an **absence of heat**. So now you understand why we are so concerned about heat: if we solve heat problems in a home, we are also solving cold problems in a home.

Heat transfers in one of three ways:

1. **Conduction** - Heat moves between two objects **that are touching** because there is a temperature difference between the two objects.
2. **Convection** - Heat moves by the **circulation of a fluid** like air or water.
3. **Radiation** - Heat moves through space when energy is released by one object and absorbed by another object. Unlike conduction or convection, radiation does **not** require objects to ever touch one another.

Let’s go through some examples of each of these to give you a better idea of how you will use this knowledge as a Building Performance professional.

## BTU

As Building Performance professional, you measure heat in BTUs. When you burn a wooden kitchen match, approximately one BTU is released.

1 lighted match = 1 BTU

## NEW TERMINOLOGY

*So what is the formal definition of a BTU?*

*A **British Thermal Unit** is the amount of heat needed to raise one pound of water one degree Fahrenheit.*

## 🔑 INSTRUCTOR NOTES & SUGGESTIONS

Some of your students may not readily see how these theories of heat movement apply to Building Performance and building science. While the curriculum will give you some ideas on how to explain these connections, use some of your preparation time to find ways to make these abstract ideas concrete for your students.



## 🔍 INSTRUCTOR NOTES & SUGGESTIONS

**TIME:** 20 minutes

You can use a laptop, internet connection, projector and speakers to go on to a media web site and search “convection current.” There are several very good videos posted by various different teachers that illustrate convection currents. Another option is to do this experiment yourself for your class.

### **MATERIALS:**

1. Clear glass container
2. Heat source: Bunsen burner or candle
3. Stand to hold the glass container above the heat source
4. Food coloring

### **A GOOD DEMONSTRATION**

Illustrate convection current to your class by heating water and adding food coloring. Set up a glass jar over a heat source (candle). Add a few drops of food coloring at the beginning of the experiment while the water is all the same temperature to illustrate that there are no currents or water moving. As the water begins to heat up, periodically add drops of food coloring to illustrate the convection currents.

### **TIPS:**

- Don't add too much food coloring or you can't see the convection current
- Practice the experiment at least once before doing this in front of the class.

## **CONVECTION**

**Convection is when heat flows or transfers to another substance by the circulation or movement of a fluid like water or air.**

Have you ever been in a cold room and turned on a radiator? At first, the whole room is cold except for the air right above the radiator. Eventually, though, you notice the whole room getting warmer. How does that happen?

What you are noticing is **convection**. Here's how **convection** creates currents in fluids (like air and water):

1. A heat source (like the radiator in the example) is added to a fluid (like the air in the room).
2. The heat is transferred to the fluid closest to the heat source, causing the fluid to rise.
3. As the heated fluid rises, it gets replaced by other cooler fluid. This “pulling in” of cooler fluid to replace the warmer fluid starts a circular current known as a **convection current**.
4. As the heated fluid rises and gets farther away from the heat source, it begins to cool, causing it to sink. This sinking fluid begins “pushing” more fluid towards the heat source.

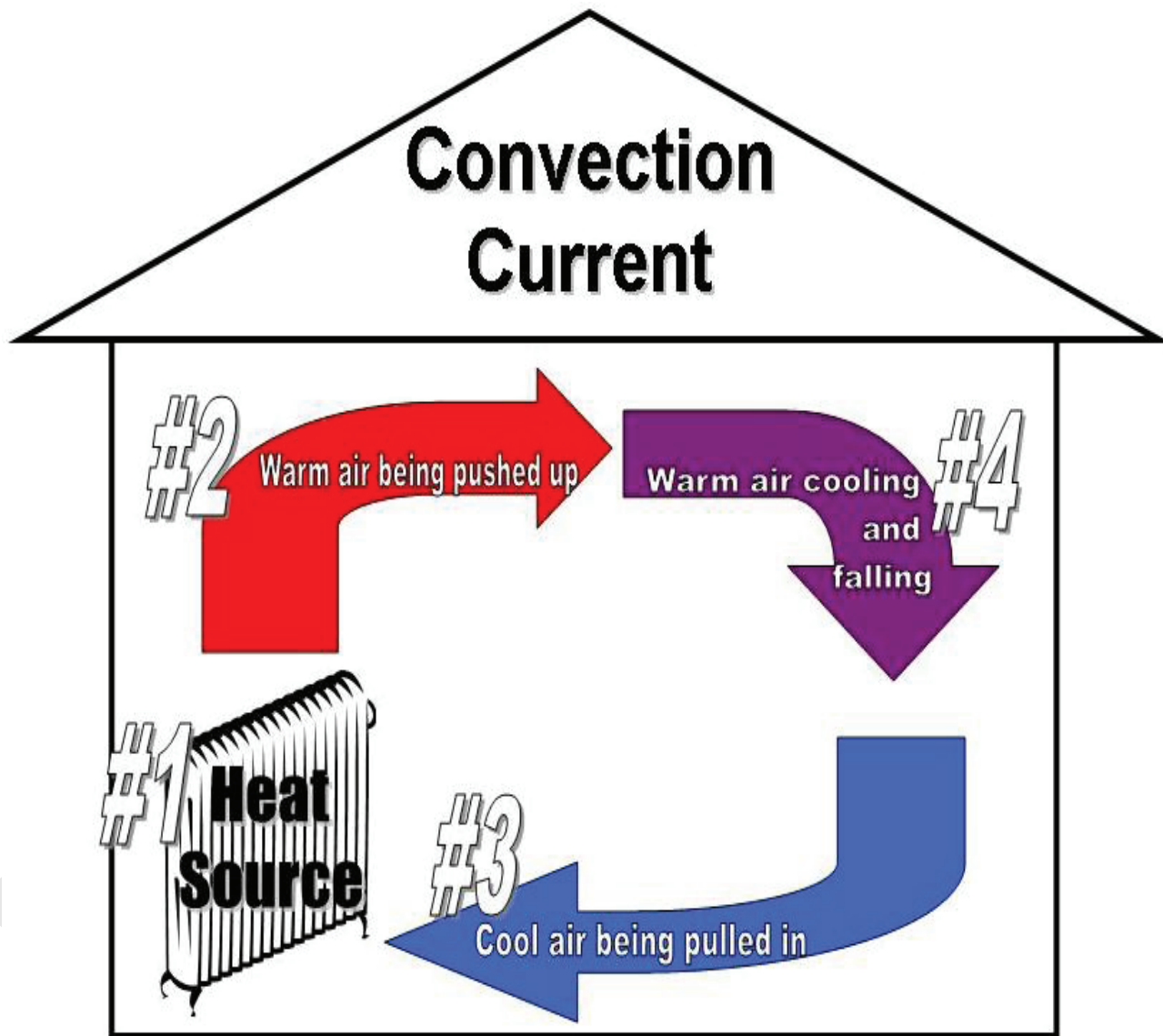
This pushing and pulling of heated and cooling fluid creates stronger and stronger circular convection currents.

What examples can you give of **convection**?

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This graphic takes you step-by-step through the convection process.



### CONVECTION ASSISTANCE

Letting a convection current develop on its own can be a slow process. Do you think there are ways of speeding up or helping the process along? The answer is “Yes! Absolutely!” Let’s think about this for a moment and review some facts:

- We know that convection currents naturally develop because warm air rises and cool air sinks.
- Warm air that has accumulated near a ceiling will eventually cool, fall towards the ground and complete a convection current

It seems like the most comfortable air in this situation is near the ceiling. Unfortunately, occupants of a home typically don’t spend a lot of time near a ceiling – instead they spend most of their time closer to the floor. If you used some type of device to move that warm air near the ceiling towards the occupants on the floor, the occupants would get the benefit of that warm air sooner. Fortunately, such a device exists: it’s called a ceiling fan.

But you may be thinking:

*“I use my ceiling fan when it’s hot outside. How is it going to help me when I’m cold?”*

Most ceiling fans have a switch that reverses the direction of the blades. This means that instead of blowing air down on to you, it will pull air up. In terms of a convection current, this means that colder air is pulled up towards the ceiling and mixed with the warmer air near the ceiling. This mixed air is then forced down to the occupants. Depending on the specifics of the home, this could mean the occupants feel the warmth of their heating system sooner. If the occupants feel warmer sooner, they do not need to run their heater for as long.

Some engineers and scientists have differing views on whether or not this improves the efficiency of a heating/cooling system or not, but, regardless, you should have this “tool” in your “toolbox.”

## **RADIATION**

**Radiation is the process in which energy is emitted by one body, transmitted through an intervening medium or space, and absorbed by another body. Radiation does not require matter-to-matter contact like conduction and convection.**

Anyone who has ever been sunburned knows all about **radiation**. While you never came in direct contact with the sun, it still managed to burn you. This is because the sun transmits heat through radiation. This means that the energy from the sun traveled through space in the form of electromagnetic waves and was absorbed by something with a lower temperature (your skin).

Here are some other examples of **radiation**:

- Warming your hands by a campfire
- Warming up by a radiant heater
- The roof of a home getting warm in the summer

What examples can you give of **radiation**?

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### **📣 INSTRUCTOR NOTES & SUGGESTIONS**

A radiating space heater is a very quick, cheap, easy and safe way to illustrate radiation to your participants. Simply turn it on and ask them how the heat is able to get to them. Is it through conduction? No, because they are not touching the heater. Is it through convection? No, because there is no system of fluids creating a current. It has to be that the heat is passing through the air to them by radiation. Using process of elimination is a good way to get participants to begin recognizing the differences between conduction, convection and radiation.



Answer these questions from today's lesson.

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## HEAT ON THE MOVE: REVIEW

1. **Cold** is actually the \_\_\_\_\_.
2. What does BTU stand for?  
\_\_\_\_\_.
3. When you burn one \_\_\_\_\_ is roughly equivalent to one BTU.
4. Name the 3 ways heat moved and give an example of each:
  1. \_\_\_\_\_ Example: \_\_\_\_\_
  2. \_\_\_\_\_ Example: \_\_\_\_\_
  3. \_\_\_\_\_ Example: \_\_\_\_\_

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# INSTRUCTOR'S ANSWER SHEET: UNIT 7

CHECK YOUR LEARNING...



## HEAT ON THE MOVE QUESTIONS

1. **ANSWER:** Cold is actually the absence of heat .

2. What does BTU stand for?

**ANSWER:** British Thermal Unit

3. **ANSWER:** When you burn one wooden kitchen match is roughly equivalent to one BTU.

4. Name the 3 ways heat moved and give an example of each:

**ANSWERS:**

1. Conduction of a hot skillet

2. Convection of a radiator in a cold room

3. Radiation of the sun

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