



WEATHERIZATION

TOPIC OF STUDY

Building Sciences



90 MINUTES

KEY TERMS

combustion
carbon monoxide (CO)
carbon dioxide (CO₂)
heat exchanger
combustion air
draft
spillage

LESSON

The Basics of Combustion Analysis

BIG IDEA(S)

Combustion is a process of burning fuel that produces heat and water.

OBJECTIVES

Students will:

- Describe the effect of combustion on other components of a house system
- Identify the chemical reaction of combustion and its by products
- Describe how furnaces work in conjunction with a heat exchanger to provide heat
- Investigate air movement with combustion appliances including drafts, spillage and back-drafting
- Outline the steps and tools used in combustion analysis

TASK LIST SUBCATEGORY

- 802 Describe the interconnection of systems using the “House As a System” framework
- 803 Identify and evaluate mechanical, electrical, plumbing and roofing systems
- 805 Perform energy audit procedures
- 810 Use energy efficiency industry vocabulary

OVERVIEW

Combustion is a process of burning fuel that produces heat and water. The furnace is the prime example of the important combustion appliance for space heating in a home, although others are important for cooking, drying clothes, and producing hot water. Auditing plays an important role in determining optimal heat distribution, control of draft, backdraft, spillage and consequent air quality. While chimneys and vents are important when diagnosing venting failures, it is important to look at the entire house during an audit.

STANDARDS

PA/SDP

- 3.2.P.B3.** Analyze the factors that influence **convection**, **conduction**, and **radiation** between objects or regions that are at different temperatures.
- 3.4.10.A2.** Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.
- 3.4.10.B1.** Compare and contrast how the use of **technology** involves weighing the trade-offs between the positive and negative effects.
- 3.4.10.D2.** Diagnose a malfunctioning **system** and use tools, materials, and knowledge to repair it.
- 3.4.10.E7.** Evaluate structure design as related to function, considering such factors as style, convenience, safety, and efficiency.





DEFINITIONS OF KEY TERMS

Combustion: burning, or the combination of oxygen and a fuel to produce heat

Carbon monoxide (CO): an odorless, tasteless, colorless and potentially deadly by product of combustion where fuels containing carbon are present

Carbon dioxide (CO₂): a bi-product of carbon combustion

Heat exchanger: metal component of a furnace that conducts heat from the fire and heats either a liquid or air.

Combustion air: heat provided in an appliance in order for combustion to take place

Draft: force that causes combustion gases to be removed from the chamber and out the flue

Spillage: the flow of combustion gases from a household combustion appliance that does not exit through a flue

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 191 - 196

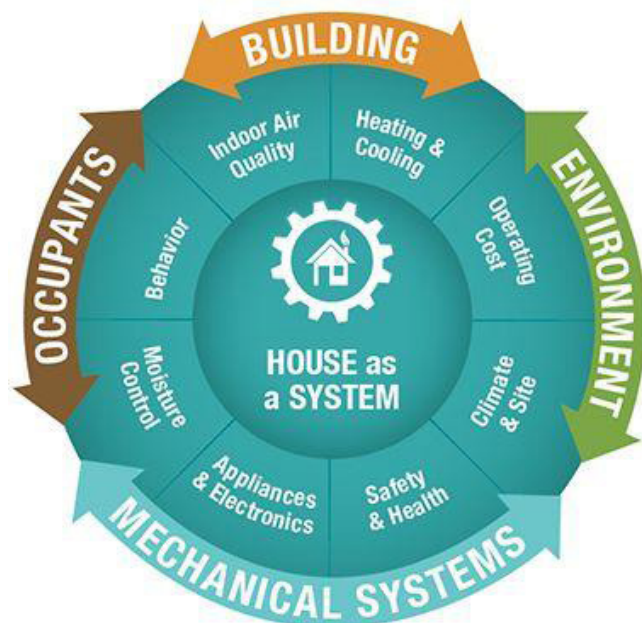
MATERIALS NEEDED

MATERIALS

- Jar with a lid
- Tea light or candle
- CO detector/monitor

IMPLEMENTATION (LESSON PLAN)

1. Review that everything we study is part of looking at a house as a system.



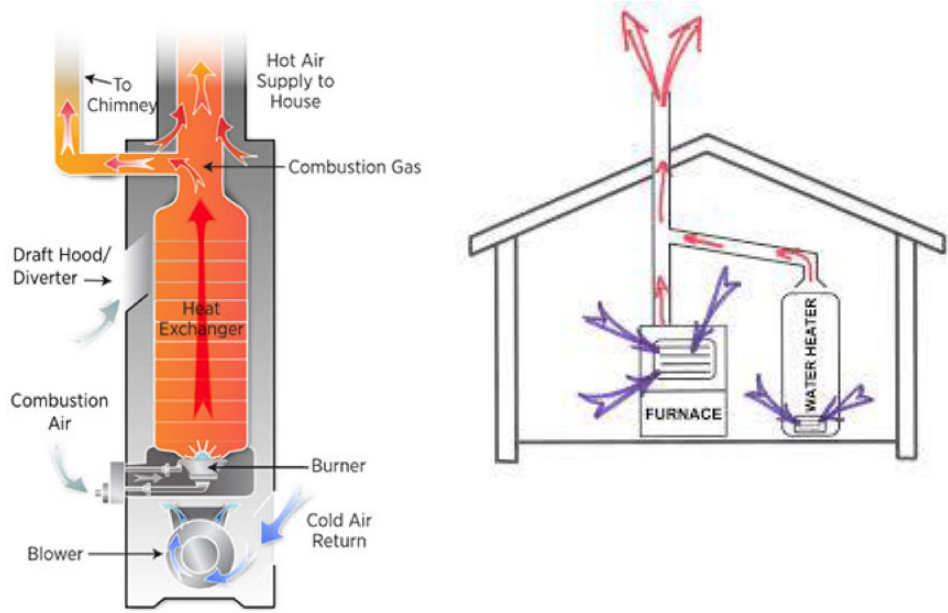
IMPLEMENTATION (LESSON PLAN) - CONTINUED

2. Combustion Demo: Using a funnel with tube, flour, lit candles, safety goggles, show the combustion of flour experiment (<http://sciencedemoguy.com/science-demo-combustion/>) or show the video. (If a live demo, be sure you are away from a smoke detector and wear safety goggles).

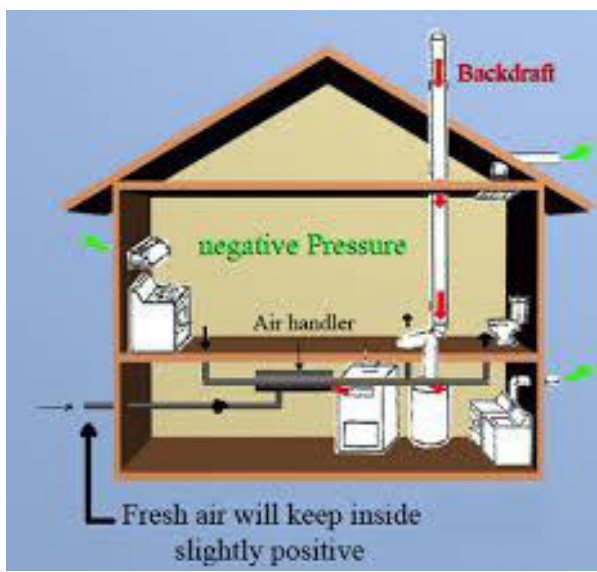
Ask students what was necessary for the combustion to take place. Explain combustion has three requirements: fuel, oxygen, and ignition. Review the chemical formulas on p. 192 for combustion. Notice that the ingredients in natural gas reaction, $\text{CH}_4 + \text{O}_2$ has similar components as in the reaction with flour $\text{C}_6\text{H}_{10}\text{O}_5$. Both are the result of organic growth.

3. Describe the 5 steps of a combustion appliance using the furnace diagram from below. Explain how conduction and convection are involved in hot air systems, water heaters, hot water heating systems, clothes dryers, cooking, etc.

Explain draft, heat distribution, cool air or water return and other aspects (*Energy Conservation Handbook*, p. 194 diagram similar to below).



Use the following to review negative pressure as a cause for back draft.



IMPLEMENTATION (LESSON PLAN) - CONTINUED

4. Combustion Analysis (*Energy Conservation Handbook*, pp.195-196). Provide equipment that is used in the 8 suggested steps of the combustion audit.

Gas Leak Detector For those homes that have natural gas and propane heating systems, a gas leak detector is essential for testing gas lines.

The CD100A is the perfect serviceman's tool designed to detect combustible gas leaks in residential and small commercial applications. The semiconductor sensor responds instantaneously to all combustible gases. The easily adjusted, steady tic rate can be used in tight quarters where others might not fit.



Carbon Monoxide Detector Carbon monoxide levels need to be monitored during an audit. The heating system is checked with the combustion analyzer and this monitor tracks atmospheric CO in the house throughout the audit.

This is a Professional Series CO detector and meter with pump by FORENSICS. It is high precision for very accurate measurements and robust for field work, inspections, occupational safety, industrial and environmental applications.



Combustion Analyzer The combustion analyzer tests the efficiency of heating and hot water systems. This is a more basic model but it does the trick, testing flue gases for O₂, CO₂, heating system efficiency and carbon monoxide. It can also double as a CO detector.

RESIDENTIAL: Perfect for residential combustion analysis and ambient air quality analysis or probe sampling / continuous sampling in confined or toxic spaces.



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RESOURCES/LINKS

Combustion and Energy Auditing Equipment

<http://www.aee-inc.com/equipment.php>

Energy Audit Equipment

<https://www.energyauditingblog.com/energy-audit-equipment/>

Easy to understand pamphlet of combustion and combustion appliances, problems, and maintenance:

<https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-homes/combustion-gases-your-home-things-you-should-know-about-combustion-spillage/18639>

