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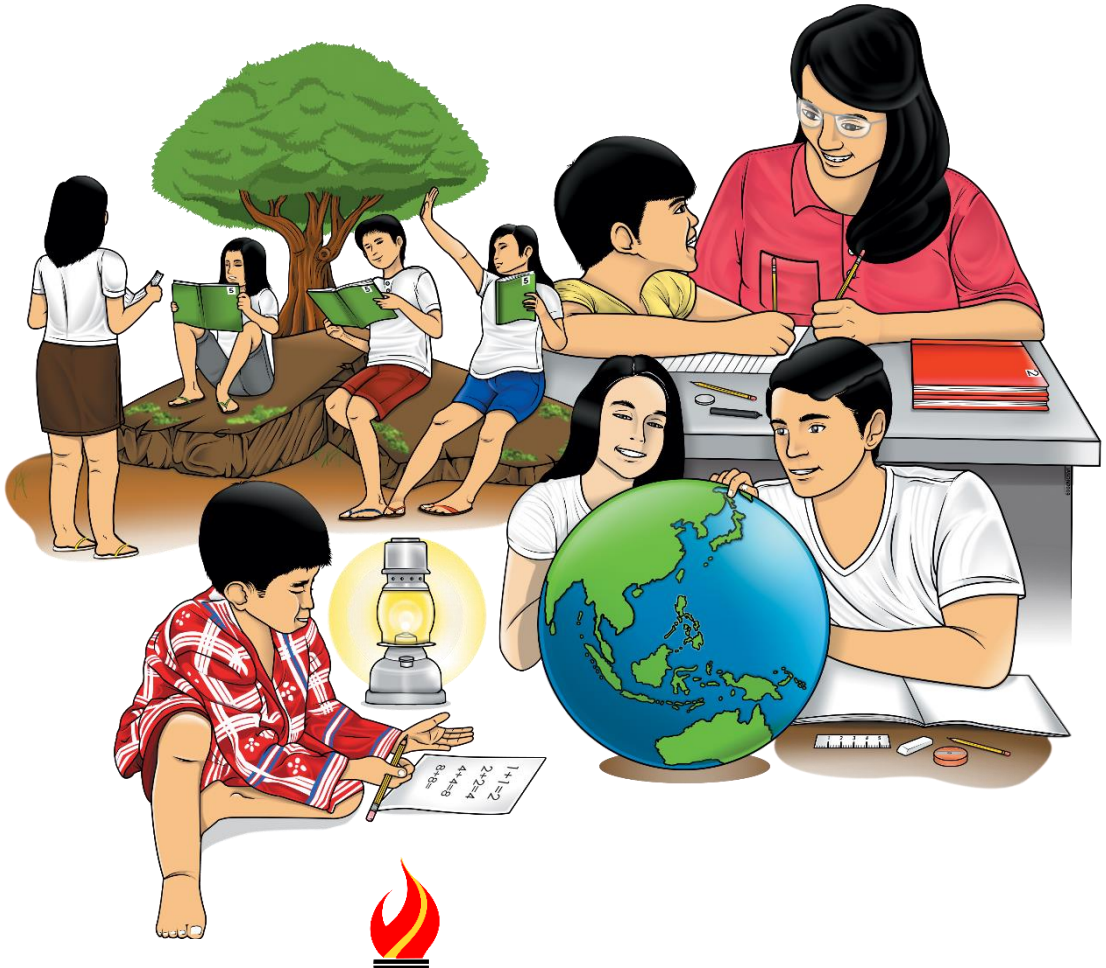
Science

Quarter 4 – Module 8.2:
Heat, Work, and Efficiency



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Secretary: Leonor Magtolis Briones
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Development Team of the Module

Writers: Genevive G. Cortes, Jenevieve D. Fernan

Editor: Richard S. Talaid

Reviewers: Jeremy Sacon, Fe G. Nijaga, Nancy Pelare, Maria Janice Corpuz

Layout Artists: May D. Arapoc, Jacqueline E. Libut

Management Team: Roy Angelo E. Gazo, PhD, CESO V
Shambaeh A. Abantas-Usman, PhD
Henry B. Abueva
Ann Q. Solijon
Rustico Y. Jerusalem
Meriam S. Otarra
Charlotte D. Quidlat

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Department of Education – Division of Iligan City

Office Address: General Aguinaldo, St., Iligan City
Telefax: (063)221-6069
E-mail Address: iligan.city@deped.gov.ph

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Quarter 4 – Module 8.2:
Heat, Work, and Efficiency

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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

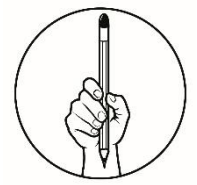
If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

At the end of this module, you should be able to:

1. infer that heat transfer can be used to do work and how work involves the release of heat. **Code: S9FE-IVf-43**



What I Know

Choose the letter of the correct answer by writing it on the space blank provided.

_____1. Based on the given table below, which type of engine has the least exhausted energy?

Type of Engine	**Efficiency (calculated maximum values) in %**
Steam Engine	29
Steam Turbine	40
Diesel Engine	56
Gasoline Engine	60

A. Steam Engine
B. Steam Turbine
C. Diesel Engine
D. Gasoline Engine

_____2. Which method of heat transfer best illustrates the cold air in contact with the skin?

A. radiation
B. conduction
C. convection
D. none of the above

_____3. Which of the following methods of heat transfer can only happen in liquids and gases but not in solids?

A. radiation
B. conduction
C. convection
D. all of the above

_____4. What happens to the thermal energy when two objects at thermal equilibrium are in contact?

A. It transfers from hotter to colder object
B. It transfers from colder to hotter object
C. There is no transfer of energy
D. Cannot be determined

_____5. Which of the following methods of heat transfer can happen even in vacuum?

A. radiation
B. conduction
C. convection
D. all of the above

_____6. The following are thermal efficiencies of different engines EXCEPT

A. 100%
B. 50%
C. 30%
D. 20%

_____7. Which method of heat transfer best illustrates land breeze?

A. radiation
B. conduction
C. convection
D. none of the above

_____8. Which is the direction of heat transfer via conduction?

A. Cold to hot fluid
B. Hot to cold fluid
C. Both directions
D. None of these

_____9. What is the reason why a wet pants can easily dry after it was put on a clothes line under the sun?

A. The water molecules in the pants gain energy and condense
B. The water molecules in the pants lose energy and evaporate.
C. The water molecules in the pants lose energy and condense
D. The water molecules in the pants gain energy and evaporate

_____10. The metallic, wooden, silicon-made and plastic spoons were placed on a bowl with hot soup. Which of the following will gain the lowest energy after 10 seconds in contact with hot soup on a bowl?

A. Plastic spoon
B. Metallic spoon
C. Wooden spoon
D. Silicon-made made

Lesson 1 Heat, Work, and Efficiency

At the end of the lesson, you will be able to:

a. define heat transfer and

b. derive conclusion that:

heat transfer can be used to do work, and

work involves the release of heat

What's In

In your Grade 7, you have learned that heat is related to temperature. Heat transfer may change one's temperature or one's phase. This change in temperature, either a decrease or an increase means that there is an energy transfer in the form of heat. In this module it focuses on heat and work and how heat can be turned into work and how work involves the release of heat.

What's New

From your previous lessons you learned that molecules exert force on one another. The closer the molecules are to each other, the stronger the force between them like in solids and liquids. That is why, their intermolecular forces are greater than those in gases. Because of these strong molecular forces, like in solids and liquids particularly, separating these molecules requires work.

Heat and work are two different ways of how energy is transferred from one body to another but they are closely related to each other. There are also different ways to transfer energy to increase the thermal energy of a system. For instance, if you rub your hands forcefully for a few seconds, they are warmed, but they were not brought into contact with a hotter body. The work done by the frictional force between the rubbed surfaces resulted in a transfer of energy into thermal energy.

Have you ever seen hot air rises? In this activity, you are going to investigate how a thermal-powered flower works.

Note: This activity uses fire and paper so an adult supervision is required.

Activity1: Thermal-Powered Flower

Materials Needed:

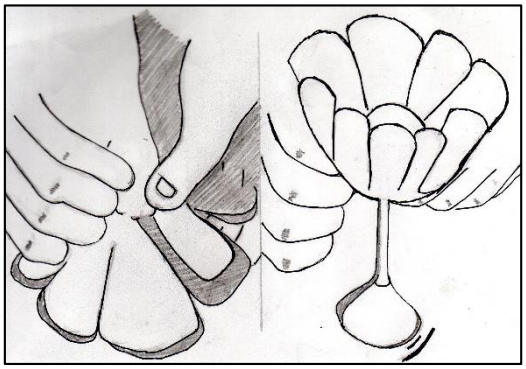
4 small candles	barbecue stick
pencil	clay
drinking straw	scissors
ruler	match
colored paper/cardboard	

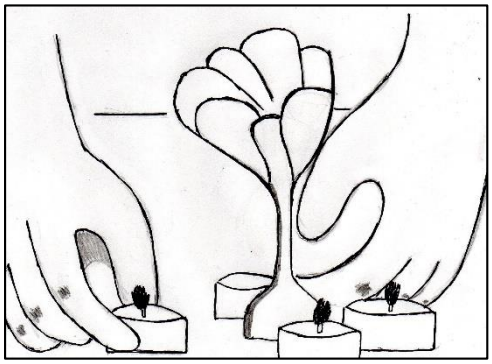
Good fire safety practice that you should follow includes

- keeping your workplace tidy and having a good standard of housekeeping
- regularly removing combustible waste, including accumulations of dust
- keeping ignition sources away from combustible material or flammable liquids and gases
- keeping use of flammable liquids to a minimum and closing containers when not in use.

Procedure:

1. Draw and cut a flower out of your cardboard or colored paper. Twist each of the flower petals to create a fan shape.
2. Cut the straw to 4 inches long and the barbecue stick to 5 inches from the pointed end.
3. Wrap the clay around the straw. Let it stand up vertically. You have to make sure that there is no clay inside the straw.
4. Get a small piece of clay to attach the center of your flower to the flat end of the barbecue stick. Then slip it inside the straw like in the Figure 1 below.
5. Place the small candles around the base of the straw and light them. See Figure 2 below. Observe what happens.





By Juana Mae Denolan

Guide Questions:

1. What is happening to your thermal-powered flower?
2. What causes the flower to spin? Why?
3. What can you infer in this activity?

Another way of increasing a body's thermal energy is by doing work on that body. Say for instance, when a bus is running, its engines and wheels turn hot. It only indicates an increase in thermal energy. When you do heavy work or do exercises, your body produces heat, which makes you perspire.

Let us try this simple activity but make sure you observe the safety measures in place. Be careful when handling electrical appliances and hot liquids.

Precautionary measures to prevent electrical related accidents:

1. Check the appliance you are going to choose and make sure that your hands are not wet.
2. Since you will be just ask to feel the back of that appliance, so do not touch it.
3. If you get a tingle or a little shock after turning it on, immediately turn off the power or call other people in your house to help you deal with it.

1. Choose one appliance available in your house (example, TV or electric fan). Make sure that it is turned off.
2. Do not touch the appliance. Just place your hands near it at a distance of 1 inch from the back of that appliance. What do you feel?
3. Turn it on and use for 2 hours. Place again your hands near it at a distance of 1 inch from the back of that appliance and feel. What do you feel?
4. What can you infer in this activity?

What is It

From the activity, as the flames from each candle heat the air up around them, the air expands and become less dense than the surrounding, the cooler air. This causes the heated air to rise upwards, creating a gentle, warm breeze that causes the flower to rotate or spin. Therefore, heat transfer can be used to do work. Another way around, when you do heavy work or do exercises, your body produces heat, which makes you perspire.

In the second activity, if you used an electric fan, mechanical energy from pushing the buttons on the electric fan will spin the fan blades which increases the internal energy of the system.

Heat transfer is always seen in our daily lives. When we conduct the majority of our household activities and even when we participate in sports, we frequently experience heat transfer. But, what exactly is heat transfer? Heat transfer occurs whenever there is a temperature change. It's when energy is transferred from a high-temperature object to a low-temperature object. Boiling water is one example of heat

transfer. The hot burner heats the kettle, which heats the water inside the kettle. It can no longer be considered heat once it has been transmitted; instead, it becomes the body's internal energy. When two things reach the same temperature, energy cannot be transferred from one to the other. Thermal equilibrium is the term used to describe the state of the things. Because there are so many processes that involve heat transfer, it's difficult to envisage a situation where there isn't any.

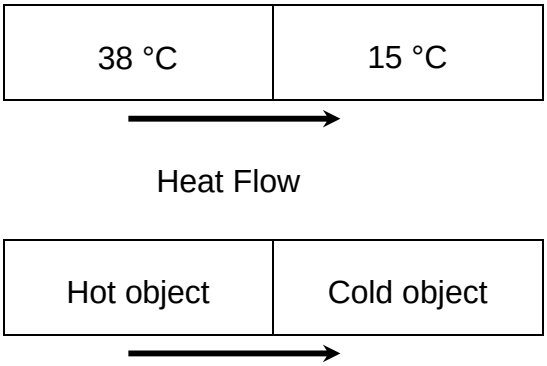
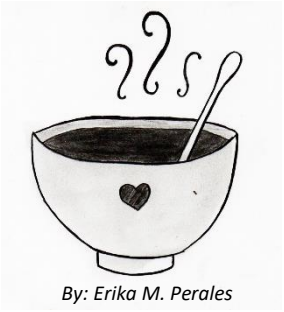


Fig. 1 Direction of Heat Flow

There are three methods that facilitate heat transfer. These methods are known as conduction, convection and radiation.

a. Conduction.

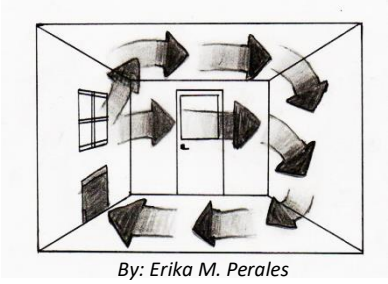


Have you ever left a spoon in a bowl of hot soup and found it was too hot to touch? This happens because the soup's energy is transferred to the spoon via conduction. When two objects of different temperatures are in direct contact with each other, energy transfers by conduction. Vibrating atoms or molecules excite the atoms or molecules nearby during conduction. Higher temperatures, such as those found in soup, have more energy, causing the soup's molecules to vibrate. However, some of this energy can be transmitted to lower-temperature atoms, such as those found in the spoon, dust particles in the air, or even water molecules in the spoon.

Furthermore, conduction can occur in solid, liquid and gas materials or substances that are directly in contact with one another until thermal equilibrium is achieved. The warm air that comes into contact with your skin is an example of conduction between solid and gas particles. You feel that the air is warm since there's a temperature difference between your skin and the air. The transfer of energy always happens from a substance of higher temperature to lower temperature. Some materials are better conductors and others are good insulators. Matter with a high kinetic energy, such as metals, would also have a high thermal conductivity, allowing it to transmit heat quickly. Metals are good conductors of heat because of its free electrons that can easily flow across the bulk of the substance. These free electrons collide with other particles at a high rate, causing a metal's internal structure to vibrate faster and heat up faster. These quick vibrations enhance energy and heat movement throughout the

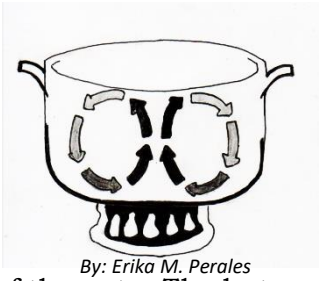
metal, which is why a wooden spatula does not get as hot as a metal spoon when used in the kitchen. Non-metals, have poor thermal conductivity which limit heat flow. Thus, good insulators such as wood, rubber and hard plastic are used in the handles of cook wares.

b. Convection


By: Erika M. Perales

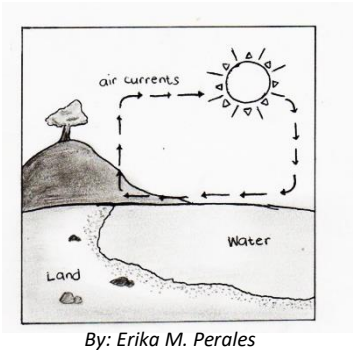
Did you know that in order to enable free air circulation, it's a good idea to open both the windows below and the slits in the upper areas of a room? Convection will allow the cold air from the outside to push the warm air inside. Convection is the process by which energy in fluids is moved from one location to another. Warmer, less dense water molecules rise in cooler, more dense surroundings, causing these flows. It is based on Archimedes' principle, according to which less dense materials float on denser materials.

Consider how energy is transferred through water that is heated in a saucepan on the stove. The stove burner is the source of thermal energy in this setup.


By: Erika M. Perales

The water is heated in the metal pot via conduction from the stove flame. As the metal kettle heats up, then, the water inside it is also heated. Water particles spread out since they move faster and collide more often with the walls of the kettle. As a result, the water at the bottom of the pot heats up and becomes less dense. The gradual formation of circulation currents is caused by differences in water density between the bottom of the pot and the top of the pot. The hot water rises to the top of the pot, displacing the colder water that had previously been present. The cooler fluid sinks to the bottom, heats up, and rises again, repeating the cycle.

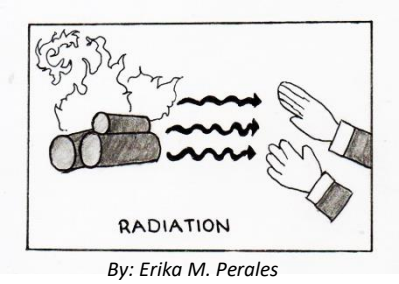
The creation of winds in our atmosphere is due to the cyclic movement of fluids. Convection is also at the heart of today's room-heating systems. Another example of convection is the land breeze and sea breeze (see picture), which are caused by temperature changes in the atmosphere.



By: Erika M. Perales

Radiation from the sun heats the ground, the ground heats the air by conduction. The air directly in contact with the ground is heated through conduction, then the air molecules heated rises up as a haze (a suspension of solid particles of dust and smoke) and contacts with the cooler air and heats the air above by convection.

c. Radiation.



By: Erika M. Perales

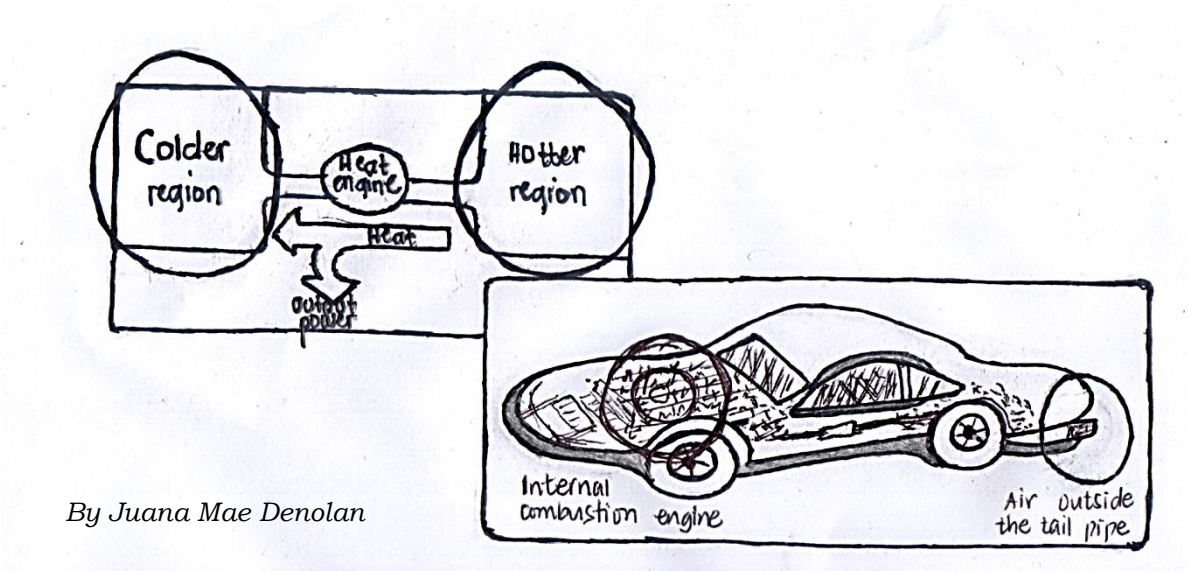
When you sit near a bonfire you would feel the heat coming from it through radiation. In *radiation,* energy travels as electromagnetic waves in the same manner as the speed of light. Radiation can transfer energy from a source to another object even if there is a vacuum between them. This is how energy from the sun travels through empty space and warms the earth. When something is hot, like the fire in a bonfire, it releases some of its energy in the form of electromagnetic waves. The waves travel through space until they hit something. These waves heat up things that absorb them. The bonfire literally 'radiates' heat that is why you can feel the heat even if your hand is not actually touching it.

Distance can be considered as one factor that could affect the amount of heat absorb by a material. The longer the distance the less the transferred energy. There are some materials that are considered as good/ideal absorber and emitter of energy like black body and in gases, carbon filters is use for greenhouse.

When you rub your hands vigorously for a few second you will feel that it gets warmer. The same happens when you hammer a nail, both tools become warmer. These are evidences that heat and work are related.


By Genevive G. Cortes

Previously, we define heat as the energy transferred from one object to another due to their temperature difference. And also, we know that work is the energy transferred when an object is moved against force. Like popping popcorn inside a pot that moves the cover as it pop. Another example where heat transfer can be used to do work is when we cook rice. When rice boils (convection inside the pot), the cover may move upward due to bubbles (where work is done).

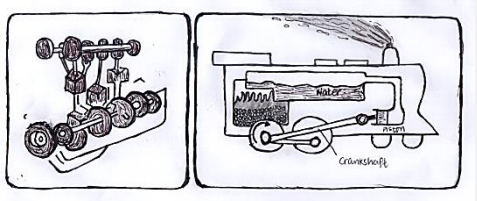


By Juana Mae Denolan

The natural or spontaneous flow of heat from a higher temperature to a lower temperature was being used to do work where external energy is not required to occur. The reverse of this process is called non-spontaneous process, wherein heat flows from lower temperature to higher temperature. For this to happen, work should be done on the system which requires mechanical energy. All the work that we do like jogging, playing basketball and even doing household chores can be completely changed into heat. However, it is impossible to convert heat totally into work, so a certain machine like heat engine is needed to make it possible cannot have 100% efficiency.

The thermal efficiency of any heat engine is the ratio of the useful work done to the heat input. Although we can only have a 100% efficiency if there is no energy being exhausted from the engine by heat, but still in reality, there is no 100% efficient engine and an example of this is an automobile's internal combustion engine. Say for instance, the engines of a car are only 35% efficient. This means that for every 100 Joules of thermal energy produced by the combustion of gasoline, only 35 Joules are used to move the car.

Types of Engine



By Juana Mae Denolan

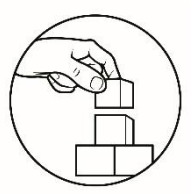
Basically the engines are of two types, and these are external combustion engines and internal combustion engines.

(i). External combustion engine: the combustion of fuel takes place outside the engine. Example: steam engine.

(ii). Internal combustion engine: the combustion of fuel takes place inside the engine. Two stroke and four stroke petrol and diesel engine are the examples of internal combustion engine.

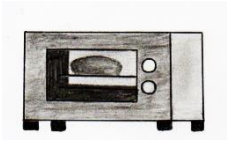
All heat engines may produce waste heat so no engine can ever convert all energy into useful motion or mechanical energy. So where does this waste heat go? In the case of gas engine of an automobile, its waste products in the form of gases are dissipated to the environment which we called thermal pollution. So exhaust from vehicles is a major source of air pollution. Electric power plants and factories also contribute to the air pollution problem because heat engines are being used which bring harms not only to the environment but also to humans. Air pollution really has a great negative impact to our health because it causes eye and respiratory problems.

In general, thermal pollution can be controlled but cannot be totally eliminated. While there is no guarantee that it can be solved entirely, there is still the chance of minimizing it.



What's More

I. Identify what method of heat transfer that takes place in each illustration. Write your answer below in each illustration/picture.



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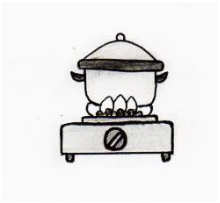


By: Erika M. Perales

_____

II. Identify the method of heat transfer (conduction, convection or radiation) is/are taking place in each of the following situation.

1. A certain type of stainless cookware has a coiled of copper applied to its bottom to help it heat evenly. The coiled copper transfer heat to the cookware by _____.
2. The cause of weather systems on earth is _____.
3. A heater is placed under one corner of a water bed mattress. Warm water moves throughout the mattress because of _____.
4. The heat from a hot burner to a pot is transferred by _____.

Activity: "Work It Out"

A. Directions: Study the pictures below. Encircle the letter of the ones that illustrate that work involves the released of heat and box the picture/s that heat transfer was used to do work.





By: Erika M. Perales

A B C D E

B. Directions: Using the following activities below, discuss how work involves the release of heat and how heat can be used to do work.

1. Jogging
2. Dancing
3. Walking

Activity: Table Analysis

Direction: Study the table below showing the Efficiencies for Different Types of Engines then answer the guide questions that follow.

Type of Engine	Efficiency (calculated maximum values) in %
Steam Engine	29
Steam Turbine	40
Diesel Engine	56
Gasoline Engine	60

Source: Science and Technology Series: Practical and Explorational Physics, Modular Approach, p.237

Guide Questions:

1. What can you say about the efficiency of each type of engine?
2. If there are no 100% efficient engines, then what will happen to a certain amount of heat (in an automobile, for example) that is not converted into work?
3. What do you think is the effect of this exhaust gas into the environment?
4. As a student, how can you help minimize the effects of thermal pollution?

What I Have Learned

Choose the letter of the correct answer by writing it on the space blank provided.

___ 1. When Gino stretched a rubber band ten times, he felt that the rubber band is warmth. Did the rubber band emit heat?

a) No, it is not evident.
b) Yes, the rubber band felt warmth means heat was given off.
c) Yes, the rubber band felt warmth means heat was absorbed.
d) No, temperature is not related to given off or absorption of heat.

___ 2. Is it possible to change the temperature of a glass of water by stirring the water, even though the glass is insulated from its surroundings?

a) No, stirring will not affect the temperature of the water.
b) No, insulation prevents the change of temperature of the water.
c) Yes, stirring the water increases its internal energy causing the increase of its temperature.
d) Yes, stirring the water decreases its internal energy causing the decrease of its temperature.

___ 3. Which of the following happens to the thermal energy of the two objects at different temperatures when they are in contact?

a) Their thermal energies remain the same.
b) Thermal energy passes from the cooler object to the warmer object
c) Thermal energy passes from the warmer object to the cooler object.
d) Thermal energy passes back and forth equally between the two objects.

___ 4. Which statement describes the direction of spontaneous heat flow?

a) Heat flows in a vacuum by conduction.
b) Heat flows between two objects at the same temperature.
c) Heat flows from an object at high temperature to one at low temperature.
d) Heat flows from an object at low temperature to one at high temperature.

___ 5. All of the following statements show that work and heat are NOT related, EXCEPT _____.

a) Using a pulley and an inclined plane
b) Rubbing hands and hammering a nail
c) Evaporation and condensation
d) Carrying heavy loads and pushing the wall

Summary

- Energy transfers naturally from a body of higher temperature to a body of lower temperature.
- The energy transferred form one body to another because of a temperature difference is called heat.

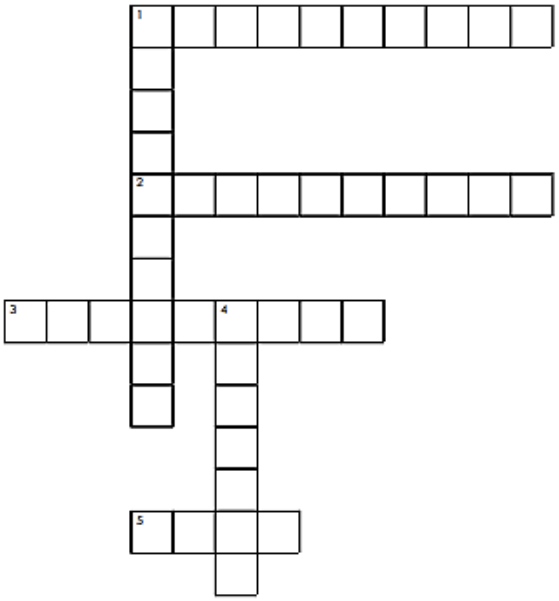
There are three methods of heat transfer:

- Conduction – is the transfer of heat due to direct contact between two objects/materials with different temperatures. The process of heat transfer in solids is called conduction. Example: A pot on firewood
- Convection – is the transfer of heat from one location to the other by the movement of fluids. Example: Boiling water
- Radiation – is the transfer of heat by electromagnetic (EM) wave. Example: microwave oven

What I Can Do

CROSS-WORD PUZZLE

A. Direction: Read the clues below and fill in the correct answer in the cross-word puzzle.



Across →

1. transfer of heat due to direct contact between two objects
2. measure how much work or energy conserve in a process ratio of the useful work done to the heat input
3. heat transfer by electromagnetic (EM) wave
5. describe the energy transfer due to temperature difference

Down ↓

1. transfer of heat by movement of fluids
4. the one being transferred during heat transfer

B. Cut out pictures of daily activities that figures out how work involves the release of heat and how heat can be used to do work. Give a short description or caption of the picture.

C. Answer the following questions:

1. Is it impossible for a ship to use internal energy of seawater to operate its engine? Explain.
2. Why heat engines are intentionally equated at high temperatures?

Assessment

Multiple Choice. Choose the letter of the correct answer by writing it on the space blank provided.

_____1. Based on the given table below, which type of engine has the greatest exhausted energy?

Type of Engine	**Efficiency (calculated maximum values) in %**
Steam Engine	29
Steam Turbine	40
Diesel Engine	56
Gasoline Engine	60

A. Steam Engine
B. Steam Turbine
C. Diesel Engine
D. Gasoline Engine

_____2. Which method of heat transfer best illustrates the heat that you feel when you are near the bonfire?

A. radiation
B. conduction
C. convection
D. none of the above

_____3. Which of the following methods of heat transfer can only happen in fluids?

A. radiation
B. conduction
C. convection
D. all of the above

_____4. What happens to the thermal energy when two objects at different temperatures are in contact?

A. It remains the same.
B. It transfers from hotter to colder object
C. It transfers from colder to hotter object
D. It transfers from hotter to colder object until thermal equilibrium is achieved

_____5. Which of the following methods of heat transfer can only happen in solids, liquids and gases?

A. radiation
B. conduction
C. convection
D. all of the above

_____6. The following are thermal efficiencies of different engines EXCEPT

A. 20%
B. 30%
C. 50%
D. 100%

_____7. Which method of heat transfer best illustrates sea breeze?

A. radiation
B. conduction
C. convection
D. none of the above

_____8. Which is the direction of heat transfer via convection?

A. Hot to cold fluid
B. Cold to hot fluid
C. Both directions
D. None of these

_____9. What is the reason why a wet shirt can easily dry after it was put on a clothes line under the sun?

A. The water molecules in the shirt gain energy and condense.
B. The water molecules in the shirt gain energy and evaporate.
C. The water molecules in the shirt lose energy and condense.
D. The water molecules in the shirt lose energy and evaporate.

_____10. The metallic, wooden, silicon-made and plastic spoons were placed on a bowl with hot soup. Which of the following will gain the highest energy after 10 seconds in contact with hot soup on a bowl?

A. Plastic spoon
B. Metallic spoon
C. Wooden spoon
D. Silicon-made made

Answer Key

Activity: Table Analysis

1. The efficiency of each type of engine differs from each other.
2. The amount of heat that is not converted into work is dissipated to the environment as waste heat and will become a thermal pollution.
3. This exhaust gas causes air pollution that will harm the environment like the formation of acid rain and global warming which give bad effects also to human health and threatens the life of people and animals.
4. (Student's answer may vary) Example: Simply reduce electrical consumption at home.

What's More

I. 1. radiation 2. convection 3. conduction

II. 1. Conduction 2. convection 3. convection 4. conduction

Activity 2

4.(The student cannot feel anything.)
5.(The student can feel a little heat given off by an appliance.)
6.When electrical energy is converted into another form of energy, then
7.heat is given off to the surrounding.

Activity1

1. The thermal-powered flower rotates/spins
2. As the flames from each candle heat the air up around them, the air expands and becomes less dense than the surrounding, cooler air. This causes the heated air to rise upwards, creating a gentle, warm breeze that causes the flower to rotate just like a pinwheel spins in the wind!
3. Hot air rises due to transfer of energy

Post-Test

1. A 2. A 3. C 4. D 5. B 6. D 7. C 8. A 9. B 10. B

Pre-Test

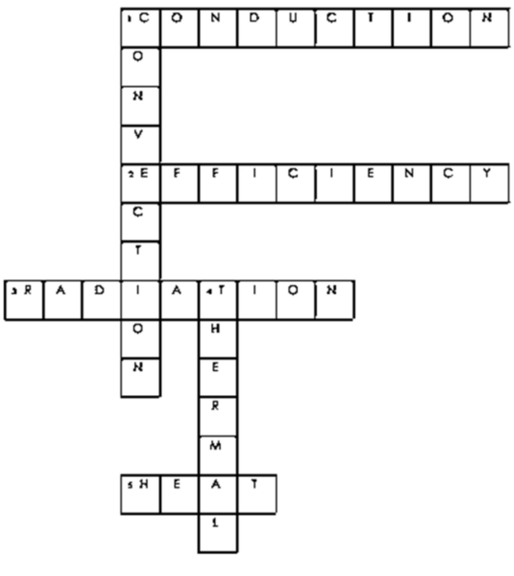
1. D 2. B 3. C 4. C 5. A 6. A 7. C 8. B 9. D 10. C

What I Have Learned

1. B 2. C 3. C 4. C 5. B

What I Can Do

A.



C. 1. In order for the heat engine to operate normally, there must be a heat Reservoir at temperature lower than the temperature of sea water. In this situation there is no heat reservoir to reject the heat which is not used for doing work so it is really impossible for a ship to use internal energy of seawater to operate its engine.

2. So that it can achieve a higher efficiency because the higher the operating steam temperature, the higher the efficiency.

Formative Assessment: A, C, and D

References

Science 9: Learner's Module. (n.d.). Department of Eduation.

For inquiries or feedback, please write or call:

Department of Education - Bureau of Learning Resources (DepEd-BLR)

Ground Floor, Bonifacio Bldg., DepEd Complex
Meralco Avenue, Pasig City, Philippines 1600

Telefax: (632) 8634-1072; 8634-1054; 8631-4985

Email Address: blr.lrqad@deped.gov.ph * blr.lrpd@deped.gov.ph