نموذج مراجعة وفق الهيكل الوزاري

EOT 2 EXAM

Grade 9 General Science

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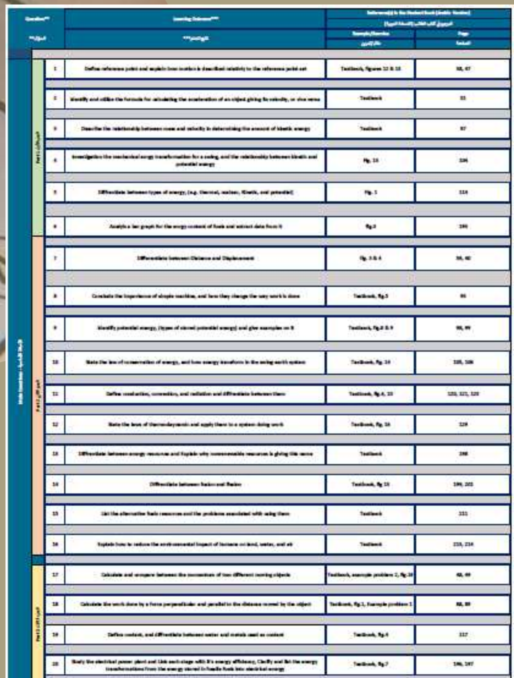

1	Define reference point and explain how motion is described relativly to the reference point set	Textbook, figures 12 & 13	38, 47

Motion and Position

You do not always need to see something move to know that motion has taken place. For example, suppose you look out a window and see a mail truck stopped next to a mailbox, as shown in **Figure 1.** One minute later, you look out again and see the same truck stopped farther down the street. Although you did not see the truck move, you know it moved because its position relative to the mailbox changed.

Reference points

A reference point is needed to determine the position of an object. In **Figure 1**, the reference point might be a mailbox. **Motion** is a change in an object's position relative to a reference point. How you describe an object's motion depends on the reference point that is chosen. For example, the description of the mail truck's motion in **Figure 1** would be different if the reference point were a tree instead of a mailbox.

After a reference point is chosen, a frame of reference can be created. A frame of reference is a coordinate system in which the position of the object is measured. The *x*-axis and *y*-axis of the reference frame are drawn so that they are perpendicular to each other and intersect the reference point.

Figure 1 As the mail truck follows its route, it stops at each mailbox along the street.

Explain *How would you know the mail truck has moved?*

3D THINKING DCI Disciplinary Core Ideas · CCC Crosscutting Concepts · SEP Science & Engineering Practices

COLLECT EVIDENCE

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INVESTIGATE

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Virtual Investigation: Describing Motion
Carry out an investigation to determine the relationship between distance, average speed, and time of cars in a race, and to predict the distance the cars will travel.

Quick Investigation: Measure Average Speed
Carry out an investigation to determine the average speed of a toy car and how average speed changes when forces of different magnitude are applied to the system.

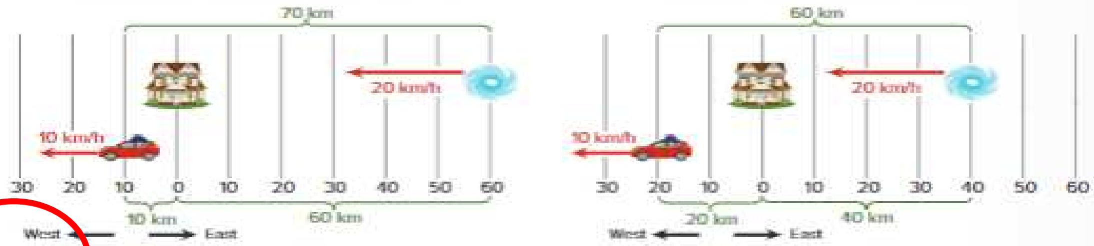


Figure 12 If the house is chosen for the reference point, the car appears to be traveling 10 km/h west, and the hurricane appears to be traveling 20 km/h west.

Relative Motion

Have you ever watched cars pass you on the highway? Cars traveling in the same direction often seem to creep by, while cars traveling in the opposite direction seem to zip by. This apparent difference in speeds is because the reference point—your vehicle—is also moving.

The choice of a moving reference point affects how you describe motion. For example, the motion of a hurricane can be described using a stationary reference point, such as a house. **Figure 12** shows the locations and velocities of a hurricane and a car relative to a house at 2:00 P.M. and 3:00 P.M. The distance between the hurricane and the house is decreasing at a rate of 20 km/h. The distance between the house and the car is increasing at a rate of 10 km/h.

How would the description of the hurricane's motion be different if the reference point were a car traveling at 10 km/h west? **Figure 13** shows the motion of the hurricane and the house relative to the car. A person in the car would say that the hurricane is approaching with a speed of 10 km/h and that the house is moving away at a speed of 10 km/h. It is important to notice that **Figure 12** and **Figure 13** show the same changes, but they use different reference points. Velocity and position always depend on the point of reference chosen.

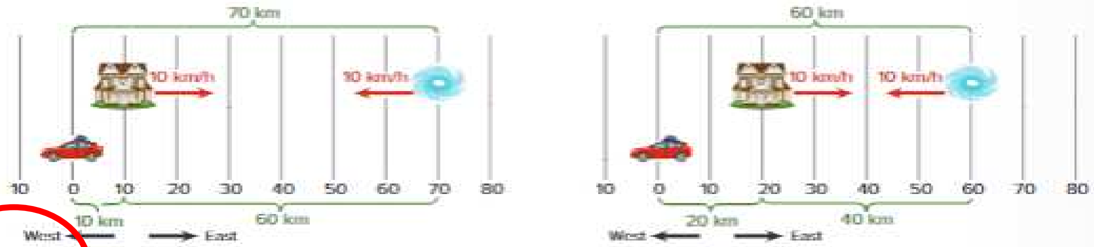
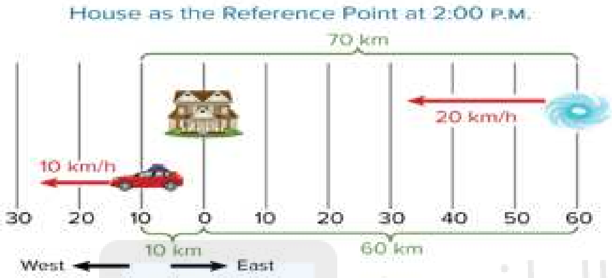


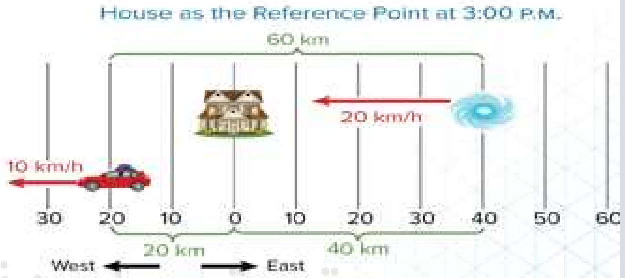
Figure 13 If the car is chosen as the reference point, the hurricane appears to be moving toward the car at 10 km/h, and the house is moving away from the car at 10 km/h.

1	Define reference point and explain how motion is described relativly to the reference point set	Textbook, figures 12 & 13	38, 47

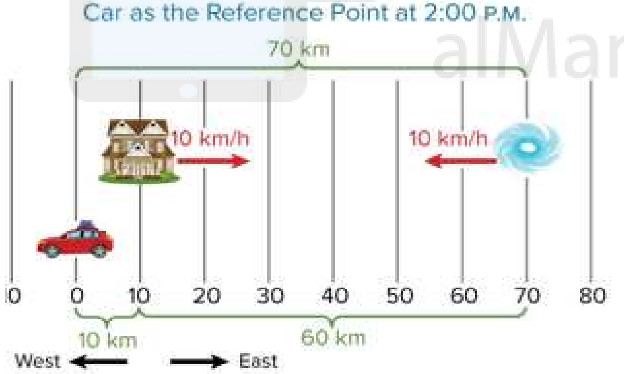
Part 1 الجزء الأول

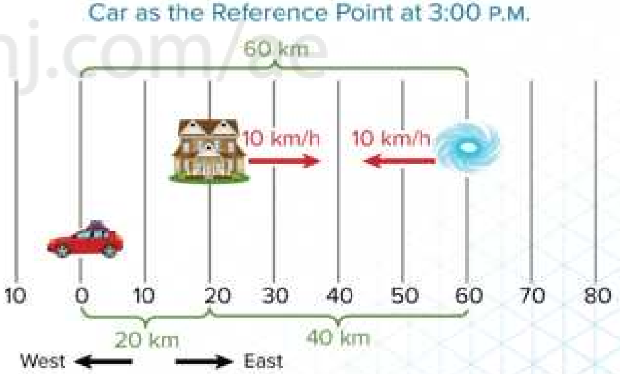
- The distance between the hurricane and the house is decreasing at a rate of 20 km/h.
- The distance between the house and the car is increasing at a rate of 10 km/h.





If the car is chosen for the reference point, the house appears to be traveling 10 km/h east and the hurricane appears to be traveling 10 km/h west.





Speed of Tamara's Car

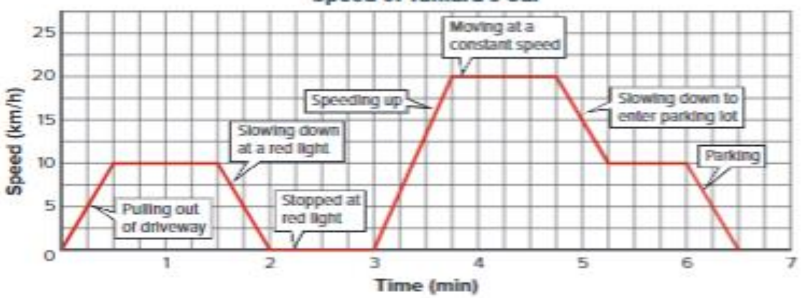


Figure 16 For objects that are speeding up and slowing down, the slope of the line on a speed-time graph is the acceleration.

Identify *the time intervals during which Tamara's car is not accelerating.*

Speed-time graphs and acceleration

When an object travels in a straight line and does not change direction, a graph of speed versus time can provide information about the object's acceleration. **Figure 16** shows the speed-time graph of Tamara's car as she drives to the store. Just as the slope of a line on a distance-time graph is the object's speed, the slope of a line on a speed-time graph is the object's acceleration. For example, when Tamara pulls out of her driveway, the car's acceleration is 0.33 km/min², which is equal to the slope of the line from $t = 0$ to $t = 0.5$ min.

Calculating acceleration

Acceleration is the rate of change in velocity. To calculate the acceleration of an object, the change in velocity is divided by the length of the time interval over which the change occurs. The change in velocity is the final velocity minus the initial velocity. If the direction of motion does not change and the object moves in a straight line, the size of the change in velocity can be calculated from the change in speed. Then, the acceleration of an object can be calculated from the following equation.

Acceleration Equation

$$\text{acceleration (in meters/second}^2\text{)} = \frac{\text{change in velocity (in meters/second)}}{\text{time (in seconds)}}$$

$$a = \frac{v_f - v_i}{t}$$

In SI units, velocity has units of m/s and time has units of s, so the SI unit of acceleration is m/s². In some cases, your calculations will result in a negative acceleration. The negative sign means *in the opposite direction*. For example, an acceleration of −10 m/s² north is the same as 10 m/s² south.

CCC CROSSCUTTING CONCEPTS

Systems and System Models Create a table to demonstrate the importance of defining the initial conditions of a system when discussing acceleration. Change the initial conditions of the system's motion to show how a given acceleration can result in different final velocities.

1. What does a straight horizontal line represent in a speed-time graph?

A The body is at rest

B At a constant speed, the body is moving

C The body is moving at a maximum acceleration

D None of the above

2. If a ball is falling from a height, then what will be its velocity-time graph before hitting the ground?

A A positive slope straight line

B A negative slope straight line

C A zero-slope straight line

D A parabola

1. If a car is traveling 100 km/h west and comes to a stop in 3 min, what is the car's acceleration?

A 0.15 m/s2 east

B 0.15 m/s2 west

C 0.56 m/s2 east

D 0.56 m/s2 west

1. Which is the SI unit of acceleration?

s/km²

km/h

cm/s

D m/s² CORRECT

2. Which is not used in calculating acceleration?

initial velocity

time interval

C average speed CORRECT

final velocity

3. In which conditions does the car not accelerate?

The car slows from 80 km/h to 35 km/h.

The car turns a corner.

C A car moves at 80 km/h on a flat, straight highway. CORRECT

The car speeds up from 35 km/h to 80 km/h.

4. Which statement is NOT true?

Acceleration has the SI units of m/s².

The slope on a speed-time graph is the object's acceleration.

C Acceleration is always a positive number. CORRECT

To calculate the acceleration of an object, the change in velocity is divided by the length of the time interval over which the change occurs.

3	Describe the relationship between mass and velocity in determining the amount of kinetic energy	Textbook	97

Kinetic energy

When you think of energy, you might think of objects in motion. Objects in motion can collide with other objects and cause change. Therefore, objects in motion have energy. **Kinetic energy** is energy due to motion. A car moving along a highway and a ballet dancer leaping through the air have kinetic energy. The kinetic energy from an object's motion depends on that object's mass and speed.

Kinetic Energy Equation

kinetic energy (in joules) = $\frac{1}{2}$ mass (in kg) × [speed (in m/s)]^2

$$KE = \frac{1}{2}mv^2$$

If mass is measured in kilograms (kg) and speed is measured in meters per second (m/s), then kinetic energy is measured in joules (J). If you drop a softball from just above your knee, the kinetic energy from that ball's falling motion is about 1 J just before the ball reaches the floor.

EXAMPLE Problem 4

SOLVE FOR KINETIC ENERGY A jogger with a mass of 60.0 kg is moving forward at a speed of 3.0 m/s. What is the jogger's kinetic energy from this forward motion?

Identify the Unknown: kinetic energy: KE

List the Knowns: mass: m = 60.0 kg speed: v = 3.0 m/s

Set Up the Problem: $KE = \frac{1}{2}mv^2$

Solve the Problem:
$KE = \frac{1}{2}(60.0\ kg)(3.0\ m/s)^2$
$KE = \frac{1}{2}(60.0\ kg)(9.0\ m^2/s^2)$
$KE = 270\ J$

Check the Answer: Check the last step by estimating. Round 9.0 m^2/s^2 up to 10 m^2/s^2. Then, $\frac{1}{2}$ (60.0 kg)(10 m^2/s^2) = 300 J. This is close to 270 J, so the final calculation was reasonable.

PRACTICE Problems ADDITIONAL PRACTICE

16. A baseball with a mass of 0.15 kg is moving at a speed of 40.0 m/s. What is the baseball's kinetic energy from this motion?
17. **CHALLENGE** A 1500-kg car doubles its speed from 50 km/h to 100 km/h. By how many times does the kinetic energy from the car's forward motion increase?

CCC CROSSCUTTING CONCEPTS

Matter and Energy Compare the kinetic energies of different objects that travel at the same speed but have different masses. Then compare objects that have the same mass but travel at different speeds. Use your results to explain whether doubling mass or doubling speed has a greater effect on kinetic energy.

Practice Problems

16. 120 J
17. The kinetic energy from the car's motion is 4 times as great when that car is moving at 100 km/h than when that car is moving at 50 km/h.

- **Kinetic energy** is energy due to motion. The kinetic energy of an object's motion depends on that objects:

1. mass
2. speed.

Kinetic Energy Equation

kinetic energy (in joules)

$$= \frac{1}{2} \text{ mass (in kg)} \times [\text{speed in m/s}]^2$$

$$KE = \frac{1}{2} m\, v^2$$

4	investigation the mechanical enrgy transformation for a swing, and the relationship between kinetic and potential energy	Fig. 13	104

Part 1 الجزء الأول

Figure 13 Visualizing Energy Transformations

A ride on a swing illustrates how kinetic energy changes to potential energy and back to kinetic energy.

Swings The mechanical energy transformations for a swing, like the one shown in **Figure 13**, are similar to the mechanical energy transformations for a roller coaster.

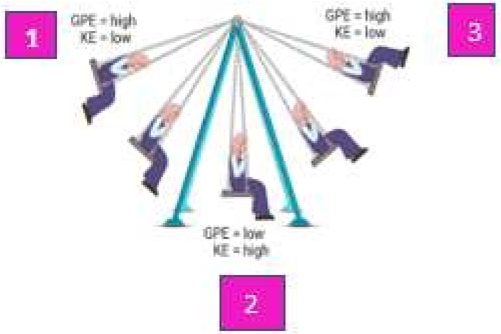
Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. The ride starts with a push, which transfers kinetic energy to the rider. As the swing rises, the rider loses speed but gains height. In energy terms, kinetic energy changes to GPE. At the top of the rider's path, GPE is at its greatest.

Then, as the swing moves back downward, gravitational potential energy changes back to kinetic energy. At the bottom of each swing, the kinetic energy is at its maximum and the GPE is at its minimum. As the rider swings back and forth, energy is continually transformed between kinetic energy and GPE. However, the rider swings less and less on each cycle unless he or she pumps the swing or gets someone to provide a push. What is happening to the rider's mechanical energy?

1. Which energy transformation is taking place in picture shown of swing earth system ?

a. GPE to kinectic energy.
b. Kinetic energy to GPE.
c. Mechanical to radiant energy.
d. Kinectic to electric energy.

2. Use the below imagesto answer the next two questions:



i. At which position of the swing – earth system the GPE is highest ?
   a. Only position 1.
   b. At both position 1 and 3.
   c. At both position 1 and 2.
   d. Only position 2.

ii. At which position of the swing – earth system the KE is highest ?
   a. Only position 1.
   b. At both position 1 and 3.
   c. At both position 1 and 2.
   d. Only position 2.

Temperature

You can use the words *hot* and *cold* to describe temperature. Something is hot when its temperature is high. When you heat water on a stove, its temperature increases. How are temperature and heat related?

Matter in motion

The matter around you is made of tiny particles—atoms, ions, and molecules. In all materials, these particles are in constant, random motion. They move in all directions at different speeds. These particles have kinetic energy because they are moving. The greater their speeds, the greater their kinetic energy. If the particles that make up an object have more kinetic energy, then that object feels hotter.

For example, in **Figure 1**, the particles that make up the electric stove burner on the left have more kinetic energy than the particles that make up the burner on the right. As a result, the burner on the left feels hotter than the burner on the right. Is there a more exact relationship between temperature and kinetic energy?

Figure 1 The particles that make up the left burner are moving faster than the particles that make up the right burner.

Predict *whether the kinetic energy of the particles that make up the water in a lake would be greater on a summer day or on a winter day.*

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Applying Practices: Coffee Cup Calorimetry

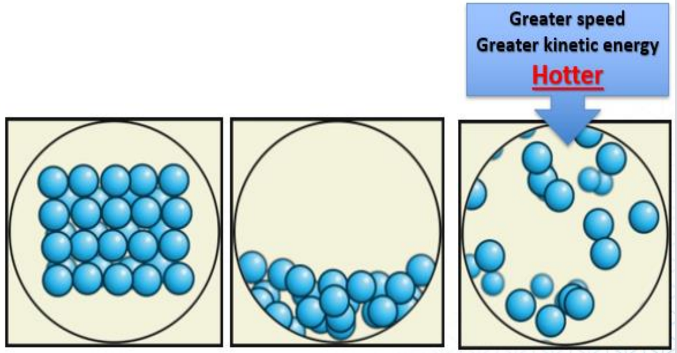
HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Matter made of tiny particles.

These particles are in constant, random motion.

They move in all directions at different speeds.

They have kinetic energy because they are moving.



1. Which term describes the measure of the average kinetic energy of the particles that make up an object?

- specific heat
- B temperature CORRECT
- potential energy
- thermal energy

The temperature is the measure of the average kinetic energy of the particles.

The SI units of temperature is Kelvins (K).

Energy use in the United States

In 2017, the United States accounted for 16.5 percent of the total energy consumption in the world, using more energy than any other country aside from China. The top chart in **Figure 2** shows energy consumption in the United States in 2017 by sector. About 20 percent of the energy was used in homes for heating and cooling, to run appliances, to provide lighting, and for other household needs. About 29 percent was used for transportation, powering vehicles such as cars and planes. Another 18 percent was used by businesses to heat, cool, and light shops and buildings. About 32 percent of the energy was used by industry and agriculture for manufacturing and food production.

The bottom chart in **Figure 2** shows that about 80 percent of the energy used in the United States in 2017 came from burning fossil fuels. Nuclear power plants provided 9 percent, and alternative energies supplied 11 percent.

Fossil Fuel Formation

In one hour of driving, a car might use two or three gallons of gasoline. It might be hard to believe that it took millions of years to make the fuels that are used to power your car, to produce electricity, and to heat your home. Coal, natural gas, and petroleum, also called crude oil, are **fossil fuels** because they form from the remains of ancient plants and animals that were buried and altered over millions of years.

Combustion reactions

When fossil fuels are burned, a combustion reaction occurs. During this reaction, carbon and hydrogen atoms combine with oxygen in the air to form carbon dioxide and water. This process converts the chemical potential energy that is stored in the bonds between atoms into thermal energy and light. Compared to wood, the energy stored in fossil fuels is much more concentrated. In fact, burning 1 kg of coal releases two to three times more energy than burning 1 kg of wood. **Figure 3** shows the energy content of different fuels.

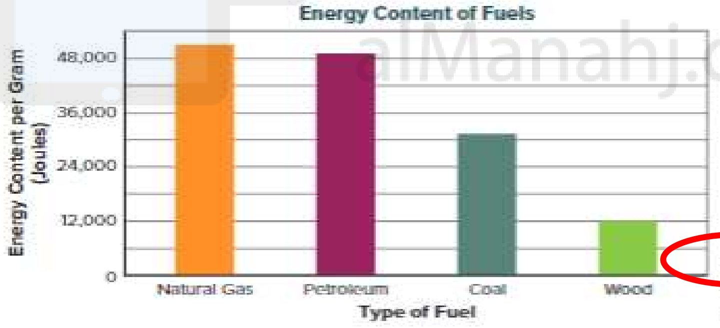
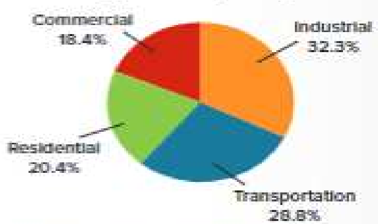


Figure 3 The fuel with the greatest chemical potential energy per gram releases the greatest amount of energy.



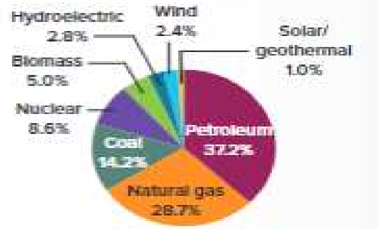
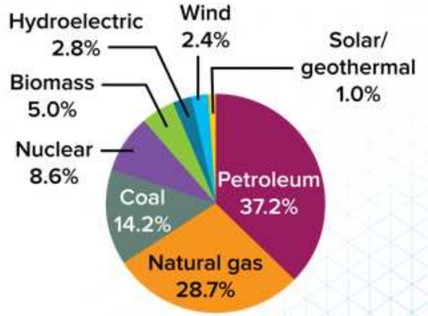


Figure 2 These circle graphs break down energy consumption in the United States in 2017. The top graph shows the percentage of energy used by different sectors. The bottom graph shows the percentage of energy obtained from different sources.

Interpret *Which energy source supplies the greatest amount of energy in the United States?*

- The chart shows United States energy consumption by source in 2017.
- About 80 percent of the energy used came from burning fossil fuels.
- Nuclear power plants provided about 9 percent.
- Alternative energies supplied about 11 percent.



1. Which sector in the United States consumes the most energy?
   - commercial
   - B industrial CORRECT
   - residential
   - transportation

2. Which of the following fuels has the greatest chemical potential energy per gram?
   - wood
   - B natural gas CORRECT
   - petroleum
   - coal

From the figure: The fuel with the greatest chemical potential energy per gram releases the greatest amount of energy.

1kg of natural gas→ 50,000 joules

1Kg of petroleum→48,000 joules

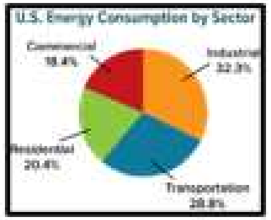
1Kg of coal→ 30,000 joules

1Kg of wood→12,000

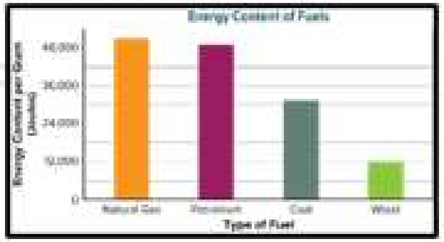
1. Why are fossil fuels considered to be nonrenewable resources?
   a. They are no longer being produced.
   b. They are being produced as fast as they are being used.
   c. They are not being produced as fast as they are being used.
   d. They contain hydrocarbon.

2. What do hydrocarbons react with whem fossil fuels are burned?
   a. Carbondioxide .
   b. Carbonmonoxide .
   c. Oxygen .
   d. Water.

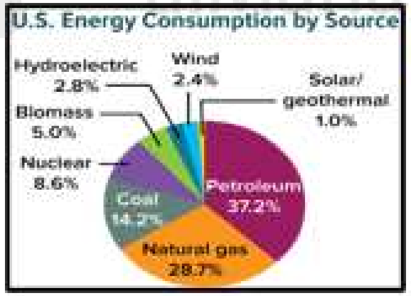
3. Which sector in the United States consumes the most energy?
   a. Industrial sector. c. commercial sector
   b. residential sector. d. transportation



4. Which of the following fuels has the greatest chemical potential energy per gram?
   a. Wood
   b. Natural gas.
   c. Petroleum oil.
   d. Coal.



5. How much of the electrical energy used in the United States was produced by burning fossil fuels in 2017?



   a. 80.1 %
   b. 36 %
   c. 14.2 %
   d. 63 %

7	Differentiate between Distance and Displacement	fig. 3 & 4	39, 40

Change in Position

Have you ever run a 50-m dash? Describing how far and in what direction you moved was an important part of describing your motion.

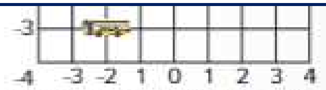


Figure 2 A coordinate system is like a map. The reference point is at the origin, and each object's position can be described with its coordinates.

Identify *the position of the orange car.*

Distance

In a 50-m dash, each runner travels a total distance of 50 m. The SI unit of distance is the meter (m). Longer distances are measured in kilometers (km). One kilometer is equal to 1000 m. Shorter distances are measured in centimeters (cm) or millimeters (mm). One meter is equal to 100 cm and to 1000 mm.

Displacement

Suppose a runner jogs to the 50-m mark and then turns around and runs back to the 20-m mark, as shown in **Figure 3.** The runner travels 50 m in the original direction (east) plus 30 m in the opposite direction (west), so the total distance that she ran is 80 m. How far is she from the starting line? The answer is 20 m. Sometimes, you may want to know the change in an object's position relative to the starting point. An object's **displacement** is the distance and direction of the object's change in position. In **Figure 3,** the runner's displacement is 20 m east.

The length of the runner's displacement and the total distance traveled would be the same if the runner's motion were in a single direction. For example, if the runner ran east from the starting line to the finish line without changing direction, then the distance traveled would be 50 m, and the displacement would be 50 m east.

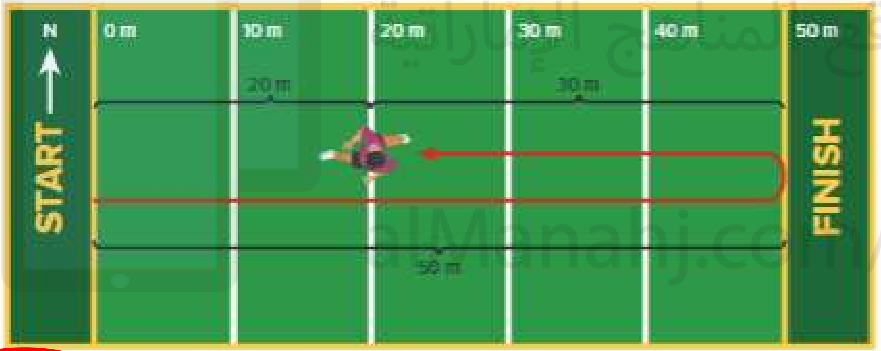


Figure 3 An object's displacement is not the same as the total distance that the object traveled. The runner's displacement is 20 m east of the starting line. However, the total distance the runner traveled is 80 m.

Describe *the difference between the total distance traveled and the displacement.*

Figure 4 These arrows represent the students' walks. The green arrows show the first part of the walk, and the purple arrows show the second part. The orange arrows show the students' displacements.

Adding displacements

You know that you can add distances to get the total distance. For example, 2 m + 3 m = 5 m. But how would you add the displacements 5 m east and 10 m east? Directions in math problems are much like units: you can add numbers with like directions. For example, suppose a student walks 5 m east, stops at a crosswalk, and then walks another 5 m east, as shown on the left in **Figure 4.** His displacement is

5 m east + 5 m east = 10 m east

But what if the directions are not the same? Then compare the two directions. If the directions are exactly opposite, the distances can be subtracted. Suppose a student walks 10 m east, turns around, and walks 5 m west, as shown in the center of **Figure 4.** The size of the displacement would be

10 m − 5 m = 5 m

The direction of the total displacement is always the direction of the larger displacement. In this case, the larger displacement is east, so the total displacement is 5 m east.

Get It?
Determine the total displacement of a dog that runs 15 m north, 6 m south, then 8 m north.

Now suppose the two displacements are neither in the same direction nor in opposite directions, as illustrated on the right in **Figure 4.** Here, the student walks 4 m east and then 3 m north. The student walks a total distance of 7 m, but the displacement is 5 m in a roughly northeast direction. The displacements of 4 m east and 3 m north cannot be directly added or subtracted, and they should be discussed separately. The rules for adding displacements are summarized in **Table 1.**

Table 1 **Rules for Adding Displacements**

1. Add displacements in the same direction.
2. Subtract displacements in opposite directions.
3. Displacements that are not in the same or in opposite directions cannot be directly added together.

SCIENCE USAGE v. COMMON USAGE

position

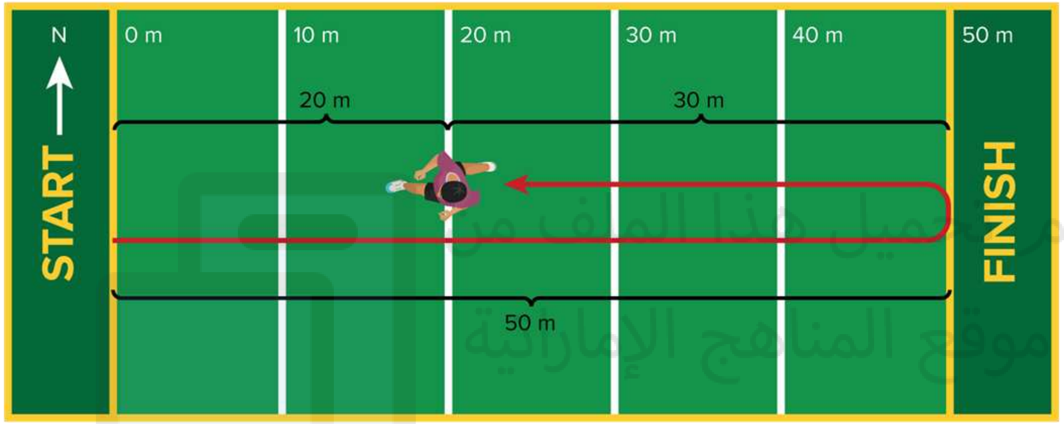
Science usage: the location of an object in relation to a reference point
The cat's position was 3 meters west of the house.

Common usage: a point of view; a job or rank
After graduation, I accepted a teller position at the bank.

7	Differentiate between Distance and Displacement	fig. 3 & 4	39, 40

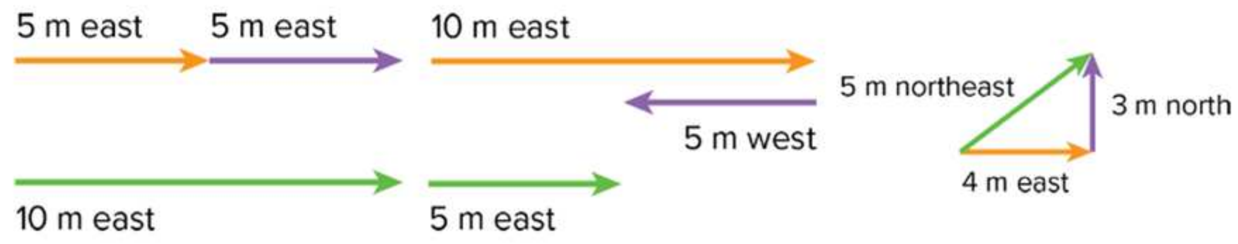
3. A wolf walks 20 km east and then turns around and walks 10 km west. What is the total displacement?

- 30 km east
- C 10 km east **CORRECT**
- 30 km west
- 10 km west



Distance = 50m+30m=80m

Displacements = 50m-30m=20m East



Displacements in the same direction can be added.

Displacements in opposite directions can be subtracted.

Displacements that are not in the same direction or opposite directions cannot be directly added or subtracted.

5 m east + 5 m east = 10 m east

$10\ m - 5\ m = 5\ m$

Table 1 Rules of Adding Displacements

1. Add displacements in the same direction.
2. Subtract displacements in opposite directions.
3. Displacements that are not in the same or in opposite directions cannot be directly added together.

8	Conclude the importance of simple machine, and how they change the way work is done	Textbook, fig.5	93

Part 2 الجزء الثاني

How are machines useful?

How are machines useful if a machine's output work is always less than its input work? Machines change the way work is done. They can increase speed, change the direction of a force, or increase force.

Increase speed Bicycles are machines that increase speed. You can travel more quickly on a bicycle than on foot. However, to increase speed, a bicycle decreases force. Look at the cyclist in the top panel of **Figure 5**. Although the cyclist can reach his destination faster by biking instead of walking, his legs must apply a larger force to the pedals to cross the distance.

Change direction of force Some machines change the direction of an applied force. The wedge-shaped blade of the ax in **Figure 5** is one example. You exert a downward force on an ax when chopping wood. The shape of the blade changes your downward force into outward forces that split the wood.

Increase force A car jack, such as the one in the bottom panel of **Figure 5**, increases force but decreases speed. The upward force exerted on the car is greater than the downward force that you exert on the handle. However, you move the car jack handle faster than the jack lifts the car.

We can describe the effectiveness of a machine at increasing force by its mechanical advantage. **Mechanical advantage** is the ratio of output force to input force.

Mechanical Advantage Equation

$$\text{mechanical advantage} = \frac{\text{output force (in newtons)}}{\text{input force (in newtons)}}$$

$$MA = \frac{F_{out}}{F_{in}}$$

The input force is the force that a person or a device such as a motor, applies to the machine. The output force is the force that the machine applies to another object. In the car jack example in **Figure 5**, the man applies an input force to the car jack, and the car jack applies an output force to the car. The mechanical advantage of the car jack is greater than 1 because the output force is greater than the input force.

Figure 5 A machine can change work to increase speed, change the direction of a force, or increase force.


Increase speed

Change direction of force

Increase force

How are machines useful? If machine's output work < input work

1.speed	2.direction	3.force
		
Increase the speed in bicycle	Change direction of force ax	Increase force A car jack

APPLICATION

1. Calculate the mechanical advantage of a hammer if the input force is 125 N and the output force is 2,000 N.
2. **Challenge** Find the force needed to lift a 3,000 N weight using a machine with a mechanical advantage of 15.

① $MA = ??$

$F_{in} = 125\,N$

$F_{out} = 2000\,N$

$MA = \frac{F_{out}}{F_{in}} = \frac{2000}{125} = 16$

② known: $F_{out} = 3000\,N$

$MA = 15$

unknown: $F_{in} = ??$

$MA = \frac{F_{out}}{F_{in}}$

$15 = \frac{3000}{F_{in}} \Rightarrow F_{in} = \frac{3000}{15}$

$\Rightarrow F_{in} = 200\,N$

4. What term indicates the number of times a machine multiplies the input force?

- efficiency
- resistance
- power
- D mechanical advantage CORRECT

Practice Problems

8. 16
9. 200 N

9	Identify potential energy, (types of stored potential energy) and give examples on it	Textbook, fig.8 & 9	98, 99

Potential energy

Energy does not always involve motion. Even motionless objects can have energy. **Potential energy** is energy that is stored due to the interactions between objects. One example is the energy stored between an apple hanging on a tree and Earth. Energy is stored between the apple and Earth because of the gravitational force between the apple and Earth. Another example is the energy stored between objects that are connected by a compressed spring or a stretched rubber band.

Get It?
Explain how a book can have energy even if it is not moving.

Elastic potential energy If you stretch a rubber band and let it go, it sails across the room. As it flies through the air, it has kinetic energy due to its motion. Where did this kinetic energy come from? Just as there is potential energy due to gravitational forces, there is also potential energy due to the elastic forces between the particles that make up a stretched rubber band. The energy of a stretched rubber band or a compressed spring is called elastic potential energy. **Elastic potential energy** is energy that is stored by compressing, stretching, or bending an object.

Get It?
Describe how the elastic potential energy of a trampoline changes as a person jumps on it.

Chemical potential energy The food that you eat and the gasoline in cars also have stored energy. This stored energy is due to the chemical bonds between atoms. **Chemical potential energy** is energy that is due to chemical bonds. You might notice chemical potential energy when you burn a substance. When an object is burned, chemical potential energy becomes thermal energy and radiant energy. **Figure 8** shows the process for burning methane.

Figure 8 When methane burns, it combines with oxygen to form carbon dioxide and water vapor. In this chemical reaction, chemical potential energy is converted to other forms of energy.

WORD ORIGINS
potential
comes from the Latin word *potens*, a form of *posse*, which means *to be able*
The rock on the cliff has potential energy because it is able to cause change if it falls.

- **Potential energy** is energy that is stored due to the interactions between objects.
- **Elastic potential energy** is energy that is stored by compressing, stretching, or bending an object.

- **Chemical potential energy** is energy that is due to chemical bonds.

Figure 8 When methane burns, it combines with oxygen to form carbon dioxide and water vapor. In this chemical reaction, chemical potential energy is converted to other forms of energy.

2. **Potential Energy**

Elastic Potential Energy

- Energy STORED in objects that are compressed or stretched
  - Springs
  - Rubber Bands

Chemical Potential Energy

- **Chemical** potential energy is energy stored in the **chemical bonds** between **atoms**. It is released when chemical **reactions** take place.

Gravitational Potential Energy

Gravitational potential energy is the energy stored in an object due to its position above the Earth's surface.

$$E_p = mgh$$

m = mass (kg)
g = gravitational field strength (N/kg)
h = height (m)
E_p = gravitational potential energy (J)

9	Identify potential energy, (types of stored potential energy) and give examples on it	Textbook, fig.8 & 9	98, 99

Gravitational potential energy Consider the blue vase in **Figure 9.** Together, the blue vase and Earth have potential energy. **Gravitational potential energy** is energy that is due to the gravitational forces between objects. Gravitational potential energy is often shortened to GPE.

Any system that has objects that are attracted to each other through gravity has gravitational potential energy. An apple and Earth have gravitational potential energy. The solar system also has gravitational potential energy. The gravitational potential energy of a system containing just Earth and another object depends on the object's mass, Earth's gravity, and the object's height. Recall that near Earth's surface, g is equal to 9.8 N/kg.

Gravitational Potential Energy Equation

gravitational potential energy (J) = mass (kg) × gravity (N/kg) × height (m)

$GPE = mgh$

Height and gravitational potential energy Look at the bookcase in **Figure 9.** Moving a vase from one shelf to another changes its GPE because the relative position of the object in Earth's gravitational field changes. Moving the vase to a higher shelf increases GPE as more energy is stored in the vase-Earth system, and moving it to a lower shelf decreases GPE as less energy is stored in the vase-Earth system.

Now imagine that this bookcase is on the second floor of a building and that this building is at the top of a large hill. How should you measure the heights of the objects on the shelves? You could measure the heights from the floor. You could also measure the heights from the ceiling, the ground outside, the bottom of the hill, or Earth's center.

To calculate gravitational potential energy, height is measured from a reference level. This means that gravitational potential energy varies depending on the chosen reference level.

Relative to the floor, the GPE of a system containing just the blue vase and Earth is about 90 J. Relative to the ceiling, the GPE of this same system might be about −40 J. Relative to Earth's center, this system's GPE is about 300 million J. All of these statements are correct. In addition, the GPE of the blue vase-Earth system is greater than the GPE of the green vase-Earth system for every reference level. However, statements such as "The gravitational potential energy is 100 J" are meaningless unless a reference level is given.

1. The gravitational potential energy of a cucumber-Earth system changes when which factor changes?

A the cucumber's mass CORRECT

the cucumber's speed

the cucumber's temperature

the cucumber's length

Figure 9 The gravitational potential energy of any system containing only an object on the bookcase and Earth depends on the object's mass, the strength of Earth's gravity, and the object's height. The object's height is measured relative to a reference level. The floor, the ground, the ceiling, and Earth's center are possible reference levels.

- **Gravitational potential energy** is energy that is due to the gravitational forces between objects.
- The gravitational potential energy of a system containing just Earth and another object depends on the object's mass, Earth's gravity, and the object's height.

Gravitational Potential Energy Equation

gravitational potential energy (J) = mass (kg) × gravity (N/kg) × height (m)

$GPE = m\,g\,h$

EXAMPLE Problem 5

SOLVE FOR GRAVITATIONAL POTENTIAL ENERGY A 4.0-kg ceiling fan is placed 2.5 m above the floor. What is the gravitational potential energy of the Earth-ceiling fan system relative to the floor?

Identify the Unknown: gravitational potential energy: GPE

List the Knowns: mass: m = 4.0 kg

gravity: g = 9.8 N/kg

height: h = 2.5 m

Set Up the Problem: $GPE = mgh$

Solve the Problem: GPE = (4.0 kg)(9.8 N/kg)(2.5 m) = 98 N • m = 98 J

Check the Answer: Round 9.8 N/kg to 10 N/kg. Then, GPE = (4.0 kg)(10 N/kg)(2.5 m) = 100 J. This is very close to the answer above. Therefore, that answer is reasonable.

PRACTICE Problems ADDITIONAL PRACTICE

18. An 8.0-kg history textbook is placed on a 1.25-m high desk. What is the gravitational potential energy of the textbook-Earth system relative to the floor?
19. **CHALLENGE** What is the GPE of the textbook-Earth system in problem 18, relative to the desktop?

Practice Problems
18. 98 J
19. 0 J; the height is 0 relative to the reference level.

10	State the law of conservation of energy, and how energy transform in the swing-earth system	Textbook, fig. 14	105, 106

Part 2 الجزء الثاني

Other energy transformations

Consider the swing again. Think about what happens when you continue to swing without getting a push or pumping. The swing slows down and eventually comes to a stop. The mechanical energy of the swing-Earth system decreases. At first, it might appear that energy is being destroyed. However, recall that there are other forms of energy aside from mechanical energy. Energy transformations often involve these other forms.

The effect of friction If the mechanical energy of the swing-Earth system decreases, then some other forms of energy must increase by an equal amount to keep the total amount of energy the same. What could these other forms of energy be? Think about friction and air resistance. With every movement, the swing's ropes or chains rub on their hooks, and air pushes on the rider, as illustrated in **Figure 14**.

Friction and air resistance convert some of the mechanical energy into a less-useful form—thermal energy. Thermal energy is the energy of heat and hot objects. With every pass of the swing, the temperature of the hooks and the air increases slightly. Mechanical energy is not destroyed. Instead, friction and air resistance transform mechanical energy into thermal energy. This thermal energy is soon transferred to the surrounding air.

Get It?
Infer why the wheels of a car get hot when the car is driven.

To keep the swing going, you must constantly put energy into the swing-Earth system. You can do this by pumping the swing, transforming the chemical potential energy from the food that you eat into additional mechanical energy.

Figure 14 In a swing-air-Earth system, air resistance and friction transform mechanical energy into thermal energy, a less useful form of energy. To keep swinging, you need to supply more mechanical energy by pumping your legs or getting a push.

Describe *how the kinetic energy and gravitational potential energy of the swing-Earth system change with time.*

CCC CROSSCUTTING CONCEPTS
Systems and System Models Create a poster to illustrate a system and the energy transformations that occur in it, such as an object that starts on a ramp, slides down the ramp and across the floor, and eventually stops.

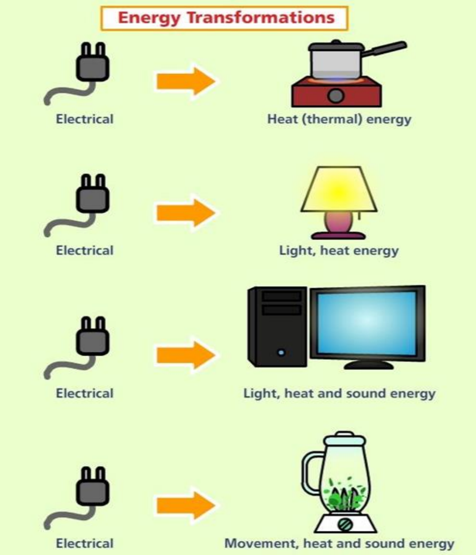
Transforming electrical energy Energy transformations can also involve electrical energy. Think about all the electric devices that you use every day. Electric stoves and toasters transform electrical energy into thermal energy. Televisions transform electrical energy into radiant energy and sound energy. The electric motor in a washing machine transforms electrical energy into mechanical energy. Lightbulbs transform electrical energy into radiant energy. **Figure 15** illustrates the energy change that occurs in a lightbulb.

What other devices have you used today that make use of electrical energy? You might have been awakened by an alarm clock, styled your hair, made toast, listened to music, or played a video game. What form or forms of energy is electrical energy converted to in each of these examples?

Transforming chemical potential energy Fuel stores energy in the form of chemical potential energy. For example, most cars run on gasoline, which has chemical potential energy. A car engine transforms this chemical potential energy into thermal energy and then into mechanical energy for the car's motion. A car engine also gets very hot when it is used. This is evidence that much of the thermal energy is never converted to mechanical energy.

Some energy transformations are less obvious because they do not result in visible motion, sound, heat, or light. Every green plant converts radiant energy into chemical potential energy. If you eat an ear of corn, the chemical potential energy from the corn is transferred to your body. Your body then extracts this energy for functions such as breathing, pumping blood, moving, speaking, and thinking.

Figure 15 A lightbulb is a device that transforms electrical energy into radiant energy.



STEM CAREER Connection
Small-Engine Mechanic
If you like working with your hands and keeping things running efficiently consider becoming a small-engine mechanic. Without proper care and re can become less efficient, causing more chemical potential energy to tra thermal energy instead of mechanical energy.

10	State the law of conservation of energy, and how energy transform in the swing-earth system	Textbook, fig. 14	105, 106

Part 2 الجزء الثاني

The law of conservation of energy

states that
1.energy cannot be created or destroyed.
2. It can only be transformed from one form to another.

2. What type of energy transformation occurs when a child uses a swing?

- chemical energy to gravitational potential energy
- B gravitational potential energy to kinetic energy CORRECT
- thermal energy to mechanical energy
- mechanical energy to chemical potential energy

3. Friction causes mechanical energy to be converted into which form?

- nuclear energy
- C thermal energy CORRECT
- kinetic energy
- potential energy

4. What type of energy transformation occurs when an object is burned?

- thermal energy to radiant energy
- thermal energy to chemical potential energy
- C chemical potential energy to thermal energy and radiant energy CORRECT
- radiant energy to chemical potential energy and thermal energy

11	Define conduction, convection, and radiation and diffrentiate between them	Textbook, fig.6, 10	120, 121, 123

Part 2 الجزء الثاني

Conduction

Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. Conduction, convection, and radiation are all processes that transfer energy. **Conduction** is the transfer of thermal energy by collisions between the particles that make up matter. Conduction occurs because particles that make up matter are in constant motion.

Collisions transfer thermal energy

If you leave a metal spoon in a pot of soup that is cooking on the stove, the spoon might get too hot to touch. As one end of the spoon heats up, the kinetic energy of the particles that make up that part of the spoon increases. These particles collide with neighboring particles. Conduction transfers thermal energy to the other end of the spoon as particles with more kinetic energy transfer kinetic energy to particles with less kinetic energy. Conduction transfers thermal energy without transferring matter. Conduction spreads thermal energy from warmer areas to cooler areas, as shown in **Figure 6.**

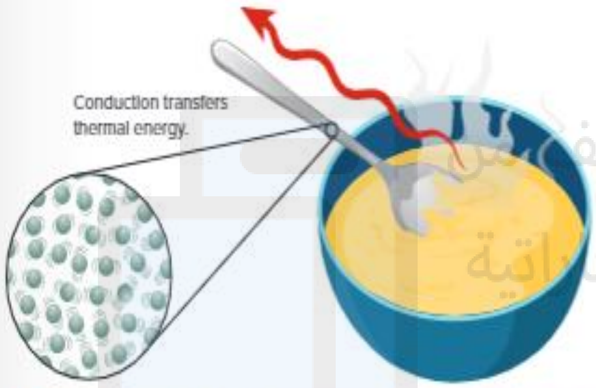


Figure 6 Conduction occurs within a material as faster-moving particles collide with slower-moving particles.

State *If two objects are in contact, would conduction be from the cooler material to the warmer material or from the warmer material to the cooler material?*

3D THINKING | DCI Disciplinary Core Ideas | CCC Crosscutting Concepts | SEP Science & Engineering Practices

COLLECT EVIDENCE

Use your Science Journal to record the evidence you collect as you complete the readings and activities in this lesson.

INVESTIGATE

GO ONLINE to find these activities and more resources.

Lab: Convection in Gases and Liquids

Carry out an investigation to demonstrate convection currents in water and air and to infer how birds utilize convection currents to conserve energy while in flight.

Lab: Conduction in Gases

Carry out an investigation to measure the temperature changes in the air near a heat source and to observe the conduction of thermal energy in air.

Thermal conductors

The rate at which conduction transfers thermal energy depends on the material. Conduction is faster in solids and liquids than it is in gases. In gases, particles are farther apart. Therefore, collisions among particles occur less frequently in gases.

The best conductors of thermal energy are metals. This is one reason why manufacturers often make cooking pots, like those in **Figure 7**, out of metal. In a piece of metal, some electrons are not bound to individual atoms. These electrons can move easily through the metal. Collisions between these electrons and other particles in the metal enable more rapid thermal energy transfers than in other materials. Silver, copper, and aluminum are among the best conductors of thermal energy.

Thermal conductors

Conduction depends on **materials**

Figure 3-27 illustrates the different rates of conduction of various metals.

Complete the following statement:

1. **Silver** is the best conductor
2. **Lead** is the poorest.
3. As previously mentioned, **copper** and **aluminum** are used in pots and pans because they are good conductors.
4. It is interesting to note that **silver, copper and aluminum** are also excellent conductors of electricity.

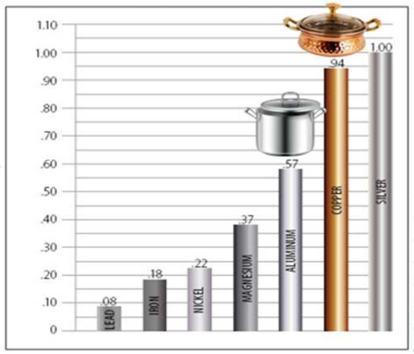


Figure 3-27. Conductivity of various metals.

Convection

Unlike solids, liquids and gases are fluids that flow. In fluids, convection can transfer thermal energy. **Convection** is the transfer of thermal energy in a fluid by the movements of warmer and cooler fluid. When conduction occurs, more energetic particles collide with less energetic particles and transfer thermal energy. When convection occurs, more energetic particles move from one place to another.

Most substances expand as their temperatures increase. That is, as the particles move faster, they tend to be farther apart. Recall that density is the mass of a material divided by its volume. When a fluid expands, its volume increases, but its mass does not change. Therefore, a fluid's density decreases when that fluid is heated.

Because fluids decrease in density as they are heated, a fluid that absorbs thermal energy also decreases in density. The density of a warmer sample of a fluid is less than the density of a cooler sample of that same fluid. The same is true for the parts of a fluid. The warmer parts of a fluid are less dense than the cooler parts of a fluid.

These differences in density within a fluid drive convection. The warmer portions of the fluid rise to the top of the fluid, and the cooler portions sink to the bottom. If a fluid is heated from below, convection currents form.

Get It?

Explain how convection and density are related.

ACADEMIC VOCABULARY

transfer

to convey from one place to another

She is going to transfer her pictures from her camera to the Web site.

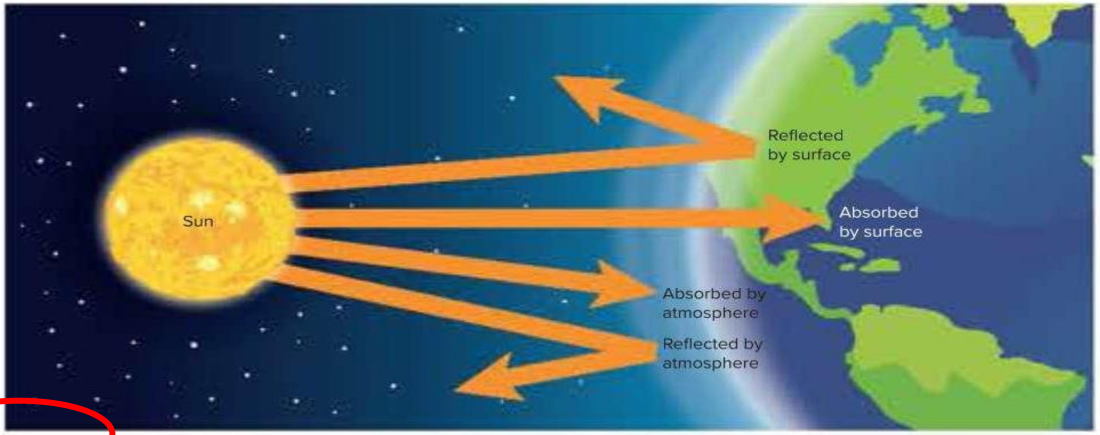


Figure 10 The arrows indicate radiation from the Sun. Not all of the Sun's radiation reaches Earth. Some of it is reflected by the atmosphere. Earth's surface also reflects some of the radiation that reaches it.

Radiation

Energy from the Sun reaches Earth, but how does that energy travel through space? Almost no matter exists in the space between Earth and the Sun, so neither conduction nor convection could warm Earth. Instead, radiation transfers energy from the Sun to Earth.

Radiation is the transfer of energy by electromagnetic waves, such as light and microwaves. These waves travel through space even when matter is not present. Energy that is transferred by radiation is often called radiant energy. When you stand near a fire, radiation transfers energy from the fire and increases the thermal energy of your body.

Get It?
Explain how energy travels through space.

Radiation and matter

When radiation strikes a material, that material absorbs, reflects, and transmits some of the energy. **Figure 10** shows what happens to radiation from the Sun as it reaches Earth. The amount of energy that a material absorbs, reflects, and transmits depends on the type of material. The thermal energy of a material increases when that material absorbs radiant energy.

Radiation in solids, liquids, and gases

In a solid, liquid, or gas, radiation travels through the space between particles. Particles can absorb and re-emit this radiation. This energy then travels through the space between particles, and other particles then absorb and re-emit the energy. Radiation usually passes more easily through gases than through solids or liquids because particles are much farther apart in gases than in solids or liquids. Thus, radiation transfers energy more rapidly and efficiently through gases than through liquids or solids.

1. Which is NOT a form of thermal energy transfer?

- conduction
- C spontaneity CORRECT
- convection
- radiation

2. Which form of thermal energy transfer does density of the substances play a key role?

- conduction
- B convection CORRECT
- radiation
- spontaneity

3. Which statement is true about radiation?

- Collision of particles transfers radiant energy.
- Fluid currents transfer radiant energy.
- Matter is required to transfer radiant energy.
- D Electromagnetic waves transfer radiant energy.

CORRECT

i. How will the thermal energy from the pot in room a move to its handle?
   a. Conduction.
   b. Convection
   c. Radiation.
   d. Spontaneity.

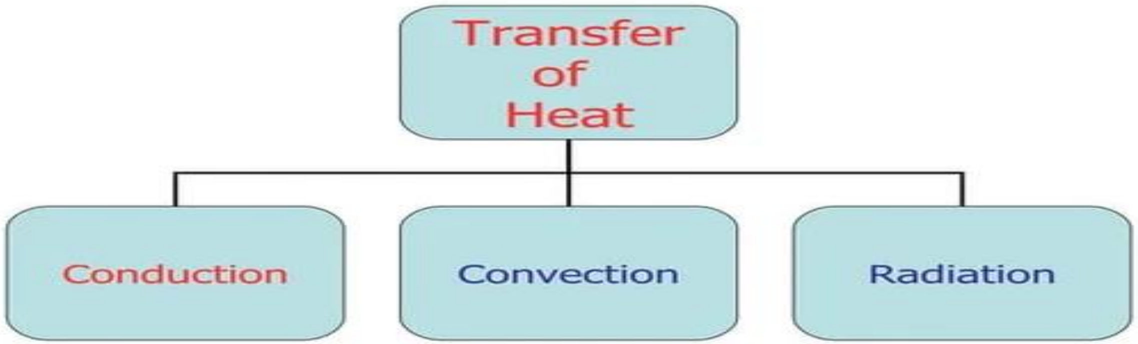
ii. Thermal energy transfer to the sunbather in room B by ....
   a. Conduction and convection.
   b. Convection
   c. Radiation.
   d. conduction.

iii. Where does most of the heat provided by the fire in room C go?
   a. Up the Chimney.
   b. Room A
   c. Room B
   d. Room D

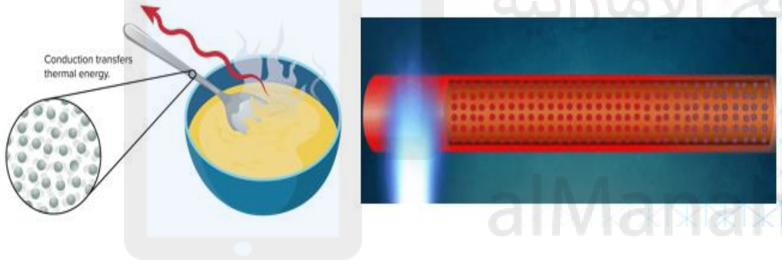
iv. In room C the thermal energy transfers to the people by?
   a. Convection and radiation.
   b. Convection
   c. Radiation.
   d. conduction.

v. In room D the thermal energy of iron transfers to the cloths by?
   a. Convection and radiation.
   b. Convection
   c. Radiation.
   d. conduction.

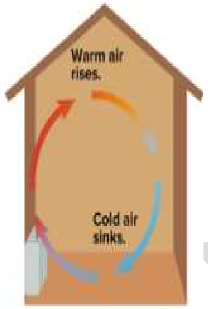
Heat Energy Transfer



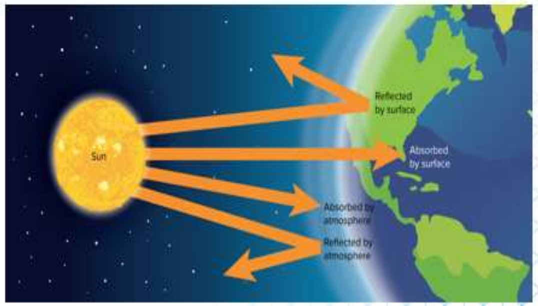
Conduction is the transfer of thermal energy by collisions between the particles that make up matter. Conduction occurs because particles that make up matter are in constant motion.



- Unlike solids, liquids and gases are fluids that flow.
- In fluids, convection can transfer thermal energy.
- **Convection** is the transfer of thermal energy in a **fluid** by the movements of warmer and cooler fluid.
- When conduction occurs, more energetic particles collide with less energetic particles and transfer thermal energy.
- When convection occurs, more energetic particles move from one place to another.



- **Radiation** is the transfer of energy by electromagnetic waves, such as light and microwaves. These waves travel through space even when matter is not present.
- Energy that is transferred by radiation is often called radiant energy.
- When you stand near a fire, radiation transfers energy from the fire and increases the thermal energy of your body.



Part 2 الجزء الثاني

Thermodynamics

There is another way to increase the thermal energy of an object besides heating it. Have you ever rubbed your hands together to warm them on a cold day? Your hands get warmer and their temperature increases, even though you are not heating them near a fire or a stove. You do work to increase your hands' thermal energy when you rub them together. Thermal energy, heat, and work are related. **Thermodynamics** is the study of the relationships among thermal energy, heat, and work.

Heat and work increase thermal energy

You can warm your hands by placing them near a fire because the fire heats your hands by radiation. If you rub your hands and hold them near a fire, the increase in your hands' thermal energy is even greater. Both the work you do and the heat from the fire increase your hands' thermal energy.

In the example above, your hands can be considered a system. Recall that a system is anything around which you can draw a boundary. A system can be a group of objects, such as a galaxy, a car's engine, or something as simple as a ball. An example of a system is shown in **Figure 16.**

Figure 16 A couch can be a system. If you define the couch in this figure as the system, then everything else is the surroundings. Work is done on this system by pushing and pulling the couch along the floor. As the couch slides along the floor, it heats the floor slightly through friction. The work done on this system is about equal to the heat from this system. The total energy of this system is nearly constant.

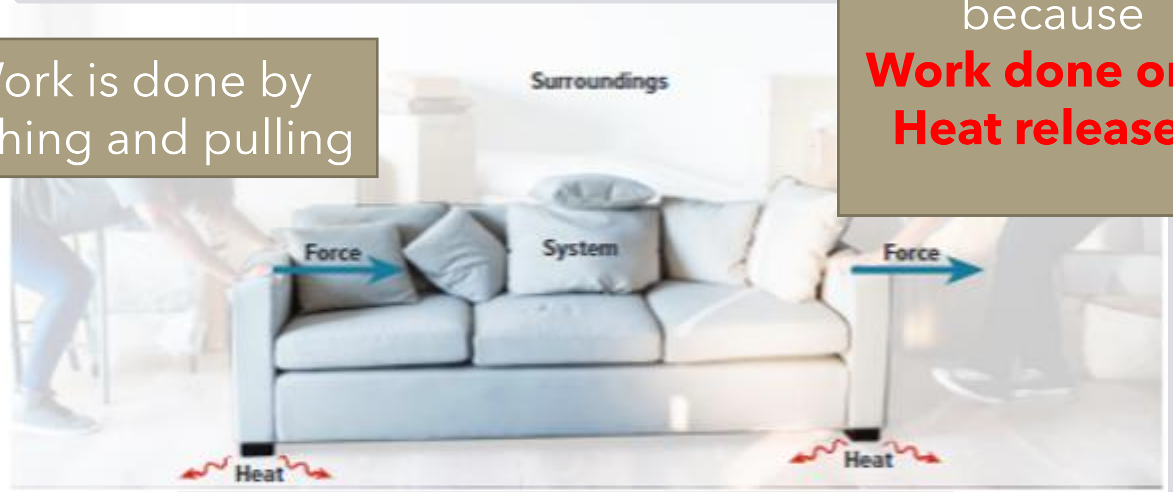
Describe *a system in which thermal energy is being transferred into that system.*

CCC CROSSCUTTING CONCEPTS

Systems and System Models Make a short video in which you use a small object such as a block to model the system shown in Figure 16. Narrate your video, describing the inputs and outputs of energy.

- Thermal energy, heat, and work are related.
- **Thermodynamics** is the study of the relationships between <u>**thermal energy**</u>, <u>**heat,**</u> and <u>**work.**</u>

Work is done by pushing and pulling



<u>Total energy is nearly constant</u> because **Work done on = Heat released**

Friction (couch slide over the floor) it's heat the floor

Part 2 الجزء الثاني

Nonrenewable Resources

Nonrenewable resources are resources that cannot be replaced by natural processes as quickly as they are used. All fossil fuels are nonrenewable resources.

Get It?
Identify three examples of nonrenewable resources.

Because they are nonrenewable resources, fossil fuels are decreasing in supply. As supplies of fossil fuels run out, fossil fuels will become more difficult to obtain. This will cause fuel to become more costly than it is today.

Even as fossil fuel supplies decrease, the demand for energy continues to increase. One way to meet these energy demands is to search for energy alternatives. Scientists have discovered numerous oil shale reserves in the United States, as shown in **Figure 9**. When oil shale is heated to extremely high temperatures, it releases an organic chemical compound called kerogen. Kerogen is a petroleum-like substance that has potential for meeting increasing energy demands as fossil fuel resources are consumed.

Figure 9 As population increases and fossil fuel resources decrease, scientists search for new solutions to the energy crisis. Energy alternatives, such as oil shale deposits found in basins in the central and midwestern United States, might help meet these energy demands.

All **Fossil Fuels** are Nonrenewable Resources: (oil -natural gas- coal) الوقود الاحفوري

<u>**Resources that can not be replaced as quickly as used.**</u>

About __85__% of the energy came from fossil fuels

Fossil fuels: **Oil, natural gas, and coal**

Scientist have discovered Oil Shale, when its heated it releases an organic chemical compound called **Kerogen** (Petroleum-like)

- **Nonrenewable resources** are resources that cannot be replaced by natural processes as quickly as they are used.
- All fossil fuels are nonrenewable resources. Therefore, they are decreasing in supply and will become more difficult to obtain.
- This will cause fuel to become more costly. However, the demand for energy continues to increase.
- One way to meet these energy demands is to search for energy alternatives.

5. Which of the following is NOT true?

An increase in atmospheric carbon dioxide is main contributor to global climate change.

B Fossil fuels will always be easy to obtain. CORRECT

The demand for energy is increasing.

All fossil fuels are nonrenewable resources.

14	Diffrentiate between fusion and fission	Textbook, fig 13	199, 201

Fusion

The Sun is a giant nuclear reactor in the sky. It transforms energy through a process called fusion. **Fusion** occurs when atomic nuclei combine at very high temperatures. In this process, a small amount of mass is transformed into a tremendous amount of thermal energy.

Fusion-based power plants are not practical. One problem with fusion is that it occurs at millions of degrees Celsius. Under these conditions, reactors use a great deal of energy. Another problem is containment—what kind of chamber can hold a reaction under these extreme conditions?

Fission

Energy is released when the nucleus of an atom splits apart in a process called **fission.** During fission, a small amount of mass is converted into a tremendous amount of thermal energy. Unlike fusion, fission-based power plants are practical. Sixty-five power plants in the United States, including the one shown in **Figure 10**, transform energy by fission reactions. These plants convert nuclear energy into electrical energy and produce 9 percent of the energy used in the United States.

Figure 10 A nuclear power plant generates electricity using the thermal energy released in fission. This concrete tower is a cooling tower that releases waste heat, a product of the fission reaction.

3D THINKING DCI Disciplinary Core Ideas CCC Crosscutting Concepts SEP Science & Engineering Practices

COLLECT EVIDENCE

Use your Science Journal to record the evidence you collect as you complete the readings and activities in this lesson.

INVESTIGATE

GO ONLINE to find these activities and more resources.

Revisit the Encounter the Phenomenon Question
What information from this lesson can help you answer the Unit and Module questions?

CCC **Identify Crosscutting Concepts**
Create a table of the crosscutting concepts and fill in examples you find as your read.

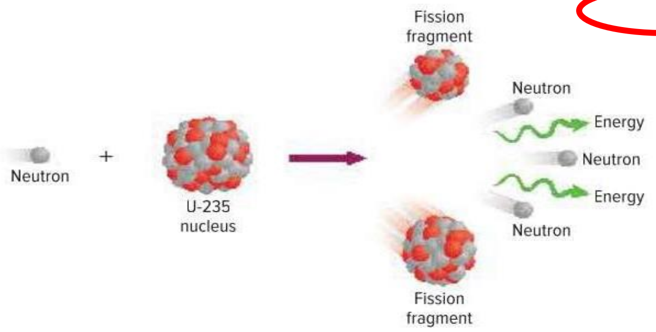


Figure 13 When a neutron strikes the nucleus of a U-235 atom, the nucleus splits apart into two smaller nuclei. In the process, two or three neutrons also are emitted. The smaller nuclei are called fission products.

Explain *what happens to the neutrons that are released in this reaction.*

The nuclear chain reaction

How does a fission reaction proceed in the reactor core? As U-235 nuclei undergo fission, neutrons are released and are absorbed by other U-235 nuclei. When a U-235 nucleus absorbs a neutron, it splits into two smaller nuclei and two or three free neutrons, as shown in **Figure 13.** These neutrons strike other U-235 nuclei, triggering the release of more neutrons, and fission continues.

Because every uranium atom that splits apart releases free neutrons that cause other uranium atoms to split apart, this process is called a nuclear chain reaction. In the chain reaction, the number of nuclei that are split can more than double at each stage of the process. As a result, an enormous number of nuclei can be split after only a small number of stages. For example, if you start with one uranium nucleus and the number of nuclei involved doubles at each stage, after only 50 stages, more than a quadrillion nuclei might be split. Nuclear chain reactions take place in a matter of milliseconds. If the process is not controlled, the chain reaction could release a tremendous amount of energy in the form of an explosion.

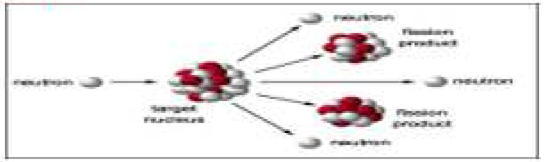
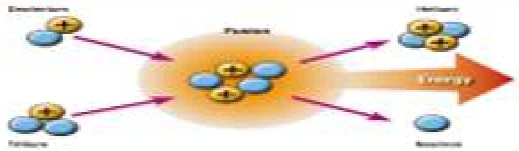
A constant rate To control the chain reaction, some of the neutrons that are released when U-235 splits apart must be prevented from colliding with other U-235 nuclei. These neutrons are absorbed by control rods containing boron or cadmium, which are inserted into the reactor core, as shown in **Figure 11.** Moving these control rods deeper into the reactor causes them to absorb more neutrons and to slow down the chain reaction. Eventually, only one of the neutrons released in the fission of each of the U-235 nuclei strikes another U-235 nucleus, so energy is released at a constant rate.

Get It?
Explain how a nuclear chain reaction is controlled in a nuclear reactor.

STEM CAREER CONNECTION

Nuclear Technician
If you enjoy working with computers and other equipment and are meticulous and safety-conscious, the job of nuclear technician might interest you. Nuclear technicians in the nuclear power industry monitor and operate nuclear reactors, ensuring they are functioning safely and efficiently to deliver electricity to homes, schools, and businesses.

14	Diffrentiate between fusion and fission	Textbook, fig 13	199, 201

fission	fusion
	
Occur when: a heavy unstable nucleus splits into two or more smaller nuclei.	Occur When: two or more small nuclei combine to form a heavier, more stable nucleus.
Small amount of mass→a tremendous amount of energy	
Practical Why??	Not Practical Why??
1. No need for high temperature to start 2. convert nuclear energy into electrical energy	1. Occurs at millions of degrees Celsius 2. No chamber can hold this high temperature

➢ The nuclear chain reaction:

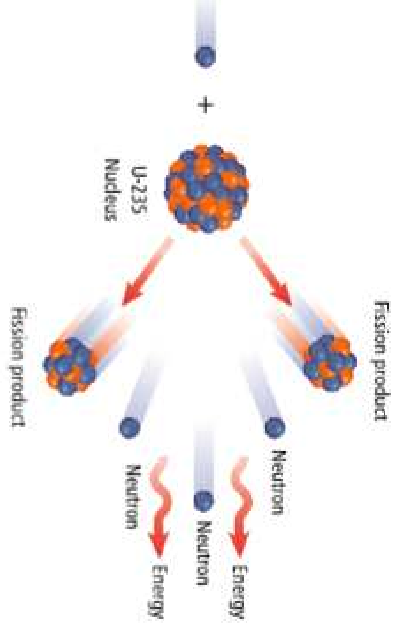
When a U-235 undergo fission:

1. Neutrons are released.
2. Another nucleus absorbs a neutron.
3. it splits into two smaller nuclei and two or three free neutrons.
4. These neutrons strike other U-235 nuclei.

Because every uranium atom that splits a part releases free neutron that cause other uranium to split apart → this process is called a nuclear chain reaction.

As a result: An enormous number of nuclei can be split after only a small number of stages.

To control the chain reaction: Some of neutrons that are released when U-235 splits must be prevented from colliding with other U-235 nuclei. By controlled rod that absorbed it.



1. What is the name of the process that occurs when the nucleus of an atom splits apart and energy is released?

A fusion CORRECT

fission

reaction

radioactivity

Alternative Fuels

The use of fossil fuels would be greatly reduced if cars could run on alternative energy resources alone. For example, some cars use electrical energy supplied by batteries as their primary power source. Hybrid cars use electric motors and gasoline engines.

Figure 24 Vegetable oils, animal fats, and recycled cooking oils can be used to make alternative fuels such as biodiesel for transportation.

Hydrogen

Hydrogen fuel cells are another possible alternative energy resource. A fuel cell behaves like a battery. It combines hydrogen with oxygen in air to generate electrical energy, water, and heat. There are several problems with using hydrogen fuel as an alternative energy resource, however. First, obtaining hydrogen requires more energy than the energy that is released by the fuel-cell reaction. Second, hydrogen fuel cells are built from expensive platinum parts. And third, there is a lack of hydrogen fueling stations, as storing hydrogen is considered to be dangerous and difficult.

Biomass

Biomass is one of the oldest energy sources. **Biomass** is renewable organic matter, such as wood, soy, corn, sugarcane fibers, rice hulls, and animal manure. It can be burned in the presence of oxygen, which converts the stored chemical potential energy to thermal energy. **Figure 24** shows a bus powered by biodiesel derived from biomass.

Check Your Progress

Summary

- Solar cells convert radiant energy into electrical energy.
- Hydroelectric power plants convert gravitational potential energy into electrical energy.
- Wind energy is converted into electrical energy using a propeller attached to an electric generator.
- Alternative energy sources, such as the Sun, water, wind, and Earth's internal heat, can help reduce human dependence on fossil fuels.

Demonstrate Understanding

14. **Explain** the need to develop and use alternative energy sources.
15. **Describe** three ways that solar energy can be used.
16. **Explain** the similarities among electricity generation by hydroelectric, tidal, and wind sources.
17. **Infer** why geothermal energy is unlikely to become a major energy source.

Explain Your Thinking

18. **Analyze** On what single energy source do most energy alternatives depend, either directly or indirectly?
19. **MATH Connection** A house uses solar cells that generate 1.5 kW of electrical power to supply some of its energy needs. If the solar panels supply the house with 40 percent of the power it needs, how much total power does the house use?

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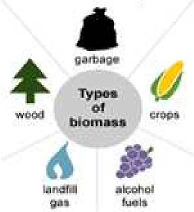
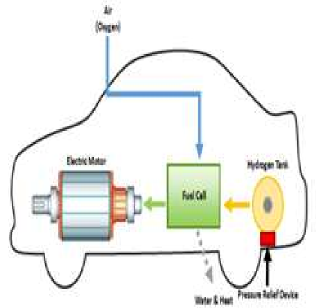
Alternative Fuels	**Hydrogen Fuel Cells** It Combines hydrogen with oxygen in air to generate electrical energy, water, and heat **Biomass** is renewable organic matter Such as wood, soy, corn, sugarcane fibres, rice hulls and animal manure. It can be burned in presence of oxygen which converts Chemical energy into thermal.		1. Obtaining hydrogen requires more energy than energy released. 2. Cells are built from expensive platinum parts. 3. Lack of hydrogen fuelling stations.





Alternative fuels

2- Biomass الكتلـــــة الحيـويـة


sugarcane

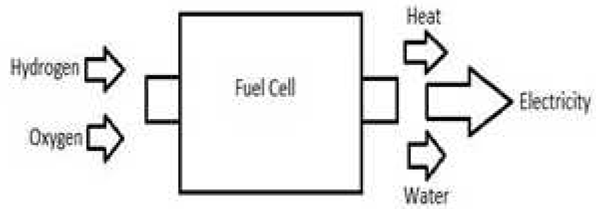

Rice hulls


Soy


wood


Animal manure


corn



5. Which of the following energy conversions takes place when biomass is used as an energy source?

- thermal to chemical potential
- radiant to thermal
- mechanical to thermal
- D chemical potential to thermal CORRECT

1. Which of the following energy conversions takes place when biomass is used as an energy source?
   a. Mechanical to electrical energy.
   b. Radiant to electrical.
   c. Thermal to electrical.
   d. Chemical potential to thermal.

2. A(n)______is a resource that is replaced by natural processes nearly as quickly as it isused.
   a. nonrenewable resource
   b. reserve
   c. energy option
   d. renewable resource

3. Which of the following is a disadvantage of hydroelectricity?
   a. It is not very efficient.
   b. It causes pollution.
   c. It is expensive compared to other options.
   d. It can disrupt ecosystems.

People and the Environment

You have an impact on the environment every day. The electrical energy that you use most likely comes from burning fossil fuels. The cars and buses you use for transportation burn fossil fuel. Fossil fuels are mined from Earth and have an impact on the air that you breathe. The water that you use must be treated, as shown in **Figure 26**, to remove as many pollutants as possible before it is recycled back into waterways. **Pollutants** include any substance that contaminates the environment.

You also use plastics and paper every day. Plastics are petroleum-based products. When petroleum is refined, it produces pollutants. In the process of harvesting trees to make paper, trees are cut down. They are transported using fossil fuels, and water and air can be polluted in the paper-making process.

Impact on Land

Land is affected when resources such as fossil fuels, water, soil, or trees are extracted from Earth. You might not think of land as a natural resource, but it is as important as fossil fuels, clean water, and clean air. We use land for agriculture, forests, urban development, and even waste management. These uses impact the land and the natural resources it provides.

Agriculture

The pears and apples that you purchase at the grocery store were grown on farms, which cover 16 million km² of Earth's total land area. To feed the world's growing population, some farmers are planting higher-yielding seeds and using stronger nitrate- and phosphate-based fertilizers. Herbicides and pesticides are also used for weed and pest control. These methods increase the amount of food grown, but, if not managed properly, they can have a negative impact by possibly polluting soil and water and endangering animals.

CCC CROSSCUTTING CONCEPTS

Stability and Change Write a paragraph to describe how the growing human population can destabilize Earth's systems. Cite evidence from the text on this page and the previous page. Then, suggest three steps you can take that will act to stabilize one or more of Earth's systems.

Organic farms Organic farming methods, as shown in **Figure 27**, use natural fertilizers, crop rotation, and biological pest controls. These methods help reduce pollution and other negative impacts on land. However, organic farming methods cannot currently produce the food that is necessary to feed the world's growing population.

Figure 27 Organic farms can reduce the environmental impact of fertilizers, pesticides, and herbicides on land.

Deforestation

Approximately 25 percent of Earth's total land area is covered by forests. Whether you are writing on paper with a pencil, sitting in a wooden chair, or wiping your face with a napkin, you are using products derived from wood. This wood comes from forests worldwide.

Deforestation is the clearing of forest land for agriculture, grazing, urban development, or logging. It is estimated that the amount of forested land decreases by 94,000 km² each year. Many of these forests are home to diverse populations of plants and animals. Cutting down trees could lead to the extinction of some of these organisms. In addition, plants remove carbon dioxide from the atmosphere. Deforestation increases the concentration of carbon dioxide in the atmosphere. Scientists believe that an increase in carbon dioxide has contributed to an increase in atmospheric temperatures worldwide.

Urban development

With a growing population, the percentage of land area devoted to urban development has increased. Highways, office buildings, stores, housing developments, and parking lots are under construction every day. This development can lead to negative impacts on land. For example, paving land prevents water from soaking into the soil. Instead, water runs off into sewers or streams, increasing stream discharge and the threat of flooding. Because water is unable to seep through pavement, this also decreases the amount of water that seeps into the ground.

Some communities, businesses, and private organizations preserve areas rather than pave them. As the population grows, more urban areas have been set aside for recreation and preservation for future generations to enjoy. Some urban areas have been designated as historic sites, parks, and monuments by the federal, state, and local governments, such as Central Park in New York City, shown in **Figure 28**.

Figure 28 Some land in urban areas, such as New York City's Central Park, is preserved for recreation.

Waste

Whether or not you realize it, you impact land when you throw garbage into a trash can. About 55 percent of our garbage is disposed of in sanitary landfills. The rest is recycled or burned. Some of the wastes release substances, such as lead from batteries, that are harmful to humans and animals. Wastes that are poisonous, that cause cancer, or that can catch fire are classified as **hazardous wastes.**

16	Explain how to reduce the environmental impact of humans on land, water, and air	Textbook	213, 214

Part 2 الجزء الثاني

	Type of pollution	causes	effects
1	Agricultural Farmers are planting higher -yielding seeds	Using stronger nitrate And phosphate-based fertilizers. Herbicides and pesticides are used for weeding and pest control.	-if they are not managed, they can have a negative impact -pollute soil and water Thereby endangering animals.
	Organic farms: Cannot produce the food that is necessary to feed the word's growing population.	Use natural fertilizers, Crop rotation, and biologic pest control.	These methods help reduce pollution and other negative impacts on land
2	Deforestation: 25% of earth total land is covered by forests. It is estimated that the amount of forested land decreases by 94,000Km² each year	Is clearing of forest land for agriculture grazing, urban development, or logging. Also, you are using products derived from wood like paper, a pencil wooding chair or wiping your face with a napkin.	Cutting down tree could lead to the extinction of some plants and animals. Also, it increases the concentration of carbon dioxide in the atmosphere which will increase in atmosphere temperature worldwide.

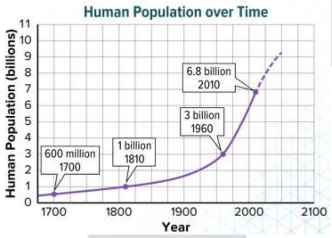
	Type of pollution	causes	effects
1	Urban development With a growing population, the percentage of land area devoted to urban development has increased	A Lots development are under construction every day like **highways, office buildings, stores, housing developments and parking**	Paving land prevents water from soaking into soil. Water runs off into sewers or streams which increasing stream and threat of flooding Amount of water underground decrease
2	waste	___55__% of our garbage is disposed of in sanitary _landfills_. The rest is _recycled_ or _burned_.	Some wastes release substance such as lead from _batteries_ that harmful to humans and animals. _hazardous wastes_ is wastes that are poisonous (cause _cancer) or catch fire.
	National Parks Like **Mangrove national park in** Abu Dhabi	These areas are safe from **urban_ development, _waste disposal and extensive deforestation_.** Parks are home to **plants, animals, and waterways.**	As the population _grows_, impact on land may _worsen_.

2. Which of the following is the correct definition of a pollutant?

- Wastes that cause cancer.
- B Any substance that contaminates the environment. CORRECT
- Smog that is results from a reaction with sunlight.
- Particulate matter that impacts the air.

5. Between 1960 and 2010, the world population increased by how many billions of people?

- 1.0
- B 3.8 CORRECT
- 4.2
- 5.9



17	Calculate and compare between the momentum of two different moving objects	Textbook, example problem 2, fig.14	48, 49

Part 3 الجزء الثالث

Momentum

An object is moving at 2 m/s toward a glass vase. Will the vase be damaged in the collision? If the object has a small mass, like a bug, a collision will not damage the vase. But if the object has a larger mass, like a car, a collision will damage the vase.

A useful way of describing both the velocity and mass of an object is to state its momentum. The **momentum** of an object is the product of its mass and velocity. Momentum is usually represented by the symbol *p* and is defined for a particular frame of reference.

Momentum Equation

momentum (in kg·m/s) = mass (in kg) × velocity (in m/s)

$$p = mv$$

The unit for momentum is kg·m/s. Like velocity, momentum has a size and a direction. An object's momentum is always in the same direction as its velocity. **Table 3** shows the momenta of some common objects.

Table 3 Typical Momenta

Object	Momentum (kg·m/s)
Tossed baseball	0.15
Person walking	100
Car on interstate	45,000

Get It?
Explain how two objects could have the same velocity but different momentums.

EXAMPLE Problem 2

SOLVE FOR MOMENTUM At the end of a race, a sprinter with a mass of 80.0 kg has a velocity of 10.0 m/s east. What is the sprinter's momentum?

Identify the Unknown: momentum: p

List the Knowns: mass: m = 80.0 kg
velocity: v = 10.0 m/s east

Set Up the Problem: $p = mv$ = (80.0 kg) × (10.0 m/s) east

Solve the Problem: p = (80.0 kg)(10.0 m/s) east = 800.0 kg·m/s east

Check the Answer: Our answer makes sense because it is greater than the momentum of a walking person but much less than the momentum of a car on the highway.

PRACTICE Problems ADDITIONAL PRACTICE

12. What is the momentum of a car with a mass of 1300 kg traveling north at a speed of 28 m/s?
13. A baseball has a momentum of 6.0 kg·m/s south and a mass of 0.15 kg. What is the baseball's velocity?
14. Find the mass of a person walking west at a speed of 0.8 m/s with a momentum of 52.0 kg·m/s west.
15. **CHALLENGE** The mass of a basketball is three times greater than the mass of a softball. Compare the momenta of a softball and a basketball if they are moving at the same velocity.

Figure 14 Both the car and the truck have a velocity of 30 m/s west, but the truck has a much larger momentum.

Comparing momenta

Think about the car and the truck in **Figure 14.** Which has the greater momentum? The truck does because it has more mass. When two objects travel at the same velocity, the object with more mass has a greater momentum. A difference in momenta is why a car traveling at 2 m/s might damage a porcelain vase, but an insect flying at 2 m/s will not.

Now consider two 1-mg insects. One insect flies at a speed of 2 m/s, and the other flies at a speed of 4 m/s. The second insect has a greater momentum. If two objects have the same mass, the object with the greater velocity has the greater momentum.

Check Your Progress

Summary

- The velocity of an object includes the object's speed and its direction of motion relative to a reference point.
- An object's motion is always described relative to a reference point.
- The momentum of an object is defined for a particular frame of reference and is the product of the object's mass and velocity: $p = mv$.

Demonstrate Understanding

16. **Describe** a car's velocity as it goes around a track at a constant speed.
17. **Explain** why streets and highways have speed limits rather than velocity limits.
18. **Identify** For each of the following news stories, determine whether the object's speed or velocity is given: the world record for the 100-meter dash is about 10 m/s; the wind is 30 km/h from the northwest; a 200,000 kg train was traveling north at 70 km/h when it derailed; a car was issued a ticket for traveling at 140 km/h on the interstate.

Explain Your Thinking

19. **Describe** You are walking toward the back of a bus that is moving forward with a constant velocity. Describe your motion relative to the frame of reference of the bus and relative to the frame of reference of a point on the ground.
20. **MATH Connection** What is the momentum of a 100-kg football player running north at a speed of 4 m/s?
21. **MATH Connection** Compare the momenta of a 6300-kg elephant walking 0.11 m/s and a 50-kg dolphin swimming 10.4 m/s.

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3. Which of the following statements is NOT true?

- Geologic evidence suggests Earth's crust is changing.
- The choice of a moving reference point affects how you describe motion.
- C An elevator moving up at 2 m/s has the same velocity as an elevator moving down at 2 m/s. CORRECT
- Velocity and position always depend on the point of reference chosen.

4. What is the momentum of a 1000-kg car that is driving 60 m/s east?

- A 60,000 kg·m/s east CORRECT
- 1.67 kg·m/s east
- 16.7 kg·m/s east
- 0.167 kg·m/s east

5. Which of the following is NOT true of momentum?

- It has a size and a direction.
- B It is the product of an object's speed and velocity. CORRECT
- An object's momentum is always in the same direction as its velocity.
- A small object moving at the same speed as larger object will have less momentum.

Which has the largest Momentum??

30 m/s east

1800 kg

30 m/s east

25000 kg

car	Truck
30 m/s east	30 m/s east
1800 kg	25000 kg
Momentum= Mass X velocity 30x1800 = 54,000Kg.m/s	Momentum= Mass X velocity 30x25000= 750,000 kg.m/s

Both the car and the truck have a velocity of 30m/s east, but the truck has a much larger momentum because it's had more mass than the car.

17	Calculate and compare between the momentum of two different moving objects	Textbook, example problem 2, fig.14	48, 49

Part 3 الجزء الثالث

EXAMPLE Problem 2

SOLVE FOR MOMENTUM At the end of a race, a sprinter with a mass of 80.0 kg has a velocity of 10.0 m/s east. What is the sprinter's momentum?

Identify the Unknown: momentum: p

List the Knowns: mass: m = 80.0 kg
velocity: v = 10.0 m/s east

Set Up the Problem: $p = mv$ = (80.0 kg) × (10.0 m/s) east

Solve the Problem: p = (80.0 kg)(10.0 m/s) east = 800.0 kg·m/s east

Check the Answer: Our answer makes sense because it is greater than the momentum of a walking person but much less than the momentum of a car on the highway.

PRACTICE Problems

ADDITIONAL PRACTICE

12. What is the momentum of a car with a mass of 1300 kg traveling north at a speed of 28 m/s?

Unknown: momentum ?
Known: mass=1300 kg
Velocity=28 m/s north

Momentum = mv
= 1300 kg X28 m/s = 36,400 kg.m/s north

13. A baseball has a momentum of 6.0 kg·m/s south and a mass of 0.15 kg. What is the baseball's velocity?

Unknown: velocity?
Known: momentum=6.0 kg.m/s south
mass=0.15 kg

Momentum = mv

V=p/m
V=6.0/0.15=40 m/s north

14. Find the mass of a person walking west at a speed of 0.8 m/s with a momentum of 52.0 kg·m/s west.

Unknown: mass?
Known: momentum=52.0 kg.m/s west
mass=0.8 m/s west

Momentum = mv

m=p/v
m=52.0/0.8=65 kg

Definition of Work

To many people, the word work means something that people do to earn money. In that sense, work can be anything from fixing cars to designing Web sites. The word work might also mean exerting a force with muscles. However, in science, the word work is used in a different way.

Motion and work

Press your hand against the surface of your desk as hard as you can. Have you done any work on the desk? The answer is no, no matter how tired you get from the effort. In science, **work** is force applied through a distance. If you push against the desk and it does not move, then you have not done any work on the desk because the desk has not moved.

Force and direction of motion

Imagine that you are pushing a lawn mower, as shown in **Figure 1**. You could push on this mower in many different directions. You could push it horizontally. You could also push down on the mower or push on it at an angle. Think about how the mower's motion would be different each time. The direction of the force that you apply to the lawn mower affects how much work you do on it.

Figure 1 You apply a force through a distance when you push a lawn mower over a lawn. In other words, you do work on the lawn mower when you push it over a lawn.

Explain *whether you could do work on the mower without moving it.*

3D THINKING DCI Disciplinary Core Ideas | CCC Crosscutting Concepts | SEP Science & Engineering Practices

COLLECT EVIDENCE

Use your Science Journal to record the evidence you collect as you complete the readings and activities in this lesson.

INVESTIGATE

GO ONLINE to find these activities and more resources.

Lab: Mechanical Advantage and Efficiency
Develop and use a model to calculate the work needed to lift objects and the effect an inclined plane has on improving mechanical advantage and efficiency.

Laboratory: Pulleys
Develop and use a model to calculate the work needed to lift objects and the effect a single fixed pulley and a block and tackle have on improving mechanical advantage and efficiency.

Force parallel to motion Imagine that you push on the lawn mower in **Figure 1** with a force of 25 N and through a distance of 4 m. In what direction would you push to do the maximum amount of work on the mower? You do the maximum amount of work when you push the lawn mower in the same direction as it is moving. When force and motion are parallel, which means they are in the same direction, work is equal to force multiplied by distance.

Work Equation

work (in joules) = applied force (in newtons) × distance (in meters)

$$W = Fd$$

If force is measured in newtons (N) and distance is measured in meters (m), then work is measured in joules (J). You do about 1 J of work on a cell phone when you pick it up off the floor.

EXAMPLE Problem 1

SOLVE FOR WORK You push a refrigerator with a horizontal force of 100 N. If you move the refrigerator a distance of 5 m while you are pushing, how much work do you do?

Identify the Unknown: work: W

List the Knowns: applied force: $F = 100$ N; distance: $d = 5$ m

Set Up the Problem: $W = Fd$

Solve the Problem: $W = (100 \text{ N})(5 \text{ m}) = 500 \text{ J}$

Check the Answer: Check to see whether the units match on both sides of the equation.
units of W = (units of F) × (units of d) = N × m = J

PRACTICE Problems — ADDITIONAL PRACTICE

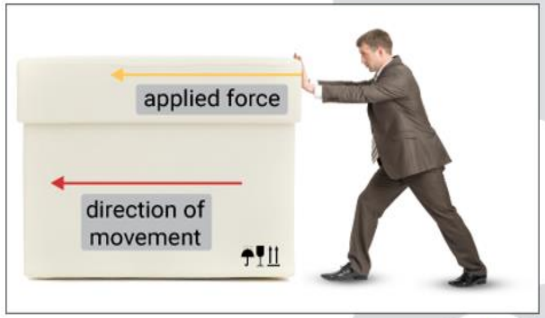
1. A couch is pushed with a horizontal force of 80 N and moves a distance of 5 m across the floor. How much work is done in moving the couch?
2. How much work do you do when you lift a 100-N child 0.5 m?
3. The brakes on a car do 240,000 J of work in stopping the car. If the car travels a distance of 40 m while the brakes are being applied, how large is the average force that the brakes exert on the car?
4. **CHALLENGE** The force needed to lift an object is equal in size to the gravitational force on the object. How much work is done in lifting an object that has a mass of 5 kg a vertical distance of 2 m?

Force perpendicular to motion When you carry books while walking at a constant velocity, you might think that your arms are doing work on those books. After all, you are exerting a force on the books to hold them, and the books are moving with you. Your arms might even feel tired. However, in this case, the force exerted by your arms does zero work on the books. This is because there is a 90° angle between this force on the books and the motion of the books. When a force is perpendicular to motion, the work from that force is zero.

Part 3 الجزء الثالث

1- Force Acts Parallel to Movement

The applied force acts parallel to the direction of movement.



Work is done

2- Force Acts at Angle to Movement

The applied force acts at an angle to the direction of movement.

- The work done is:
  - less than when the force and movement are parallel
  - more than when the force and movement are perpendicular

3- Force Acts Perpendicular to Movement

The applied force acts perpendicular to the direction of movement.

This applied force does not cause the box to move forward.

No work.

Work Equation

$$\text{work (in joules)} = \text{applied force (in newtons)} \times \text{distance (in meters)}$$

$$W = Fd$$

Figure 1 You apply a force through a distance when you push a lawn mower over a lawn. In other words, you do work on the lawn mower when you push it over a lawn.

Explain *whether you could do work on the mower without moving it.*

18	Calculate the work done by a force perpendicular and parallel to the distance moved by the object	Textbook, fig.1, Example problem 1	88, 89

Part 3 الجزء الثالث

EXAMPLE Problem 1

SOLVE FOR WORK You push a refrigerator with a horizontal force of 100 N. If you move the refrigerator a distance of 5 m while you are pushing, how much work do you do?

Identify the Unknown: work: W

List the Knowns: applied force: $F = 100$ N distance: $d = 5$ m

Set Up the Problem: $W = Fd$

Solve the Problem: $W = (100 \text{ N})(5 \text{ m}) = 500$ J

Check the Answer: Check to see whether the units match on both sides of the equation.

units of W = (units of F) × (units of d) = N × m = J

PRACTICE Problems ADDITIONAL PRACTICE

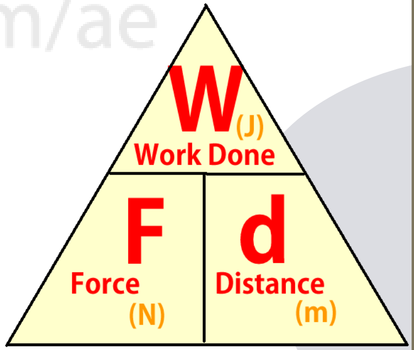
1. A couch is pushed with a horizontal force of 80 N and moves a distance of 5 m across the floor. How much work is done in moving the couch?

Unknown: work
Known: force =80N
distance=5m

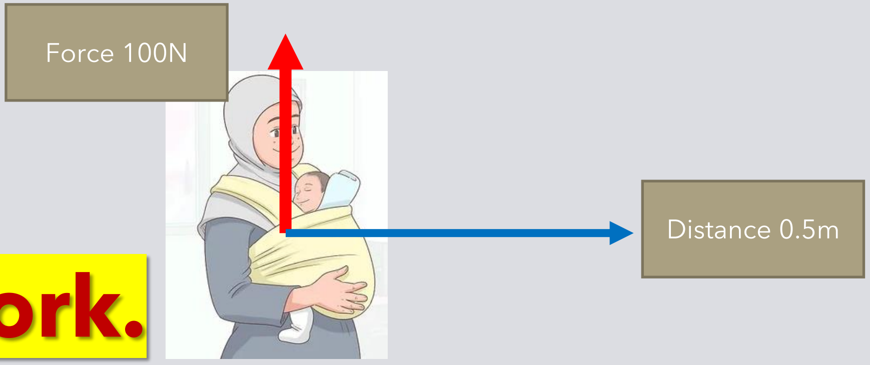
Work= F.d
W=80N X 5m= 400 J

1. Using the scientific definition, which statement is always true of work?

- It is difficult.
- It involves levers.
- It is done with a machine.
- D It involves a transfer of energy. CORRECT



2. How much work do you do when you lift a 100-N child 0.5 m?



No work.

The applied force acts perpendicular to the direction of movement.

This applied force does not cause the child to move forward

3. The brakes on a car do 240,000 J of work in stopping the car. If the car travels a distance of 40 m while the brakes are being applied, how large is the average force that the brakes exert on the car?

Unknown: force
Known: work =240,000 J
distance=40m

Work= F.d
F= w/d = 240000/40=6000 N

19	Define coolant, and diffrentiate between water and metals used as coolant	Textbook, fig.4	117

Specific Heat

Have you ever been to the beach during the summer? The ocean was probably cool, but the sand was probably hot. Energy from the Sun falls on the water and sand at nearly the same rate. However, the Sun's energy changes the sand's temperature more quickly than it changes the water's temperature.

A substance's temperature changes when that substance absorbs thermal energy. This temperature change depends on the amount of thermal energy that the substance absorbs and the mass of the substance. This temperature change also depends on the nature of the substance.

The **specific heat** of a material is the amount of heat needed to raise the temperature of 1 kg of that material by 1°C. Scientists measure specific heat in joules per kilogram degree Celsius [J/(kg · °C)]. **Table 1** compares the specific heats of some familiar materials.

Compare water with iron in **Table 1.** Water has a very high specific heat. Metals, such as iron, have low specific heats. To raise equal masses of water and iron 1°C, water must absorb almost 10 times more thermal energy than iron. **Figure 4** explains why this is so.

Table 1 Comparison of Specific Heats*

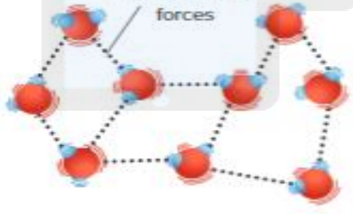
Substance	Specific Heat [J/(kg·°C)]
Water	4200
Wood	1700
Sand	830
Carbon (graphite)	710
Iron	450

*Values have been rounded.

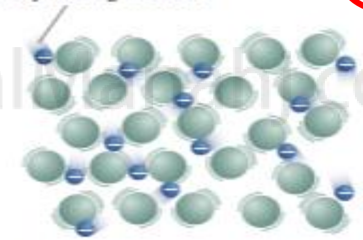
Get It?
Define *specific heat.*

Water as a coolant

A coolant is a substance that can absorb a great amount of thermal energy with little change in temperature. Water is useful as a coolant because it can absorb thermal energy without a large change in temperature. For example, people use water as a coolant in automobile engines. Thermal energy transfers from the engine to the water as long as the water temperature is lower than the engine temperature.



When thermal energy is added to water, some of the added thermal energy has to overcome some of the attraction between the molecules before those molecules can start moving faster.



In metals, electrons can move freely. When thermal energy is added, no strong attractions need to be overcome before the electrons can start to move faster.

Figure 4 The change in temperature due to the transfer of thermal energy depends on the nature of the substance. Water molecules have strong attractions to each other. Therefore, the specific heat of water is high. The electrons in metals move easily, transferring thermal energy throughout that metal quickly. As a result, the specific heats of metals are low.

The **specific heat** of a material is the amount of heat needed to raise the temperature of 1 kg of that material by 1°C.

Scientists measure specific heat in joules per kilogram degree Celsius [J/(kg · °C)]. Sample values are below.

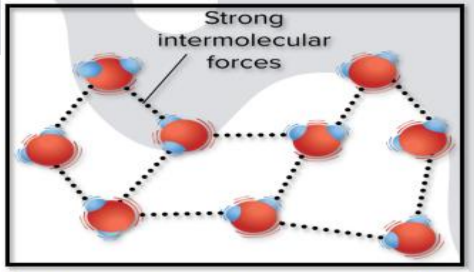
Substance	Specific Heat [J/(kg·°C)]
Water	4200
Wood	1700
Sand	830
Carbon (graphite)	710
Iron	450

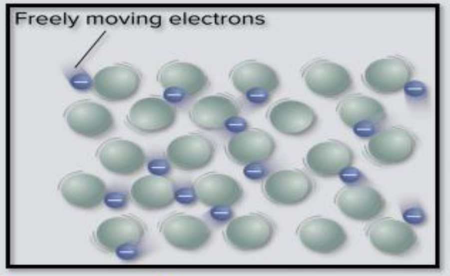
*Values have been rounded

Water → very high specific heat

Iron → low specific heat

Coolant: is a substance that can absorb a great amount of thermal energy with little change in temperature





When thermal energy is added to water, some of the added thermal energy must over- come some of the attraction between the molecules before those molecules can start moving faster.

In metals, electrons can move freely. When thermal energy is added, no strong attractions need to be overcome before the electrons can start to move faster.

4. Which substance is often used as a coolant?

- wood
- sand
- C water CORRECT
- graphite

Water is useful as coolant because it can absorb thermal energy without a large change in temperature.

5. Which is used to determine the specific heat of a substance?

- A calorimeter CORRECT
- thermometer
- burner
- probe

20	Study the electrical power plant and Link each stage with it's energy efficiency, Clarify and list the energy transformations from the energy stored in fossile fuels into electrical energy	Textbook, fig.7	196, 197

Part 3 الجزء الثالث

Origin of coal

Coal mines were once the sites of ancient swamps. Coal formed as swampy plant material, buried beneath sediments, decayed and compacted into peat. Over millions of years, heat and pressure converted the peat into coal.

Coal is a mixture of hydrocarbons and other chemical compounds. Compared to petroleum and natural gas, coal contains more chemical impurities, such as sulfur and nitrogen-based compounds. As a result, more pollutants, including sulfur dioxide and nitrogen oxides, are produced when coal is burned.

Get It?
Describe how coal forms.

Coal use

Coal is the most abundant fossil fuel in the world. The amount of coal available is estimated to last between 200 and 250 years at our current rate of consumption. Because of its supply, scientists are looking for ways to make coal a cleaner energy source. For example, filters on smoke stacks and stricter government standards have reduced harmful particulates released into the atmosphere when coal is burned.

U.S. Electricity Generation by Source

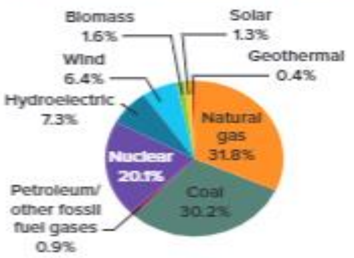


Figure 6 This circle graph shows the percentage of electrical energy that came from different energy sources used in the United States in 2017.

Fuel burned in a boiler or combustion chamber converts chemical potential energy into thermal energy, which heats water and produces pressurized steam. This steam strikes the blades of a turbine, causing it to spin, converting thermal energy into mechanical energy. The shaft of the turbine connects to an electric generator, which converts mechanical energy into electrical energy. The electrical energy is then transmitted to homes, schools, and businesses through power lines.

Power plant efficiency

In the power plant, not all of the chemical potential energy stored in fuel is converted into electrical energy. Some energy is converted into thermal energy. As a result, no stage of the process of electricity production is 100 percent efficient.

The overall efficiency of a fossil fuel-burning power plant is roughly 35 percent. This means that only 35 percent of the energy stored in fossil fuels is transported to homes, schools, and businesses as electrical energy. The remaining 65 percent is converted into thermal energy. Often, this heat is released into the environment.

Atmospheric CO_2 Concentration

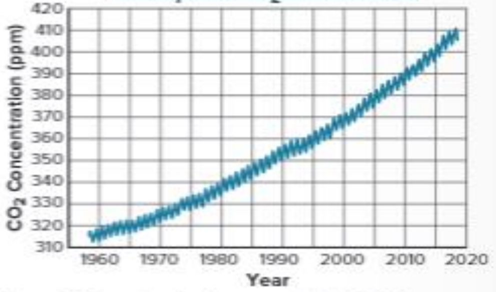


Figure 8 The carbon dioxide concentration in Earth's atmosphere has been measured at Mauna Loa Observatory in Hawaii. From 1958 to 2018, the carbon dioxide concentration has increased by 1.56 parts per million (ppm) per year.

Predict *how the concentration of carbon dioxide will change in the next several decades based on the graph trend.*

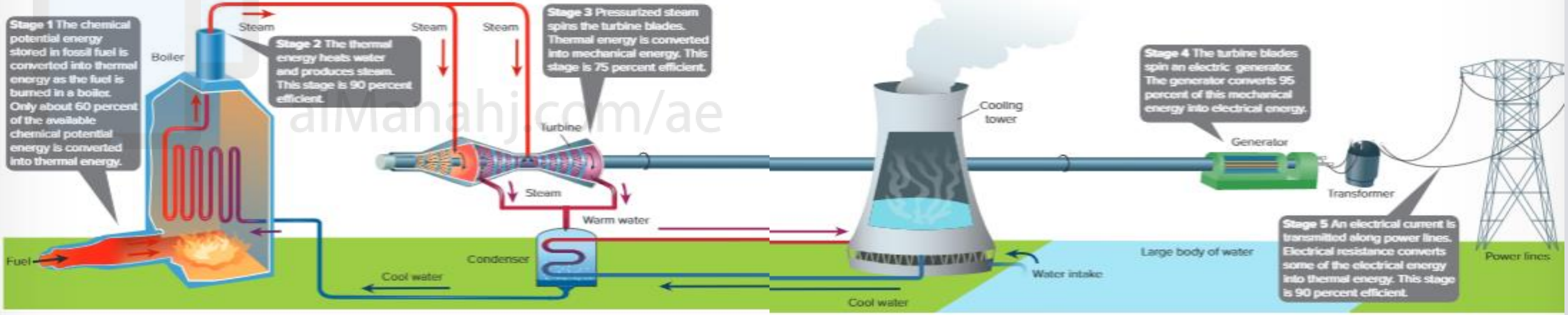
Electricity

Figure 6 shows that 63 percent of the electrical energy used in the United States in 2017 was produced by burning fossil fuels, such as natural gas and coal. How is the chemical potential energy stored in fossil fuels converted to electrical energy in a power plant? The process of energy conversion is shown in **Figure 7**.

The Cost of Fossil Fuels

Although fossil fuels are common energy resources, their uses have associated costs and risks. Burning fossil fuels releases small particulates into the atmosphere, which can cause breathing problems. Fossil fuels also release carbon dioxide (CO_2) when they are burned. **Figure 8** shows how the CO_2 concentration in the atmosphere has increased from 1958 to 2018. This increase in atmospheric CO_2 concentration is the chief contributor to global climate change.

Figure 7 Power plant efficiency describes how much energy is available to do work and produce electricity.
Determine *which stage in this process is the most inefficient.*



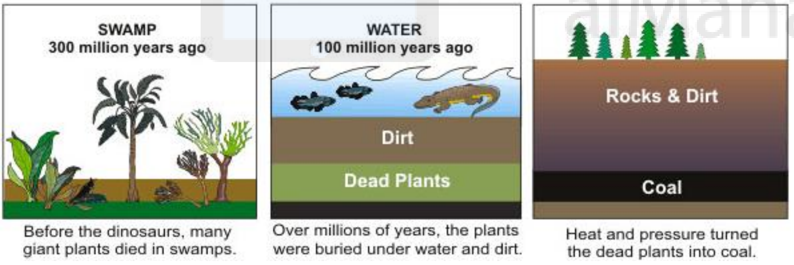
20	Study the electrical power plant and Link each stage with it's energy efficiency, Clarify and list the energy transformations from the energy stored in fossile fuels into electrical energy	Textbook, fig.7	196, 197

Part 3 الجزء الثالث

➤ **Coal**
Is a solid fossil fuel can be found in mines formed as swampy plant buried beneath sediments decayed and compacted into peat
Mixture of hydrocarbons and other chemical compounds It's contained more impurities such as sulfur dioxide and nitrogen oxides.
Produce electricity ✓ ***Note:*** The most abundant fossil fuel. Estimated to last for 250 years

- In a power plant, not all of the chemical potential energy stored in fuel is converted into electrical energy.
- Some energy is converted into thermal energy.
- No stage of the process of electricity production is 100 percent efficient.

HOW COAL WAS FORMED

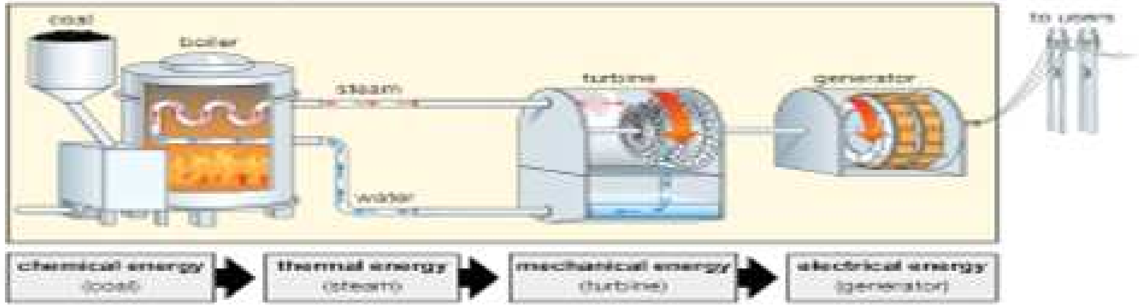


How is the chemical potential energy stored in fossil fuels converted to electrical energy?

➤ **Electricity**: 63% of electrical energy used in US is produced by burning fossil fuels.

The process is shown below:

The conversion of energy at a coal-fired power plant



Part of power station	What happens here?	What energy transfer happens here?
boiler combustion chamber	Coal is burned	Chemical energy in the coal → Thermal Energy that heats water and produces pressurized steam
turbine	Steam strikes the blades of the turbine and turns it around. (spin)	Thermal energy → Mechanical energy of the turbine
generator	An electric current produce	Mechanical energy → electrical energy that transmitted to homes, schools through power line

➤ **Power plant efficiency:**

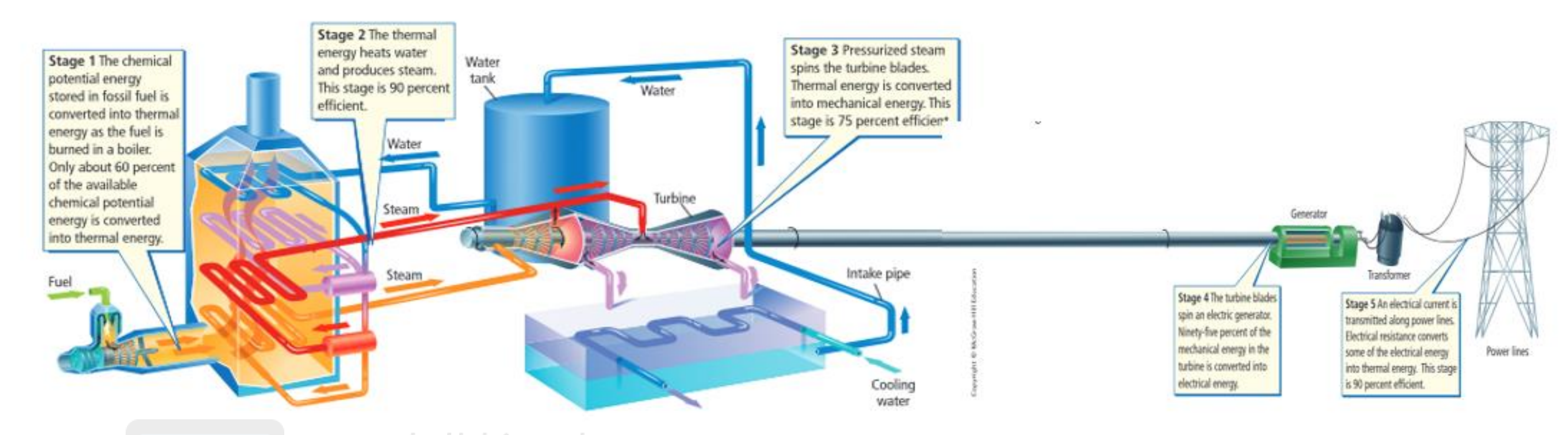
35% of energy stored in fossil fuels is transported to homes, schools and business

65% is converted into thermal energy.

> Fossil Fuels release carbon dioxide (CO_2) when they are burned
>
> Scientists think the increase in atmospheric CO_2 concentration causes global warming

20	Study the electrical power plant and Link each stage with it's energy efficiency, Clarify and list the energy transformations from the energy stored in fossile fuels into electrical energy	Textbook, fig.7	196, 197

الجزء الثالث Part 3



Chemical potential energy in a fossil fuel

Fossil fuel is burned (combustion) (**thermal energy**)

This makes steam which turns a turbine (**mechanical energy**)

Turbine turns on a generator (**electrical energy**)

Burning fossil fuels is NOT efficient – most of the energy is lost in the combustion stage

4. How much of the electrical energy used in the United States was produced by burning fossil fuels in 2017?

- 6%
- c 63% CORRECT
- 36%
- 93%

3. Which fossil fuel is the most abundant in the world?

- natural gas
- c coal CORRECT
- wood
- petroleum