



ثانوية التكنولوجيا التطبيقية
Applied Technology High School

Technology Exploration_II

Module 1 Electrical Machines



PREPARED BY

Academic Services

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Module 1: Electrical Machines

Module Objectives

After the completion of this module, students should be able to:

- Define energy.
- Differentiate between the different forms of energy.
- Draw energy transfer diagrams.
- Give examples of electrical machines.
- Define the purpose of motors and generators.
- State the function of a capacitor.
- State the purpose of a Power Distribution Network.
- Conduct practical tasks to demonstrate the application of motors, generators, and capacitors.

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1.1 Introduction to Energy

What is energy?

Energy does things for us. It makes televisions and laptops work. It moves cars along the road and boats on the water. It helps our bodies grow and makes us do things. Energy is the ability to do work.

What are the different forms of energy?

Energy can have several forms, but they all fall into two main types- potential or kinetic.

Potential energy is the energy stored in an object/body due to its position. Examples of potential energy are, water in a lake in the mountains, or an object held at a certain height as shown in figure 1.1. Gravity gives potential energy to an object.

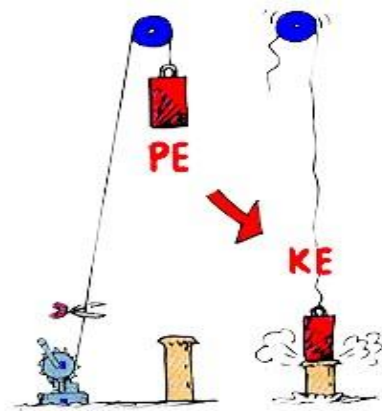


Figure 1.1: Potential energy example

Kinetic energy is the energy which a body has due to its motion. A boy running, flowing water and wind are good examples of kinetic energy. Electricity is also kinetic energy because it involves the movement of electrons.



Figure 1.2: Kinetic energy example

Transfer of Energy

Energy can be changed or transferred from one form to another. An example is the roller coaster illustrated in figure 1.3. When it is on its way up, it is using kinetic energy since the energy is in motion. When it reaches the top it has potential (or stored) energy. When it goes down the hill it is using kinetic energy again.



Figure 1.3: Roller coaster

The example of a cycle rider (shown in figure 1.4) riding to the top of the hill, and then downwards demonstrates how the energy is transferred from one form to another during his ride.

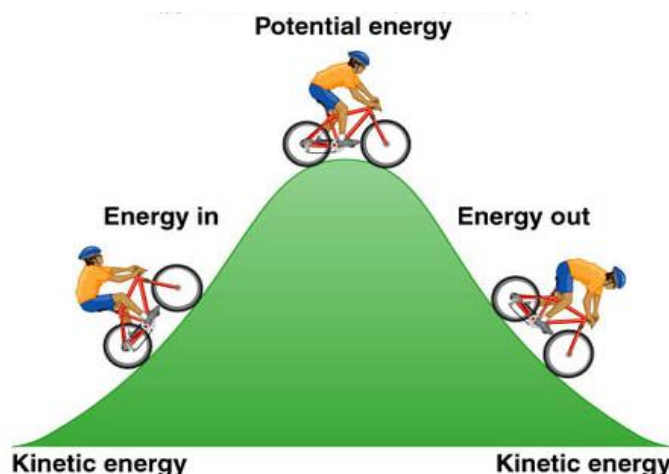


Figure 1.4: Cycle rider

Other Forms of Energy

Examples of other forms of energy are light energy, heat (or thermal) energy, chemical energy, electrical energy and so on. This module will focus on electrical energy, and the electrical machines.

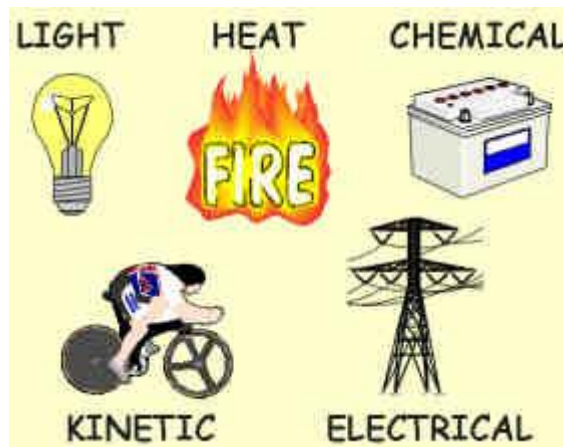


Figure 1.5: Energy forms

Some energy changes (transformations) are useful, while others are not.

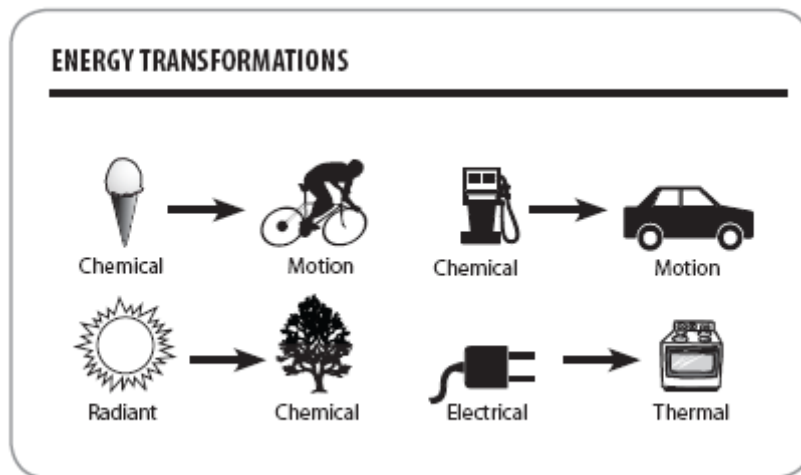


Figure 1.6: Energy transformation

For example, a windmill collects kinetic energy from the wind and converts it into useful mechanical and electrical energy. The Chinese used windmills to water their farms as illustrated in figure 1.7. This kind of energy is called Renewable Energy. This will be covered in details in

Module 2.

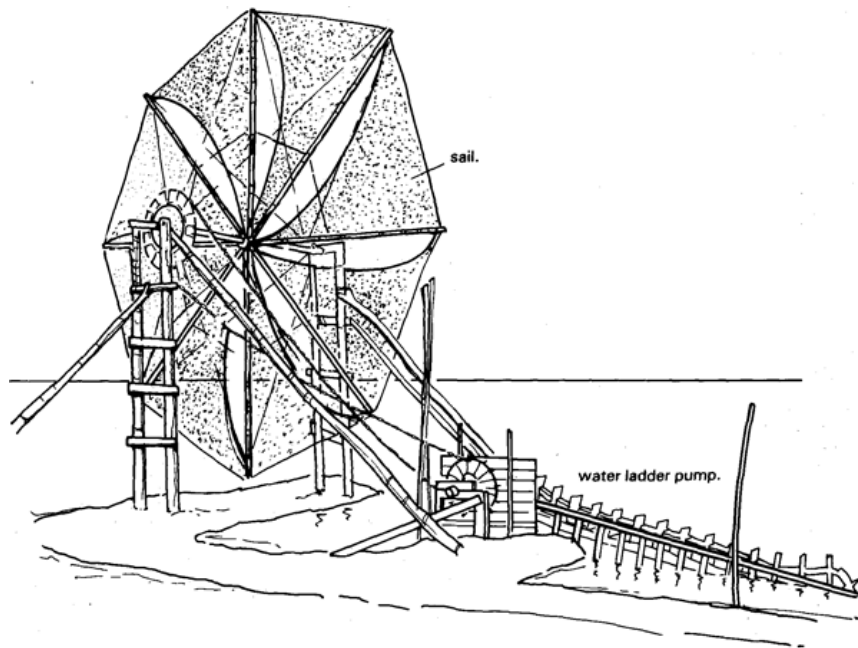


Figure 1.7: Windmill

Class Activity 1:

Energy transfer tables and diagrams are an excellent way of displaying the energy transfers taking place in a process. Complete the energy transfer table given below:

Energy Converter	Energy in	Energy out	Other Energy out
Windmill	Wind	Mechanical	Electrical

1.2 Electrical Energy

Electrical energy is what is stored in a battery, and can be used to power a cell phone or start a car. Electrical energy is delivered by tiny charged particles called electrons, typically moving through a wire.

Generating Electrical Energy

Electrical machine is a device that converts either mechanical energy to electrical energy or vice versa. **Motors** and **generators** are examples of electrical machines.



Figure 1.8: DC Motor

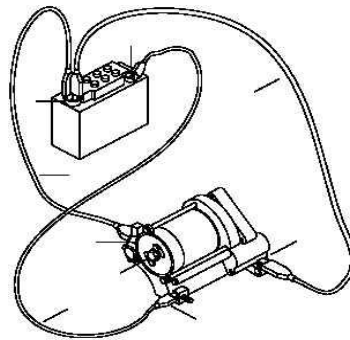


Figure 1.9: DC Motor connected to a battery

If a motor is connected to a battery as shown in figure 7.9, the motor will turn. Here it converts electrical energy to kinetic (Mechanical) energy.

A motor can also be used to generate electricity, and when a motor functions in this way, it is called a generator or a dynamo. Electricity is generated when the axle of the motor is turned.

Storing Electrical Energy

A capacitor is a device that could be used to store electrical energy. Unlike the battery, it does not use chemicals to store the electricity. It is made from two metal plates with a thin layer of insulator in between them. When the capacitor is charged (filled), the positive (+) charge goes on one plate, and an equal negative (-) charge goes on the other plate. When the capacitor is discharged (empty), both plates will have no charge.

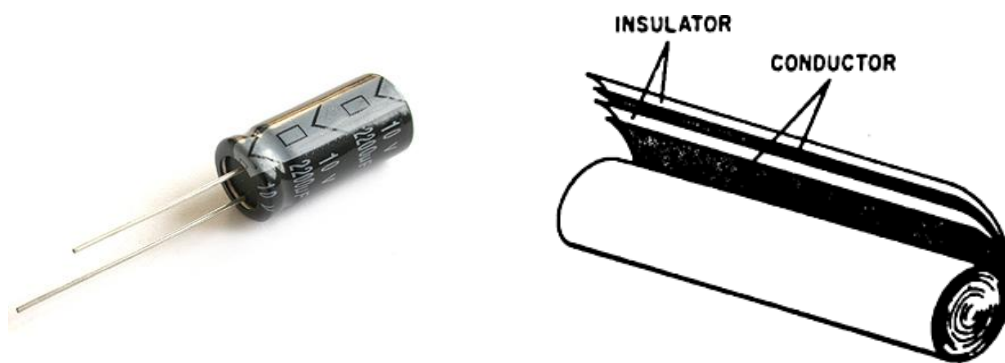


Figure 1.10: Capacitor

1.3 Practical Tasks

1.3.1 Task 1:

1. Connect the Lego motor to a battery and watch the motor run. In this case, the motor converts _____ energy to _____ energy.
2. Attach a large pulley wheel to the motor axle. A grey connector peg makes a good handle. Add two green tiles to show that the motor is being used as a generator of electricity.

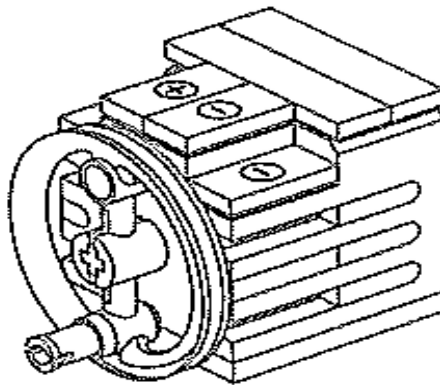


Figure 1.11: Generator

3. Turn the handle and feel how it turns
 - a. Was it easy or hard to turn the handle?

 - b. When you turn the handle, what sort of energy do you put in?

4. Connect a lamp at one end of a connecting wire and attach the other end to the motor/generator. Turn the handle to light the lamp. Feel how it turns.

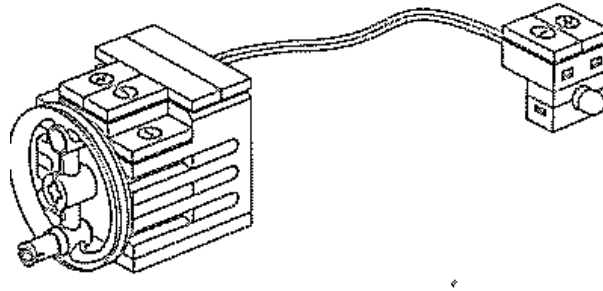


Figure 1.12: Lamp connected to the generator

- a. Was it easier or harder to turn the handle than before?

- b. Is the motor used as a generator in this activity?

5. Write down the energy transfer taking place in a generator:

From _____ to _____

6. Explain why it is harder to turn the handle when the lamp is connected?

7. Write down the useful energy transfer in a lamp.

From _____ to _____

8. Complete the energy transfer diagram for the lamp.

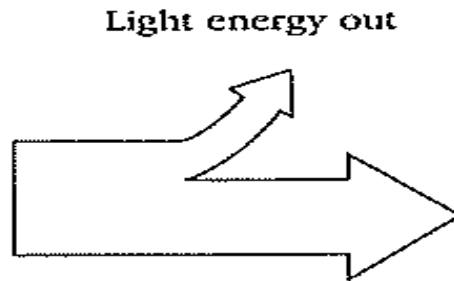


Figure 1.13: Lamp connected to the generator

9. Which form of energy do we get from the lamp that we do not use?

1.3.2 Task 2: Connect a generator to drive a motor

1. Connect a motor to a generator with a wire. Put a large pulley wheel on each. Add a connector peg to act as a handle on the generator. Add two green tiles to indicate that it is a generator.

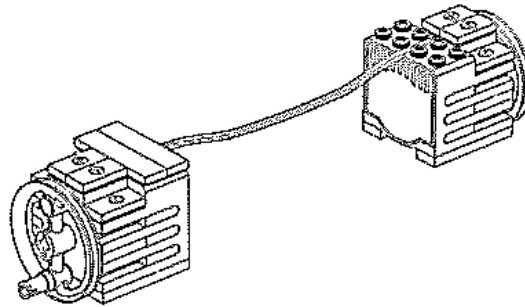


Figure 7.14: Motor connected to the generator

2. Turn the generator handle. Watch what happens to the pulley wheel on the motor. What is your observation regarding the other motor?

3. Use a force-meter to measure the force needed to turn the generator handle. What force was needed (in Newtons)?

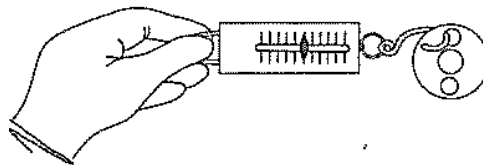
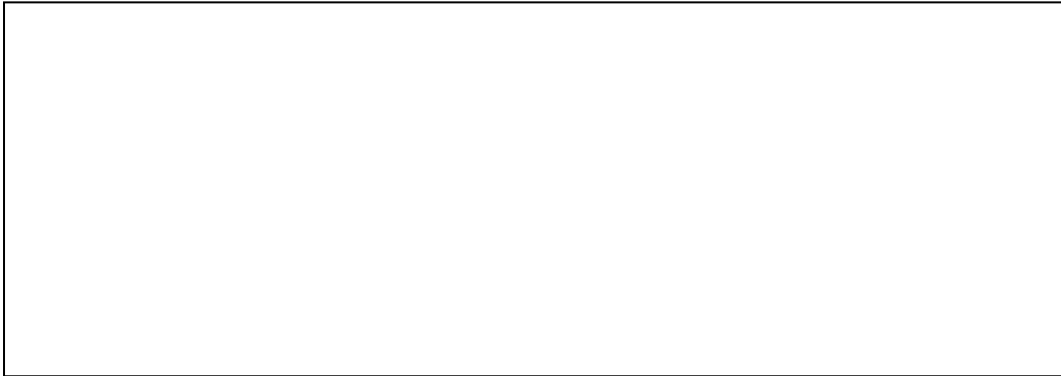
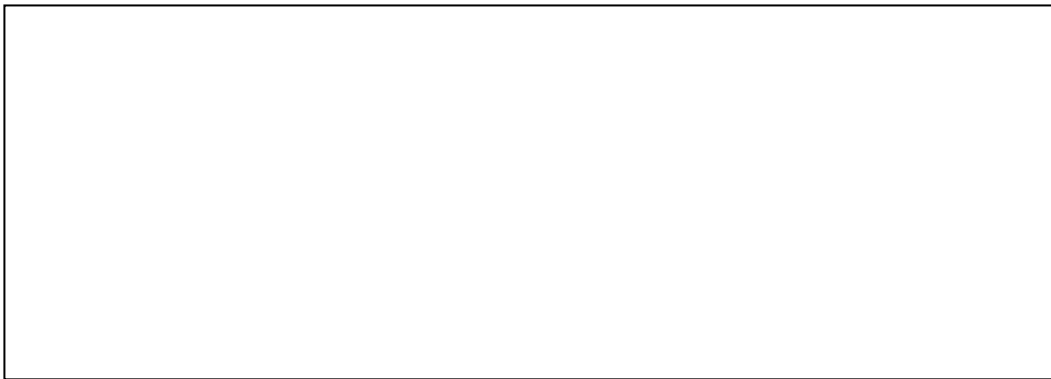


Figure 7.15: Measuring force with a force-meter

4. Draw an energy transfer diagram for the motor.



5. Draw an energy transfer diagram for the generator.



1.3.3 Task 3: Storing Electrical Energy

In this task, you will see how a capacitor could be used to store electrical energy.

1. As a first step, check that the capacitor is discharged or empty. This can be done by connecting the capacitor to the motor as shown in figure 1.16. The motor will not turn if the capacitor has discharged.
2. Put a large pulley wheel on the axle of the motor and add a grey connector peg to make a handle. Add two green tiles to indicate that it is a generator.
3. Now, connect the capacitor to the generator. Take care to connect it as shown on page 18 of the building booklet.

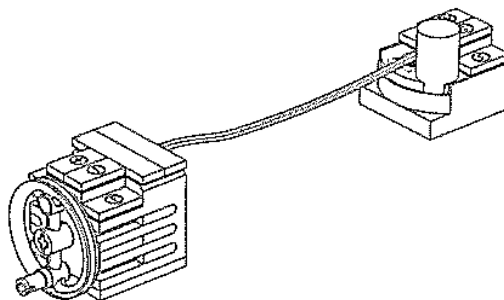


Figure 1.16: Capacitor connected to the motor

4. Turn the handle clockwise a few times then let go. What happens to the pulley?

5. When it is discharged (motor stops turning) try turning it 20 turns. What was different?

6. Next try turning the handle until the red light shows that the capacitor is fully charged. What was different?

1.3.4 Task 4: Power Distribution Network

This activity will let you build an electricity grid system.

1. Attach a handle and green tiles to the generator, then connect a motor to the generator. Turn the generator. Note what happens to the motor and how hard it is to turn the generator handle.

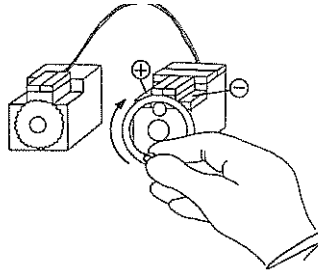


Figure 1.17: Motor connected to the generator

2. Now connect a lamp and another motor.

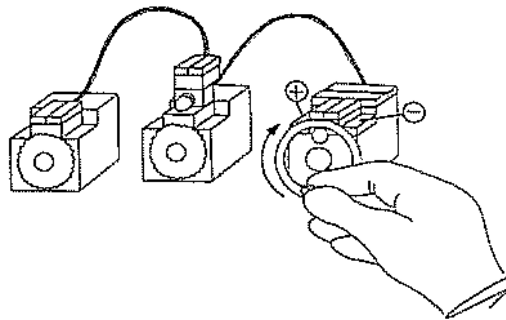


Figure 1.18: Lamp connected to the motor and generator

Keep turning at the same speed and feel how hard it will turn. When you add more load what happens to:

- a. The torque (turning force) needed by the generator?

- b. The motors and lamps?

- c. What happens to the motors when you stop generating

electricity?

3. Add a second generator to your system.

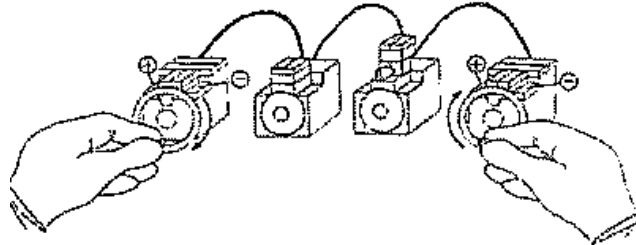


Figure 1.17: A second generator connected to the system

What happens to:

- a. The torque needed by the first generator when the second generator was added?

- b. The motors and lamps?

4. Having a real power station on standby, ready to take over when demand is high, is very expensive. A storage capacitor could be added to smooth out demand.

Connect a generator, capacitor and motor. Check the connections.

Turn the handle to generate electricity to charge the capacitor and turn the motor. What did you notice about the torque (turning force) as the capacitor charged up?

5. Add a lamp, or second motor.

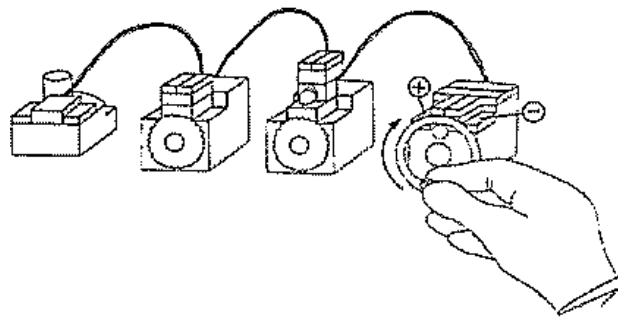


Figure 1.18: Generator, lamp, motor and capacitor connected

What happens when you start turning the generator?

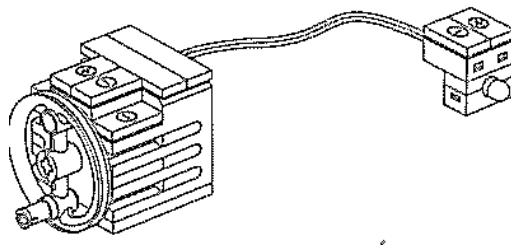
1.4 Worksheet

1. What are the two main types of energy?

2. Classify the following examples as potential and kinetic energy:

- Flowing water
- A ball held at a certain height
- A stretched rubber band
- A boy running

3. A lamp is connected to the generator as shown in the figure below.
The lamp turns on when the handle of the generator is turned.



Draw the energy transfer diagram for the lamp.

4. Complete the energy transfer table given below:

Energy Converter	Energy in	Energy out	Other Energy out
Windmill	_____	_____	_____
Car engine	_____	_____	_____
Electric lamp	_____	_____	_____