

LOWER SECONDARY CURRICULUM

Competency Based Physics

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BY WUNNA EDUCATIONAL SERVICES

THEME: MACHINES AND PROPERTIES OF MATTER

CHAPTER 1: WORK, ENERGY AND POWER

Learning outcomes

1. Know that the sun is our major source of energy and the different forms of energy.
2. Know that energy can be changed from one form to another and understand the law of conservation of energy.
3. Understand the positive and negative effects of solar energy.a

4. Understand the difference between renewable and non- renewable energy resources with respect to Uganda.
5. Know and use the relationship between work done, force, distance moved and time taken
6. Understand that an object may have energy due to its motion or its position and change between kinetic energy and potential energy.
7. Know the mathematical relationship between gravitational potential energy and kinetic energy and use it in calculations.
8. Understand the meaning of machines and explain how simple machines simplify work.
9. Understand the principles behind the operation of simple machines.

Key words

- Work done
 - Energy
 - Kinetic energy
 - Efficiency
 - Mechanical advantage
 - Work input
- Power
 - Potential energy
 - Joule
 - Energy wasted.
 - Velocity ratio
 - Work output

Introduction

- This chapter will introduce us to work, energy, power and how they apply in simple machines. We always engage in many activities such as playing, digging, cutting among others. We need tools in order to carry out these activities. However, as we conduct these activities, through the use of energy, we eventually perform work.
- At times we employ machines to do for us the work, what do you understand by machines? How do they simplify work? In this section we will learn all the above mentioned concepts.

ENERGY

Energy is the ability or capacity to do work. The S.I unit of work done and energy is a **joule** (J).

SOURCES OF ENERGY (ENERGY SOURCES)

The raw material for the production of energy is called the energy source. There are two types of energy sources.

- Renewable sources of energy
- Non-renewable sources of energy

RENEWABLE ENERGY SOURCES

These are energy sources which can be replaced when they get used up.

They can never get exhausted. They include;

Solar Energy

Energy from the sun captured using solar panels or photovoltaic cells.

Advantages:

- Abundant and inexhaustible source
- Low operating costs after installation
- No greenhouse gas emissions during operation

Disadvantages:

- Unreliable energy supply (dependent on weather and time of day)
- High initial installation costs
- Requires significant space for large-scale installations

Wind Energy

Energy from wind captured using wind turbines.

Advantages:

- Renewable and abundant
- Low operating costs after installation
- No greenhouse gas emissions during operation

Disadvantages:

- Unreliable energy supply (dependent on wind availability)
- Noise and visual impact concerns
- Requires suitable locations with consistent wind

Hydropower

Energy from moving water, typically harnessed using dams on rivers.

Advantages:

- Reliable and consistent power generation
- Can provide large-scale power
- No greenhouse gas emissions during operation

Disadvantages:

- Ecological impact on aquatic ecosystems
- Displacement of communities and wildlife
- High initial construction costs

Biomass Energy

Energy from organic materials (plant and animal matter), including wood, agricultural residues, and biofuels.

Advantages:

- Can use waste materials, reducing landfill use
- Renewable if managed sustainably
- Can reduce greenhouse gas emissions if replacing fossil fuels

Disadvantages:

- Air pollution from burning biomass
- Land and water resource competition with food production
- Can contribute to deforestation if not managed sustainably

Hydrogen Energy

Energy from hydrogen, used in fuel cells to generate electricity or as a direct fuel.

Advantages:

- High energy density
- Can be produced from various resources (including water and renewable energy)
- No greenhouse gas emissions when used in fuel cells

Disadvantages:

- High production and storage costs.
- Infrastructure for widespread use is still scarce.
- Energy-intensive production process if not using renewable sources.

Tidal and Wave Energy

Energy from ocean tides and waves captured using specialized turbines and generators.

Advantages:

- Predictable and reliable energy source
- High energy potential in coastal areas
- No greenhouse gas emissions during operation

Disadvantages:

- High initial capital costs
- Environmental impact on marine ecosystems
- Limited to suitable coastal locations

NON-RENEWABLE SOURCES OF ENERGY

These are energy sources, which cannot be replaced when they get used up.

Examples of non- renewable sources of energy include;

Fossil fuels

These are formed from plant remains that died million years ago. They include;

Coal: A solid fossil fuel used primarily for electricity generation and steel production.

Oil: A liquid fossil fuel used for transportation, heating, and generating electricity.

Natural Gas: A gaseous fossil fuel used for heating, electricity generation, and as a raw material in chemical industries.

Advantages:

- High energy density
- Established infrastructure and technology
- Reliable and consistent power generation

Disadvantages:

- Significant greenhouse gas emissions
- Air pollution and health impacts
- Causes resource exhaustions, leading to depletion concerns

Nuclear Energy

Generated through nuclear fission, where atomic nuclei (typically uranium-235 or plutonium-239) are split to release energy.

Advantages:

- Low greenhouse gas emissions during operation
- High energy density and reliable power generation
- Long-term energy supply with abundant fuel resources

Disadvantages:

- Radioactive waste disposal issues
- High initial capital costs
- Risk of nuclear accidents (e.g., Chernobyl, Fukushima)

Questions

1. Are the sources given above natural sources or artificial sources or both? Explain how you were able to differentiate the two kinds of sources.
2. What is the major source of energy for all living things on earth? Explain your response.
3. What do plants use the energy from the sun for?
4. Imagine that the sun goes down for a week, how would life be? Explain your response.

NOTE;

On earth, all the energy we use comes originally from the sun. For example all plants get their energy from the sun in order to manufacture their own food and we are able to get food because plants got energy from the sun.

RESEARCH ASSIGNMENT.

1. In your groups, discuss and make a presentation on how wind mill, waterfalls, nuclear power stations and tides generate energy.
2. Think about daily activities we engage in that require use of energy and include them in your presentation.

FORMS OF ENERGY

Energy cannot be touched because it has no mass, neither does it occupy space. We define energy by what it does or what it can do. Therefore energy is defined as the ability to do work and can exist in the following forms;

Chemical energy:

Chemical energy is the form of energy a body has due to the nature of its atoms and molecules and the way they are arranged. In the combination of atoms to form compounds, there is gain or loss of energy. This energy is stored in the compound as chemical energy.

If the atoms in such compounds are rearranged to form a new compound, this energy is released. E.g If sugars in the human body are burnt, a lot of chemical energy is released.

Nuclear energy:

This is the energy released when atomic nuclei disintegrate during nuclear reactions. In nuclear reactions, the energy, which holds the nuclear particles together (Binding energy), is released.

There are two types of nuclear reactions i.e. fission (Where large nuclei break to form smaller ones) and fusion (Where smaller nuclei combine to form larger ones). In both cases, large amounts of energy are released.

Electrical energy (Electricity):

This is the form of energy which is due to electric charges moving from one point of a conductor to another.

This form of energy is most easily converted to other forms, making it the most useful form.

Light energy:

This is the form of energy which enables us to see. Light is part of a wider spectrum of energy called the electromagnetic spectrum. Light consists of seven visible colours, of red, orange, yellow, green, blue, indigo and violet. We are able to see because the eye is sensitive to the colours.

Heat energy:

Heat is a form of energy, which results from random movement of the molecules in the body. It is responsible for changes in temperature. When a body is heated or when heat energy of the body increases;

- (i) The internal kinetic energy of the molecules increases leading to a rise in temperature.
- (ii) The internal potential energy of molecules increases leading to expansion and change of state of the body.

Sound energy:

This is the energy which enables us to hear. Like light, sound is also a form of wave motion, which makes particles to vibrate. Our ears are able to detect sound because it produces vibrations in the ear.

Mechanical energy:

Mechanical energy is classified into two major categories; potential energy and kinetic energy. In other words, mechanical energy is the sum of kinetic energy and all forms of potential energy associated with an object. That is;
Mechanical energy = kinetic energy + potential energy

$$M.E = K.E + P.E$$

Types of potential energy

There are three main types of potential energy and these are;

- Chemical potential energy
- Elastic potential energy
- Gravitational potential energy

Kinetic energy

This is energy a body possesses because of its motion.
The kinetic energy is given by

$$K.E = \frac{1}{2} mv^2,$$

where m is mass of the body and v is its velocity.

Assignment.

1. Research about the above types of potential energy and write brief notes about each.
2. Research and write brief notes about the types of kinetic energy.

Trial Questions

- 1) A ball of mass 2kg is kept on a hill of height 3km. calculate the potential energy possessed by the body.
- 2) 145g spear is thrown at a speed of 25ms^{-1} to kill a wild animal. What is its kinetic energy? How much work was done on the spear to make it reach this speed, if started from rest?
- 3) If you drop a 3kg ball from a height h of 10m, ignoring frictional forces, what is;
 - a) The velocity when the ball hits the ground?
 - b) The kinetic energy of the body as it hits the ground (take $g = 10\text{ms}^{-2}$)

ENERGY TRANSFORMATION

As we saw earlier that all energy in the universe comes from the sun, using both natural and man-made systems, we can transform it into many forms.

For example, Green plants change sun energy into chemical energy and the solar panel transform sun energy into electrical energy and light we use.

Group discussion work (Energy transformation)

1. (a) Discuss the energy changes that take place in the bulb, flat iron and loud speaker.
(b) State the energy transformation in the following devices/events
 - i. A torch using dry cells
 - ii. A man running
2. In groups, discuss the energy transformations that take place in:
 - a) a mango falling from a tree
 - b) A swinging pendulum
 - c) Using a catapult
 - d) A ball is thrown vertically upwards

CONSERVATION OF ENERGY.

One of the major features of energy is that it can be changed from one form to more forms of energy. For example;

1. When lighting a match box;

Chemical energy $\longrightarrow$ Heat + Light

2. When a boy compresses the spring

Mechanical energy $\longrightarrow$ Elastic potential energy

3. When lighting a lamp connected to a battery

Chemical energy $\longrightarrow$ Electrical energy $\longrightarrow$ heat + light

4. Catapult pulled by a person to propel a stone

Mechanical energy $\longrightarrow$ Elastic potential energy $\longrightarrow$ kinetic energy

The following devices can be used to carry out the following energy changes;

- i) Electrical energy to mechanical energy —————> Motor
- ii) Mechanical energy to electrical energy —————> Dynamo
- iii) Electrical energy to sound energy —————> Loudspeaker
- iv) Sound energy to electrical energy —————> Microphone
- v) Heat energy to electrical energy —————> Thermopile
- vi) Electrical energy to heat energy —————> Electrical heater
- vii) Electrical energy to light energy —————> Electric lamps
- viii) Light energy to electrical energy —————> Photocells
- ix) Chemical energy to electrical energy —————> Cell
- x) Electrical energy to chemical energy —————> Battery charging
- xi) Nuclear energy to heat energy —————> Nuclear reactor
- xii) Electromagnetic to electrical energy —————> Aerial

Note: For a body falling freely its kinetic energy before impact is equal to potential energy above the ground.

In an electrical bulb, electrical energy is transformed into light energy and heat energy. As energy changes from one form to another, the overall amount must remain constant. Hence during transformation, energy is conserved.

The law of conservation of energy states that **energy can neither be created nor destroyed but transformed from one form to another**. For example, if a fruit falls freely from a tree, the potential energy of the fruit before falling is conserved into kinetic energy as it hits the ground. Therefore; **Loss in potential energy = gain in kinetic energy**

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

NOTE:

Don't confuse the expressions “**conservation of energy**”. And “**energy conservation**”. Conservation of energy is law of nature while energy conservation refers to the wise use of energy resources aimed at saving energy by reducing the length of use.

ACTIVITY (group work)

1. In groups, discuss different ways a man has innovated to save the amount of energy used.
2. A brick of mass 3kg resting on a wall fall freely to the ground through a vertical height of 3m. calculate the;
 - a) Kinetic energy of the brick as it hits the ground.
 - b) Velocity with which the brick hits the ground. (take $g = 10\text{ms}^{-2}$)
3. Using internet and other sources, Suggest and explain ways in which energy can be stored.
 - a) How are the ways suggested above useful to the environment and the society?

POSITIVE AND NEGATIVE EFFECTS OF SOLAR ENERGY

The sun is a powerful energy source, it supplies the universe with its energy all the time. The solar energy has various advantages and disadvantages for creatures living on earth.

Research assignment

Make a comprehensive research and write down the advantages and disadvantages of solar energy.

Advantages:

Disadvantages:

RELATIONSHIP BETWEEN WORK, ENERGY AND POWER

When we walk, push a wheel barrow or even ride a bicycle, we say we have done work. Therefore, in our everyday life, work describes any activity that a person does. Work is defined as a product of force and distance moved in the direction of the force. The S.I unit of work is joules (J) If the object is moved through a distance of 1m by a force of 1N, then from the definition for work,

Work done (W) = Force (F) x Distance (D)

S.I unit of work is Joule. Thus $1J = 1N \times 1m$

Therefore a joule is defined as the work done when a force of 1 newton moves the point of application through a distance of 1m.

Trial questions

1. Jane pushes a trolley in a super market full of goods with a force of 150N through a distance of 10m . How much work did Jane do?
2. Isaac pushes a concrete wall in his room with a force of 300N . How much work does he do? Explain your answer.

POWER

We normally use the term “power”. It always requires a powerful person to accomplish any work on time. We all do work but at different rates.

For example:

The power developed by Isaac whose weight is 750N is different from the power developed by Ivan whose weight is 650N if they are climbing the same stair case in the same time.

Power is defined as the rate at which work is done. The S.I unit of power is the watt (W).

From the definition

$$\text{Power} = \frac{\text{Work done}}{\text{time taken}}$$

$$\text{Power} = \frac{\text{Force X distance}}{\text{time taken}}$$

$$P = \frac{F \times D}{T}$$

$$\text{But } \frac{D}{T} = V \text{ (velocity)}$$

$$\text{Therefore } P = F \times \frac{D}{T}$$

$$P = F \times V, \text{ Where } V \text{ is Velocity}$$

Examples

1. An engine raises 200kg of sand through the height of 50m in 20 seconds, Calculate the power of the engine.

Solution

$$\text{From the power} = \frac{\text{work done}}{\text{time taken}}$$

$$\text{Power} = \frac{\text{Force} \times \text{distance}}{\text{time}}$$

$$P = \frac{m \times g \times d}{t}$$

$$P = \frac{200 \times 10 \times 50}{20} = 5000W$$

2. Joseph of mass 60kg walks up a flight of 15 steps each of height 20cm. Calculate the power he develops in 30seconds.

$$\text{From, } P = \frac{F \times d}{t}$$

$$\text{Force, } F = m \times g = 60 \times 10 = 600\text{N}$$

$$\text{Distance, } d = \text{number of step (n)} \times \text{height (h)}$$

$$\text{Distance} = n \times h = 15 \times 20\text{cm} = 300\text{cm} = \frac{300}{100} = 3\text{m}$$

$$\text{Therefore } P = \frac{m \times g \times d}{t}, t = 30\text{seconds}$$

$$P = \frac{F \times d}{t}$$

$$P = \frac{600 \times 3}{30} = 60\text{W}$$

3. At what average velocity can a motor rated 400W raise a load of mass 80kg?

Solution

$$\text{From power} = \frac{\text{Force} \times \text{distance}}{\text{time}}$$

$$400 = \frac{m \times g \times d}{t}$$

$$400 = 80 \times 10 \times \frac{d}{t}$$

$$400 = 800 \times V$$

$$\frac{400}{800} = \frac{800V}{800}$$

$$V = 0.5\text{ms}^{-1}$$

TRIAL QUESTIONS

1. a) Define a watt
2. Convert 2.5 kilowatts to watts.
3. 3. A crane lifts 20 bricks per minute through a height of 15m.
Calculate the power that is expended if each brick weighs 5N.
4. 4. A block of mass 2kg falls freely from rest through a height of 20m above the ground. Find,
 - a. The potential energy of the block above the ground.
 - b. The velocity with which the block hits the ground.

HOLIDAY ZOOM LESSONS



S.1 – S.6 ARTS & SCIENCES

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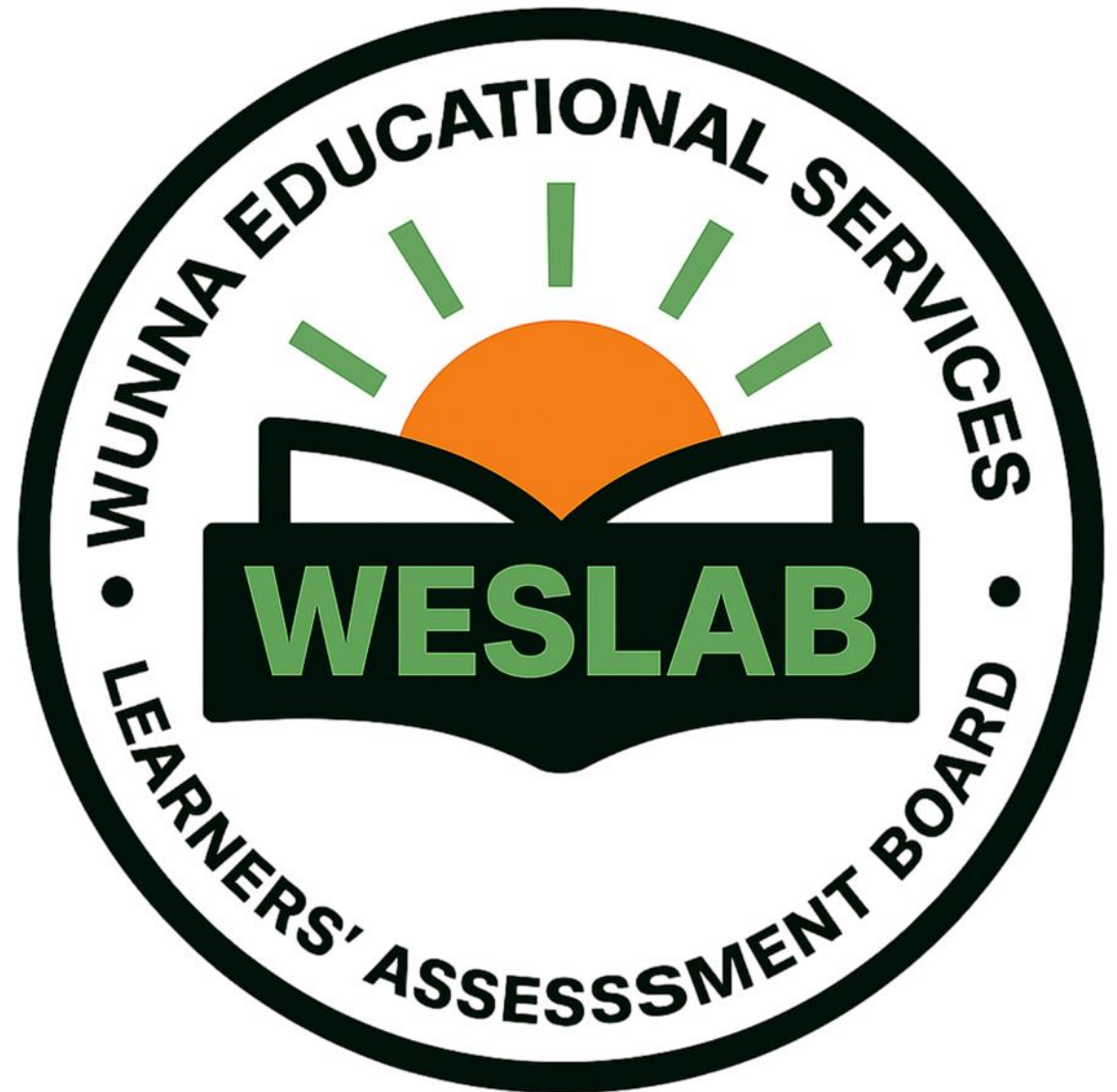
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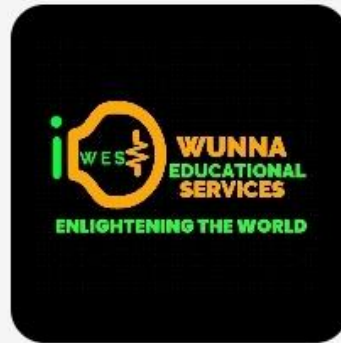
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