25SCHOOLS
FREE LEARNING NOTES FOR ZAMBIA

FORM 2

Physics

Mechanics 2: simple machines and pressure

Lesson notes for learners · Competence-Based Curriculum

INSIDE

1. Simple machines and their types
2. Mechanical advantage, velocity ratio and efficiency
3. Pressure
4. Pressure in liquids and measuring pressure
5. Check yourself

A simple machine is a basic device that helps us apply a force to another object, such as a crowbar lifting a heavy stone or a wheelbarrow carrying sand. Pressure explains why a sharp knife cuts maize stalks easily and why a tractor with wide tyres does not sink into soft ground. You meet both every day on Zambian farms, building sites and in kitchens.

AFTER THESE NOTES YOU SHOULD BE ABLE TO

- Name the types of simple machine and the three classes of lever
- Work out mechanical advantage, velocity ratio and efficiency of a machine
- Explain pressure as force on an area and calculate it
- Describe how a manometer and a barometer measure pressure
- Use the pressure in a liquid to solve simple problems

KEY WORDS

simple machine	a basic mechanical device used to apply force to another object
load	the force a machine has to overcome, for example the weight of a stone
effort	the force we apply to the machine
mechanical advantage (MA)	the ratio of the load to the effort
velocity ratio (VR)	the ratio of the distance moved by the effort to the distance moved by the load
efficiency	the mechanical advantage divided by the velocity ratio, written as a percentage
pressure	the force acting at right angles on a surface for each unit of area
pascal (Pa)	the unit of pressure, equal to one newton on each square metre

1 Simple machines and their types

A simple machine is a basic mechanical device used to apply force to another object. The force we put in is the effort and the force we want to overcome is the load. The main types are the lever, the pulley, the inclined plane, the wedge, the screw, the wheel and axle, and gears.

Levers are sorted into first, second and third class, depending on where the fulcrum, load and effort are placed. Pulleys are sorted into fixed, movable and block and tackle.

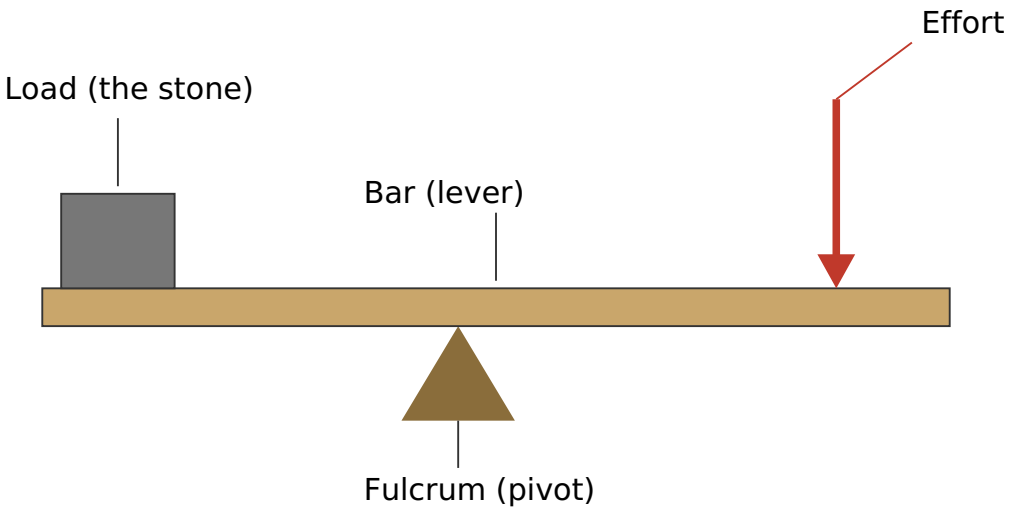

Figure 1. A lever lifting a stone: the bar turns about the fulcrum

2 Mechanical advantage, velocity ratio and efficiency

Mechanical advantage is the ratio of the load to the effort, so MA = load / effort. It has no unit because it compares two forces. A machine with MA = 4 lets a 100 N effort overcome a 400 N load.

Velocity ratio is the ratio of the distance moved by the effort to the distance moved by the load, so VR = distance moved by effort / distance moved by load.

Efficiency tells us how much of the work we put in comes out as useful work. Efficiency = (MA / VR) × 100%. No real machine reaches 100% because some work is lost, for example to friction in a pulley.

WORKED EXAMPLE

A farmer uses a pulley system to raise a 600 N sack of maize with an effort of 200 N. The effort moves 6 m while the sack rises 2 m. Find the MA, the VR and the efficiency.

MA = load / effort = 600 / 200 = 3

VR = effort distance / load distance = 6 / 2 = 3

Efficiency = (MA / VR) × 100% = (3 / 3) × 100% = 100%

In real life friction lowers this, so the effort would be a little more than 200 N

3 Pressure

Pressure depends on force and area. It is the force acting at right angles to a surface for each unit of area, so pressure = force / area, or $p = F / A$. It is measured in pascals (Pa), which is the same as newtons on each square metre (N/m^2).

For the same force, a small area gives a large pressure and a large area gives a small pressure. This is why a sharp pencil tip feels sharp on your palm and a blunt eraser feels dull: the pencil tip concentrates the force on a tiny area.

WORKED EXAMPLE

A box pushes down on the floor with a force of 600 N. Its base area is 0.5 m^2. Find the pressure on the floor.

$p = F / A$

$p = 600\ N / 0.5\ m^2$

$p = 1200\ Pa$

4 Pressure in liquids and measuring pressure

The pressure in a liquid is found from $p = \rho gh$, where ρ is the density of the liquid, g is the gravitational field strength and h is the depth. The pressure grows with depth and with the density of the liquid.

Pressure can be measured with a manometer, a barometer or a pressure sensor. A simple manometer is a U-shaped clear tube holding coloured water. When you blow into one end, the water rises on one side and falls on the other, and the difference in height shows the pressure difference. A barometer is used to measure the pressure of the atmosphere.

WORKED EXAMPLE

Find the pressure due to the water at a depth of 3 m in a dam. Use density 1000 kg/m^3 and $g = 10\ N/kg$.

$p = \rho gh$

$p = 1000 \times 10 \times 3$

$p = 30\ 000\ Pa$

TRY THIS

Make a simple manometer: fix a clear plastic tube of about 1 to 2 m into a U-shape on a board, pour in coloured water until both sides are level, then blow gently into one end and measure the difference in height between the two water levels. Press a pencil tip and a blunt eraser on your palm and tell which one gives the greater pressure and why.

REMEMBER

- A simple machine is a basic device used to apply force to another object
- Levers are first, second or third class; pulleys are fixed, movable or block and tackle
- MA = load / effort and VR = effort distance / load distance
- Efficiency = (MA / VR) × 100%
- Pressure = force / area, measured in pascals (N/m²)
- Pressure in a liquid is p = ρgh

? Check yourself

1. Write down the formula for mechanical advantage.
2. What is the unit of pressure, and what does it equal?
3. Why can no real machine have an efficiency of 100%?
4. A machine has MA = 4 and VR = 5. Find its efficiency.
5. Find the pressure when a force of 200 N acts on an area of 0.1 m².
6. A builder at a site in Lusaka uses a crowbar to lift a block with a weight of 800 N by pushing down with an effort of 100 N. The effort moves 80 cm while the block rises 10 cm. (a) Find the MA. (b) Find the VR. (c) Find the efficiency and say what it tells you about the crowbar.
7. A fisherman in Luangwa stands in a canoe on a river. He dives and notices that his ears hurt more at 4 m depth than at 1 m depth. (a) Use p = ρgh to find the pressure from the water at 1 m and at 4 m (density 1000 kg/m³, g = 10 N/kg). (b) Compare the two answers. (c) Explain why the pain increases.
8. A woman in a village has a wide-based basin and a narrow-based tin, both weighing the same when full of water. (a) Which one gives less pressure on a soft sandy floor? (b) Give the formula that explains your answer. (c) Suggest why a wide-tyred tractor suits wet fields.

ANSWERS

1. MA = load / effort.
2. The pascal (Pa), which equals one newton on each square metre (N/m²).
3. Some of the work put in is lost, for example to friction, so the useful work out is always less.
4. (4 / 5) × 100% = 80%.
5. p = 200 / 0.1 = 2000 Pa.
6. (a) MA = 800 / 100 = 8. (b) VR = 80 / 10 = 8. (c) Efficiency = (8 / 8) × 100% = 100%, so in this ideal case no work is lost; in real life friction would make it lower.
7. (a) At 1 m: p = 1000 × 10 × 1 = 10 000 Pa. At 4 m: p = 1000 × 10 × 4 = 40 000 Pa. (b) The pressure at 4 m is four times that at 1 m. (c) Pressure in a liquid grows with depth, so the deeper he goes the greater the force on his ears.
8. (a) The wide-based basin. (b) p = F / A: for the same force, a larger area gives a smaller pressure. (c) The wide tyres spread the weight over a bigger area, so the pressure on the soil is small and the tractor does not sink.

Written by 25Schools to follow the Form 2 Physics syllabus of the Zambian competence-based curriculum. Free for learners to read, download and share. More notes and quizzes at 25schools.com.