Mechanics 2: simple machines and pressure

Lesson plan and teacher's notes · Form 2 Physics · 1 period of 40 minutes

School	(write school name)	**Teacher**	(write name)
Date	(date)	**Class**	Form 2
Subject	Physics	**Enrolment**	Boys ___ Girls ___ Total ___
Time	40 minutes	**Topic**	Mechanics 2: simple machines and pressure

Learners name the types of simple machine and the three classes of lever, work out mechanical advantage, velocity ratio and efficiency, explain pressure as force on an area and calculate it, and use p = ρgh for pressure in a liquid. Examples come from farms, dams and kitchens.

Specific outcomes

By the end of the lesson, learners should be able to:

1. Name the types of simple machine and the three classes of lever
2. Work out mechanical advantage, velocity ratio and efficiency of a machine
3. Explain pressure as force on an area and calculate it
4. Use the pressure in a liquid to solve simple problems and say how a manometer and a barometer are used

Prior knowledge

- Force and its unit, the newton
- Area of a rectangle
- Division and multiplication of decimals

Teaching and learning materials

- chalk and board
- a pencil and an eraser
- a ruler or stick as a lever with a stone as the load
- a plastic bottle with water
- a calculator if available

References

Ministry of Education (CDC) Form 2 Physics syllabus and module; 25Schools learners' note: Mechanics 2: simple machines and pressure.

Lesson development

Stage and time	Teacher activities	Learner activities
Introduction 5 min	Ask why a sharp knife cuts maize stalks easily and why a crowbar lifts a heavy stone. Write simple machine, effort, load and pressure on the board.	Suggest examples of machines and sharp tools from home and the farm.
Development: simple machines 10 min	Name the lever, pulley, inclined plane, wedge, screw, wheel and axle, and gears. Show the three classes of lever by the places of the fulcrum, load and effort and the three kinds of pulley.	Draw a lever lifting a stone and label the fulcrum, load and effort.
Development: MA, VR and efficiency 10 min	Give MA = load/effort, VR = distance moved by effort/distance moved by load and efficiency = (MA/VR) × 100%. Work the pulley and sack example.	Calculate MA, VR and efficiency for two machines.
Development: pressure 12 min	Show p = F/A in pascals and compare a pencil tip with an eraser on the palm. Work the box on the floor. Then teach p = ρgh with the dam example and mention the manometer and the barometer.	Calculate three pressures and explain why a small area gives a large pressure.
Conclusion 3 min	Ask why no real machine is 100% efficient. Set the homework.	Answer and copy the homework.

Teacher's content notes

Read these before the lesson. They are what you need to know, not what to copy onto the board.

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.

Mechanical advantage, velocity ratio and efficiency

MA = load ÷ effort. It has no unit because it compares two forces. VR = distance moved by effort ÷ distance moved by load. Efficiency = (MA ÷ VR) × 100%. No real machine reaches 100% because some work is lost, for example to friction in a pulley.

Pressure

Pressure is the force acting at right angles to a surface for each unit of area, so p = F ÷ A. It is measured in pascals (Pa), the same as newtons on each square metre (N/m²). For

the same force, a small area gives a large pressure and a large area gives a small pressure.

Pressure in liquids and measuring pressure

The pressure in a liquid is found from $p = \rho g h$, 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 manometer shows a pressure difference by the difference in height of liquid in a tube, and a barometer measures the pressure of the atmosphere.

Questions to ask during the lesson

Question	Expected answer
A man uses a crowbar and a machine with MA = 4 to lift a stone, and a friend asks what MA means. (a) Write the formula for MA. (b) Say why it has no unit. (c) Say what effort a machine with MA = 4 needs to overcome a load of 400 N.	(a) MA = load ÷ effort. (b) It compares two forces. (c) 400 ÷ 4 = 100 N.
A learner tests a machine that has MA = 4 and VR = 5. (a) Write the formula for efficiency. (b) Find the efficiency. (c) Say why no real machine reaches 100%.	(a) (MA ÷ VR) × 100%. (b) (4 ÷ 5) × 100% = 80%. (c) Some work is lost, for example to friction.
A force of 200 N acts on an area of 0.1 m² on a table. (a) Write the formula for pressure. (b) Find the pressure. (c) Give the unit and what it equals.	(a) $p = F \div A$. (b) 200 ÷ 0.1 = 2000 Pa. (c) The pascal, which equals one newton on each square metre.
A learner presses a pencil tip and the blunt end of an eraser on her palm with the same force. (a) Say which feels sharp. (b) Say which area is smaller. (c) Explain the difference using pressure.	(a) The pencil tip. (b) The pencil tip. (c) The same force on a smaller area gives a larger pressure.

Worked examples for the board

Example 1: pulley and sack of maize

A farmer raises a 600 N sack with an effort of 200 N. The effort moves 6 m while the sack rises 2 m. MA = 600 ÷ 200 = 3. VR = 6 ÷ 2 = 3. Efficiency = (3 ÷ 3) × 100% = 100%. In real life friction lowers this.

Example 2: pressure of a box

A box pushes down on the floor with a force of 600 N and its base area is 0.5 m². $p = F \div A = 600 \div 0.5 = 1200$ Pa.

Example 3: pressure in a dam

Find the pressure due to water at a depth of 3 m. Use density 1000 kg/m³ and g = 10 N/kg. $p = \rho g h = 1000 \times 10 \times 3 = 30\,000$ Pa.

Board plan

Write the title. Left: types of simple machine and the three classes of lever. Centre: the formulas for MA, VR and efficiency with the pulley example. Right: p = F/A and p = ρgh with their worked examples.

Quantity	Formula	Unit
Mechanical advantage (MA)	load ÷ effort	No unit
Velocity ratio (VR)	distance moved by effort ÷ distance moved by load	No unit
Efficiency	(MA ÷ VR) × 100%	Percentage
Pressure	force ÷ area, p = F/A	Pa, which is N/m²
Pressure in a liquid	p = ρgh	Pa

Formulas used in the lesson

Mistakes to expect

Learners often think	Put it right
A machine with an MA of 4 gives 4 times as much work out.	MA compares forces only. A machine with MA = 4 lets a 100 N effort overcome a 400 N load, but some work is always lost, for example to friction.
A real machine can have an efficiency of 100%.	No real machine reaches 100% because some work is lost, for example to friction in a pulley.
Mechanical advantage has a unit in newtons.	MA has no unit because it compares two forces.
Pressure depends only on the force.	Pressure is force on each unit of area. For the same force a small area gives a large pressure and a large area gives a small pressure.

Differentiation

Learners who struggle

Give learners a card with the four formulas and the units. Let them copy the worked examples line by line and then do the next one with the same steps.

Learners who finish early

Ask learners who finish early to compare the pressure of the same box standing on its small face and on its large face, and to say which face gives the larger pressure and why.

Hearing or visual impairment

For learners with visual impairment, let them feel a pencil tip and an eraser on the palm and handle the lever model. For learners with hearing impairment, write each formula and each step of a worked example on the board in order.

No projector, no printing

Use a ruler or stick on a block of wood as a lever and a stone as the load. Use a pencil and an eraser to feel pressure. Do the calculations in exercise books without a calculator.

If time is short

Teach MA, VR and efficiency with the pulley example, then p = F/A. Leave pressure in liquids and the manometer and barometer for the next lesson.

Evaluation

Question or task	A correct answer shows
A farmer uses a pulley system to raise a 600 N sack of maize with an effort of 200 N, and the effort moves 6 m while the sack rises 2 m. (a) Find the MA. (b) Find the VR. (c) Find the efficiency and say what it means.	(a) 600 ÷ 200 = 3. (b) 6 ÷ 2 = 3. (c) (3 ÷ 3) × 100% = 100%, and in real life friction lowers this.
A box pushes down on the floor with a force of 600 N and its base area is 0.5 m^2, and a pencil tip pushes on a palm with the same force on a tiny area. (a) Find the pressure under the box. (b) Give the unit. (c) Say which area gives the larger pressure for the same force and why.	(a) 600 ÷ 0.5 = 1200. (b) Pa, the same as N/m^2. (c) The tiny area gives a large pressure because the force is concentrated.
A dam holds water of density 1000 kg/m^3 and a learner wants the pressure due to the water at a depth of 3 m, using g = 10 N/kg. (a) Write the formula. (b) Substitute. (c) Find the pressure.	(a) p = ρgh. (b) 1000 × 10 × 3. (c) 30 000 Pa.

Homework

A builder raises a load of 800 N with an effort of 200 N, and the effort moves 10 m while the load rises 2 m. (a) Find the MA and the VR. (b) Find the efficiency. (c) A force of 800 N also acts on an area of 0.4 m^2. Find the pressure.

Extra practice with answers

Question	Answer
1. A worker raises a load of 500 N with an effort of 125 N, and the effort moves 10 m while the load rises 2 m. (a) Find the MA. (b) Find the VR. (c) Find the efficiency.	(a) 500 ÷ 125 = 4. (b) 10 ÷ 2 = 5. (c) (4 ÷ 5) × 100% = 80%.
2. A man uses a crowbar with an effort of 50 N to lift a stone with a load of 300 N. (a) Find the MA. (b) Say what class of machine a crowbar is. (c) Say which parts must be placed to name the class of a lever.	(a) 300 ÷ 50 = 6. (b) A lever. (c) The positions of the fulcrum, the load and the effort.
3. A force of 300 N acts on an area of 0.2 m^2 on a table. (a) Write the formula. (b) Find the pressure. (c) Say what happens to the pressure if the same force acts on a larger area.	(a) p = F ÷ A. (b) 300 ÷ 0.2 = 1500 Pa. (c) It becomes smaller.

4. A diver goes to a depth of 5 m in a dam of water with density 1000 kg/m³ and g = 10 N/kg. (a) Write the formula. (b) Substitute the values. (c) Find the pressure due to the water.	(a) p = ρgh. (b) 1000 × 10 × 5. (c) 50 000 Pa.
5. A box of weight 600 N stands on a base of area 0.25 m² and then on a base of area 0.5 m². (a) Find the pressure on the smaller base. (b) Find the pressure on the larger base. (c) Say which is larger and why.	(a) 600 ÷ 0.25 = 2400 Pa. (b) 600 ÷ 0.5 = 1200 Pa. (c) 2400 Pa, because the same force acts on a smaller area.

Answers to the learners' check-yourself questions

1. Write down the formula for mechanical advantage.
   MA = load / effort.
2. What is the unit of pressure, and what does it equal?
   The pascal (Pa), which equals one newton on each square metre (N/m²).
3. Why can no real machine have an efficiency of 100%?
   Some of the work put in is lost, for example to friction, so the useful work out is always less.
4. A machine has MA = 4 and VR = 5. Find its efficiency.
   (4 / 5) × 100% = 80%.
5. Find the pressure when a force of 200 N acts on an area of 0.1 m².
   p = 200 / 0.1 = 2000 Pa.
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.
   (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 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.
   (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 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.
   (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.

Teacher's reflection

What went well:

What I will change next time:

Learners who need follow-up: