Gears and Levers

Learning Aims	
Knowledge	**Skills**
• How levers work • How gears work • How teeth count affects gear wheel movement • The principle of force magnifiers and distance magnifiers • Understand Torque	• Develop a simple mathematical rule • Ratio and proportionality • Applications of gears and levers • Explain engineering concepts using descriptions and mathematics

Teaching classroom PowerPoint	
0-15 minutes	Slides 3 to 8. Introduction to Levers. While working through the slides ask student for other examples of levers and which class they fall under.
15-20 minutes	Slide 9. Mechanical Advantage (a Force multiplier): the output force is greater than the input force. Velocity ratio (Distance multiplier): To achieve Mechanical Advantage the distance moved by the input Force is greater than the distance moved by the output.
	Equilibrium, when a lever (or beam) is balanced. How to calculate the Force required to balance a lever with a given load and pivot point (fulcrum). Slide 10 has three examples of Class 1 levers. In the first two examples students should calculate the Force required to achieve equilibrium. And can also calculate the Mechanical Advantage using the equation show on Slide 9. In the third example students will need to rearrange the formula to calculate the load required to achieve equilibrium for the identified input Force. Slide 11 shows the answers Slide 12 is optional. This example shows a class 2 lever.
20-35 minutes	Slide 13: Gears Slides 14 and 15 provide some common terminology and types of gears. Slide 16. Introducing gear ratios and how it's calculated.
35-40 minutes	Slide 17 is animated and explanatory text is revealed at different times over a period of about 1minute. Click the slide once to start the animation.
40-45 minutes	Slide 18: Two examples for students to work through in class. Refer to the Notes section f the slide.
45-50 minutes	Slide 19: Torque, an introduction to Torque. Slide 20: explains Torque and Force with respect to opening a door. Slide 21: How to calculate Torque.
50-60minutes May roll-over into next lesson.	Slide 22: Classroom Task. Students working in small teams can select one of the tasks. Please see the Student Guide document for detailed explanation of each task. There's also suggested homework.

Gears and Levers

Achieving equilibrium (balanced loading on a lever or beam)
Slide 10 and 11 with optional slide 12. In the Student Guide there's a simple classroom experiment using a rulers and small laboratory weights. Students can experiment with different combinations of weights at different distances from the fulcrum to achieve equilibrium.

Simplifying:
The "**Levers as Distance Magnifiers**" activity is the simplest of the 4 choices outline on Slide 22. This task will typically rollover into a following class unless good progress is made with the previous slides.

Extending:
For students who want a more challenging activity the "**Force Magnifiers**" activity has the more challenging mathematics.

Students also teach each other – requiring them to express their understanding of these concepts which can be challenging for some.

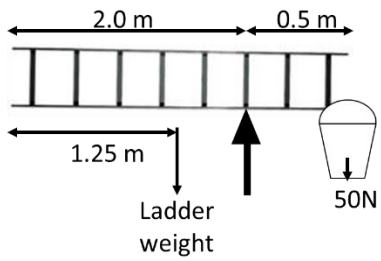
Using fibre board and pins allows pivots to be moved and multiple ratios explored. Note the marks on some wheels to allow counts of rotation.

Gears and Levers

Solutions

Levers as Force Multipliers

Left side (anticlockwise turning force)			Right side (clockwise turning force)			Balanced?
Force (N)	Distance (cm)	Torque (Nm)	Force (N)	Distance (cm)	Torque (Nm)	
50	10	**5**	5	100	**5**	**Yes**
30	15	**4.5**	9	40	**3.6**	**No**
4	25	**1**	10	10	**1**	Yes
5 and 5	20 and 40	**1 + 2 = 3**	20	30	**6**	**No**



Assume that the centre of weight of the ladder is at 1.25 metres from each end (midpoint); the ladder weight acts at 0.75m from the pivot.

Clockwise: 0.5 x 50 = 25Nm

Anticlockwise: 0.75 x 200 = 150Nm

In order to balance, the clockwise moment must equal 150Nm which will be achieved by adding 250N of water to the bucket making a total of (0.5 x 300) = 150Nm.

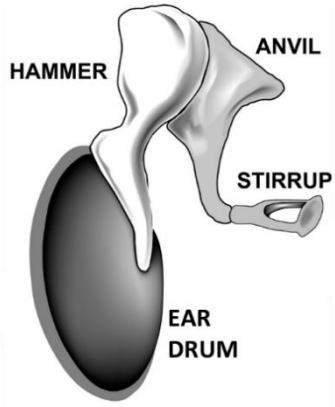
Gears and Levers

Solutions

Levers as Distance Multipliers

	Distance from pivot	Distance from pivot	Distance moved
Fishing Rod	20 cm away, and moves 15cm	Tip is 3 metres away	**2.25m**
Fore arm	Muscle is attached 5cm from elbow joint, and can move by 8cm	Fingertips are 40cm from elbow	**64cm**

Challenge



Biomechanics: Inside your ear there are a 3 bones which act as levers. They take the small vibrations of your eardrum easier to detect.

This is quite a simplification, but using the figures below, what would the final movement of the stirrup be?

	Input movement	Input length	Output length	Output movement
Hammer	0.01mm	1mm	3mm	**0.03mm**
The output of the hammer moves the anvil				
Anvil	**0.03mm**	0.5mm	4mm	**0.24mm**
The output of the anvil moves the stirrup				
Stirrup	**0.24mm**	1mm	1.5mm	**0.36mm**

Gears and Levers

Solutions

Gears as Distance Multipliers

Number of teeth on the left wheel	**8**
Number of teeth on the centre wheel	**24**
If the left wheel turns 30 times, how many times will the centre wheel turn?	**20**
How many teeth on the right wheel?	**16**
For each turn of the centre wheel, how many turns does the right wheel make?	**1 1/3 or 1.333**
If the left wheel goes clockwise, which way do each of the other wheels go?	**centre = anticlockwise, right = clockwise**

Challenge

Driven gear wheel turns (3 x 75) = 225 revolutions per minute.

Rear wheel circumference = 2.51 metres

225 rpm x 2.51 = 565 metres

565 x 60 = 33900 metres = 33.9 kilometres per hour

Solutions

Gears as Force Multipliers

Driving wheel			Driven wheel		
Teeth count	Radius (mm)	Turning force (Nm)	Teeth count	Radius (mm)	Turning force (Nm)
15	100	1.5	30	**200**	**3**
24	**50**	6	**72**	150	18
6	30	**10**	60	300	100
18	60	100	72	**240**	**400**

Gears and Levers

Equipment	Suggested supplier
Gear Wheels	Technology Supplies assortment of 100 wheels
Slotted masses (10g)	Timstar (www.timestar.com)
Gear wheel platforms	Locally sourced
30 to 100cm wooden rulers drilled every 5cm	Locally sourced
Triangle pivot blocks	Locally sourced

Safety:

Hazard	Likelihood	Injury	Action Recommended
Masses dropping	Likely	Impact on foot	Use small masses of under 100g
Sharp pins	Likely	Puncture	Brief students on hazard. Restrict distribution of pins if students untrustworthy.