

# ANALYSING MECHANISMS

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You can find out about a mechanical system by looking at it. However, you can get more detailed information by taking measurements. This will help you find the mathematical relationships between output and input.

A mechanism is a device for producing a particular output movement from a given input movement:



We can analyse mechanical systems by asking three questions:

## 1. WHAT IS THE MECHANICAL SYSTEM?

How is the input converted into the output needed (e.g. by the use of gears, pulleys, belts, gears, etc.)?

## 2. WHAT IS THE ENERGY TRANSFER?

- What is the energy input?
- What is the energy output?
- How much friction is there?
- Is friction an advantage or disadvantage?
- How efficient is the energy transfer?

## 3. HOW ARE THE INPUT AND OUTPUT RELATED MATHEMATICALLY?

Calculating transmission ratios is a useful way of presenting the information you collect about mechanical systems. It allows you to make comparisons between different mechanical systems.

The transmission ratio is found using this equation:

$$\text{Transmission ratio} = \frac{\text{Output}}{\text{Input}}$$

The inputs and outputs in the mechanical system might be distance, angle, revolutions per minute or force, but they must be in the same units (e.g. both in cm).

For example, if we apply a force of 56 newtons to the handle of a car jack to lift a car weighing 8400 newtons (that is a mass of 856 kg), the transmission ratio is:

$$\frac{8400}{56} = 150$$

When we are measuring forces, we call this ratio the mechanical advantage.

If, in a gear system, the output rotates at 600 revolutions per minute while the input rotates at 60 revolutions per minute, the transmission ratio is:

$$\frac{600}{60} = 10$$

ANALYSING AN EXAMPLE MECHANISM

**Examples of equipment needed**

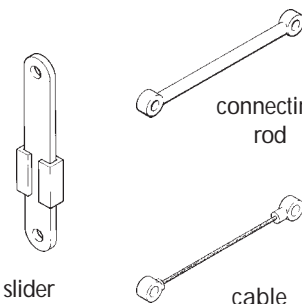
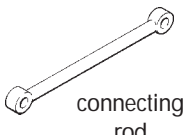
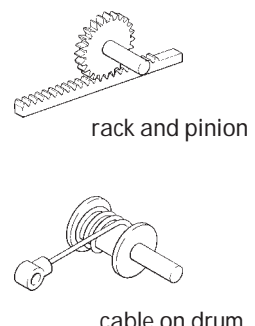
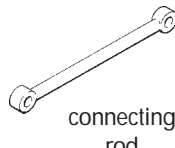
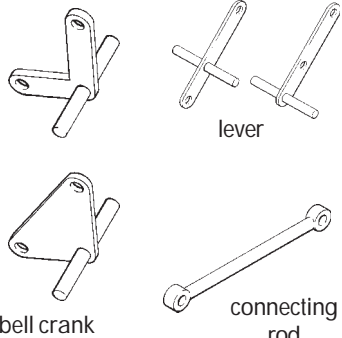
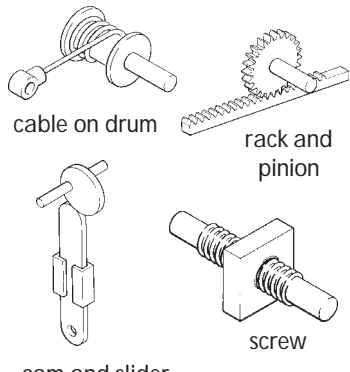
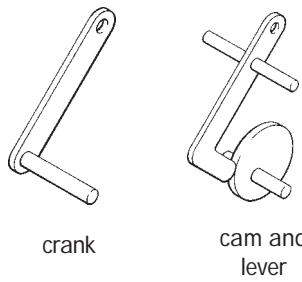
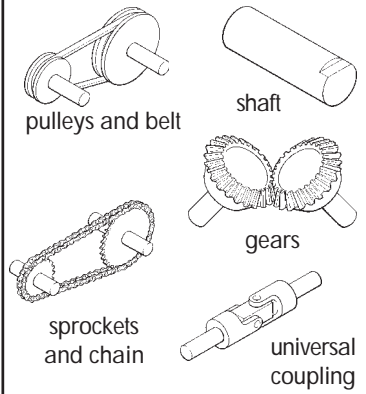
Kitchen whisk, potato chipper, mechanical saw, hand drill, hole punch, pantograph, model gearbox, scissors, pliers, pedal bin, car jack, G clamp.

A range of measuring devices are also needed to measure distance, speed of rotation and force.

**What to do**

Examine the mechanism your teacher has given you.

- Write a full list of all the ways in which your mechanism changes the motion between the input and the output. Use the chart to help you do this.

		TO		
		LINEAR	ARC	ROTARY
FROM	LINEAR	 <p>slider</p> <p>cable</p> <p>connecting rod</p>	 <p>connecting rod</p>	 <p>rack and pinion</p> <p>cable on drum</p>
	ARC	 <p>connecting rod</p>	 <p>bell crank</p> <p>lever</p> <p>connecting rod</p>	
	ROTARY	 <p>cable on drum</p> <p>rack and pinion</p> <p>cam and slider</p> <p>screw</p>	 <p>crank</p> <p>cam and lever</p>	 <p>pulleys and belt</p> <p>shaft</p> <p>gears</p> <p>sprockets and chain</p> <p>universal coupling</p>

- Write down your answers to the following questions on energy transfer:
  - What is the energy input?
  - What is the energy output?
  - How much friction is there?
  - Is friction an advantage or disadvantage?
  - How efficient is the energy transfer?

- Compare input and output motion.

Decide which of the following is the best quantity to measure:

- Speed of rotation.
- Distance that it moves.
- Number of turns.

Decide how you will make these measurements and the equipment you will need to take the measurements.

Decide how many measurements you will need to take.

RECORDING

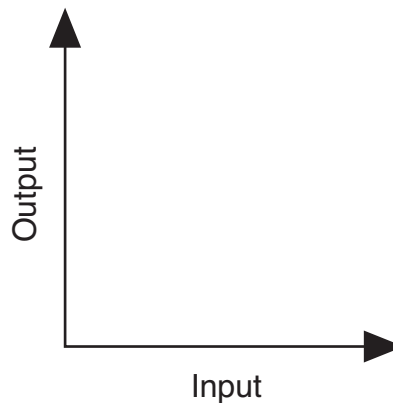
Make a copy of this table for your results but replace input/output measurements by the quantities you are measuring:

Input Measurements	Output Measurements	Transmission = $\frac{\text{output}}{\text{input}}$ Ratio

PROCESSING

You can now work out your mechanism's transmission ratio using the equation given in the table above for each pair of input and output values.

To get a better understanding of how the input and output measurements are related, you can plot a graph using the axes shown below:



As you plot your graph, use the 'Graph Quality Checklist' on the next page to help you build your graph properly.

**GRAPH QUALITY CHECKLIST**

The following provides a quality checklist for your graph:

**Horizontal axis:**

1. Is the axis labelled? (e.g. time)
2. Are the units correct? (e.g. seconds, mins)

**Horizontal scale:**

3. Is the scale uniform? (e.g. 2 mins per cm)
4. Is the available space used sensibly?
5. Is the scale easy to read? (e.g. 1:2, 1:5 or 1:10, not 1:3.)

**Vertical axis:**

6. Is it labelled?
7. Are the units correct?

**Vertical scale:**

8. Is the scale uniform? (e.g. 5 degrees per cm)
9. Is the available space used sensibly?
10. Is the scale easy to read? (e.g. 1:2, 1:5 or 1:10, not 1:3.)
11. Is the title of graph clear and correct?
12. Are the points correctly plotted? Are they in the correct place?

**ANALYSING**

Is the ratio the same all the time or does it vary? (If your graph is not a straight line, the ratio is not constant.)

If the ratio varies, find its largest and smallest values.

Describe in words the way the output measurement is related to the input measurement. (The shape of the graph should help you.)

**WHAT TO DO**

- Now repeat the measurements but this time measure the input and output force.
- Record the results using a table.
- Calculate the transmission ratio for each pair of input and output forces.
- Plot a graph of output force against input force (remember to use the 'Graph Quality Checklist').

**ANALYSING**

- Compare the transmission ratios for movement and for force.
- Write down any similarities and differences between them.
- Can you see any link between them?