

# INVESTIGATING THE FOUR-BAR LINKAGE

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The purpose of this unit is to help you:

- Understand better the four-bar linkage, how it works and what it does.
- Design a particular linkage you might use in your project work.

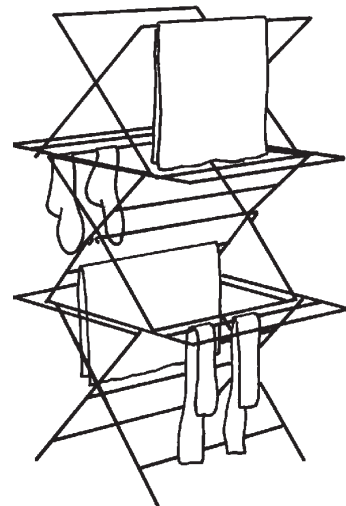
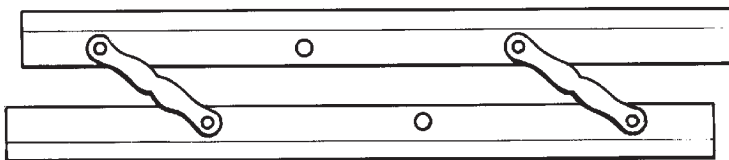
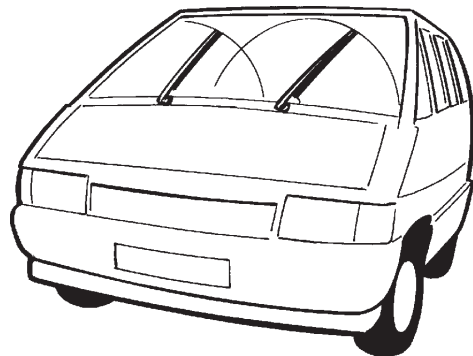
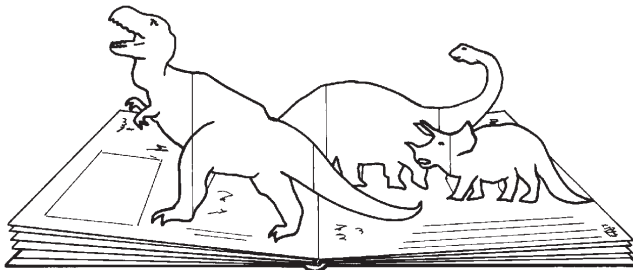
A four-bar linkage has **four** connected parts (bars).

A four-bar linkage can be used to convert motion from

- One type to another.
- One speed to another.
- One size to another.
- One axis to another.

It often happens that more than one conversion happens at the same time i.e. the speed and size of a motion change together - usually by design.

In each of these mechanisms, there is a four-bar linkage:

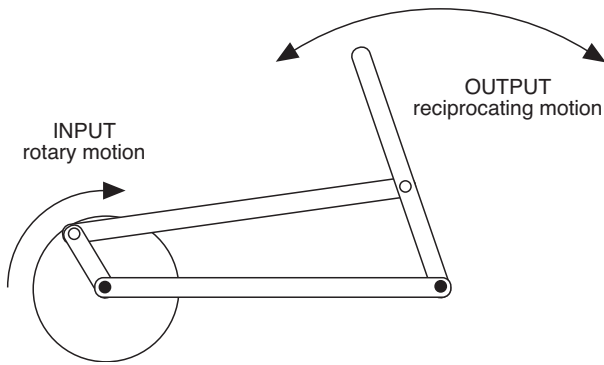


- Identify the four bars in each of these mechanisms.
- Think of some more examples of four-bar linkages. Include some where the four-bar linkage is a parallelogram.

CONVERTING MOVEMENTS

Engines and many other mechanical devices have different types of movement. Pistons go up and down (reciprocate) while helicopter blades go round in a circle (rotate). Some movements are fast, others slow. Also the size of a movement (its amplitude) can be large or small.

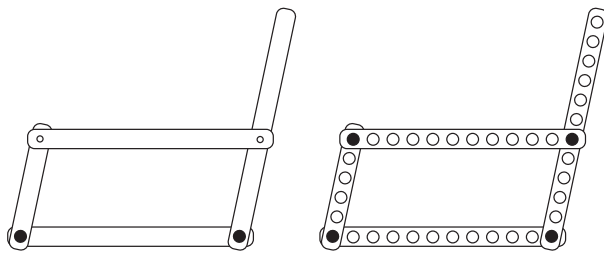
A four-bar linkage can change the type, speed or size of a movement or motion. It can also change vertical movement to horizontal movement. Take the example of the windscreen wiper mechanism shown below.



Here, a four-bar linkage converts the rotary motion of an electric motor into the reciprocating motion of the wiper blade.

INVESTIGATING FOUR BAR LINKAGES WITH MOVING MODELS

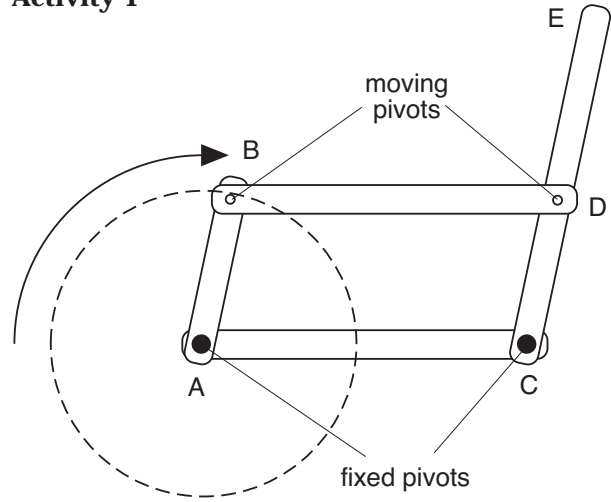
Make up a four-bar linkage as shown using strips of card. The moving pivots can be paper fasteners. The fixed pivots can be drawing pins. (Drilled strips and fastenings can be used instead.)



Card strips joined using paper fasteners and drawing pins

Plastic strips joined using plugs

Activity 1



1. Rotate the arm AB of the linkage and observe the motion of the arm CE. If the motion of AB is the input and the motion of CD is the output, describe the motions of AB and CD and put your results in a table:

	<i>Input (AB)</i>	<i>Output (CD)</i>
<i>Type of motion</i>		
<i>Axis of rotation</i>		

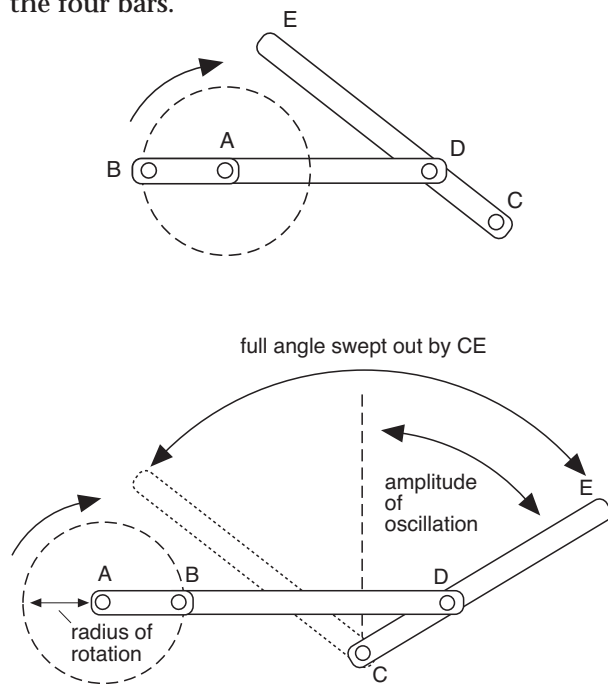
2. Reposition the arm BD to make it longer and complete another table. Try again and complete a new table each time you find something new. What if ABCD is a parallelogram?
3. In each of the pictures of four-bar linkages on the previous page, describe the changes in motion taking place.

TRANSMISSION RATIO

$$\text{Transmission ratio} = \frac{\text{output}}{\text{input}}$$

For the examples given, there is one oscillation or rotation of the output for each input oscillation or rotation. The transmission ratio is therefore 1:1. If you need to change the ratio of turning, you may have to add some gears, for example, to the drive shaft.

The important point, however, is the amplitude (size) of the oscillation or the radius of the rotation. These are determined by the lengths of the four bars.



The amplitude (i.e. half the angle swept by the line CE) is an angle.

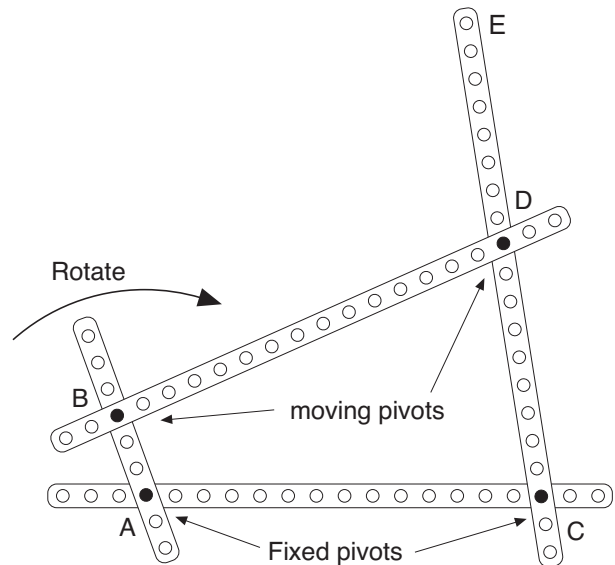
If the input and output are oscillations, their amplitudes may not be the same. But the ratio of the amplitudes is not regarded as a transmission ratio.

Using your model, find the amplitude of an oscillation output like the one shown in the diagram.

Activity 2

This practical investigation describes the motion of the wiper as the drive arm rotates and how the design (i.e. the lengths of the other links) affects it.

1. Set up the linkage shown in the diagram. Rotate AB steadily and observe the motion of the wiper CE.

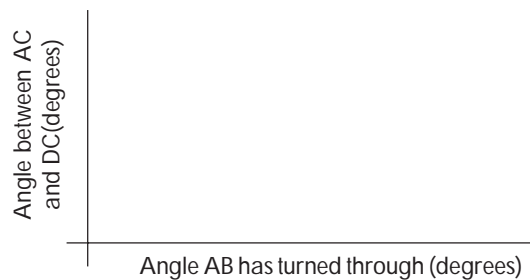


Check that:

- AB is at opposite ends of a diameter when the wiper is at the 'ends' of its oscillation.
- The wiper does one oscillation for each rotation of AB.

2. Make a sketch showing the motion of the wiper as AB turns through one revolution.

- Using graph paper, draw a graph for the motion of the wiper. The axes represent the angle the wiper has turned through (in degrees) and the rotation of AB (in degrees) from its original position.



3. Record the amplitude of the wiper arm. Think about how you could modify the linkage to increase this amplitude.
- Describe what will happen to the motion of the wiper as you increase the length of the connecting arm BD.
  - Try reconnecting the arm AB to a new position and see what happens. Make rough sketches of the wiper's movement and amplitude each time.
  - Draw a new graph. You could add this to the last one.
4. Investigate the effect of other modifications in the linkage on the amplitude of the wiper blade.
- Write a brief conclusion to your research: 'The effect of increasing the length of the connecting arm while keeping the same radius is...'