Lesson 5: The Stationary Exercise Bicycle

How to transfer motion and forces using a chain and sprocket mechanism

Time: 1 - 1.5 hours

Learning Objectives - Children should learn:

- to investigate and disassemble products in order to learn how they work
- how to transfer motion and forces using a chain and sprocket mechanism
- to communicate information about products and mechanisms through labelled drawings

Possible Teaching and Learning Activities

Introduction

Whole Class

- Review with the children the ways in which gears are connected and how motion and forces are transmitted through a gear system.
- Talk about the differences they have identified between spur gears and crown gears. The spur gear system changed the output speed or amplified the output force. The crown gear system changed the direction of motion through 90-degrees. In both cases, however, the gears meshed or touched each other.
- Explain that in this lesson they will explore another type of gear system, one in which the gears do not touch each other. This gear arrangement is the system that is used in bicycles. Explain that they will examine how it operates in a **stationary exercise bicycle**.
- Talk about how people need to exercise to keep fit and healthy.
  - What sort of activities do the children take part in to keep themselves fit?
- Many people use fitness clubs with specially designed machines.
  - Ask the children to identify different types of exercise machines.
  - What parts of the body are the exercise machines designed to exercise?
  - How do they meet this need?
- Cycling is a healthy and very popular activity, but until the development of the stationary exercise bicycle it was not possible to do it indoors.
- Discuss how the stationary exercise bike design is based on a 2-wheeled bicycle.

Vocabulary

axle, handle, crank, gears, sprocket, chain, chain drive, rim, opposite, clockwise, anticlockwise, faster, slower, rotary, movement, motion, mechanism, input, output, driver, follower, gear ratio, gearing up, gearing down, speed, modify

Resources

Each group of 2-3 children will need:

- *1 K'NEX Understanding Mechanisms: Gears Kit with Building Instructions booklet*
- *Dot stickers or pieces of masking tape*
- *Felt-tipped pens*

You will need

- *Stationary exercise bicycle (or the K'NEX model) and/or a bicycle*

Useful Internet Web Sites:

Please refer to ***A Quick Guide to Gears****, Page 13.*

- If possible, provide an example of an exercise bike (you could use the K'NEX model) or a bicycle for the children to investigate. Alternatively, ask the children to look at the photograph on Page 12 of the Building Instructions booklet to interpret how they think the mechanism works.

- Children may be encouraged to think about and discuss what they are doing through facilitating questions such as:
  - What does the machine do?
  - How well does it do the job it is designed to do?
  - What are the functions of the moving parts?
  - How are the moving parts connected? How do they make other parts move?
  - What are the moving parts called?
  - What stops the bike from falling over?
  - Where does the power come from to drive the bicycle?
  - How is the power transferred to the drive wheel?
  - When riding a bicycle, in which gear is it hardest to push the pedals round?

- As they describe its workings, encourage the children to use terms they already know that are associated with a bicycle's gear system.

Teacher's Notes
Write the questions you want the children to investigate on the board for reference and post activity discussions.

Foot power, via the pedals

By a chain and sprocket mechanism.

The highest gear.

Working in Groups of 2-3

- Ask each group to build and investigate their K'NEX Stationary Bike model (Pages 12-13 of the Building Instructions booklet) and provide time for them to investigate their model.

Whole Class

- Using a stationary bike model/bicycle, demonstrate and explain the **input and output movements, pedal, sprocket, chain drive mechanism, links, driver, follower/driven gear, and axle.**

As part of the demonstration and discussion you may find it useful to add new terms to the class word wall to help the children as they create labels, discuss their investigations, make labelled drawings and write descriptions. Words could be written on cards, possibly with simple descriptors on the reverse side.

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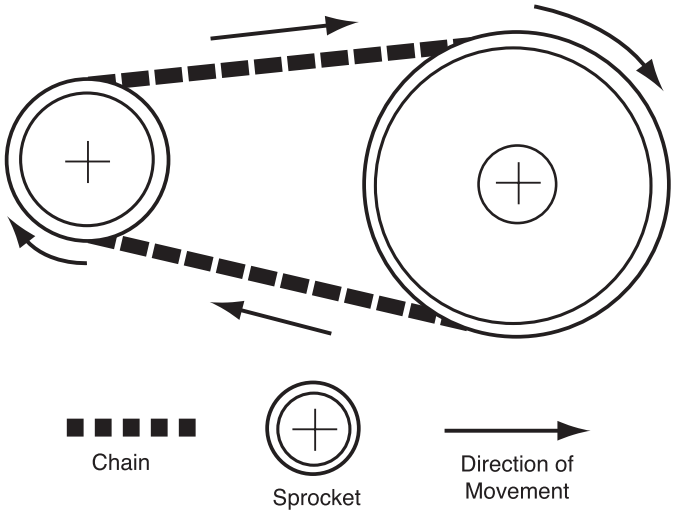
- With the model as an example, demonstrate on the board how to make simple labelled drawings, using arrows to show the direction of movement. The diagram below, for example, could be used as a symbolic representation of a chain and sprocket drive system.



The chain and sprocket drive system uses a chain to transmit rotary motion from a driver axle to a follower or driven axle. Sprockets are toothed wheels on which a chain runs. The sprockets are placed a certain distance apart and the chain links mesh with the teeth on the sprocket so that turning the driver sprocket moves the chain and thus turns the driven or follower sprocket.

Spur gears must mesh to transmit movement but with a chain drive mechanism the distance between sprockets can be adjusted by shortening or lengthening the chain.

*See **A Quick Guide to Gears** for additional information.*

- Encourage the children to record their observations through the use of labelled drawings and notes. They should employ the correct vocabulary and terminology to show how the chain and sprocket drive mechanism works. They should use arrows to show the direction of movement and indicate the speeds of movement of each sprocket.

To help the children see the directions of movement of each moving part they might place a dot sticker or piece of masking tape on each sprocket and one on the chain.

- Children should:
  - Describe the parts that move and their function.
  - Show how the gears are connected to transfer the drive force from the pedals to the rear wheel.
  - Identify and name the input and output movements.
  - Identify the direction of rotation of the pedals and rear wheels. Use the terms clockwise/anticlockwise.

The teeth on the sprockets mesh with the chain links and push it along when they turn. The chain connects the two sprockets.

- Ask the children to respond to the following questions using the word, “because…”

  * **Do the pedals rotate at the same speed as the rear wheel?**

    * **Yes, because the sprockets are the same size.**

  * **Do the pedals and rear wheel turn in the same direction?**

    * **Yes.**

*** Will the mechanism be easier or more difficult to turn without the pedals?**

*** More difficult because a pedal functions just like a crank handle in a winding mechanism. It helps to amplify turning forces.**

Whole Class

- Discuss how the pedals on a bicycle are similar to the handle (crank) in a winding mechanism and in the other K'NEX models they have made, such as the crank fan, blender and record player.
  - Would longer pedal cranks be easier to turn?
  - Would it be a good idea to have longer pedals on a bicycle? If not…why not?
- Talk about the differences and similarities between sprocket and chain drive mechanisms and simple gear trains.
- Ask the children if they can think of one reason why a bicycle uses a chain and sprocket system and not a spur gear system.

Teacher's Notes

Bicycle pedals are another example of a crank, identical in practice to the handle operating the K'NEX Crank Fan model. Cranks work as if they are rotating levers. Remember that long levers allow you to create large turning forces.

You may find it useful to have a K'NEX Crank Fan model available to compare with the children's K'NEX Stationary Bike models. Both models use the same sized driver and follower gears. In both cases the number of input turns by the pedal crank will equal the number of output turns produced by the wheel. In other words the gear ratio in both drive systems is 1 to1.

The main differences are:
(a) The direction of rotation. In the stationary bike's chain and sprocket mechanism, both driver and follower rotate in the same direction, whereas in the K'NEX crank fan model – a simple gear train using spur gears – the gears rotate in opposite directions. If a spur gear system were used on a bicycle you would need to pedal backward in order to move forward.

(b) In the chain and sprocket mechanism the rotary motion is transmitted over a longer distance, determined by the length of the chain, whereas spur gears must mesh.

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- Ask for volunteers, taking turns, to summarize the way in which motion is transferred through the stationary bike system. The first volunteer should start the description at the pedals and the last volunteer describes what happens at the rear wheel.

Teacher's Notes
Turning the pedals transfers motion and energy through the driver axle to the sprocket at the front of the bike (driver sprocket). As the front sprocket turns, motion is transferred to the chain. The chain transfers motion and energy to the rear sprocket (follower sprocket). The turning of the follower sprocket turns the rear wheel.

- Discuss how they might modify their stationary bike's drive mechanism to make it harder to push the pedals. This would make the person exercising on the bike work harder. They should be prepared to explain the reasons for their proposed modifications.
- Refer the children to:
  - The photograph on Page 12. Do the sizes of the wheel casings give them a clue?
  - The outcomes of their investigations using the K'NEX Crank Fan model.

(i) One possible way is to make the driver sprocket larger. This will cause the back wheel to turn much faster but it will need more effort to turn the pedals – just like using a high gear on a bicycle.

(ii) A second way might be to make the pedal cranks shorter. Because a crank acts like a rotating lever, a short lever will not be able to amplify forces as much as a long lever. More effort, therefore, will be needed to turn the pedals.

Extension Activity 1
If time is available, ask the children to modify their bike models to meet the new specification.

There are not enough K'NEX components in one kit to do this activity. Two groups of children will have to work together.

At the end of the lesson ensure that the parts are returned to the kits from which they were taken and that the children check the contents of each kit.

Plenary Session
Ask the children to explain the movements and the function of the mechanism they have investigated.

What would they do to improve the stationary exercise bike design?