The Stationary Bike:

An example of a chain and sprocket system.

OBJECTIVES

Students will:

1. Build and investigate the mechanism of a model system that represents a real-life object.
2. Observe how motion and force are transmitted through a distance using a chain and sprocket system.

MATERIALS

Each student group will need:

- 1 K'NEX Intro To Simple Machines: Gears set with Building Instructions booklet
- Student Journals

You will need:

- A bicycle (optional)

PROCEDURE

Introduction

- Review with the students how gears are connected and how energy/motion is transferred through a spur gear system.

In a spur gear system, the gears are meshed and in line. Force and motion are transferred from one gear to another along this line. If your students are familiar with the term "plane" you can explain that the force and energy are transferred along the same plane.

- Remind students that a spur gear system makes work easier by changing the output speed or multiplying the output force. Remind students that they cannot use a machine to gain both speed and force. There is always a trade-off when you use a simple machine. They can gain speed at the expense of force or multiply force at the expense of speed. Ask the students to tell you what is gained, if anything, when a gear system uses gears of the same size in a gear train.

Students should remember that when gears are the same size, neither speed nor force is gained. Your gain is that you may be able to change the direction of motion.

- Explain that a spur gear system is just one type of gear arrangement. Tell the students that they will explore another type of gear system, one in which the gears DO NOT touch. The system they will investigate is one that is used in a stationary bicycle.

- Discuss how the stationary bicycle's design is based on a 2-wheel bicycle. If possible provide an example of a bicycle for the students to investigate. Alternatively, ask the students to look at Pages 12 and 13 of the Building Instructions booklet to interpret how they think the mechanism works.
- Ask them questions about how the bicycle works and encourage them to use terms they already know that are associated with a bicycle's gear system:

Where does the power come from to drive the bicycle?	*Foot power, via the pedals.*
Which parts move and what are their functions?	*Various answers.*
How is the power transferred to the rear wheel?	*Chain.*
How is the gear arrangement in this mechanism different from the spur gear system they have studied? Responses to this question will give you the opportunity to discuss the chain and sprocket drive system.	*The chain and sprocket drive system uses a chain to transmit rotary power from a driver axle to a driven axle. Sprockets are toothed wheels on which a chain runs. They are placed a certain distance apart but the chain links mesh with the teeth on the sprocket so that turning one gear moves the chain and thus turns the second gear.*

- Divide the class into groups made up of 2 to 3 students.

Building Activity

- Distribute a K'NEX Gears set to each group.

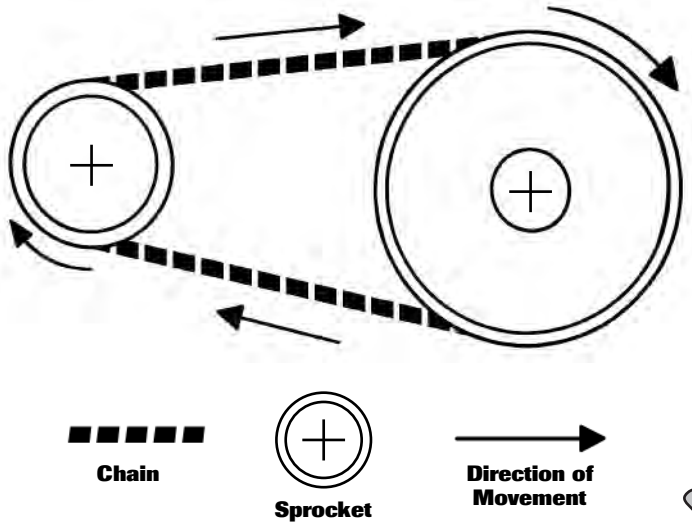
Ask the students to turn to Pages 12 and 13 of the Building Instructions booklet and construct the model of the **STATIONARY BIKE.** To save time, we suggest that one student completes Steps 1-6 at the same time as another group member completes Steps 7-11.

Inquiry Activity: How is motion and force transferred using a chain and sprocket system?

Steps

1. (a) Following completion of the construction phase, allow students time to explore their models. Encourage the students to identify the parts of their model bicycle.

   (b) Using the model as an example, demonstrate on the chalkboard how to make simple labeled diagrams using arrows to show the direction of movement. See example to the right:



(c) Ask the students to sketch a diagram of their bicycles. Encourage them to give names to the various parts of their model. You can then decide whether or not to formalize these. The following terms may be helpful:

Sprocket, chain, pedal, drive mechanism, links, driver gear, driven gear, driver axle, driven axle.

(d) Have the students draw arrows on their diagrams to show the direction each part moves as the pedals are turned.

(e) Ask the students to compare the direction of motion of the axle on the driver gear with the direction of motion of the axle on the driven gear.

Both axles turn in the same direction.

(f) Students should record all their observations.

2. Encourage the students to continue exploring the chain and sprocket mechanism as they answer the questions below. Ask the students to record their responses.

(a) Where is the effort force applied? What type of motion is the input motion?

The effort force is applied to the pedals. The input motion is a rotational or circular motion.

(b) Where does the output motion take place? What type of motion is it?

The output motion happens at the back wheel. The output motion is also a rotational or circular motion.

(c) What is the function of the chain in this system?

The chain transfers energy/motion from the gear at the pedals to the gear at the rear wheel.

(d) Describe the transfer of energy/motion through your stationary bike system. Start at the pedals and end at the rear wheel.

Turning the pedals transfers motion and its energy along the driver axle to the sprocket at the front of the bike (driver gear). As the front sprocket turns, motion is transferred to the chain. The chain transfers that motion and its energy to the rear sprocket (driven gear). The turning of the driven gear turns the rear wheel.

Applying The Idea

NOTE: It may be helpful to have a model of the crank fan available for comparison at this point in the lesson.

Ask the students to write one reason why bicycles use a chain and sprocket system rather than a spur gear system. Remind them to use their crank fan notes if they need a little refresher on spur gears.

Answers will vary. Possible answer: In a spur gear system, the driven gear turns in the opposite direction to the driver gear. To go forward, you would have to pedal backwards.

- When the students are finished, ask individual students to share their ideas with the class. Record student responses on the board.
- Review the list. Ask the students to think about other machines that transfer motion over a distance. Tell the students that chains are not the only way to transfer motion over a distance. Encourage them to brainstorm a list of other machines that use a sprocket system to transfer motion. They will need help with this and it may be a good idea to have pictures of some of the machines listed below. You can then ask the students to work out where the chain and sprocket system is found in them. Examples you could use:
  - The checkout counter at the grocery store - a checkout uses a conveyor system.
  - A roller coaster at an amusement park - a chain is used to pull the roller coaster up the first big hill.
  - An escalator in a department store.

Extending The Idea

[Grade: 5]

1. Remind students that the term **gear ratio** refers to the number times the driven gear turns relative to the number of times the driver gear turns. Ask the students to estimate the gear ratio of their stationary bike models.

Students should be able to conclude that the gear ratio is 1:1 based on the identical nature of the gears used.

[Grade: 5]

2. Ask students to explain why ten-speed and mountain bikes use several different sized gears.

Possible answers: *Different combinations of gears provide different gear ratios. Most will probably suggest that they use different sized gears going up hills compared to riding on flat streets.*

JOURNAL CHECK:

The following should be recorded:

- ✔ Identification of the gear mechanism.
- ✔ Diagram of the stationary bicycle, including labels and arrows.
- ✔ Record of student observations as indicated by responses to questions in Step 2.
- ✔ Identification of relative motions of moving components.
- ✔ Description of the transfer of energy/motion through the bicycle system.