Subject Area(s): Physical Science

Associated Unit

Associated Lesson

Activity Title: The Claw

Header

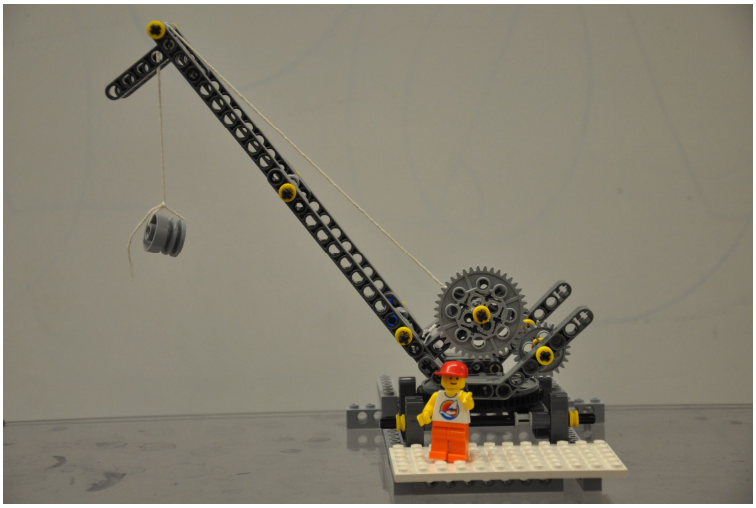

Image 1
ADA Description: Lego Crane
Caption: Lego Crane

Activity Dependency

Time Required: 45

Group Size: Class divided into three groups

Expendable Cost per Group US$ 5

Summary:
In this lesson, students will lift multiple objects using a crane incorporating different gear ratios. A fun spin on the project could be basing it off the popular movie trilogy Toy Story (hence, the name of the lesson). Students will be engaged in learning how to operate a toy mechanical crane, while learning about the concept of gear ratios and power. They will be able to experiment picking up objects of different weights to witness how much power they must apply to the system in order to combat the force of gravity.

Engineering Connection:
Gears are incorporated into almost all mechanical machines. From cars to cranes, gears provide different ratios and ways to increase or decrease torque depending on the task at hand. Engineers have the duty of deciphering what torque is needed for a situation and the corresponding gear ratio for a fixed power.

Engineering Category:
(#3) provides engineering analysis or partial design

Keywords: Gear Ratio, Power, Simple Machines, Torque

Educational Standards:
State science:
PS 5.1f Demonstrate how mechanical energy may cause change in motion through the application of force or the use of simple machines such as:

- Levers, pulleys, inclined planes
- Wheel and axle

State math:

3.M.2 Use a ruler/yardstick to measure to the nearest standard unit (whole and ½ inches, whole feet, and whole yards)

3.N.22 Demonstrate fluency and apply single-digit division facts

3.N.23 Use tables, patterns, halving, and manipulatives to provide meaning for division

3.R.8 Use mathematics to show and understand physical phenomena (e.g., estimate and represent the number of apples in a tree)
3.R.1 Use verbal and written language, physical models, drawing charts, graphs, tables, symbols, and equations as representations
3.CN.6 Recognize the presence of mathematics in their daily lives
3.CN.1 Recognize, understand, and make connections in their everyday experiences to mathematical ideas

Pre-Requisite Knowledge:
Students should be familiar with the mathematical operation of division. They should also know how to use measuring tools such as rulers. They also should be familiar with the concepts of speed and energy.

Learning Objectives:
After this activity, students should be able to:

- Measure gear diameters
- Compute gear ratios used in a simple machine
- Understand characteristics of different gear ratios (ex. Speed, Torque)

Materials List:
Each group needs:

-

To share with the entire class:

- Three pre-made cranes with differing gear ratios (Lego)

- Three objects that differ in weight for each crane
- String and hooks in order to pick up the objects.

Introduction / Motivation:

Who here has been to a Chucky Cheese or a fair? Anyone who has been to an arcade, carnival, or Chucky Cheese knows about the crane game. That game at the front and center contains the dreams of little children, whether it is unthinkable loads of candy or that next stuffed animal to keep them safe. Who has seen "Toy Story?" For those of you who are fans of "Toy Story," "The Claw," is quite the mystical device to the Pizza Planet Aliens, but does anyone know how it works? The crane that picks up candy and other objects uses pulleys and gears (draw a diagram of two gears showing one making the other rotate).These simple machines enable an operator to use different amounts of power, depending on the rigging, to pick up an object. You can imagine power as being the amount of energy you put in to crank the gears over a certain amount of time. If we hook a string up to the spool that is turning, we can make a small crane ourselves that can pick up objects like those in "Toy Story," or an arcade. When we use the crane, we will be able to tell how different setups of gears lift objects differently. Furthermore, we can calculate the gear ratio, which is the ratio of diameters of the gears, and see what ratios work best for a specific task, like which setup gives us the fastest raise or easiest time cranking the gears.

Vocabulary / Definitions

Word	Definition
Speed	Relative rapidity in moving, going, etc.; rate of motion or progress
Power	Work done or energy transferred per unit of time; the time rate of doing work.
Gear Ratio	The ratio of the diameters of the pitch surfaces of any two meshing gears or of the numbers of their teeth.
Diameter	A straight line passing through the center of a circle or sphere and meeting the circumference or surface at each end.
Crane	A machine for hoisting and moving heavy objects by means of cables attached to a movable boom.
Torque	Something that produces or tends to produce torsion or rotation; the moment of a force or system of forces tending to cause rotation; the measured ability of a rotating element, as of a gear or shaft, to overcome turning resistance.
Gear	A part, as a disk, wheel, or section of a shaft, having cut teeth of such form, size, and spacing that they mesh with teeth in another part to transmit or receive force and motion.
Work	Exertion or effort directed to produce or accomplish something; labor; toil.

Procedure:

Background

There are a few terms that the teacher should know before teaching the lesson. Firstly, they should understand the diameter of the circle to be a straight line passing through the center of the circle between two points on the circle or $d = c/\pi$, where, c, is the circumference. Secondly, they should know the concept of a ratio, meaning a comparison of the magnitude of quantities relative

to one another. Lastly, teachers should be familiar with the concept of power and its relation to work, P = W/t, where t is time.

Before the Activity

- Become familiar with the terms associated with gears (pinion, idler, ratio)
- Understand how to compute a gear ratio
- Understand the basic meaning of power in terms of torque and angular velocity
- Find three objects with differing weights that can be used to demonstrate a substantial change power when picking up each one
- Build three basic cranes with differing gear ratios (Lego suggested)
- Prepare worksheets for students to list differences of each crane

With the Students

1. Have the students draw circles and measure their diameters
2. Have the students draw circles within circles to visualize a ratio
3. Now have them make a ratio of the diameters of the small and big circles
4. Draw two gears with differing diameters interlocked by teethe
5. Explain how if one gear is turned, the other gear turns as a result
6. Explain the setup of the cranes (handle connected to gear, gears connected to spool, which changes the rope size.
7. Divide students into three groups for the three different cranes
8. Allot time for students in each group to pick up objects with the crane
9. Have them write down observation of the difference in speed when lifting objects and how much effort it took to crank the gears
10. At the end of the session, have the students measure the diameters of the gears.
11. Compute the gear ratios with the classroom
12. List characteristics of each gear ratio (speed, energy used to turn gear)

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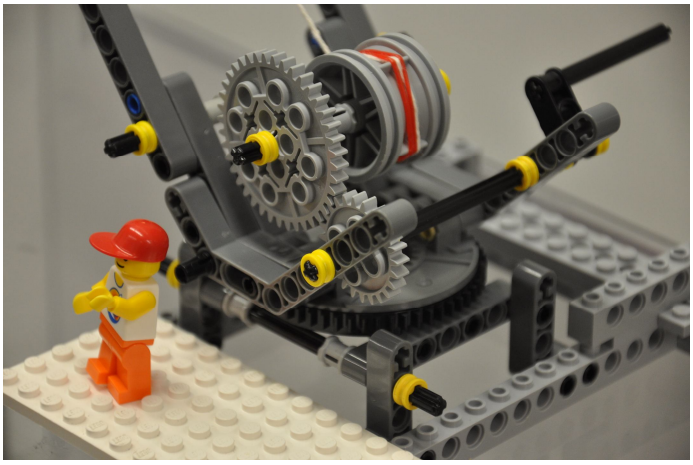

Figure 1

ADA Description: This is a close-up of the gear ratio and the spool used to collect the string. Also seen is the lever used to turn the gears.

Caption: Figure 2: Close-Up of Mechanism

Safety Issues

- Do not let children put crane pieces in their mouth
- Students should not swing the crane arm excessively. The claw could injure surrounding students.

Assessment:

For a quick review, and to make sure the students have grasped the concepts, give the students specific situations in which they would need to use the crane to pick up objects. For example, if you say there is a very heavy object that you can barely lift, what gear ratio would you want to use? If you have an object that you need moved/lifted quickly, what gear ratio would you want to use?

Pre-Activity Assessment
Descriptive Title: Evaluating the gear ratio
During the background information session, after the kids have measured and computed gear ratios, give the children different sizes of gears and ask their ratio to one another.

Activity Embedded Assessment
Descriptive Title: Evaluating observations
Ask the characteristics of each crane while children use them to pick up objects. How fast did the rope pick up the object? How easy was it to pick up the object compared to another gear ratio?

Post-Activity Assessment
Descriptive Title: Evaluating understanding of concepts
At the end of the activity, give the students real life situations in which they would need to choose a specific gear ratio. Ask them why they chose the ratio, and what could happen if they used another ratio.

Activity Scaling

- For upper grades, dissect the force needed for each person to pick up certain objects while considering the gear ratio. How much torque does the crane need to lift a heavy block?

Owner

Zachary Nishino

Supporting Program:

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