TeachEngineering

STEM Curriculum for K-12

HARE AND SNAIL CHALLENGES

PRE-ACTIVITY QUIZ

1. **What are some design considerations to make a fast robot?**

2. **What are some design considerations to make a slow robot?**

PRE-ACTIVITY QUIZ ANSWERS

1. **What are some design considerations to make a fast robot?**
   Make the robot very light, that is, use a minimal number of parts.
   Make the wheels turn faster.

2. **What are some design considerations to make a slow robot?**
   Make the robot very heavy, that is, use many and heavier parts.
   Make the wheels turn slower.

CHALLENGES TRACK SPECS

- Make the track a straight path
- Make the track 5 to 15 feet in length
- Make the track about 3 feet wide
- Clearly identify the start and finish lines

- Use a stopwatch to time the races

DAY 1: HARE CHALLENGE

50 minutes

To construct a LEGO MINDSTORMS EV3 robot and program it to travel the given track as fast as possible.

THE FASTEST ROBOT WINS!

- **Use the concepts from the gear lesson we just completed:**
  - **What gear ratio should you use?**
  - **What happens to torque when you have a high gear ratio?**
- **Let's review those concepts once again quickly before you start the challenge.**

WHAT IS A GEAR?

Lesson Review

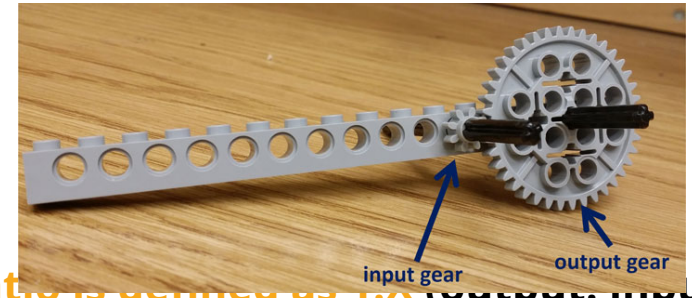
A gear is a wheel with teeth that meshes with another similar gear that is typically larger or smaller.

- **Gears come in various sizes and types.**
- **Depending on the situation, one gear may work better than another.**
- **What are gears used for?**
  - **Changing speed**
  - **Changing direction of motion**
  - **Changing torque**

MOST COMMONE GEAR: SPUR GEARS

Lesson Review

Look at the photograph below. **The small (input gear) has 8 teeth and the large (output gear) has 40 teeth. Assume that X turns of the small one causes 1 turn of the large one. *What is X?***



In this case, the gear ratio is defined as 1:X (output: input). Notice that this is in the same ratio as the number of teeth, that is, 8:40 or 1:5.

GEAR RATIO: EFFECT ON SPEED & TORQUE

Lesson Review

- **Imagine two 40-teeth gear contacting each other.** ***When one 40-tooth gear turns once, how many times will the other 40-tooth gear turn?*** **Answer = 1**
- **Now, imaging replacing one of the 40-tooth gears with an 8-tooth gear, with the 40-tooth gear turning the 8-tooth gear.** ***When the 40-tooth gear turns once, how many times will the 8-tooth gear turn?*** **Answer = 5**

In this last case (8-tooth connected to 40-tooth), the 40-tooth gear's axle will have 5 times the torque (rotational force) than the 8-tooth gear's axle.

So, although the large gear turns slowly, it can push more!

WHAT IS TORQUE? WHY IS IT IMPORTANT?

Lesson Review

- **Think of torque as a rotational force, that is, a force that causes rotation and not forward movement.**
- **For the same motor power setting, more torque in a machine (such as a bicycle or car) leads to lower speeds, and less torque leads to higher speeds. This is because**

  power = torque * speed.
- **So, when we increase speed from the input to the output gear, we decrease torque by the same amount!**
- **So, in any design you develop, you must decide which is more important: speed or torque, or maybe both...**

  and then select the appropriate gear ratio!

Now, begin the hare challenge!

DAY 2: SNAIL CHALLENGE

50 minutes

To construct a LEGO MINDSTORMS EV3 robot to travel the same track as *slowly as possible.*

THE SLOWEST ROBOT WINS!

- **Use the concepts from the gear lesson that you just used with the hare challenge.**
- **Important factors:**
  - **Robot weight**
  - **Motor power setting**

POST-ACTIVITY QUIZ

1. **What did you find as the most effective design elements to make your robot a) faster and b) slower?**

2. **What are some problems you faced when you designed a fast robot for the Hare Challenge?**

POST-ACTIVITY QUIZ ANSWERS

1. **What did you find as the most effective design elements to make your robot a) faster and b) slower?**

   a) **FASTER: increasing gear ratio, increasing motor power, decreasing robot weight**

   b) **SLOWER: decreasing gear ratio, decreasing motor power, increasing robot weight**

2. **What are some problems you faced when you designed a fast robot for the Hare Challenge?**

   When you make a light robot, it is not structurally stable and can fall apart. You also lose torque, making the robot unstable.

HARE CHALLENGE SOLUTION

- In the Hare Challenge, use the minimal number of parts on the LEGO robot, that is, keep the weight low.
- Then attach the largest gear (40-tooth) to the motor and the smallest gear (8-tooth) to the wheel. It doesn't matter what gears are in between the 40-tooth gear and 8-tooth gears since they act as idler gears.
- Use the maximum power setting on the motor.
- If an odd number of gears, have the program tell the robot to go forwards.
- If an even number of gears, have the program tell the robot to go backwards (in order to make the robot move forwards since even # of gears reverses direction).
- Expect some trial and error to be necessary.

SNAIL CHALLENGE SOLUTION

- In the Snail Challenge, make a heavy LEGO robot (use as many parts as possible) since heavy machines move slowly with the same motor.
- Then attach the smallest gear (8-tooth) to the motor and the largest gear (40-tooth) to the wheel. It doesn't matter what gears are in between the 8-tooth gear and 40-tooth gears since they act as idler gears.
- Use the minimum power setting on the motor.
- If an odd number of gears, have the program tell the robot to go forwards.
- If an even number of gears, have the program tell the robot to go backwards (in order to make the robot move forwards since even # of gears reverses direction)
- Expect some trial and error to be necessary.

VOCABULARY

- **design:** Loosely stated, the art of creating something that does not exist.
- **gear:** A rotating machine part with cut teeth that mesh with another toothed part in order to transmit torque; in most cases, the teeth on both gears are identical in shape.
- **torque:** The tendency of a force to rotate an object about its axis or pivot.