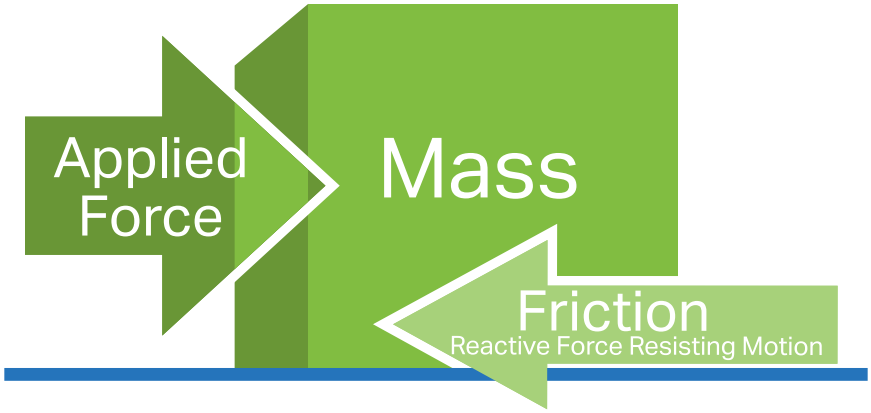
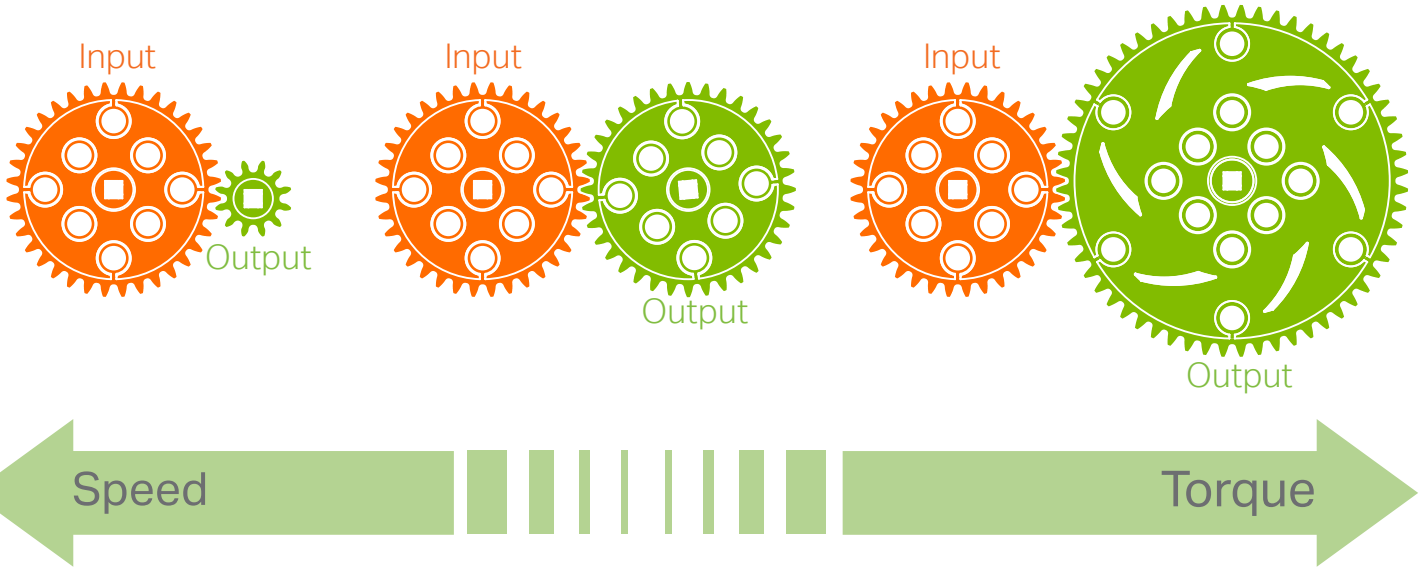
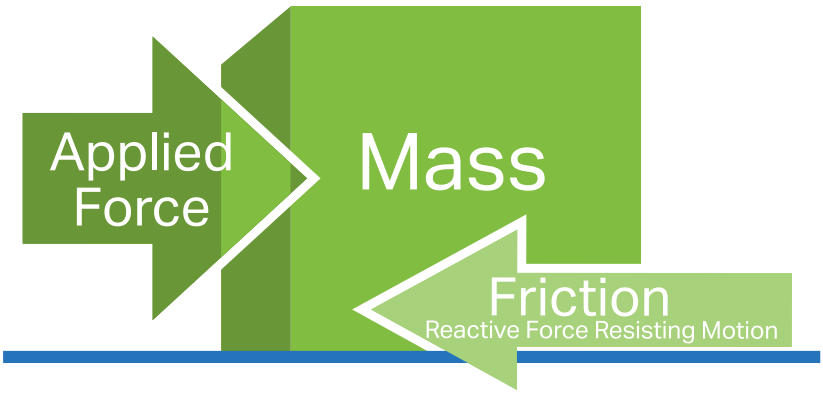
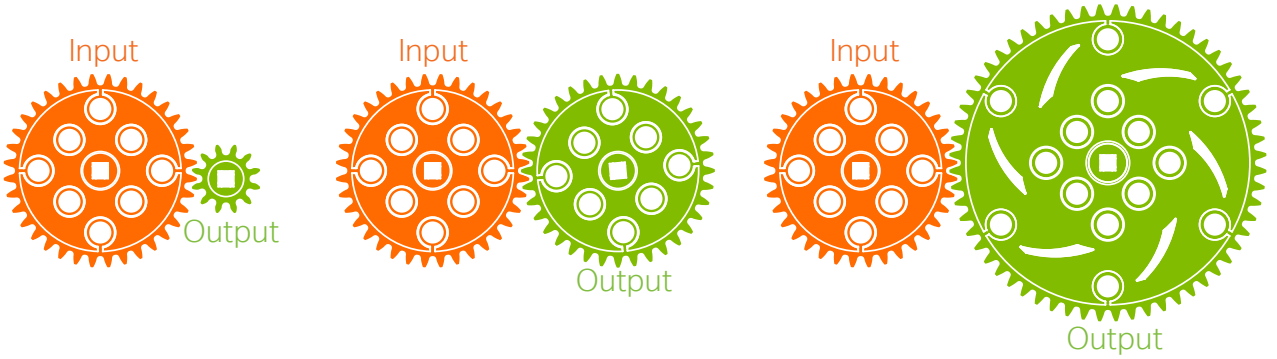
Key Concepts









F.1

Key Concepts

Unit Overview:

In this unit you will explore key STEM concepts that many engineers use in their everyday work. These concepts are also very useful when it comes to the design of mechanical systems.

Unit Content:

- Friction
- Center of Gravity
- Speed, Torque, and Power
- Mechanical Advantage

Unit Activities:

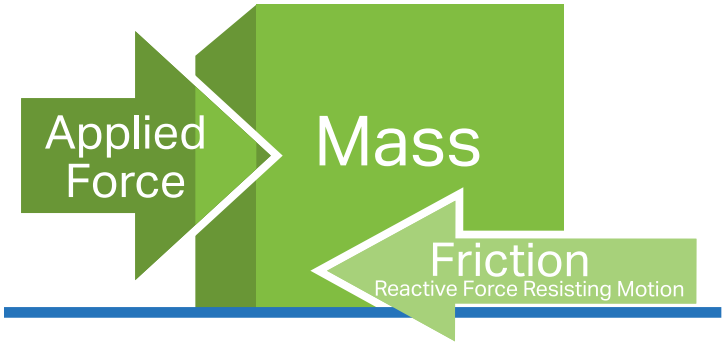
- Matching Exercise
- Idea Book Exercise

Note: Separate copies and/or printouts of activities may be used for student work. Please see your teacher BEFORE writing in this guide. Visit www.vexiq.com/curriculum to download and print PDFs of all exercises!

F.2

Friction

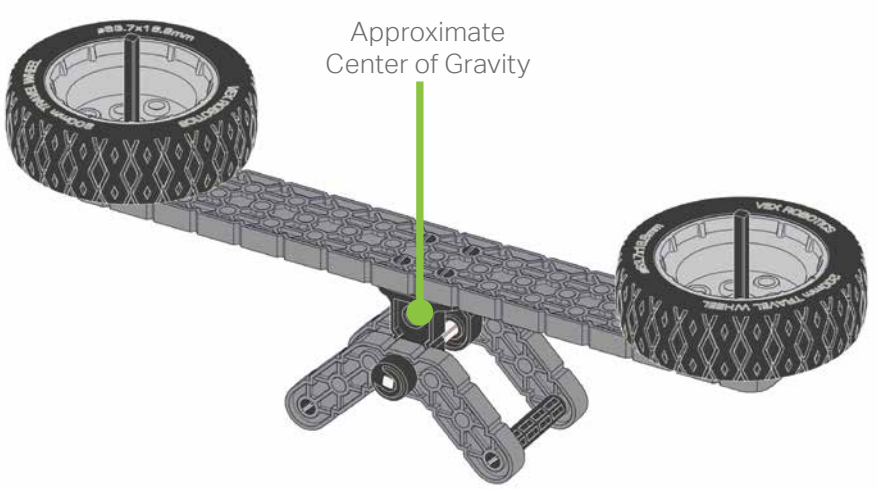
Friction is the force that resists motion through the rubbing of one object against another. It is a reaction force only. It occurs when two surfaces are in contact and a force is applied to a mass, causing the surfaces to slide against one another. If an object has no forces trying to cause motion, there is no friction. No applied force means no reaction force.



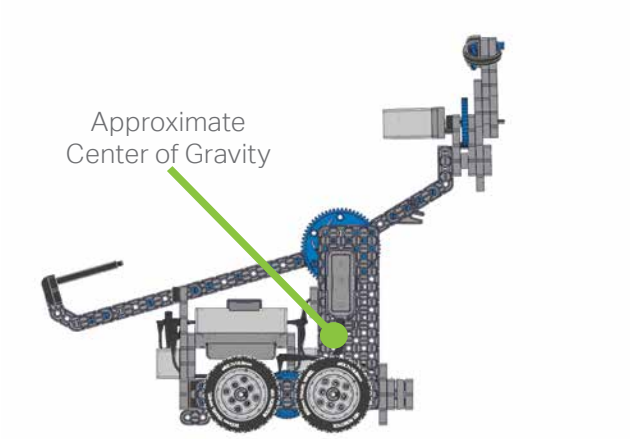
F.3

Center of Gravity

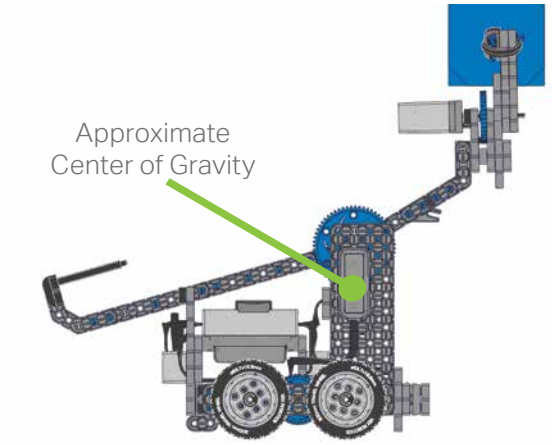
Center of Gravity is the place in a system or body (such as a robot) where the weight is evenly distributed and all sides are in balance. An example of center of gravity is the middle of a seesaw when it is balanced.



You can think of a robot's center of gravity as the "center position" of all the weight on the robot. Because **Center of Gravity** uses both weight and position, heavier objects have a greater effect than lighter ones in determining where the center of gravity is. For example, if your robot can collect, hold, and/or manipulate objects, those objects change the center of gravity as they are being manipulated because they add weight.



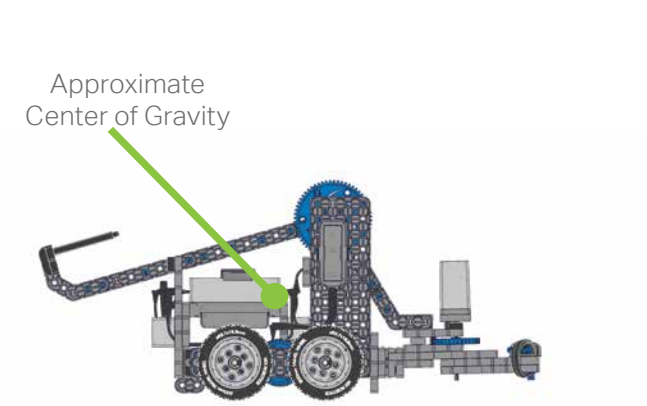
Robot Arm Empty



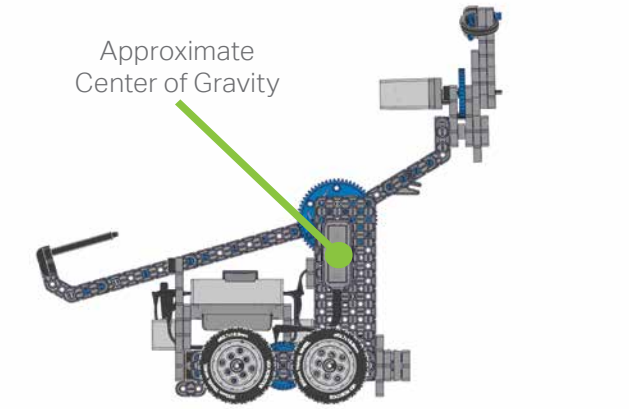
Robot Arm With Cube

F.3 cont.

Likewise, pieces that are farther out have a greater effect than pieces that are near the middle of the robot. So, if your robot has an arm that lifts and/or reaches, its center of gravity changes with that movement.



Robot Arm Down and In



Robot Arm Up and Out

F.4

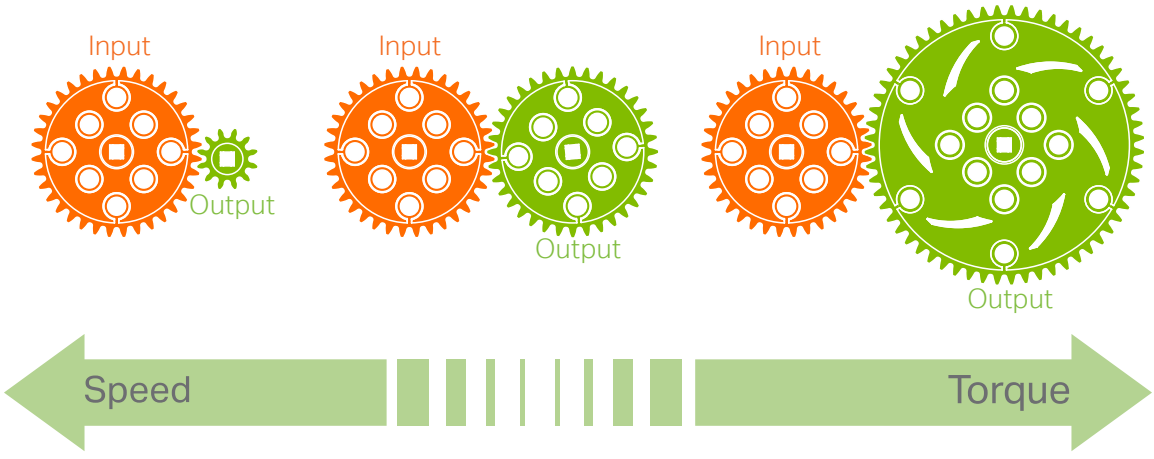
Speed, Torque, and Power

Speed is a way of measuring how fast an object is moving. Speed measures how far an object will travel over a given period of time. This measure is given in units of distance per time such as Miles per Hour or Feet per Second.

Torque is a force directed in a circle, most often rotating an object. Torque is a spinning force. When torque is spinning an object, the object will create a linear (straight line) force at its edge, such as an axle spinning a tire and causing the tire to move in a straight line along the ground. Torque is measured in units of force × distance, such as Inch-Pounds or Newton-Meters.

Power is the rate at which work is done. With VEX IQ, Smart Motors convert electrical energy into mechanical energy and produce power for a mechanical system. Power is most commonly measured in **Watts**.

The physical principles of **Speed**, **Torque**, and **Power** all fit together in what engineers call **Classical Mechanics**. In Classical Mechanics, **speed and torque have an inverse** (or opposite) **relationship** – as one increases the other decreases. Higher speed means lower torque, and higher torque means lower speed.



Also, **the amount of power supplied has an effect on how much speed and/or torque can be produced in a mechanical system.**

F.5

Mechanical Advantage

Mechanical Advantage is the calculation of how much faster and easier a machine makes your work. It compares the output force a mechanism or machine gives you to the input force that is applied to that mechanism or machine to get it to work. Mechanical advantage can be adjusted to meet specific needs. For example, bicycle gears can be set one way to ride uphill, then adjusted to ride downhill. The rider has limited power, but by adjusting the mechanical advantage to appropriate speed and torque outputs, the output from the rider's power can be maximized in varying conditions. With VEX IQ, changing gear ratios is also a great way to adjust mechanical advantage.

A bike's high-speed gear ratio can maximize its efficiency on a downhill or flat slope.

A high-torque gear ratio can help a bike to climb up hills easily using mechanical advantage.

F.6

Key Concepts Matching Exercise

Student Name(s): _____

Teacher/Class: _____ Date: _____

Instructions:

Match terms from the word bank to the correct definition by writing terms on the correct line. Each term is only used once.

Word Bank:

Center of Gravity	Feet per Second	Friction	Inch-Pounds
Inverse	Speed	Weight	Mechanical Advantage
Torque	Position	Watts	Power

_____ is the force that resists motion when one object rubs against another.

_____ is the place in a system or body where the weight is evenly distributed and all sides are in balance.

Center of Gravity uses both _____ and _____.

_____ is a measure of how fast an object is moving.

_____ is a force directed in a circle, most often rotating an object.

_____ is the rate at which work is done.

Speed is measured in Miles per Hour or _____.

Torque is measured in units of force × distance, such as _____ or Newton-Meters.

Power is most commonly measured in _____.

In Classical Mechanics, speed and torque have an _____ relationship.

_____ is the calculation of how much faster and easier a machine makes your work.

F.7

Key Concepts Idea Book Exercise: Mechanical Advantage

Student Name(s): _____

Teacher/Class: _____ Date: _____ Page #: _____

Mechanical Advantage is the calculation of how much faster and easier a machine makes your work. It compares the output force a mechanism or machine gives you to the input force that is applied to that mechanism or machine to get it to work. Mechanical advantage can be adjusted to meet specific needs.

Instructions:

Your task is to "imagine" a mechanism or device that can adjust its mechanical advantage to meet changing needs. For example, in the lesson on Mechanical Advantage we described a bicycle's ability to change gears for both uphill and downhill riding to meet varying speed and torque needs.

STEP 1. "THINK" - Think of any situation (other than the bicycle) where a machine, device, or mechanism with the ability to change its mechanical advantage would be helpful in some way. Describe that situation or "problem" in words below. Use terms from our unit matching exercise whenever possible (friction, center of gravity, speed, power, torque, etc.) in your description:

STEP 2. "DO" – Draw and describe your machine, device, or mechanism. Name it, label its parts, show and describe how it would work and how mechanical advantage would be changed. Use terms from our unit matching exercise where possible (friction, center of gravity, speed, power, torque, etc.) in your description.

Draw, name, and label your machine, device, or mechanism here:

Describe how it would work and how mechanical advantage would be changed below: