

## INTRODUCING YOUR CHILD TO STEM

Science, Technology, Engineering, and Mathematics (STEM) education provides young adults with the opportunity to participate in many themed, **hands-on activities**, including those with connections to sports, history, and other subjects.

Activities involving the Forklift construction toys by Hexbug help individuals learn more about **physics** and **engineering** by engaging in activities that are useful and enjoyable while providing them hands-on experiences in those key areas.

This activity with the Forklift provides a fun and interesting way for students to learn about the **physics** involved in **hand-powered machine systems**, how power is transferred, and how gear ratios yield mechanical advantages.

## GENERAL SOLUTIONS

At	The power's direction changes from	To moving
<b>Location #1</b>	<b>Left-right</b> or Up-down	Left-right or <b>Up-down</b>
<b>Location #2</b>	Left-right or <b>Up-down</b>	<b>Left-right</b> or Up-down

Students focused on the faces/motion of the bevel gears instead of the orientations of their shafts might answer in the opposite way. That is okay as long as they recognize the change in the force's direction at each location.

Speed of Rotation	Number of balls successfully lifted two-ball loads in 1 minute	Other notes on Forklift performance
<b>Slowly</b> (1 rotation = 4 seconds)	10	Sometimes too many balls for pickup; sometimes only one or none
<b>Moderately</b> (1 rotation = 2 seconds)	22	The ball return ramp sometimes does not drop two balls
<b>Quickly</b> (1 rotation = 1 seconds)	29	Balls fall out of machine, sometimes one or no balls are waiting to be lifted

Students can decide which speed was the most effective based on their best evidence. To reason through the number of successful loads, students should consider the maximum number of attempts. Slowly rotating had 15 attempts in 1 minute, whereas Moderately and Quickly rotating has 30 and 60 attempts in 1 minute, respectively. Other performance factors (e.g., control of the return ramp) could also be considered in the decision.

## EXTEND YOUR LEARNING

### DISCUSS

A machine makes work easier by increasing a force, changing its direction, or transporting a force across a distance.

### APPLY

Explain why the Forklift is a machine. Did it increase a force, change its direction, or transport the force across a distance? Did it do more than one?

### EXPLORE

You can explore additional VEX Hexbug builds and investigations here:  
<https://www.hexbug.com/vex>

## VOCABULARY TO KNOW

### BEVEL GEAR

Perpendicular gears that change the direction of a force

### DRIVEN VS. DRIVING GEARS

Driving gears (input) rotate driven gears (output) because their teeth (notches) are meshed

### FORCE

A push or pull exerted on an object

### GEAR RATIO

The difference in size of the driven (output) and the driving (input) gear; the number of times the driving gear rotates in one rotation of the driven gear predicts either a torque (rotational power) or speed mechanical advantage

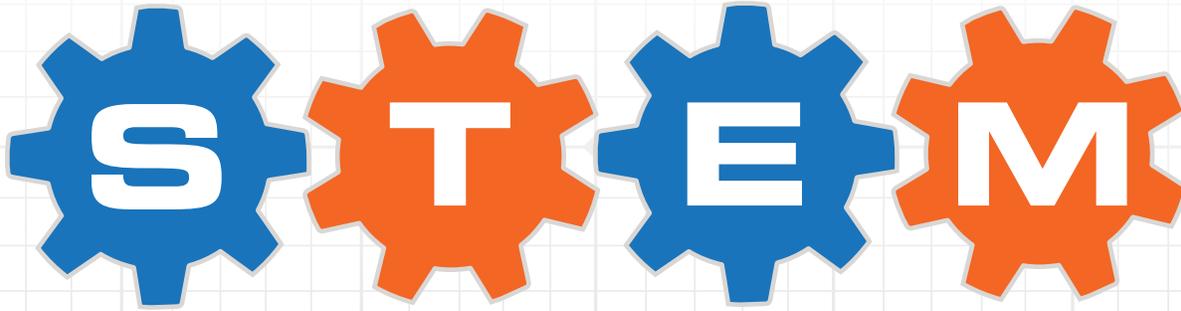
### MECHANICAL POWER

Power in mechanical systems is the combination of forces and movement

## FORMULAS

$$\text{Gear Ratio} = \frac{\text{Output Gear}}{\text{Input Gear}} = \frac{60 \text{ teeth}}{12 \text{ teeth}} = \frac{5}{1} \text{ or } 5:1$$

# STEM STANDARDS ADDRESSED



## MS-ESS1-1

Patterns can be used to identify cause and effect relationships.

## 3-PS2-1

Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

## 3-PS2-2

Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

## MS-PS2-2

Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

## HE-ETS1-2

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

## ISTE1.1D

Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

## ISTE3.3D

Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories, and pursuing answers and solutions.

## ISTE4.4D

Students exhibit a tolerance for ambiguity, perseverance, and the capacity to work with open-ended problems.

## 3-5-ETS1-1

Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

## MS-PS3-2

Develop a model to describe unobservable mechanisms.

## MS-ETS1-4

Develop a model to generate data to test ideas about designed systems, including those representing inputs and output.

## CCSS.MATH.PRACTICE.MP1

Make sense of problems and persevere in solving them.

## CCSS.MATH.PRACTICE.MP3

Construct viable arguments and critique the reasoning of others.

## CCSS.MATH.PRACTICE.MP4

Model with mathematics.

## CCSS.MATH.PRACTICE.MP7

Look for and make use of structure.

## CCSS.MATH.CONTENT.6.RP.A.1

Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

## CCSS.MATH.CONTENT.6.RP.A.2

Understand the concept of a unit rate  $a/b$  associated with a ratio  $a:b$  with  $b \neq 0$ , and use rate language in the context of a ratio relationship.

## CCSS.MATH.CONTENT.6.RP.A.3

Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

## CCSS.MATH.CONTENT.6.RP.A.2

Recognize and generate simple equivalent fractions.

### STANDARDS REFERENCED

#### MATH

Common Core Standards for Math  
<http://www.corestandards.org/math/>

#### SCIENCE & ENGINEERING

Next Generation Science Standards  
<http://www.nextgenscience.org/>

#### TECHNOLOGY

International Society for Technology in Education  
<http://www.iste.org/standards/>