**Robot Hill Climb**

# Description

Before you begin this activity you will need to assemble or construct an inclined hill course. Figure 1 in the *Materials* section shows an example.

This activity can be approached as a driver challenge and/or as a programming challenge.

Students will build a robot that will climb a number of different ramps or inclined hills at varying degrees of incline. Students will experiment with different-sized gear wheels to test and assess optimal performance in the various hill climbs. Once this activity has been completed as a driver challenge (using a driver with a remote control), it can be repeated as an autonomous challenge (using a computer program to control the robot).

This activity helps students to apply mathematics and science to their robot design and their computer program, allowing them to learn from their mistakes and course-correct to improve their performance.

# Lesson Outcomes

Students will be able to:

* Construct and operate a robot to climb a number of ramps or inclined hills
* Follow instructions to complete a complex task
* Solve technical problems using prior learning from other courses such as Science and Math
* Understand and apply gear ratios to design
* Apply design thinking to improve their robot’s performance
* Understand the importance of teamwork

# Assumptions

Students will have:

* Knowledge and understanding of basic construction techniques
* Formed teams and partnerships within the classroom
* Access to robotics platforms and necessary equipment
* Some knowledge of gear ratios, robots and design
* Some experience with basic mathematics and friction



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# Key Terminology

**Center of gravity**: a focal point where an object is standing at its design maximum without falling down.

**Friction**: heat caused by opposing forces acting on a surface. **OR** a force that resists motion between two surfaces sliding against each other; strength of the force is determined by their textures.

**Gear ratio**: the science of mechanical advantage using gears.

**Torque**: also known as *moment*. The force of a moving object connected to a single point.

**OR** the measurement of force causing rotation.

**Traction**: the ability to grip a surface.

# Estimated Time

Approximately 16 hours:

* + Project overview and group formation – 1 hour
  + Build time to test phase – approximately 10 hours
  + Rebuild time and modifications – 5 hours

# Recommended Number of Students

Two to five students per robot, per team (ideal: three students) Two to five teams

# Facilities

Any classroom that fits the hill course you have constructed

# Tools

Tools are platform-specific based on the robotics platform selected.

A basic tool kit that includes pliers, wrenches, nail files (to round off sharp corners)

Computer with programming software for the robot (e.g., FLOWOL, RobotC, EasyC, Modkit, etc.)

# Materials

A construct that includes multiple ramps and inclines (see Figure 1)

Multiple-sized gear wheels to attach to the robots (included with the robot kits) Paper to draw diagrams and to track progress

**Figure 1—**Example of an inclined hill course.

# Resources

An example of an inclined hill course made from cardboard: https://vsbrobotics.wordpress.com/challenge-1b-king-of-the-hill/

### VEX Robotics

<http://www.vexrobotics.com/>

### LEGO

<http://www.lego.com/en-us/mindstorms>

Website forums for team-to-team or peer-to-peer online discussions:

### VEX IQ Forum

<http://www.vexiqforum.com/>

### VEX EDR Forum

<http://www.vexforum.com/>

### FIRST Forums

<http://forums.usfirst.org/>

# Demonstration

It is recommended that teachers preview the following videos before showing them to their students.

The following videos provide an understanding of gear ratios: **Gear Ratios - Part 1**  https://[www.youtube.com/watch?v=B4j2VPHVm6o](http://www.youtube.com/watch?v=B4j2VPHVm6o)

### Gear Ratios - Part 2

https://[www.youtube.com/watch?v=h1vfR9YvjMA](http://www.youtube.com/watch?v=h1vfR9YvjMA)

### Gear Ratios - Part 3

https://[www.youtube.com/watch?v=-q5FmanzCw4](http://www.youtube.com/watch?v=-q5FmanzCw4)

The following videos provide an understanding of speed vs. strength (torque):

**Understanding Gears: Speed Vs. Torque**: a two-minute demo of simple gear ratios https://[www.youtube.com/watch?v=UUfZnZ\_0Cb8](http://www.youtube.com/watch?v=UUfZnZ_0Cb8)

### LEGO Technic - Torque, Speed, Gearing

https://[www.youtube.com/watch?v=KKQHqPIuEVc](http://www.youtube.com/watch?v=KKQHqPIuEVc)

Also, discuss centre of gravity as a concept, and how it affects the construction and operation of your rolling platform.

# Procedure

## Before beginning the activity:

* + Construct the inclined hill course using available materials or cardboard (see Figure 1).
  + Teacher should decide how students will best track their observations and findings, with the understanding that there will be an opportunity to present their findings. Suggestion: have students track their progress by creating a table, PowerPoint using slides, design notebook, etc.

1. Create a rolling platform with driving wheels connected directly to the motor.
2. Run the rolling platform up one of the ramps (inclined hill course) and observe the performance of the robot.
3. Experiment with different sizes of gear wheels, as illustrated in Figures 2–5, below. Test the rolling platform on the ramp again and notice the changes (if any) to the overall performance. Some guiding questions for this experiment include: How will the performance of the robot improve if more gears of the same size are added? How might performance of the robot improve if more gears of different sizes are added?
4. After experimenting with different-sized gear wheels, draw a conclusion as to which set of gears works best for this particular ramp. Repeat this process until the robot has completed all the ramps.

Students will take turns presenting to the class their understanding of speed vs. strength (torque), explaining how the different gear wheel sizes influence climbing performance.

1. Complete the activity by testing the robot’s ability to climb the various inclines.

It is recommended that this activity be completed using a driver-controlled robot first and, if time permits, again using an autonomous controlled robot to demonstrate programming skills.

|  |  |  |
| --- | --- | --- |
| Figure 2 | Wheel Gear wheels | Motor attached to this gear wheel |
| Figure 3 | Wheel Gear wheels | Motor attached to this gear wheel |
| Figure 4 | Wheel Gear wheels | Motor attached to this gear wheel |
| Figure 5 | Wheel Gear wheels | Motor attached to this gear wheel |

# Assessment

The evaluation of this lesson is based on the learning outcomes outlined above.

Prior to teachers using the evaluation grid it is recommended that students perform some form of peer-assessment and self-assessment.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Outcome To Be Assessed** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |
| **Outcome 1** | **Construction of a robot** | | | | | | | |
| **1.1** | Constructs a robot to specifications. |  |  |  |  |  |  |  |
| **1.2** | Robot performs to expectation. |  |  |  |  |  |  |  |
| **Outcome 2** | **Climbing a series of hills** | | | | | | | |
| **2.1** | Understands/applies gear ratios. |  |  |  |  |  |  |  |
| **2.2** | Understands external influences such as friction. |  |  |  |  |  |  |  |
| **Outcome 3** | **Use of design thinking to solve challenge** | | | | | | | |
| **3.1** | Uses the design thinking cycle. |  |  |  |  |  |  |  |
| **3.2** | Uses and applies prior learning from other courses such as Science and Math. |  |  |  |  |  |  |  |
| **3.3** | Successfully adapts robot performance to different incline challenges. |  |  |  |  |  |  |  |
| **Outcome 4** | **Teamwork** | | | | | | | |
| **4.1** | Able to resolve errors when encountered. |  |  |  |  |  |  |  |
| **4.2** | Division of work. |  |  |  |  |  |  |  |
| **4.3** | Effort of each team member. |  |  |  |  |  |  |  |
| **Outcome 5** | **Understanding Key Terminology** | | | | | | | |
| **5.1** | Demonstrates the use of Key Terminology. |  |  |  |  |  |  |  |
| **5.2** | Applies terminology appropriately. |  |  |  |  |  |  |  |

## Total Points:

|  |  |  |
| --- | --- | --- |
| 6 | Completed successfully at the exceptional level | Exemplary |
| 5 | Completed successfully at higher than the expected level | Accomplished |
| 4 | Completed successfully to the expected level | Emerging |
| 3 | Attempted successfully at the minimum level | Developing |
| 2 | Attempted - Unsuccessful - Close to Successful | Beginning |
| 1 | Attempted - Unsuccessful | Basic |
| 0 | Not Attempted | N/A |

**Comments:**

**Extension Activities**

Consult the ”Classroom Challenges” on the following website for additional activities as extensions of this activity:

### Jr. Robotics: a place for teachers, students and parents

https://vsbrobotics.wordpress.com/