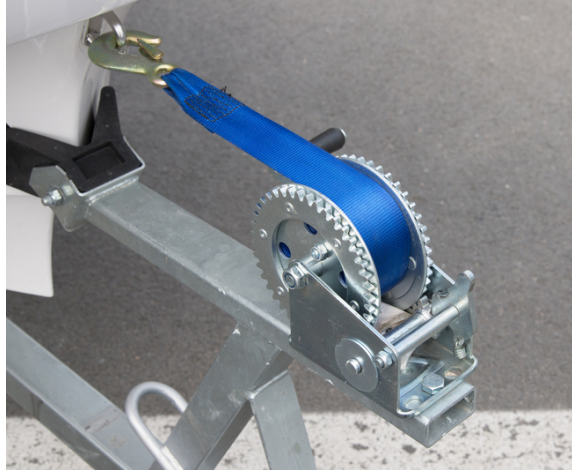# 6. ENGINEERING A WINCH: PROGRAMMING A STEPPER MOTOR

A winch is a pulley device, also known as a compound machine, that uses a wheel and axle to wind up or wind down a rope, cable, or chains. In this activity you will engineer a device that can lift up and place down an object.

Goals

- Determine the circumference of a winch wheel and use it to determine distance traveled.

- Investigate and successfully program a high-speed stepper motor.

- Engineer a model of a working winch.

Materials and Equipment

- Computing device
- //code.Node
- //control.Node
- High-speed stepper with stepper hub, screws and nuts to secure to bracket
- Motor bracket
- Screwdriver
- Winch wheel

- Screws, (2)
- Magnet
- Meter stick
- Paper, plastic, or Styrofoam™ Cup, (1)
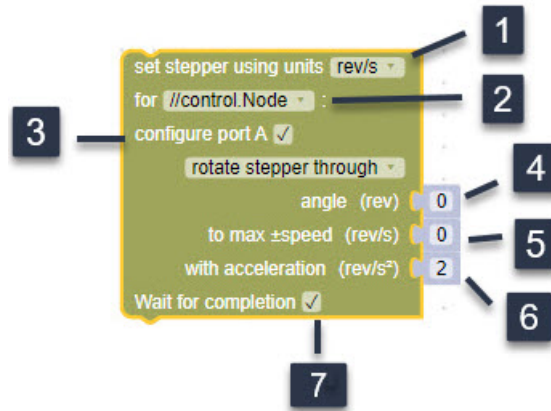- String
- Paper clip
- Tape

Safety

Follow regular laboratory safety precautions.

Research

Programming a High Speed Stepper

To move your winch in this engineering challenge, you will need to use the stepper block. The stepper motor is controlled using the block provided in the Hardware Group of the Code tool.

1. **Units** : Select which units you want to use for the angle, max speed, and acceleration.

2. **//control.Node selector** : If using more than one //control.Node, select which //control.Node you want to control.

3. **Port** : Select the box to configure port A or B.

4. **Angle (*through mode only*)** : Enter and angle that the stepper will rotate through. For example, if 3.5 revolutions is entered, the stepper will rotate 3.5 revolutions.

5. **Max speed** : Enter the maximum speed that the motor will move. A positive number will rotate the stepper counterclockwise and a negative number clockwise.

6. **Acceleration** : This indicates the acceleration of the stepper motor to the max speed when the motor starts. In **through** mode, this value also indicates how much the motor will decelerate before completing the rotation.

7. **Wait for completion (*through mode only*)** : Select this box to allow the motor to complete its rotation before moving to the next block in the program.

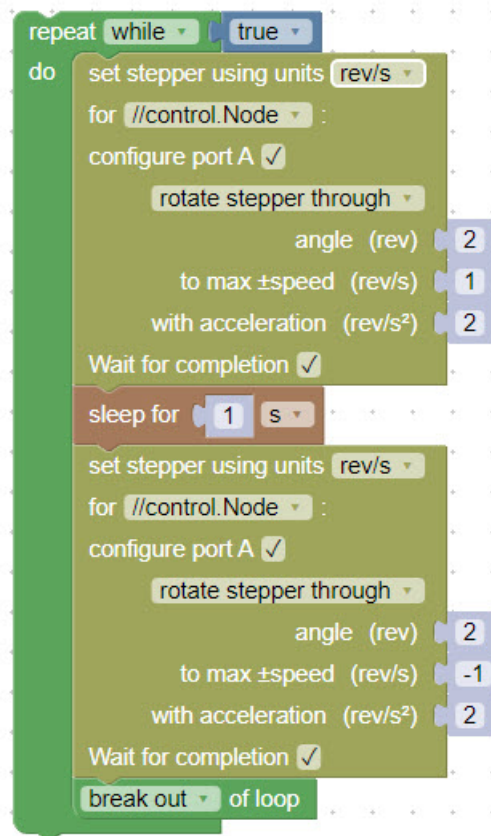**Making the Stepper Motor Rotate Counterclockwise and Clockwise**

1. Attach the high speed stepper to the motor bracket and ensure the stepper hub is attached. See Figure 1.

Figure 1. Stepper Attached to Bracket

2. Connect the stepper to port A on the //control.Node.

3. Select Sensor Data in SPARKvue and connect your //control.Node to your computing device.

4. Select Angle and Position under High-Speed Stepper and disable the //control.Node On-board Sensor.

5. Select the Line Graph Display ☑. You should have two line graphs. One for Angle (rev) versus Time and one for Position versus Time.

6. Click on the code tool 🔳 and recreate the following code.

```
repeat while ▾    true ▾
do    set stepper using units  rev/s ▾
      for  //control.Node ▾  :
      configure port A ☑
            rotate stepper through ▾
                        angle  (rev)   2
                to max ±speed  (rev/s)   1
           with acceleration  (rev/s²)   2
      Wait for completion ☑
      sleep for    1    s ▾
      set stepper using units  rev/s ▾
      for  //control.Node ▾  :
      configure port A ☑
            rotate stepper through ▾
                        angle  (rev)   2
                to max ±speed  (rev/s)   -1
           with acceleration  (rev/s²)   2
      Wait for completion ☑
      break out ▾  of loop
```

7. Start recording data. It will stop recording on its own due to the **break out of loop** block.

8. Using data from the Angle (rev) versus Time graph, how many revolutions occurred?

9. Using data from the Position (m) versus Time graph, can you explain the movement of the wheel?

10. Looking at the program you recreated, what section was changed to make the hub rotate clockwise? What number is located in that section?

Determining Winch Wheel Circumference

The circumference of a circle is the total distance around its outside. Circumference equals the diameter of the circle times π (pi), which is about 3.14. One rotation of a wheel will make it move a distance equal to its circumference.

1. Using a measuring tool, determine the diameter of the winch wheel. Try to get to the nearest millimeter (mm).

2. Convert the measurement to meters (m).

3. Using this number, determine the circumference of the winch wheel. (Diameter x 3.14). Show your work below. Round your answer to the nearest hundredth.

4. If the winch wheel made 2.3 revolutions, what distance would it travel? Round your answer to the nearest hundredth.

Prototype

Now it is time to put all your research together. Create a model winch using Blockly that will pick up a cup using a magnet and then lower it. Use the //code.Node to trigger the winch movements. In this activity, you will only use a single stepper block. Set the block in **rotate stepper through** mode. Make sure that **Wait for completion** is selected.

1. Start a New Experiment in SPARKvue. Connect both the //code.Node and //control.Node to your computing device.

2. Remove the stepper hub from the motor and attach it to the winch wheel with screws.

3. Attach the high-speed stepper to the motor bracket and attach to winch wheel to the stepper. You will need to place the device on the edge of a table for it to move freely. See Figure 2.
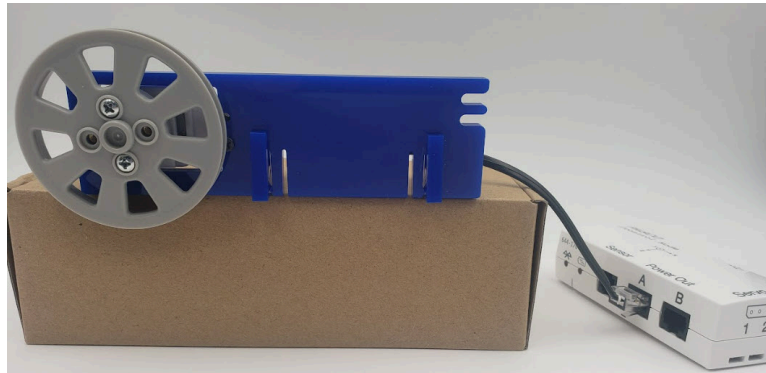

Figure 2. Example Winch Set-up

4. The goal of this challenge is to pick up a cup from the ground and lift it up and down. To do this, you will need to know just how many rotations the winch wheel will need to make to get down to the cup. Using a measuring device, determine the distance from the table to the top of the paperclip on your cup.

5. In the research portion of the activity, you determined the circumference of the winch wheel. You then determined the distance it would travel in one complete revolution. Now you have to determine how much string to loop around the wheel so it will reach the paperclip on top of your cup. What was the distance from the table to the top of the cup? Based on this measurement, how many rotations will the wheel need to make? Explain and show your work below.

6. What do you need to attach to the bottom of the string to grasp the paper clip?

7. Now that you have all your materials, calculations, and knowledge of how to program the high-speed stepper, create a program that uses the //code.Node to trigger the winch to go down and pick up the cup and then lift it back up.

Test

Once you completed your prototype program, execute the code and test to see if it works. This may take some trial and error.

1. When your prototype is complete, share your program along with your process below.

2. What challenges did you face and how did you overcome them?

Improve

- Can you engineer a Rube Goldberg machine? Think of another mechanism, such as falling dominoes, that could trigger your winch to move up or down.