Skill Builder 1: Moving Forward

Overview:

Students will write a program on their calculator to control the two motors on Rover. They are challenged to spin the motors fast, slow, clockwise and counter clockwise. Next students are challenged to control the motors to drive in a straight line. As the final challenge, students are asked to drive a distance and then stop as close as possible to a barrier without touching that barrier.

Goals:

Students will:

1. learn to begin, open, close, edit and run programs from the editor.
2. write a TI BASIC program that controls the speed and direction of the motors.
3. write a program that controls how far forward Rover will drive.
4. use proportional thinking, or pattern recognition, or linear modeling to predict how far Rover will travel based on their measurements.

Background:

Rover will move forward when a TI BASIC program sends the command named RV FORWARD from the calculator to the TI-Innovator Hub connected to Rover. When the Hub interprets the command, it turns on Rover's motors. The longer the motors are turned on, the further Rover goes. When the motors spin slowly, Rover goes a short distance in a given amount of time. If the motors spin quickly, Rover goes a greater distance in the same amount of time. The distance Rover travels in a given amount of time is called **speed**. The speed of rover can be calculated by dividing the distance traveled by the amount of time. While automobile speed is calculated in miles per hour, Rover speed is in meters per second.

Rover Command	Example	Behavior
RV.MOTOR.L CW/CCW *power* TIME	RV.MOTOR.L CCW 255 **** TIME 10	Left motor spins fast counter-clockwise for 10 seconds
RV.MOTOR.R CW/CCW *power* TIME	RV.MOTOR.R CW 75 TIME 5	Right motor spins slowly clockwise for 5 seconds
RV.MOTORS side direction power side direction power	RV.MOTORS LEFT CCW 200 RIGHT CW 200 TIME 10	RV moves forward for 10 seconds
RV FORWARD *distance unit*	RV FORWARD 1.2 M	Go forward 1.2 Meters at default speed of .20 M/S **
RV FORWARD *distance unit* SPEED *speed unit*	RV FORWARD 1.5 M SPEED .18 M/S	Go forward 1.5 Meters at a speed of.18 M/S**
RV FORWARD *distance unit* TIME *time*	RV FORWARD 1.7 M TIME 10.6	Go forward 1.7 Meters in a time of 10.6 sec.
RV FORWARD speed unit TIME time	RV FORWARD .23 M/S TIME 5.3	Go forward at a speed of .23 M/S** in a time of 5.3 sec.
RV BACKWARD *distance unit*	RV BACKWARD .75 M	Go backward .75 Meters at default speed of .20 M/S **

Note: Motor commands are found on the Hub-Rover RV control menu. FORWARD and BACKWARD are found on the Hub-Rover-Drive RV menu. CCW, CW, LEFT, RIGHT, TIME, M, M/S and SPEED are all found on the Hub-Rover-RV Settings menu

* The above commands are not the only usages of FORWARD, for a complete list please reference the user's guide.
https://education.ti.com/html/webhelp/EG_Innovator/EN/content/resources/pdf/v1.5/ti-innovator_rover_commands_en.pdf

** The speed of the Rover will vary from the stated values depending on the floor surface. Some surfaces cause Rover to move more slowly. If accuracy is important, the speed should be measured by a method similar to the one in this activity.

*** The BACKWARD command works just like the FORWARD command except travel is in the opposite direction.

**** The Power setting for the motors is 0(still) to 255(fastest).

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Rover Set up:	Supplies:
Students may work in groups of two or three. Choose an area to work that has at least 2 meters of clear uniform floor space. Carpeted flooring is less desirable than tile. If needed, driving mats may be used for a driving surface. For the 2nd and 3rd challenges, a driving lane is setup using tape or cones.	• Miniature traffic cones • Masking tape • Drive mats or hard, flat, clean surfaces

Student Activity	Teacher Activity

Challenge 1: Write a program named **c1** that makes the left wheel spin slowly clockwise for 5 seconds. Now modify your program to make it spin faster and then in the opposite direction. Try to make it turn for a longer time. Try the other wheel. Be sure to flip Rover on its back before running your program.	**Guidance during challenge 1:**
	• Visit 10 Minutes of Code for the TI-Innovator Hub for an introduction to programming in TI-BASIC at https://education.ti.com/en/activities/ti-codes/nspire/10-minutes-innovator
	• Introduce the TI-BASIC editor and how to run a program to students.
	  1. Basic navigation on the calculator.
	  2. Saving and opening files.
	  3. Editing new and existing programs.
	  4. Running programs.
	  5. Editing program features.
	  6. See example program c1 in Unit 1 Skill Builder 1 Example Programs.tns
	• The wheel-spinning activity is intended to be an introduction to Rover programming. Students should work with a partner and encourage them to explore how to control each motor's direction and speed. Students should remove their calculator from the Rover and place Rover on its back to complete challenge 1, be sure the calculator is plugged into Rover and Rover's power switch is set to "ON".
	• Discuss with students what clockwise means and the frame of reference for that designation. Ask them to consider the Earth's rotation. Is it clockwise (CW) or counter clockwise (CCW)? Is that designation using a frame of reference viewed from the North or South Pole? Is there an absolute frame of reference? Or is it a relative choice? The wheels of rover are designated as CW or CCW based on looking at the wheel from outside Rover and along the motor shaft. Demonstrate to students for a particular object's rotation if it is designated as a CW motion, observing from the opposite direction along the axis of rotation, the same motion will be designated as CCW. Ask students what direction each wheel should rotate in order to go forward?
	• For students who finish quickly, have them place a piece of tape on the wheel and count the number of rotations for the time interval. Challenge them to calculate the revolutions per minute (RPM) of the wheel.

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Send "CONNECT RV"
Send "RV.MOTOR.L CW 100 TIME 5"
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Challenge 2: Write a program named **c2** to make the Rover drive straight path down the lane that is setup in your classroom. Do you think you could backup down the lane?

Guidance during challenge 2:

- This challenge is a variation of the prior challenge. Students will need to control both motors at the same time. The trick is, since the motors are mounted in opposite directions, the frames of reference for the two motors are opposite. As a result to move forward, the left motor must turn in the CCW while the right must turn a CW direction. Do not offer this to the students, let them discover it instead.

Send "CONNECT RV"

Send "SET RV.MOTORS LEFT CCW 200 RIGHT CW 200 TIME 20"

- In addition, each motor is manufactured with variation; as a result, the motors will spin at different rates for the same power setting. This causes Rover to pull either left or right of a straight line depending on the unit. When this happens, ask the students which wheel must compensate by turning faster to straighten out the pulling? Then ask them what parameter in the motor command needs to be adjusted to change the speed of that wheel. Let students discover the correct answer.
- Fortunately, all of this is taken care of in more advanced ROVER commands, such as FORWARD. Since both motors are required to turn concurrently to go forward, the individual motor commands will not work since they are executed sequentially. Instead use the MOTORS command which will set both motors at the same time. You could allow your students to discover the need for this new command. See example program c2 in Unit 1 Skill Builder 1 Example Programs.tns

Challenge 3: Write a program named **c3** to drive your Rover straight down the challenge lane and make it stop as close to the final target as possible without making contact. You will use the TIME command and predict how long it will take your Rover to reach the mark. Can your Rover be the closest?

Guidance during challenge 3:

- In the previous challenges, students experienced the difficulty of getting their Rover to drive a straight line. In this next challenge, students will use the FORWARD command which makes use of the built-in rotary encoders on Rover to automatically drive a straight line.
- In this challenge, students are asked to make a prediction of the time needed to drive their Rover and stop at a predetermined distance. Discuss with your students the idea of prediction using patterns, proportional reasoning or linear extrapolation.
- In order to accomplish this challenge, students will need to run some tests of the Rover using the FORWARD command. Have the students record the times required to travel three or four uniform distances and then set the challenge distance beyond the last measured distance (see example on the following page)
- Students should program the distances into the FORWARD command and then use a stopwatch to time the drive path. They should record the ordered pairs of time and distance on paper. Students will then use that data to predict the time needed for Rover to drive the challenge distance. There are several approaches students could use to make this prediction. They could use the skill of identifying a pattern in their data table and extend the pattern to the

challenge distance. Alternatively, they could use proportional thinking, or they could plot a graph of time vs. position and extrapolate a linear model. The teacher is encouraged to let the student decide. The teacher could ask questions to direct a student who is having trouble arriving at a schema for solving the problem. Below are possible solutions. See example program c3 in Unit 1 Skill Builder 1 Example Programs.tns Note, students could use the timer widget on the TI-Nspire as a stopwatch, the stopwatch app on their cell phone, or a physical stopwatch.

Drive for a distance with unknown time:
Send "CONNECT RV"
Send "RV FORWARD .4 M "

Drive for a time with unknown distance:
Send "CONNECT RV"
Send "RV FORWARD TIME 11"

Identifying Patterns:

Time (sec)	Distance (M)
0	0
2.43	.4
4.85	.8
7.17	1.2
9.68	1.6
12.5	2.0
~15	2.4

$$\Delta t_1 = 4.85 - 2.43 = 2.42$$

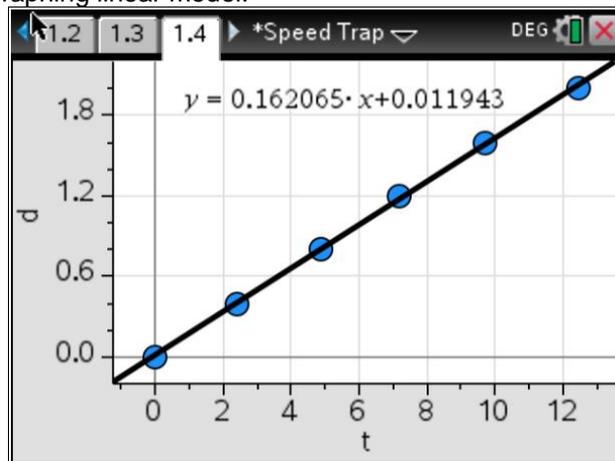$$\Delta t_2 = 9.68 - 7.17 = 2.51$$

$$t = 12.5 + 2.47 = 14.97$$

Proportional Reasoning:

$$\frac{12.5}{2.0} = \frac{X}{2.4}, \ X = 2.4 \times \frac{12.5}{2.0}, \ X = 15$$

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Graphing linear model:

$$2.4 = .162X + .012$$

$$X = \frac{2.4 - .012}{.163}$$

$$X = 14.7$$