Activity
In this activity, you build a complete robot called Protobot. You start by building the base.

1. To complete the first step:
   - Locate and select one Chassis Rail [R15] and one Angle [A15].
   - Overlap the pieces to form a corner.
   - Fasten the pieces together using three #8-32 x 1/4" screws [S2] and nuts.

![Diagram of step 1]

The completed model is as shown:

![Completed model diagram]

2. To complete the next step:
   - Locate an additional Angle and Chassis Rail from the kit.
   - Repeat step 1 to form the other three corners.
The completed model is as shown:

3. To complete the next step:
   - Orient the frame so a Chassis Rail is facing you.
   - Attach two Bearing Flats [BF] using Bearing Rivets [BR].
   - Repeat on the opposite Chassis Rail.
The completed model is as shown:

4. To complete the next step:

- Locate and position the 5 x15 Plate [P15].
- Attach to the frame using four screws and nuts.
5. To complete the next step:

- Locate two Motor Modules [MOT] in the kit and four [SS2] screws. Double check to make sure you have two motors and not servo modules.
- Attach the motors as shown. Be sure to locate the motor in the middle holes in the rail.
6. To complete the next step:
   - Flip the entire assembly over.
   - Attach the Antenna Holder [AH] using a #8-32 x 3/8" screw and nut.

The Antenna Straw shown will not be attached until the Receiver is attached later.
The finished model is as shown:

7. To complete the next step:
   - Locate another Chassis Rail.
   - Attach three Bearing Flats using the Bearing Rivets.
The completed model is as shown:

The finished model is as shown:

10. To complete the next step:

- Place a 60-tooth gear [G60] on each axle.
- Place a shaft collar [COL] on the middle gear and lightly tighten in position. You will need to adjust the position of the collar when you attach the shaft to the motor.
- Place a thin spacer [SP1] on the other axles.
The completed model is as shown:

11. To complete the next step:
   - Place a 4" Wheel [W4] on the two outer shafts.
   - Position and tighten shaft collars to hold the wheels.
The completed model is as shown:

12. To complete the next step:

- Turn the assembly around and attach shaft collars. Tighten the outer two collars. Leave the middle collar loose on the shaft. You will reposition and tighten the collar when you add the wheel assembly to the base.
13. To complete the next step:

- Make an identical assembly for the other side of the robot by repeating steps 7-12.

The completed model is as shown:
14. To complete the next step:

- Loosen the outer shaft collar on the middle shaft on one of the completed wheel assemblies. The inner shaft collar should already be loose.
- Align the wheel assembly with the base assembly.
- Push the two assemblies together making sure that the middle axle slides into the clutch smoothly. You may need to rotate the wheels slightly to line up the axle with the square hole in the clutch.
- Add two screws [S2] into the threaded beams on the wheel assembly.
- Tighten the shaft collars on the middle shaft.

The completed model is as shown:
15. Repeat the wheel attachment on the other side.

The completed model is as shown:
16. Attach the receiver module [RX75] with two 8-32 x 3/8" screws and nuts. Feed the antenna through the antenna tube and insert the tube into the Antenna Holder.
17. Attach two Battery Straps [BST] using four 8-32 x 3/8" screws and nuts.
18. To complete the next step:

- Flip the assembly over.
- Attach four 1/2" beams [B0.5] in the positions shown using #8-32 x 1/4" screws [S2].

The completed model is as shown:
19. To complete the final step:

- Fasten the Microcontroller [VMC] to the tops of the threaded beams using #8-32 x 3/8" screws [S3].
- Plug the right and left drive motors into motor ports 2 and 3 respectively (not shown).
- Attach the yellow receiver wire to the receiver and the "Rx1" jack on the Microcontroller (not shown).
- Install a 7.2V battery into the straps and plug it into the controller (cable not shown).
Protobot Stand Assembly Instructions

1. To complete the first step:
   - Locate the appropriate C-channel [C15] from the kit.
   - Attach two 3” beams [B3] to the C-channel with screws [S2].

20. You are ready to drive!
The completed model is as shown:
2. Repeat step 1 but complete a mirror-image assembly.
The completed model is as shown:
3. Attach a Bearing Flat [BF] to the C-channel assembly from step 1. Be sure to use the matching assembly for this step, and to place the heads of the rivets on the inside of the C-channel.
The completed model is as shown:
4. To complete the next step:

- Attach a Bearing Flat in the same position on the C-channel assembly completed in step 2.
- Attach an additional Bearing Flat to the same C-channel in the position shown.
The completed model is as shown:

[Diagram of a model with labeled parts: BR X 4 and BF X 2]
5. Both stand sides should appear as shown when positioned in this manner.

6. Attach a Motor [MOT] to the near C-channel assembly so that the clutch lines up with the center hole in the opposite side's bearing flat.
7. Place and attach a 2" beam [B2] and two thin spacers [SP1] to the end of the stand assembly as shown. Be sure to attach the beam in the top holes of the C-channel.
The completed model is as shown:

8. To complete the next step:
   - Feed a 3" shaft [SQ3] through the bearing hole opposite the motor.
   - Thread a thin spacer [SP1], a 12-tooth gear [G12], a collar [COL], a thick spacer [SP2], a thin spacer [SP1], a 12-tooth gear [G12], and one more collar [COL] on the axle as it is pushed into the motor clutch.
   - Seat the shaft into the clutch and tighten the collars.
9. The stand assembly is now complete.
Protobot Arm Assembly Instructions

1. To complete the first step:
   - Locate a 1 x 2 x 1 x 25 C-channel [C25].
   - Attach a Motor [MOT] as shown.

The completed model is as shown:
2. Use Bearing Rivets [BR] to attach five Bearing Flats [BF] in the positions shown.

The completed model is as shown:
3. Attach an 84-tooth gear [G84] to the end of the C-channel using two screws [S3] and nuts. Be sure to position the gear off-center, fastening it through the holes shown.

The completed model is as shown:
4. Attach two 1" beams [B1] in the positions shown using two screws [S2].

The completed model is as shown:
5. Attach another 84-tooth gear on the opposite side of the arm using the same fasteners.

The completed model is as shown:

6. Place one 4" shaft [SQ4] through the end bearing blocks and two 2" shafts [SQ2] through the center of the other two
blocks. When inserting the 2" shafts, place a collar [COL] between the bearing blocks on the inside of the C-channel. Do not tighten! Be sure to firmly seat the driven axle into the clutch.

The completed model is as shown:

7. To complete the next step:
   - Fit three 36-tooth gears [G36] to the shafts.
   - Place two thin spacers [SP1] on each side of the end shaft.
   - Place two collars [COL] to the outside of the other two gears.
• Tighten the collars, allowing for smooth movement of the gears.

The completed model is as shown:

8. To complete the next step:

• Place two low-friction wheels on the end shaft.
• Place collars on the axle shaft and tighten.
The completed model is as shown:

9. To complete the next step:

- Attach three 2" beams [B2] in the position shown using three screws [S2].
- Bend a 25-hole bar [B25] at the locations shown and attach to the beams using screws [S2].
- The angle of the bends will be modified later to adjust for the size of the scoring component.
The completed model is as shown:
- Flip the assembly over.
- Attach a limit switch [SWL] in the position and orientation shown. This will be used to stop the arm's rotation in order to prevent damage to the motor.

The completed model is as shown:

11. The completed arm assembly.
Protobot Final Assembly Instructions

1. To complete the first step:
   - Get your completed drive base.
   - Position the completed stand above the base.
   - Attach the stand to the base using four #8-32 x 1/4" screws [S2].
The completed model is as shown:
2. To complete the next step:

- Position the completed arm assembly between the C-channels of the stand.
- Thread a 3" shaft [SQ3] through the 84-tooth gear's center using a spacer [SP2] and a collar [COL] as shown.

The completed model is as shown:
3. Attach another Limit Switch to the bumper on the front of the robot as shown.

The completed model is as shown:
4. The final step is to connect the PWM connectors into the appropriate ports on the Microcontroller as follows:

   - Arm Rotation motor to Motor Port 6.
   - Roller Motor to Motor Port 5.
   - Arm Mounted Limit Switch to Analog/Digital Port 5.

5. Your Protobot is ready to roll!

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**Configure the Transmitter**

You now configure the Transmitter so the directional controls on channel 1 are in standard mode. See the VEX Inventor's Guide for detailed information on configuring the transmitter.

1. Turn on the Transmitter.
2. Check the voltage. If the voltage is less than 8.9 volts, recharge the batteries in the transmitter.

3. Press and hold the MODE and SELECT buttons simultaneously until the CONFIG menu is displayed.

4. Press the MODE button once to display the REVERSE menu.

5. Channel 1 should be in standard direction mode (the arrow is next to STD). If it is in reverse direction mode (the arrow is displayed next to REV), press the DATA INPUT plus key.
6. Press and hold the MODE and SELECT buttons simultaneously until the voltage is displayed.

7. Turn on the Microcontroller and go for a drive!