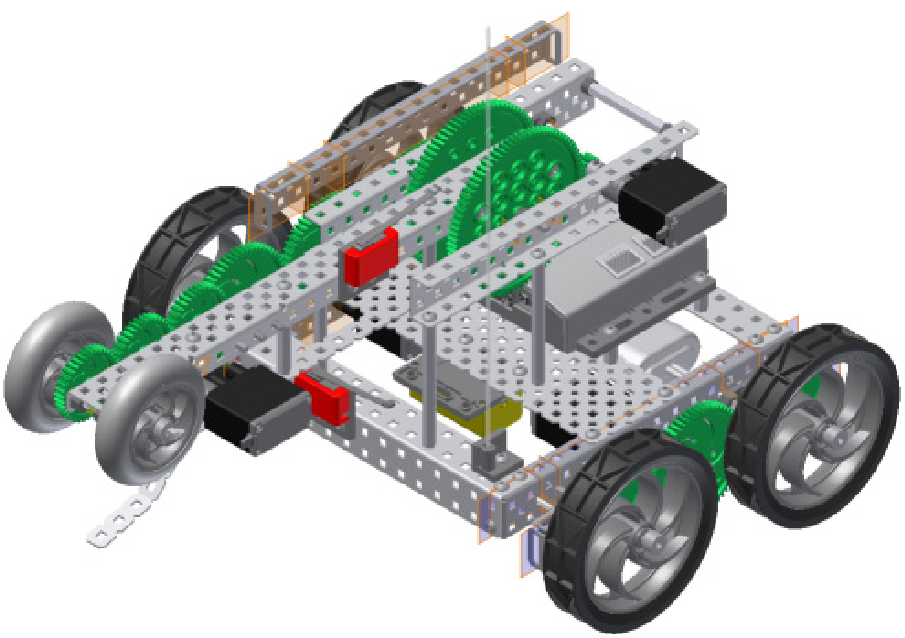
Unit

1

Introduction to VEX and Robotics

VEX lab kits bring robotics into the classroom, making it a fun and educational experience for all. In this introductory unit, you review the kit and parts that make up the VEX Protobot. In addition, you start using Autodesk® Inventor®. This solid modeling software makes it easy to design and analyze robot parts.

VEX Protobot



Unit Objectives

After completing Unit 1: Introduction to VEX and Robotics, you will be able to:

- Review the basic components of a robot.
- Review the parts in the VEX Classroom Lab Kit.
- Work with VEX parts.
- Get started with Autodesk Inventor.
- Identify and use the different parts of the VEX Classroom Lab Kit to complete subassemblies in the creation of a tumbler.
- Build a robot component.

Prerequisites

Before starting Unit 1: Introduction to VEX and Robotics, it would be helpful to:

- Open and unpack your VEX Classroom Lab Kit.
- Read the VEX documentation provided in the VEX Classroom Lab Kit. (VEX documentation is also available under "Education and Competition Resources" on the VEX Robotics web site at *http://www.VEXrobotics.com/edr-resources*.)
- Install Autodesk® Inventor® Professional 2009. Teachers, join and invite your students to join the Student Community to download free Autodesk Inventor software, so they can continue their coursework at home. Join the Autodesk Student Engineering and Design Community at *http://www.autodesk.com/edcommunity*.

Key Terms and Definitions

The following key terms are used in Unit 1: Introduction to VEX and Robotics.

Term	Definition
Autonomous	Describes a robotic system that carries out programs or performs tasks without outside control by acquiring, processing, and acting on environmental information.
Behavior	Behavior is exhibited in response to different inputs. The output devices of a robot are how the robot exhibits its behavior.
Body	The robot body can be of any shape and size. The majority of actual robots look nothing like their human creators. They are typically designed more for function than appearance.
Central Processing Unit (CPU)	Directs a robot's behavior autonomously, through human instructions, or from a combination thereof. It must also be able to receive input from sensors that provide information on its position and environment.
Control System	A program that tells the robot how to act in different circumstances, and the electronics that process the information. This programming can be very simple or extraordinarily complex, but it is designed to enable the machine to react to its environment through code or sensory input such as touch, temperature, and light sensors.

Term	Definition
Robot	A programmable, mechanical device that can perform tasks and interact with its environment.
Tele-operated	Describes a robotic system that is human controlled.

Required Supplies and Software

The following supplies and software are used in Unit 1: Introduction to VEX and Robotics.

Supplies	Software
VEX Classroom Lab Kit	Autodesk Inventor Professional 2009
Notebook and pen	
Work surface	
Small storage container for loose parts	
Two “obstacles.” This can be any small object in your class.	
10' x 4' of open space against a wall	

Academic Standards

The following national academic standards are supported in Unit 1: Introduction to VEX and Robotics.

Phase	Standard
Think	**Science (NSES)** *Unifying Concepts and Processes*: Form and Function *Science and Technology*: Abilities of Technological Design **Technology (ITEA)** 3.2: Core Concepts of Technology 3.3: Relationships Among Technologies 4.5: The Effects of Technology on the Environment 4.7: The Influence of Technology on History **Mathematics (NCTM)** *Connections* Recognize and apply mathematics in contexts outside of mathematics.

Phase	Standard
Create	**Science (NSES)** *Unifying Concepts and Processes*: Form and Function *Physical Science:* Motions and Forces *Science and Technology*: Abilities of Technological Design **Technology (ITEA)** 5.8: The Attributes of Design 5.9: Engineering Design 6.12: Use and Maintain Technological Products and Systems **Mathematics (NCTM)** *Numbers and Operations* Understand numbers, ways of representing numbers, relationships among numbers, and number systems. *Algebra Standard* Understand patterns, relations, and functions. *Geometry Standard* Use visualization, spatial reasoning, and geometric modeling to solve problems. *Measurement Standard* Understand measurable attributes of objects and the units, systems, and processes of measurement.
Build	**Science (NSES)** *Unifying Concepts and Processes*: Form and Function *Science and Technology*: Abilities of Technological Design **Technology (ITEA)** 3.2: Core Concepts of Technology 3.3: Relationships Among Technologies **Mathematics (NCTM)** *Connections* Recognize and apply mathematics in contexts outside of mathematics.
Amaze	**Science (NSES)** *Unifying Concepts and Processes*: Form and Function *Science and Technology*: Abilities of Technological Design **Technology (ITEA)** 3.2: Core Concepts of Technology **Mathematics (NCTM)** *Connections* Recognize and apply mathematics in contexts outside of mathematics.

What Is Robotics?

What Is a Robot?

A robot is a programmable mechanical device that can perform tasks and interact with its environment (with no human interaction).

The word *robot* was coined by the Czech playwright Karel Capek in 1921. He wrote a play called *R.U.R.* (Rossum's Universal Robots) that was about a slave class of manufactured human-like servants and their struggle for freedom. The Czech word *robota* loosely means "compulsive servitude." The word *robotics* was first used by the famous science fiction writer, Isaac Asimov.

A child's wind-up toy shares many of the characteristics of a robot, but lacks a control system that guides its behavior.

Basic Components of a Robot

The components of a robot are the body, control system, central processing unit, and behavior.

Body – The body can be of any shape and size. Most people are comfortable with human-sized and shaped robots that they have seen in movies, but the majority of actual robots look nothing like their human creators. They are typically designed more for function than appearance.

Control System – The control system is a program that tells the robot how to act in different circumstances and the electronics that process the information. This programming can be very simple or extraordinarily complex, but it is designed to allow the machine to react to its environment through code or sensory input (touch, temperature, and light sensors). The program is the robot's set of instructions.

Central Processing Unit – The Central Processing Unit (CPU) of a robot directs its behavior in response to different circumstances or inputs. If not autonomous, the robot must be able to receive human instructions that define its tasks. It must also receive input from sensors that provide information on its position and environment.

Behavior – Behavior is exhibited in response to different inputs. The output devices of a robot are how the robot exhibits its behavior.

Uses of Robots

Robots are used for:

- Precision work
- Repetitive/monotonous work
- Dangerous work
- Exploration
- Competition
- Education

Precision Work

Programming a robotic arm to make something like a peanut butter and jelly sandwich could take hundreds of instructions. That is why in factories that use robotic devices, each device is designed and programmed to do just a few steps of the manufacturing process over and over again. The item being manufactured goes from one robotic station to the next until it is completed.

Robots can be programmed to do things that humans would grow tired of very easily or cause damage to the human body by repetitive movements (weld cars together, stack boxes, and so on).

A Boeing X-45A Unmanned Combat Aerial Vehicle (UCAV) during flight tests at NASA Dryden Flight Research Center. (NASA image)

Dangerous Work

Robots can be designed to perform tasks that would be difficult, dangerous, or impossible for humans to do. For example, robots are now used to defuse bombs, service and clean nuclear reactors, investigate the depths of the ocean and the far reaches of space. Quasi-autonomous unmanned aerial vehicles are now undertaking many of the military's most dangerous reconnaissance and strike missions. The MQ-1 Predator is a medium-altitude, long-endurance, remotely piloted aircraft. The MQ-1's primary mission is interdiction and conducting armed reconnaissance against critical, time-sensitive targets. The RQ-4 Global Hawk flies at altitudes up to 65,000 feet for up to 35 hours at speeds approaching 340 knots. It can image an area the size of the state of Illinois in just one mission. The National Aeronautics and Space Administration (NASA) and corporate entities are working on autonomous machines to transport materials and provide robotic aerial refueling of aircraft.

Robots and NASA

Some of the most dangerous and challenging environments are found beyond the Earth. For decades, NASA has utilized probes, landers, and rovers with robotic characteristics to study outer space and planets in our solar system.

Sojourner sampling a large rock formation on the Martian surface. (Image courtesy of NASA)

Pathfinder and Sojourner

The Mars Pathfinder mission developed a unique technology that allowed the delivery of an instrumented lander and a robotic rover, Sojourner, to the surface of Mars. It was the first robotic roving vehicle to be sent to the planet Mars. Sojourner weighs 11.0 kg (24.3 lbs.) on Earth (about 9 lbs. on Mars) and is about the size of a child's wagon. It has six wheels and could move at speeds up to 0.6 meters (1.9 feet) per minute. Pathfinder not only accomplished this goal but also returned an unprecedented amount of data and outlived its primary design life.

Computer-generated rendering of a Mars Exploration Rover (MER). (NASA image)

Spirit and Opportunity

The Mars Exploration Rovers (MERs), Spirit and Opportunity, were sent to Mars in 2003 and landed there in early 2004. Their mission was to search for and characterize a wide range of rocks and soils that hold clues to past water activity on Mars in hopes that a manned mission may someday follow. Both rovers are still operating, far surpassing their 90-day warranty period.

On space shuttle mission STS-41B, February 1984, the Canadarm was used as a platform for spacewalk work by astronauts Bruce McCandless II (pictured) and Robert L. Stewart. (NASA image)

Space Shuttle Robotic Arm

When NASA scientists first began the design for the space shuttle, they realized that there would have to be some way to get the enormous, but fortunately weightless, cargo and equipment into space safely and efficiently. The remote manipulator system (RMS), or Canadarm, made its first flight into space on November 13, 1981.

The arm has six joints. Two are in the shoulder, one is at the elbow, and three in the highly dextrous wrist. In the weightless environment of space, it can lift more than 586,000 pounds and place it with incredible accuracy.

The RMS has been used to launch and rescue satellites and has proven itself invaluable in helping astronauts repair the Hubble Space Telescope.

An unprecedented "handshake in space" occurred on April 28, 2001, as the Canadian-built space station robotic arm, also referred to as Canadarm2, transferred its launch cradle over to Endeavour's Canadian-built robotic arm. (NASA image)

The International Space Station

In the 25 years since the RMS's first flight, it has been joined by a new more advanced design that resides on the International Space Station. Canadarm2 works in tandem with its cousin on nearly every shuttle flight to help build the space station by passing school-bus-sized modules between them and placing them for the astronauts to assemble.

Computer rendering of the Special Purpose Dexterous Manipulator, or "Dextre." (NASA inage)

Dextre

As part of the Space Shuttle mission STS-123 in 2008, the shuttle Endeavour carried the final part of the Special Purpose Dexterous Manipulator, or "Dextre."

Dextre is a robot with two smaller arms. It is capable of handling the delicate assembly tasks currently performed by astronauts during spacewalks. Dextre can transport objects, use tools, and install and remove equipment on the space station. Dextre also is equipped with lights, video equipment, a tool platform, and four tool holders. Sensors enable the robot to "feel" the objects it is dealing with and automatically react to movements or changes. Four mounted cameras enable the crew to observe what is going on.

Dextre's design somewhat resembles a person. The robot has an upper body that can turn at the waist and shoulders that support arms on either side. (NASA)

Astronaut spacewalk helper the "Robonaut."
(NASA image)

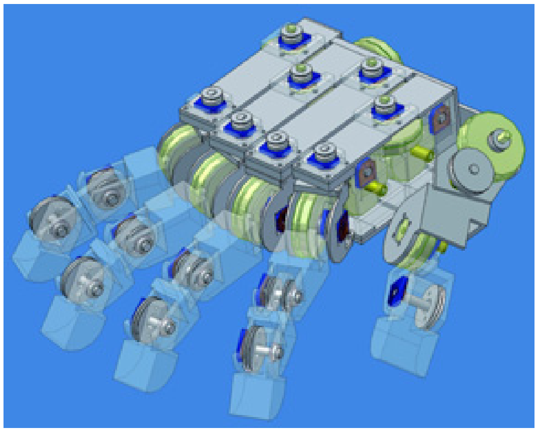
Robonaut

Robonaut is a humanoid robot designed by the Robot Systems Technology Branch at NASA's Johnson Space Center (JSC) in a collaborative effort with DARPA. The Robonaut project seeks to develop and demonstrate a robotic system that can function as an Extravehicular Activity (EVA) astronaut equivalent.

The challenge is to build machines that can help humans work and explore in space. Working side by side with humans, or going where the risks are too great for people, machines like Robonaut will expand our ability for construction and discovery. (NASA)

Robots in the Future: Nanotechnology

Nanotechnology is molecular manufacturing or, more simply, building things one atom or molecule at a time with programmed nanoscopic robot arms. A nanometer is one billionth of a meter (3 to 4 atoms wide). The trick is to manipulate atoms individually and place them exactly where needed to produce the desired structure. This ability is almost in our grasp.



Computer designed robotic hand to reproduce human movement. (Autodesk image)

Robotics in Our Future?

During the Industrial Revolution, humans used their increasing skill to build machines that were essentially larger, stronger, and improved models of human design to do the work of many. In the modern age, these machines are still being constructed, but now a new type of machine has evolved that more closely resembles the human nervous system. Recently, these concepts of copying human design and control were merged, ushering in the era of bionics and cybernetics.

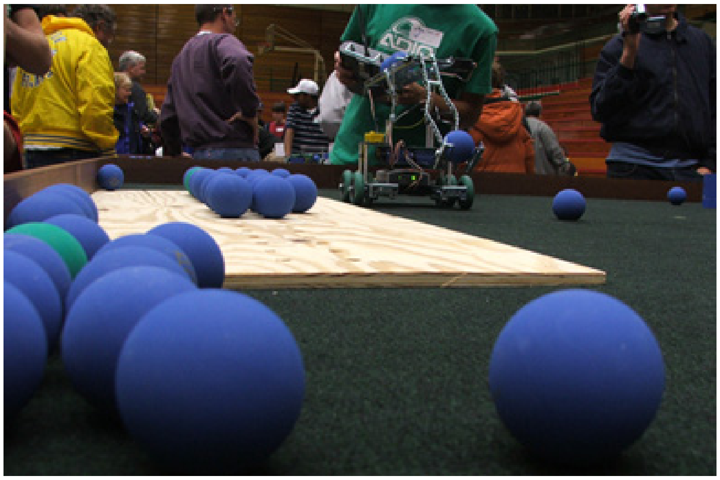
The field of cybernetics, derived from the Greek word for *steersman* (kybernetes), was first developed in the 1940s. It can best be described as the science of communication and control in an animal or a machine. Bionics is merging these devices with living beings to replace or supplement organs or limbs lost to accident or disease.

Robotics in Education

The field of robotics is quickly becoming an exciting and accessible tool for teaching and supporting science, technology, engineering, mathematics (STEM), design principles, and problem solving. Robotics enables students to use their hands and minds to create like an engineer, artist, and technician does, all at once.

In today's education system with its budgetary constraints, middle and high schools are on a constant search for cost-effective exciting ways to deliver high-impact programs that integrate technology with multiple disciplines while preparing students for careers in the twenty-first century. Educators quickly see the advantages that robotics projects and curriculum provide to link in a cross-curriculum method with other disciplines. Additionally, robotics can provide more affordability and reusability of equipment as compared to other prepackaged options.

Today, more than ever, schools are adopting robotics in the classroom to revitalize curriculum and meet ever increasing academic standards required for students. Robotics not only has a unique and broad appeal throughout various teaching fields, but it is, quite possibly, the technical field that will have the largest influence upon our society throughout the next century.



Robotics gather racquetballs to score at a student robotics event.
(Image from Daniel Ward II)

Introduction to Competitive Robotics

The true test of a robot's abilities is to challenge others in a competitive environment. There is no better way to evaluate design parameters, sturdiness of construction, and student ability than a well-designed competition. This scenario is very realistic; large projects in industry that require tremendous investment such as a building, military vehicle, or aircraft, are often put head-to-head in order to select the winner that gets the work.

Robotics competition is designed to provide students of all ages, backgrounds, and levels of study with the opportunity to demonstrate their knowledge and understanding of design, manufacturing processes, materials, programming, and other technologies. Students are judged on their application of technology principles to solve the challenge, knowledge of engineering concepts that aid them in solving the problem, and their ability to solve real-world problems in a team environment as they work together to overcome their opponents, all while having fun.

Introduction to VEX

VEX Robotics Design System

In the relatively short history of hobbyist robotic kits in the commercial market, a wide chasm has existed between the "Lego Mindstorms," marketed primarily to young children, and the far more complex, high-end machines offered by other companies.

Innovation First, Inc. and their VEX Robotics Design System, bridges that gap with a robust, and challenging robot kit for students in the middle school environment. In fact, this well-machined, reasonably-priced kit succeeds as a helpful introduction to technology for students of any age.

VEX Classroom Lab Kit

VEX Classroom Lab Kit

IFI's VEX EDR Robotics Design System is a leading classroom robotics platform designed to nurture creative advancement in robotics and knowledge of science, technology, engineering, and math (STEM) education. The VEX EDR system provides teachers and students with an affordable, robust, and state-of-the-art robotics system suitable for classroom use and the playing field. VEX's innovative use of premanufactured and easily formed structural metal, combined with a powerful and user-programmable microprocessor for control, leads to infinite design possibilities.

What's in the VEX Classroom Lab Kit?

VEX Parts Details

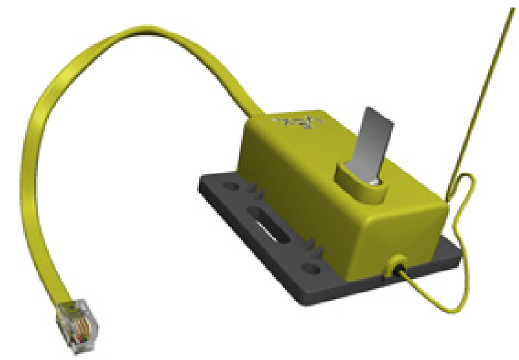
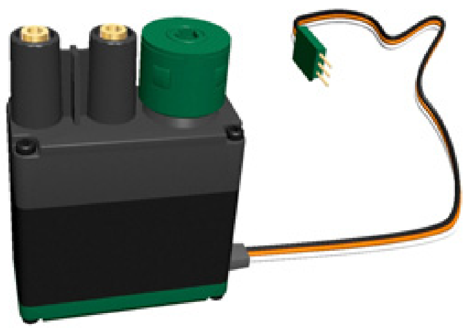
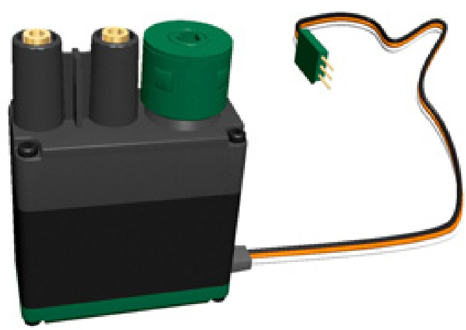
VEX Robotics Design System

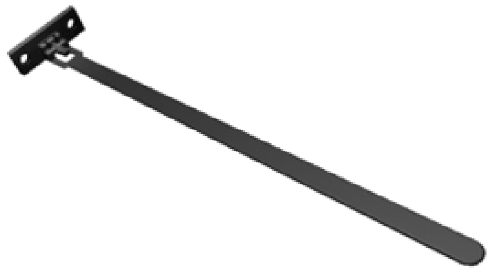
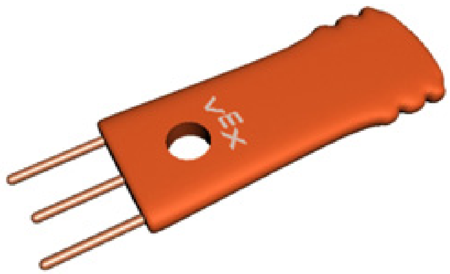
The VEX Classroom Lab Kit consists of rugged reusable metal and plastic parts designed for durability. The entire kit can be assembled with the basic hand tools included. Some designs may require cutting of structural parts, which can be accomplished by using a cutoff tool or snips. Always keep safety in mind and wear safety glasses when using tools or running the robot.

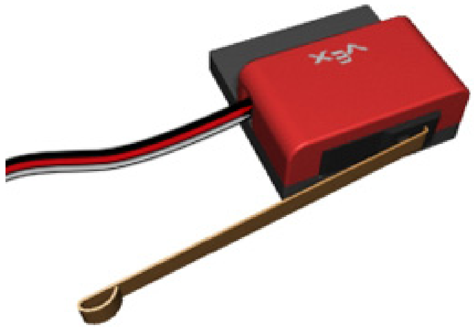
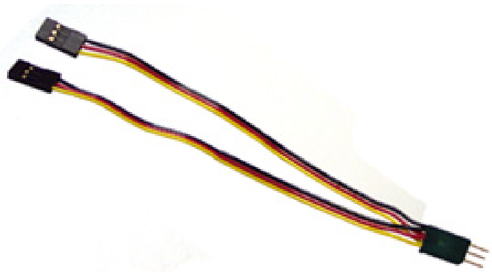
What's in the VEX Classroom Lab Kit

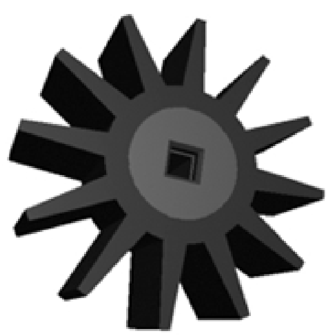
This list below details what parts are included in the VEX Classroom Lab Kit, their assigned part quantities and VEX part abbreviations. Refer to the *Working with VEX Parts* section for more information on each subsystem and their uses.

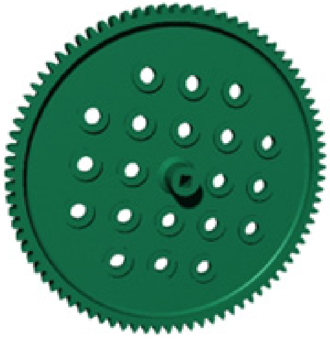
Part	Part Description/ Quantity	Part Abbreviation
	VEX Transmitter Quantity: 1	
	VEX Microcontroller Quantity: 1	VMC

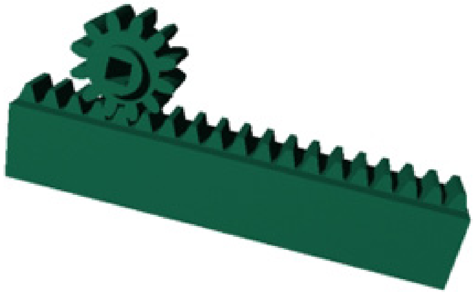
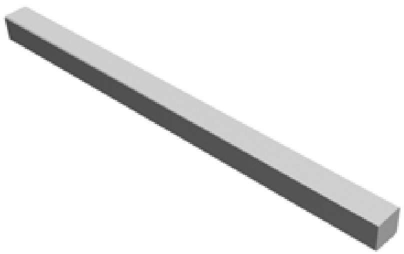
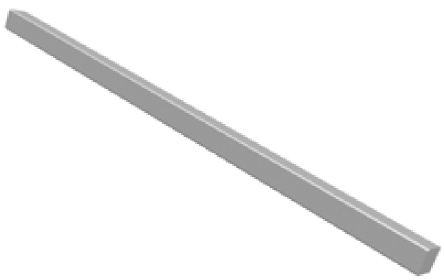
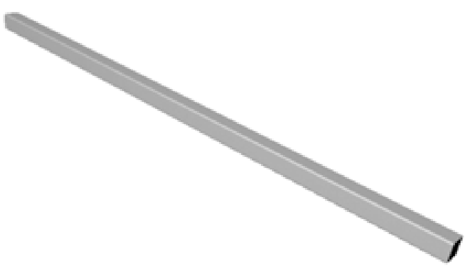
Part	Part Description/ Quantity	Part Abbreviation
	VEX Receiver Module Quantity: 1	RX75
	VEX Motor Module Quantity: 4	MOT
	VEX Servo Module Quantity: 1	SRV
	VEX 7.2-Volt battery Box Quantity: 1	

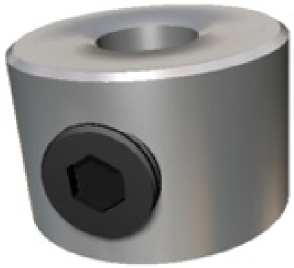
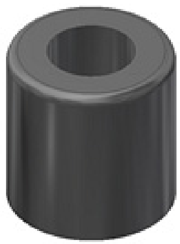
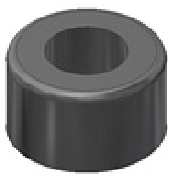
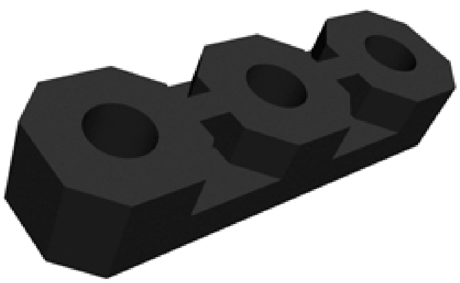
Part	Part Description/ Quantity	Part Abbreviation
	Battery Strap Quantity: 2	BST
	Jumper Pins Quantity: 3	JMP
	Antenna Tube Quantity: 1	AT
	Antenna Holder Quantity: 1	AH
	Zip Tie Quantity: 100	ZIP

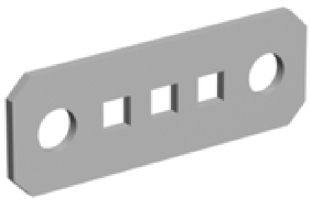
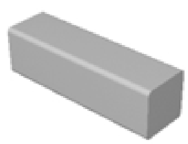
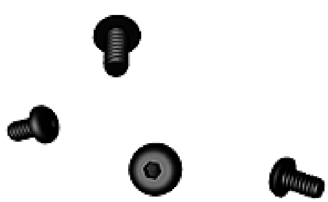
Part	Part Description/ Quantity	Part Abbreviation
	VEX Limit Switch Quantity: 2	SWL
	VEX Bumper Switch Quantity: 2	SWB
	6" PWM Extension Cable Quantity: 2	
	12", 24", and 36" PWM Extension Cables Quantity: 2 12" PWM Extension Cables 1 24" PWM Extension Cable 1 36" PWM Extension Cable	
	PWM Y-Cable Quantity: 2	

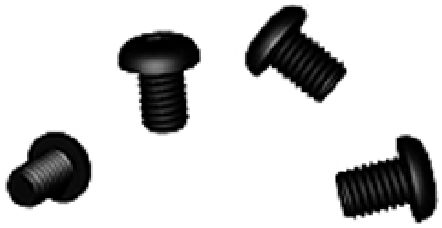
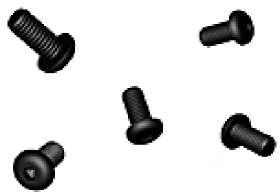
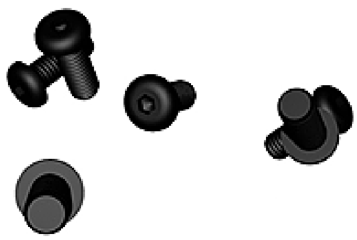
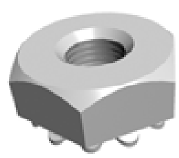
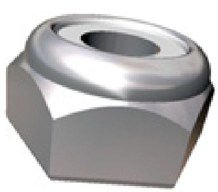
Part	Part Description/ Quantity	Part Abbreviation
	Rough Terrain Wheel Quantity: 4	W5
	All Purpose Wheel Quantity: 4	W4
	Low Friction Wheel Quantity: 4	W2.8
	Intake Roller Quantity: 2	ROL

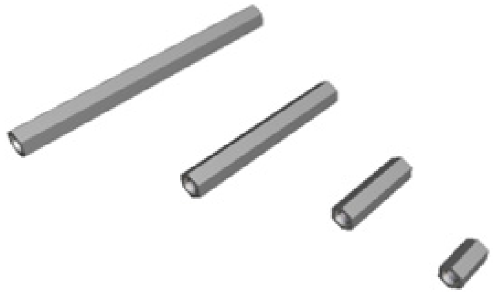
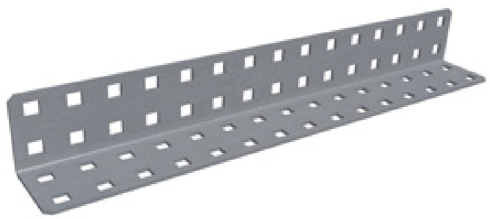
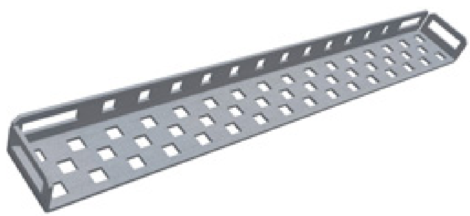
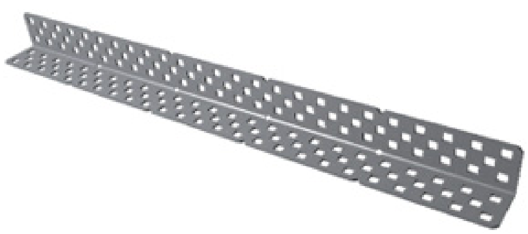
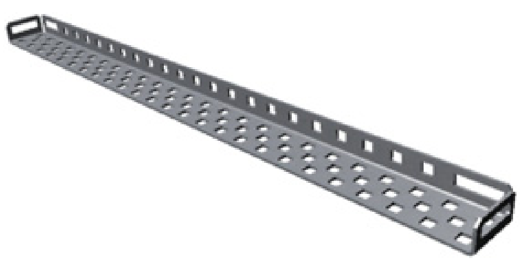
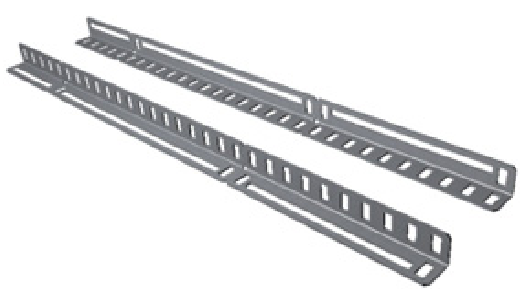
Part	Part Description/ Quantity	Part Abbreviation
	84-Tooth Gear Quantity: 4	G84
	60-Tooth Gear Quantity: 10	G60
	36-Tooth Gear Quantity: 8	G36
	12-Tooth Gear Quantity: 8	G12

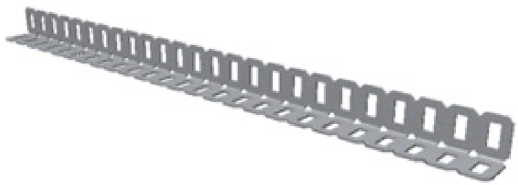
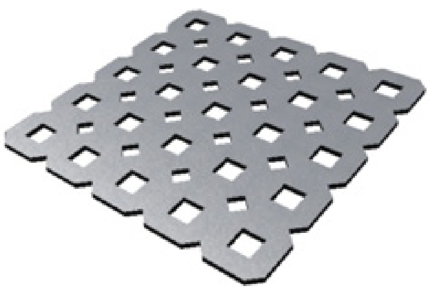
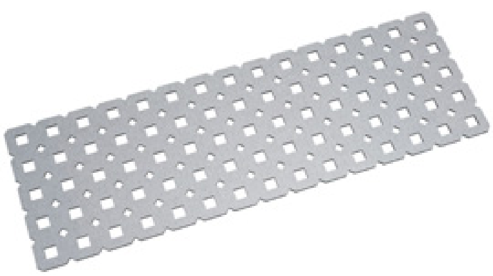
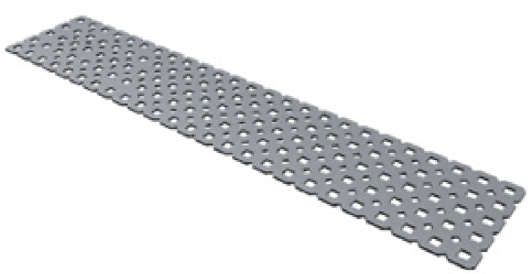
Part	Part Description/ Quantity	Part Abbreviation
	19 -Tooth Rack (Drive Gear shown) Quantity: 4	GR19
	Drive Shaft, Square-Bar 2" Quantity: 8	SQ2
	Drive Shaft, Square-Bar 3" Quantity: 10	SQ3
	Square-Bar 4" Quantity: 3	SQ4
	Shaft 12" Quantity: 2	SQ12

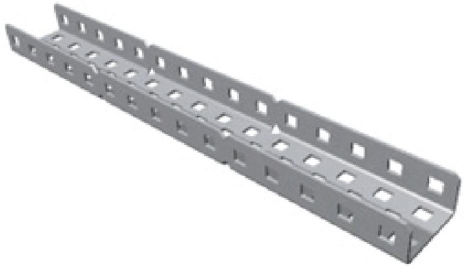
Part	Part Description/ Quantity	Part Abbreviation
	Shaft Collar Quantity: 37	COL
	Thick Spacer Quantity: 21	SP2
	Thin Spacer Quantity: 31	SP1
	Bearing Flat Quantity: 36	BF
	Bearing Block Quantity: 6	BB

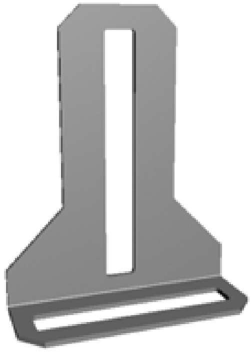
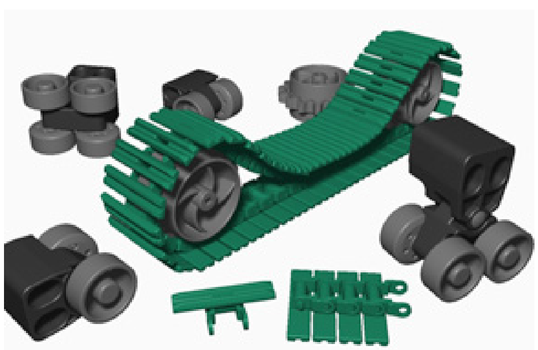
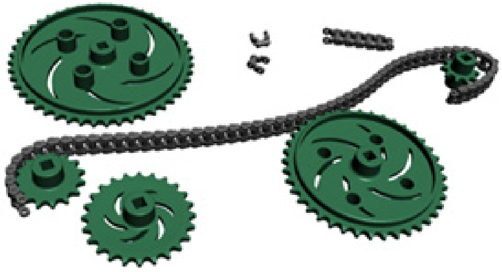
Part	Part Description/ Quantity	Part Abbreviation
	Shaft Lock Bars Quantity: 6	LB
	Bar Lock Quantity: 0	
	Plastic and Steel Washers Quantities: 10 Plastic 10 Steel	WP & WS
	Clutch Post Quantity: 4	MCL
	Motor Screw, Short (1/4") Quantity: 21	SS2
	Motor Screw, Long (1/2") Quantity: 18	SS4

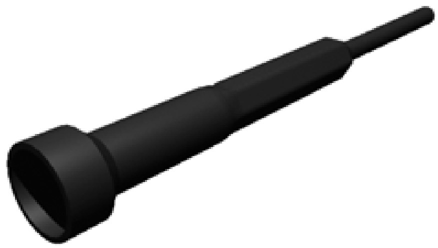
Part	Part Description/ Quantity	Part Abbreviation
	Screw #8-32 x 1/4" Long Quantity: 120	S2
	Screw #8-32 x 3/8" Long Quantity: 43	S3
	Screw #8-32 x 1/2" Long Quantity: 38	S4
	Screw #8-32 x 3/4" Long Quantity: 16	S6
	Keps Nuts Quantity-96	NK
	Nylock Nuts Quantity: 14	NL
	Plastic Bearing Rivets Quantity: 100	BR

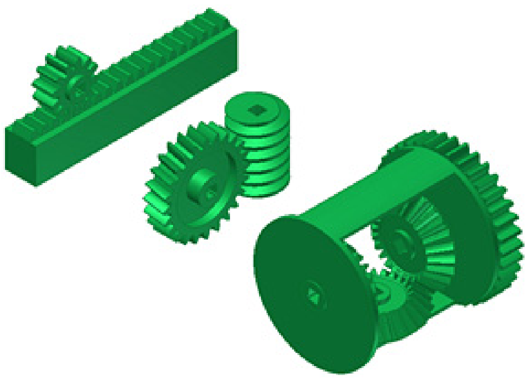
Part	Part Description/ Quantity	Part Abbreviation
	Threaded Beams, 1/2", 1", 2", 3" Quantities: 14 1/2" 12 1" 8 2" 8 3"	B0.5, B1, B2, B3
	Chassis Bumper (2x2x15) Quantity: 2	A15
	Chassis Rail (15 Hole) Quantity: 4	R15
	Chassis Bumper (2x2x25) Quantity: 2	A25
	Chassis Rail (25-Hole) Quantity: 4	R25
	Angle Bars (mirror images of each other) Quantity: 2 of each	AS30 & AS30R

Part	Part Description/ Quantity	Part Abbreviation
	Angle Bar (1x1x 25) Quantity: 2	AR25
	25 Hole Bar Quantity: 10	B25
	Plate 5x5 Quantity: 2	P5
	Plate 5x15 Quantity: 3	P15
	Plate 5x25 Quantity: 2	P25

Part	Part Description/ Quantity	Part Abbreviation
	C-Channel 1x2x1x15 Quantity: 4	C15
	C-Channel 1x2x1x25 Quantity: 3	C25
	C-Channel 1x5x1x25 Quantity: 3	CW25
	Pivot Gusset Quantity: 4	GP

Part	Part Description/ Quantity	Part Abbreviation
	Angle Gusset Quantity: 4	GA
	Plus Gusset Quantity: 4	G+
	Tank Tread Kit Quantities: 4 Tank Tread Double Bogie Wheels 2 Tank Tread Single Bogie Wheels 170 Tank Tread Links 4 Tank Tread Sprockets 12 Screws, #8-32 x 1" Long 12 Keps Nuts	TDB, TSB, TL, TS15, S8, NK
	Chain and Sprocket Kit Quantities: 326 Chain Links 2 10 Tooth Sprockets 4 15 Tooth Sprockets 4 24 Tooth Sprockets 2 40 Tooth Sprockets 2 48 Tooth Sprockets	CL, CS10, CS15, CS24, CS40, CS48

Part	Part Description/ Quantity	Part Abbreviation
	Nut Starter Quantity: 1	
	Allen Wrenches 3/32" and 5/64" Quantity: 1 of each	
	Open-Ended Wrench Quantity: 1	
	Safety Glasses Quantity: 4	
	Programming Cable Quantity: 1	

Part	Part Description/ Quantity	Part Abbreviation
	Power Pack Quantities: 1 7.2 Volt Robot Battery 1 9.6 Volt Transmitter Battery 1 7.2 Volt Wall Charger 1 9.6 Volt Wall Charger	
	Advanced Gear Kit Quantities: 7 Bevel Gears 1 Differential Gear Housing 8 Rack Gears 4 Worm Wheels 4 Worm Gears 2 12 Tooth Gears 16 Motor Screws, Short (1/4")	BG24, GR19, GW24, GW, DG36

Working with VEX Parts

VEX Robotics Design System

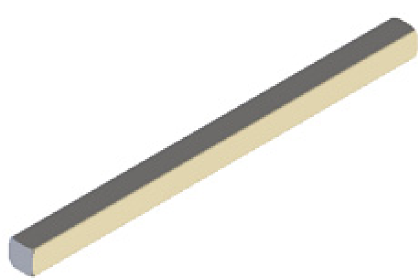
VEX Classroom Lab Kit

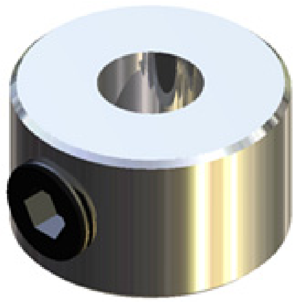
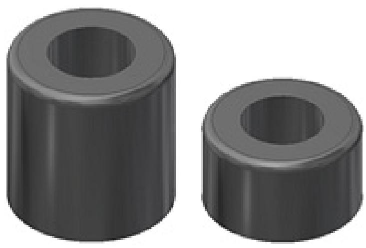
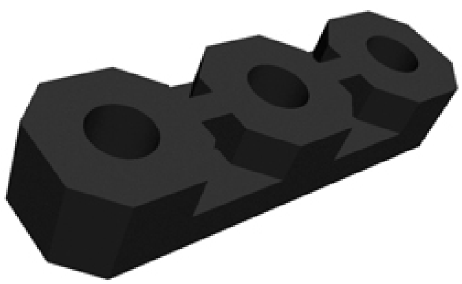
The VEX Robotics Design System is divided up into several different Subsystems:

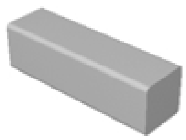
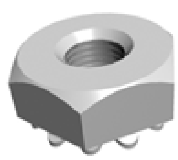
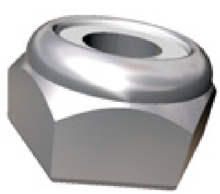
- Structure Subsystem
- Motion Subsystem
- Power Subsystem
- Sensor Subsystem
- Logic Subsystem
- Control Subsystem

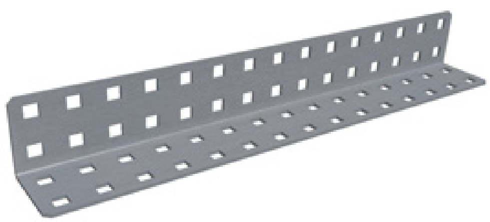
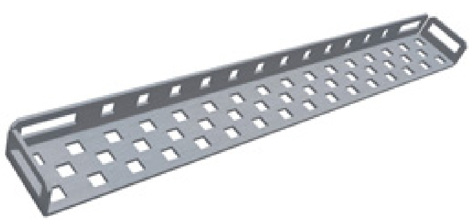
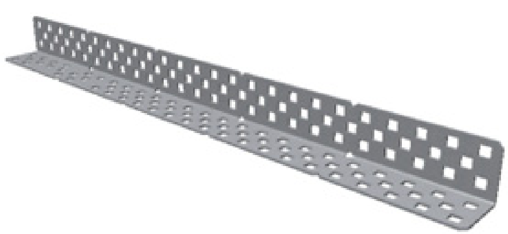
Every VEX component falls into one of these categories. Refer to the VEX Inventor's Guide for more information on each Subsystem, their uses, and their interactions with other Subsystems. The Inventor's Guide will provide users of all levels with instruction and background to begin their journey with VEX Robotics. It also provides a reference which advanced users can refer back to.

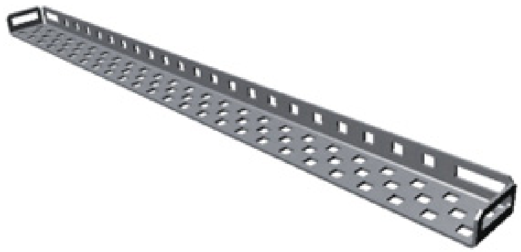
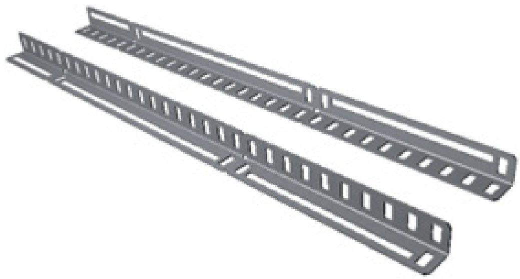
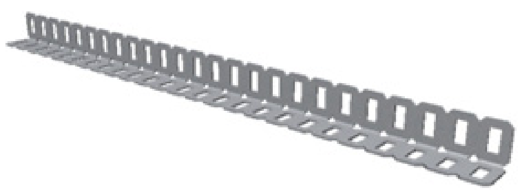
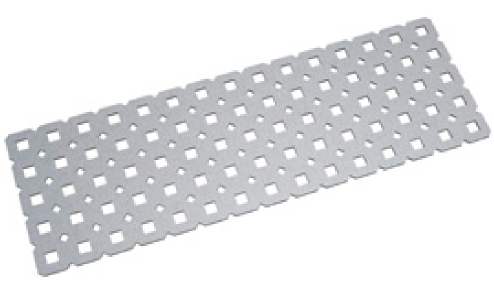
Structure Subsystem

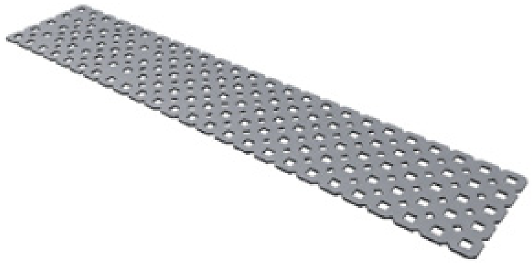
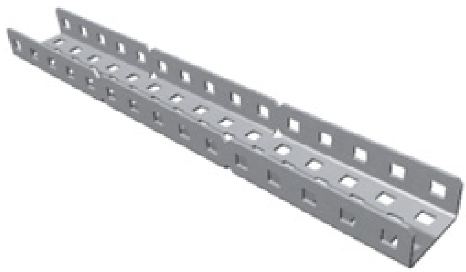
Part	Part Description
	Square Bars come in an assortment of lengths and have a variety of uses. Their primary use is axles. The motors and servos are designed to receive the square stock for transfer of motion. They may also be used as structural pieces and can be reshaped (bent) into many different shapes.

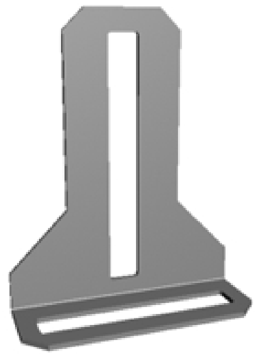
Part	Part Description
	Shaft collars are used to hold components in place axially on a shaft. Combined with spacers, they allow for the precise axial positioning of gears and other components in the VEX Motion Subsystem. They can also be used to retain shafts in location axially (keep them from sliding in and out).
	Spacers are used to offset components and to position components on a shaft. Two thicknesses are provided.
	Bearing Flats attach to structural components to provide a smooth, low-friction surface for a rotating shaft.
	Bearing Blocks can support shafts or act as guides for ropes or cables.
	Lock Plates fix a shaft to a structural element so that both components rotate together.

Part	Part Description
	Washers are used to distribute the load from the bolt head or nut. Washers are also used as spacers and to reduce friction between rotating components. Both plastic and steel washers are included.
	Clutch Posts are used to join a clutch to a motor or servo.
	Screws are used to fasten structural elements and other components together.
	Keps Nut – A nut with an attached conical, toothed, lock washer. When you tighten the nut, the washer flattens slightly and the teeth dig in to the adjacent surface, reducing the chance of the nut loosening from the bolt.
	Nylock Nut – A nut with a nylon insert that is slightly smaller than the threaded portion. When you tighten the nut, the nylon grips the bolt tightly, reducing the chance of the nut loosening from the bolt under vibration.

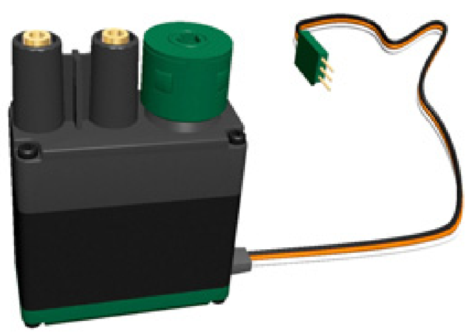
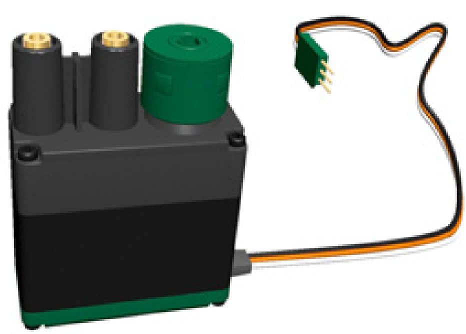
Part	Part Description
	Plastic Bearing Pop-Rivets are used to fasten bearings onto structural elements.
	Threaded Beams are used to separate components. They are available in four lengths.
	Chassis Bumper 15-hole
	Chassis Rail 15-hole
	Chassis Bumper 25-Hole

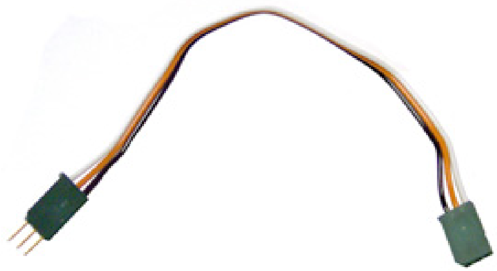
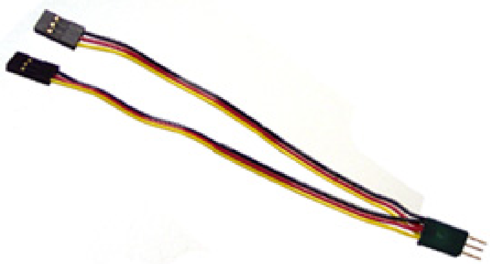
Part	Part Description
	Chassis Rail-25-Hole
	Angle Bars (mirror images of each other)
	Angle Bar 1x1x 25-Hole
	25-Hole Bar
	Plate 5x5
	Plate 5x15

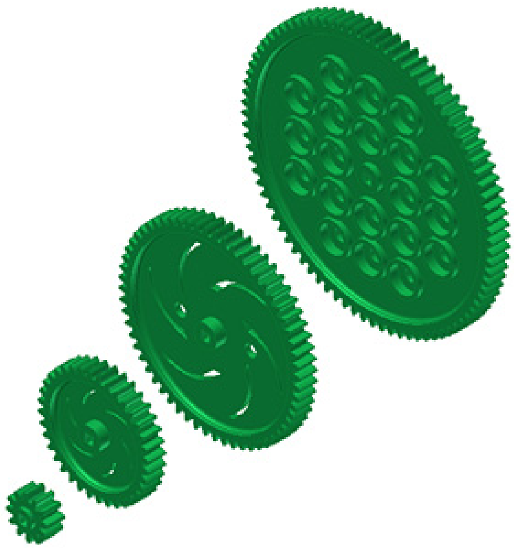
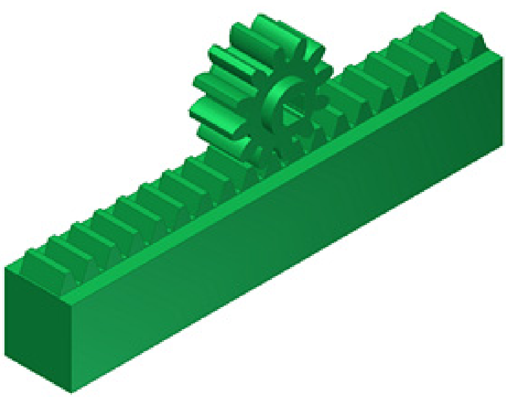
Part	Part Description
	Plate 5x25
	C-Channel 1x2x1x15
	C-Channel 1x2x1x25
	C-Channel 1x5x1x25
	Pivot Gusset – Used to join structural elements at angles other than 90 degrees or where one element rotates with respect to the other.

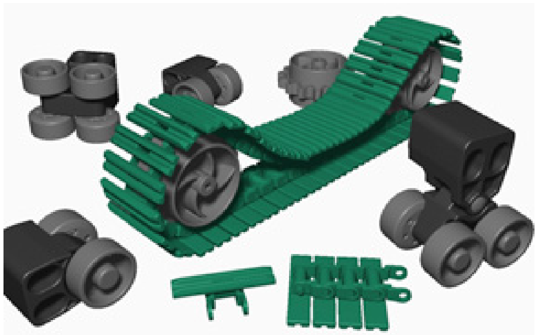
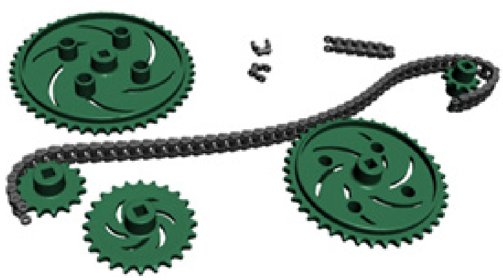
Part	Part Description
	Angle Gusset – Used to join structural elements at 90 degrees.
	Plus Gusset – Used to join structural elements at 90 degrees in a cross formation.

Motion Subsystem

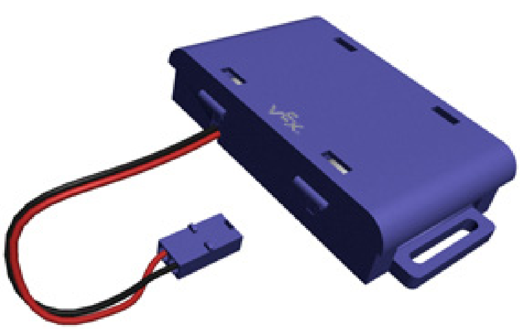
Part	Part Description
	The VEX Motor Module with Clutch and VEX Servo Module with Clutch, while similar in appearance, are suited to distinctly different types of tasks. Regular motors should be used whenever continuous rotation is needed, such as in a robot's main drive system.
	Servomotors can only be used in cases where the boundaries of motion are well defined, but have the invaluable ability to self-correct to maintain any specific position within those boundaries. Be sure to check the text on the green back to make sure you have the right module.

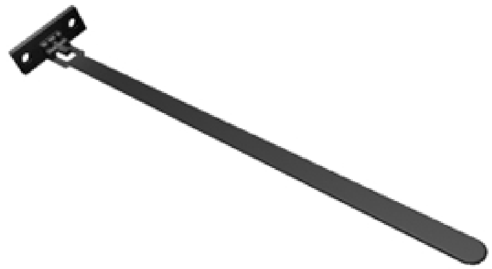
Part	Part Description
	PWM Extensions allow distant positioning of motors, servos, and sensors. Available in three lengths.
	PWM Y-Cable allows for the running of two motors or servos from one output.
	Knobby Wheels can be used for locomotion and feeder applications. The material is hard so best traction will occur in soft materials like dirt or heavy carpet. Their large diameter provides maximum clearance over obstacles.
	The All Purpose Wheel is also used for locomotion and feeder applications. Due to its flat profile and tread, the best surfaces to use it on are flat with high friction.
	The Low Friction Wheel is the most versatile wheel in the kit. Its soft rubber tread provides maximum traction on a variety of smooth surfaces and low-pile carpets. Its tread may also be removed to expose a smooth low-friction surface that will enable the wheel to slide when force is applied to the side of the wheel. Be sure to match up the arrows on the hub and tread when reinstalling the treads.

Part	Part Description
	Intake Rollers are typically used to pull in balls or other objects. They are very pliable and provide enough friction to firmly hold objects.
	Gears (various sizes) are used to transmit power and motion from a motor or servo to a driven component. Gears are often used to increase torque or change the speed.
	A Rack is used with a gear (as shown) to turn rotational motion into straight-line motion.

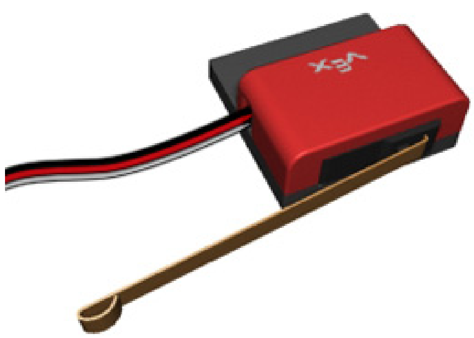
Part	Part Description
	Tank Tread Kit is used to add a tank tread drive to a robot.
	Chain and Sprocket Kit is used to transmit motion and power over a greater distance than with gears.
	Zip Ties are one of the more useful items in the kit. They may be used to fasten nearly any parts together, but their primary use is to secure loose cables to structure components. They are also commonly used in sweeping collection mechanisms.

Power Subsystem

Part	Part Description
	The 7.2-Volt battery Box is for AA batteries when you do not have access to a 7.2 Ni-H battery. It is recommended that you invest in rechargeables.

Part	Part Description
	The Battery Strap is used to secure the 7.2-volt battery to the robot frame.
	The Vex Power Pack contains the Vex 7.2 Volt Battery for the robot, the Vex 9.6 Volt Battery for the transmitter, and a wall charger for each battery.

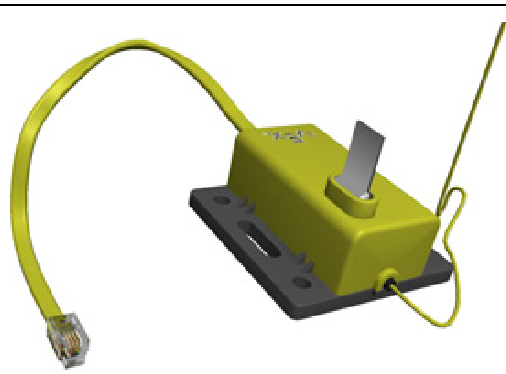
Sensor Subsystem

Part	Part Description
	Limit Switches can be used to cut power to motors when depressed and enable power to pass when released. They are either on or off. These are frequently used when a design calls for movement to stop.
	Bumper Switches are similar to limit switches in operation. They are typically used to detect when a robot has made contact with an obstacle.

Logic Subsystem

Part	Part Description
	The Vex Robotics Programming Kit is a combination of hardware and software that enable you to write programs on your computer and download them to the robot's microcontroller. You use the Vex programming cable to connect your computer's USB port to the serial port located on the back of the microcontroller.
	The VEX Microcontroller has eight motor (output) ports, six interrupt ports, two 100 mA open collector outputs, and sixteen I/O sensor ports. It is possible to load custom programming through the serial port located on the back of the box with a USB to serial convertor. There are also two receiver or tether ports for connecting up to two receiver modules for two-transmitter control.

Control Subsystem

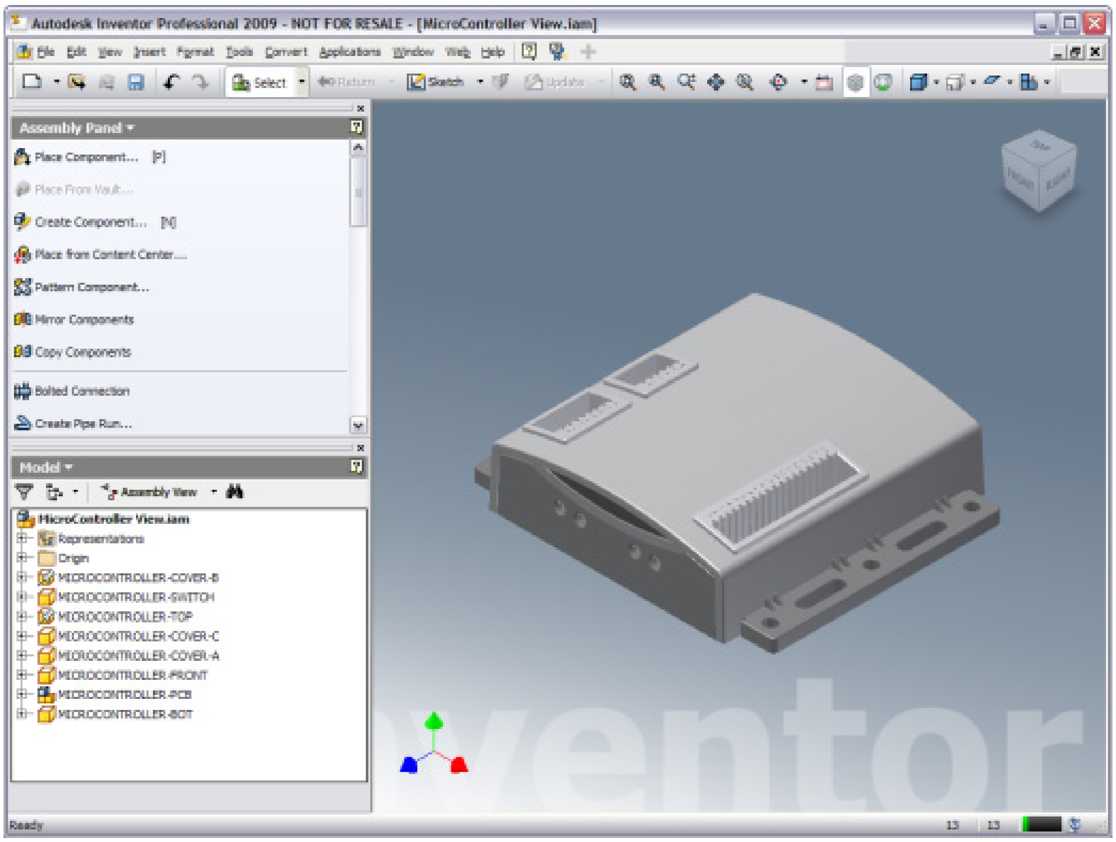
Part	Part Description
	The VEX Robotics Transmitter accepts different frequency crystals to allow for operation of multiple robots simultaneously. It also has options for trim and scaling of its 6 channels.
	The Receiver Module can accept different receiver crystals to receive signasl from the matching transmitter crystal and pass those signals along to the VEX Micro-Controller.

Part	Part Description
	The Antenna Tube is used to hold the antenna wire in order to receive the maximum signal from the transmitter. This is especially important if running the robot at a distance.
	The Antenna Base holds the Antenna Tube and enables it to be mounted to the frame.

Getting Started with Autodesk Inventor

Overview

This lesson describes the application interface. You are introduced to the different file types (part, assembly, presentation, and drawing) you work with as you create and document your designs, and you examine the common user interface elements and view management tools in these environments.



Objectives

After completing this lesson, you will be able to:

- Review the modeling process in Autodesk Inventor.
- Identify the major components of the Autodesk Inventor user interface.
- Identify the tools that are available in the graphics window.
- Explore the user interface using the view navigation tools.

The Modeling Process with Autodesk Inventor

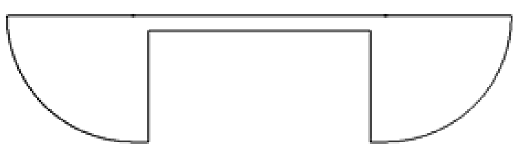
You can use a modeling tool like Autodesk Inventor through most of the design process. Whether you want to try out some ideas, test a design, or create the final model, Autodesk Inventor contains the tools you require. The basic modeling process in Autodesk Inventor consists of the following steps:

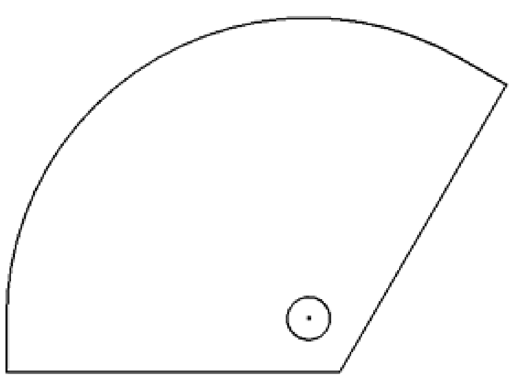
1. Create one or more parts.
2. Assemble the parts.
3. Document the parts and assemblies.

The following discussion explores the modeling process in Autodesk Inventor showing you how two different parts of a scooter are created.

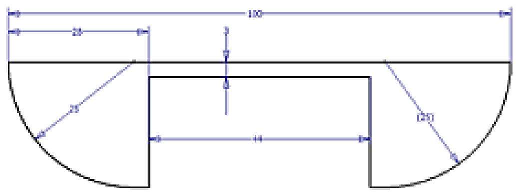
Create Parts

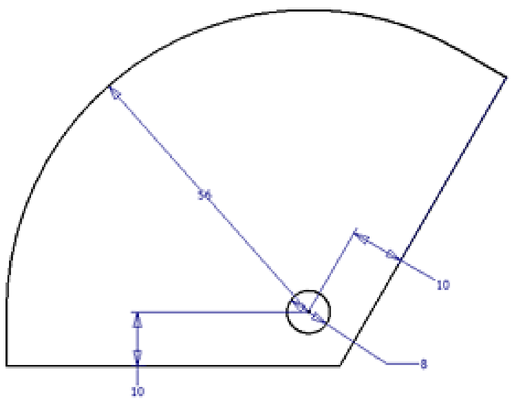
To create a part, you start by drawing a two-dimensional shape called a sketch. A typical sketch consists of lines, arcs, and circles.



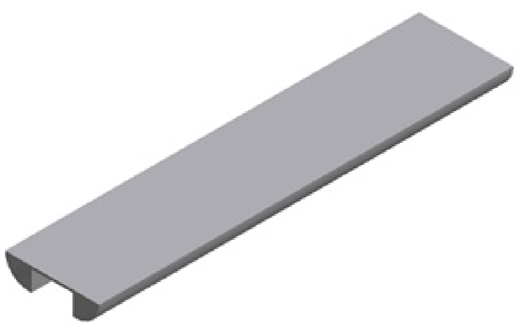


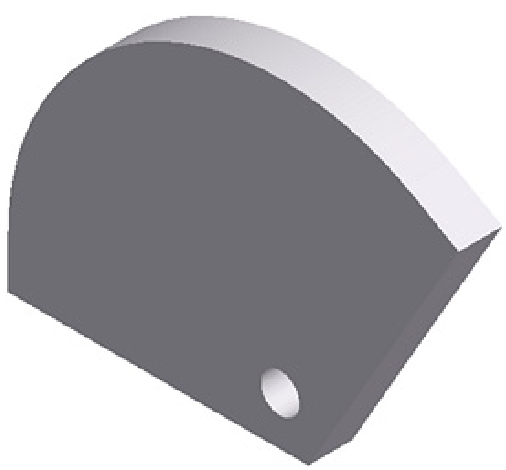
You make the shape the right size using dimensions.



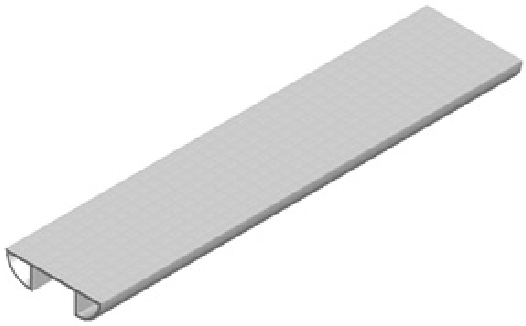


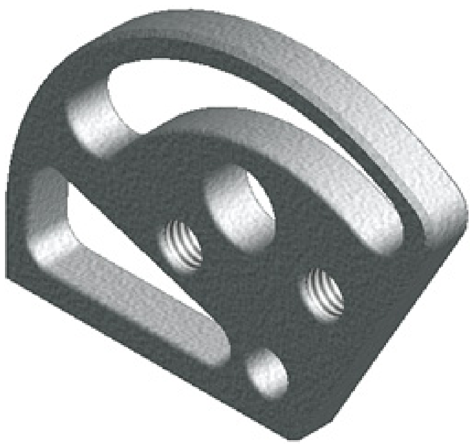
You then turn the two-dimensional sketch into a three-dimensional (3D) model. In this example, the parts were extruded to create the 3D model. You use other methods such as revolve, sweep, or loft to create other shapes.



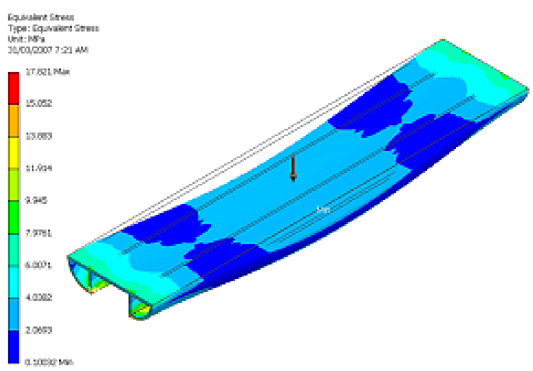


To complete the part, you add more features such as slots, cutouts, and holes. You can round over edges (rounds are called fillets) and change the material and color to match the real part.





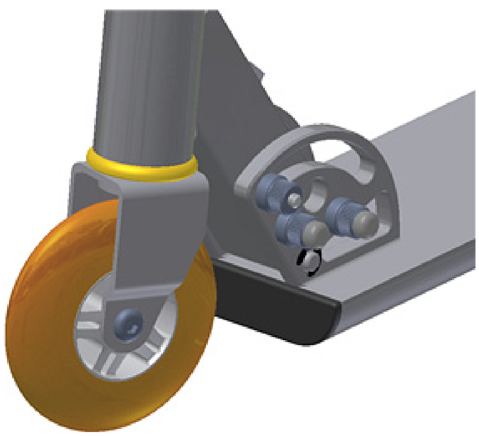
You can even test the parts in Autodesk Inventor before you build them to see how the parts deform and if they will be strong enough. You might have to make the part stronger in some areas but you can also save weight and material by identifying areas where the part is stronger than it needs to be.



Assemble Parts

After you create the parts, you join them together into an assembly. You do not have to create all of the parts before you start assembling them. Some parts are easier to design once you have the basic model.

Many common parts that you would purchase rather than make, such as bolts, nuts, and screws, are supplied with Autodesk Inventor. You can add these to the model without having to make them yourself.

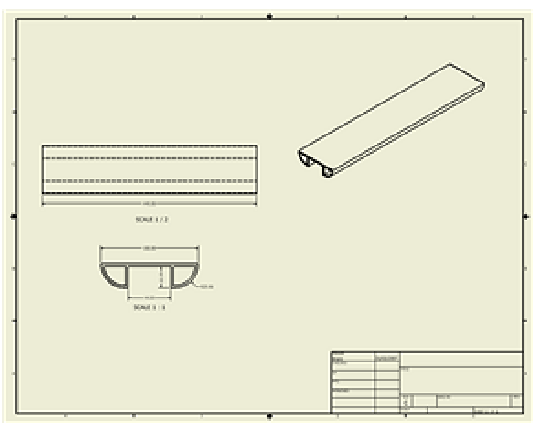


Now that you have a complete, virtual model of the real object, you can view the model from different directions and with different materials and lighting to see if it looks good.

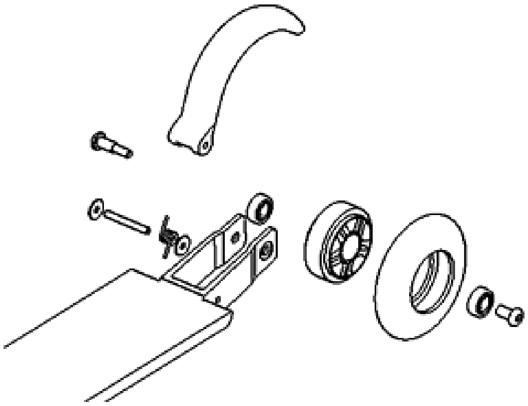
You can determine how much it weighs, how much material it uses, and how much it will cost to make. You can test the assembly to see if it functions correctly before you build it. Do the parts move correctly? How much force is required to move the parts? The following image shows the results of simulating the motion of a concrete breaker.

Document the Design

When you are satisfied that your design looks and performs correctly, it is time to make it (or have someone else make it). You create drawings of each part so the parts are made to the correct size and shape.

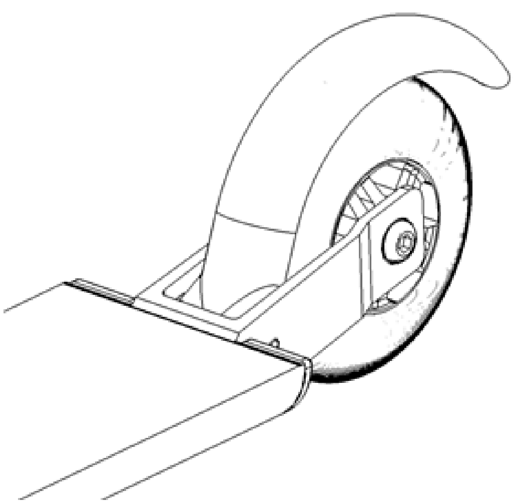


You also create drawings to show how to assemble the parts.



You can use the rendered images that you created from your virtual model for marketing your design before it is even made.

Other documentation might include assembly manuals and maintenance manuals. It is easy to generate the images for these manuals from your virtual model. You can even create black and white images that look like technical illustrations.

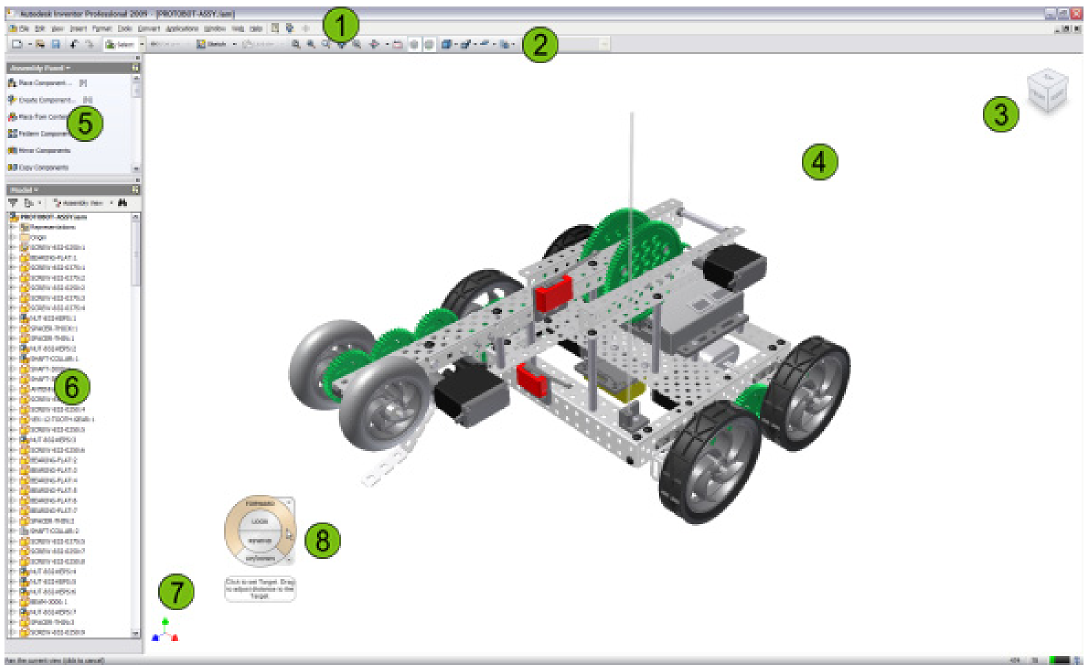


You have now seen how Autodesk Inventor can be used throughout the modeling process.

Menus and Toolbars

As you design and document parts in Autodesk Inventor, you change back and forth between several environments such as part modeling, assembly, drawing, and presentations. All environments share a common layout for menus and a single toolbar across the top of the application window. Each environment displays menu items and tools specific to that environment. As you change tasks within a single environment, menus and the toolbars adjust to present the appropriate tools.

The major components of the Autodesk Inventor user interface are as shown. Menus and toolbars are displayed at the top of the application window.



1 Menu

2 Toolbar

3 ViewCube

4 Graphics window

5 Panel bar

6 Browser

7 3D Indicator

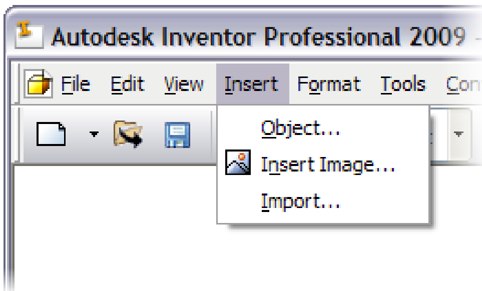
8 SteeringWheels

Menu Structure

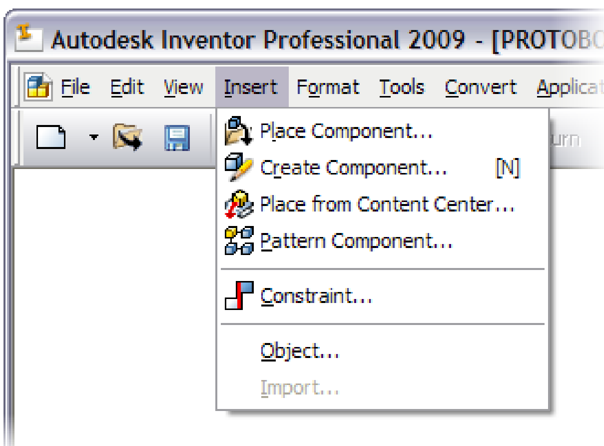
Autodesk Inventor uses the standard menu structure common in all Microsoft Windows applications. The menu structure is context-sensitive based on the environment and mode you are using.

As you learn the application more thoroughly, you should take the time to familiarize yourself with the different options displayed on the menu while working in different environments.

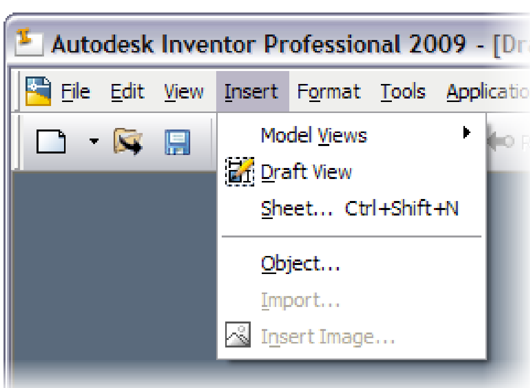
The Insert menu in the part modeling environment is as shown.



The Insert menu in the assembly modeling environment is as shown.



The Insert menu in the drawing environment is as shown.

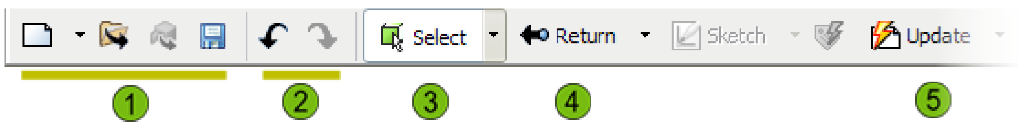


Toolbars

By default, a single Inventor Standard toolbar is displayed in all environments. When you change between environments, the toolbar updates to display valid tools for the environment. The toolbar contains tools for file handling, settings, view manipulation, and model or document appearance.

Overview of the Standard Toolbar

A section of the Inventor Standard toolbar is shown. It is organized into groups based on functionality. This area of the toolbar displays tools for standard file and modeling operations.



1 Standard file management tools

2 Undo and redo

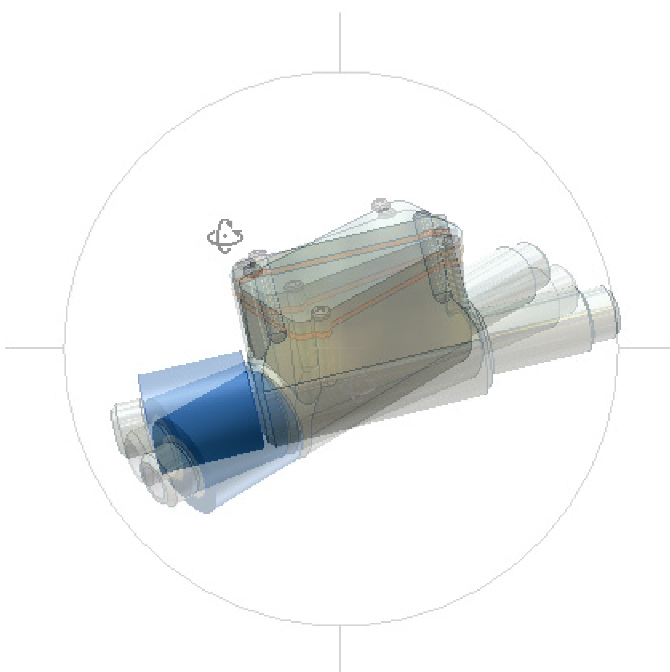
3 Selection filters

4 Environment navigation

5 Update document

About the Graphics Window

Your 3D part and assembly models, presentations, and drawings are displayed in the graphics window. Many tools are available to manipulate the view and appearance of your model in the graphics window.



View Manipulation Tools

View manipulation is a key 3D modeling skill. You are often required to view different areas of a model, and changing your view can help you visualize solutions for the current task. Most of the view manipulation tools are common to all environments.

The view manipulation tools on the Inventor Standard toolbar are as shown.

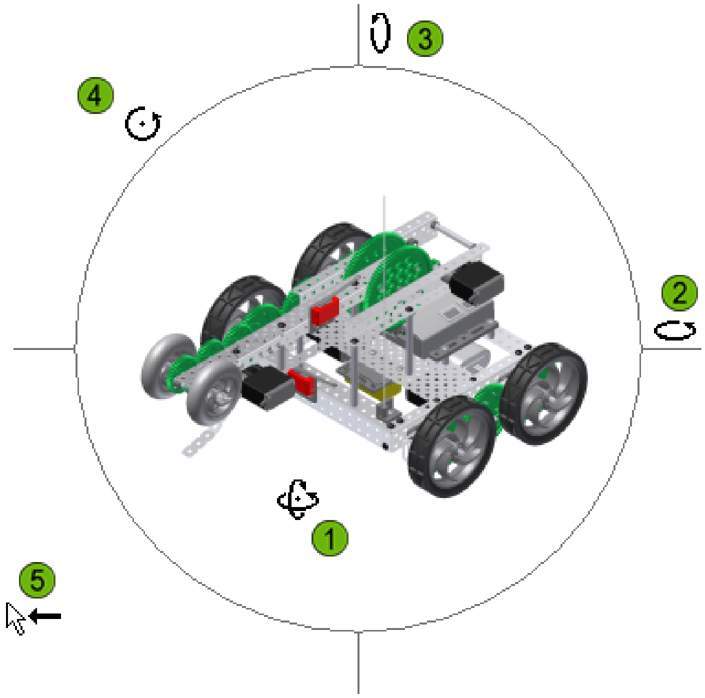
1. Zoom All
2. Zoom Window
3. Dynamic Zoom
4. Pan
5. Zoom to Selection
6. Orbit
7. Look At – Reorients the view normal to the current selection
8. ViewCube – Provides a persistent, clickable interface where you can switch between standard and isometric views.
9. SteeringWheels – Saves you time by combining many of the common navigation tools into a single interface.

> You can use the mouse to accomplish most pan and zoom tasks.
>
> - Roll the mouse wheel to zoom at the cursor location.
> - Click and hold the mouse wheel then move the mouse to pan.
> - Double-click the mouse wheel to zoom all.

Dynamic View Rotation

The Orbit tool enables you to dynamically change your view of the model. It is important to remember that the model does not move; you change your viewing position with the Orbit tool.

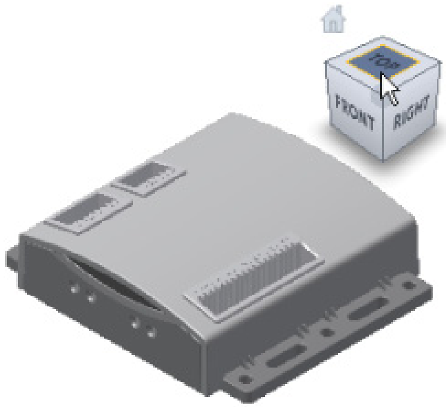
The rotation modes available are outlined as shown. The cursor provides feedback on the rotation mode available. You click and drag to rotate the view. You can set the center of rotation by clicking a location on the model.



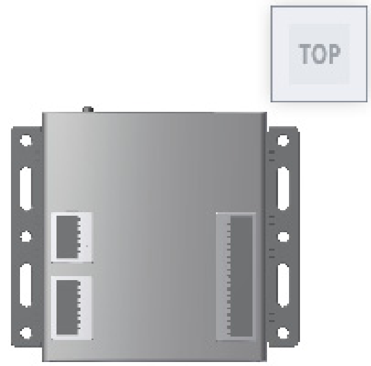
1. Click and drag here to rotate the view about all axes.
2. Click and drag here to rotate the view about a vertical axis.
3. Click and drag here to rotate the view about a horizontal axis.
4. Click and drag here to rotate the view about an axis normal to the screen.
5. Position and click here to exit.

ViewCube Rotation

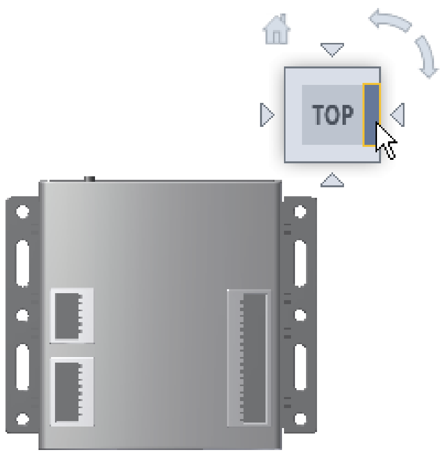
ViewCube rotation mode enables you to view the model from common directions, including top, bottom, front, back, right, left, or any isometric view in between.



Click Top

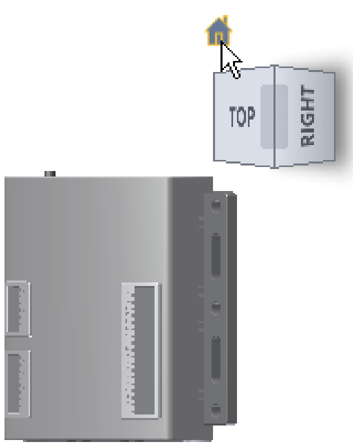


Resulting view

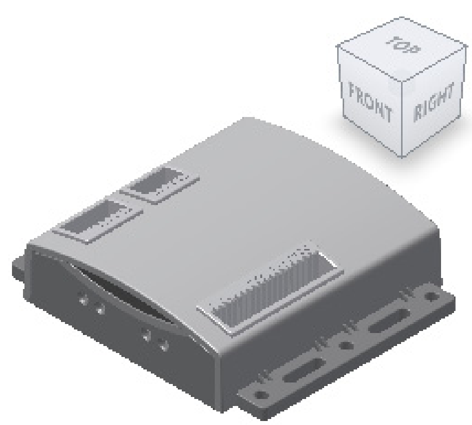


Click an edge

Resulting view



Click Home



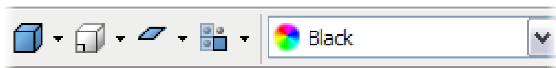
Resulting view

In all modeling environments you can quickly return to a default isometric view using either of the following methods:

- On the ViewCube, click Home.
- Right-click in the graphics window background. Click Home View.
- Press the F6 function key.

Display Modes

This area of the toolbar displays appearance-related tools for controlling the appearance of your model. Select a render style from the list to change the color and texture of your model.



3D Indicator

While using the assembly, part modeling, and presentation environments, the 3D Indicator is displayed in the lower-left area of the graphics window. The indicator displays your current view orientation in relation to the *X*, *Y*, and *Z* axes of the coordinate system.

The 3D Indicator is positioned below and to the left of the assembly as shown.

- **Red –** *X*-axis
- **Green –** *Y*-axis
- **Blue –** *Z*-axis

Exercise: Use the View Navigation Tools

In this exercise, you open an assembly and explore the view navigation tools. You also examine the relationship between the objects in the browser and graphics window. The view navigation tools are common to all environments.

The completed exercise

Use the ViewCube

In this exercise, you open an assembly and explore the view navigation tools. You also examine the relationship between the objects in the browser and graphics window. The view navigation tools are common to all environments.

1. Start Autodesk Inventor.

NOTE: If you are already in Autodesk Inventor, close all files.

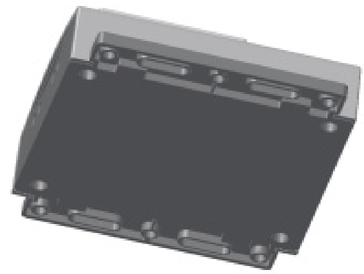
2. If the Open dialog box is displayed, click Projects. Otherwise, click File menu > Projects.

3. Click Browse. Navigate to the Unit1 folder.

4. Select *IFI_Unit1.ipj*. Click Open.

5. Click Done to close the dialog box.

6. Open *MicroController View.iam*. Your view should be as shown.



7. On the ViewCube, click Home.

The view is reoriented as shown.

8. On the ViewCube, click Front.

The view is reoriented as shown.

9. Right-click the background in the graphics window. Click Home View.

The view is reoriented as shown.

10. In the graphics window, move the cursor near the center of the model. Roll the mouse wheel away from you.

11. Roll the mouse wheel toward you until the model fills the screen.

12. Hold down the mouse wheel and drag the mouse.

The view pans to match the movement of the mouse.

13. Release the mouse wheel. Press F6.

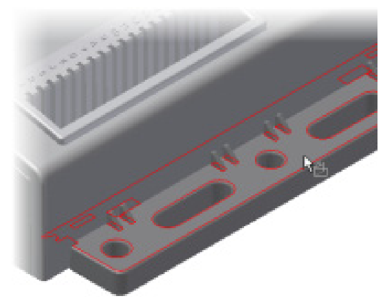
The view is reoriented to the default Home view.

Use the Viewing Tools

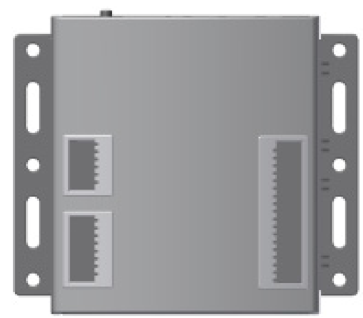
In this section of the exercise, you rotate the microcontroller assembly and redefine the default Home view.

1. On the Standard toolbar, click Look At.

2. Select the face of the microcontroller as shown.



The view rotates normal to the selected face.



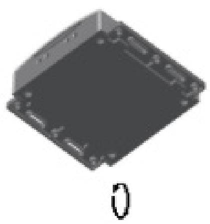
3. Press F5. The previous view is restored. It should be the default Home view.

4. On the Standard toolbar, click Orbit.

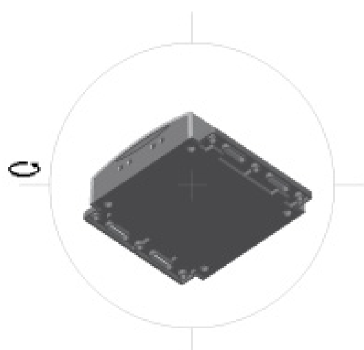
5. Move the cursor over the handle at the bottom of the 3D Rotate symbol.

- Click and drag upward to rotate the view about the horizontal axis.
- Release the mouse button.

The first image shows the isometric view, and the second image shows the rotated view.

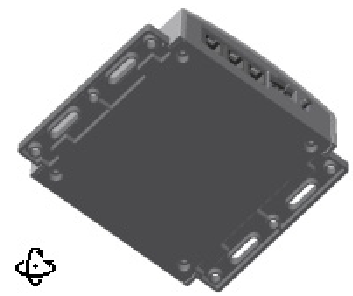


6. Click the handle at the left side of the 3D Rotate symbol. Drag to the right to rotate the view about the vertical axis.



7. Click inside the 3D Rotate symbol near the location as shown.

8. Drag down and to the left. The view rotates about the center of the 3D Rotate symbol to match the movement of the cursor.



9. Press F6 to view the model as the Home view.

10. On the ViewCube, click the top-right corner.

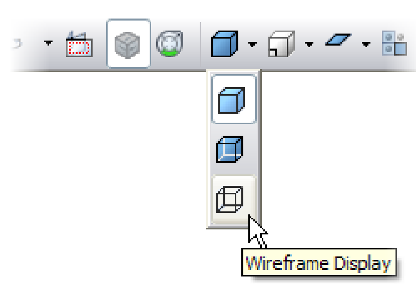
The view is reoriented as shown.

11. Right-click the ViewCube. Click
Set Current View as Home > Fixed Distance.

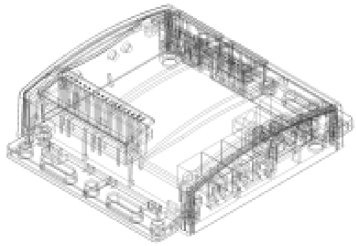
Change the Display

In this section of the exercise, you change the display of the assembly.

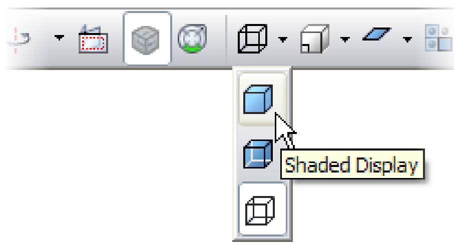
1. On the Standard toolbar, Display Mode flyout, click Wireframe Display.



The view changes to a wireframe view.

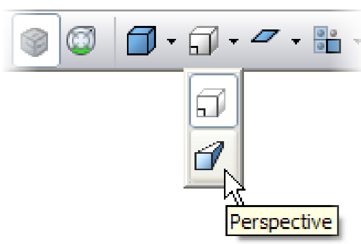


2. On the Standard toolbar, Display Mode flyout, click Shaded Display.



The model returns to a shaded display.

3. On the Standard toolbar, View Mode flyout, click Perspective.



The view changes to a perspective view.

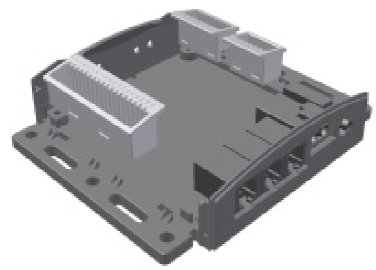
4. With the perspective camera active, use the Orbit, Pan, and Zoom tools to reorient your view.

5. Press F6 to return to the Home view.

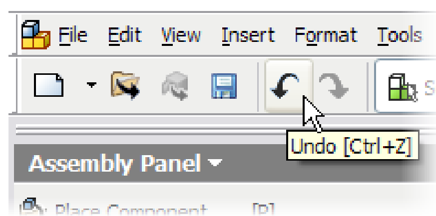
6. In the browser, move the cursor over MICROCONTROLLER-TOP. The part is highlighted in the graphics window.

7. In the browser, right-click MICROCONTROLLER-TOP. Click Visibility to turn off visibility. The check mark next to the option is cleared.

   The part is no longer visible in the graphics window.



8. On the Standard toolbar, click Undo.



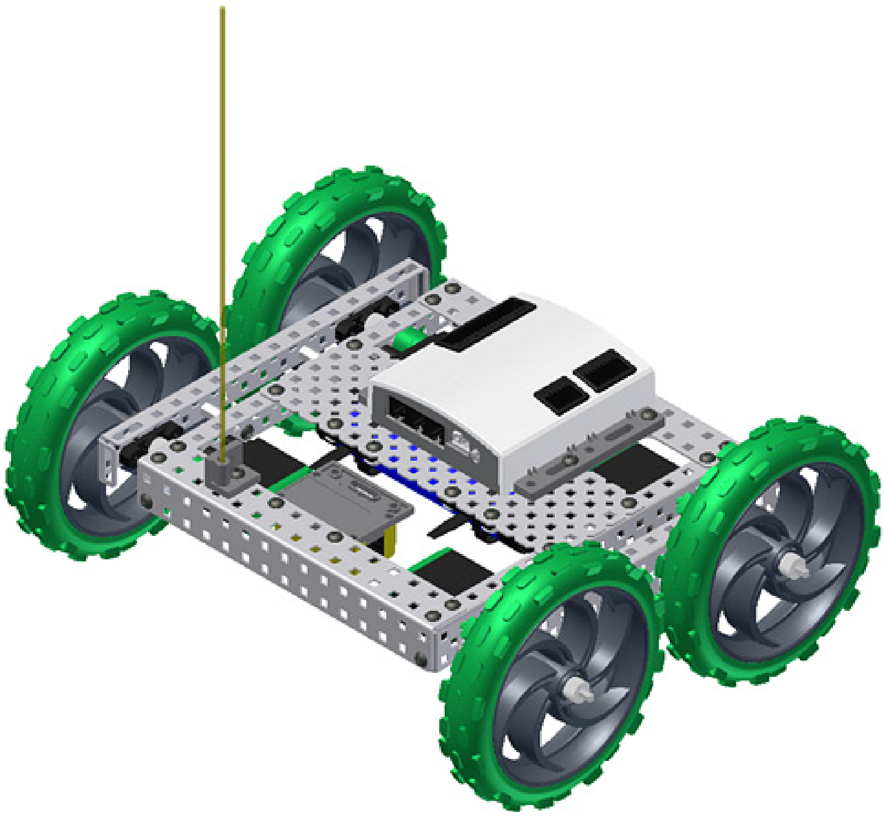
   The MICROCONTROLLER-TOP part is visible in the graphics window.

9. Close *MicroController View.iam*. Do not save changes.

Build Phase

Overview

This phase describes the steps for building a VEX Tumbler robot.



The Vex Tumbler Robot

Phase Objectives

After completing this phase, you will be able to:

- Identify and use the different parts of the VEX Classroom Kit.
- Identify and use VEX parts to complete subassemblies in the creation of the Tumbler robot.
- Assemble and drive a VEX Tumbler robot.

Prerequisites and Resources

Related phase resources are:

- Introduction to VEX and Robotics.

Required Supplies and Software

The following supplies are used in this phase:

Supplies
VEX Classroom Lab Kit
Work surface
Small storage container for loose parts

VEX Parts

The following VEX parts are used in this phase:

Quantity	Part Number	Abbreviations
1	ANTENNA HOLDER	AH
1	ANTENNA TUBE	AT
1	7.2 VOLT RECHARGEABLE BATTERY	BP
2	BATTERY-STRAP	BST
4	BEAM-1000	B1
4	BEARING-FLAT	BF
8	BEARING-RIVET	BR
2	CHASSIS BUMPER, 15 HOLE	A15
4	CHASSIS RAIL, 15 HOLE	R15
1	JUMPER	JMP
4	ROUGH TERRAIN WHEEL	W5
1	MICROCONTROLLER	VMC
25	NUT-832-KEPS	NK
1	PLATE, 5x15 HOLE	P15
1	RECEIVER	RX75
8	SCREW-632-0250	SS2
24	SCREW-832-0250	S2
9	SCREW-832-0375	S3
4	SHAFT-3000	SQ3
8	SHAFT COLLAR	COL
4	SPACER-THIN	SP1
4	VEX MOTOR with CLUTCH	MOT

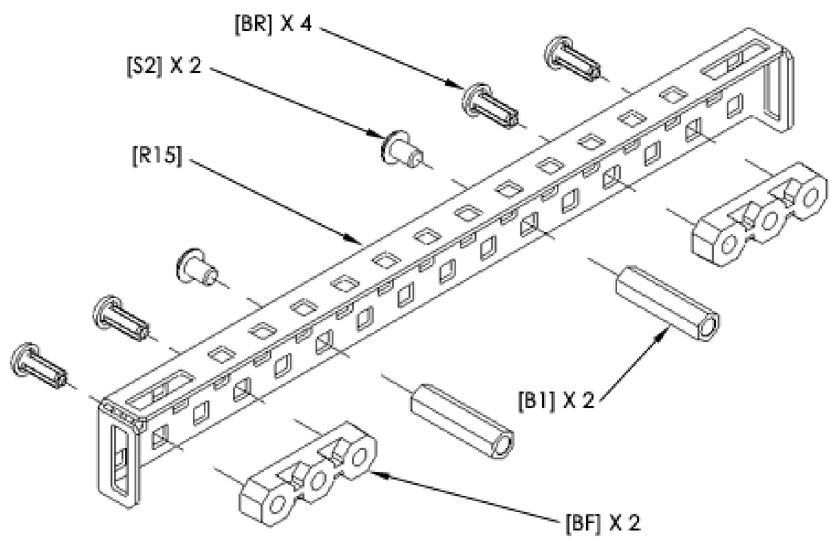
Activity

In this activity, you build a complete robot called Tumbler.

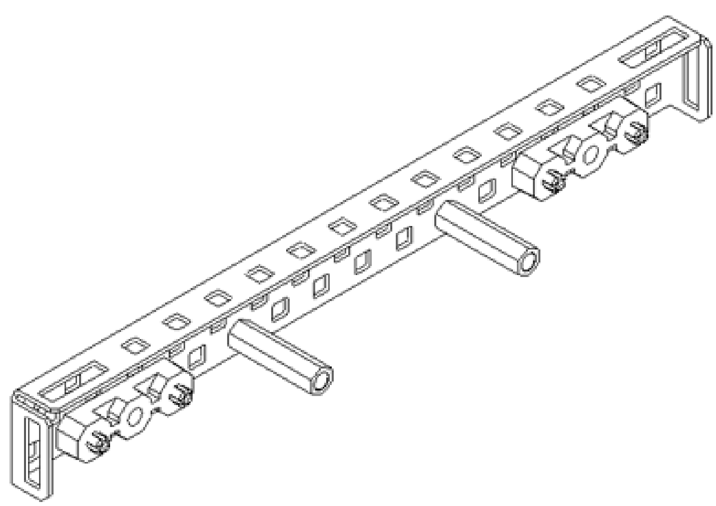
You start by building the right-side drive train.

1. To complete the first step:

- Locate one Chassis Rail [R15].
- Fasten two Bearing Flats [BF] to the Chassis Rail using two Bearing Rivets [BR] for each Bearing Flat.
- Fasten two 1" Beams [B1] to the Chassis Rail using #8-32 x 1/4" screws [S2].

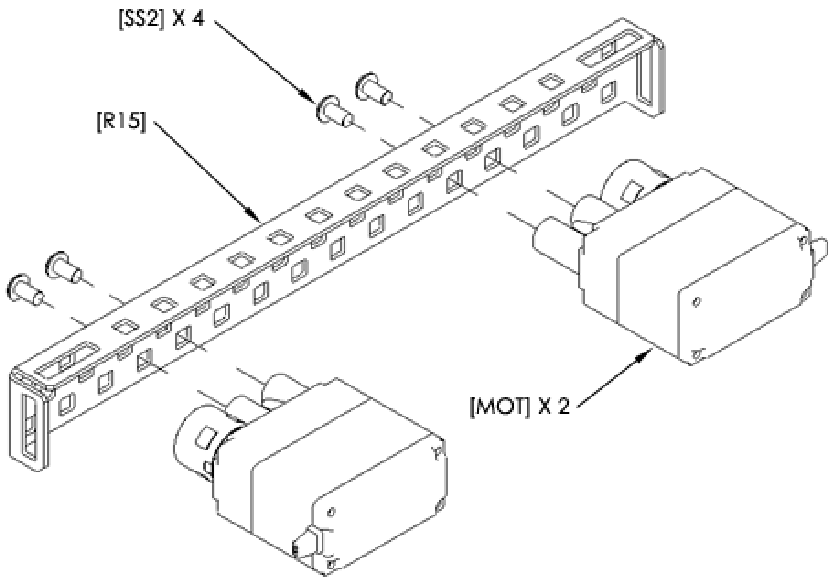


The completed model is as shown:

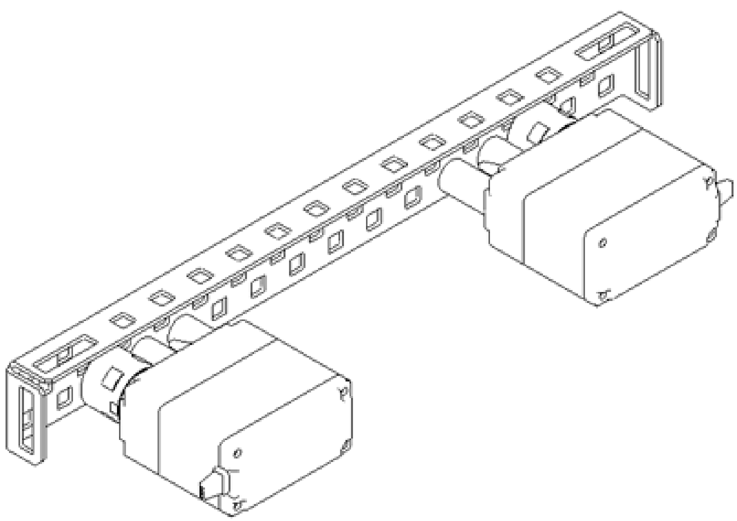


2. To complete the next step:

- Locate an additional Chassis Rail [R15] from the kit.
- Fasten two motors [MOT] to the Chassis Rail using two #6-32 x 1/4" screws [SS2] per motor. Make sure the motors are oriented correctly.

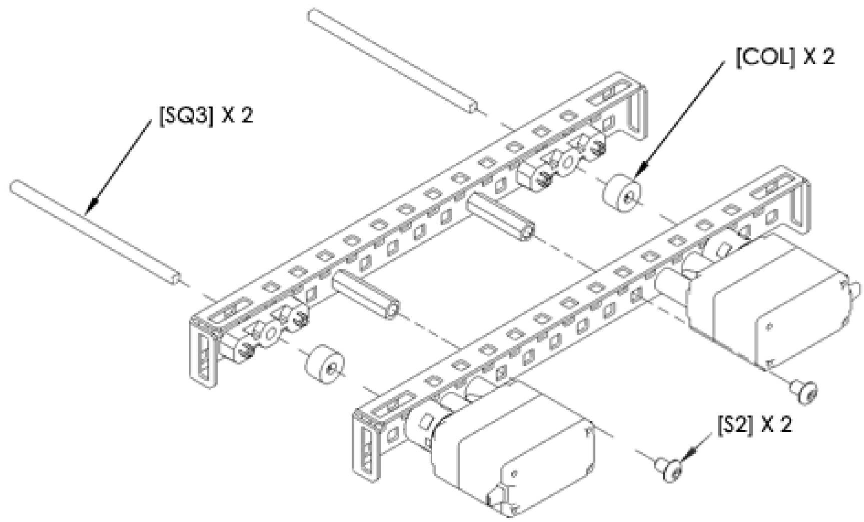


The completed model is as shown:

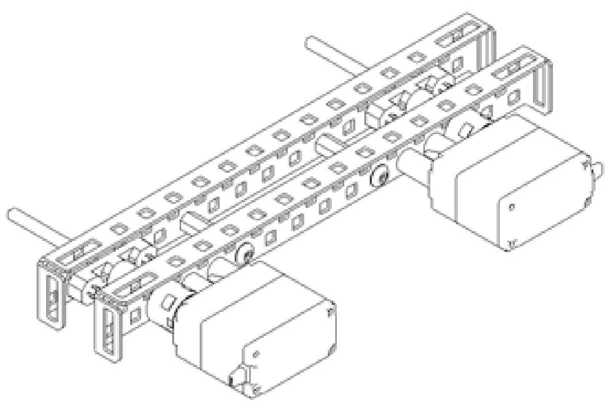


3. To complete the next step:

- Orient the two assemblies and connect them by inserting #8-32 x 1/4" Screws [S2] into the end of the Beams.
- Insert a 3" Shaft [SQ3] into each motor, adding a Collar [COL] to the shaft as you insert it through the two rails.
- When you have seated the shaft into the motor, slide the collar against the Bearing Flat and tighten. The collar prevents the shaft from coming out of the motor.

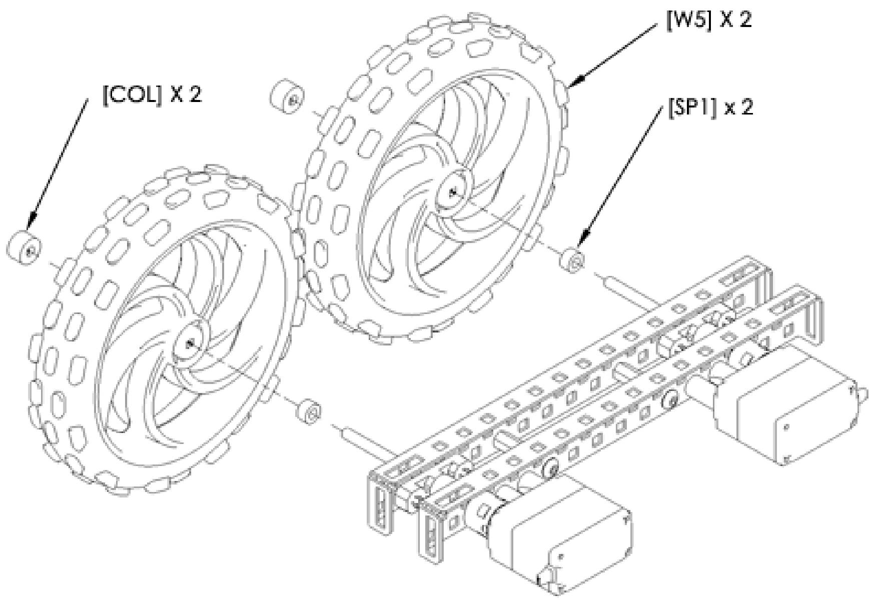


The completed model is as shown:

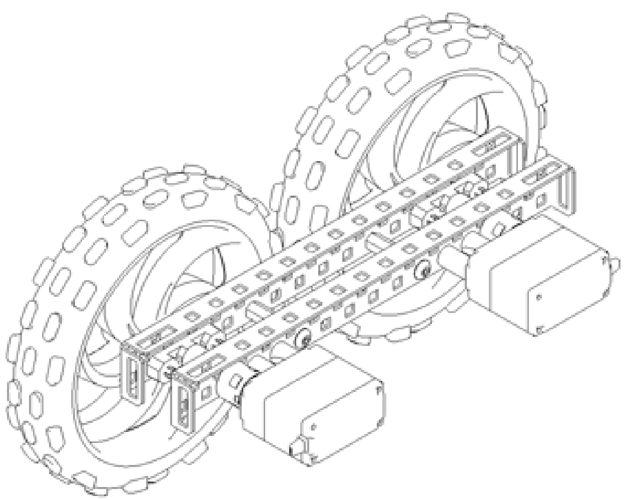


4. To complete the next step:

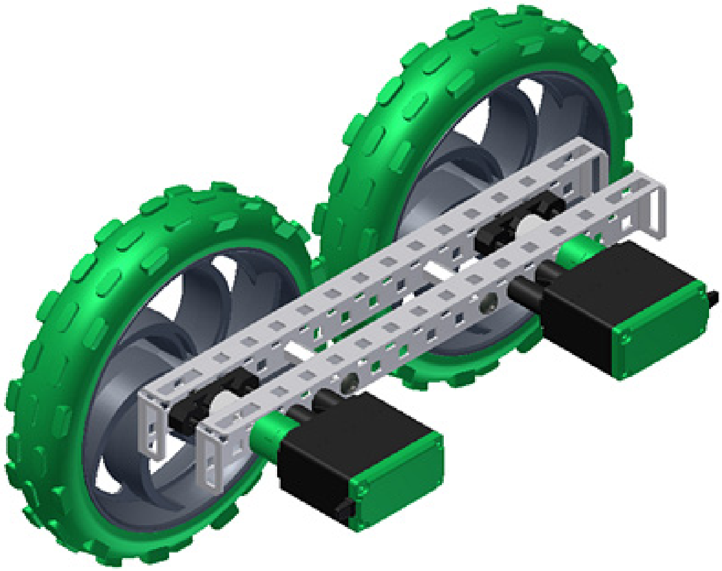
- Slide a Thin Spacer [SP1] onto each shaft.
- Slide a Rough Terrain Wheel [W5] onto each shaft.
- Slide Shaft Collars [COL] up against the wheels and tighten.



The completed model is as shown:



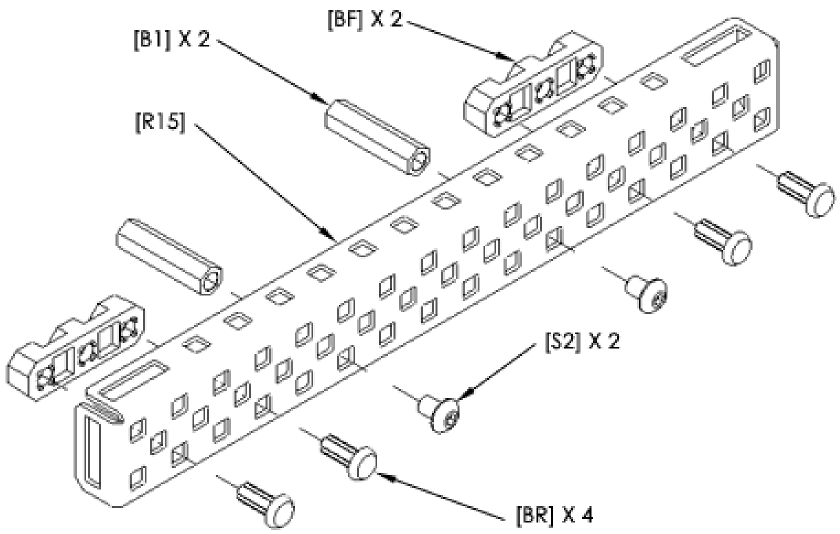
5. The right-side drive train is complete!



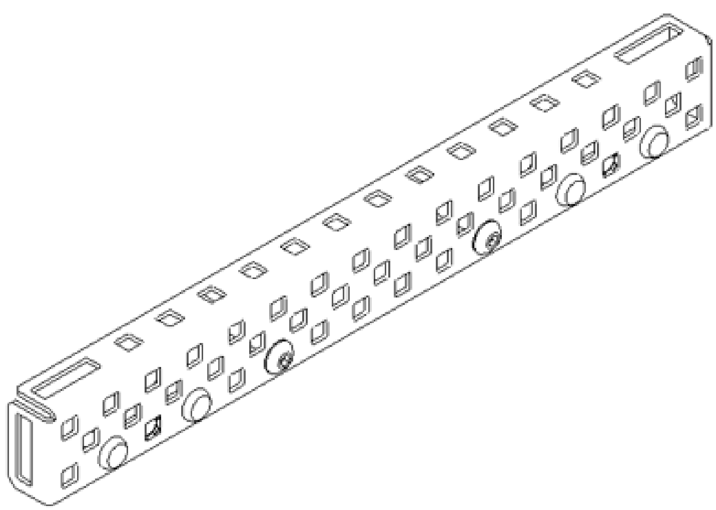
Assemble the Left Side Drive

You now build the left side of the drive train.

1. To complete the first step:
   - Locate one Chassis Rail [R15].
   - Fasten two Bearing Flats [BF] to the Chassis Rail using two Bearing Rivets [BR] for each Bearing Flat.
   - Fasten two 1" Beams [B1] to the Chassis Rail using #8-32 x 1/4" screws [S2].

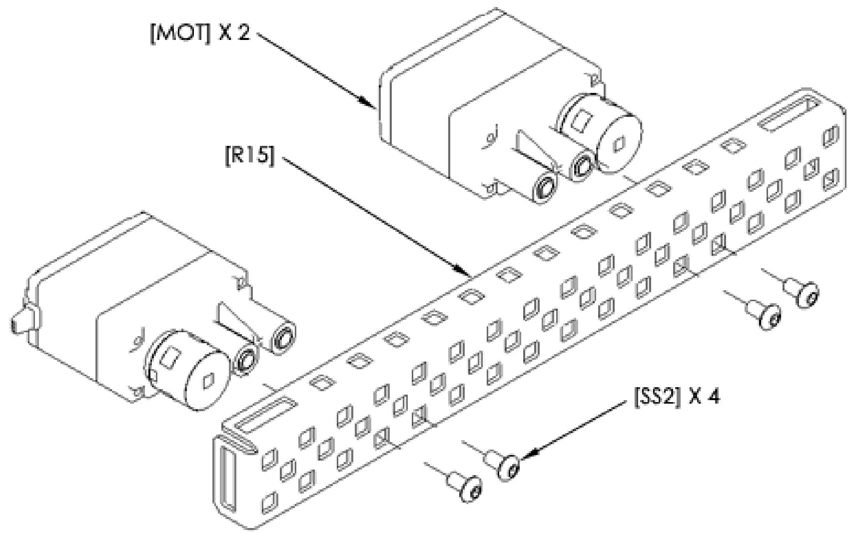


The completed model is as shown:

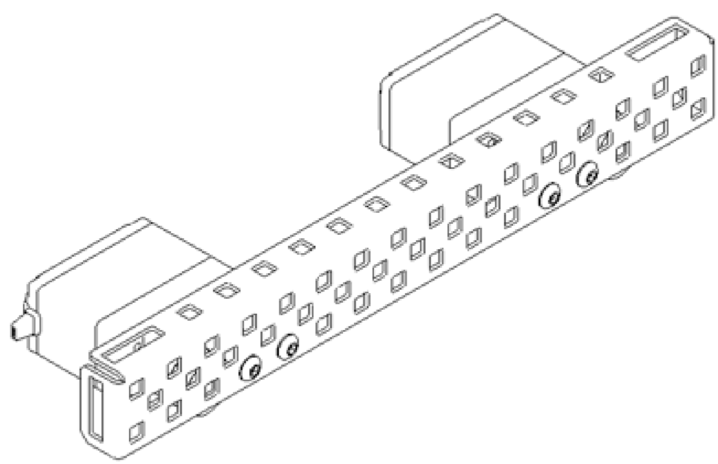


2. To complete the next step:

- Locate an additional Chassis Rail [R15] from the kit.
- Fasten two motors [MOT] to the Chassis Rail using two #6-32 x 1/4" screws [SS2] per motor. Make sure the motors are oriented correctly.

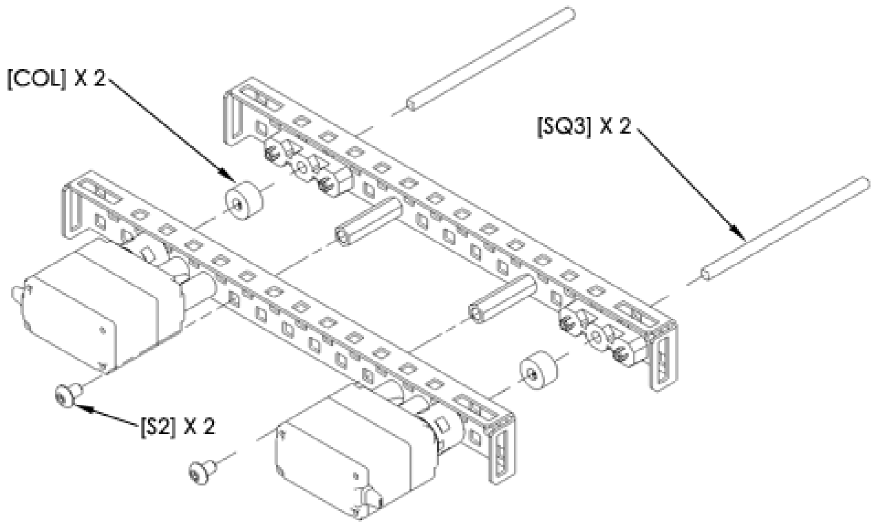


The completed model is as shown:

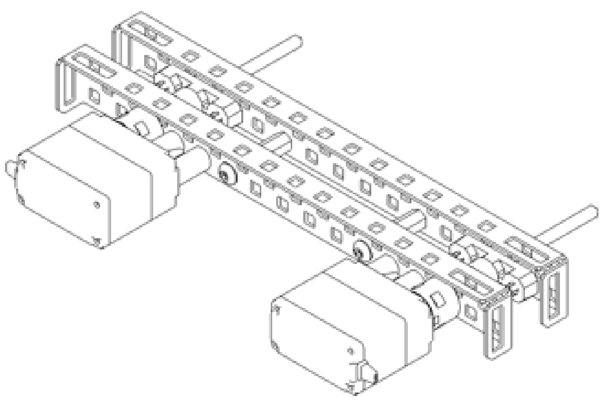


3. To complete the next step:

- Orient the two assemblies and connect them by inserting #8-32 x 1/4" Screws [S2] into the end of the Beams.
- Insert a 3" Shaft [SQ3] into each motor, adding a Collar [COL] to the shaft as you insert it through the two rails.
- When you have seated the shaft into the motor, slide the collar against the Bearing Flat and tighten. The collar prevents the shaft from coming out of the motor.

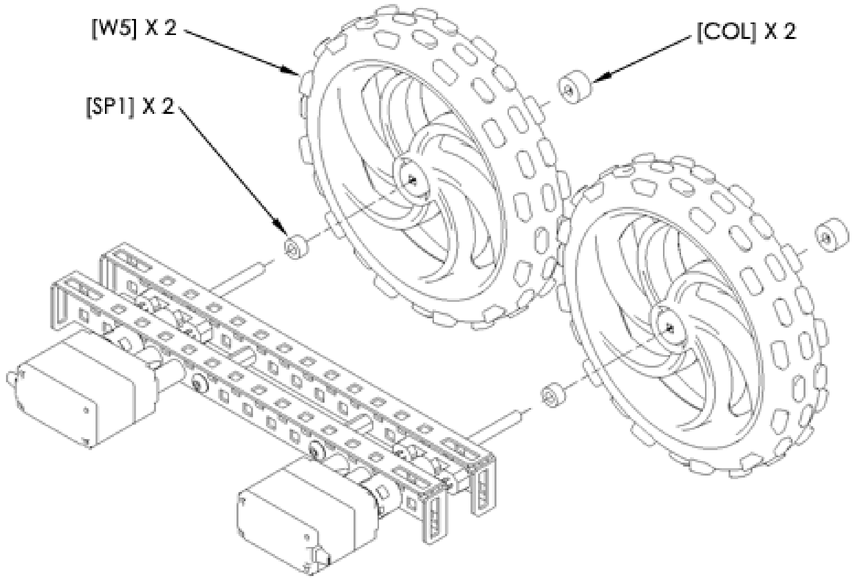


The completed model is as shown:

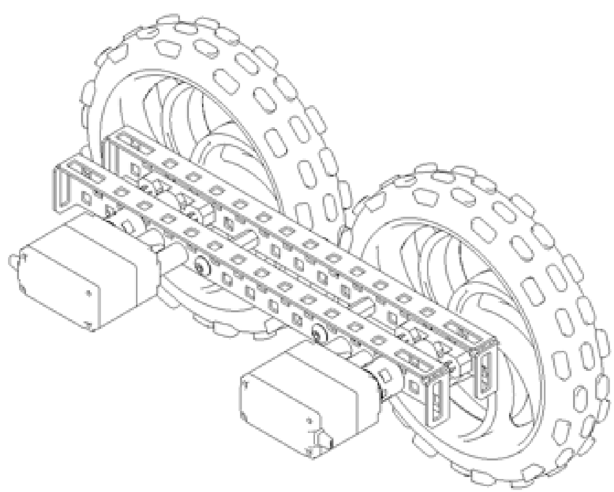


4. To complete the next step:

- Slide a Thin Spacer [SP1] onto each shaft.
- Slide a Rough Terrain Wheel [W5] onto each shaft.
- Slide Shaft Collars [COL] up against the wheels and tighten.



The completed model is as shown:



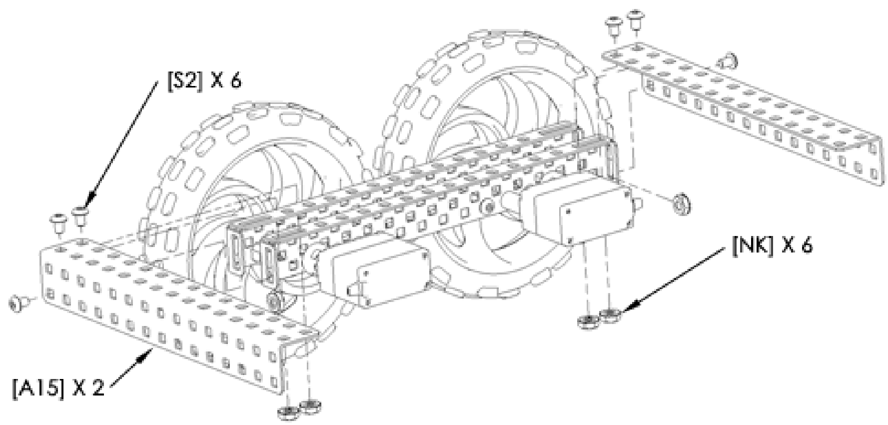
5. The left side drive train is complete!

Assemble the Base

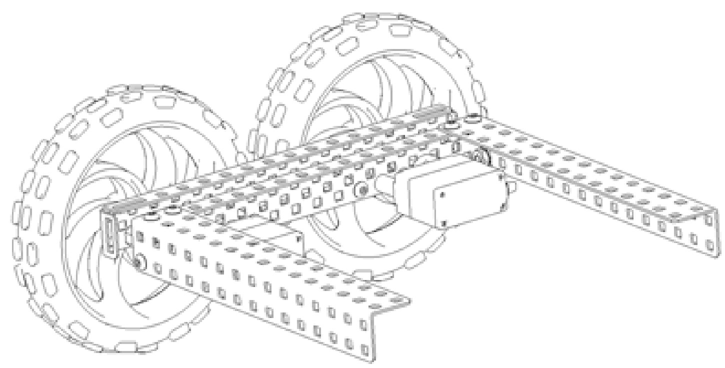
You now assemble the base then add the receiver, controller, battery, and antenna.

1. To complete the first step:

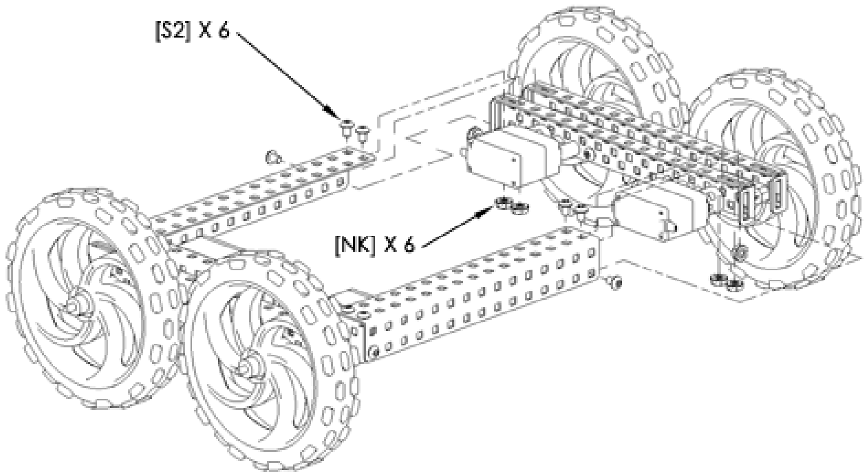
- Bolt a Chassis Bumper [A15] to one end of the right side drive assembly using three #8-32 x 1/4" screws [S2] and corresponding Keps Nuts [NK] for each joint. The Nut Starter might be useful to help start the nuts on the screws.
- Add a second Chassis Bumper as shown.



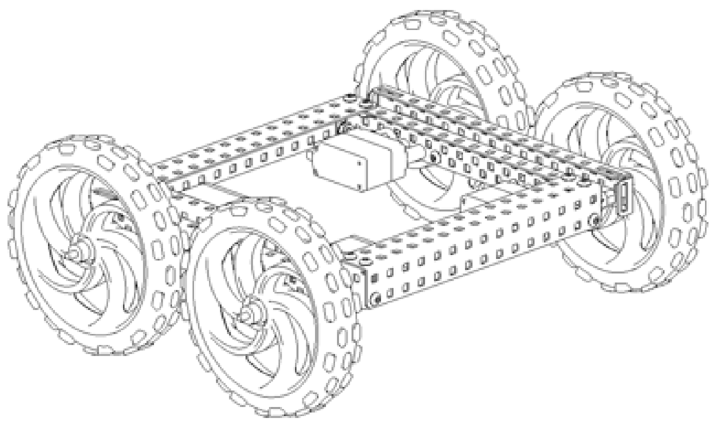
The completed model is as shown:



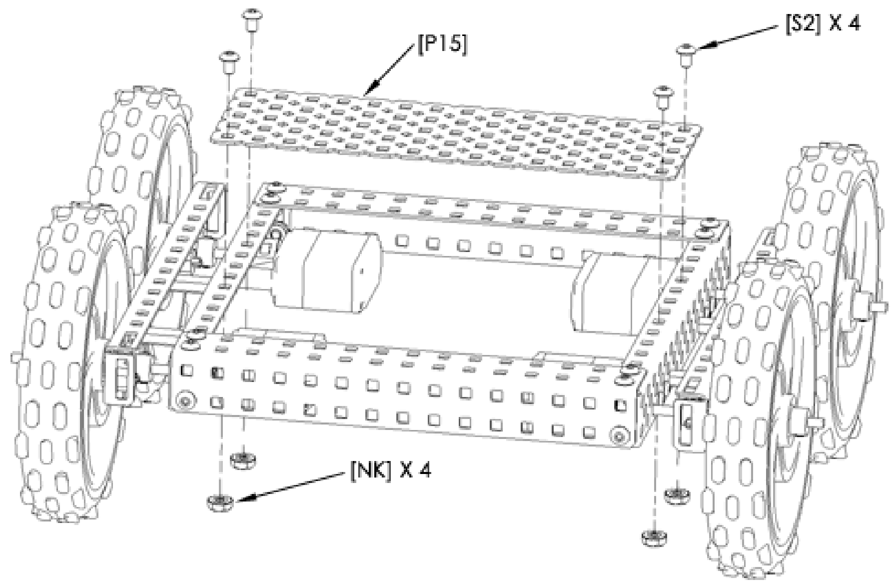
2. Attach the left side drive assembly using the same procedure as the previous step.



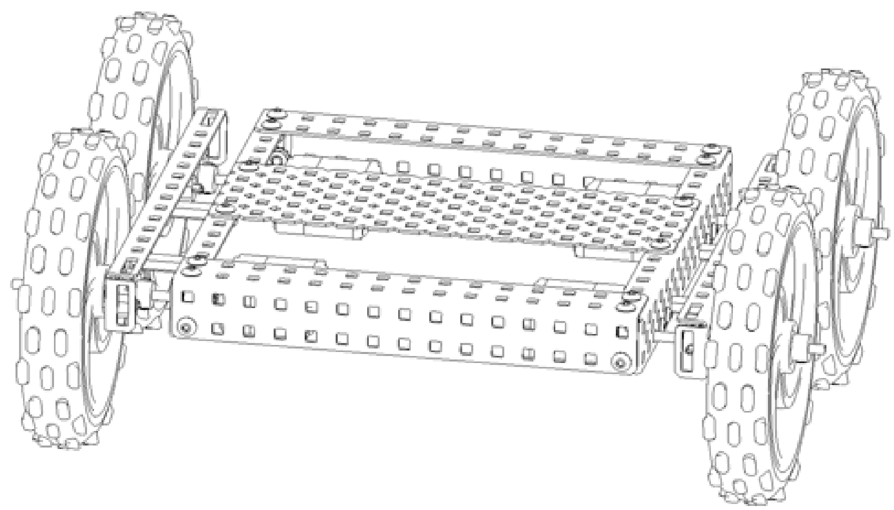
The completed model is as shown:



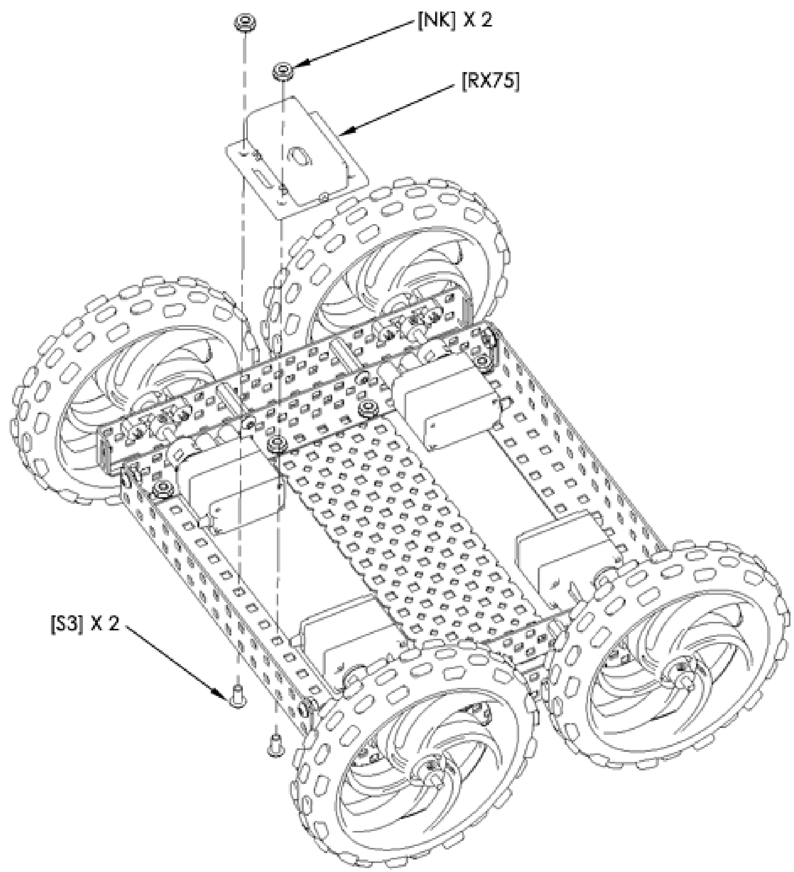
3. Attach a Plate 5x15 [P15] to the top of the chassis using #8-32 x 1/4" screws [S2] and Keps Nuts [NK].



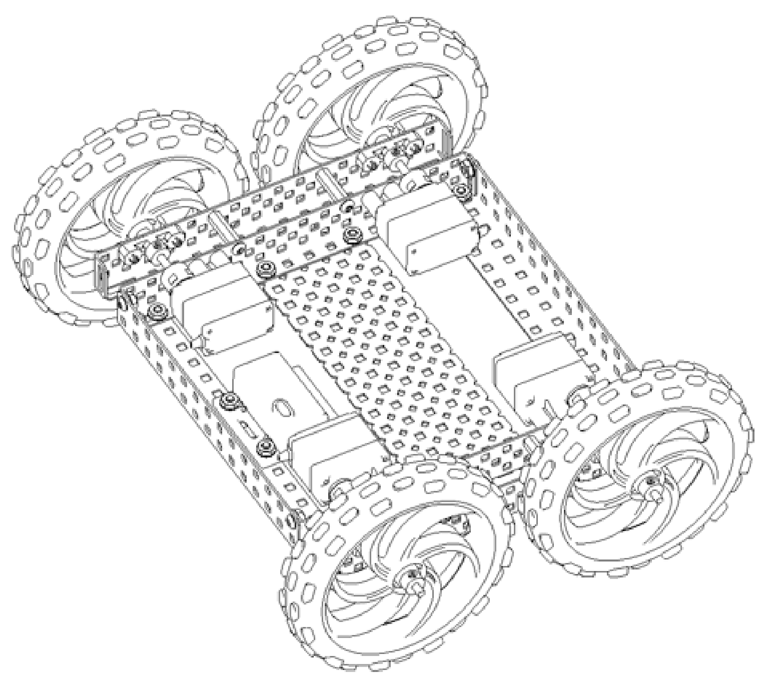
The completed model is as shown:



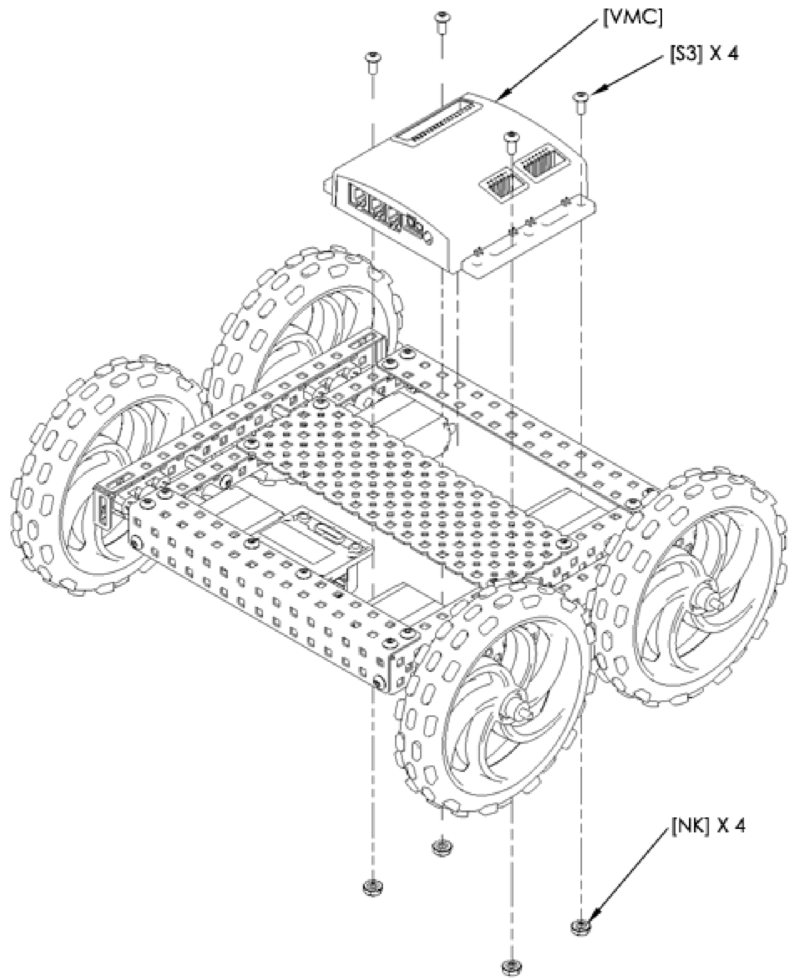
4. Attach the Receiver Module [RX75] to the underside of the chassis using two #8-32 x 3/8" screws [S3] and Keps Nuts [NK].



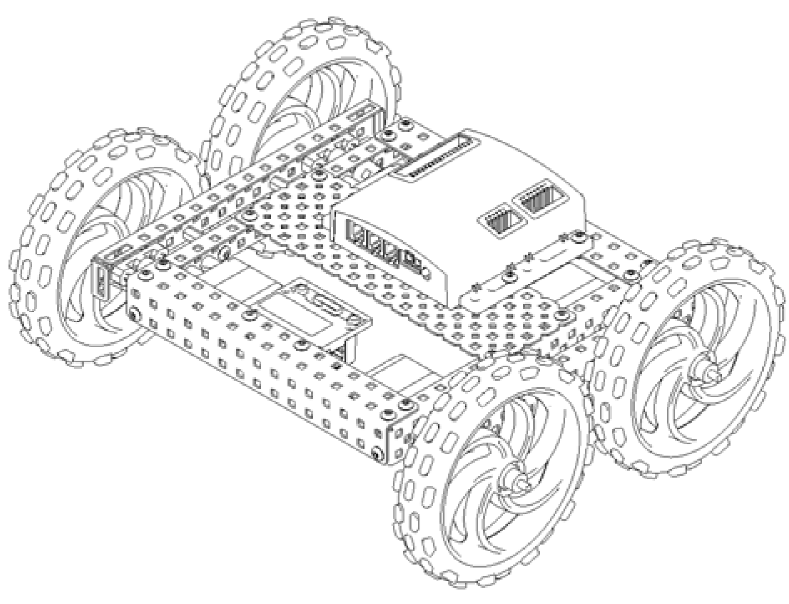
The completed model is as shown:



5. Attach the Microcontroller [VMC] to the top of the chassis using two #8-32 x 3/8" screws [S3] and Keps Nuts [NK].

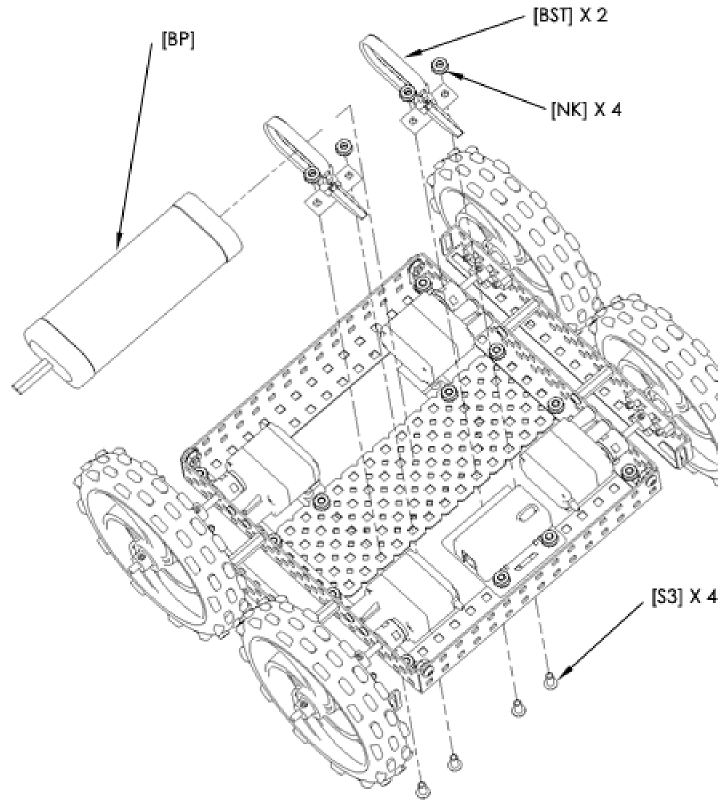


The completed model is as shown:

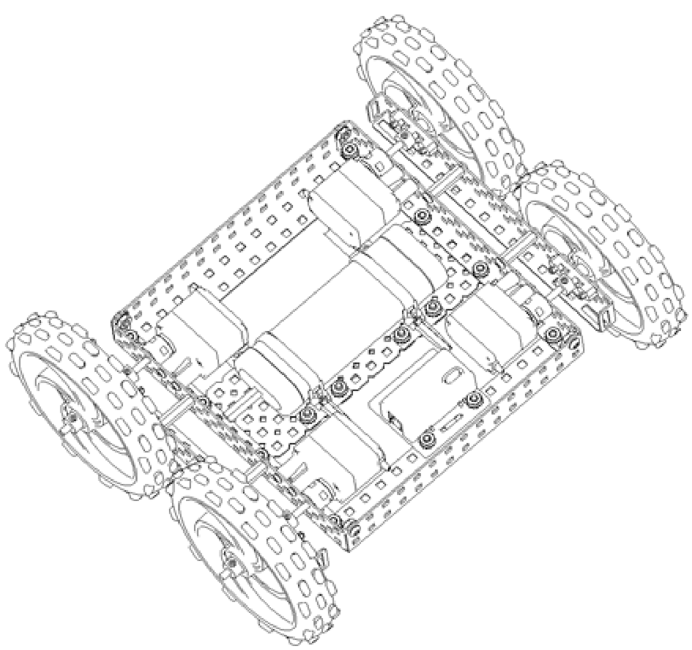


6. To complete the next step:

   - Attach two Battery Straps [BST] to the underside of the chassis using two #8-32 x 3/8" screws [S3] and Keps Nuts [NK] per strap.
   - Attach the 7.2 Volt Robot Battery [BP].

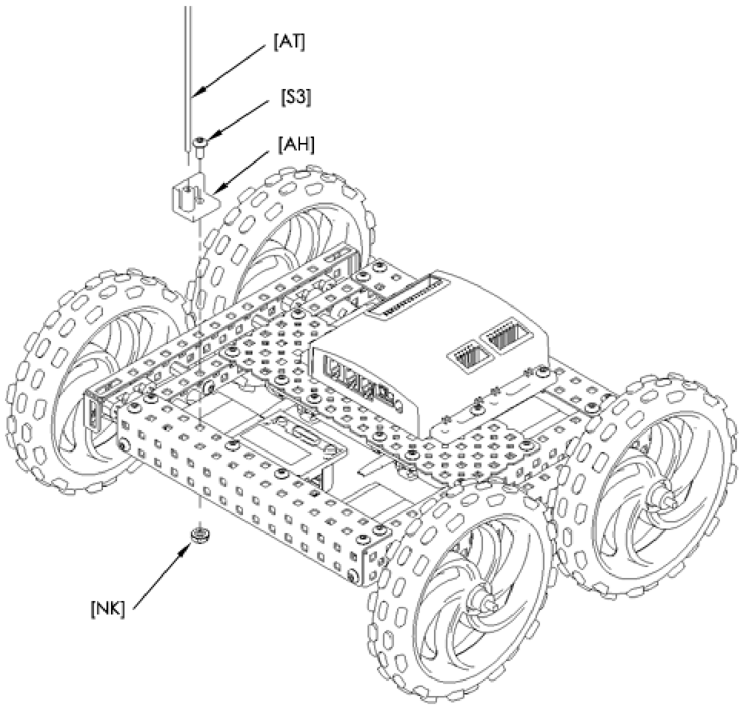


The completed model is as shown:

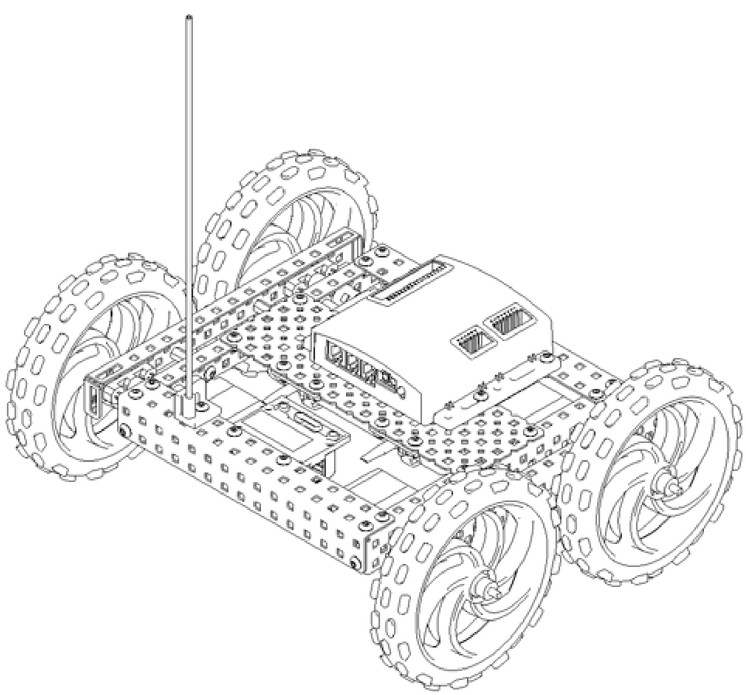


7. To complete the next step:

- Attach the Antenna Holder [AH] to the top of the chassis using one #8-32 x 3/8" screw [S3] and Keps Nut [NK].
- Slide the antenna wire into the Antenna Tube [AT].
- Insert the Antenna Tube into the Antenna Holder.

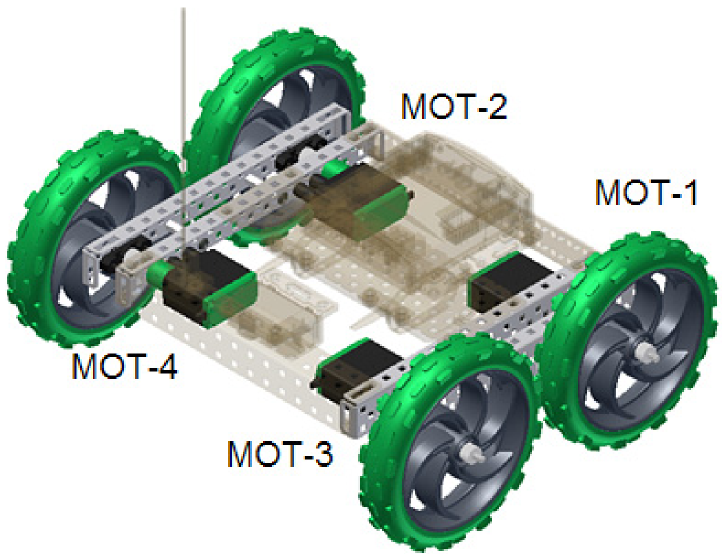


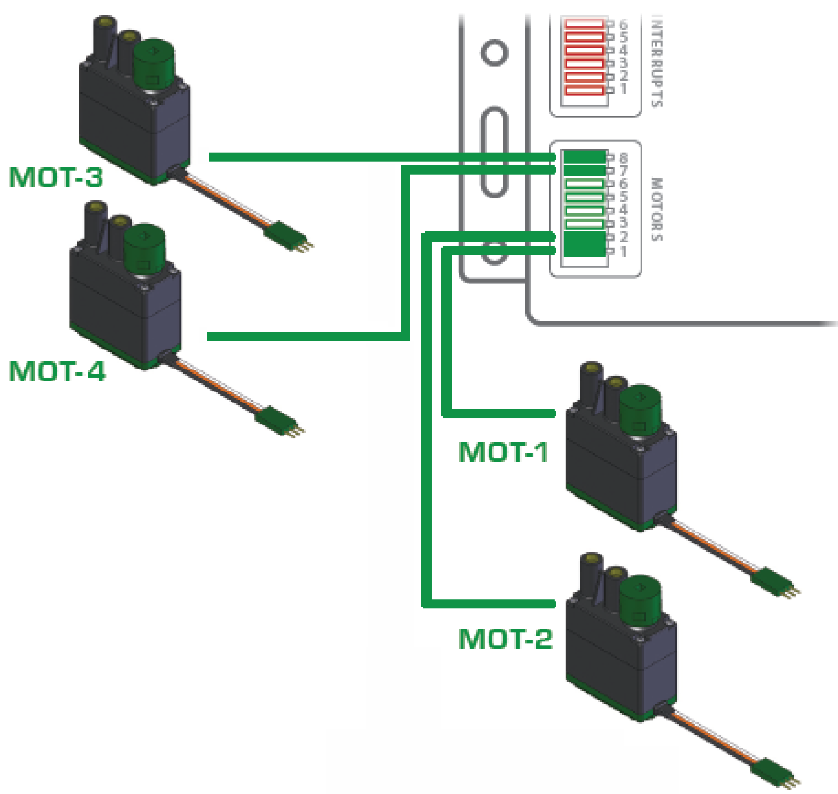
The completed model is as shown:



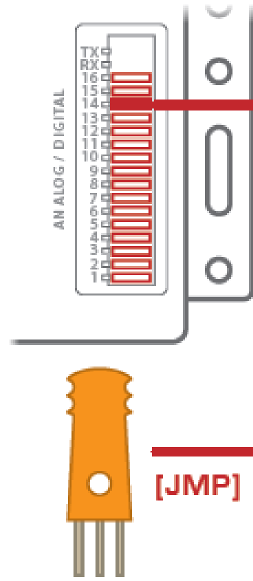
8. Connect the motor connectors into the appropriate MOTORS ports on the Microcontroller as follows:

- Connect motor 1 [MOT-1] to port 1.
- Connect motor 2 [MOT-2] to port 2.
- Connect motor 3 [MOT-3] to port 8.
- Connect motor 4 [MOT-4], the motor nearest the antenna, to port 7.



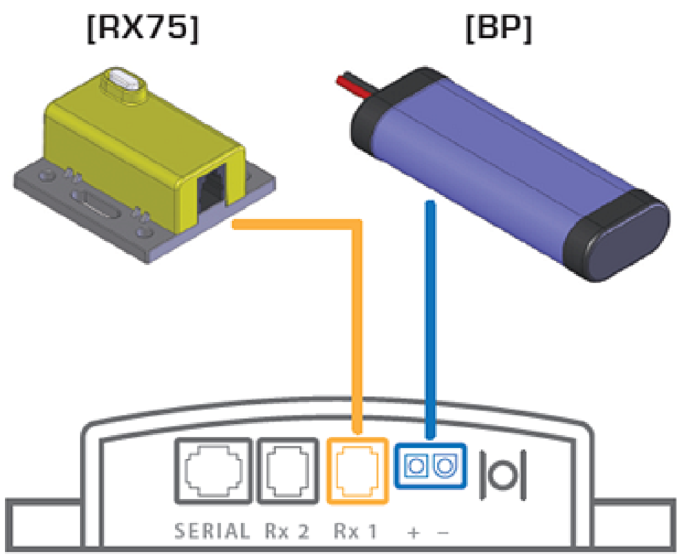


9. Insert a jumper into ANALOG/DIGITAL port 14 on the Microcontroller.

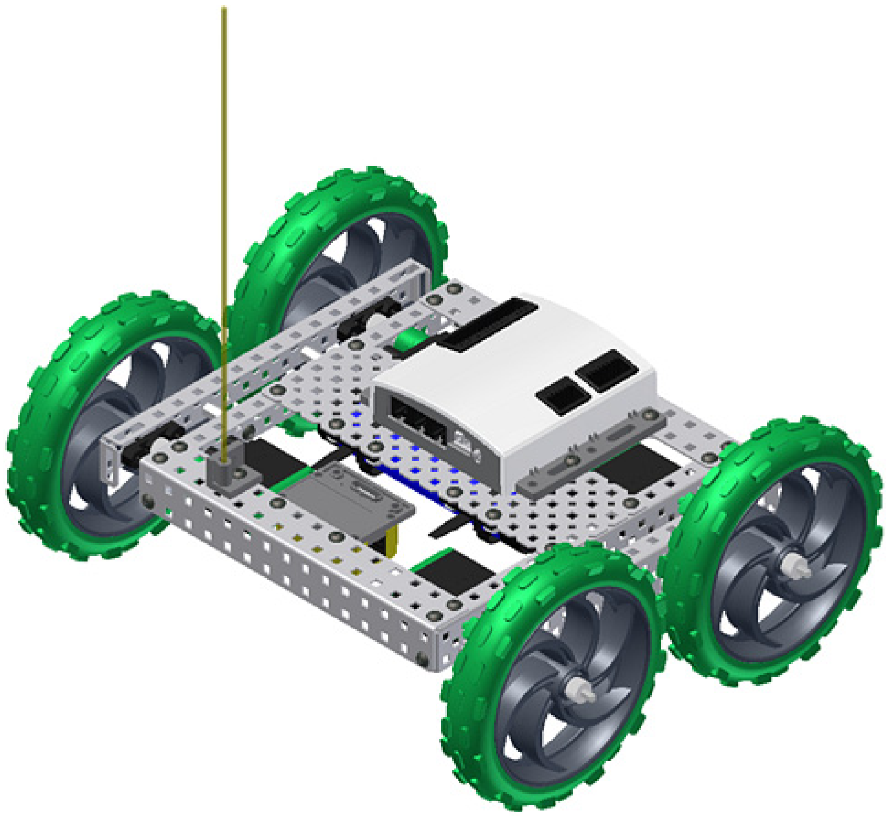


10. To complete the next step:

- Connect the Receiver Module to port Rx1 on the microcontroller.
- Connect the Battery to the power port.



11. Your Tumbler is ready to roll!

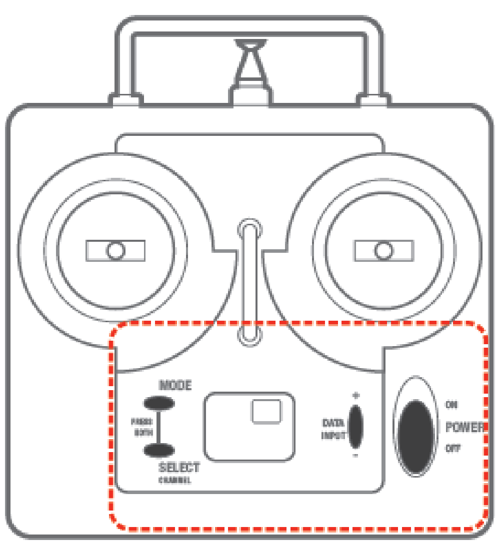


NOTE: Electrical connections are not shown.

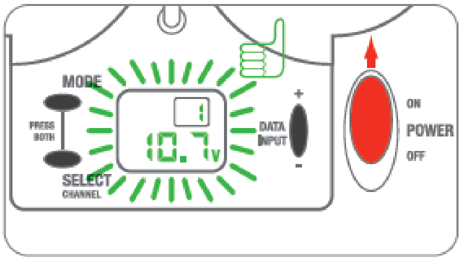
Configure the Transmitter

You now configure the Transmitter to reverse the directional controls on channel 1. See the VEX Inventor's Guide for detailed information on configuring the transmitter.

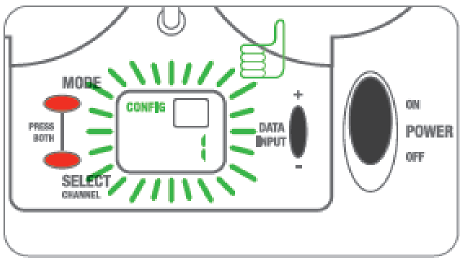
1. Turn on the Transmitter.



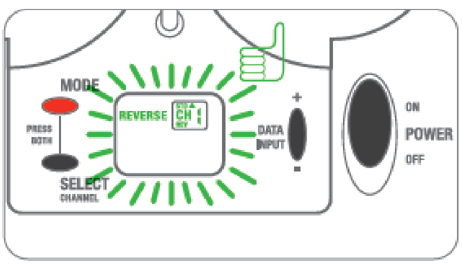
2. Check the voltage. If the voltage is less than 8.9 volts, recharge the batteries in the transmitter.



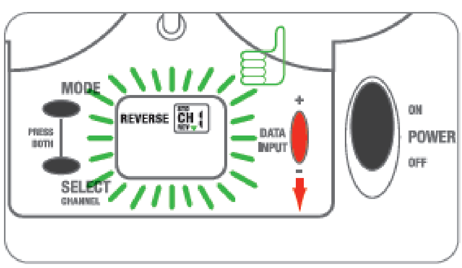
3. Press and hold the MODE and SELECT buttons simultaneously until the CONFIG menu is displayed.



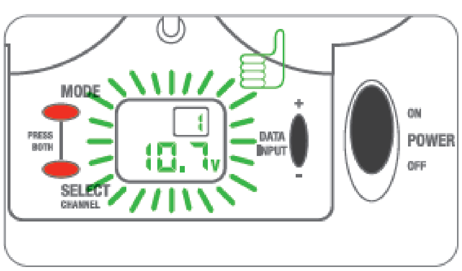
4. Press the MODE button once to display the REVERSE menu.



5. Press the DATA INPUT minus key once. The arrow should display next to REV (below CH on the display).



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!

Amaze Phase

Overview

In this phase, students test their first VEX robot, Tumbler.

Phase Objectives

After completing this phase, you will be able to:

- Test and demonstrate a VEX robot.
- Identify the basic components of a VEX robot.

Prerequisites and Resources

Before starting this phase, you must have:

- Completed all sections in the Unit 1: Introduction to VEX and Robotics up to the Amaze phase.

Required Supplies and Software

The following supplies are used in this phase:

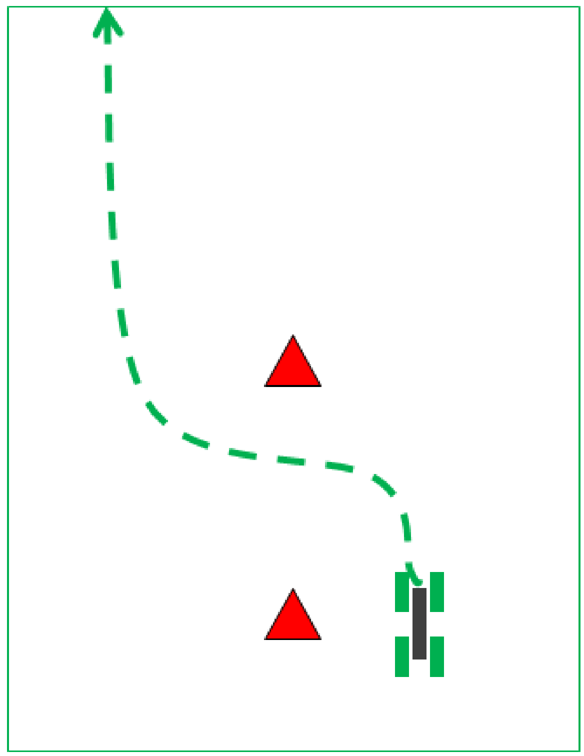
Supplies
One assembled Tumbler robot.
Notebook and pen.
Two obstacles. This can be any small object in your class.
10' x 4' of open space against a wall.

Evaluation

Tumbler Challenge

In this challenge, you set up a basic obstacle course to test drive the Tumbler. You learn to drive a VEX robot, while discovering some of the neat features that Tumbler showcases.

Instructions

	Figure 1
1. Choose any two "obstacles" available to you in your classroom. These obstacles act as pylons for the robot to navigate around. 2. Place the two obstacles approximately 4' apart. See Figure 1. 3. Place Tumbler beside the obstacle furthest from the wall. See Figure 1. 4. Turn Tumbler and its transmitter on. 5. Using the joysticks, have Tumbler drive the path shown in Figure 1. 6. When Tumbler approaches the wall, drive directly into it and cause Tumbler to flip over. 7. Follow the same path back to your starting position. 8. If time permits, experiment with Tumbler and drive it around your classroom.	

Engineering Notebook

In your engineering notebook, record a journal entry describing your experiences with the Tumbler robot. Now that you have gotten a taste of the VEX Robotics Design System, brainstorm a list of robots you would like to create.

Presentation

- Prepare a short presentation for your class describing your favorite and most challenging parts of Unit 1: Introduction to VEX and Robotics.
- Prepare a short presentation describing some ideas of VEX robots you would like to build.