

Building with VEX

Robot Design

Every robot is designed with a purpose in mind – What will the robot do? Determining this is sometimes the most difficult step. Tasks can range from very easy to very difficult, and some may require quite complex robots. Some robots will be capable of completing multiple tasks.

After determining what the robot will do, the next step is to decide how the robot will accomplish the task. It is tempting to start building immediately, but often a little bit of planning and design will result in a much better robot. Creativity and innovation will be important during this part of the design process.

Some engineers and designers have trouble thinking of how to accomplish their challenge. In this situation one of the best things to do is to search for outside inspiration. Inspiration can come from anywhere, so good designers are always looking for ideas. Examples of designs from the “real world” can sometimes be adapted successfully into a VEX robot design. There is no shame in improving an existing design or refining a previously used mechanism. Two brains are better than one, and bouncing ideas off of another designer will often help stimulate creativity. Good designers will collaborate with others to improve their designs.

Design is an Iterative Process

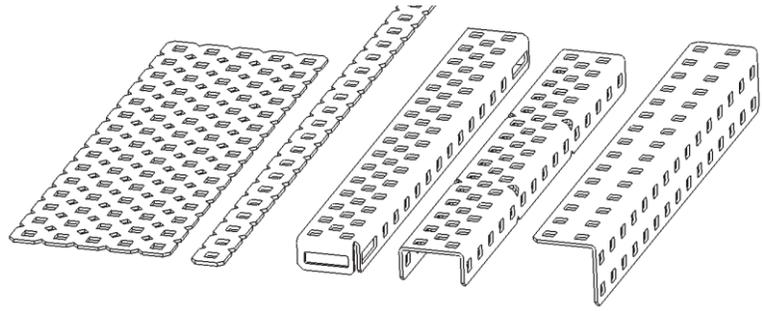
The most important thing to remember about building a VEX robot is that it is an iterative process. Most designers will find themselves building and rebuilding things over and over again until they get the robot functioning well. The VEX Robotics Design System is well suited for this iteration. It is easy to take things apart and modify assemblies without any major fabrication of parts. This allows users to build VEX systems quickly, while a less versatile kit might take much longer. When building robots, a designer should never be afraid to modify work if this process makes the overall product better. Designers are always thinking of ways to improve their design.

Introduction to the Structure Subsystem

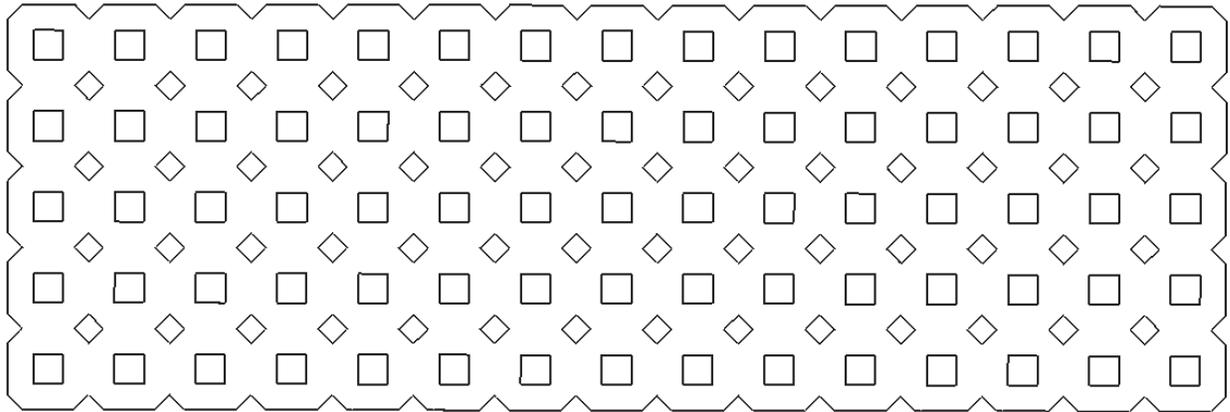
The parts in the VEX Structure Subsystem form the base of every robot. These parts are the “skeleton” of the robot to which all other parts are attached. This subsystem consists of the main structural components in the VEX Design System, including all metal components and hardware pieces. These pieces connect together to form the “skeleton” or frame of the robot.

In the VEX Robotics Design System, the majority of the components in the Structure Subsystem are made from bent sheet metal.

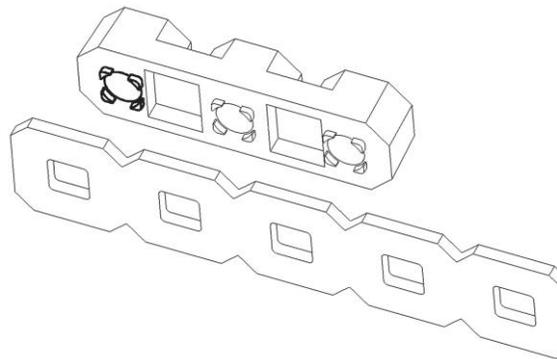
These pieces (either aluminum or steel) come in a variety of shapes and sizes and are suited to different functions on a robot. Different types of parts are designed for different applications.

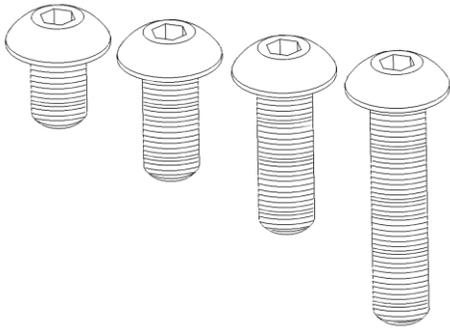


The VEX structural pieces all contain square holes (0.182 in. square) on a standardized $\frac{1}{2}$ in. grid. This standardized hole spacing allows for VEX parts to be connected in almost any configuration. The smaller diamond holes are there to help users cut pieces using tin snips or fine-toothed hacksaws without leaving sharp corners.



VEX square holes are also used as alignment features on some components. These pieces will snap in place into the square holes. For example, when mounting a VEX Bearing Flat, the small tabs will stick through the square hole and hold it perfectly in alignment. This allows for good placement of components with key alignment requirements (it would be bad if a bearing slipped out of place). Note that hardware is still required to hold the Bearing Flat onto a structural piece.





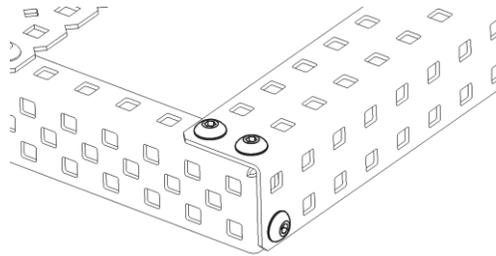
Hardware is an important part of the Structure Subsystem. Metal components can be directly attached together using the 8-32 screws and nuts which are standard in the VEX kit. The 8-32 screws fit through the standard VEX square holes. These screws come in a variety of lengths and can be used to attach multiple thicknesses of metal together or to mount other components onto the VEX structural pieces. Allen wrenches and other tools are used to tighten or loosen the hardware.

Note: There are two types of screws that are part of the VEX Robotics Design System.

- Size 8-32 screws are the primary screws used to build robot structure.
- Size 6-32 screws are smaller screws which are used for specialty applications like mounting the VEX Motors and Servos.

Hint:

Attach components together with multiple screws from different directions to keep structural members aligned correctly and for maximum strength.



When using screws to attach parts, there are three types of nuts which can be used.

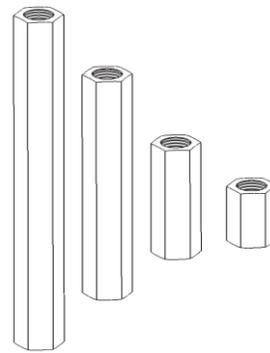
- Nylock nuts have a plastic insert in them which will prevent them from unscrewing. These are harder to install, as you need to use an open-ended wrench to tighten them up. These nuts will not come off due to vibration or movement.
- KEPS nuts have a ring of “teeth” on one side of them. These teeth will grip the piece they are being installed on. This means you do not NEED to use an open-ended wrench to tighten them (but it is still recommended). These nuts are installed with the teeth facing the structure. These nuts can loosen up over time if not properly tightened; however, they will work great in most applications.
- Regular nuts have no locking feature. These basic hex nuts require a wrench to install and may loosen up over time, especially when under vibration or movement. They are very thin and can be used in some locations where it is not practical to use a Nylock or KEPS nut.



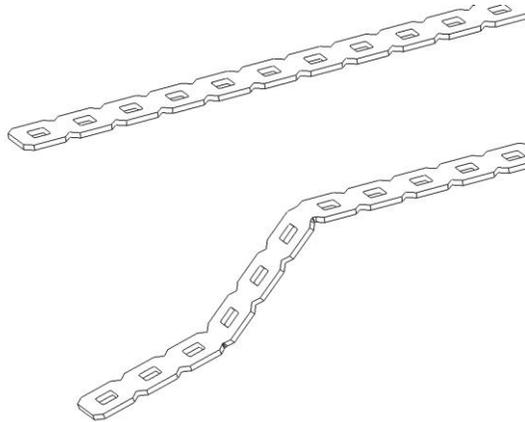
WARNING:

It is important to be careful when tightening screws. The allen wrenches may round or “strip out” the socket on the head of the screw if they are not fully inserted into the socket. Use care when tightening

Components can also be offset from each other using 8-32 threaded standoffs; these standoffs come in a variety of lengths and add great versatility to the VEX kit. These standoffs work great for mounting components in the VEX system as well as for creating structural beams of great strength.



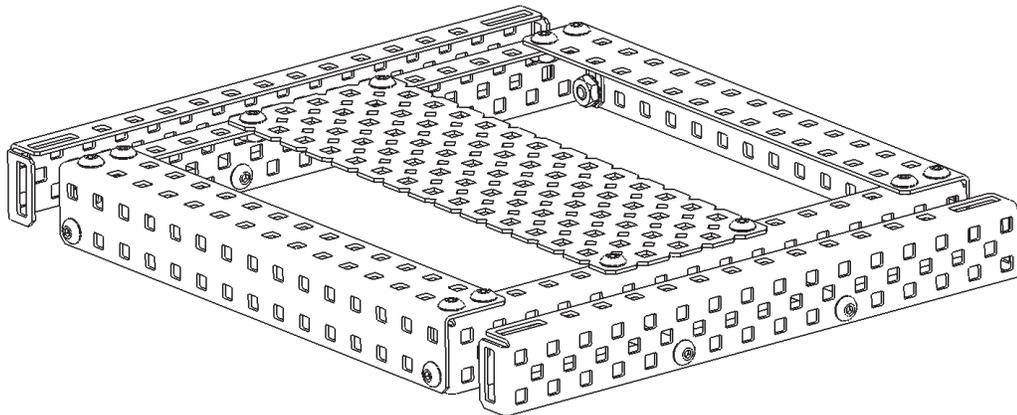
screws to prevent stripping out the head of the screw.



One of the key features of many VEX structural parts is their bend-able and cut-able nature. Users can easily modify many of these structural parts into new configurations better suited for their current needs. Flat plates can be bent into brackets. Many metal components can be cut to custom lengths. These parts were designed to be modified.

Note: It is almost impossible to fully flatten a piece once it has been bent.

The VEX structural components come in a variety of shapes and sizes. Each of these structural shapes may be strong in some ways but weak in others. It is very easy to bend a piece of VEX Bar in one orientation, but it is almost impossible to bend it when it is in another orientation. Applying this type of knowledge is the basis of structural engineering. Experiment with each piece and see how it can be used to create an extremely strong robot frame.



When designing a robot's structure, it is important to think about making it strong and robust while still trying to keep it as lightweight as possible. Sometimes overbuilding can be just as detrimental as underbuilding. The frame is the skeleton of the robot and should be designed to be integrated cleanly with the robot's other components. The

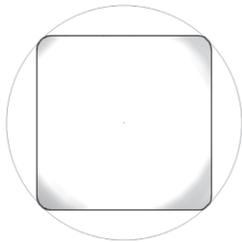
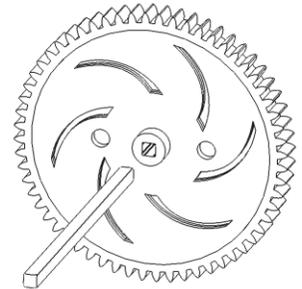
overall robot design should dictate the chassis, frame, and structural design; not vice-versa.

Design is an iterative process; experiment to find out what works best for a given robot.

Introduction to the Motion Subsystem

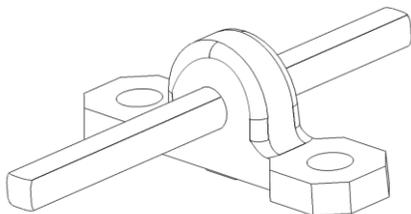
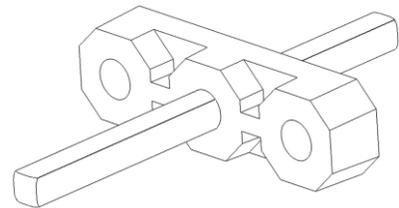
The Motion Subsystem is comprised of the components in the VEX Robotics Design System which make a robot move. These components are critical to every robot. The Motion Subsystem is tightly integrated with the components of the Structure Subsystem in almost all robot designs. In the VEX Robotics Design System, the motion components are all easily integrated. This makes it simple to create very complex systems using the basic motion building blocks.

The most fundamental concept of the Motion Subsystem is the use of a square shaft. Most of the VEX motion components use a square hole in their hub which fits tightly on the square VEX shafts. This square hole – square shaft system transmits torque without using cumbersome collars or clamps to grip a round shaft.



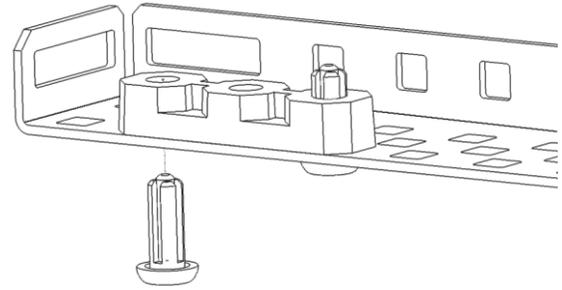
The square shaft has rounded corners which allow it to spin easily in a round hole. This allows the use of simple bearings made from Delrin (a slippery plastic). The Delrin bearing will provide a low-friction piece for the shafts to turn in.

These VEX Delrin bearings come in two types, the most common of which is a Bearing Flat. The Bearing Flat mounts directly on a piece of VEX structure and supports a shaft which runs perpendicular and directly through the structure.

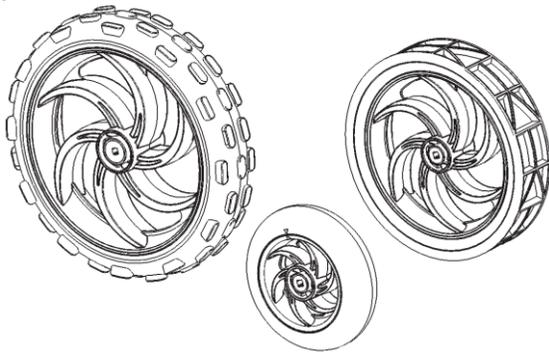


Another type of bearing used in the VEX Motion Subsystem is a Bearing Block; these are similar to the “pillowblocks” used in industry. The Bearing Block mounts on a piece of structure and supports a shaft which is offset above, below, or to the side of the structure.

Some bearings can be mounted to VEX structural components with Bearing Pop Rivets. These rivets are pressed into place for quick mounting. These Rivets are removable; pull out the center piece by pulling up on the head of the Rivet to get it to release.



The VEX Motion Subsystem contains a variety of components designed to help make robots mobile. This includes a variety of wheel sizes, tank treads, and other options. Robots using these in different configurations will have greatly varying performance characteristics.



Tank Tread components and wheels can also be used to construct intake mechanisms and conveyor belts. These are frequently used on competition robots.

When designing the Motion Subsystem of a robot, it is important to think about several factors:

- First, it needs to be able to perform all moving functions of the robot.
- Second, it needs to be robust enough to survive normal robot operation. It also needs to be robust enough to survive some abnormal shock loads.
- Third, it needs to be well integrated into the overall robot system.

The Motion Subsystem combines with the Structure Subsystem to form the primary physical parts of the robot. The motion components will be used throughout a robot's construction and will likely be part of every major robot function. As such, this Subsystem needs to be well thought out in advance.

Document created in conjunction with VEX Robotics Design System