# FVC Robot Design Tips & Best Practices

For more technical support, refer to the Vex Inventor's Guide that comes as part of the Vex Starter kit. Also refer to http://www.vexforum.com for Community Discussion, Vex FAQ's and additional technical support.

## Quick Tips for Designing a Robot to Play Hangin'-A-Round

1. Decide "what" you want the robot to do, then decide "how" the robot will do it.
    a. There are tradeoffs to be made
2. The key to design is iteration. Experimentation & Redesign of a robot will help tune it closer to perfection. Try building as many field elements as your team budget allows and see what works best with the elements.
    a. Those teams with small budgets can creatively substitute for actual field elements. (i.e. use a trashcan or cardboard structure to simulate the tall goal.)
3. Since there are tall objects on the field which and many robots will likely reach high in the air, it is important to consider robot stability and Center of Gravity.
    a. A larger robot footprint will provide great stability, but may decrease robot turning.
    b. A low robot CG will also enhance stability.
4. The motors in the Vex kit are limited in power, and each robot is only allowed to use a maximum of ten (10). This is a significant limitation. When it comes to robots, bigger is NOT always better. Design accordingly.
    a. It is possible to have a fully functional drive system and ball mechanism using only the motors/servos in one kit, buying more Vex parts may not be necessary or practical for your team. Developing a strategy and design that matches your budget are the keys to being competitive.
5. There are many different options for a robot's drive-train; each comes with its own set of benefits and weaknesses. A team must decide how important these things are, when deciding on a drive configuration.
    a. How fast is it? (Will it damage the motors, is it too fast?)
    b. How maneuverable is it?
    c. How well can it climb onto the platform?
    d. Will it get hung-up on softballs on the field?
6. Teams need to make sure their robot performs well in autonomous mode to excel in this competition. Design accordingly. Decide what your robot will try to do in Autonomous mode, and then figure out the best way to do it. There are many options for autonomous mode, each with their own pros and cons. Experiment to see what works best.
    a. Dead Reckoning?
    b. Line Following?
    c. Wall Following?
    d. Some Combination?
    e. Other?

# Specific Mechanism Advice for Hangin'-A-Round

1. In this game, one may decide to be an offensive "ball scoring" robot. When designing a mechanism for picking up soft balls there are several things to consider; a designer must try to maximize the performance of the mechanism. Some of these considerations are:
    a. Does it need to pick up the balls, or can it just plow?
    b. How many balls will it hold at one time?
    c. How fast can it pick up the balls?
    d. Will the balls jam during pickup?
    e. Can the robot pick up off the floor?
        i. Can it pick up off the floor while moving full speed?
    f. How will it score the balls?
    g. How fast can it score the balls?
    h. Will the balls jam during scoring?
    i. What goals can it score in?

2. In this game, one may decide to hang from the bar. There are many considerations associated with this type of mechanism as well:
    a. How easy is it for the driver to hook onto the bar?
    b. How far away does the robot have to be to hook on?
    c. Can the robot hook on if it isn't lined up straight?
    d. How much force is required to lift the robot?
    e. Can the robot pull "through" a defensive robot trying to stop it from hanging?
    f. How long does it take the robot to lift off the ground, once it is hooked on?
    g. Will the robot stay "up" after it has hung, or will it fall back down?
        i. Can something be built that will hang, and lock in place?

# Important Principles for Choosing Game Strategy

## 1. Choose a Path

You cannot build a robot without knowing what it is supposed to do. Brainstorm through all the different scoring and defensive tasks. From there, choose the task or tasks that you think will be optimal. Now and only now should you start thinking about implementation. “Figure out what it’s going to do, before how it’s going to do it”.

## 2. Simplify

A simpler mechanism is a better mechanism. Always try to limit complexity as much as possible. The simpler solution is always better.

## 3. Unify

Combine mechanisms wherever possible. Make things multifunctional, yet do not sacrifice the effectiveness of either function. It is important that the robot is not a collection of parts, or components, but a single integrated system.

## 4. Specialize

The robot does not have to do everything. Pick one thing for the robot to do, and specialize in it. It is better to do one thing very well, with some secondary supporting functions, than to try to do everything. “Jack of all trades, master of none” is NOT the way to be. Decide what things are most important for playing the game. If possible, be “the best” at something, but do not make success hinge on your being “the best”. There is ALWAYS someone better. A rule of thumb: If I have 30 units of robot functionality available to me, it’s better to do three things at 10/10 as opposed to five things at 6/10.

## 5. Innovate

Think outside the box. Come up with new things, but be prepared to test/prove them. Often, it is the “crazy” solution that works best. It is better to brainstorm EVERYTHING, and then narrow things down from there, than to be narrow-minded from the beginning and miss something important.

## 6. Be Versatile

Someone once said: “May the nimblest robot win”, and in many cases, this holds true. Make sure the robot is adaptable for any situation, and able to move through each match with grace. Do not hinge everything on one set event occurring in the match. Try not to rely on brute-force. The robot must be able to play the entire match.

## 7. Let the drivers win matches

Make sure the robot is a tool the drivers & coach can use to win. Allow them to play their game, and use their skills. Build a robot that can score quickly. One that is capable of playing a defensive role, as well as an offensive role, one that can quickly adapt to the changing situations that occur during a match. Do not try to predict everything that will happen, give the coach a tool that will work in any situation.

## 8. Do less, faster

This goes along with versatility. It is much easier to build a mechanism that scores “2 balls” than it is to build one that scores “6 balls”. Simply build the “2 ball” one, and make it 3x as fast. Speed is important; matches are short.

## 9. Remember Diminishing Returns.

Always ask yourself what *small* things will get **BIG** gains, and what **BIG** things will only get *small* gains. Some things may seem like a good idea, but aren't worth the huge effort to pull off. Others might take a little extra effort, but will pay up big time. Always be on the lookout for these 2 types of ideas, and know what to do with each!

# Important Principles to Remember During Robot Design

## 1. Know the rules, knowledge is power

Make sure you know all restrictions and specifications placed upon you by as part of the *FIRST* Vex Challenge. Look closely at what field parts/playing objects you are, and aren't allowed to interact with.

## 2. Know your resources

Understand what it is you have to work with. Learn about the components in the Vex kit, and their limitations. Also realize what "human" resources you have to use. Know what everyone is capable of. Know what YOU are capable of, realize your limitations, and do not be afraid to ask for help. If you don't know how to do something, try to learn. Ask someone to teach you.

## 3. Do research

Seek inspiration from anywhere & everywhere. Try to find examples of designs in the "real world" that could be applied to the current challenge. Learn as much as possible about the materials given. There is no shame in using, and improving an existing design. Take old mechanisms and refine them. Look for things that have already been done, that can be adapted to the current design challenge. Don't reinvent the wheel. Ask for help from others.

## 4. Design is an iterative process

Do not be afraid to go through several different revisions before deciding on a final mechanism. Work the bugs out of designs through testing and redesign. Changes are often necessary to make sure the robot integrates together smoothly, and functions well as a whole.

## 5. Two brains are better than one

Work together as a team. Brainstorm lots of ideas and hit upon several that seem most promising. Throw out NO ideas, even silly suggestions could inspire someone to come up with the perfect solution. Experiment and test ideas to find out what solutions work best; then further refine those solutions.

## 6. Strive to improve

Always work to improve things. Ask yourself "designer's questions":

- How can I make this **lighter**?
- How can I make this **faster**?
- How can I make this more **robust**?
- How can I make this **smaller**?
- How can I make this **simpler**?
- How can I make this **more efficient**?
- How can I make this **easier to construct**?
- How can I combine this component with something else?
- What else can I make this component do, easily?
- Who can help me with this?
- Do I really have to do it this way? Is there a better way?

## 7. Design for use

The robot has to be driven. Design everything for usage during actual competition conditions. Plan ahead for this, make everything robust, easy to operate, and ROBUST. The most dangerous phrase ever uttered is: "Don't drive it, you might break it!" Make everything as tough as possible.

## 8. Design for ease of control

The Vex receiver offers many control outputs. Do not fall into the trap of trying to use them all. In a 2:00 match, every second counts. Your drivers must be able to operate the robot without constantly trying to remember which button does what. Make the controls as simple and intuitive as possible. If necessary, use two receivers to spread the operations among two people.

## 9. Design for repair

Nothing is invincible. Make sure everything can be easily repaired without any major hassle, or time delay. Changing out spare parts should be simple and painless. Something relatively trivial like, providing easy access to a screw head can be the difference between victory and defeat during competition conditions.

## 10. Design for assembly

Someone has to put the robot together. Make sure there is no interference. If necessary, create an assembly guide. Everything should easily fit together. Try to avoid having parts trapped by other parts. (As in: we can't remove mechanism A, without removing mechanisms B, and C.)