Tips & Best Practices for Robot Design

This document provides additional tips and best practices for designing your *FIRST* Vex Challenge robot. For more technical support, refer to the Vex Inventor's Guide that is included with the Vex Starter kit. Also visit http://www.vexlabs.com/forum/ for Vex FAQ's and additional technical support.

Quick Tips for Designing a Robot to Play Half-Pipe Hustle:

1. 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 to simulate a center-goal.)
2. In this game in order to be a strong offensive robot, one needs a highly effective scoring mechanism. When designing a mechanism for picking up racquetballs there are several things to consider; a designer must try to maximize the performance of the mechanism. Some of these considerations are:
    a. How many balls will it hold at one time?
    b. How fast can it pick up the balls?
    c. Will the balls jam during pickup?
    d. Can the robot pick up off the floor?
        i. Can it pick up off the floor while moving full speed?
    e. Can the robot pick up from the auto-feeder?
    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?
3. Since there are inclined ramps on the field, 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 eight (8). 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. 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 the ramps?
6. Teams need to make sure their robot performs well in both autonomous and operator-controlled matches. Design accordingly. 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. Combination?
    e. Other?

Important Principles for Choosing Game Strategy:

1. Simplify.

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

2. 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.

3. 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.

4. 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.

5. 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.

6. Let the drivers win matches.

Make sure the robot is a tool the drivers and 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.

7. 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 three times as fast. Speed is important; matches are short.

8. 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 of. Others might take a little extra effort, but will pay up big time. Always be on the lookout for these two 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 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.

9. 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. (For example: we can’t remove mechanism A, without removing mechanisms B, and C.)