

BASICS IN ROBOTICS

ROBOTECH

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Index:

1. Introduction	1-3
2. Anatomy of a Robot	4-6
3. Locomotion	7-8
4. Sensors	9
5. How to build a Robot	10-19
• Electronics part	11-12
• Tools Required	13-15
• Construction Techniques(Electronics)	14-16
• Construction of a platform	17-19
6. Computer and Electronic Control	20-23
• Robot's Brain	20-22
• Programming a Robot	22
• Remote Control	23
7. How to increase the Performance of a Robot	24-26
8. Principles of Robot's Locomotion	27
9. Centre of Gravity (CG)	28-29
10. Motor Drives	29-32
11. Building a Advanced Locomotion Robot	32-35
12. 3-Laws	36
13. About the Author	37

ROBOTECH

INTRODUCTION

To the robotics experimenter, *robot* has a completely different meaning than what most people think of when they hear the word. A robot is a special brew of motors, solenoids, wires, and assorted electronic odds and ends, a marriage of mechanical and electronic gizmos. Taken together, the parts make a half-living but wholly personable creature that can vacuum the floor, serve drinks, protect the family against intruders and fire, entertain, educate, and lots more. In fact, there's almost no limit to what a well-designed robot can do. In just about any science, it is the independent experimenter who first establishes the pioneering ideas and technologies.

Today, robotics is well on its way to becoming a necessary part of everyday life; not only are they used in automotive manufacturing, but they are exploring the solar system and prototype robot servants are walking upright, just like humans, as they learn to navigate and interact with our world.

What does this mean for the robotics experimenter?

There is plenty of room for growth, with a lot of discoveries yet to be made—perhaps more so than in any other hightech discipline.

BASIC SKILLS NEEDED FOR ROBOTICS

What skills do you need as a robot experimenter?

Certainly, if you are already well versed in electronics, programming, and mechanical design, you are on your way to becoming a robot experimenter.

But intimate knowledge of these fields is not absolutely necessary;

All you really need to start in the right direction as a robot experimenter is a basic familiarity with electronic theory, programming concepts, and mechanics (or time and interest to study the craft). The rest you can learn as you go. If you feel that you're lacking in either beginning electronics or mechanics, pick up a book or two on these subjects at the bookstore or library. In addition, you may wish to read through the seven chapters in Part 1 of this book to learn more about the fundamentals of electronics and computer programming.

ELECTRONICS BACKGROUND

Start by studying analog and digital electronic theory, and learn the function of resistors, capacitors, transistors, and other common electronic components. Your knowledge need not be extensive, just enough so that you can build and troubleshoot electronic circuits for your robot. You'll start out with simple circuits with a minimum of parts, and go from there.

As your skills increase, you'll be able to design your own circuits from scratch, or at the very least, customize existing circuits to match your needs.

Schematic diagrams are a kind of recipe for electronic circuits.

PROGRAMMING BACKGROUND

Sophisticated robots use a computer or microcontroller to manage their actions. In this book you'll find plenty of projects, plans, and solutions for connecting the hardware of your robot to any of several kinds of robot "brains." Like all computers, the ones for robot control need to be programmed. If you are new or relatively new to computers and programming, start with a beginners' computer book, then move up to more advanced texts.

MECHANICAL BACKGROUND

Some robot builders are more comfortable with the mechanical side of robot building than the electronic and programming sides—they can see gears meshing and pulleys moving. Regardless of your comfort level with mechanical design, you do not need to possess an extensive knowledge of mechanical and engineering theory to build robots.

There are a wealth of books, articles, and online reading materials on mechanical design equations and engineering formulas for you to draw upon when you are designing and building robots.

TWO MAIN IMPORTANT SKILLS

Two important skills that you can't develop from reading books are *patience* and the *willingness to learn*.

Both are absolutely essential if you want to build your own working Robots.

Give yourself time to experiment with your projects.

Don't rush into things because you are bound to make mistakes if you do. If a problem continues to nag at you, put the project aside and let it sit for a few days.

Keep a small notebook handy and jot down your ideas so you won't forget them.

If trouble persists, perhaps you need to bone up on the subject before you can adequately tackle the problem.

Take the time to learn more about the various sciences and disciplines.

ANATOMY

THE ROBOT'S BODY

We humans are fortunate. The human body is, all things considered, a nearly perfect machine: it is (usually) intelligent, it can lift heavy loads, it can move itself around, and it has built-in protective mechanisms to feed itself when hungry or to run away when threatened. Other living creatures on this earth possess similar functions, though not always in the same form.

Robots are often modelled after humans, if not in form then at least in function. For decades, scientists and experimenters have tried to duplicate the human body, to create machines with intelligence, strength, mobility, and auto-sensory mechanisms. That goal has not yet been realized, but perhaps someday it will.

Nature provides a striking model for robot experimenters to mimic, and it is up to us to take the challenge. Some, but by no means all, of nature's mechanisms—human or otherwise—can be duplicated to some extent in the robot shop. Robots can be built with eyes to see, ears to hear, a mouth to speak, and appendages and locomotion systems of one kind or another to manipulate the environment and explore surroundings.

SKELETAL STRUCTURES

In nature and in robotics, there are two general types of support frames: endoskeleton and exoskeleton. Which is better?

Both: in nature, the living conditions of the animal and its eating and survival tactics determine which skeleton is best. The same is true of robots.

- Endoskeleton support frames are found in many critters, including humans, mammals, reptiles, and most fish. The skeletal structure is on the inside; the organs, muscles, body tissues, and skin are on the outside of the bones. The endoskeleton is a characteristic of vertebrates.
- Exoskeleton support frames have the “bones” on the outside of the organs and muscles. Common creatures with exoskeletons are spiders, all shellfish such as lobsters and crabs, and an endless variety of insects.

FRAME CONSTRUCTION

The main structure of the robot is generally a wood, plastic, or metal frame, which is constructed a little like the frame of a house—with a bottom, top, and sides.

This gives the automaton a boxy or cylindrical shape, though any shape is possible.

It could even emulate

the human form, like the robot ASIMO of HONDA

Onto the frame of the robot are attached motors, batteries, electronic circuit boards, and other necessary components. In this design, the main support structure of the robot can be considered an exoskeleton because it is outside the “major organs.” Further, this design lacks a central “spine,” a characteristic of endoskeletal systems and one of the first things most of us think about when we try to model robots after humans. In many cases, a shell is sometimes placed over these robots, but the “skin” is for looks only (and sometimes the protection of the internal components), not support.

Of course, some robots are designed with endoskeletal structures, but most such creatures are reserved for high-tech research and Development projects and science fiction films. For the most part, the main bodies of your robots will have an exoskeleton support structure because they are cheaper to build, stronger, and less prone to problems.

SIZE AND SHAPE

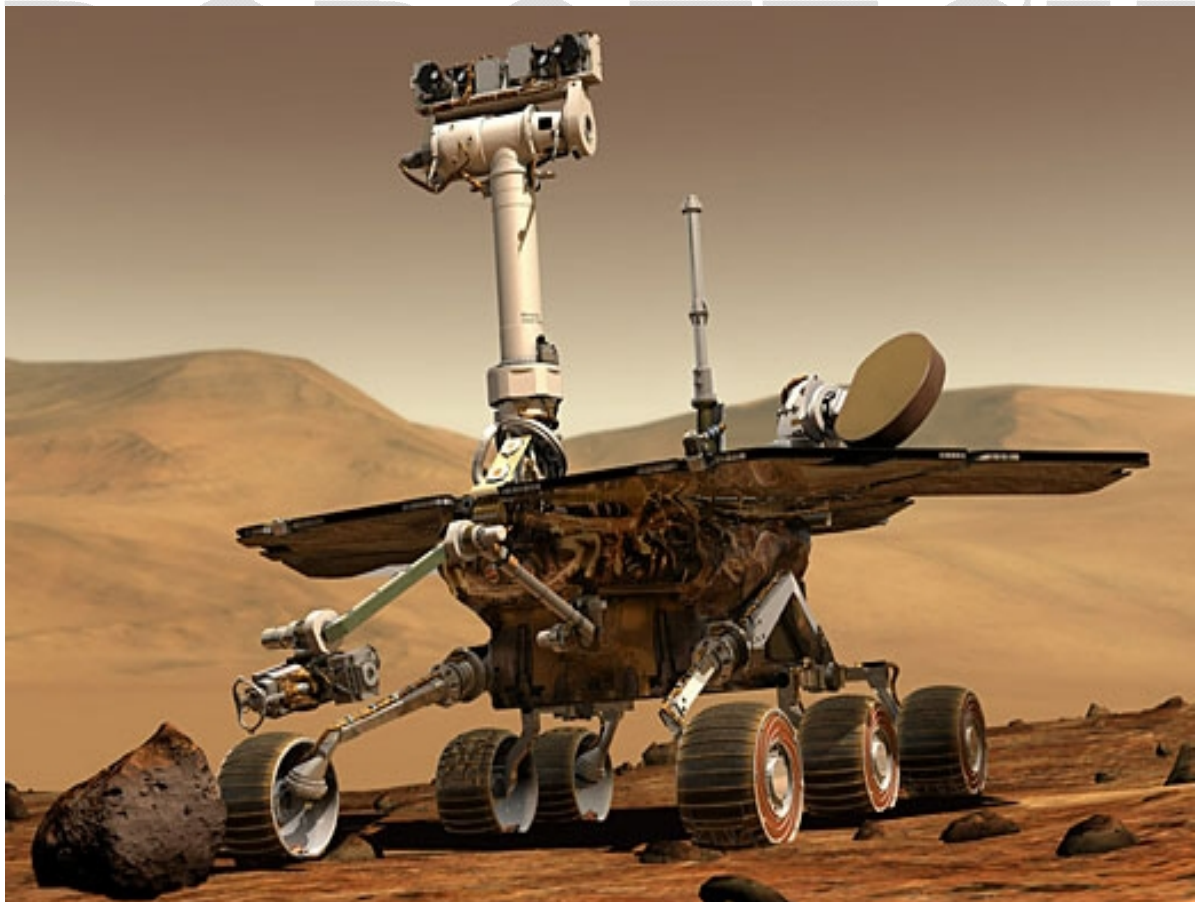
The size and shape of the robot can vary greatly, and size alone does not determine the intelligence of the machine or its capabilities.

Home-brew robots are generally the size of a small dog, although some are as compact as an aquarium turtle and a few as large as Arnold Schwarzenegger.

The overall shape of the robot is generally dictated by the internal components that make up the machine, but most designs fall into one of the following categories :-

Vehicle:

These scooter-type robots are small automatons with wheels. In hobby robotics, they are often built using odds and ends like used compact discs, extra LEGO parts, or the chassis of a radio-controlled car. The small vehicular robot is also used in science and industry: the Mars Rovers, built by NASA, to explore the surface of Mars are examples of this type of robot.



MARS ROVER

Rover:

Greatly resembling the famous R2-D2 of *Star Wars*, rovers tend to be short and stout and are typically built with at least some humanlike capabilities, such as firefighting or intruder detection. Some closely resemble a garbage can—in fact, not a few hobby robots are actually built from metal and plastic trash cans! Despite the euphemistic title, garbage can robots represent an extremely workable design approach.



Android / Humanoid:

Android robots are specifically modeled after the human form and are the type most people picture when talk turns to robots. Realistically, android designs are the most restrictive and least workable, inside or outside the robot lab.



LOCOMOTION

Some robots aren't designed to move around. These include robotic arms, which manipulate objects placed within a work area.

But these are exceptions rather than the rule for hobby robots, which are typically designed to get around in this world.

They do so in a variety of ways, from using wheels to legs to tank tracks.

In each case, the locomotion system is driven by a motor, which turns a shaft, cam, or lever. This motive force affects forward or backward movement.

WHEELS

Wheels are the most popular method for providing robots with mobility.

There may be no animals on this earth that use wheels to get around, but for us it's the simple and foolproof choice.

Robot wheels can be just about any size, limited only by the dimensions of the robot and your outlandish imagination.

Robots can have just about any number of wheels, although two is the most common,

creating a *differentially driven robot*. In this case, the robot is balanced on

the two wheels by one or two free-rolling casters, or perhaps even a third swivel wheel.

Larger, more powerful four- and six-wheel differentially driven robots have also been built.

In these cases all the wheels on a side turn together and provide the robot with better stability and traction than just two wheels. There is a great deal of friction to be overcome, which necessitates powerful drive motors.

Other common wheeled robots use a layout similar to a car or a tricycle. These robot chassis do not have the agility or stability of the differentially driven robot, but they can often be easily adapted from commercially available products such as toys.



LEGS

A minority of robots—particularly the hobby kind—are designed with legs, and such robots can be conversation pieces all their own. You must overcome many difficulties to design and construct a legged robot. First, there is the question of the number of legs and how the legs provide stability when the robot is in motion or when it's standing still. Then there is the question of how the legs propel the robot forward or backward—and more difficult still the question of how to turn the robot so it can navigate a corner.

Legged robots create some tough challenges, but they are not insurmountable.

Legged robots are a challenge to design and build, but they provide you with an extra level of mobility that wheeled robots do not.

Wheel-based robots may have a difficult time navigating through rough terrain, but legged robots can easily walk right over small ditches and obstacles.

A few robot experimenters have come out with two-legged robots, but the challenges in assuring balance and control render these designs largely impractical for most robot hobbyists.

Four-legged robots (quadrupods) are easier to balance, but good locomotion and steering can be difficult to achieve.

Robots with six legs (called hexapods) are able to walk at brisk speeds without falling and are more than capable of turning corners, bounding over uneven terrain, and making the neighborhood dogs and cats run for cover.



SENSORS

Imagine a world without sight, sound, touch, smell, or taste.

Without these sense *inputs*, we'd be nothing more than an inanimate machine, like the family car or the living room television, waiting for something to command us to do something.

Our senses are an integral part of our lives—if not life itself.

It makes good sense (pardon the pun) to provide at least one type of sense into your robot designs.

The more senses a robot has, the more it can interact with its environment and respond to it.

The capacity for interaction will make the robot better able to go about its business on its own, which makes possible more sophisticated tasks.

Detecting *objects* around the robot is a sensory system commonly given to robots and helps prevent the robot from running into objects, potentially damaging them or the robots themselves, or just pushing against them and running down their batteries. There are a number of different ways of detecting objects that range from being very simple to very sophisticated.

Robot Work:

In Czech, the term *robota* means “compulsory worker,” a kind of machine slave like that used by Karel Capek in his classic play *R.U.R. (Rossum's Universal Robots)*.

In many other Baltic languages the term simply means *work*. It is the work aspect of robotics that is often forgotten, but it defines a robot more than anything else.

A robot that is not meant to do something useful is not a robot at all but merely a complicated toy or display piece.

HOW TO BUILD A ROBOT

Building a robot from scratch can be hard or easy. It's up to you. As a recommendation, when you are starting out, go for the easy route; life is too demanding as it is. The best way to simplify the construction of a robot is to use standard, off-the-shelf parts—things you can get at the neighborhood hardware, auto parts, and electronics store. Exactly where can you find robot parts? The neighborhood robot store would be the logical place to start—if only such a store existed! Not yet, anyway. Fortunately, other local retail stores are available to fill in the gaps. Moreover, there's a veritable world of places that sell robot junk, probably close to where you live and also on the Internet.

WHAT YOU CAN GET SURPLUS

Shopping surplus can be a tough proposition because it's hard to know what you'll need before you need it. And when you need it, there's only a slight chance that the store will have what you want. Still, certain items are almost always in demand by the robotics experimenter. If the price is right (especially on assortments or sets), stock up on the following.

- *Gears.* Small gears between 1/2 and 3 in are extremely useful. Stick with standard tooth pitches of 24, 32, and 48. Try to get an assortment of sizes with similar pitches. Avoid grab bag collections of gears because you'll find no mates. Plastic and nylon gears are fine for most jobs, but you should use larger metal gears for the main drive systems of your robots.
- *Roller chain and sprockets.* Robotics applications generally call for 1/4-in (#25) roller chain, which is smaller and lighter than bicycle chain. When you see this stuff, snatch it up, but make sure you have the master links if the chain isn't permanently riveted together. Sprockets come in various sizes, which are expressed as the number of teeth on the outside of the sprocket. Buy a selection. Plastic and nylon roller chain and sprockets are fine for general use; steel is preferred for main drives.
- *Bushings.* You can use bushings as a kind of ball bearing or to reduce the hub size of gears and sprockets so they fit smaller shafts. Common motor shaft sizes are 1/8 in for small motors and 1/4 in for larger motors. Gears and sprockets generally have 3/8-in, 1/2-in, and 5/8-in hubs. Oil-impregnated Oilite bushings are among the best, but they cost more than regular bushings.
- *Motors.* Particularly useful are the 6-V and 12-V DC variety. Most motors turn too fast for robotics applications but you can often luck out and find some geared motors. Final speeds of 20 to 100 r/min at the output of the gear reduction train are ideal. If gear motors aren't available, be on the lookout for gearboxes that you can attach to your motors. Stepper motors are handy, too, but make sure you know what you are buying.
- *Rechargeable batteries.* The sealed lead-acid and gel-cell varieties are common in surplus outlets. Test the battery immediately to make sure it takes a charge and delivers its full capacity (test it under a load, like a heavy-duty motor). These batteries come in 6-V and 12-V capacities, both of which are ideal for robotics. Surplus nickel-cadmium and nickel-metal hydride batteries are available, too, in either single 1.2-V cells or in combination battery packs. Be sure to check these batteries thoroughly.

ELECTRONICS PART

Electronics are the central nervous system of your robot and will be responsible for passing information to and from peripheral functions as well as processing inputs and turning them into the output functions the robot performs. Any given hobby robot project might contain a dozen or more electronic components of varying types, including resistors, capacitors, integrated circuits, and light-emitting diodes, etc.,.

Resistors:

resistor supplies a predetermined resistance to a circuit. The standard unit of value of a resistor is the ohm (with units in volts per ampere, according to Ohm's law), represented by the symbol Ω .

The higher the ohm value, the more resistance the component provides to the circuit.

The value on most fixed resistors is identified by color coding.

Capacitors:

After resistors, capacitors are the second most common component found in the average electronic project. Capacitors serve many purposes. They can be used to remove traces of transient (changing) current ripple in a power supply, to delay the action of some portion of the circuit, or to perform an integration or differentiation of a repeating signal. All these applications depend on the ability of the capacitor to hold an electrical charge for a predetermined time.

Capacitors come in many more sizes, shapes, and varieties than resistors, though only a small handful are truly common. However, most capacitors are made of the same basic stuff: a pair of conductive elements separated by an insulating dielectric. This dielectric can be composed of many materials, including air, paper, epoxy, plastic, and even oil.

Most capacitors actually have many layers of conducting elements and dielectric. When you select a capacitor for a particular job, you must generally also indicate the type such as ceramic, mica, or Mylar.

Diodes:

The diode is the simplest form of semiconductor.

It is available in two basic flavors, germanium and silicon, which indicates the material used to manufacture the active junction within the diode.

Diodes are used in a variety of applications, and there are numerous subtypes.

Here is a list of the most common.

- *Rectifier*. The average diode, it rectifies AC current to provide DC only.
- *Zener*. It limits voltage to a predetermined level. Zeners are used for low-cost voltage regulation.
- *Light-emitting*. These diodes emit infrared or visible light when current is applied.
- *Silicon-controlled rectifier (SCR)*. This is a type of high-power switch used to control AC or DC currents.

LED: All diodes emit light when current passes through them. This light is generally only in the infrared region of the electromagnetic spectrum. The light-emitting diode (LED) is a special type of semiconductor that is expressly designed to emit light in human visible wavelengths. LEDs are available to produce any of the basic colors (red, yellow, green, blue, or white) of light as well as infrared. The infrared LEDs are especially useful in robots for a variety of different applications.

Transistors :

Transistors are used in similar applications, either to amplify a signal by providing a current control or to switch a signal on and off.

There are several thousand different transistors available.

Besides amplifying or switching a current, transistors are divided into two broad categories:

- *Signal*. These transistors are used with relatively low-current circuits, like radios, telephones, and most other hobby electronics projects.

- *Power*. These transistors are used with high-current circuits, like motor drivers and power supplies.

You can usually tell the difference between the two merely by size. The signal transistor is rarely larger than a pea and uses slender wire leads. The power transistor uses a large metal case to help dissipate heat, and heavy spokelike leads.

Transistors are identified by a unique code, such as 2N2222.

Refer to a data book to ascertain the characteristics and ratings of the particular transistor you are interested in.

Transistors are rated by a number of criteria.

These ratings include collector-to-base voltage, collector-to-emitter voltage, maximum collector current, maximum device dissipation, and maximum operating frequency.

None of these ratings are printed directly on the transistor.

Signal transistors are available in either plastic or metal cases.

The plastic kind is suitable for most uses, but some precision applications require the metal variety.

GROUNDING

When wiring electronic circuits, it is useful to have a large common negative voltage connection or *ground* built into the robot.

This connection is normally thought of as being at *earth ground* and is the basic reference for all the components in the circuit.

Having a common ground also simplifies the task of drawing schematics.

Positive voltages are normally indicated with an arrow pointing upward and the label of the positive voltage to be used.

ICs:

The integrated circuit(IC) forms the backbone of the electronics revolution.

The typical integrated circuit comprises many transistors, diodes, resistors, and even capacitors.

As its name implies, the integrated circuit, or IC, is a discrete and wholly functioning circuit in its own right.

Integrated circuits are most often enclosed in dual in-line packages (DIPs)

This type of component has a number of pins that can be inserted into

As with transistors, ICs are identified by a unique code, such as ULN2003AN. This code indicates the type of device.

You can use this code to look up the specifications and parameters of the IC in a reference book.

Many ICs also contain other written information,

including manufacturer catalog number and date code. Do not confuse the date code or catalog number with the code used to identify the device.

TOOLS REQUIRED

Construction tools are what you use to fashion the frame and other mechanical parts (or structure) of the robot.

We will look at the tools needed to assemble the electronics later in this chapter.

The basic tools for creating a robot include:

- *Claw hammer.* These can be used for just about any purpose.
- *Rubber mallet.* For gently bashing together pieces that resist being joined, nothing beats a rubber mallet; it is also useful for forming sheet metal.
- *Measurement tools.* You should have a variety of metal scales, wood and plastic rulers all of varying lengths, as well as a cheap analog dial or digital calipers. You may also want to keep a drill diameter gauge handy along with tools for measuring screw diameters and pitches. Finally, kitchen and fishing scales are useful tools for keeping track of how much the robot is going to weigh.
- *Screwdriver assortment.* Have several sizes of flat-head and Phillips-head screwdrivers. It's also handy to have a few long-blade screwdrivers, as well as a ratchet driver. Get a screwdriver magnetizer/demagnetizer; it lets you magnetize the blade so it attracts and holds screws for easier assembly.
- *Hacksaw.* To cut anything, the hacksaw is the staple of the robot builder. Buy an assortment of blades. Coarse-tooth blades are good for wood and PVC pipe plastic; fine-tooth blades are good for copper, aluminum, and light-gauge steel.
- *Miter box.* To cut straight lines, buy a good miter box and attach it to your worktable (avoid wood miter boxes; they don't last). You'll also use the box to cut stock at near-perfect 45° angles, which is helpful when building robot frames.
- *Wrenches, all types.* Adjustable wrenches are helpful additions to the shop but careless use can strip nuts. The same goes for long-nosed pliers, which are useful for getting at hard-to-reach places. One or two pairs of Vise-Grips will help you hold pieces for cutting and sanding. A set of nut drivers will make it easy to attach nuts to bolts.
- *Measuring tape.* A 6- or 8-ft steel measuring tape is a good length to choose. Also get a cloth measuring tape at a fabric store so you can measure things like chain and cable lengths.
- *Square.* You'll need one to make sure that pieces you cut and assemble from wood, plastic, and metal are square.
- *File assortment.* Files will enable you to smooth the rough edges of cut wood, metal, and plastic (particularly important when you are working with metal because the sharp, unfinished edges can cut you).
- *Motor drill.* Get one that has a variable speed control (reversing is nice but not absolutely necessary). If the drill you have isn't variable speed, buy a variable speed control for it. You need to slow the drill when working with metal and plastic. A fast drill motor is good for wood only. The size of the chuck is not important since most of the drill bits you'll be using will fit a standard 1/4-in chuck.

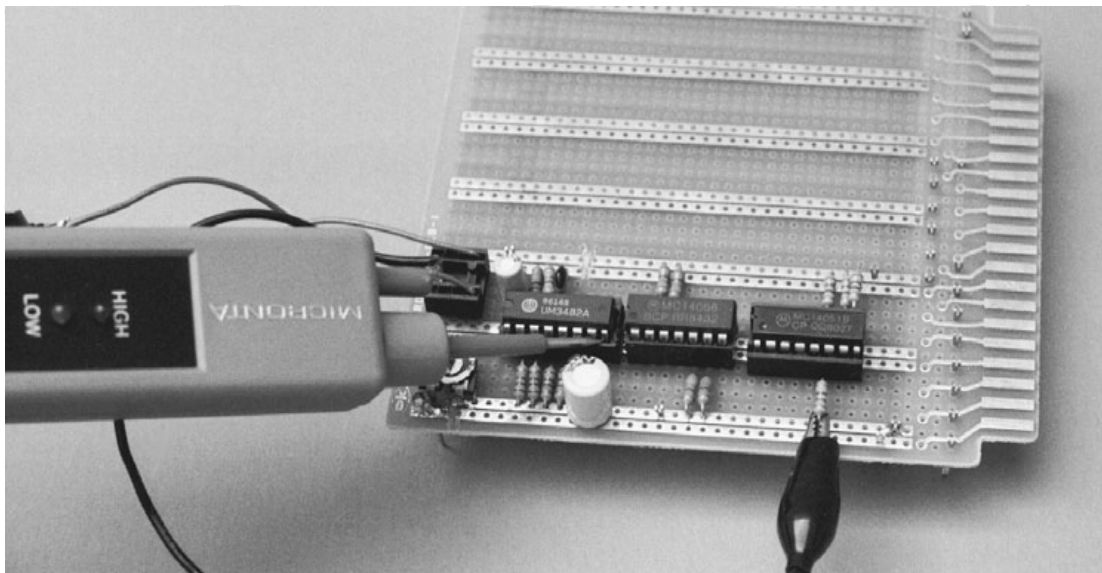
- *Drill bit assortment.* Use good sharp ones only. If yours are dull, have them sharpened (or do it yourself with a drill bit sharpening device), or buy a new set.
- *Vise.* A vise is essential for holding parts while you drill, nail, and otherwise torment them. An extra large vise isn't required, but you should get one that's big enough to handle the size of the pieces you'll be working with. A rule of thumb: a vice that can't close around a 2-in block of metal or wood is too small.

DIGITAL MULTIMETER

A *digital multimeter* (DMM and also known as a volt-ohm meter or multimeter) is used to test voltage and current levels along with the resistance of different parts of circuits. Along with these basic functions, you can find DMMs that can test transistors and capacitors, and measure signal frequencies and temperature.

LOGIC PROBES

Meters are typically used for measuring analog signals. Logic probes test for the presence or absence of low-voltage digital data signals. The 0s and 1s are usually electrically defined as 0 and 5 V, respectively, when used with TTL integrated circuits (ICs). In practice, the actual voltages of the 0 and 1 bits depend entirely on the circuit and the parts used to make it up. You can use a meter to test a logic circuit, but the results aren't always predictable. Further, many logic circuits change states (pulse) quickly, and meters cannot track the voltage switches quickly enough.



OSCILLOSCOPE

An oscilloscope is a pricey tool, but for performing serious work or understanding how the circuitry behaves in your robot, it is invaluable and will save you hours of frustration. Other test equipment will do some of the things you can do with a scope, but oscilloscopes do it all in one box and generally with greater precision. Among the many applications of an oscilloscope, you can do the following:

- Test DC or AC voltage levels
- Analyze the waveforms of digital and analog circuits
- Determine the operating frequency of digital, analog, and RF circuits
- Test logic levels
- Visually check the timing of a circuit to see if things are happening in the correct order and at the prescribed time intervals.

CONSTRUCTION TECHNIQUES (ELECTRONICS)

To operate all but the simplest robots requires an electronic circuit of one type or another. The way you construct these circuits will largely determine how well your robot functions and how long it will last.

Poor performance and limited life inevitably result when hobbyists use so-called rat's nest construction techniques such as soldering together the loose leads of components.

Using proper construction techniques will ensure that your robot circuits work well and last as long as you have a use for them.

Soldering:

Soldering is the process of heating up two pieces of metal together and electrically joining them using a (relatively) low melting temperature metal (normally a lead-tin alloy).

Discrete components, chips, printed circuit boards, and wires can all be joined by soldering them together.

HOW TO SOLDER:

The basis of successful soldering is to use the soldering iron to heat up the work, whether it is a component lead, a wire, or whatever. You then apply the solder to the work. If the solder doesn't flow onto the joint, then check the iron's temperature, add a bit more rosin core solder or even add a bit of liquid flux. Once the solder flows around the joint (and some will flow to the tip), remove the iron and let the joint cool. The joint should look smooth and shiny. If the solder appears dull and crinkly, then you have a cold joint. To fix the joint, apply the soldering iron again to remelt the solder.

Avoid disturbing the solder as it cools; a cold joint might be the result. Do not apply heat any longer than necessary. Prolonged heat can permanently ruin electronic components. A good rule of thumb is that if the iron is on any one spot for more than 5 s, it's too long. If at all possible, you should keep the iron at a 30° to 40° angle for best results. Most tips are beveled for this purpose.

Apply only as much solder to the joint as is required to coat the lead and circuit board pad. A heavy-handed soldering job may lead to soldering bridges, which is when one joint melds with joints around it. At best, solder bridges cause the circuit to cease working; at worst, they cause short circuits that can burn out the entire board. When soldering on printed circuit boards, you'll need to clip off the excess leads that protrude beyond the solder joint. Use a pair of diagonal or nippy cutters for this task. Be sure to protect your eyes when cutting the lead.

How to eliminate Static Electricity,...?

The ancient Egyptians discovered static electricity when they rubbed animal fur against the smooth surface of amber. Once the materials were rubbed together, they tended to cling to one another. Similarly, two pieces of fur that were rubbed against the amber tended to separate when they were drawn together. While the Egyptians didn't understand this mysterious unseen force—better known now as static electricity—they knew it existed.

Today, you can encounter static electricity by doing nothing more than walking across a carpeted floor. As you walk, your feet rub against the carpet, and your body takes on a static charge. Touch a metal object, like a doorknob or a metal sink, and that static is quickly discharged from your body. You feel the discharge as a shock.

Carpet shock has never been known to kill anyone. The amount of voltage and current is far too low to cause great bodily harm. But the same isn't true of electronic circuits.

Considering how your body can develop a 10,000- to 50,000-V charge when you walk across a carpet.

Try to imagine what that might do to electrical components rated at just 5 or 15 V.

The sudden crash of electrical energy can burn holes right through a sensitive transistor or integrated circuit, rendering it completely useless.

Using connectors makes for more manageable robots.

Transistors and integrated circuits designed around a metal-oxide substrate can be particularly sensitive to high voltages, regardless of the current level. These components include MOSFET transistors, CMOS integrated circuits, and most computer microprocessors.

Consider using any and all of the following simple techniques to reduce and eliminate the risk of electrostatic discharge.

- *Wear low-static clothing and shoes.* Your choice of clothing can affect the amount of static buildup in your body. Whenever possible, wear natural fabrics such as cotton or wool. Avoid wearing polyester and acetate clothing, as these tend to develop large amounts of static.
- *Use an anti-static wrist strap.* The wrist strap grounds you at all times and prevents static buildup. The strap is one of the most effective means for eliminating electrostatic discharge, and it's one of the least expensive.
- *Ground your soldering iron.* If your soldering pencil operates from AC current, it should be grounded. A grounded iron not only helps prevent damage from electrostatic discharge; it also lessens the chance of receiving a bad shock should you accidentally touch a live wire.
- *Use component sockets.* When you build projects that use ICs, install sockets first. When the entire circuit has been completely wired, you can check your work, then add the chips. Note that some sockets are polarized so the component will fit into them one way only. Be sure to observe this polarity when wiring the socket.

How To Construct a Platform for a Robot,.....?

PLASTIC PLATFORMS:

Plastic is sometimes the object of ridicule—from plastic money to plastic furniture—Yet even its critics are quick to point out its many advantages.

- Plastic is cheaper per square inch than wood, metal, and most other construction materials.
 - Certain plastics are extremely strong, approaching the tensile strength of such light metals as copper and aluminum.
 - Some plastic is unbreakable.
- Plastic is an ideal material for use in hobby robotics. Its properties are well suited for numerous robot designs.

Wooden Platforms:

Wood may not be high-tech, but it's an ideal building material for hobby robots. Wood is available just about everywhere. It's relatively inexpensive, easy to work with, and mistakes can be readily covered up, filled in, or painted over.

Metal Platforms:

Metal is perhaps the best all-around material for building robots because it offers better strength than other materials. If you've never worked with metal before, you shouldn't worry; there is really nothing to it.

Building a Mini Robot:

You can use a small piece of scrap sheet acrylic to build the foundation and frame of the Mini Robot differentially driven robot.

The robot is about 6 in around the floor or table on two small rubber tires.

The basic version is meant to be wire-controlled, although in upcoming chapters you'll see how to adapt the Minibot to automatic electronic control, even remote control.

The power source is a set of four AA flashlight batteries because they are small, lightweight, and provide more driving power than 9-V transistor batteries.

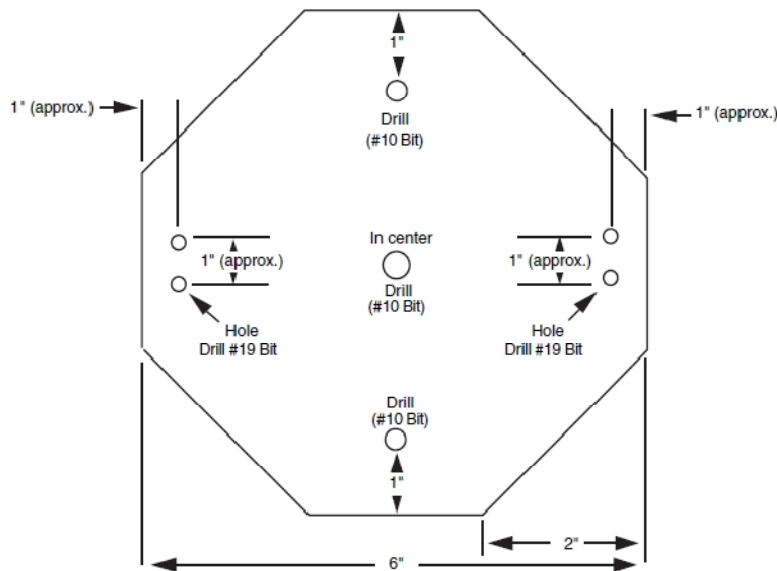
The parts list for the Minibot can be found in the Table Below :

- | |
|---|
| <ol style="list-style-type: none">1. 1 6-in-by-6-in acrylic plastic (1/16- or 1/8-in thick)2. 2 Small hobby motors with gear reduction3. 2 Model airplane wheels4. 1 3/2-in (approx.) 10/24 all-thread rod5. 1 6-in-diameter (approx.) clear plastic dome6. 1 Four-cell AA battery holder7. Misc. 1/2-in-by-8/32 bolts, 8/32 nuts, lock washers, 1/2-in-by-10/24 bolts, 10/24 nuts, lock washers, cap nuts... |
|---|

FOUNDATION OR BASE

The foundation is clear acrylic sheet plastic. The thickness should be at least 1/8 in, but avoid very thick plastic because of its heavy weight. The prototype Minibot used 1/8-in-thick acrylic, so there was minimum stress caused by bending or flexing.

Cut the plastic as shown Below.



Remember to keep the protective paper cover on the plastic while you cut. File or sand the edges to smooth the cutting and scoring marks.

The corners are sharp and can cause injury if the robot is handled by small children. You can easily fix this by rounding off the corners with a file. Find the center and drill a hole with a #10 bit.

MOTOR MOUNT

The small DC motors used in the prototype Mini Robot were surplus gear motors with an output speed of about 30 r/min.

The motors for your Mini Robot should have a similar speed because even with fairly large wheels, 30 r/min makes the robot scoot around the floor or a table at about 4 to 6 in/s.

Choose motors small enough so they don't crowd the base of the robot and add unnecessary weight.

Remember that you have other items to add, such as batteries and control electronics.

Use some metal mending braces to secure the motor.

You may need to add spacers or extra nuts to balance the motor in the brace.

Drill holes for 8/32 bolts (#19 bit), spaced to match the holes in the mending plate.

Another method is to use small U-bolts, available at any hardware store. Drill the holes for the U-bolts and secure them with a double set of nuts.

Attach the tires to the motor shafts. Tires designed for a radio-controlled airplane or race car are good choices.

The tires are well made, and the hubs are threaded in standard screw sizes (the threads may be metric, so watch out!). On the prototype, the motor shaft was threaded and had a 4-40 nut attached on each side of the wheel.

Installing the counterbalances completes the foundation-base plate.

These keep the robot from tipping backward and forward along its drive axis.

You can use small ball bearings, tiny casters, or—as was used on the prototype—the head of a 10/24 locknut. The locknut is smooth enough to act as a kind of ball bearing and is about the right size for the job.

Attach the locknut with a 10/24-by-1/2-in bolt (if the bolt you have is too long to fit in the locknut, add washers or a 10/24 nut as a spacer).

BATTERY HOLDER

You can buy battery holders that hold from one to six cells in any of the popular battery sizes. The Mini Robot motors, like almost all small hobby motors, run off 1.5 to 6 V.

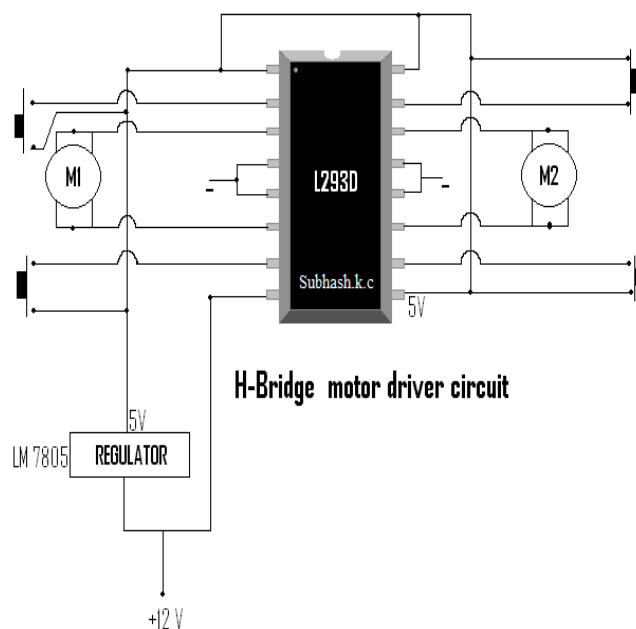
A four cell, AA battery holder does the job nicely. The wiring in the holder connects the batteries in series, so the output is 6 V. Secure the battery holder to the base with nuts and bolts.

Drill holes to accommodate the hardware. Be sure the nuts and bolts don't extend too far below the base or they may drag when the robot moves.

Likewise, be sure the hardware doesn't interfere with the batteries.

Now the Mini Robot is almost finished...

Circuit Diagram:



The above circuit diagram is a H-Bridge remote control circuit diagram in which M1, M2 are Motors.

The same procedures can also be implemented on Wooden and Metal platforms. But have to use the Respective Tools to cut, drill, etc...

COMPUTERS AND ELECTRONIC CONTROLL

Robot's BRAIN:

Brain, brain, what is brain?" If you're a Trekker, you know this is a line from one of the original *Star Trek* episodes entitled "Spock's Brain." The quality of the story notwithstanding (it is universally regarded as one of the worst, yet paradoxically one of the most popular), the episode was about how Spock's brain was surgically removed by a race of temporarily hyper intelligent women who needed it to run their underground environmental control system.

Dr. McCoy was able to create a control mechanism that would allow somebody to operate Spock's brainless body in order for it to be present when the brain was found.

Without its brain, Spock's body was not much more than a remotely controlled model car; capable of performing some operations under direct human control, but not able to operate autonomously.

The brains of a person or robot process information from the environment; then based on the programming or logic they determine the proper course of action.

Without a brain of some type and the ability to respond to different environmental information, a robot is really nothing more than just a motorized toy.

A computer of one type or another is the most common brain found in a robot.

A robot control computer is seldom like a PC on your desk, though robots can certainly be operated by most any personal computer.

And of course not all robot brains are computerized. A simple assortment of electronic components—a few transistors, resistors, and capacitors—is all that is really needed to make a rather intelligent robot.

Endowing your robot with electronic smarts is a huge topic, so additional material is provided in the following chapters to help you understand how electronic sensors and actuators are interfaced to computers and how decisions are made on which actions to take.

Brain From Computers and μ controllers:

An almost endless variety of computers can be used as a robot's brain. The most common types that are used are:

- *Microcontroller.* These are programmed either in assembly language or a high-level language such as BASIC or C. There are literally hundreds of different microcontrollers with a plethora of different interfacing capabilities that you can choose from to control your robot.
- *Personal Digital Assistant.* An old Palm Pilot provides a lot of processing power in a fairly small space with a number of features that make it very attractive for use as a robot controller. It can be difficult to interface with.

- *Single-board computer.* A few years ago, complete computer systems built on a PCB were the preferred method of controlling robots. These systems are still used but are much less popular due to the availability of low-cost PC motherboards and more powerful, easy to use microcontrollers.

- *Personal computer motherboards and laptops.* Very small form factor PC motherboards and laptops are common controllers for larger robots. These controllers can be programmed using standard development tools and commercial, digital I/O add-ons for the interfaces needed for the different robot functions.

MICROCONTROLLERS

Microcontrollers are the preferred method for endowing a robot with smarts.

The reasons for this include their low costs, simple power requirements (usually 2.5 to 5 V), and ability of most to be programmed using software and a simple hardware interface on your PC.

Once programmed, the microcontroller is disconnected from the PC and operates on its own.

Microcontrollers can either be downloaded with a program that provides all the functions required of it or execute a *tokenized* program, which provides a set of basic functions for the application and the software already built into the microcontroller handling the various interfaces. Virtually all microcontrollers can be used as either device; the reason for choosing one over the other really comes down to cost, your experience and skills, available features, and ease of use.

You shouldn't be scared at the idea of having to come up with all the code that executes within a microcontroller. If you are familiar with a PC, you know that there are several megabytes of code for the BIOS (basic input/output system) as well as several hundred megabytes of code devoted to the operating system. Going by this standard, it will seem like developing a complete application for a microcontroller is a daunting task. In reality, the operation of the code within the microcontroller is quite simple, and other than requiring a few configuration commands, the software is quite straightforward. The advantage of using a microcontroller that requires a complete application is cost; a microcontroller suitable for use in robots can cost as little as \$1.00. A potential drawback to this type of microcontroller is the cost of a programmer, which can be very substantial for some chips.

When source code is *tokenized*, it is passed through a compiler, just like regular application code, but instead of producing a series of instructions, the compiler produces a set of commands that are executed within the microcontroller.

This type of microcontroller can have a series of very complex commands programmed into it, which makes them available to new application developers instead of having to puzzle out how to implement them.

To further simplify the operation of this type of microcontroller, a boot loader program is typically already burned into them, allowing a simple programming operation that does not require any additional hardware. The Parallax BASIC Stamp 2 discussed later in this book is a boot loader-equipped microcontroller, which has a simple RS-232 programming (and console) interface.

Both kinds of microcontroller are fully programmable, but bootloader-equipped microcontrollers, like the BASIC Stamp 2, are programmed in a high-level language such as

BASIC. Stand-alone microcontrollers can usually be programmed in a variety of different high-level languages (BASIC, Java, C) as well as assembly language, giving a lot more flexibility to the application developer.

Microcontrollers are available with 8, 16, or 32-bit processors. While PCs have long since graduated to 32-bit and higher architectures with protect mode and virtual memory operating systems, most applications for microcontrollers do not require more than eight bits.

The exact format and contents of an assembly-language microcontroller program vary between manufacturers. The popular PIC microcontrollers from Microchip follow one language convention.

Microcontrollers from Intel, Atmel, Motorola, Texas Instruments, Philips, Hitachi, and other companies all follow their own conventions. While the basic functionality of microcontrollers from these different companies is similar, learning to use each one involves a learning curve.

As a result, robot developers tend to fixate on one brand, and even one model, since learning a new assembly language and processor architecture can require a lot of extra work.

Programming A Robot:

When programming is first taught, the concept that a program follows the “input—processing—output” model is used in which data inputs to the program are passed to a processing block and then passed out of the program in the form of outputs.

This model is good for initial programs on a PC in which some number crunching is done to help you learn how the different programming statements work, but they have little relevance when programming robots.

The delay block is critical for robot programming as it allows the code to be tuned for the operation of the robot and its parts.

If the delay is too short, the robot may vibrate more than move because one set of commands from some input conditions are countermanded by the next set of input conditions, resulting in the original input conditions are true again . . . Specifying the appropriate amount of delay is something that will have to be found by trial and error.

The total loop time should be less than 1 s, but as to the “best” time, that is something that you will have to find by experimenting with your robot. As a rule of thumb, try to keep the total loop time at least 100 ms (0.1 s) so that the motors have time to start up and initiate action before stopping and a new set of inputs polled.

You may also want to leave the motors running during the delay based on the assumption that chances are the processed output will not change radically from loop to loop. This will help make your robot move more smoothly, which is always desirable.

Remote Controls

The most basic robot designs—just a step up from motorized toys—use a wired control box on which you flip switches to move the robot around the room or activate the motors in the robotic arm and hand.

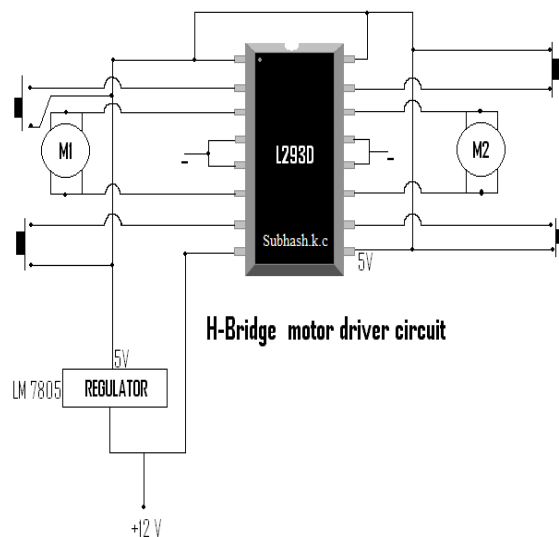
The wire link can be a nuisance and acts as a tether preventing your robot from freely navigating through the room.

You can cut this physical umbilical cord and replace it with a fully electronic one by using a remote control receiver and transmitter.

You can use the remote controller to activate all of the robot's functions, or, with a suitable on-board computer working as an electronic recorder, you can use the controller as a teaching pendant.

You manually program the robot through a series of steps and routines, then play it back under the direction of the computer. Some remote control systems even let you connect your personal computer to your robot.

You type on the keyboard, or use a joystick for control, and the invisible link does the rest.



This H-Bridge Wired remote controller circuit can be used to control your 'RoBot via wire. Or can be controlled by RF Remotes available in Market.

HOW TO INCREASE THE PERFORMANCE OF A ROBOT?

It is not widely known or understood, but of the various parameters that are used to choose a battery for an application (such as voltage output, amp-hour rating, recharge rate, etc.)

The most important one for robot applications is very rarely considered—the battery's internal resistance.

Often people describing themselves as experts will tell you that you should buy the cheapest carbon zinc batteries you can find instead of expensive alkaline or rechargeable batteries because the *ampere hour* (AH) rating of the cheaper batteries is similar to that of the much more expensive battery.

This is true, but the inexpensive batteries have a very high internal resistance, which will shorten their lives in your robot and make it difficult for your robot to work reliably.

When you think of electrical circuits, you tend to think of the idealized case where there is no resistance in wiring.

This is a reasonable approximation when low power and current power sources are being considered. In a robot application, which draws a great deal of current,

The voltage drop is actually a power loss to the robot. The batteries' internal resistances create heat, which is power lost in its most basic form.

To make matters worse, most batteries lose the ability to output electrical energy as their internal temperature rises, so this internal resistance not only robs the robot of power, but also reduces the total amount of power available from the batteries.

POWERING SYSTEMS TO THE ROBOT

Combining the Batteries:

- To increase voltage, connect the batteries in series. The resultant voltage is the sum of the voltage outputs of all the cells combined.
- To increase current, connect the batteries in parallel. The resultant current is the sum of the current capacities of all the cells combined.

Voltage Regulation:

ZENER DIODE VOLTAGE REGULATION:

A quick and relatively small method for providing regulated voltage is to use *zener* diodes.

With a zener diode, current does not begin to flow through the load circuitry until the voltage exceeds a certain level (called the breakdown voltage).

Voltage over this level is then “shunted” through the zener diode, effectively limiting the voltage to the rest of the circuit.

Zener diodes are available in a variety of voltages.

LINEAR VOLTAGE REGULATORS:

The zener diode regulator can be thought of as a tub of water with a hole at the bottom; the maximum pressure of the water squirting out is dependent on the level of water in the tub. Ideally, there should be more water coming into the tub than will be ever drawn to ensure that the pressure of the water coming out of the hole is constant. This means that a fair amount of water will spill over the edge of the tub. As was shown in the previous section, this is an extremely inefficient method of providing a regulated voltage, as the electrical equivalent of the water pouring over the edge is the power dissipated by R1

To improve upon the zener diode regulator's inefficiency, a voltage regulator that just lets out enough current at the regulated voltage is desired. The *linear voltage* regulator only allows the required current (at the desired voltage) out and works just like a car's carburetor. In a carburetor, fuel is allowed to flow as required by the engine—if less is required than is available, a valve closes and reduces the amount of fuel that is passed to the engine. The linear voltage regulator works in an identical fashion: an output transistor in the regulator circuit only allows the required amount of current to the load circuit.

Two of the most popular voltage regulators, the 7805 and 7812, provide +5 and +12V, respectively. Other 7800 series power regulators are designed for +15, +18, +20, and +24 V.

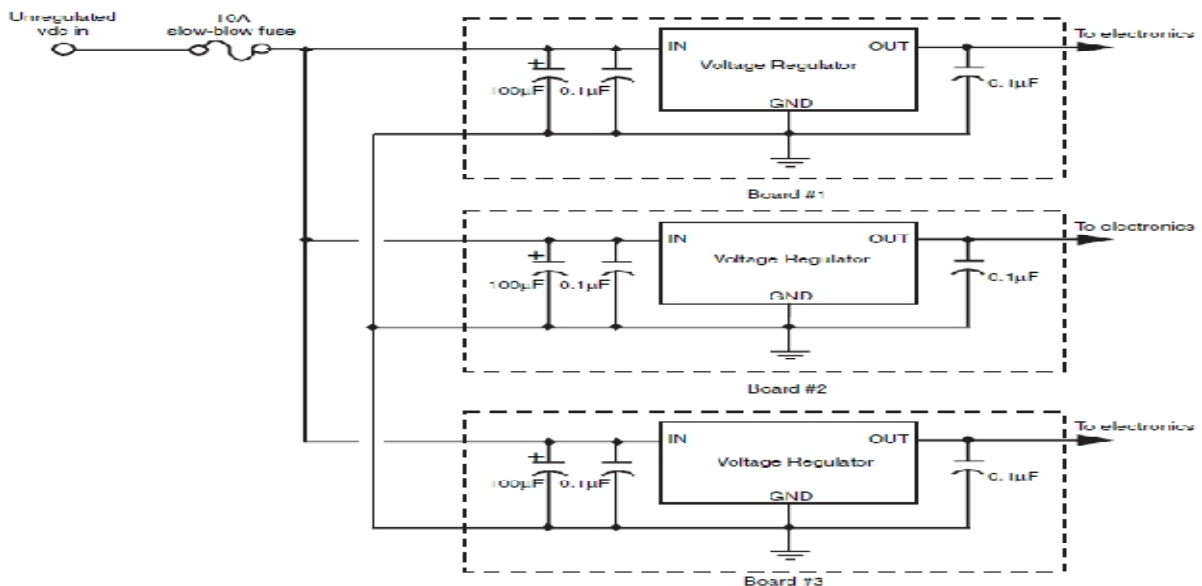
The 7900 series provides negative power supply voltages in similar increments. The current capacity of the 7800 and 7900 series that come in the TO-220 style transistor packages (these can often be identified as they have no suffix or use a "T" suffix in their part number) is limited to less than 1 A.

As a result, you must use them in circuits that do not draw in an excess of this amount.

POWER DISTRIBUTION

You may choose to place all or most of your robot's electronic components on a single board. You can mount the regulator(s) directly on the board. You can also have several smaller boards share one regulator as long as the boards together don't pull power in excess of what the regulator can supply.

Fig. Below shows how to distribute the power from a single battery source to many separate circuit boards. The individual regulators provide power for one or two large boards or a half dozen or so smaller ones.



PRINCIPLES OF ROBOT'S LOCOMOTION

As you graduate to building larger mobile robots, you should consider the physical properties of your creations, including their size, weight, and mode of transport.

A robot that is too heavy for its frame, or a locomotion mechanism that doesn't provide sufficient stability, will greatly hinder the usefulness of your mechanical invention.

Weight:

Most hobbyist robots weigh less than 20 lbs, and a high percentage of those weigh under 10 lbs. Weight is one of the most important factors affecting the mobility of a robot.

A heavy robot requires larger motors and higher capacity batteries—both of which add even more pounds to the machine. At some point, the robot becomes too heavy to even move.

On the other hand, robots designed for heavy-duty work often need some girth and weight. Your own design may call for a robot that needs to weigh a particular amount in order for it to do the work you have envisioned.

The parts of a robot that contribute the most to its weight are the following, in (typical) descending order:

- Batteries
- Drive motors
- Frame

Then How to Reduce The Weight,...?!

If you find that your robot is becoming too heavy, consider putting it on a diet, starting with the batteries. Nickel-cadmium and nickel metal hydride batteries weigh less, volt for volt, than their lead-acid counterparts.

While nickel-cadmium and nickel metal hydride batteries may not deliver the amp-hour capacity that a large, sealed lead-acid battery will, your robot will weigh less and therefore may not require the same stringent battery ratings as you had originally thought.

When looking at reducing the weight of your robot or modifying it in any way, remember to try to come up with changes that result in additional benefits.

For example, if you were to change your batteries to a lighter set, you will discover that you do not need as powerful a motor.

Less powerful motors weigh less than the originally specified motors, further decreasing the weight of the motor.

This decrease in the weight of the motor could result in the need for smaller and lighter batteries, which allows you to look at using even smaller and lighter batteries, smaller motors, smaller structure.

This process can repeat multiple times and it isn't unusual to see a situation where a 10 percent decrease in battery weight results in a 50 percent reduction in overall robot weight. The repeating positive response to a single change is known as a *supereffect*, and you should remember that the reverse is also true: a 10 percent increase in weight in a robot's components could result in

a 50 percent increase in weight in the final robot.

If your robot must use a lead-acid battery, consider carefully whether you truly need the capacity of the battery or batteries you have chosen.

You may be able to install a smaller battery with a lower amp-hour rating. The battery will weigh less, but, understandably, it will need to be recharged more often. An in-use time of 60 to 120 minutes is reasonable (that is, the robot's batteries must be recharged after an hour or two of continual use).

If you require longer operational times but still need to keep the weight down, consider a replaceable battery system. Mount the battery where it can be easily removed. When the charge on the battery goes down, take it out and replace it with a fully charged one. Place the previously used battery in the charger.

The good news is that smaller, lower capacity batteries tend to be significantly less expensive than their larger cousins, so you can probably buy two or three smaller batteries for the price of a single big one.

Drive motors are most often selected because of their availability and cost, not because of their weight or construction. In fact, many robots are designed around the specifications of the selected drive motors.

The motors are selected (often they're purchased surplus), and from these the frame of the robot is designed and appropriate batteries are added. Still, it's important to give more thought to the selection of the motors for the robot that you have in mind.

The Frame weight can also be reduced by using Aluminium but its cost is high compared to other metals.

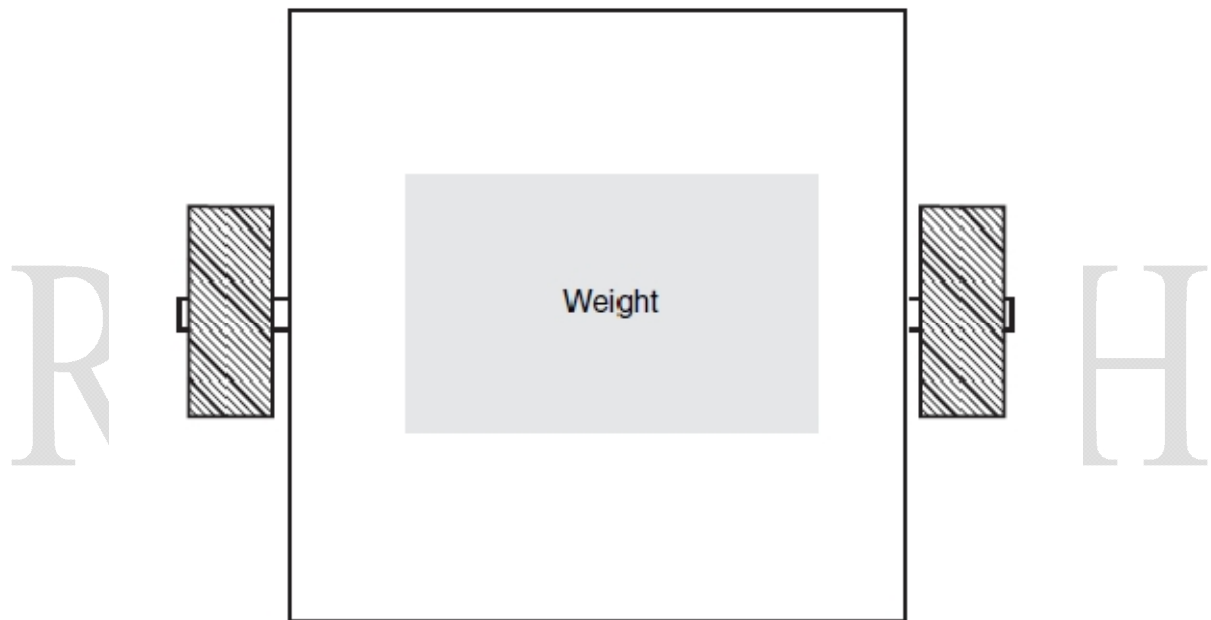
So, it's better to go for a cheaper and the stronger one like wood which is available in plenty and Acrylic plastics / Sun Boards which are very strong and lighter when compared to metals and Wood.

Centre of Gravity (CG):

In any Robots, Centre of Gravity is the most important aspect, this controls the robot's body in any type of surroundings like, on earth, in air, under water, etc...

Horizontal CG:

Your robot's horizontal CG (think of it as a balance scale) indicates how well the weight of the robot is distributed on its base. If all the weight of a robot is to one side, for example, then the base will have a lopsided horizontal CG. The result is an unstable robot: the robot may not travel in a straight line and it might even tip over. Ideally, the horizontal CG of a robot should be the center of its base (see Fig. Below).



Some variation of this theme is allowable, depending on the construction of the robot. For a robot with a single balancing caster, as shown in Fig Below.



it is usually acceptable to place more weight over the drive wheels and less on the caster. This increases traction, and as long as the horizontal CG isn't extreme there is no risk that the robot will tip over.

Unequal weight distribution is the most troublesome result if the horizontal CG favours one wheel or track over the other—the right side versus the left side, for example.

This can cause the robot to continually “crab” toward the heavier side. Since the heavier side has more weight, traction is improved, but motor speed may be impaired because of the extra load.

Vertical CG:

City skyscrapers must be rooted firmly in the ground or else there is a risk they will topple over in the slightest wind.

The taller an object is, the higher its CG. Of critical importance to vertical CG is the “footprint” or base area of the object—that is, the amount of area in contact with the ground. The ratio between the vertical CG and the area of the base determines how likely it is that the object will fall over.

A robot with a small base but high vertical CG risks toppling over. You can correct such a design in either of two ways:

- Reduce the height of the robot to better match the area of the base, or

- Increase the area of the base to compensate for the height of the robot.

(There is also a third method called *dynamic balance*. Here, mechanical weight is dynamically repositioned to keep the robot on even kilter. These systems are difficult to engineer and, in any event.)

Which method you choose will largely depend on what you plan to use your robot for.

For example, a robot that must interact with people should be at least toddler height. For a pet-size robot, you'll probably not want to reduce the height, but rather increase the base area to prevent the robot from tipping over.

Motor Drives:

Next to the batteries, the drive motors are probably the heaviest component in your robot.

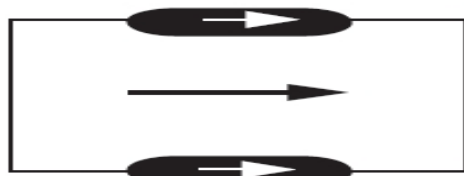
You'll want to carefully consider where the drive motor(s) are located and how the weight is distributed throughout the base.

One of the most popular mobile robot designs uses two identical motors to spin two wheels on opposite sides of the base (the differentially driven robot).

These wheels provide forward and backward locomotion, as shown in Fig. 18-4, as well as left and right steering.

If you stop the left motor, the robot turns to the left. By reversing the motors relative to one another, the robot turns by spinning on its wheel axis (turns in place). You use this forwardreverse movement to make hard or sharp right and left turns.

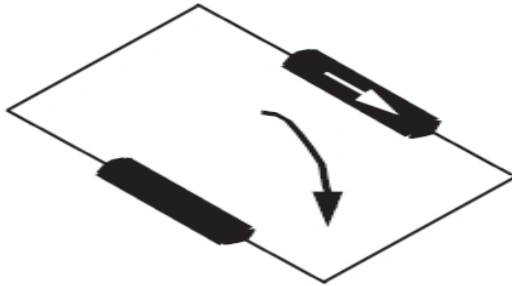
You can place the wheels—and hence the motors—just about anywhere along the length of the platform. If they are placed in the middle, as shown in Fig. Below



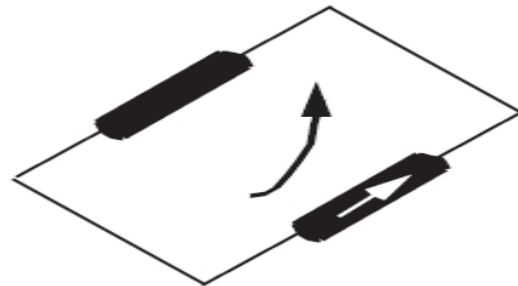
Forward



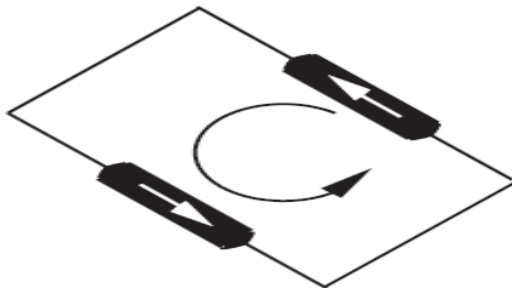
Reverse



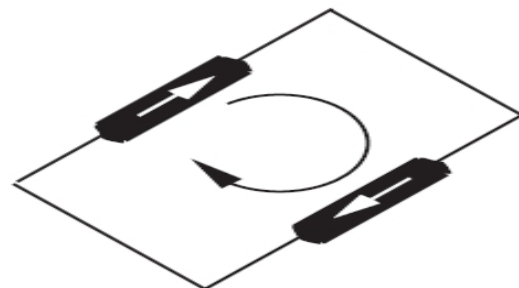
Right Turn



Left Turn



Hard Left Turn



Hard Right Turn

you should add two casters to either end of the platform to provide stability.

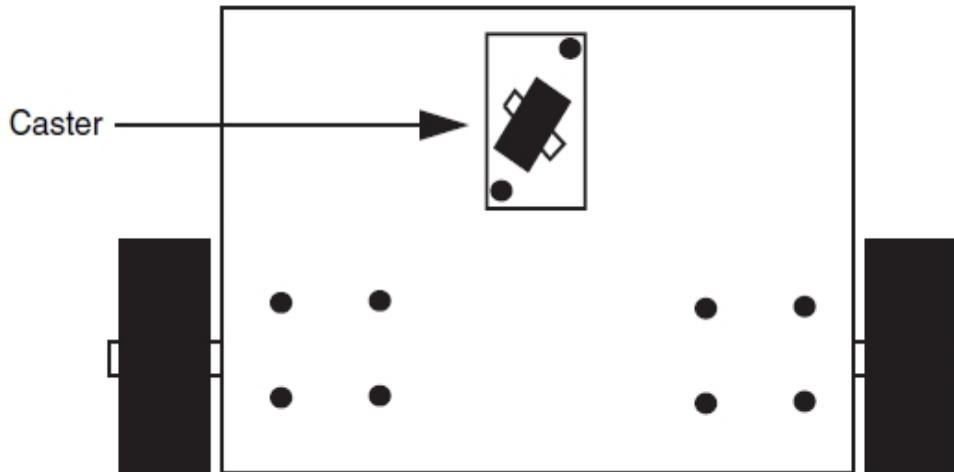
Since the motors are in the center of the platform, the weight is more evenly distributed across it. You can place the battery or batteries above the centerline of the wheel axis, which will maintain the even distribution.

A benefit of centerline mounting is that the robot has no “front” or “back,” at least as far as the drive system is concerned.

Therefore, you can create a kind of multidirectional robot that can move forward and backward with the same ease. Of course, this approach also complicates the sensor arrangement of your robot. Instead of having bump switches only in the front of your robot, you’ll need to add additional ones in the back in case the robot is reversing direction when it strikes an object.

FRONT-DRIVE MOTOR MOUNT

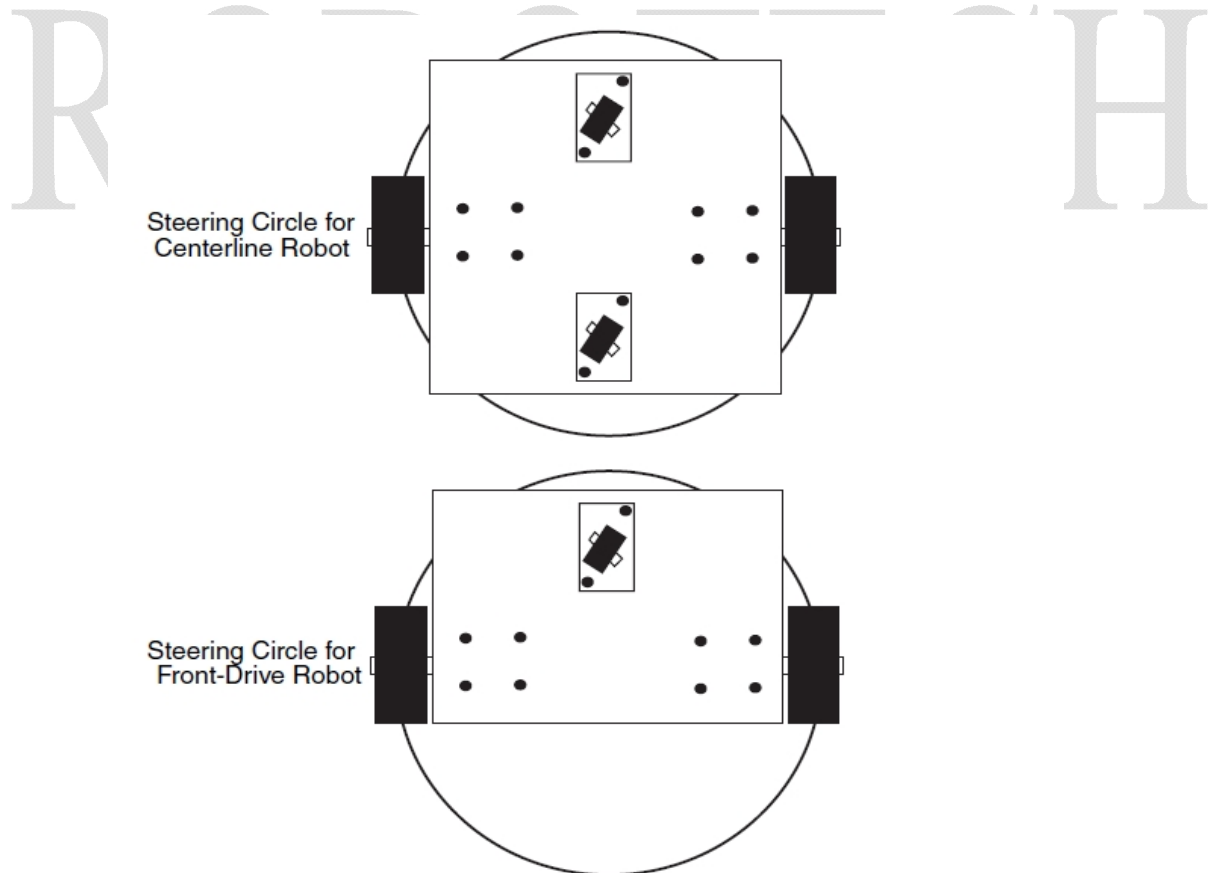
You can also position the wheels on one end of the platform. In this case, you add one caster on the other end to provide stability and a pivot for turning, as shown in Fig. below.



Obviously, the weight is now concentrated more on the motor side of the platform. You should place more weight over the drive wheels, but avoid putting all the weight there since Maneuverability and stability may be diminished.

One advantage of front-drive mounting is that it simplifies the construction of the robot. Its *steering circle*, the diameter of the circle in which the robot can be steered, is still the same diameter as the centerline drive robot.

However, it extends beyond the front/back dimension of the robot (see Fig. below).



This may or may not be a problem, depending on the overall size of your robot and how you plan to use it. Any given front-drive robot may be smaller than its centerline drive cousin. Because of the difference in their physical size, the diameter of the steering circle for both may be about the same.

BUILDING A ADVANCED LOCOMOTION ROBOT

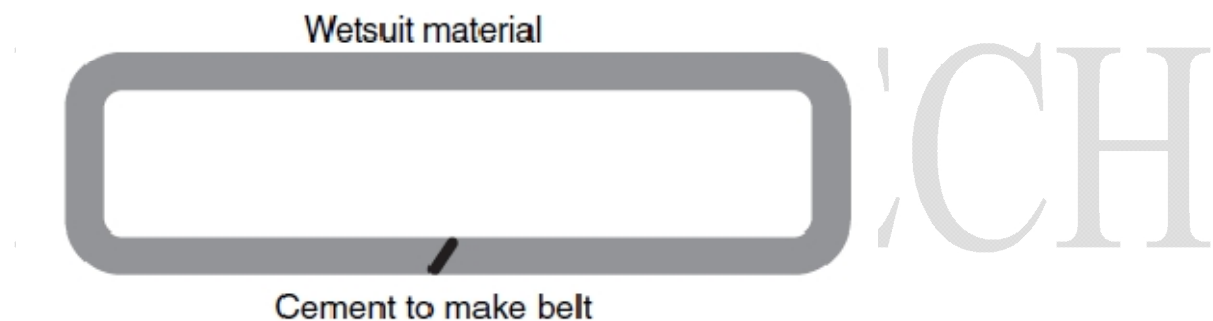
Two drive wheels aren't the only way to move a robot across the living room or workshop floor. Here, in this chapter, you'll learn the basics of applying some unique drive systems to propel your robot designs, including a stair-climbing robot, an outdoor tracked robot, and even a six-wheeled Buggybot.

Making Tracks

There is something exciting about seeing a tank climb embankments, bounding over huge boulders as if they were tiny dirt clods. A robot with tracked drive is a perfect contender for an automaton that's designed for outdoor use. Where a wheeled or legged robot can't go, the tracked robot can roll in with relative ease. Tracked robots, using metal tracks just like tanks, have been designed for the Navy and Army and are even used by many police and fire departments. The all-terrain ability and ruggedness of metal tracked robots made them the design of choice during rescue efforts after the 9/11 attacks.

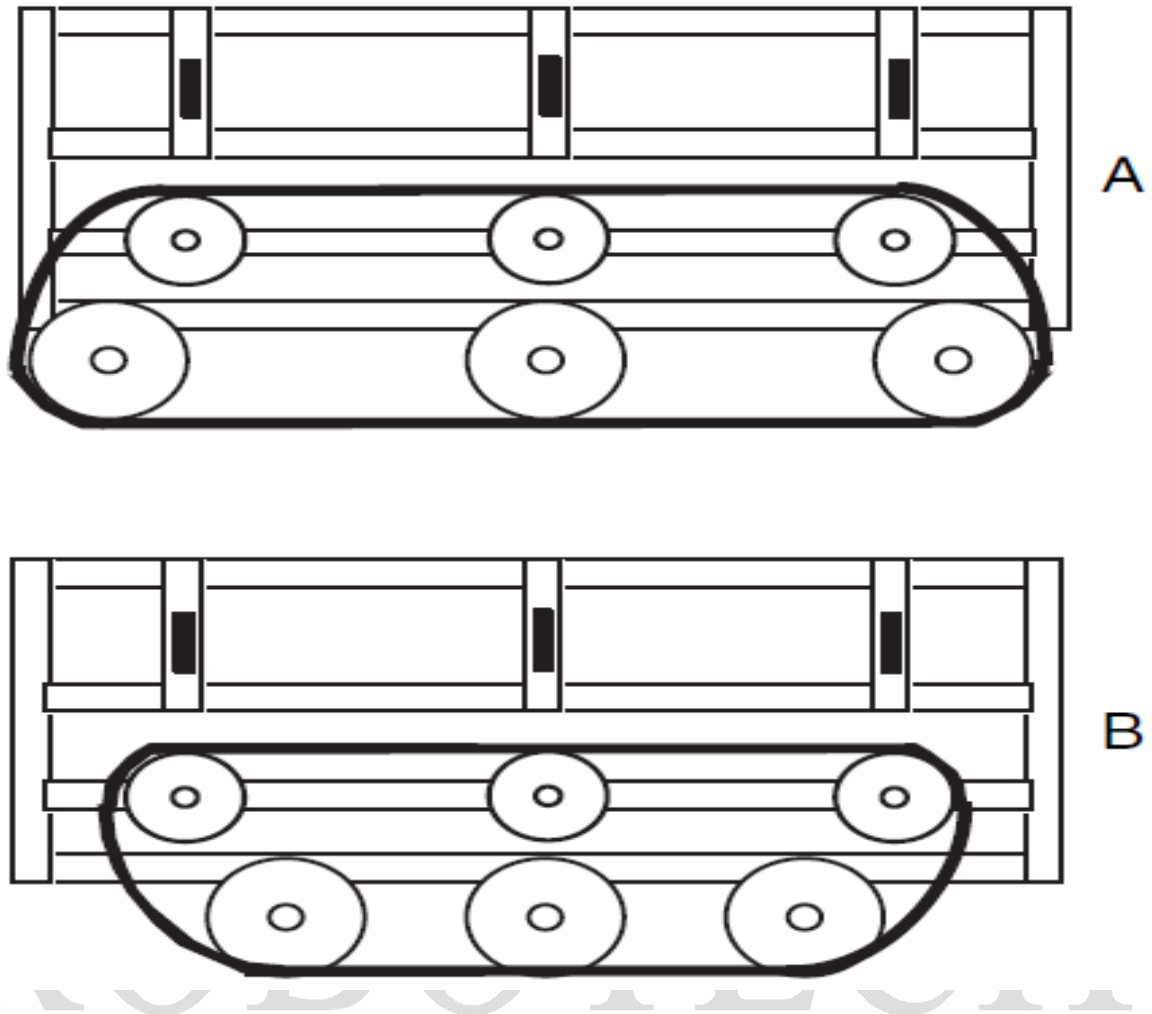
Using a metal track for your personal robot is decidedly a bad idea. A metal track will be too heavy and much too hard to fabricate. For a home-brew robot, a rubber track is more than adequate. You can use a large timing belt, even an automotive fan belt, for the track or a large rubber O ring (like the one used to drive your vacuum cleaner).

Another alternative that has been used with some success is rubber wetsuit material. Most diving shops have long strips of the rubber lying around that they'll sell or give to you.



You can mend the rubber using a special waterproof adhesive. You can glue the strip together to make a band, then glue small rubber cleats onto the band.

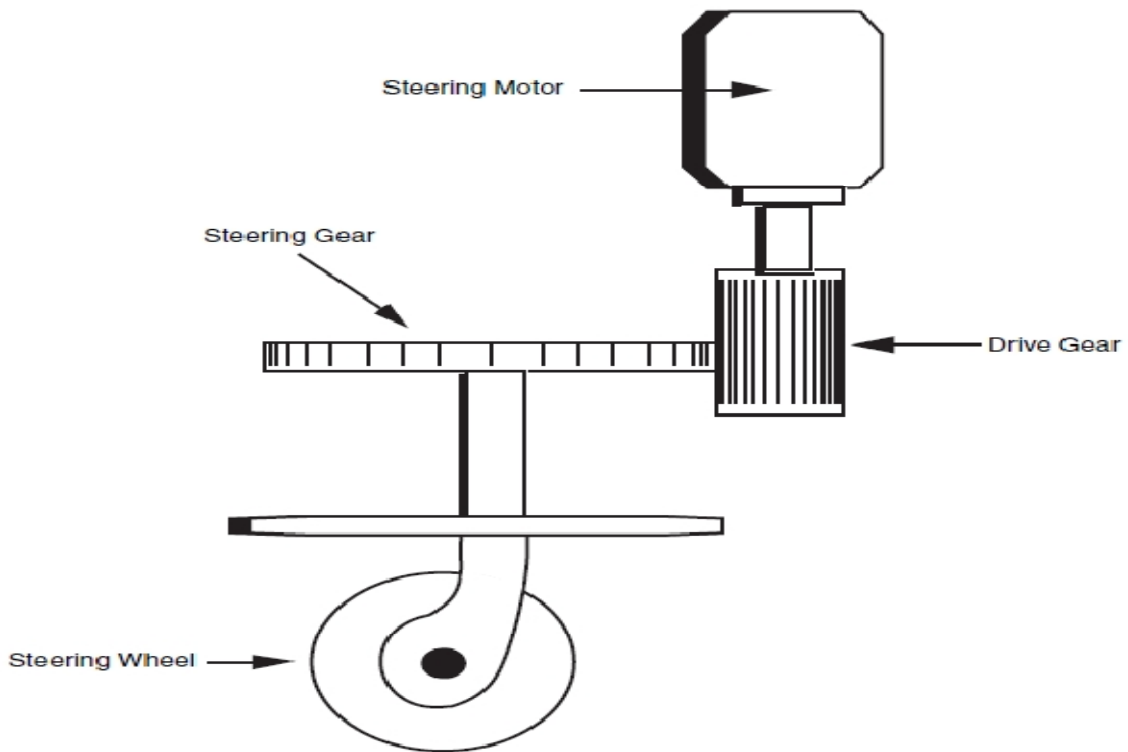
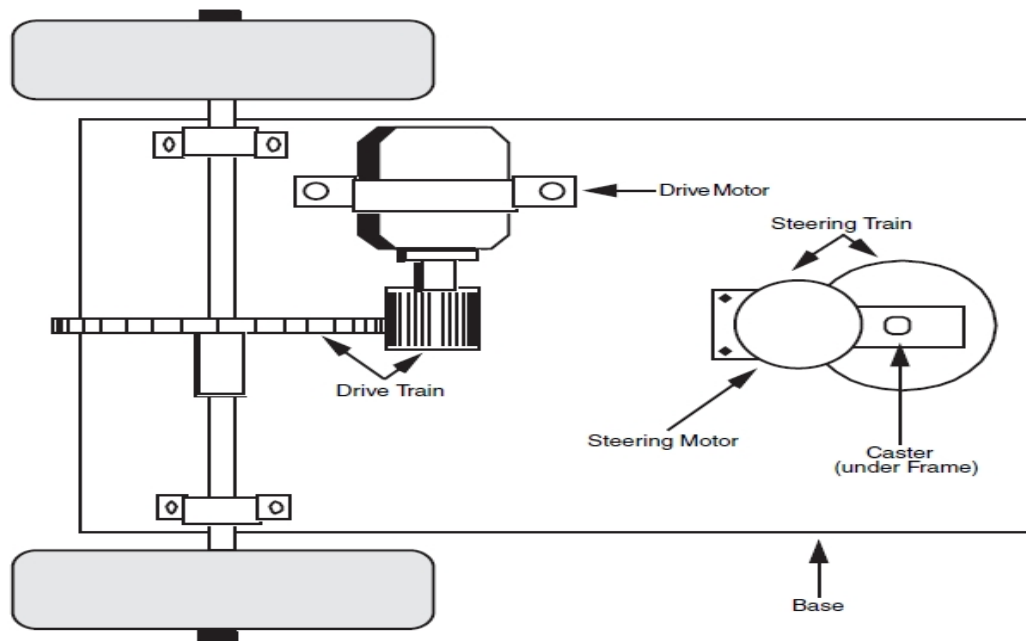
The drive train for a tracked robot must be engineered for the task of driving a track. A two-wheel differentially driven robot (like the wooden and metal platform robots presented earlier) can be used as a base for a tracked robot. Install three free-turning large pulleys and three small drive pulleys (one driven on each side of the robot), as diagrammed in Fig. below. The track fits inside the groove of the pulleys, so it won't easily slip out



To propel the robot, you activate both motors so the tracks move in the same direction and at the same speed. To steer, you simply stop or reverse one side (the same as the basic differentially driven robot). For example, to turn left, stop the left track. To make a hard left turn, reverse the left track.

Steering Wheel Systems

Using dual motors to effect propulsion and steering is just one method for getting your robot around. Another approach is to use a pivoting wheel to steer the robot. The same wheel can provide power, or power can come from two wheels in the rear (the latter is much more common). The arrangement is not unlike golf carts, where the two rear wheels provide power and a single wheel in the front provides steering. See Fig. Below for a diagram of a typical steering-wheel robot. Fig. below shows a detail of the steering mechanism. The advantage of a steering-wheel robot is that you need only one powerful drive motor. The motor can power both rear wheels at once as shown in Fig. below, but this isn't recommended for a reason that anyone who is aware of car drivetrains understands. With the



two wheels turning together, there is a lot of friction when the robot wants to turn because both wheels are locked together even though they will be turning at different speeds as the robot changes direction.

The solution to this dilemma in an automobile is a gear system known as a differential, which allows the wheels to turn at different speeds when the car is changing direction. Finding or making a differential for a robot is a daunting challenge but there are two simple solutions to the dilemma. The first is to drive only one of the two rear wheels and let the other turn freely. This way the other wheel will turn at the appropriate rate for the current motion. The second solution is to let both rear wheels turn freely and independently and drive the *turning wheel*.

The steering-wheel motor needn't be as powerful since all it has to do is swivel the wheel back and forth a few degrees. The biggest disadvantage of steering-wheel systems is the steering! You must build stops into the steering mechanisms (either mechanical or electronic) to prevent the wheel from turning more than 50° or 60° to either side. Angles greater than about 60° cause the robot to suddenly steer in the other direction. They may even cause the robot to lurch to a sudden stop because the front wheel is at a right angle to the rear wheels.

The servo mechanism that controls the steering wheel must know when the wheel is pointing forward. The wheel must return to this exact spot when the robot is commanded to forge straight ahead. Not all servo mechanisms are this accurate. The motor may stop one or more degrees off the center point, and the robot may never actually travel in a straight line. A good steering motor, and a more sophisticated servo mechanism, can reduce this limitation.

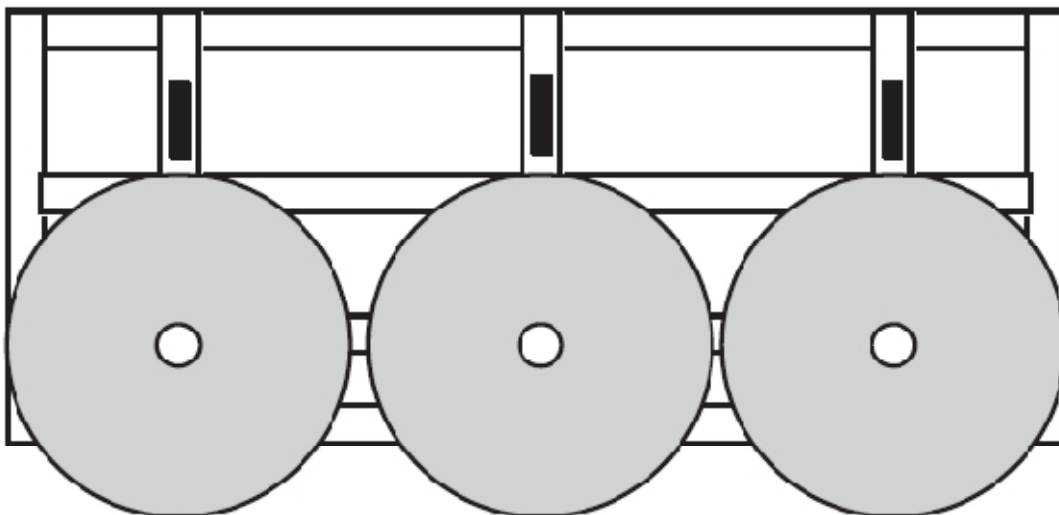
Six-Wheeled Robot Cart

A variation on the tracked robot is the six-wheeled rugged terrain cart (also known as a Buggybot), shown in Fig. below.

The larger the wheels the better, as long as they aren't greater than the centerline diameter between each drive shaft.

Pneumatic wheels are the best choice because they provide more bounce and handle rough ground better than hard rubber tires. Most hardware stores carry a full assortment of pneumatic tires. Most are designed for things like wheelbarrows and hand dollies. Cost can be high, so you may want to check out the surplus or used industrial supply houses. Steering is accomplished as with two-wheeled or tracked differentially driven robots. The series of three wheels on each side act as a kind of track tread, so the vehicle behaves much like a tracked vehicle.

The maneuverability isn't as good as with a two-wheeled robot, but you can still turn the robot in a radius a little longer than its length. Sharp turns require you to reverse one set of wheels while applying forward motion to the other.



3 Laws in Robotics

1st LAW:

A Robot may not injure the human being or, through inaction, allow human being to come to harm.

2nd LAW:

A Robot must obey orders given by the human being except where such orders conflicts with the first law.

3rd LAW:

A Robot must protect its own existence as long as such protection does not conflict with first and the second laws.

ABOUT THE AUTHOR

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Right now Studying Bachelor degree in Electronics and Communication Engineering 2nd year in Amruta Institute of Engineering and Management Science, Bangalore.

He had done a lot of research in the field of Robotics like Medical robots, Fire fighting robots, Defence robots, House automation, etc...

He is opening a new company in Bangalore by the name ROBOTECH Bangalore shortly.....

ROBOTECH