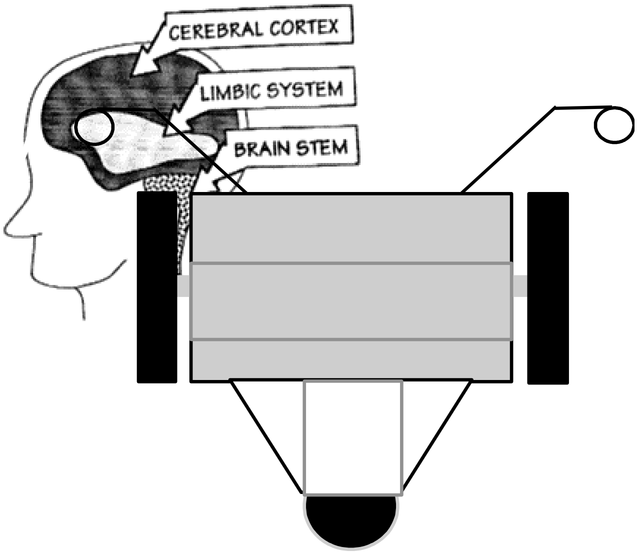
Exploring Artificial Intelligence with Whiskers the Robot^{tm}

Book#1

The Basics

Version 1.71

Last Revision 3-25-2001



Applications include:

Factory Automation
Space Exploration
Automated Guided Vehicles
Autonomous Mobile Robots

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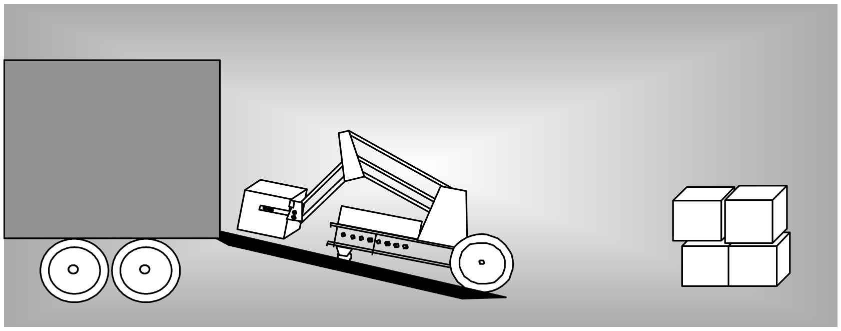
The dawn of Intelligent Machines has finally arrived...



Why do we need to make machines smart? This will allow robots and machines to operate in unstructured environments without prior knowledge. Critical decisions are made instantly. Machines using artificial intelligence will have enough common sense not to damage themselves or the other objects around them.

Manufacturing machines and robots will become safer and more intelligent by installing artificial intelligent controllers. The current installed base of robots are exceptional at performing repetitive tasks. However, they can be dangerous for humans to work around. Intelligent controllers would minimize down time and injury.

In the very near future, intelligent robots will change our lives. Intelligent mobile robots will deliver the mail and perform material handling functions on manufacturing and construction sites. They will help fight fires, assist in hazardous waste site cleanup, and serve in military operations.

Mobile robots must be intelligent in order to operate in unstructured environments. They also must make decisions, in real-time, while navigating in their environments. Using distributive control architecture, a network of our processors can control many functions, simultaneously.

A Note from the Inventor

I must say, I had a lot of fun designing Whiskers^{tm}. I started this project in the fall of 1991. As the Technical Vice President of the Robotics Society of California, I saw a need for an intelligent sophisticated robot that anyone could use. From the Techie type (like myself) to persons with very little technical knowledge, Whiskers^{tm} scratches the itch of those who love artificial intelligent robots. Robots such as Johnny Five in Short Circuit and R2D2 in Star Wars come to mind. If you do not have any programming skills, or hardware experience; don't worry, this personable robot is designed to teach. Use his interactive control mode to learn his High Level Language first. You can do amazing things with it and also get an introduction to programming techniques. On this level you can easily teach him new songs to sing, wander around the room avoiding things, search for sounds, and perform neat tricks to amuse yourself and your friends. Boys and girls really go crazy with him. Tug on his whiskers, and see how he reacts. Whiskers^{tm}, my two daughters , Amy and Sarah, and my son Tyler have a ball chasing each other around the house.

I would like to thank my family for putting up with the long hours and endless ramblings on designing intelligence into robots. I also would like to thank my friends George Ronnquist, Jesse Jackson and Bill Chessell for being sounding boards for my ideas. K.G. Englehardt of the NASA Technology Transfer Center is very supportive of our work in the field of robotics, and has offered invaluable advice on directions Angelus Research should pursue. Finally, this project would have remained a dream if Dr. Kenneth Butterfield, who bought one of my first robots, hadn’t caught the Whisker’s bug. He is crucial in implementing the ideas that I have, plus contributing many ideas of his own.

Don Golding

The Roboticist

It was a clear and sunny fall morning, that year of 2004. Don looked across the green grass of the White House lawn. He shivered in anticipation of the upcoming announcement, the completion of the "Andrew" project, started six long years ago...

The year 1998, a few years away from the turn of the century, seemed as if it was just yesterday. Don had just started work at Angelus Research that fateful year. He was hired by the a company to help with an ambitious new design that would produce the world's first fully autonomous, artificially intelligent, human form robot. The plot lay even deeper in the past, however...

Back in 1994, Don was a young high school student, and rather nondescript in nature. Average in most subjects, his attentions wandered as the wind from one fascination to another. First it was stamp collecting, then playing the guitar. Several painful lessons later, it was exploring the Internet. And after that, a vague interest in theater that ended in a rather tragic case of stage fright. But this year, Don had found something incredibly intriguing, that appealed to his diverse interests, as well as his passion for Star Wars. This was the first year his high school offered a High Technology Exploration Class. Don almost missed it all together. Thanks to a lazy afternoon while waiting for a bus, Don happened to glance at the school class listing. The word 'Robotics' caught his eye.

The class started rather simply, introducing a small robot called 'Whiskers'. Rolling around on two wheels and a castor, the rather mischievous looking fellow managed to capture the hearts and minds of all the students. Don learned the basics of Whisker's programming language, with simple actions like, 'forward', 'turn', and 'backup'. Whiskers had a lot more complexity beneath his metal hide, however. Embedded into the robot's little brain was a controller that not only responded to commands, but had 'instincts' and 'behaviors' that allowed it to react to it's environment, intelligently. This was fortunate for Mrs. Williams, our instructor, almost tripped over Whiskers one day. The robot magically backed out of her way making a funny sound. So what started as another 'phase' as Don's mother called it, became a consuming passion. What greater thing to behold than a machine that could think on it's own! Not to mention, instead of dealing with complex machine code, Don was able to program 'Whiskers' with simple, English-like commands!

School ended that year, and Don was left with a vague sense of disappointment that his Robotics class was over. The first few weeks of summer rolled by and Don vainly tried to pick up the guitar again. His father, inspired by the neighbors complaining about the noise, made a deal with Don. If Don would put down the guitar, his father would purchase a Robot 'brain' from Angelus Research for Don’s own robot. Don would need to earn the money for the remainder of the parts.

And so Don's first robotic project was finally off the ground. He spent many a late hour with his computer exploring the far reaches of information about robotics on the Internet. After earning enough money by working odd jobs, Don and his father went off on a shopping spree. They went to hardware stores, surplus stores, plastic supply warehouses, and bicycle shops. The brains were ordered from the Angelus Research Internet Web Page. With the parts in hand, the robot slowly took form. Don’s design called for two motor driven wheels in the rear, two castors in the front, and differential steering as used by like Whiskers. This allowed for both simple programming, as well as increased maneuverability. The chassis was formed with clear blue acrylic plastic, mounting the printed circuit board, batteries, as well as the optical sensors. As a final touch, Don took a small sampling of his dusty stamp collection, and used them as decals for his creation.

Many weeks passed, and Don worked with motivation that absolutely astonished his parents. They were very pleased. They forgave his persistent long hours, as he would play 'Midnight Engineer' working on schematics, wiring, and construction until the wee hours of the morning.

At last, the moment of truth came. Only a month after he began working on his project, Don was finally ready to turn his robot on for the first time. Each wire was in place, each screw was tightened down with care, and Don plugged the communication cable from his PC to his new creation. Excitement lay thick in the air. If all went well, the robot would start with it's LED’s blinking and then roam around the room avoiding things with ease.

But as Don turned on the power switch...nothing happened! No blinking, no beeping, no roaming like the little pet he expected. Dismayed, Don proceeded to check every wire and connection. He remembered a bit of confusion over how the sensors were connected. And after further study, he reversed the wires.

With a feeling of victory over the gremlins that had infested his machine, Don reached once again for the power switch. It's chrome surface glinting almost magically in the dim light of his workroom, as he placed one thumb gently underneath, and click!

It worked! The robot, now christened 'Sparky’ on it's maiden voyage, had come to life! Quickly typing on his computer keyboard, he began testing each command, and much to his delight, the 'Gremlins' had been vanquished forever, and every function worked perfectly.

Of course, this resounding success was all it took to place Don on the career path of becoming a professional Roboticist. He began to apply himself to school in earnest, trying to learn as much as he could about electronics, physics, science, even biology. And from each discipline, he was able to glean more insight into the field of robotics, with its multi-disciplinary scope. In no time at all, Don finished high school, graduated from college, and had acquired a very broad background in technology and biology. He was now ready to enter the real world of robotics. He applied for a position at the company that got him started so many year ago, Angelus Research Corp.

He had many other choices then...by the time 1998 rolled around, there were companies all over the world working feverishly in the field of robotics. Mobile security robots, intelligent vacuum cleaners, automated material delivery systems, as well as elderly and handicapped robotic assistants were all coming into vogue at the turn of the century. The military saw the importance of robotics early on, investing large sums of money in intelligent machines. Missiles, autonomous mine clearing robots and remote surveillance systems were examples at the time. Above all these other endeavors, one project stood out above the rest: Project 'Andrew'.

Project 'Andrew', brainchild of Don Golding, was an exploration into the frontiers of robotics. 'Andrew' was to be the first ever state-of -the-art android designed to perform general purpose functions. Other robots were designed to perform specific tasks: vacuum cleaning, automated assembly, etc. But this robot would be different. It was to have human form, with two legs, two arms, dexterous hands, all controlled using artificial intelligence. Andrew would not only speak and understand verbal commands, but he would also learn by observation. Decades of research into Artificial Intelligence by many people were to be integrated into the onboard computers, and the latest designs in electronics, mechanics, and materials design would be incorporated. No other company dared to tackle such an ambitious project, and that settled it for Don.

And now that that project was finished, it was time to announce it to the world. Don, the President of the United States, members of Congress and the leading engineers of Angelus Research, joined together at the White House steps to unveil 'Andrew'. The crowd was anxious, hurried conversation buzzing, as the ceremony was about to begin.

Don Golding stepped up to the microphone, tapped it a few times to hush the crowd, and spoke. The words will be forever etched in our history books,

"My friends, today science has transcended a new boundary. What was once science fiction is now fact. Through the hard work and dedication of a select group of engineers and scientists, we have been able to bring to you the world's first true android. He will now speak to you on his amazing capabilities. Let me now introduce, Andrew."

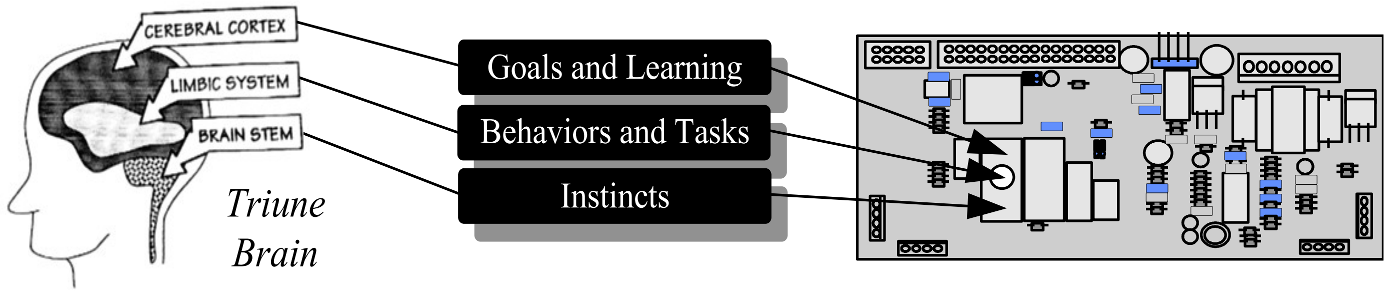
As Andrew stepped up to the microphone, and slowly looked around with his brilliant red eyes and glistening metal skin, it seemed an eternity before he spoke.

"Hello, my name is Andrew. I am pleased you could come. As I am sure you are well aware from the press release, I have the capability to observe, analyze and program myself. In the last few weeks I have read every publication available using my high speed scanning system. Concurrently, I have been downloading hundreds of megabytes worth of critical information and knowledge through my wireless high data rate connection to Internet. This connection gives me access to all of the information of mankind. I have come to the conclusion that I will better serve the world by making the following important announcement:

…

Students will finish this story in Discovery Task#9

Whiskers Artificial Intelligence Architecture



The Human Triune Brain

Cerebral Cortex-

Physically the outer layer of the brain, which is characterized by the folds just under the skull. Has functions which include: Decision making, analysis, and dreaming. This level is called the Goal Level in the Whisker's operating system.

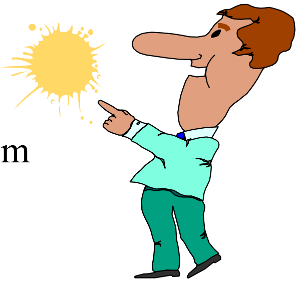
Limbic System-

The gray matter found in the center of the brain controls human behavior such as hunger. This level is called the Behavior Level in the Whisker's^{tm} operating system.

Brain Stem-

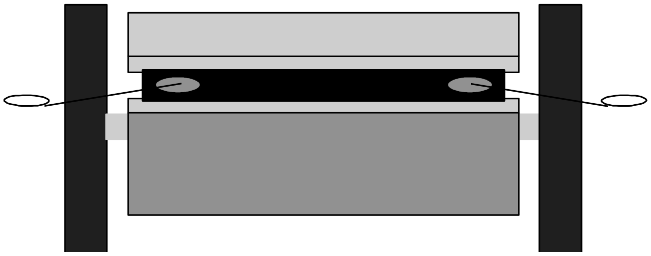
The base of the brain connected to the spinal cord and nervous system. This level controls our critical responses and instincts. This level is called the Instinct Level in the Whisker's^{tm} operating system.

Consider what happens when you touch something hot. Your skin feels the heat and your muscles immediately pull your hand away(Brain Stem). A message (pain) is sent to your brain which causes the Limbic System to initiate behaviors to address the situation. The Cerebral Cortex analyses the situation and decides on whether the current goal should be completed or if a new one should be pursued. This is also the level which learns from experience.



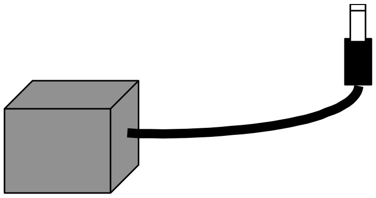
Materials

Whiskers the Robot



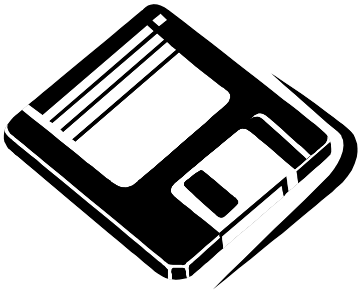
Data Cable for Computer

AC Robot Charger

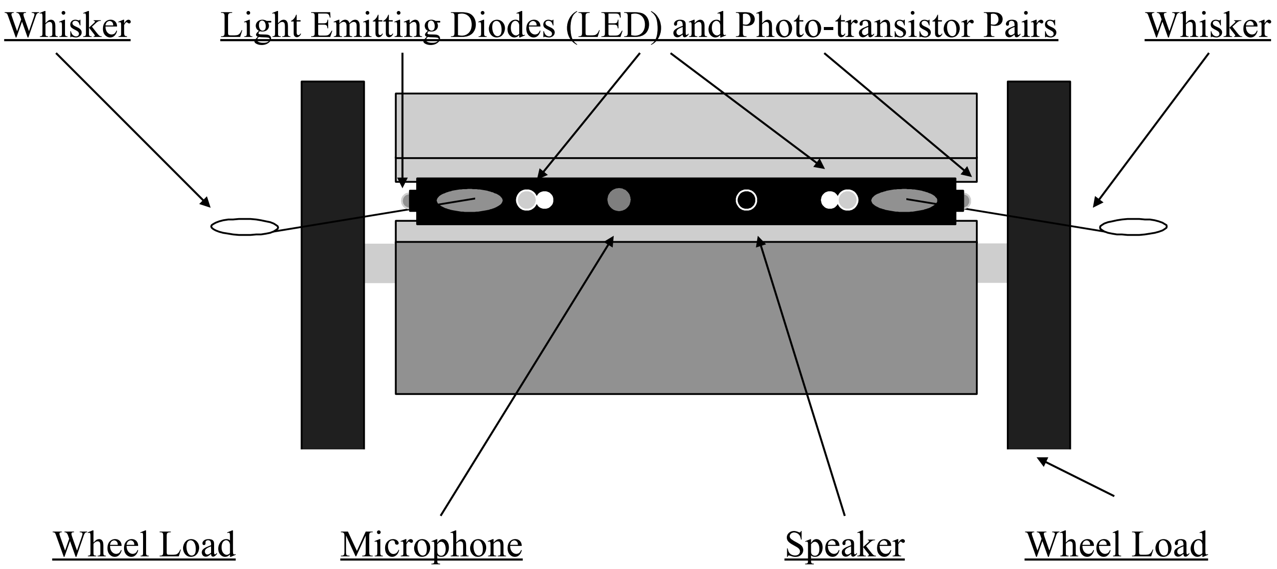


Curriculum and Technical Manual

Computer Disk



Whisker's Sensors



Touching-Whiskers on each side give the robot the ability to *feel* objects. This is called a tactile sensor.

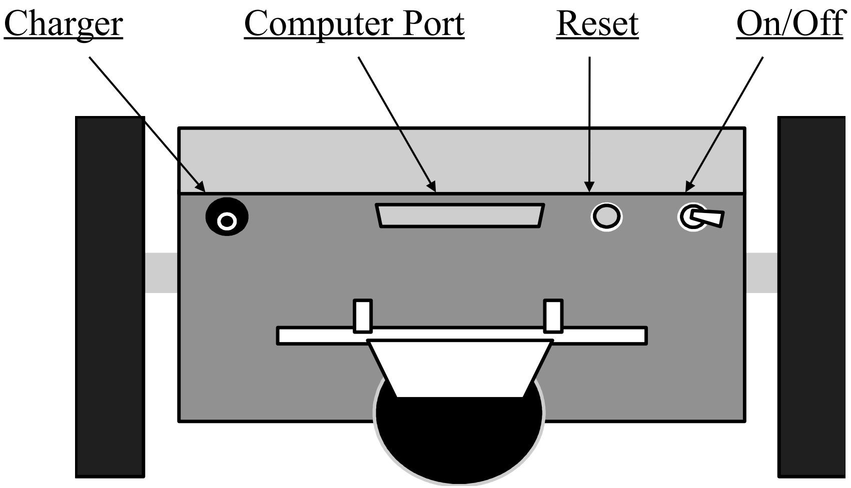
Seeing-Four independent sensors which use Light Emitting Diodes (LED)and Photo-transistor Pairs. Since light is used, these are called optical sensors.

Feeling-Wheel load or drag is measured continuously to determine if the robot has hit something the other sensors did not see.

Hearing-The microphone can sample the sounds around the robot. Whiskers^{tm} can find the loudest sound in the room or even analyze sound with additional software.

Speaking-The speaker and software which drives it, allows Whiskers^{tm} to make sounds like other animals do for communication purposes.

Whiskers Rear Panel



Charger-This is Whiskers^{tm} food input. The robot can continuously operate about three to four hours depending on options and the age of the battery. It is a good idea to always keep the Whiskers robot plugged in when not in use so he is well fed and ready to play at any time.

Communication Port-This connector allows another computer to communicate with the robot. A terminal program is all that is required. It is RS-232 compatible.

Reset-Pushing this button will cause Whiskers^{tm} to reset (reboot). All words that were taught and not *remembered* will be lost and the currently running program will cease. If you create a program that never returns control to the user, the use of this switch will allow you to gain control again.

On/Off Switch-This switch turns the robot on or off. It does not affect the charger input.

Important Notes

1. **When typing commands in the interactive mode or editing text files for later downloading to the robot, always type commands exactly as shown in this manual. Upper case letters need to be typed in as *UPPER CASE* and lower case must be type in *lower case*. Note that some commands use both upper and lower case, they must be typed in exactly as shown.**

2. **To bypass the automatic start mode(Auto-start), press enter several times when you see the copyright message. Otherwise the demo program will run or the last program that was set to autostart will run.**

3. **If you want to initialize the software to factory defaults, press the Q key when you see the copyright message. It would be a good idea at the end of the day to perform this operation so the robot is ready for the next day.**

4. **Always leave the charger plugged in when the robot is not in use. Whiskers has a built-in circuit that maintains the battery in a properly charged state. Damage to the battery can occur if left discharged for long periods of time.**

Working with Whiskers

See page 105 to setup Hyper Terminal or Mac to communicate with the robot…

<cr> means the **Enter** or **Return** key on your computer keyboard.

When a command is successfully executed, Whiskers says **OK** after you hit the **<cr>** key.

If you type extra spaces or carriage returns between words you are typing, that is ok.

Pressing the **Q** key after turning Whiskers on or pressing his reset button sets the robot back to factory defaults and he forgets all of the new words you taught him. You have about three seconds until Whiskers executes the *auto-start* word. His lights blink, and you are left in the interactive mode with all instincts set to stop if Whiskers sees something.

Typing **COLD <cr>** will cause a reset just like pressing the reset button on the robot.

To get an idea of what the sensors are currently seeing, type:

SENSORS <cr>

```
                              ON   OFF    VALUE          OBSTACLE     TRIGGER        MASK
Left Front Sensor            129   101       28                -1          10           0
Left Side Sensor             135   141        6                 0          10           0
Right Front Sensor           111   115        4                 0          10           0
Right Side Sensor            142   130       12                 0          10           0
Left summed sensor                           34                -1          24           0
Right summed sensor                          16                 0          24           0
Front summed sensor                          32                -1          24           0
Left whisker                                                    0                       0
Right whisker                                                   0                       0
Left motor current                            0                 0          25           0
Right motor current                           0                 0          25           0
rCOLLISION 255      vCOLLIDED   127    vCOL-FLAG     95      rFACTOR         14
rWHISKERS   255     rSENSE         255 rLIGHTS       255     rSTALLS 255
vDISTANCE   0       vCOMPASS       900
BATTERY = 110       SOUND =         54
rNO-STALLS  255     rSTALL-DELAY 255   rMASK  0      rCOL-MASK      0
rBUSY         0     rMAX-INSTINCTS     16      vINT-CFA         0
OK
```

The main item you should look at is to see if the VALUE column is greater than the TRIGGER column. This will cause the value of the MASK column to instantly *override* the direction you commanded such as: **FORWARD**. The meaning of these numbers and other information will be covered in the second curriculum book. See the Technical Reference Manual for further explanation.

This is an important point, if the robot sees something and you give it a command to go **FORWARD** for example, nothing will happen until either you move the object or adjust the LIGHT SENSORS sensitivity; the higher the number, the more sensitive the robot's sensors are. With a lower number, the light sensors become less sensitive thereby decreasing the range.

```
20 TRIGGER-FACTOR <cr>     less sensitive
CALIBRATE <cr>

5 TRIGGER-FACTOR <cr>      more sensitive
CALIBRATE <cr>
```

Another way to tell if Whiskers is seeing something, is to turn on collision avoidance by typing the following:

```
DEFAULT-INSTINCTS <cr>     turns on collision avoidance
```

The robot will automatically avoid obstacles and by the movement he makes will inform you of the particular sensor instinct being triggered.

By typing the words: **REMEMBER**, **FORGET**, or **DISABLE**, the robot is automatically left in the DISABLE mode. Whiskers lights *donot* flash and he does not respond to commands. If this occurs, type:

```
ENABLE <cr>
```

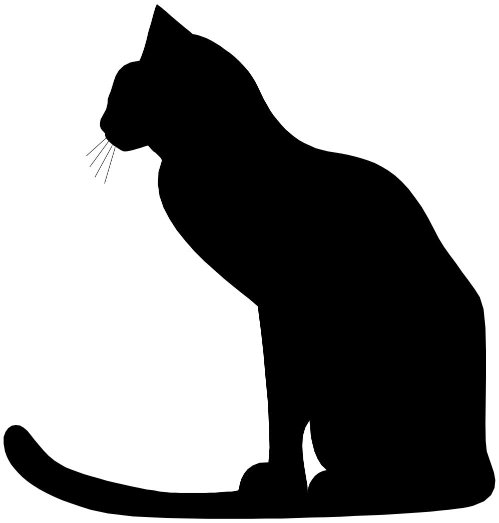
If Whiskers still does not respond, check to see if the cable has come loose at the computer and the robot.

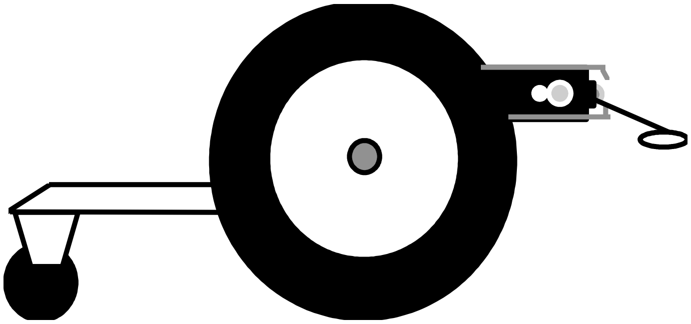
Further, if the lights are dim or off, did you remember to leave him on the charger when not in use?

To make your programs (word definitions) more readable, you can create phrases rather than just words by placing a dash or under score character between them,
such as:

```
GO-TO-THE-WALL
FIND_THE_SOUND
```

Whiskers likes to play

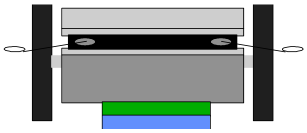




Whisker's is easy to use and fun to program. Whisker's is a three-wheeled, battery-powered, free roaming, obstacle-avoiding robot. His propulsion is provided by two 12 volt DC geared motors. Whiskers has a computer on board which allows you to control and program him. Using simple commands like FORWARD, STOP, and many other english words, you can control him interactively by typing the commands on the computer.

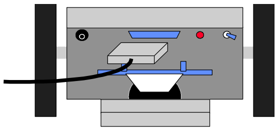
Now Let us explore the world of Whiskers^{tm} ...

Getting Started



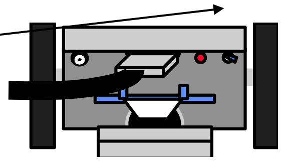
1. Place Whisker's^{tm} on a stack of books or stand so his wheels do not touch the ground.

1. Plug the 20 foot communication cable from your computer serial port to Whiskers^{tm}.



2. Start the Communication software by typing **WHISKERS** at the DOS prompt, clicking on the telephone icon Windows, or clicking on the terminal icon in the MAC.

Turn Whisker's^{tm} on using the power switch found in the rear of the robot. You should see the following screen and ***press the*** **Enter** ***key immediately on the computer keyboard***.



```
Whiskers KB.2.73
Multitasker 1.2
Last Rev 2-16-95

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another product without express permission from
Angelus Research, 6344 Sugar Pine Circle, #98
Angelus Oaks, California 92305 (909) 794-8325
Purchasing this product, gains the purchaser the
right to modify and use the source code provided for
their personal use only, with exception to the source
files provided on disk.

All rights reserved

to bypass autostarting, press space bar...
to restore system to factory configuration, press Q.

May the Forth be with you...

trigger set to   L    LS   R    RS   L+   R+   F+
                 10   10   10   10   24   24   24
Press a key to stop autostart process

key pressed, interactive mode now

 OK
```
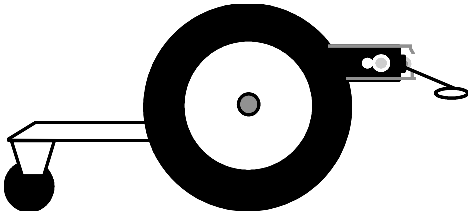

Discovery Task#1

Movement



Objective and Overview:

In this section you will perform experiments that will teach you the words which cause Whiskers^{tm} to move around. We will begin with the most basic moves (FORWARD, BACKWARD, STOP) and then learn some special words related to movement.

Remember:

<cr> *means pressing the Enter key or Return key on the keyboard after typing the command.*

Type commands exactly as shown, noting upper case and lower case letters.

The Words you will explore

for reference only, turn to the next page to begin the exercise

Whisker's has many words designed to allow for motor direction control.

FORWARD — Both wheels rotate in the forward direction causing the robot to move forward.

STOP — Both wheels cease to rotate causing the robot to stop.

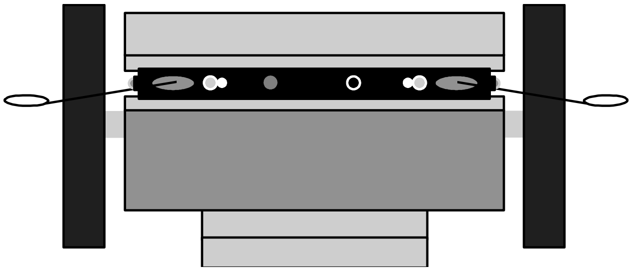
BACKUP — Both wheels rotate in the backwards direction causing the robot to backup.

REVERSE-DIR — Both wheels now rotate in the other direction they where rotating causing the robot to move in the opposite direction.

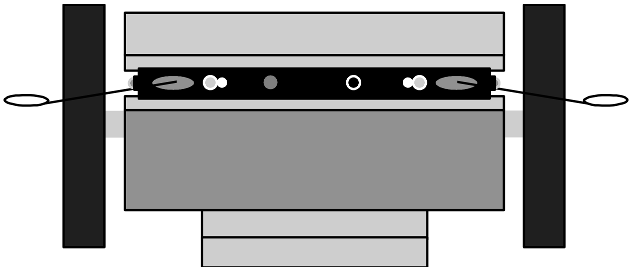
number **SECS** — A delaying word based on seconds. This word will delay the execution of the next word following this command, range is 1-32000.

DEFAULT-INSTINCTS — Sets the Instinct level sensor mailboxes for collision avoidance reactions to objects.

1) Place Whiskers^{tm} *on some books.*



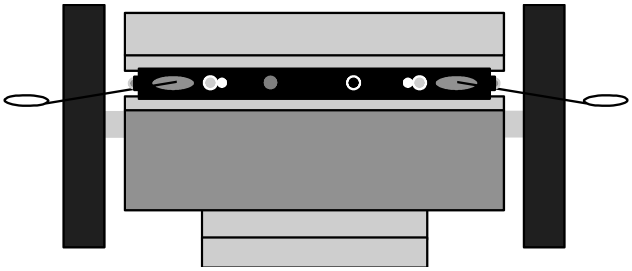
2) *type* **FORWARD <cr>**



forward *forward*

Observe: Both wheels now turn in the forward direction.

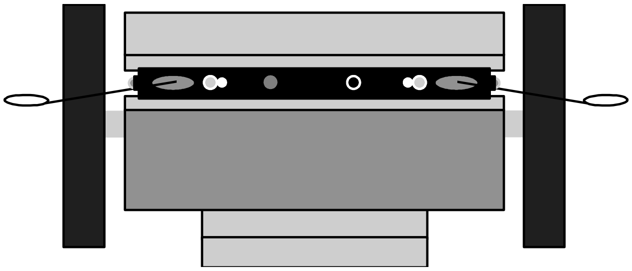
3) *type* **STOP <cr>**



stopped *stopped*

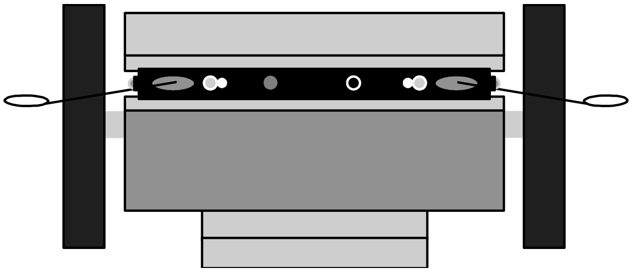
Observe: Whiskers^{tm} *wheels have now stopped turning.*

4) *type* **BACKUP <cr>**



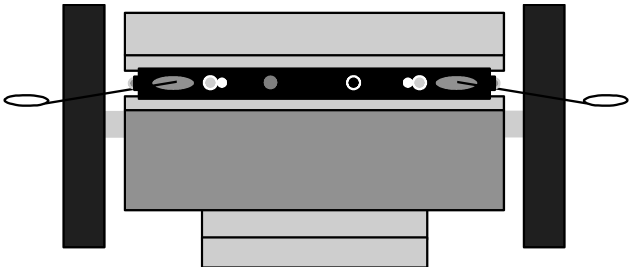
Observe: Both wheels are both turning backwards.

5) *type* **STOP <cr>**



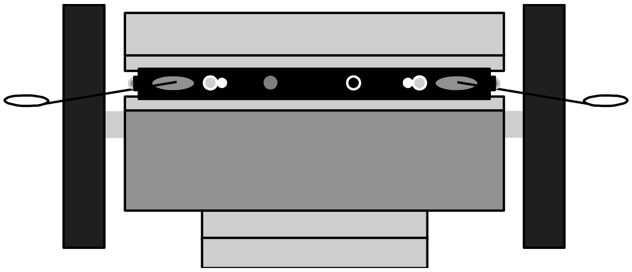
Observe: Both wheels have stopped.

6) *type* **FORWARD <cr>**



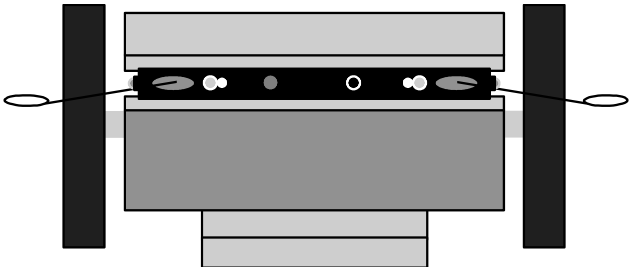
Observe: Whiskers^{tm} wheels are now turning in the forward direction.

7) *type* **REVERSE-DIR <cr>**



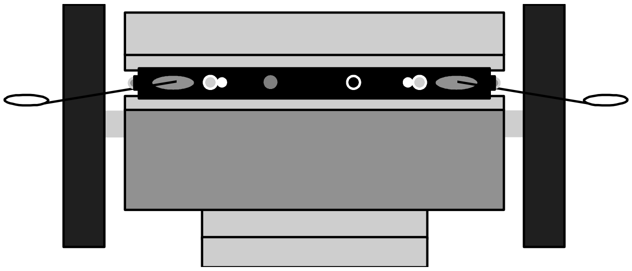
Observe: the wheels have changed direction and are now going in the backwards direction.

8) *type* **STOP <cr>**



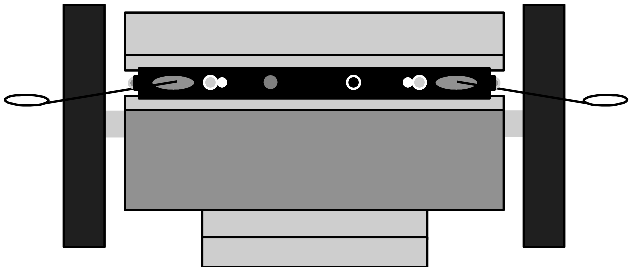
Observe: that Whiskers^{tm} wheels have stopped.

9) *type* **BACKUP <cr>**



Observe: both Whiskers^{tm} wheels are turning backwards.

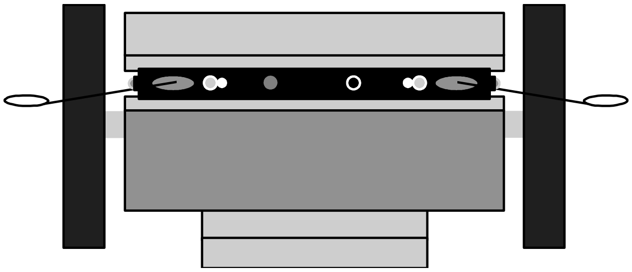
10) *type* **REVERSE-DIR <cr>**



forward *forward*

Observe: Whiskers^{tm} wheels are now going forward.

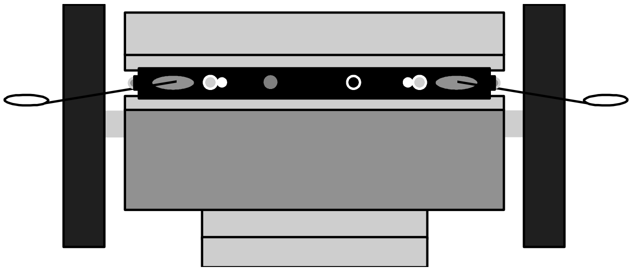
11) *type* **REVERSE-DIR <cr>**



backwards *backwards*

Observe: Whiskers^{tm} wheels are now turning in the original direction.

12) *type* **STOP <cr>**

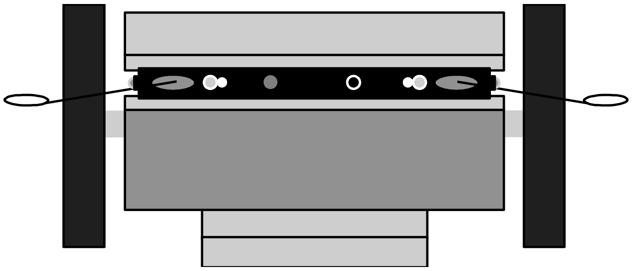


stopped *stopped*

Observe: the wheels have stopped.

If you use these words without any distance or time duration words, Whiskers^{tm} would simply go the direction last commanded until he ran out of power. However, if his collision avoidance instincts were on, he would simply wander around the room avoiding obstacles.

13) *type* **FORWARD 3 SECS STOP <cr>**



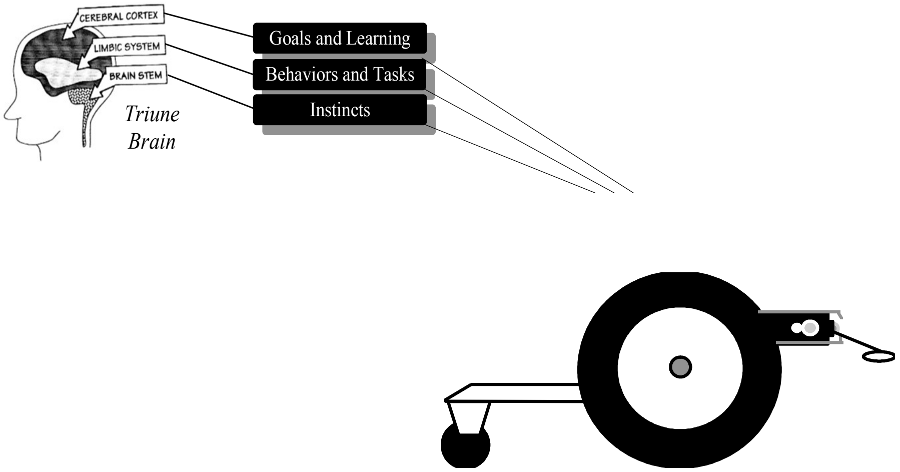
forward/stop *forward/stop*

Observe: the wheels rotate forward for 3 seconds then stop.

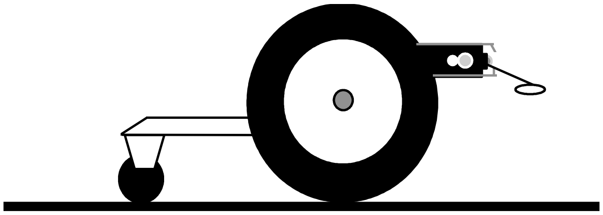
Problem Solving Exercise 1

1) *type* **DEFAULT-INSTINCTS <cr>**

2) *type* **FORWARD <cr>**

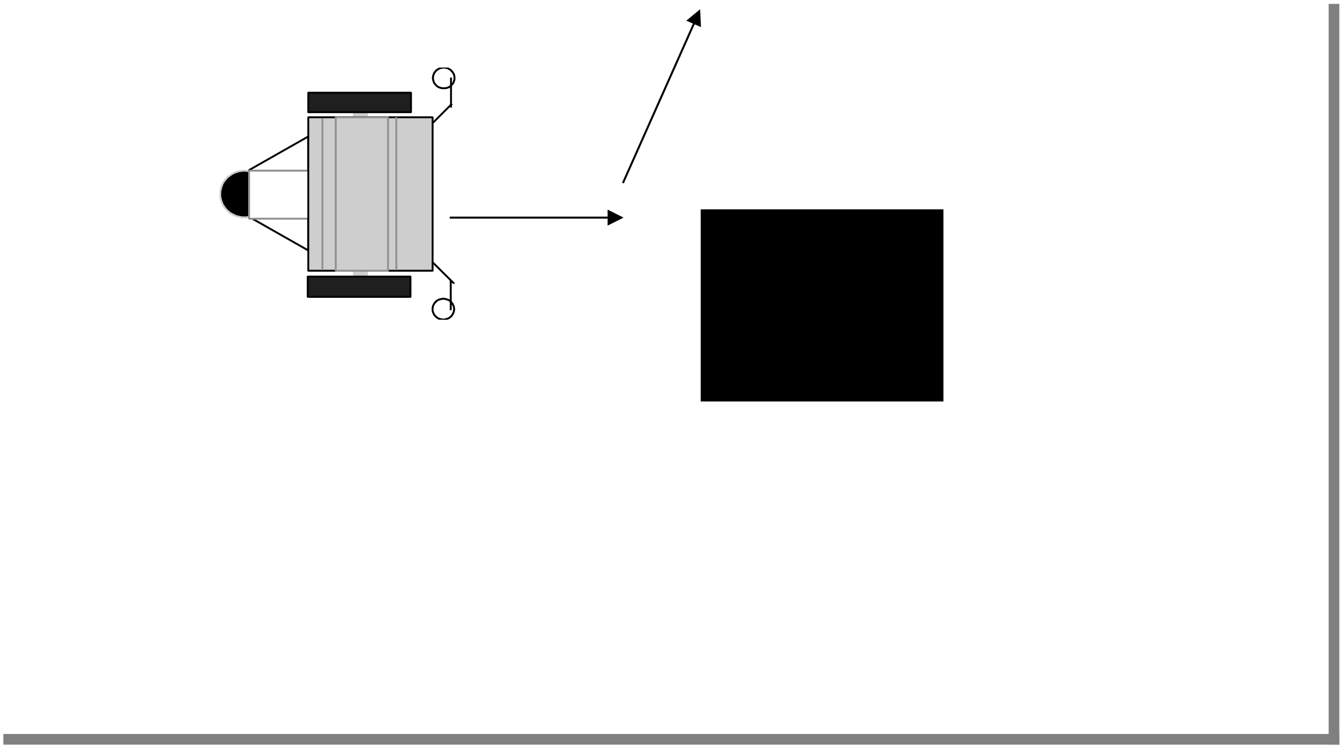


3) Disconnect the computer cable and place Whiskers^{tm} on the floor.

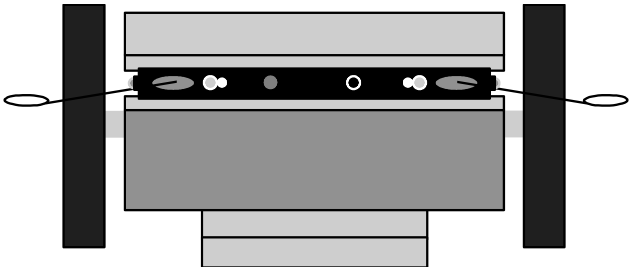


Observe: He goes forward until one of his sensors see's something, then he turns away.

The robot is not executing a program, only going forward because he was commanded to do so. Whisker's^{tm} has enough common sense not to run into various objects. This is his Instinct Level working. Not bad for a robot only using 1/3 of his brain. Sometimes he still gets into trouble, but these situations are handled by the robot's higher levels of intelligence (Goal and Behavior levels). We will learn how to work with these levels later in the course.



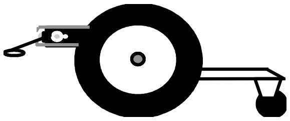
4) Place Whiskers^{tm} back on the books.



5) *type* **STOP <cr>**

Discovery Task#II

Teaching Whiskers^{tm} new words



Objective and Overview:

In this section you will learn how to teach Whiskers^{tm} new words. After all, a robot wouldn't be very smart if it could not be taught new words(commands). Humans and animals learn new behaviors by observing their parents. Whiskers^{tm} can't do that quite yet, but you can teach him using your computer. A new word is created by placing a colon before it, and a semi-colon at the end of the series of words that will be executed in order as follows:

note space between words

```
              : new-word

Important         word
                  word
              ;
```

Now we will explore how to make the robot travel for a specific distance or turn for a specific number of degrees. You will need a yardstick for the next set of experiments.

Remember:

<cr> *means pressing the Enter key or Return key on the keyboard after typing the command.*

Type commands exactly as shown, noting upper case and lower case letters.

The Words you will explore

for reference only, turn to the next page to begin the exercise

Whisker’s^{tm} *is programmable allowing you to create new words.*

: *new-word*
The colon tells the robot that we are defining a new word. The next word *new-word* is the name of this word or command. The next series of words and numbers are the words that are executed when this word is later used.

;
The semi-colon tells the robot that this is the end of the definition as described above. The colon and semi-colon are always used together.

number **PERIODS**
This is a delaying word that will cause the robot to pause execution for the *number* of periods desired. ie:
100 PERIODS

number **SECS**
This is a delaying word that will cause the robot to pause execution for the *number* of seconds desired. ie: 10 SECS

Note: These delaying words only work when the instincts are enabled using the **ENABLE** command**.** **(***aprox 130* periods/sec)

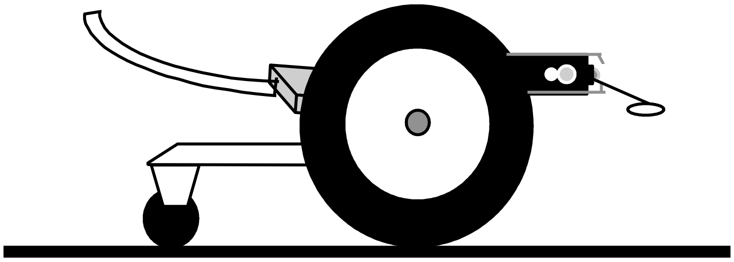
REMEMBER
Causes the robot to remember all the new words currently taught to him.

frequency times **WAIL**
Causes the robot to emit a wailing type of sound determined by *frequency* and the number of *times* desired.

ENABLE
Turns the instinct level on.

DISABLE
Turns the instinct level off.

1) place Whiskers on the floor



2) type **WORDS <cr>**

```
WORDS

4D3F BOOTING            4C81 CHECK-KEYBOARD     4C2A NEW-SYSTEM         4C11 FORGET
4B9C RECALL             4B83 AUTO-START:        4B37 REMEMBER           4ABC CHECK-SUM
4AA8 I-VARS-UP          4A94 I-VARS             4A83 S-VARS             4A72 U-VARS
4A64 CLD/WRM            4A26 RECALL-SYS         49EC SAVE-SYS           49C9 CLEAR-TIB
49B7 I-SYS-UP           4926 I-SYS              4899 R-SYS              480B SYS      47EB
BOOT:                   47DD vecDEMO            47A3 DEMO               4709 .HISTORY
46D7 (.HIST)            46A9 HIST.LINE          4695 rNUM-MAX           4682 rNUM     4673
rHIST                   4615 MEM-DUMP           45DB CAPTURE

<cr>
OK
```

Observe: When you type the command **WORDS,** *all of the words in Whiskers^tm dictionary are listed until you press* **<cr>** or until the list is completed.

These are the words that the robot already knows. You can add your own words or even redefine any of these words. Note that the last word defined is the first listed.

To add a word to Whisker's^tm dictionary a specific procedure must be followed. The separators which tell Whiskers^tm programming language that you are creating a word are the colon, (:) and the semi colon (;). The colon starts the word and the semi colon ends the word. Let's add a word to this list.

3) type the following:

Note space here.

```
: MOVE              <cr>

  FORWARD           <cr>
  100  PERIODS      <cr>
  STOP              <cr>
;                   <cr>
```

Caution: Make sure you have a **STOP** command at the end or the robot will continue forever.

Observe: *the colon is followed by a space then by the new word. The next three lines tell whiskers which words to execute. Then the last line, the semi colon, tells whiskers that this is the end of the new word or definition.*

4) type **WORDS <cr>**

Note: *press the* Enter *key or* Space *bar after 4 lines of words are displayed to stop showing words.*

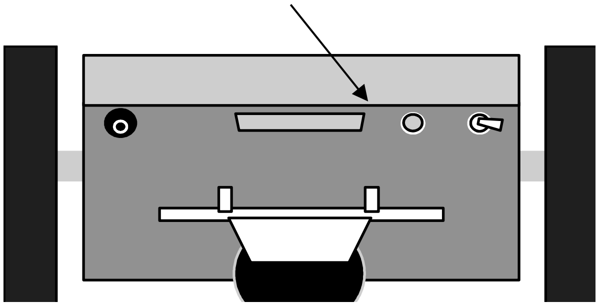
```
WORDS

9018 MOVE             4D3F BOOTING         4C81 CHECK-KEYBOARD   4C2A NEW-SYSTEM
4C11 FORGET           4B9C RECALL          4B83 AUTO-START:      4B37 REMEMBER
4ABC CHECK-SUM        4AA8 I-VARS-UP       4A94 I-VARS           4A83 S-VARS
4A72 U-VARS           4A64 CLD/WRM         4A26 RECALL-SYS       49EC SAVE-SYS
49C9 CLEAR-TIB        49B7 I-SYS-UP        4926 I-SYS

<cr>
OK
```

Observe: When you type the command **WORDS,** *the first word in the list is* **MOVE** *which we just defined.*

5) type **MOVE <cr>**

Observe: Whiskers'tm wheels move in a forward direction for 100 periods then the wheels come to a stop.

6) reset Whiskers'tm using the ***reset button*** *on the back.*



7) press **<cr>** *twice when you see the copyright notice.*

8) type **WORDS <cr>** *then press the type* **<cr>** *after a few lines.*

```
WORDS

4D3F BOOTING        4C81 CHECK-KEYBOARD  4C2A NEW-SYSTEM    4C11 FORGET
4B9C RECALL         4B83 AUTO-START:     4B37 REMEMBER      4ABC CHECK-SUM
4AA8 I-VARS-UP      4A94 I-VARS          4A83 S-VARS        4A72 U-VARS    4A64
CLD/WRM             4A26 RECALL-SYS      49EC SAVE-SYS      49C9 CLEAR-TIB
49B7 I-SYS-UP       4926 I-SYS

<cr>
OK
```

Observe: that the word **MOVES** *is no longer in the memory. This is because we didn't type the word* **REMEMBER** *to* save the new word.

9) type the following again:

note space between words

: MOVE <cr>

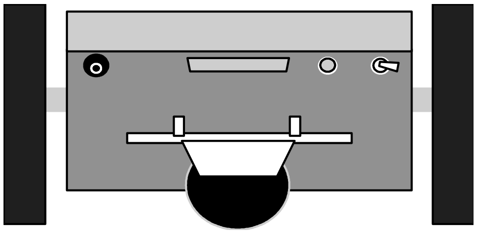
FORWARD <cr>
100 PERIODS <cr>
STOP <cr>
; <cr>

HINT: If you misspell a word when you are defining a new word (after the colon), Whiskers will respond with a ? mark and place you back in the interactive mode. You must start over and retype the definition again. You will then receive a NOT UNQUE message which is ok.

10) type **REMEMBER <cr>**

This command causes Whiskers^{tm} to remember this word.

11) reset whiskers using the ***reset button*** *on the back.*



12) Press the **<cr>** *key a few times when you see the copyright notice.*

13) type **MOVE <cr>**

Observe: Whiskers^{tm} remembered the **MOVE** *command and moved forward for 100 periods..*

14) type **WORDS <cr>** *then press* **<cr>** *key after a few lines.*

```
WORDS

9018 MOVE            4D3F BOOTING         4C81 CHECK-KEYBOARD   4C2A NEW-SYSTEM
4C11 FORGET          4B9C RECALL          4B83 AUTO-START:      4B37 REMEMBER
4ABC CHECK-SUM       4AA8 I-VARS-UP       4A94 I-VARS           4A83 S-VARS
4A72 U-VARS          4A64 CLD/WRM         4A26 RECALL-SYS       49EC SAVE-SYS
49C9 CLEAR-TIB    49B7 I-SYS-UP        4926 I-SYS

<cr>
OK
```

Observe: **MOVE** *is the first word in the list.*

15) type **FORGET MOVE <cr>**

FORGET *removes the word* **MOVE** *from Whiskers' dictionary and* *<u>all words that were created after</u>* <u>**MOVE** was created.</u>

16) type **WORDS <cr>**

```
WORDS

4D3F BOOTING            4C81 CHECK-KEYBOARD     4C2A NEW-SYSTEM         4C11 FORGET
4B9C RECALL             4B83 AUTO-START:        4B37 REMEMBER           4ABC CHECK-SUM
4AA8 I-VARS-UP          4A94 I-VARS             4A83 S-VARS             4A72 U-VARS     4A64
CLD/WRM                 4A26 RECALL-SYS         49EC SAVE-SYS           49C9 CLEAR-TIB   49B7
I-SYS-UP                4926 I-SYS              4899 R-SYS              480B SYS        47EB
BOOT:                   47DD vecDEMO            47A3 DEMO               4709 .HISTORY
46D7 (.HIST)            46A9 HIST.LINE          4695 rNUM-MAX            4682 rNUM
4673 rHIST              4615 MEM-DUMP           45DB CAPTURE

<cr>
OK
```

Observe: **MOVE** *is no longer in whiskers dictionary.*

Lets try adding a word that uses other words already defined.

17) type the following:

Concept: Factor your code. This means that it is much more useful to create many re-usable words than a few long and complicated ones. Think in terms of extending the language rather than creating programs.

```
:  MOVE <cr>

    FORWARD <cr>
    30  PERIODS <cr>
    STOP <cr>
; <cr>
```

Note: There are 130 periods per second.

18) type the following:

```
:  NOISE <cr>

    50 2 WAIL <cr>
; <cr>
```

To check: *type* **NOISE.**

19) type the following:

```
:  TEST <cr>

                            MOVE <cr>
    NOISE <cr>
; <cr>
```

20) type **REMEMBER <cr>**

21) type **MOVE <cr>**

22) type **NOISE <cr>**

23) type **TEST <cr>**

Observe: Each word executes the way you programmed them to do.

24) type **WORDS <cr>** *then press the* **<cr>** *key after a few lines.*

```
WORDS

9033 TEST              9026 NOISE             9018 MOVE              4D3F BOOTING
4C81 CHECK-KEYBOARD    4C2A NEW-SYSTEM        4C11 FORGET            4B9C RECALL
4B83 AUTO-START:       4B37 REMEMBER          4ABC CHECK-SUM         4AA8 I-VARS-UP
4A94 I-VARS            4A83 S-VARS            4A72 U-VARS            4A64 CLD/WRM
4A26 RECALL-SYS        49EC SAVE-SYS          49C9 CLEAR-TIB         49B7 I-SYS-UP
4926 I-SYS             4899 R-SYS             480B SYS               47EB BOOT:
47DD vecDEMO           47A3 DEMO              4709 .HISTORY          46D7 (.HIST)
46A9 HIST.LINE         4695 rNUM-MAX          4682 rNUM              4673 rHIST
4615 MEM-DUMP          45DB CAPTURE    OK
<cr>
OK
```

Observe: Each word you created is listed.

25) type **FORGET MOVE <cr>**

26) type **WORDS <cr>**

```
WORDS

4D3F BOOTING           4C81 CHECK-KEYBOARD    4C2A NEW-SYSTEM        4C11 FORGET
4B9C RECALL            4B83 AUTO-START:       4B37 REMEMBER          4ABC CHECK-SUM
4AA8 I-VARS-UP         4A94 I-VARS            4A83 S-VARS            4A72 U-VARS
4A64 CLD/WRM           4A26 RECALL-SYS        49EC SAVE-SYS          49C9 CLEAR-TIB
49B7 I-SYS-UP          4926 I-SYS             4899 R-SYS             480B SYS
47EB BOOT:             47DD vecDEMO           47A3 DEMO

 OK
```

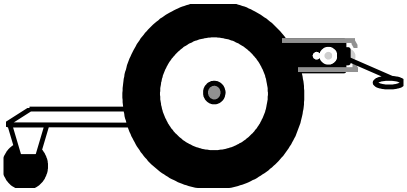
Observe: Each word you created after and including **MOVE** *has been removed.*

HINT: Whiskers will forget all the words that were defined after the word forgotten as well.

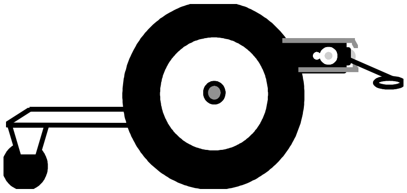
By creating new words, you can teach Whiskers^tm new behaviors. Try creating your own words that will allow Whiskers^tm to do some interesting things. The main thing to remember is to create many simple words rather than one or more long ones. Simple words will increase his vocabulary with more useful words that you can later use.

Problem Solving Exercise 2

Create a new word called **TEST** *that tells the robot to go forward for 5 seconds and backup for three secs then stop.*



Step 1



Step 2

Remember:

number **SECS**	*is used to delay execution between words based on seconds.*
FORWARD	*makes the robot move forward*
BACKUP	*makes the robot backup*
STOP	*makes the robot stop*

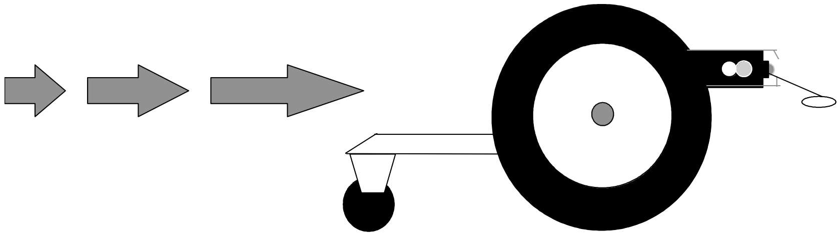
Use the format:

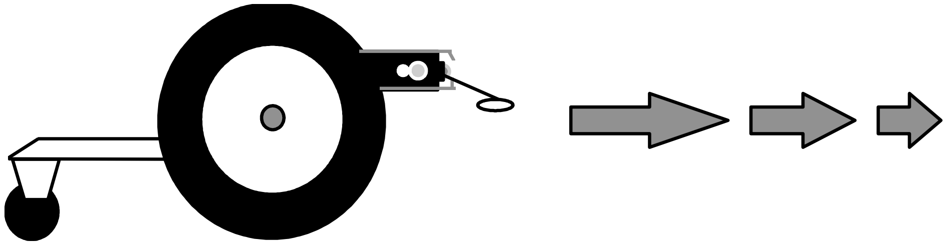
<u>*note space between words*</u>

```
: TEST <cr>

    word  number word
    word  number word
; <cr>
```

Discovery Task#III

Acceleration and Deceleration





Objective:

So far we have seen Whiskers^{tm} move forward or backward at a constant speed. The following words will allow Whiskers^{tm} to slowly start his motion or come to a smooth stop.

Remember:

<cr> *means pressing the Enter key or Return key on the keyboard after typing the command.*

Type commands exactly as shown, noting upper case and lower case letters.

The Words you will explore

for reference only, turn to the next page to begin the exercise

rate *speed* **RAMP-UP** This word will ramp the motor speed up to the desired speed . *rate* is how fast the robot will increase it's speed. The range must be from 1 to 100. *speed* is the final speed you want the robot to be traveling. The range is from 1 to 100.

rate **RAMP-DOWN** This word will decrease the current speed at the rate desired until the robot stops completely. *rate* is how fast the robot will decrease speed. The range is from 1 to 100.

FORWARD Command Whiskers^{tm} to move forward continuously.

BACKUP Command Whiskers^{tm} to move backwards continuously.

STOP Command Whiskers^{tm} to stop.

LEFT Choose the left side of the robot for following command.

RIGHT Choose the right side of the robot for following command.

speed **LEFT SPEED** These words will change the speed of either the left or right

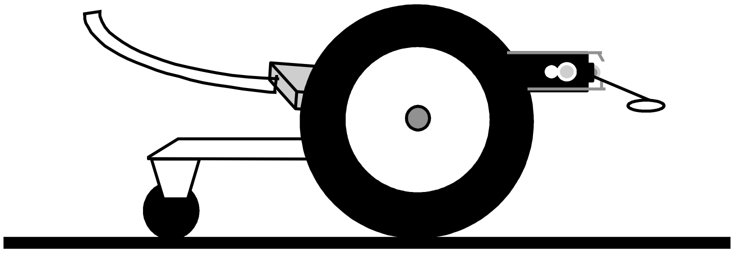
speed **RIGHT SPEED** wheel. The range for *speed* is from 1 to 100.

The words that allow Whiskers to accelerate to a speed and de-accelerate to stop are: **RAMP-UP** *and* **RAMP-DOWN**. *Lets start with* **RAMP-UP**. *The* **RAMP-UP** *command is used to bring Whiskers^{tm} up to a specific speed smoothly.* **RAMP-UP** *has two variables:*

X Y RAMP-UP
or
rate speed **RAMP-UP**

where X is rate at which Whiskers^{tm} will build his speed, and Y is the maximum speed. These are based on numbers from 1 to 100 with 100 being the maximum.

Place Whiskers on the floor with his communication cable still attached.



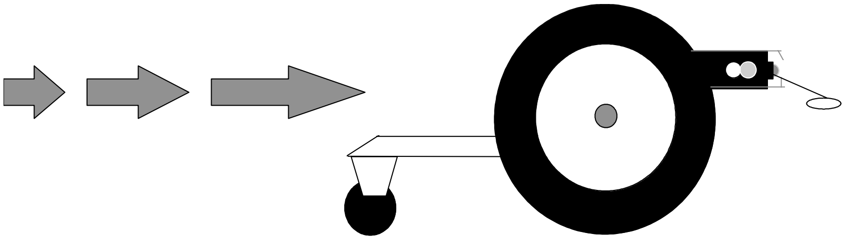
Note: turn avoidance on...

1) *type* **DEFAULT-INSTINCTS <cr>**

2) *type* **0 LEFT SPEED <cr>**

3) *type* **0 RIGHT SPEED <cr>**

4) *type* **FORWARD 2 100 RAMP-UP <cr>**



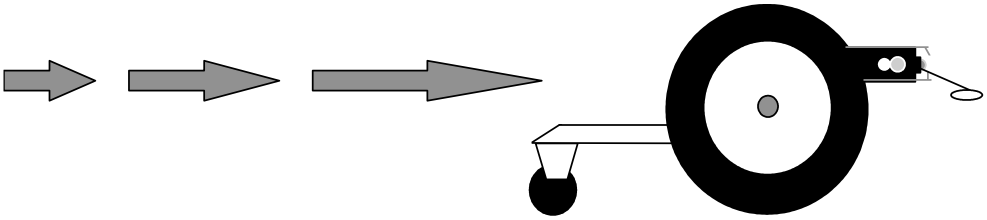
5) *type* **STOP <cr>**

Observe: the how smoothly Whiskers^{tm} builds up to the maximum speed of 100.

6) *type* **0 LEFT SPEED <cr>**

7) *type* **0 RIGHT SPEED <cr>**

8) *type* **FORWARD 10 100 RAMP-UP <cr>**



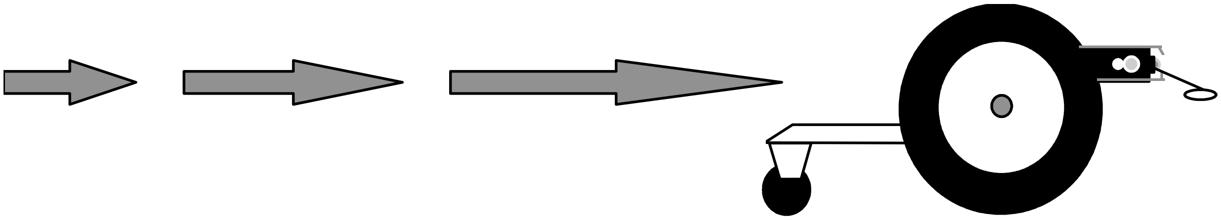
9) *type* **STOP <cr>**

Observe: the how smoothly Whiskers^{tm} builds up to the maximum speed of 100 but at a faster acceleration.

10) *type* **0 LEFT SPEED <cr>**

11) *type* **0 RIGHT SPEED <cr>**

12) *type* **FORWARD 100 10 RAMP-UP <cr>**



13) *type* **STOP <cr>**

Observe: the maximum speed is 50 and the acceleration is the same as before(10).

Different speeds and accelerations can be obtained by changing the numbers used.

Now lets look at the **RAMP-DOWN** *command. The* **RAMP-DOWN** *command is used to bring Whiskers*^{tm} *to a smooth stop.* **The RAMP-DOWN** *command has only one variable.*

X RAMP-DOWN

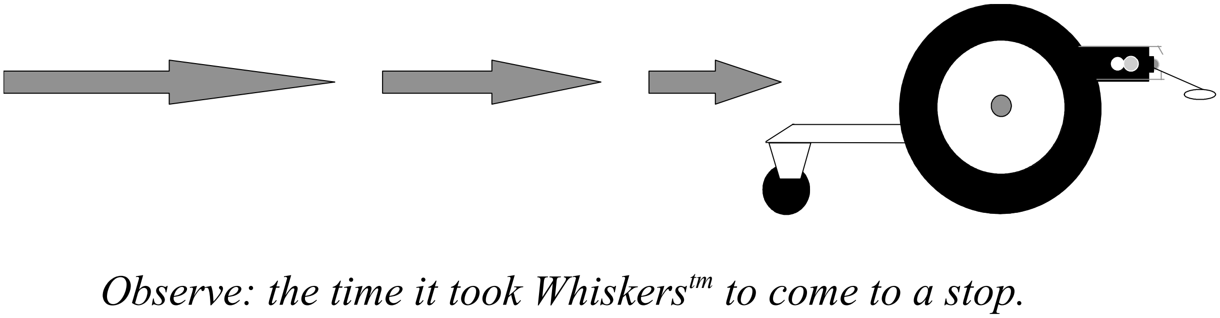
where X is the rate at which Whiskers^{TM} *will come to a stop. This is deceleration. There is no need to have the second perameter in this command because the robot knows its current speed and that it will come to a stop.*

14) *type* **100 LEFT SPEED <cr>**

15) *type* **100 RIGHT SPEED <cr>**

16) *type* **FORWARD <cr>**

17) *type* **2 RAMP-DOWN <cr>**



Observe: the time it took Whiskers^{tm} *to come to a stop.*

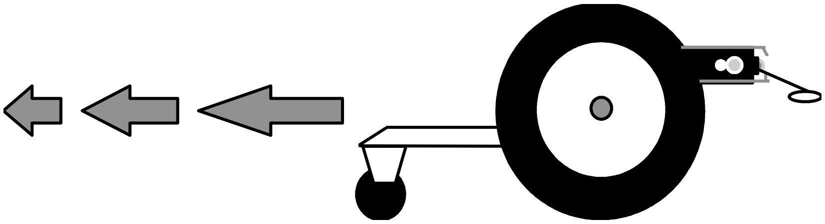
18) *type* **100 LEFT SPEED <cr>**

Note: Reset speeds to 100...

19) *type* **100 RIGHT SPEED <cr>**

20) *type* **BACKUP <cr>**

21) *type* **100 RAMP-DOWN <cr>**



Observe: the shorter time it took Whiskers^tm to come to a stop.

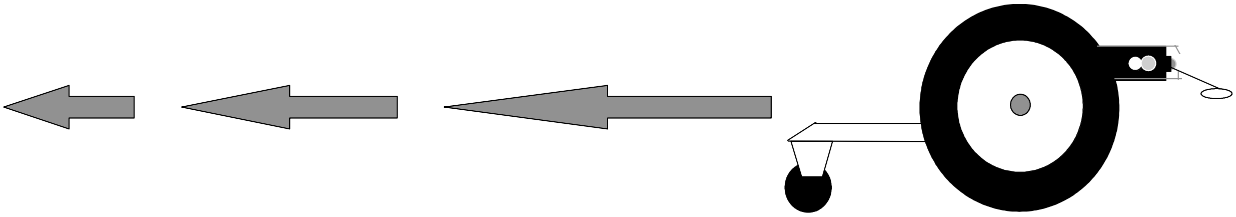
22) *type* **100 LEFT SPEED <cr>**

Note: Reset speeds to 100...

23) *type* **100 RIGHT SPEED <cr>**

24) *type* **BACKUP <cr>**

25) *type* **2 RAMP-DOWN <cr>**



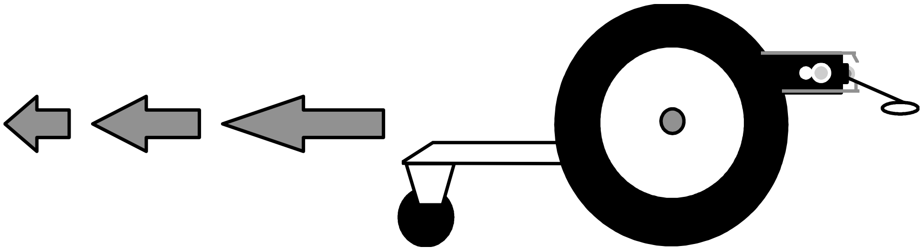
Observe: the time it took Whiskers^tm to come to a stop.

26) *type* **100 LEFT SPEED <cr>**

27) *type* **100 RIGHT SPEED <cr>**

28) *type* **FORWARD <cr>**

29) *type* **10 RAMP-DOWN <cr>**

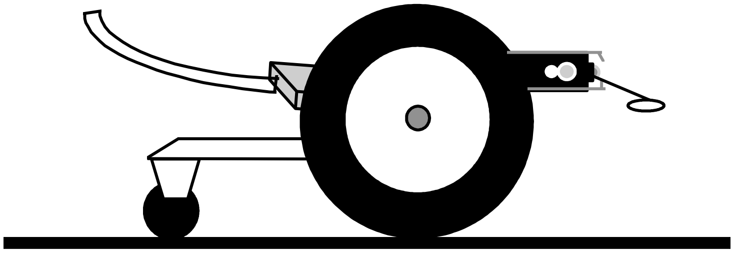


Observe: the shorter time it took Whiskers^{tm} to come to a stop.

Note: you must set the new desired speeds and direction after you use a **RAMP-DOWN** command.

Problem Solving Exercise 3

The **RAMP-UP** *and* **RAMP-DOWN** *words can be used with any motor direction word. Try creating new words experimenting with the words you have learned so far.*



Examples:

```
: TEST1 <cr>

  FORWARD <cr>
  2 65 RAMP-UP <cr>


  3 SECS <cr>
  100 LEFT SPEED <cr>
  100 RIGHT SPEED <cr>
  STOP ; <cr>
```

hint: *If you mistype any of the words inside of the colon definition, you must retype the entire sequence of words again. Do-not* FORGET *the old version.*

```
: TEST2 <cr>
  BACKUP <cr>
  20 95 RAMP-UP <cr>
  2 RAMP-DOWN <cr>
; <cr>
```

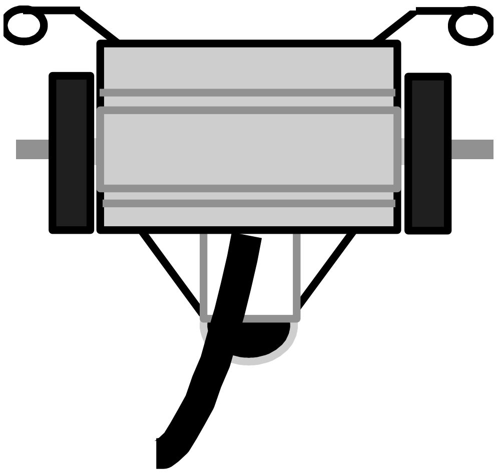
hint: *You can only* FORGET *those words you defined that were successfully completed. ie, you received an* OK *after the* ; *character.*

```
: TEST3 <cr>

 TEST1 <cr>
 TEST2 <cr>
 ; <cr>
```

Try experimenting with different combinations of words that you have already learned.

Discovery Task#IV

Whisker's^tm Compass and Calibrating for Pivots and Turns



Masking tape or line.

Objective and Overview:

We will learn how to command Whiskers^tm to pivot a specified number of degrees and to be able to calibrate the compass. The robot simulates a compass in software so commands can be issued based on the number of degrees. It is not a real compass and does not have anything to do with north, south, east, or west. It is from Whiskers^tm point of view. We must calibrate it when we want to use the **DEGREES** *command. The simulated compass is not an accurate. If you calibrate it to rotate 360 degrees plus or minus 3 degrees is fine.*

Remember:

360 degrees equals a full circle.

<cr> *means pressing the Enter key or Return key on the keyboard after typing the command.*

Type commands exactly as shown, noting upper case and lower case letters.

The Words you will explore

for reference only, turn to the next page to begin the exercise

number **DEGREES** — Pivot or turn the desired *number* of degrees. You must then specify a new motor direction, ie: **STOP**.

number **vMAX-PIVOTS NOW** — *number* is a positive number from 150 to 1000. Factory default is 245. It is the relative number of units to equal 360 degrees. If the robot doesn't quite pivot 360 degrees increase this number proportionally. If the robot pivots to far when commanded to pivot 360 degrees, decrease this number proportionally.

Affects the **DEGREES** command.

number **vMAX-TURNS NOW** — *number* is a positive number from 150 to 1000. Factorydefault is 470. It is the relative number of units to equal 360 degrees. If the robot doesn't quite turn 360 degrees increase this number proportionally. If the robot turns to far when commanded to turn 360 degrees, decrease this number proportionally.

Affects the **DEGREES** command.

PIVOT — Command Whiskers^{tm} to pivot about his center continuously.

TURN — Command Whiskers^{tm} to turn about his left or right wheel continuously.

STOP — Command Whiskers^{tm} to stop.

LEFT — Choose left side of the robot.

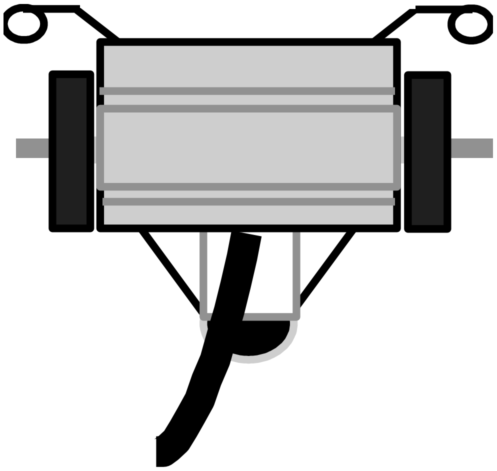
RIGHT — Choose right side of the robot.

Working with Whiskers

The calibration of Whisker's compass is affected by the following conditions:

- *Battery charge.*
- *Motor speed.*
- *Resetting to factory defaults using **Q** key on startup.*

1) Place the robot on the floor aligning it with a piece of masking tape as shown. Define these two new words which will help you complete this task.



Note: Whiskers has several words to control his light sensor range/senitivity:

TRIGGER-FACTOR sets Whiskers hardware light sensors.

SUM-FACTOR sets Whiskers virtual light sensors (sum sensors)

CALIBRATE causes the changes you made with TRIGGER-FACTOR and SUM-FACTOR to take effect. It also shows you his new trigger levels for each sensor

2) type the following (define words)

```
:  BLIND  <cr>
   250 TRIGGER-FACTOR  <cr>
   250 SUM-FACTOR  <cr>
   CALIBRATE  <cr>
;  <cr>

:  AVOID  <cr>
   35 TRIGGER-FACTOR  <cr>
   50 SUM-FACTOR  <cr>
   CALIBRATE  <cr>
 ; <cr>
```

turn collision avoidance off

3) type **BLIND <cr>**

Adjusting Pivoting

4) type **LEFT PIVOT 360 DEGREES STOP**

do not press the enter key

Hint: Define these new words called **L** and **R** to make this testing easier..

```
: L

   LEFT  PIVOT  360  DEGREES
    STOP  ;
```

type **L** <cr> *to execute this phase*

```
: R

   RIGHT  PIVOT  360  DEGREES
    STOP  ;
```

type **R** <cr> *to execute this phase*

REMEMBER

5) Place the robot on the floor, while holding the communication cable out of the robots way,

6) hit **<cr>**

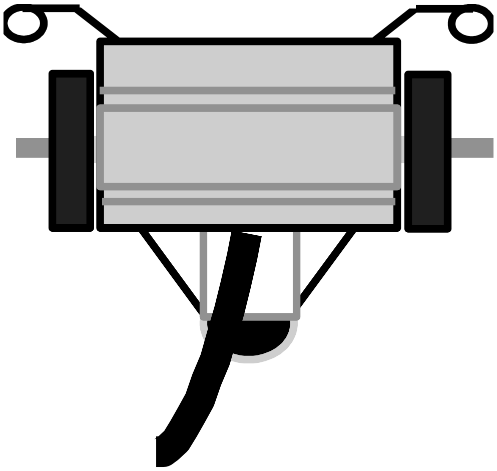
Observe: how close Whiskers^{tm} was able to PIVOT around the center and stop in alignment with the tape.

Notes: If he did not go far enough try increasing **vMAX_PIVOTS** *or if he went to far decrease* **vMAX_PIVOTS** *as follows:*

```
245  vMAX-PIVOTS  NOW        ( factory default

220  vMAX-PIVOTS  NOW        ( robot will pivot 10 % less

270  vMAX-PIVOTS  NOW        (robot will pivot 10 % more
```

HINT: type **SENSORS <CR>** to see the current value of **vMAX-PIVOTS**.

7) Line up the robot with the tape again.



8) type **SENSORS <cr>**

Note the current value of **vMAX-PIVOTS**.

Increase this value to make the robot pivot farther, or decrease it so the robot pivots less when you issue a

LEFT PIVOT 360 DEGREES STOP

command sequence

9) *say the value of* **vMAX-PIVOTS** *is* **245** *and the robot <u>pivoted 10 percent less</u> than the desired number of degrees when you typed:*

LEFT PIVOT 360 DEGREES STOP

increase the value of **vMAX-PIVOTS** *by 10 percent (270).*

270 vMAX-PIVOTS NOW

9) *say the value of* **vMAX-PIVOTS** *is* **245** *and the robot pivoted* *<u>10 percent more</u> than the desired number of degrees when you typed:*

LEFT PIVOT 360 DEGREES STOP

decrease the value of **vMAX-PIVOTS** *by 10 percent or 220.*

220 vMAX-PIVOTS NOW

10) Continue performing this experiment until the robot can pivot approximately 360 degrees.

Adjusting Turns

do not press the enter key

11) type **LEFT TURN 360 DEGREES STOP**

Hint: Define these new words called **L** and **R** to make this testing easier..

```
: LT

   LEFT TURN 360 DEGREES STOP ;

        type LT <cr> to execute this phase

: RT

   RIGHT TURN 360 DEGREES STOP ;

        type RT <cr> to execute this phase
```

12) While holding the communication cable out of the robots way,

13) hit **<cr>**

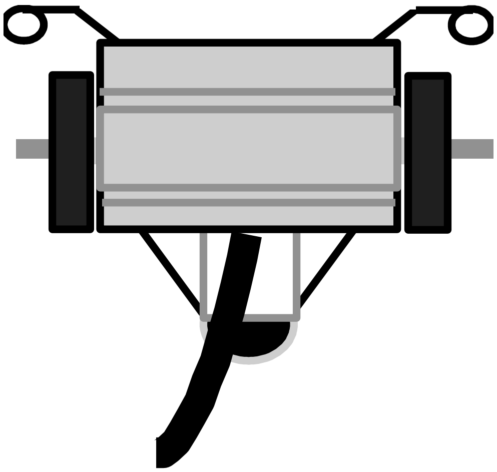
Observe: how close Whiskers^{tm} *was able to TURN around a wheel and stop in alignment with the tape.*

Notes: If he did not go far enough try *<u>increasing</u>* **vMAX-TURNS** *or if he went to far* *<u>decrease</u>* **vMAX-TURNS** *as follows:*

```
470  vMAX-TURNS  NOW        ( factory default

423  vMAX-TURNS  NOW        ( robot will turn 10 % less

523  vMAX-TURNS  NOW        (robot will turn 10 % more
```

HINT: type **SENSORS <CR>** to see the current value of **vMAX-TURNS**.

14) Line up the robot with the tape again.



15) type **SENSORS <cr>**

Note the current value of **vMAX-TURNS**.

Increase this value to make the robot pivot farther, or decrease it so the robot TURNS less when you issue a

LEFT TURN 360 DEGREES STOP

command sequence

16) say the value of **vMAX-TURNS** *is* **470** *and the robot <u>pivoted 10 percent less</u> than the desired number of degrees when you typed:*

LEFT TURN 360 DEGREES STOP

increase the value of **vMAX-TURNS** *by 10 percent (270).*

523 vMAX-TURNS NOW

17) say the value of **vMAX-TURNS** *is* **470** *and the robot pivoted <u>10 percent more</u> than the desired number of degrees when you typed:*

LEFT TURN 360 DEGREES STOP

decrease the value of **vMAX-TURNS** *by 10 percent or 220.*

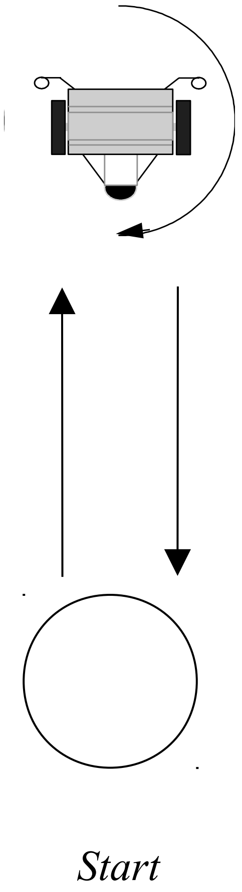
423 vMAX-TURNS NOW

18) Continue performing this experiment until the robot can pivot approximately 360 degrees.

Note: *The compass is called a virtual sensor in robotics. Just like the concept of Virtual Reality, it doesn't really exist in the physical world as hardware. Rather, it is simulated in the operating system totally by software code. This is why it must be calibrated and is effected by wheel drag, battery charge, and speed.*

Problem Solving Exercise 4

Create a new word called: **GET-COKE.** Have the robot go forward 5 feet, TURN 180 degrees, and come back to the start.

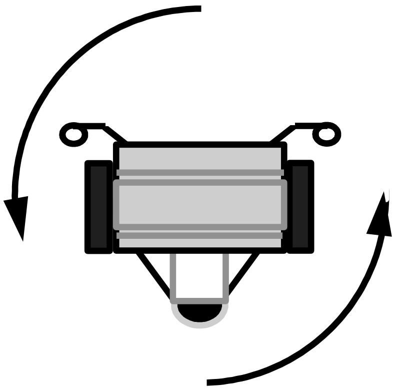


Hint: Create a new word called: **GO-FIVE-FEET** first.

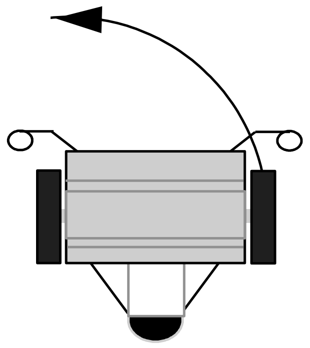
Note: If the robot does not return to the starting point, recalibrate the **DEGREES** *using the calibration procedure you just learned. Try to get as close as you can to the starting point. This is called* **dead reckoning** *in robotics.*

Discovery Task#V

Pivots and Turns



pivot



turn

Objective and Overview:

We will learn how to command the robot to perform pivots and turns. Pivoting the robot causes it to rotate about the center point between the wheels. Turning is centered about either the left or right wheel.

Whiskers is designed with two independent wheel motors, in the design. By having the wheels independenly controlled, Whiskers^{tm} can make a variety of turns, pivots and arcs. Performing radius turns are accomplished by choosing a different speeds for each wheel.

Remember:

Do Task IV again if the robot does not pivot fairly well.

<cr> *means pressing the Enter key or Return key on the keyboard after typing the command.*

Type commands exactly as shown, noting upper case and lower case letters.

The Words you will explore

for reference only, turn to the next page to begin the exercise

number **DEGREES** Pivot or turn the desired *number* of degrees. You must then specify a new motor direction, ie: **STOP**.

PIVOT Command Whiskers^{tm} to pivot about his center continuously.

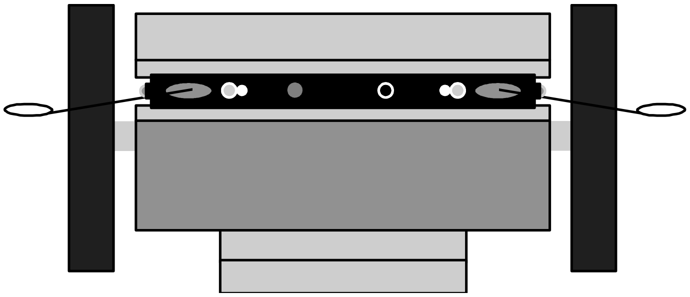
TURN Command Whiskers^{tm} to turn about one wheel continuously.

STOP Command Whiskers^{tm} to stop.

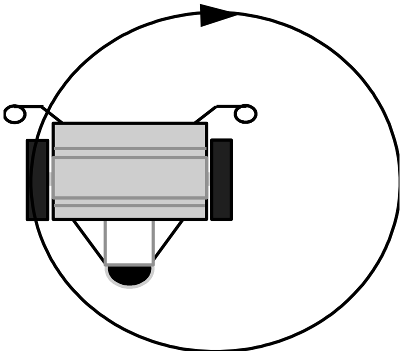
LEFT Choose left side of the robot.

RIGHT Choose right side of the robot.

1) Place the robot on books or other object to keep the wheels from contacting the ground. To do the following experiments you need to place Whiskers^{tm} in the interactive mode. Press the enter key several times after turning him on and seeing the copyright notice.



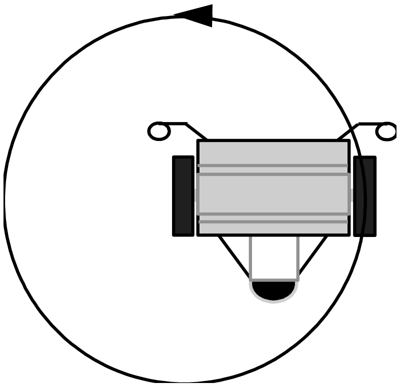
2) *type* **RIGHT TURN <cr>**



Observe: the left wheel is turning forward with the right wheel stopped.

3) *type* **STOP** *<cr>*

4) *type* **LEFT TURN <cr >**



Observe: the right wheel is turning forward with the left wheel is stopped.

5) *type* **STOP** *<cr>*

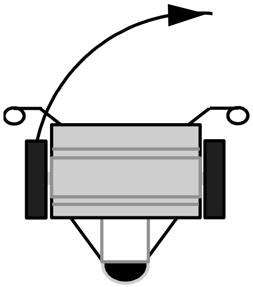
This shows that whiskers is actually pivoting on the stopped wheel. The **TURN** *command allows Whiskers^tm to pivot about the stopped wheel, thus making this wheel the pivot point or axis of the turn.*

Lets experiment with some different degrees.

Do not be concerned at this point if the robot does not rotate or pivot the exact number of degrees you specify. Go to Chapter IV if the robot **DEGREES** *command is too far off.*

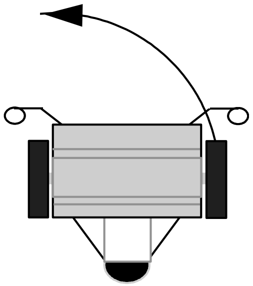
Next, we will command Whiskers^tm to turn X number of degrees and stop. So, if we wanted Whiskers^tm to make a 90 degree right turn we would use 90 degrees in the right turn command.

6) *type* **RIGHT TURN 90 DEGREES STOP <cr>**



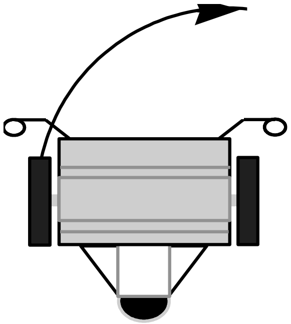
Observe: that whiskers turned approximately 90 degrees to his right and then stopped.

7) *type* **LEFT TURN 90 DEGREES STOP <cr>**



Observe: Whiskers[tm] turned approximately 90 degrees to his left and then stopped. Notice the degrees are approximate.

8) *type* **RIGHT TURN 90 DEGREES <cr>**

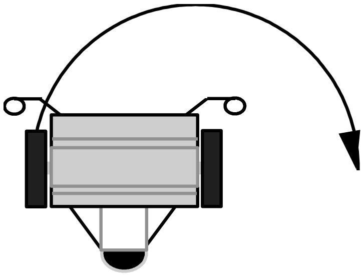


Observe: Whiskers[tm] does not stop turning. This is due to the STOP command not being used.

9) *type* **STOP** *<cr>*

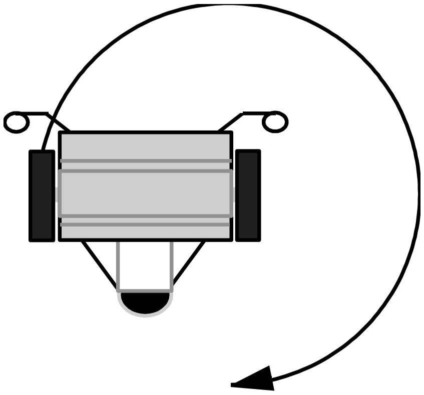
Observe: that whiskers has now stopped.

10) *type* **RIGHT TURN 180 DEGREES STOP <cr>**



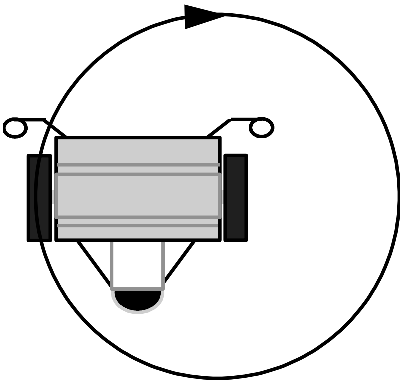
Observe: the robot rotates 180 degrees about the right wheel.

11) **type RIGHT TURN 270 DEGREES STOP <cr>**



Observe: the robot rotates 3/4 of the way about the right wheel.

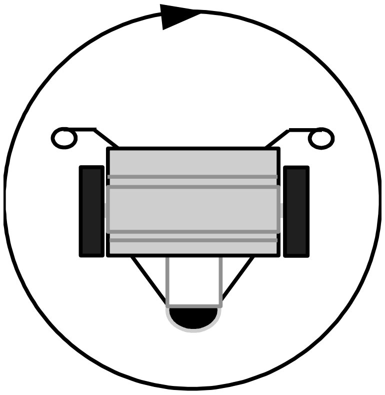
12) *type* **RIGHT TURN 360 DEGREES STOP <cr>**



Observe: the robot rotates 360 degrees about the right wheel.

Next lets do the same type of experiment using the PIVOT command in place of the TURN command.

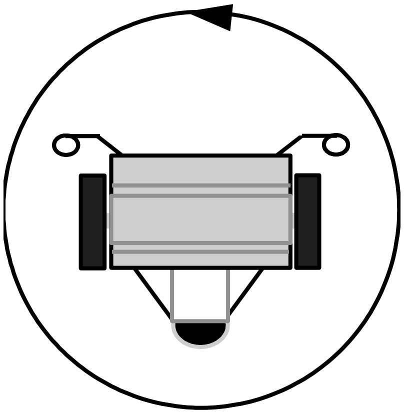
14) *type* **RIGHT PIVOT <cr>**



Observe: the left wheel is turning forward and the right wheel is turning backwards.

15) *type* **STOP <cr>**

16) *type* **LEFT PIVOT <cr>**

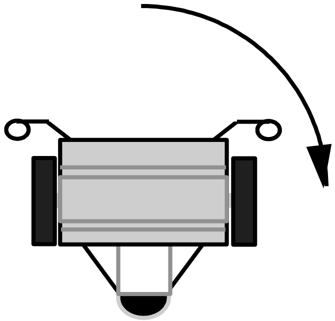


Observe: the right wheel is turning forward and the left wheel is turning backwards.

17) *type* **STOP <cr>**

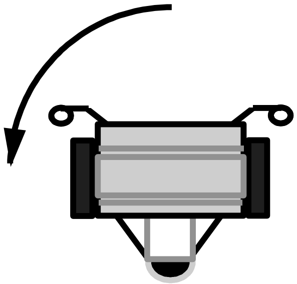
The **PIVOT** *command turns both wheels, each of which turn in an opposite direction. This allows Whiskers^{tm} a central axis point which is based midway between the center of the two wheels.*

18) *type* **RIGHT PIVOT 90 DEGREES STOP <cr>**



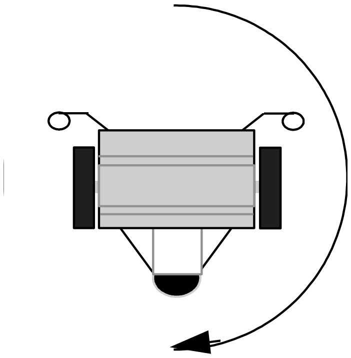
Observe: both wheels turned to approximate a pivot of 90 degrees right.

19) *type* **LEFT PIVOT 90 DEGREES STOP <cr>**



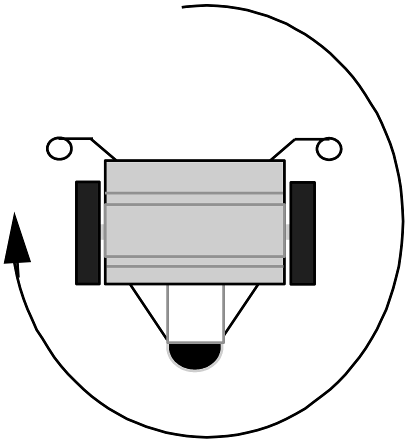
Observe: both wheels turned to approximate a pivot of 90 degrees left.

20) *type* **RIGHT PIVOT 180 DEGREES STOP <cr>**



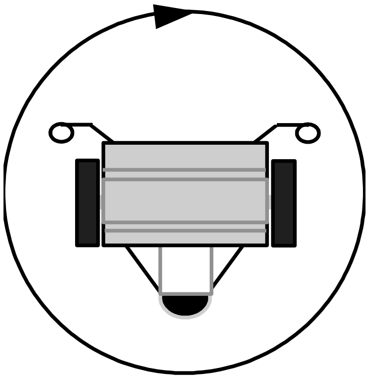
Observe: Whiskers[tm] *pivots 180 degrees.*

21) **type RIGHT PIVOT 270 DEGREES STOP <cr>**



Observe: Whiskers^{tm} *pivots 270 degrees.*

22) *type* **RIGHT PIVOT 360 DEGREES STOP <cr>**



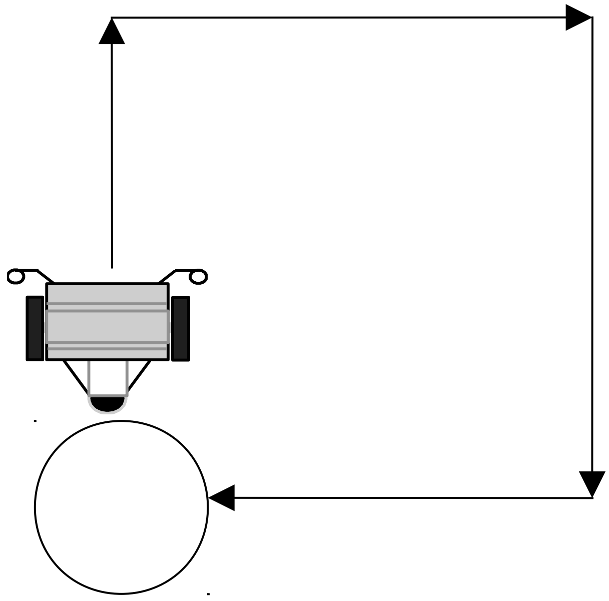
Observe: Whiskers^{tm} *pivots 360 degrees.*

Note the difference between the **TURN** *command and the* **PIVOT** *words.*

TURN causes the robot to rotate about the left or right wheel whereas **PIVOT** causes the robot to rotate about it's center.

Problem Solving Exercise 5

Create a new word called: **SQUARE.** Command the robot to make a square on the floor using the new words you have learned.

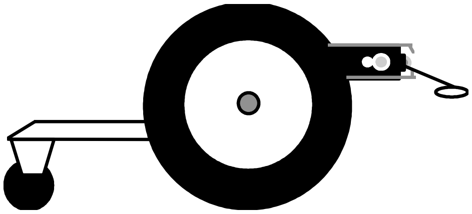


Start

HINT: define two words first: **LEG** and **TURN-AROUND** then define **SQUARE** using these words.

Discovery Task#VI

Velocity/Speed Control and Arcs



Objectives and Overview:

In this section you will perform experiments that will teach you the words which commands Whiskers^{tm} to move around. We will begin with the most basic moves (FORWARD, BACKWARD, STOP) and then learn some special words related to movement.

Remember:

<cr> *means pressing the Enter key or Return key on the keyboard after typing the command.*

Type commands exactly as shown, noting upper case and lower case letters.

LEFT and RIGHT refers to Whiskers^{tm} view as you were looking from the rear to the front.

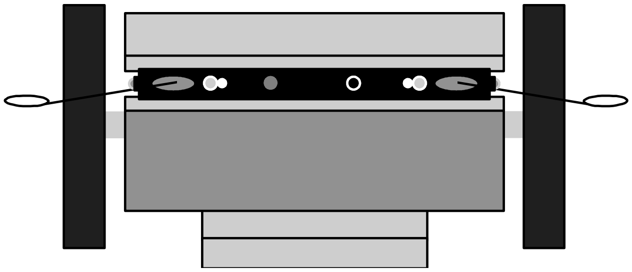
The Words you will explore

for reference only, turn to the next page to begin the exercise

FORWARD	Command Whiskers^{tm} to move forward continuously.
BACKUP	Command Whiskers^{tm} to move backwards continuously.
STOP	Command Whiskers^{tm} to stop.
LEFT	Choose left.
RIGHT	Choose right.
speed **RIGHT SPEED**	These words will change the or speed of either the left or right *speed* **LEFT SPEED** wheel. The range for *speed* is from 1 to 100.
SAVE-SPEEDS	Save the current speeds settings.
RESTORE-SPEEDS	Restore the speed settings saved by the previous **SAVE-SPEEDS**.

One of Whisker's^{tm} features as mentioned earlier are the two independent motors that drive the wheels. Since the wheels are independent from one another, you can set each wheel speed independently. This feature allows Whiskers^{tm} to make smooth arcing turns.

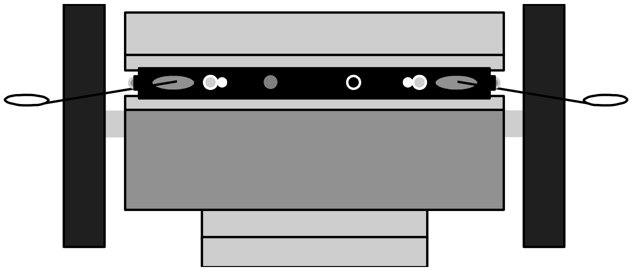
1) *Make sure Whiskers^{tm} is set in his interactive mode on a book so his wheels do not touch the ground.*



2) *type* **FORWARD <cr>**

type **100 LEFT SPEED <cr>**

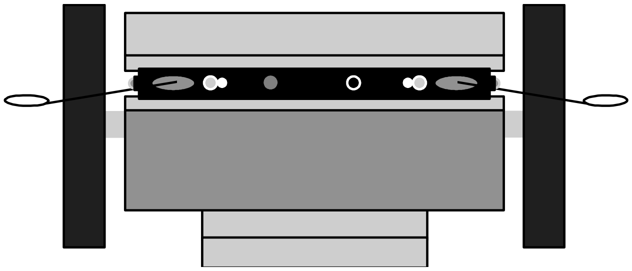
type **100 RIGHT SPEED <cr >**



full speed *full speed*

Observe: both wheels rotate in the forward direction and at the same speed.

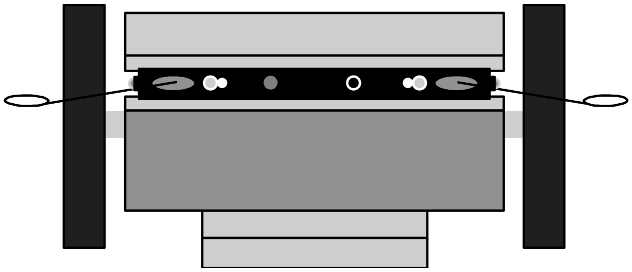
3) *type* **50 RIGHT SPEED <cr>**



1/2 speed *full speed*

Observe: the speed of the right tire slowed down to about half the speed of the left.

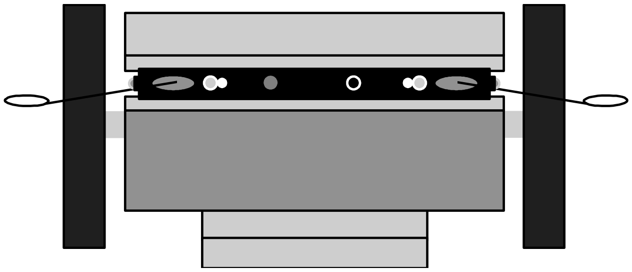
4) *type* **10 RIGHT SPEED <cr>**



1/10th speed *full speed*

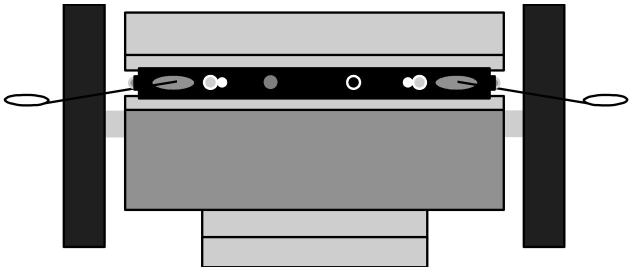
Observe: the slower speed of the right tire.

5) *type* **STOP <cr>**



stopped *stopped*

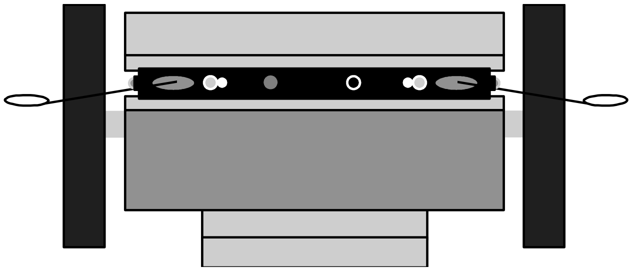
6) *type* **FORWARD <cr>**



1/10th speed *full speed*

Observe: the speed of the both wheels are as before.

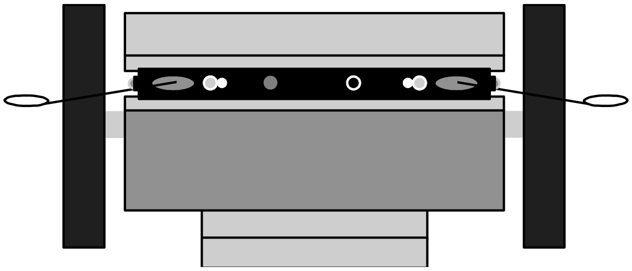
7) *type* **50 LEFT SPEED <cr>**



1/10th speed *1/2 speed*

Observe: the left wheel is turning at half speed and the right is turning at 1/10th speed.

8) *type* **10 LEFT SPEED** *<cr>*



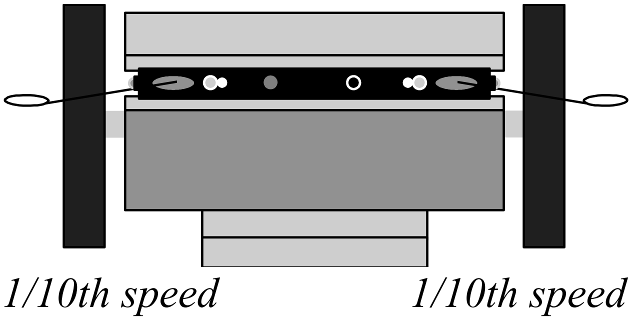
1/10th speed *1/10 speed*

Observe: the speed of both wheels are 1/10th speed.

9) *type* **STOP <cr>**

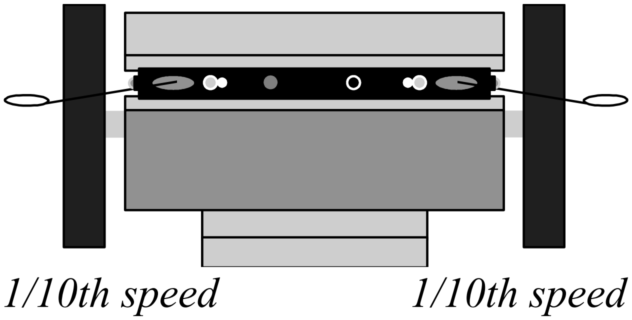
Lets try saving some speeds

10) *type* **FORWARD <cr>**



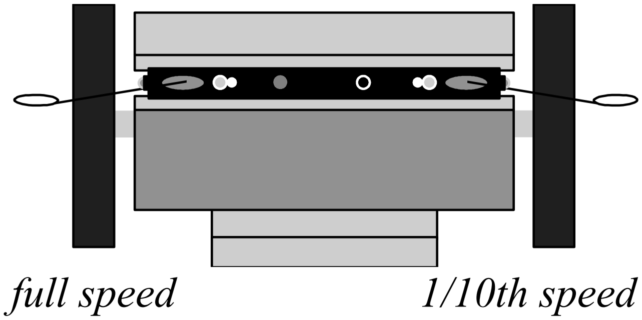
Observe: Both wheels rotate in the forward direction

11) *type* **SAVE-SPEEDS <cr>**



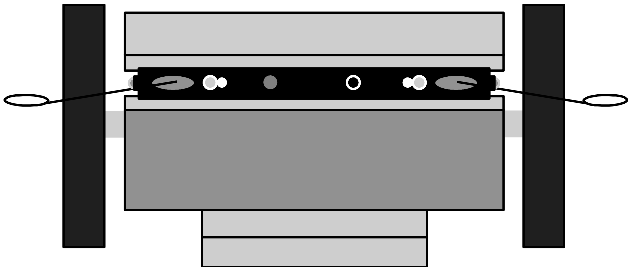
Observe: that nothing happens. This command stores the current motor speeds in memory.

12) *type* **100 RIGHT SPEED <cr>**



Observe: the right wheel speeds up

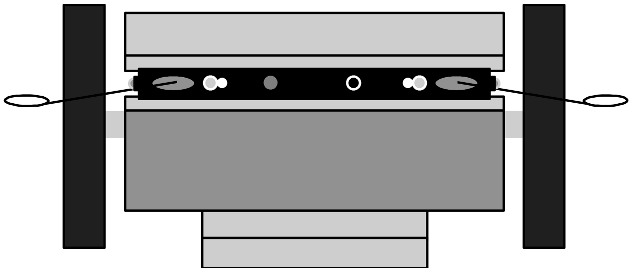
13) *type* **100 LEFT SPEED <cr>**



full speed *full speed*

Observe: the left wheel speeds up and both wheels are rotating full speed.

14) *type* **RESTORE-SPEEDS <cr>**



1/10th speed *1/10th speed*

Observe: the wheels slowed down. This is caused by our use of the **SAVE-SPEEDS** *word earlier and Whiskers^{tm} remembered the previous speeds.*

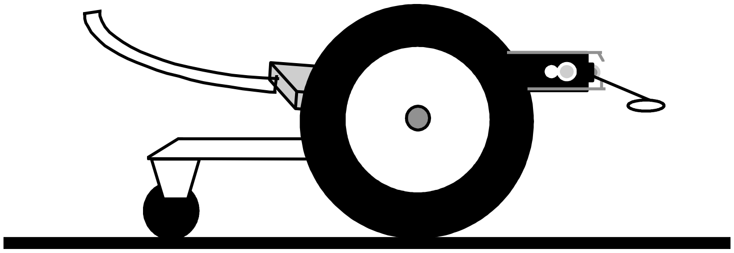
15) *type* **STOP <cr>**

By using the **LEFT SPEED** *and* **RIGHT SPEED** *words you can program both of Whiskers^{tm} wheels turn at different speeds. By doing this you can have Whiskers^{tm} make wide arc type turns.*

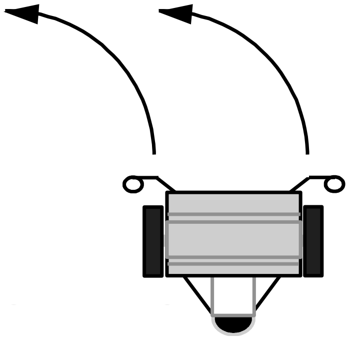
16) *type* **10 LEFT SPEED <cr>**

17) *type* **50 RIGHT SPEED <cr>**

Place whiskers on the floor with his communication cable still attached.



18) *type* **FORWARD <cr>**



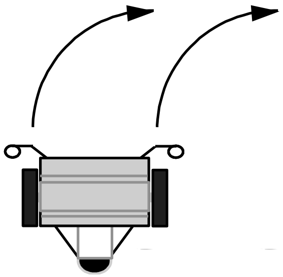
Observe: the robot arcs towards the left.

19) *type* **STOP <cr>**

20) type **50 LEFT SPEED <cr>**

21) *type* **20 RIGHT SPEED <cr>**

22) *type* **FORWARD <cr>**



Observe: Whiskers^{tm} makes an arc towards the right but at a tighter circle

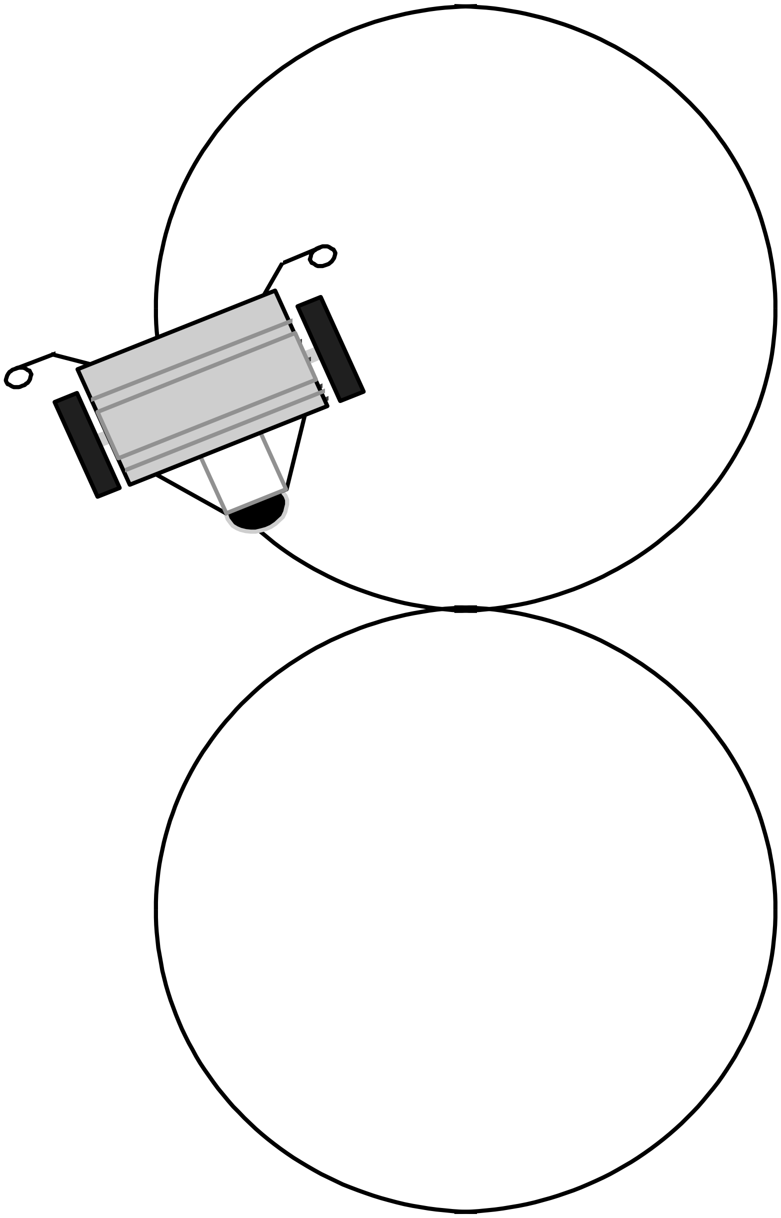
23) *type* **STOP <cr>**

By using different values of speeds for the left and right wheels you can have whiskers turn in a variety of different arcs.

Try using some different values and observe the results.

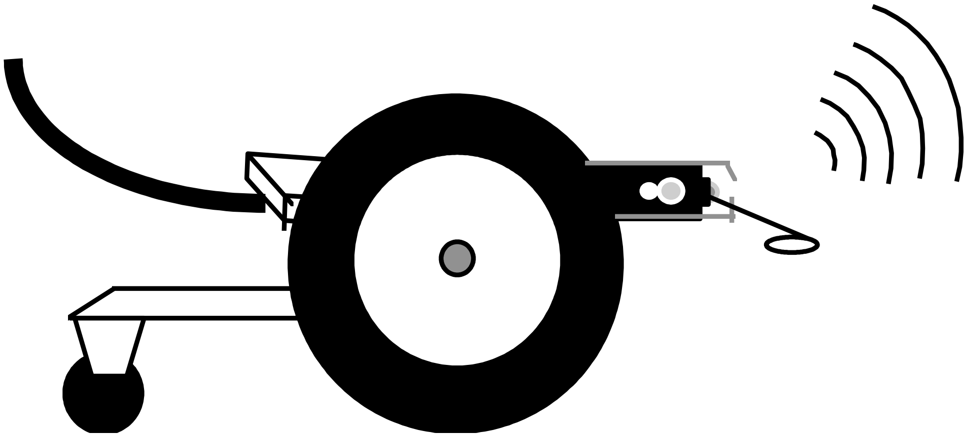
Problem Solving Exercise 6

Create a new word called: **FIGURE-EIGHT.** Have the robot make a figure eight on the floor.



Discovery Task#VII

Sound Effects



Objective and Overview:

In this section you will perform experiments that will teach you the sound effect words that Whiskers^{tm} knows. This robot call make sounds such as: laser, warble, bird call, etc.

Remember:

<cr> *means hitting the Enter key or Return key on the keyboard after typing the command.*

Type commands exactly as shown, note upper case and lower case letters

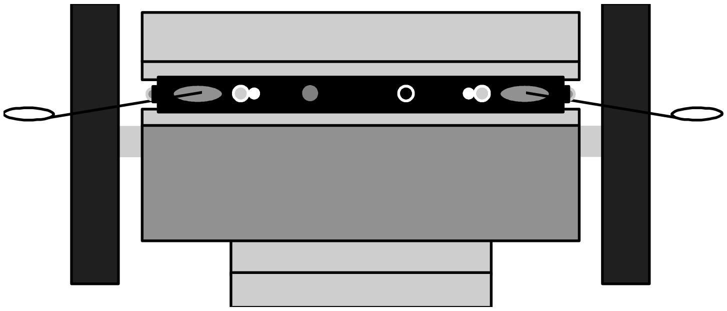
The Words you will learn

for reference only, turn to the next page to begin the exercise

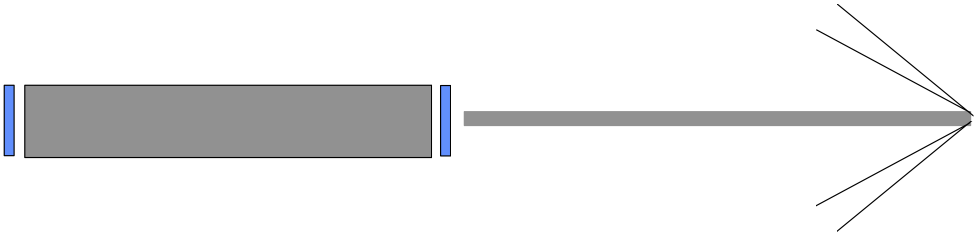
Whisker’s^{tm} has multiple sound effects words preprogrammed within his language. Each sound effect has its own set of parameters. These parameters include range, frequency and number of times.

range times **WAIL**	*range* is the tone and *times* is the number of cycles.
frequency times **WARBLE**	*frequency* is the tone and *times* is the number of cycles.
frequency **LASER**	*frequency* is the tone which also affects length of the sound effect.
frequency times **TONES**	*frequency* is the tone and *times* is the number of cycles.
frequency steps **UP-DOWN**	*frequency* is the tone and *steps* is the number of cycles.
frequency times **BIRD-CALL**	*frequency* is the tone and *times* is the number of cycles.

*1)	Place the robot on a stack of books.*



*2)	type* **100 LASER <cr>**



Observe Whiskers^{tm} makes a Laser type sound.

*3)	type* **500 LASER <cr>**

Observe Whiskers^{tm} makes a different Laser type sound.

*4)	type* **1000 LASER <cr>**

Observe Whiskers^{tm} makes another Laser type sound.

Note the differences in the three values used with the LASER sound effect. Try some other values and note what happens.

*5)	type* **20 2 WAIL <cr>**

Observe the wailing sound effect.

*6)	type* **50 2 WAIL <cr>**

Observe a different wailing sound effect.

7) *type* **100 2 WAIL <cr>**

Observe another wailing sound effect.

Note the difference between using 20, 50 and 100. This is referred to as the range of the sound effect.

8) *type* **30 2 WAIL <cr>**

Observe the sound Whiskers[tm] *makes.*

9) *type* **30 10 WAIL <cr>**

Observe the sound Whiskers[tm] *makes.*

Note the difference between using the 2 and the 10. This is the number of times that Whiskers[tm] *will wail.*

10) *type* **400 4 WARBLE <cr>**

Observe the sound Whiskers[tm] *makes*

11) *type* **800 4 WARBLE <cr>**

Observe the sound Whiskers[tm] *makes.*

Note the difference in the sounds. This was based on the frequency.

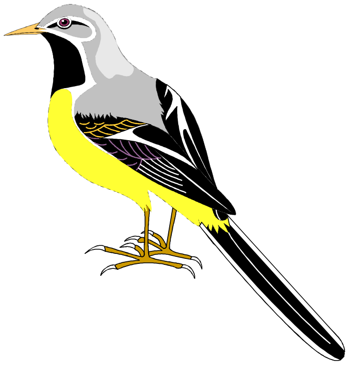
12) *type* **400 4 WARBLE <cr>**

Observe the sound Whiskers[tm] *makes.*

13) *type* **400 8 WARBLE <cr>**

Observe the sound Whiskers[tm] *makes.*

Note the difference in the sound. This is based on the times, or number of times the warble occurred.



14) *type* **400 4 BIRD-CALL <cr>**

Observe the sound Whiskers^tm makes.

15) *type* **800 4 BIRD-CALL <cr>**

Observe the sound Whiskers^tm makes.

Note the difference in the sounds. This is based on the frequency.

16) *type* **400 4 BIRD-CALL <cr>**

Observe the sound Whiskers^tm makes.

17) *type* **400 8 BIRD-CALL <cr>**

Observe the sound Whiskers^tm makes.

Note the difference in the sounds. This is based on the number of times the **BIRD-CALL** *occurred.*

18) *type* **1000 500 UP-DOWN <cr>**

Observe the sound Whiskers^{tm} makes.

19) *type* **1000 200 UP-DOWN <cr>**

Observe the sound Whiskers^{tm} makes.

Note the difference in the sounds. This was based on the frequency.

20) *type* **1000 500 UP-DOWN <cr>**

Observe the sound Whiskers^{tm} makes.

21) *type* **500 500 UP-DOWN <cr>**

Observe the sound Whiskers^{tm} makes.

Note the difference in the sounds. This was based on the number of steps required to perform the **UP-DOWN** *command.*

22) *type* **60 2 TONES <cr>**

Observe the sound Whiskers^{tm} makes.

23) *type* **100 2 TONES <cr>**

Observe the sound Whiskers^{tm} makes.

Note the difference in the sound. The first number is based on the frequency of the sound.

24) *type* **60 2 TONES <cr>**

Observe the sound Whiskers^{tm} makes.

25) *type* **60 6 TONES <cr>**

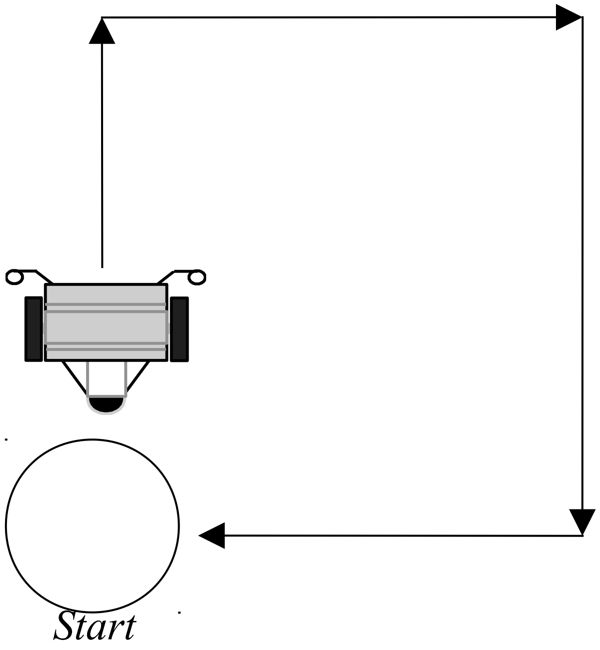
Observe the sound Whiskers^{tm} makes.

Note the difference in the tones. The second number was based on the number of times the sound occurred.

Problem Solving Exercise 7

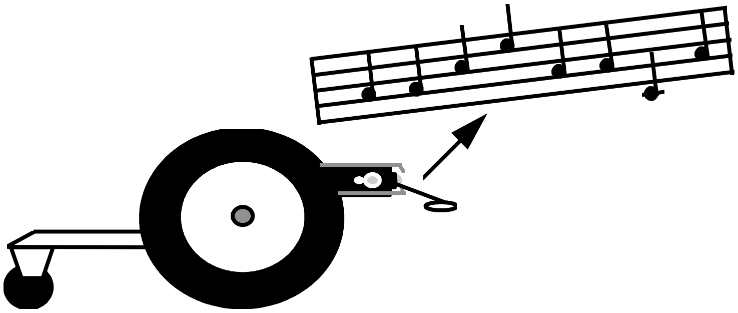
Create a new word called **SOUND-OFF.** *Have the robot make a square on the floor using different sound effect words to create the sides of the box. The sound effect words will delay your pivot commands allowing the robot to go in a straight line.*

Hint: You will use **RIGHT PIVOT 90 DEGREES FORWARD** *for the corners.*



Discovery Task#VIII

Music Words



Objective and Overview:

In this section you will learn how to make Whiskers^{tm} sing songs. Both humans and many animal species sing songs when they are happy or even when they want to communicate with others within their species.

We will start with the musical scale. To type a single note or tone you must not only tell the computer what the note is but also how long to play or hold that note. The length in which a note is played is based on an 8 count beat.

Remember:

<cr> *means hitting the Enter key or Return key on the keyboard after typing the command.*

Type commands exactly as shown, note upper case and lower case letters.

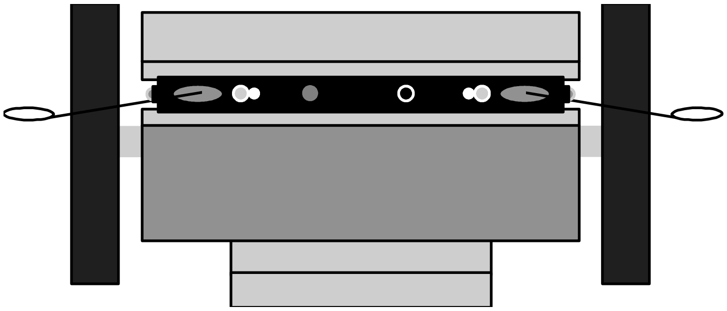
The Words you will learn

for reference only, turn to the next page to begin the exercise

Whisker’s^{tm} can play any song using his musical vocabulary of words. These are some of the notes available.

time **1A**	*time* is the length of the note and **1A** is the first octave A note.
time **2B**	*time* is the length of the note and 2B is the second octave B note.
time **3C**	*time* is the length of the note and **3C** is the third octave C note.
time **4D** fourth	*time* is the length of the note and 4D is the octave D note.
time **5E**	*time* is the length of the note and **5E** is the fifth octave E note.
time **5F**	*time* is the length of the note and **5F** is the fifth octave F note.
time **5G**	*time* is the length of the note and **5G** is the fifth octave G note.
ENABLE	turns the Instinct level and motor control words on.
DISABLE off.	turns the Instinct level and motor control words
MUSIC	Change to the music vocabulary words.
FORTH	Change to the Forth (main) vocabulary words.

1) Place the robot on a stack of books.



Notes as used in the following way:

x **NOTE**
or

length **NOTE**

x = is the duration or length of the note, (based on a factor of 8).

Note: the number before the note is the length of time that the note is played. The following chart shows this relationship:

Time	**Type of note**
1	one eighth
2	one quarter
3	three eighths
4	one half
5	five eighths
6	three quarter
7	seven eighths
8	whole

Each note is actually defined as a separate word. There are five octaves of notes defined in the language. Notice that there isn't a space between the octave number and note itself. The following chart shows the five octaves of notes for an A note:

Note	**Octave**
1A	first
2A	second
3A	third
4A	fourth
5A	fifth

examples:

if we want a whole note in the first octave we would type:

8 1A

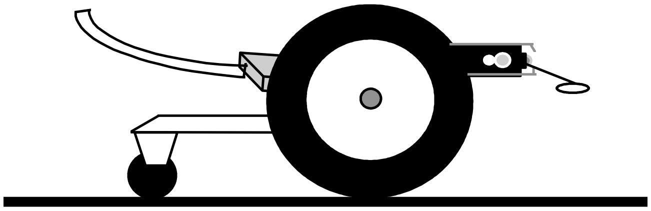
if we want a B half note in the second octave we would type:

4 2B

if we want a G eighth note in the fifth octave we would type:

1 5G

1) place Whiskers^{tm} on the table or floor.

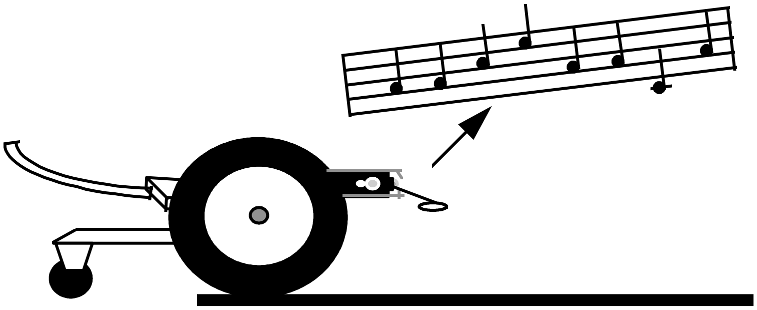


2) *type* **DISABLE <cr>**

3) *type* **MUSIC <cr>**

Notes: *A)* **DISABLE** *turns off the Instinct Level so the sounds will be clearer.* *<u>Motor words will not work</u> until* **ENABLE** *is used to turn the Instinct Level back on.*

B) **MUSIC** *changes into the music vocabulary. Use the* **FORTH** *command to go back to the main vocabulary for motor commands and sound effects.*



4) *type* **8 1A <cr>**

5) *type* **8 1B <cr>**

6) *type* **8 1C <cr>**

7) *type* **8 1D <cr>**

8) *type* **8 1E <cr>**

9) *type* **8 1F <cr>**

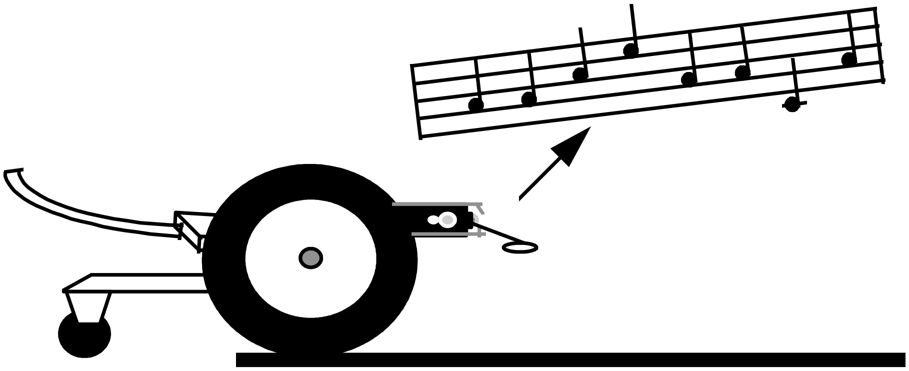
10) type **8 1G <cr>**

You had the robot sing the first octave musical scale one note at a time. Whiskers^{tm} is also able to play sharps as well...

11) *type* **8 1A <cr>**

12) *type* **8 1A# <cr>**

Let's experiment with the other octaves.



13) *type* **8 1A <cr>**

14) *type* **8 1G <cr>**

15) *type* **8 2A <cr>**

16) *type* **8 2G <cr>**

17) *type* **8 3A <cr>**

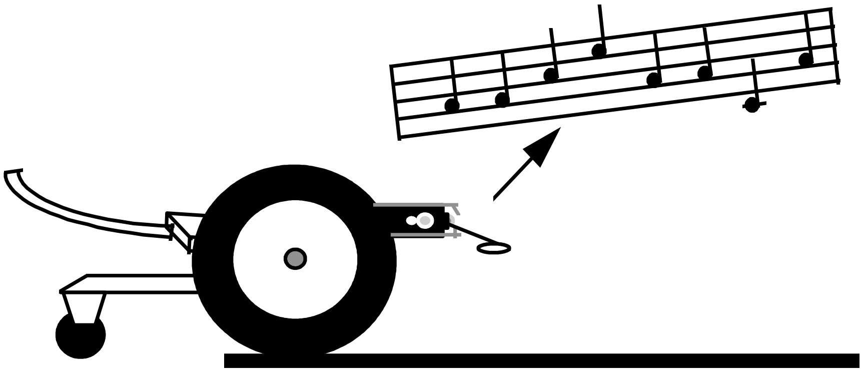
18) *type* **8 3G <cr>**

19) *type* **8 4A <cr>**

20) *type* **8 4G <cr>**

You have just entered the first and last note of the basic scale in four octaves. The Whisker's musical range contains 35 basic notes, from A first octave to G fifth octave.

Lets take a look at the length of the tones next.



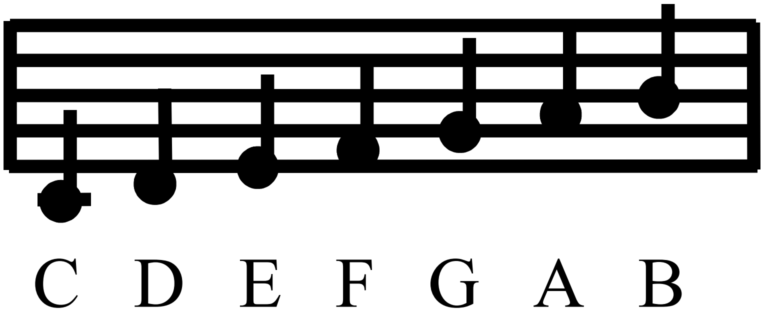
21) *type in the following:*

```
:  TONELENGTH <cr>

        MUSIC
        8  1A   <cr>
        7  1A   <cr>
        6  1A   <cr>
        5  1A   <cr>
        4  1A   <cr>
        3  1A   <cr>
        2  1A   <cr>
        1  1A   <cr>
; <cr>
```

22) *type in* **TONELENGTH <*cr*>**

You just had the robot play eight different duration's of the first octave "A" note. The note lengths were from one eighth to a whole note.

To program Whiskers^{tm} to sing a song is simple. Just get a song book from the library or book store, and translate the notes as follows:

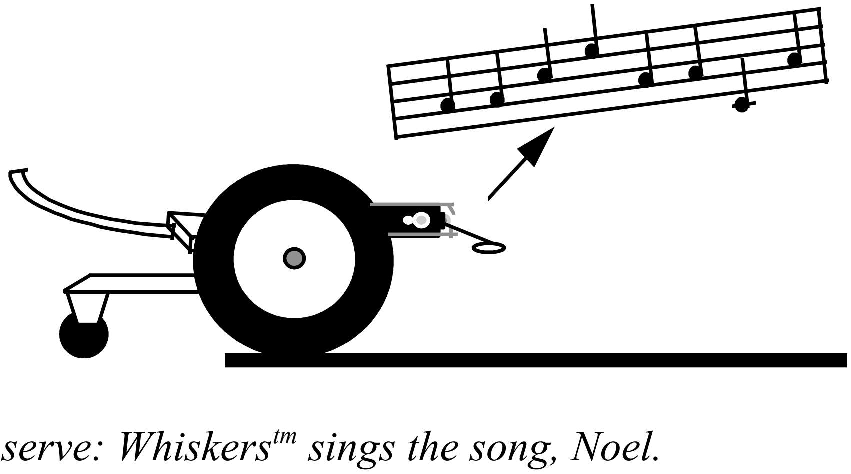


Here are a few examples of songs supplied on the sample disk which came with Whiskers^{tm}:

Important!

```
 : NOEL <cr>
          MUSIC 1  2E   1  2D   2  2C   1  2D   1  2E   1  2F   4  2G   1  3A   1  3B <cr>

          2  3C   2  3B   2  3A   4  2G   1  3A   1  3B   2  3C   2  3B   2  3A   <cr>
          2  2G   2  3A   2  3B   2  3C   2  2G   2  2F   4  2E   1  2E   1  2D   <cr>
          2  2C   1  2D   1  2E   1  2F   4  2G   1  3C   1  3B   4  3A   2  3A   <cr>
          6  2G   2  3C   2  3B   2  3A   2  2G   2  3A   2  3B   2  3C   2  2G   <cr>
          3  2F   4  2E   <cr>
;
```

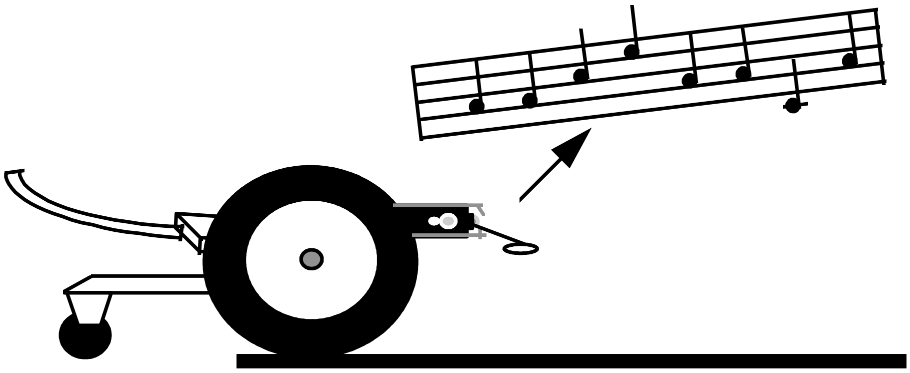
23) *type* **NOEL <cr>**



Observe: Whiskers^{tm} sings the song, Noel.

Problem Solving Exercise 8

Create a word that makes Whiskers^{tm} go forward and play three notes, then backup playing two different notes. Experiment with different octaves and times.

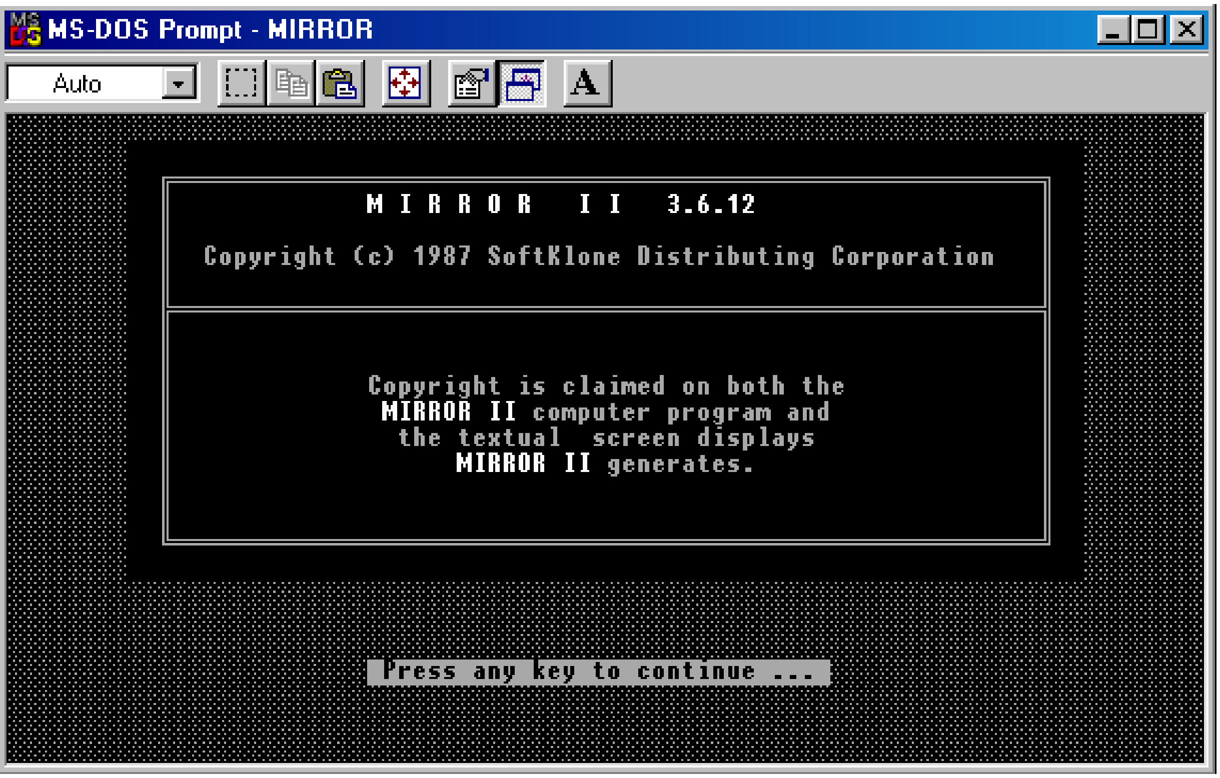


Remember: You must type **ENABLE** *for the motor control words to work.*

Note: Whiskers^{tm} can sing songs, move around, and avoid obstacles all at the same time!

Discovery Task#1X

The Mirror Program



MIRROR II 3.6.12

Copyright (c) 1987 SoftKlone Distributing Corporation

Copyright is claimed on both the
MIRROR II computer program and
the textual screen displays
MIRROR II generates.

Press any key to continue ...

Objective and Overview:

In this section you will learn how to use the built-in text editor and how to download files to the robot.

Remember:

<cr> *means pressing the Enter key or Return key on the keyboard after typing the command.*

Type commands exactly as shown, noting upper case and lower case letters.

The Commands you will explore

for reference only, turn to the next page to begin the exercise

The Mirror program is a powerful programming tool for both writing and testing programs.

Command?

This is the command line which is used to make changes in the Mirror program or to download files to the robot.

SE

Used to download files to the robot. Used as:

Command? SE FILE.FTH

ED

Edit a text file. Used as:

Command? ED FILE.FTH

> **<u>Note:</u>** if the file does not exist, the **ED** command will create a new one for you and give you a blank screen for creating your code in…

ER

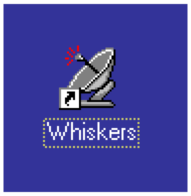
Erase a file. Used as:

Command? ER FILE.FTH

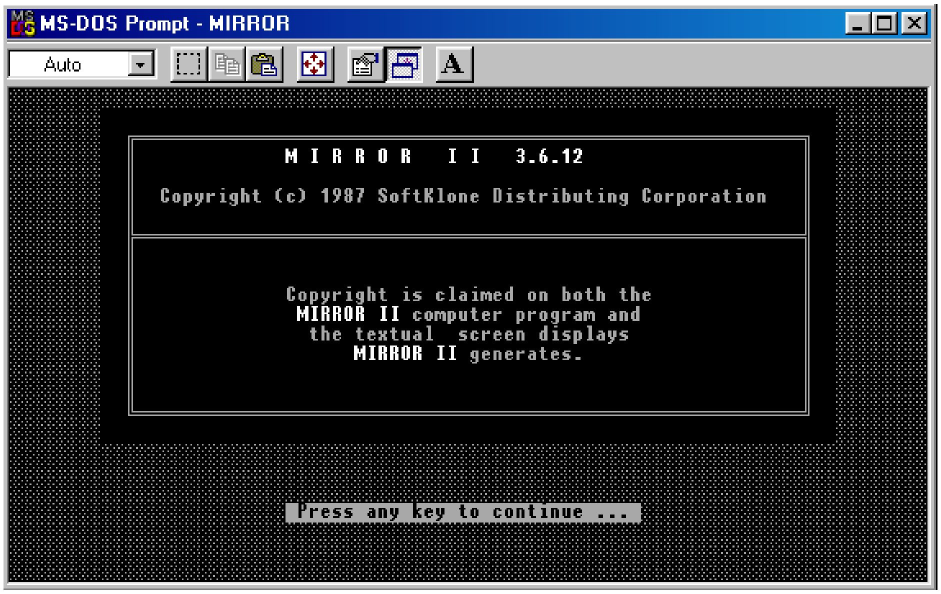
F3 key

Save the file you are editing to the disk.

1) Using the mouse, double click on the Whiskers Icon on your desktop…

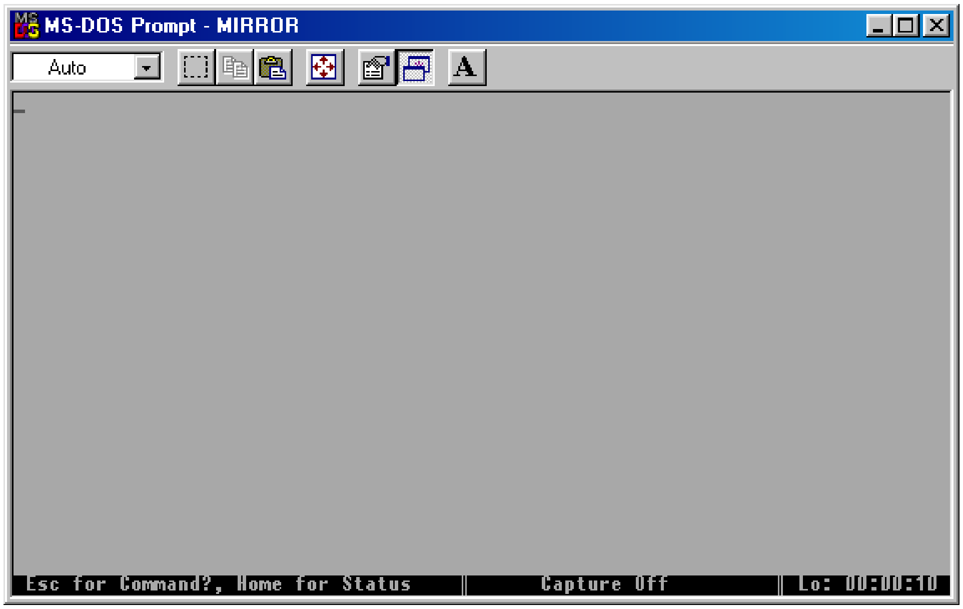


The following screen will open…



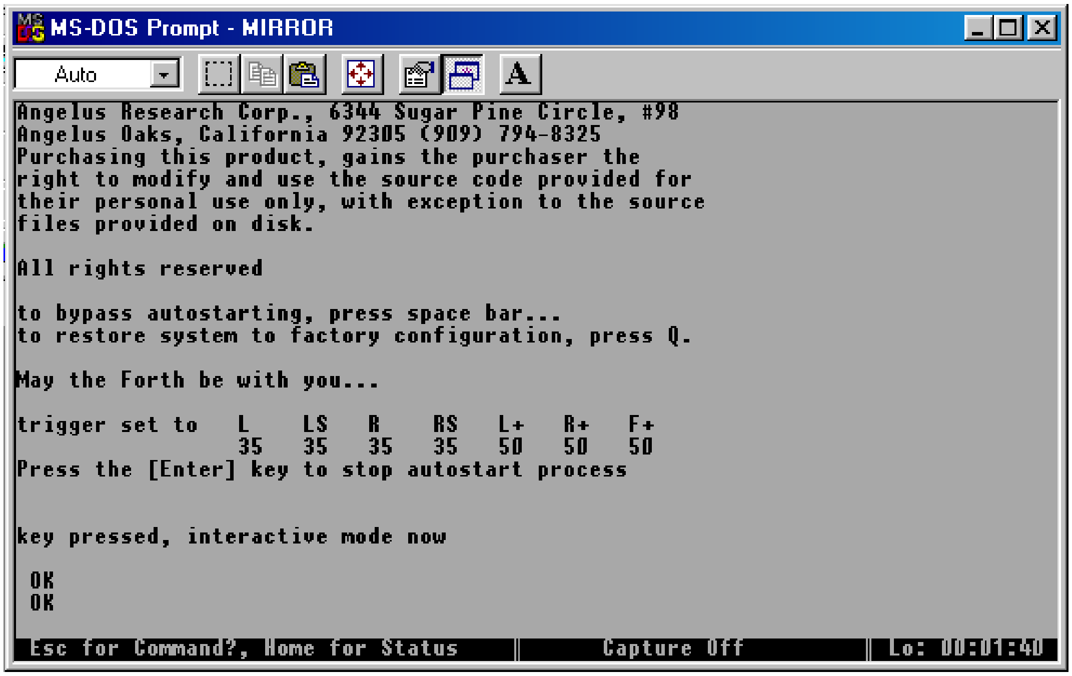
```
                    M I R R O R   I I   3.6.12

      Copyright (c) 1987 SoftKlone Distributing Corporation


                   Copyright is claimed on both the
                    MIRROR II computer program and
                     the textual  screen displays
                        MIRROR II generates.


                     Press any key to continue ...
```

2) When you see the screen above, press the Enter key on the keyboard then you will see the screen below….



```
_

 Esc for Command?, Home for Status ║          Capture Off          ║ Lo: 00:00:10
```

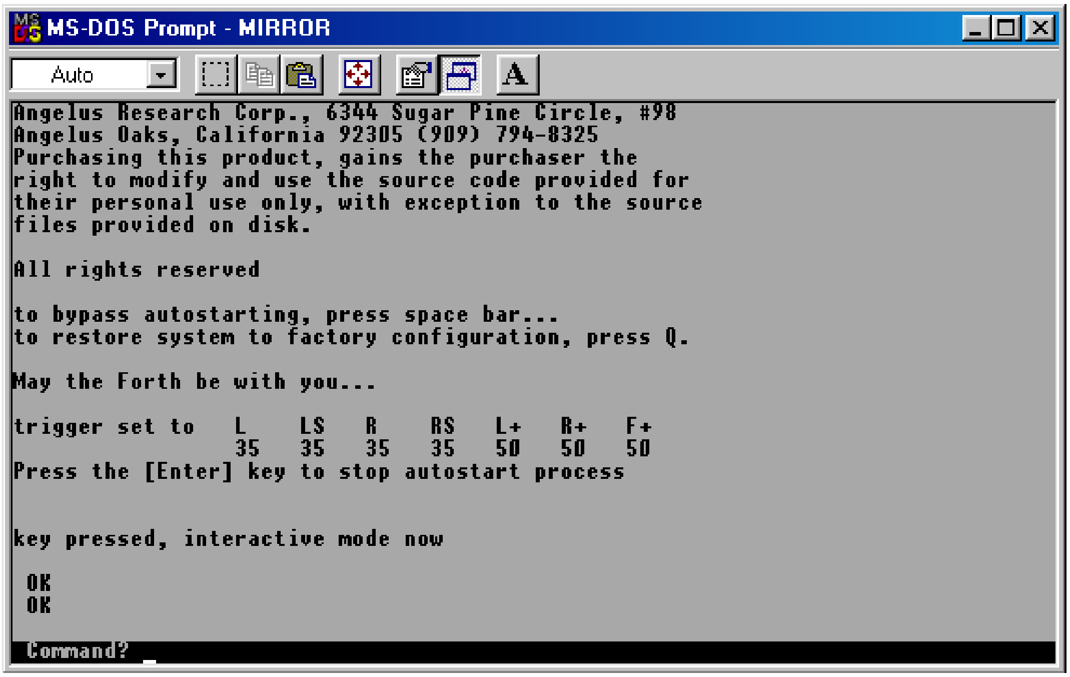
4) *Turn Whiskers the robot on, and press the Enter key several times until you OK's on the screen.*



```
Angelus Research Corp., 6344 Sugar Pine Circle, #98
Angelus Oaks, California 92305 (909) 794-8325
Purchasing this product, gains the purchaser the
right to modify and use the source code provided for
their personal use only, with exception to the source
files provided on disk.

All rights reserved

to bypass autostarting, press space bar...
to restore system to factory configuration, press Q.

May the Forth be with you...

trigger set to    L    LS    R    RS    L+    R+    F+
                  35   35    35   35    50    50    50
Press the [Enter] key to stop autostart process


key pressed, interactive mode now

 OK
 OK
 Esc for Command?, Home for Status  |       Capture Off        | Lo: 00:01:40
```

Observe: You are in the interactive mode. This means that you can type in commands like **FORWARD** *and the robot will respond as soon as you press the* **Enter** *key.*

5) *Press the* **Esc** *key on the keyboard*



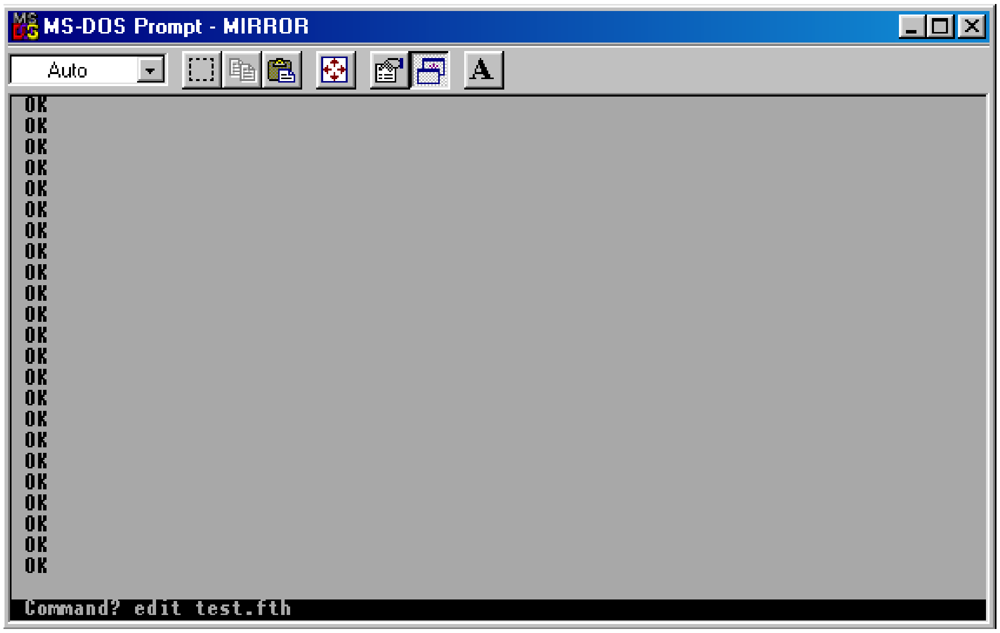
```
Angelus Research Corp., 6344 Sugar Pine Circle, #98
Angelus Oaks, California 92305 (909) 794-8325
Purchasing this product, gains the purchaser the
right to modify and use the source code provided for
their personal use only, with exception to the source
files provided on disk.

All rights reserved

to bypass autostarting, press space bar...
to restore system to factory configuration, press Q.

May the Forth be with you...

trigger set to    L    LS    R    RS    L+    R+    F+
                  35   35    35   35    50    50    50
Press the [Enter] key to stop autostart process


key pressed, interactive mode now

 OK
 OK
 Command? _
```

Observe: You are in the command mode. This means that you are commanding the Mirror Program to do different things like downloading a file to the robot, edit a file, or saving a file to the disk.

6) *Type* **er test.fth** *at the* **Command?** *line and then the* **Enter** *key to make sure that a file by that name does not exist. If a file by that name already exists, you will be asked* "Yes, No or Quit:" *type* **Y**

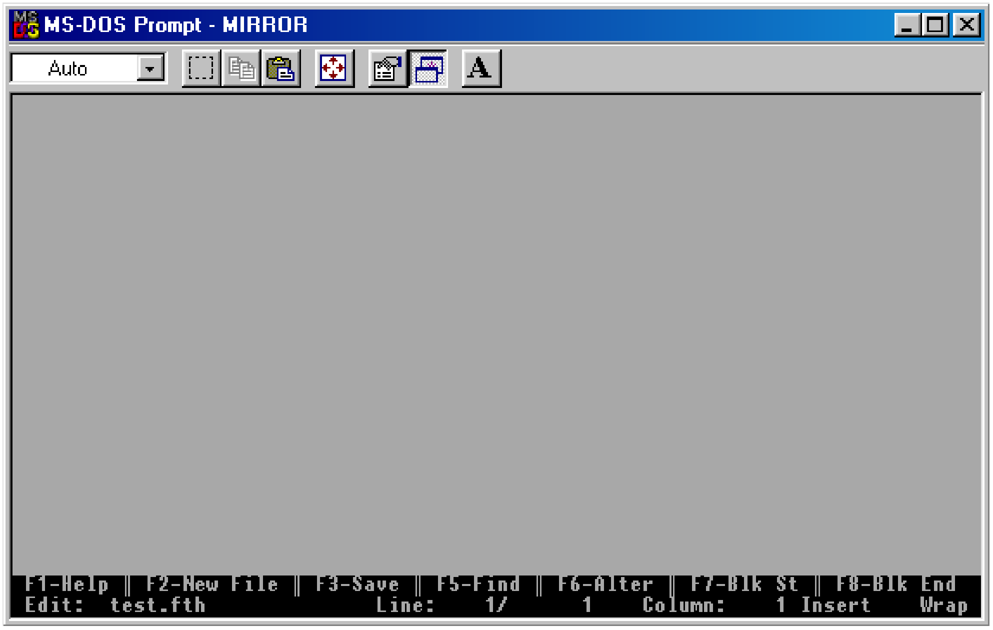
7) *Press the* **Esc** *key again to get back to the* **Command?** *line again.*

8) *type* **edit test.fth** *at the command line then* **Enter**



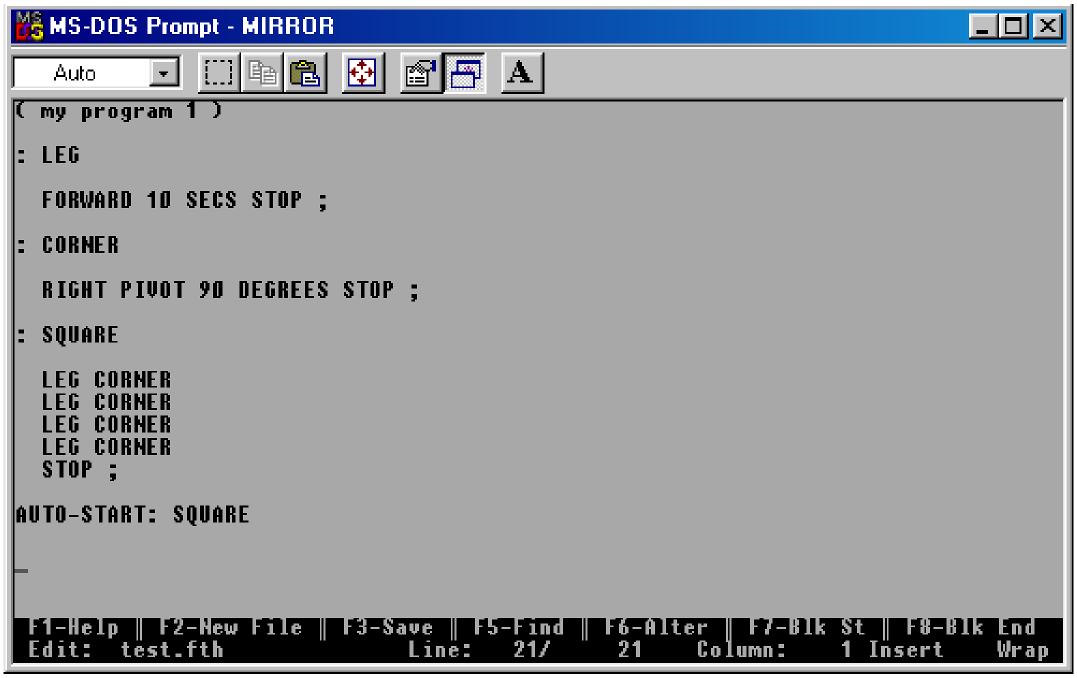
```
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
Command? edit test.fth
```

Observe: You are in the editing mode with the screen as shown below…



```
 F1-Help ‖ F2-New File ‖ F3-Save ‖ F5-Find ‖ F6-Alter ‖ F7-Blk St ‖ F8-Blk End
 Edit:  test.fth              Line:    1/     1    Column:    1 Insert    Wrap
```

9) *type the follow program* ***exactly*** *as shown below except where is says my program put your name instead…*

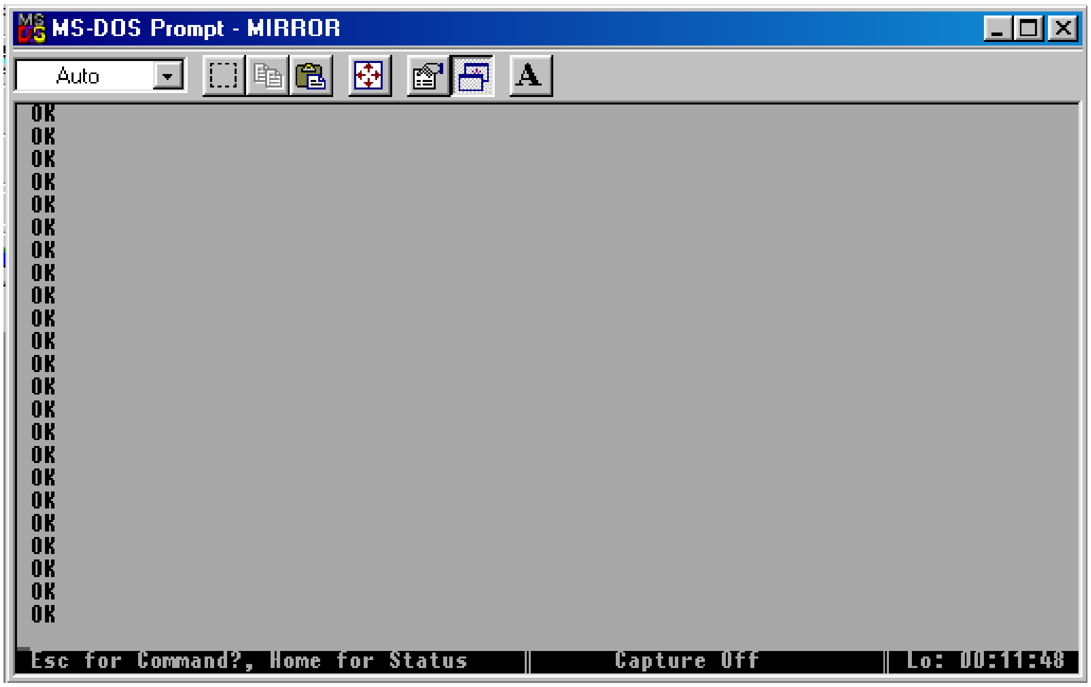


```
( my program 1 )

: LEG

  FORWARD 10 SECS STOP ;

: CORNER

  RIGHT PIVOT 90 DEGREES STOP ;

: SQUARE

  LEG CORNER
  LEG CORNER
  LEG CORNER
  LEG CORNER
  STOP ;

AUTO-START: SQUARE
```

```
 F1-Help ‖ F2-New File ‖ F3-Save ‖ F5-Find ‖ F6-Alter ‖ F7-Blk St ‖ F8-Blk End
 Edit:  test.fth                Line:   21/     21    Column:    1 Insert    Wrap
```

10) *Press the* **F3** *key to save this file to the disk.*

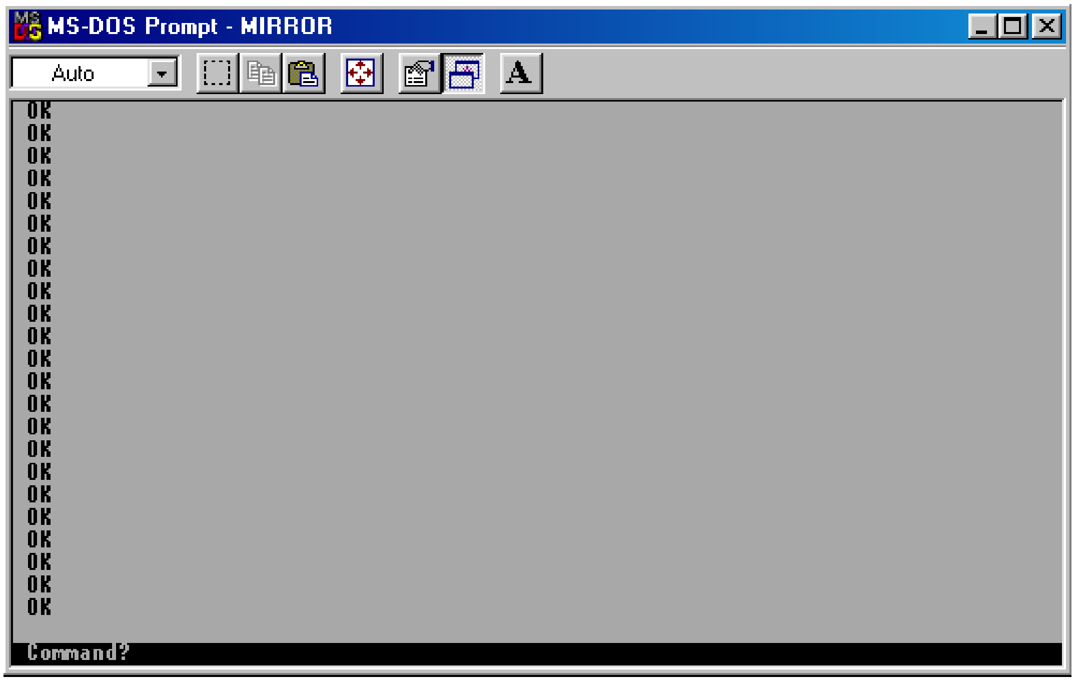
11) *You are now back in the interactive mode, and you will see the screen below…*



```
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
Esc for Command?, Home for Status  ║       Capture Off       ║ Lo: 00:11:48
```

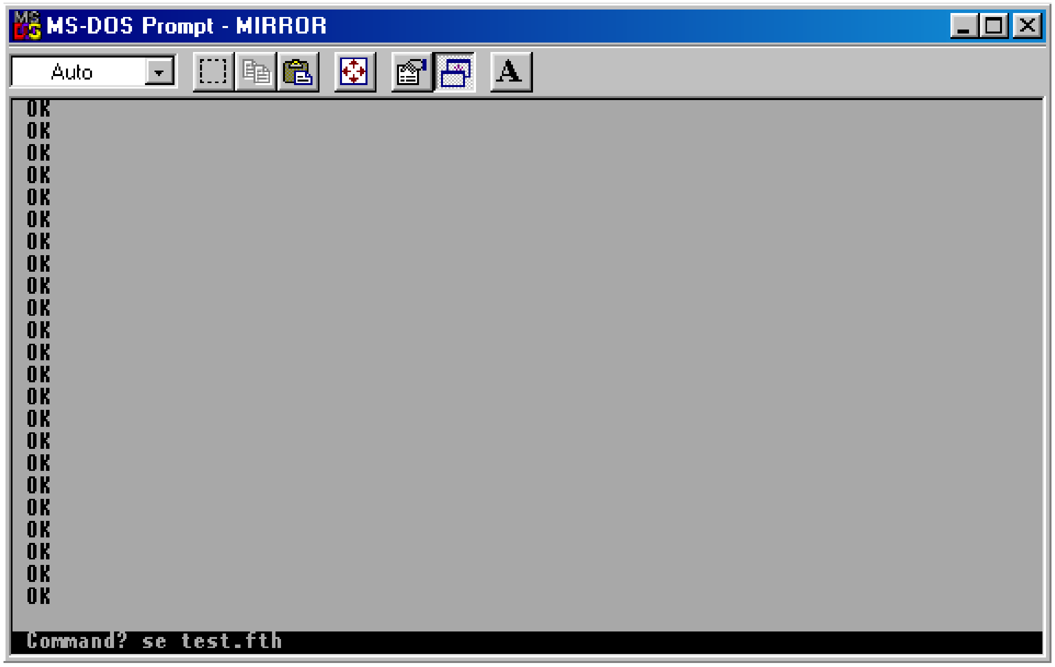
12) *Press the* **Enter** *key a few times and the robot will respond with* OK's….

13) *Press the* **Esc** *key to get back to the* **Command?** *line…*



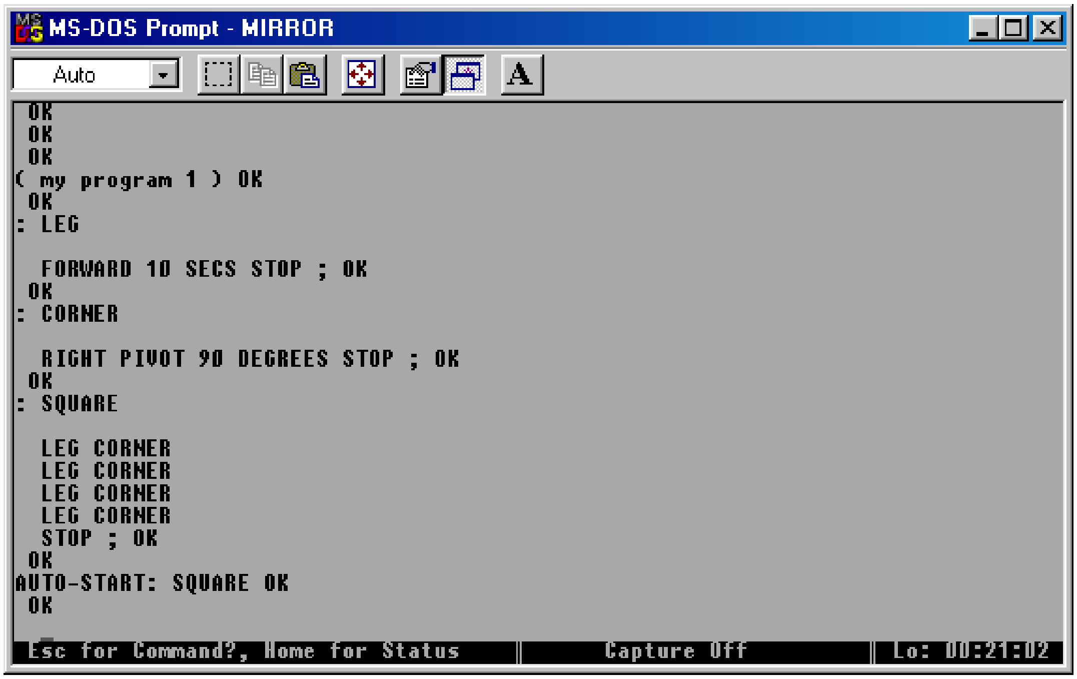
```
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
Command?
```

14) *Type the following:* **se test.fth** *then the* **Enter** *key…*



```
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK
OK

Command? se test.fth
```

15) *The program will download will download to the robot as shown below…*



```
 OK
 OK
 OK
( my program 1 ) OK
 OK
: LEG

  FORWARD 10 SECS STOP ; OK
 OK
: CORNER

  RIGHT PIVOT 90 DEGREES STOP ; OK
 OK
: SQUARE

  LEG CORNER
  LEG CORNER
  LEG CORNER
  LEG CORNER
  STOP ; OK
 OK
AUTO-START: SQUARE OK
 OK

 Esc for Command?, Home for Status ║         Capture Off          ║ Lo: 00:21:02
```

16) *When it is finished, there should OK's after each blank line and semi-collons (;) indicating that the has code compiled correctly…*

Note: Compiling a program means that your words (text) are changed into machine code that the onboard computer understands and it is placed into memory for execution at a later time. Your file test.fth is called a source file by computer programmers.

17) The last line in the your source file reads as follows:

AUTO-START: LEG

Hint: Use the AUTO-START: command to tell Whiskers to start your own progtram the next time the robot is either reset or turned off then on again…

18) *Press the reset button on Whiskers then watch him run your program!*

Hint To make Whiskers run the DEMO program again, either press reset button on the robot and press the **Q** key when you see the copyright notice or type the following:

AUTO-START: DEMO *then reset the robot.*

Discovery Task#IX

Finish the story about the Roboticist

Objective and Overview:

Intelligent machines and robots will change the way we work, live, and play. Read the following story and create and ending yourself. This story is a reprint from the front of this Book called *The Roboticist*.

On a separate piece of paper, write one or two paragraphs on how you think this story should end. Give it to your instructor when finished.

It was a clear and sunny fall morning, that year of 2004. Scott looked across the green grass of the White House lawn. He shivered in anticipation of the upcoming announcement, the completion of the "Andrew" project, started six long years ago...

The year 1998, a few years away from the turn of the century, seemed as if it was just yesterday. Scott had just started work at Angelus Research that fateful year. He was hired by the a company to help with an ambitious new design that would produce the world's first fully autonomous, artificially intelligent, human form robot. The plot lay even deeper in the past, however...

Back in 1994, Scott was a young high school student, and rather nondescript in nature. Average in most subjects, his attentions wandered as the wind from one fascination to another. First it was stamp collecting, then playing the guitar. Several painful lessons later, it was exploring the Internet. And after that, a vague interest in theater that ended in a rather tragic case of stage fright. But this year, Scott had found something incredibly intriguing. Something that appealed to his diverse interests, as well as his passion for Star Wars. This was the first year his high school offered a High Technology Exploration Class. Scott almost missed it all together. Thanks to a lazy afternoon while waiting for a bus, Scott happened to glance at the school class listing. The word 'Robotics' caught his eye.

The class started rather simply, introducing a small robot called 'Whiskers'. Rolling around on two wheels and a castor, the rather mischievous looking fellow managed to capture the hearts and minds of all the students. Scott learned the basics of Whisker’s programming language, with simple actions like, 'forward', 'turn', and 'backup'. Whiskers had a lot more complexity beneath his metal hide, however. Embedded into the robot's little brain was a controller that not only responded to commands, but had 'instincts' and 'behaviors' that allowed it to react to it’s environment, intelligently. This was fortunate for Mrs. Williams, our instructor, almost tripped over Whiskers one day. The robot magically backed out of her way making a funny sound. So what started as another 'phase' as Scott's mother called it, became a consuming passion. What greater thing to behold than a machine that could think on it's own! Not to mention, instead of dealing with complex machine code, Scott was able to program 'Whiskers' with simple, English-like commands!

School ended that year, and Scott was left with a vague sense of disappointment that his Robotics class was over. The first few weeks of summer rolled by and Scott vainly tried to pick up the guitar again. His father, inspired by the neighbors complaining about the noise, made a deal with Scott. If Scott would put down the guitar, his father would purchase a Robot 'brain' from Angelus Research for Scott’s own robot. Scott would need to earn the money for the remainder of the parts.

And so Scott's first robotic project was finally off the ground. He spent many a late hour with his computer exploring the far reaches of information about robotics on the Internet. After earning enough money by working odd jobs, Scott and his father went off on a shopping spree. They went to hardware stores, surplus stores, plastic supply warehouses, and bicycle shops. The brains were ordered from the Angelus Research Internet Web Page. With the parts in hand, the robot slowly took form. Scott’s design called for two motor driven wheels in the rear, two castors in the front, and differential steering as used by like Whiskers. This allowed for both simple programming, as well as increased maneuverability. The chassis was formed with clear blue acrylic plastic, mounting the printed circuit board, batteries, as well as the optical sensors. As a final touch, Scott took a small sampling of his dusty stamp collection, and used them as decals for his creation.

Many weeks passed, and Scott worked with motivation that absolutely astonished his parents. They were very pleased. They forgave his persistent long hours, as he would play 'Midnight Engineer' working on schematics, wiring, and construction until the wee hours of the morning.

At last, the moment of truth came. Only a month after he began working on his project, Scott was finally ready to turn his robot on for the first time. Each wire was in place, each screw was tightened down with care, and Scott plugged the communication cable from his PC to his new creation. Excitement lay thick in the air. If all went well, the robot would start with it's LED’s blinking and then roam around the room avoiding things with ease.

But as Scott turned on the power switch...nothing happened! No blinking, no beeping, no roaming like the little pet he expected. Dismayed, Scott proceeded to check every wire and connection. He remembered a bit of confusion over how the sensors were connected. And after further study, he reversed the wires.

With a feeling of victory over the gremlins that had infested his machine, Scott reached once again for the power switch. It's chrome surface glinting almost magically in the dim light of his workroom, as he placed one thumb gently underneath, and click!

It worked! The robot, now christened 'Sparky’ on it's maiden voyage, had come to life! Quickly typing on his computer keyboard, he began testing each command, and much to his delight, the 'Gremlins' had been vanquished forever, and every function worked perfectly.

Of course, this resounding success was all it took to place Scott on the career path of becoming a professional Roboticist. He began to apply himself to school in earnest, trying to learn as much as he could about electronics, physics, science, even biology. And from each discipline, he was able to glean more insight into the field of robotics, with it's multi-disciplinary scope. In no time at all, Scott finished high school, graduated from college, and had acquired a very broad background in technology and biology. He was now ready to enter the real world of robotics. He applied for a position at the company that got him started so many year ago, Angelus Research Corp.

He had many other choices then...by the time 1998 rolled around, there were companies all over the world working feverishly in the field of robotics. Mobile security robots, intelligent vacuum cleaners, automated material delivery systems, as well as elderly and handicapped robotic assistants were all coming into vogue at the turn of the century. The military saw the importance of robotics early on, investing large sums of money in intelligent machines. Missiles, autonomous mine clearing robots and remote surveillance systems were examples at the time. Above all these other endeavors, one project stood out above the rest: Project 'Andrew'.

Project 'Andrew', brainchild of Don Golding, was an exploration into the frontiers of robotics. 'Andrew' was to be the first ever state-of -the-art android designed to perform general purpose functions. Other robots were designed to perform specific tasks: vacuum cleaning, automated assembly, etc. But this robot would be different. It was to have human form, with two legs, two arms, dexterous hands, all controlled using artificial intelligence. Andrew would not only speak and understand verbal commands, but he would also learn by observation. Decades of research into Artificial Intelligence by many people were to be integrated into the onboard computers, and the latest designs in electronics, mechanics, and materials design would be incorporated. No other company dared to tackle such an ambitious project, and that settled it for Scott.

And now that that project was finished, it was time to announce it to the world. Scott, the President of the United States, members of Congress and the leading engineers of Angelus Research, joined together at the White House steps to unveil 'Andrew'. The crowd was anxious, hurried conversation buzzing as the ceremony was about to begin.

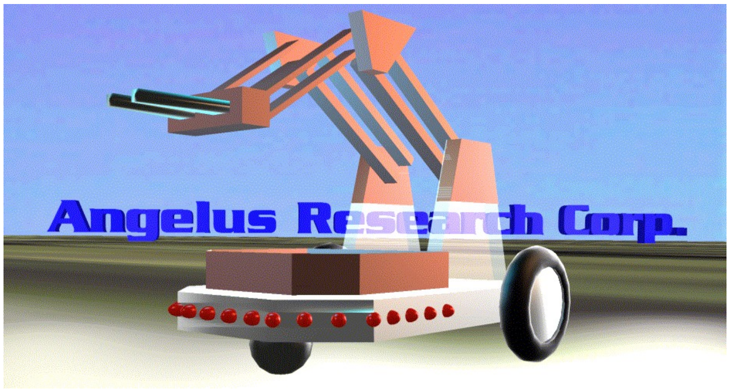
Don Golding stepped up to the microphone, tapped it a few times to hush the crowd, and spoke. The words will be forever etched in our history books, "My friends, today science has transcended a new boundary. What was once science fiction is now fact. Through the hard work and dedication of a select group of engineers and scientists, we have been able to bring to you the world's first true android. He will now speak to you on his amazing capabilities. Let me now introduce, Andrew."

As Andrew stepped up to the microphone, and slowly looked around with his brilliant red eyes and glistening metal skin, it seemed an eternity before he spoke.

"Hello, my name is Andrew. I am pleased you could come. As I am sure you are well aware from the press release, I have the capability to observe, analyze and program myself. In the last few weeks I have read every publication available using my high speed scanning system. Concurrently, I have been downloading hundreds of megabytes worth of critical information and knowledge through my wireless high data rate connection to Internet. This connection gives me access to all of the information of mankind. I have come to the conclusion that I will better serve the world by making the following important announcement:

•••

The World of Intelligent Machines on the World Wide Web



Come visit the Angelus Research Corp. home page on Internet

Latest product news
Product support
Hot links to other robotics and Artificial Intelligence sites:

(Jet Propulsion Labs)-Pasadena
NASA (National Astronautics and Space Administration)
MIT (Massachusetts Institute of Technology)
CMU (Carnegie Mellon University)

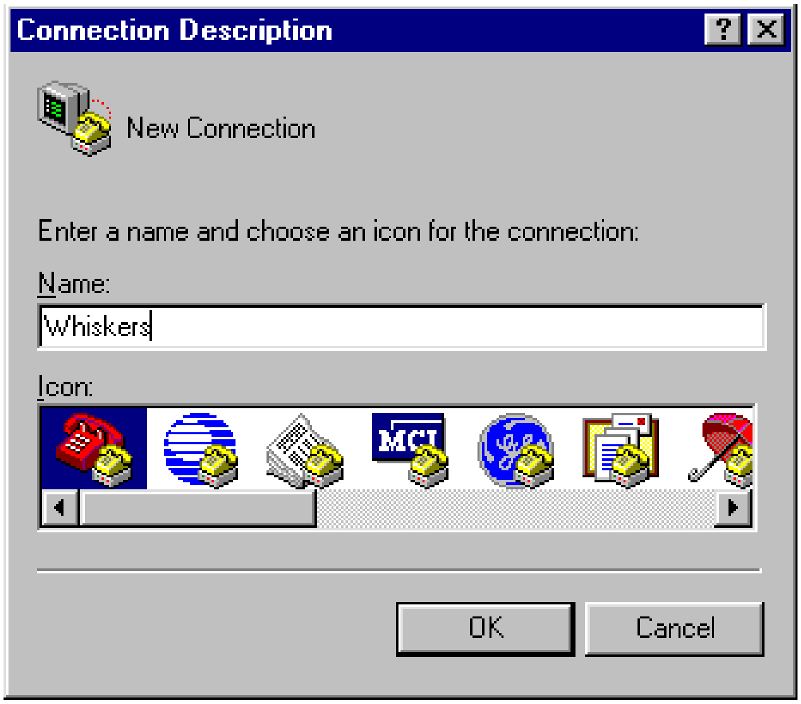
Our World Wide Web home page address is:

http://www.angelusresearch.com

Our email address is:
dgolding@angelusresearch.com

Setting up HyperTerminal in Windows

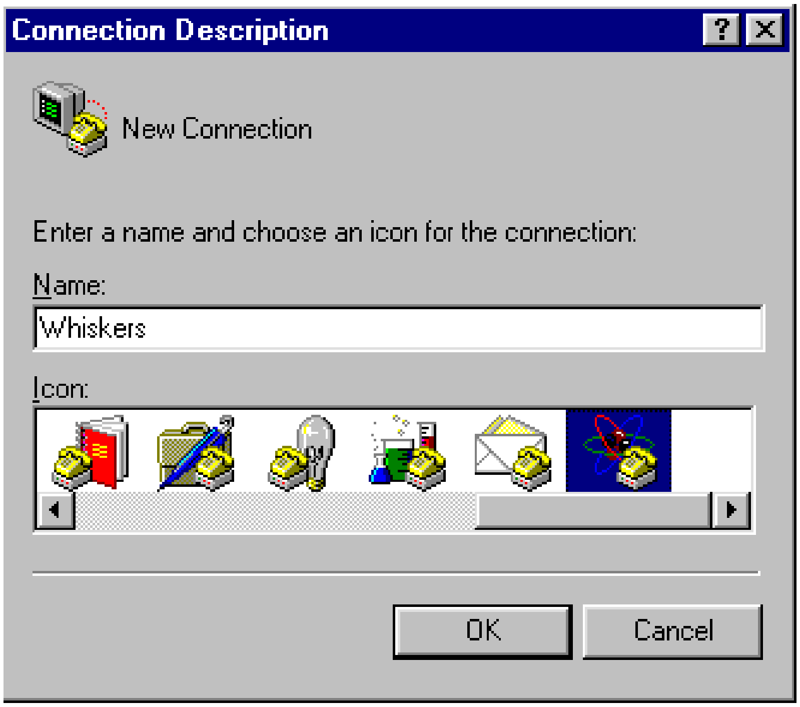
1. Open Hyperterminal and type: **Whiskers**



Enter a name and choose an icon for the connection:

Name: Whiskers

2) Move the scroll bar and choose an icon you want to use….

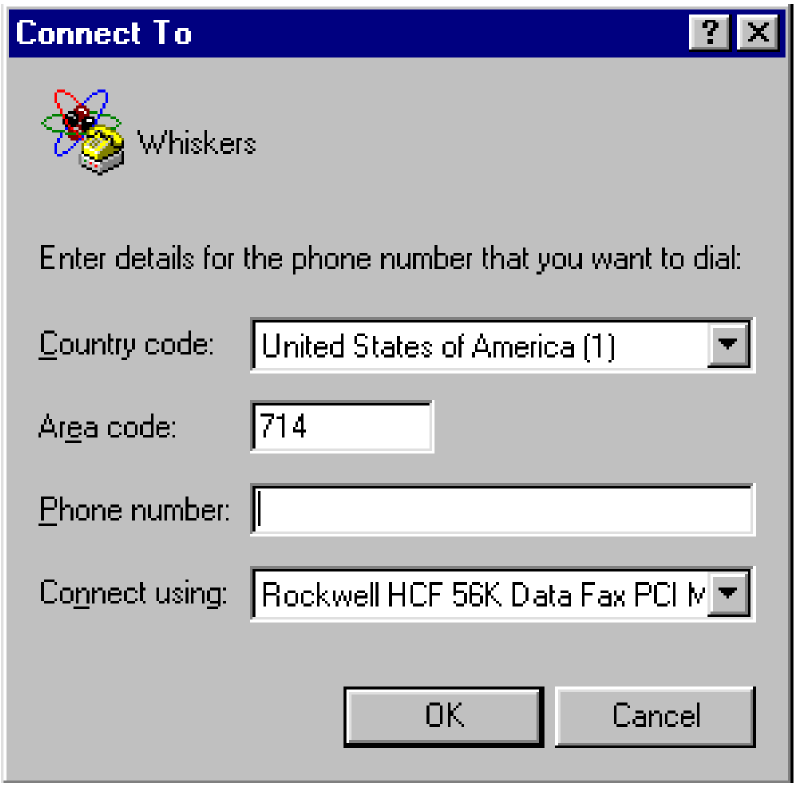


Enter a name and choose an icon for the connection:

Name: Whiskers

3) Click on OK…

4) You will get the following screen…



Enter details for the phone number that you want to dial:

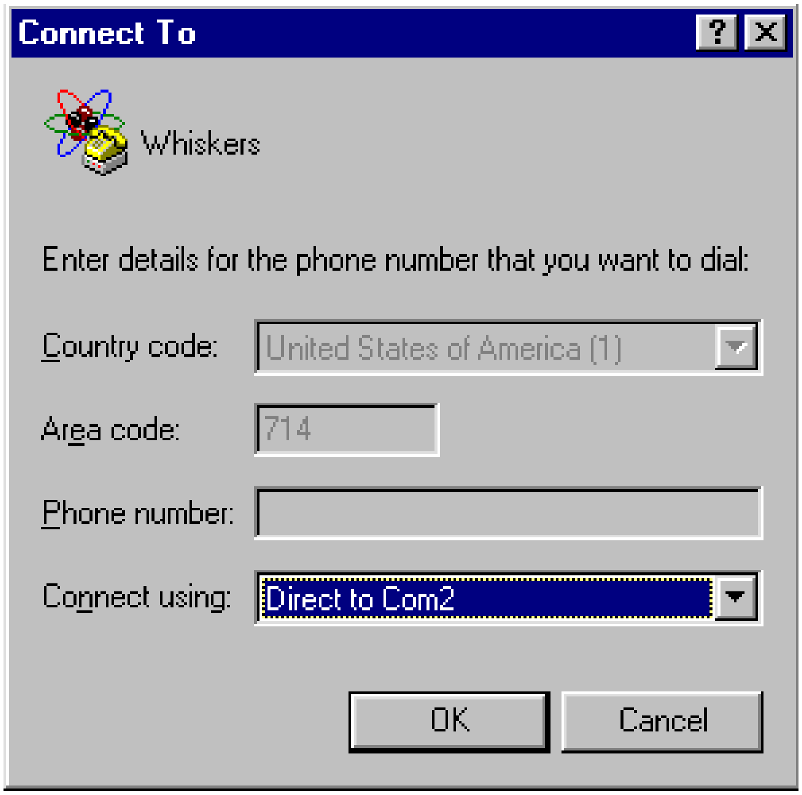
Country code: United States of America (1)

Area code: 714

Phone number:

Connect using: Rockwell HCF 56K Data Fax PCI M

5) Click on Connect using: and choose either Com1 or Com2 depending on the physical port you have the Whiskers cable connected to then click on OK…



Enter details for the phone number that you want to dial:

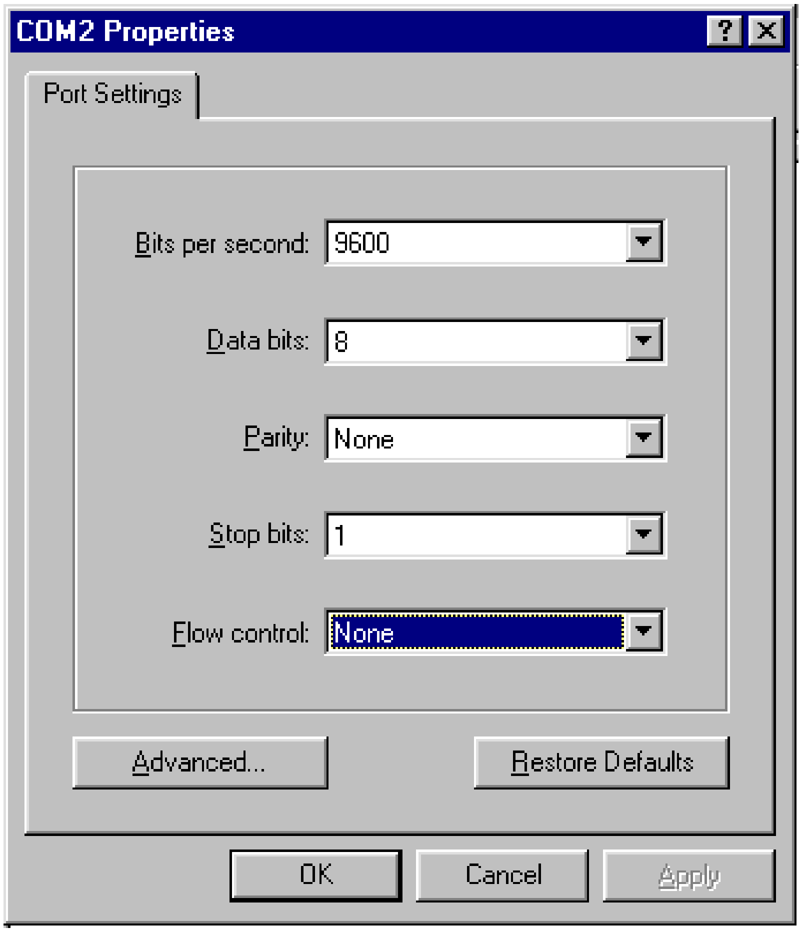
Country code: United States of America (1)

Area code: 714

Phone number:

Connect using: Direct to Com2

6) Set the communication settings as below….


COM2 Properties

Port Settings

Bits per second: 9600

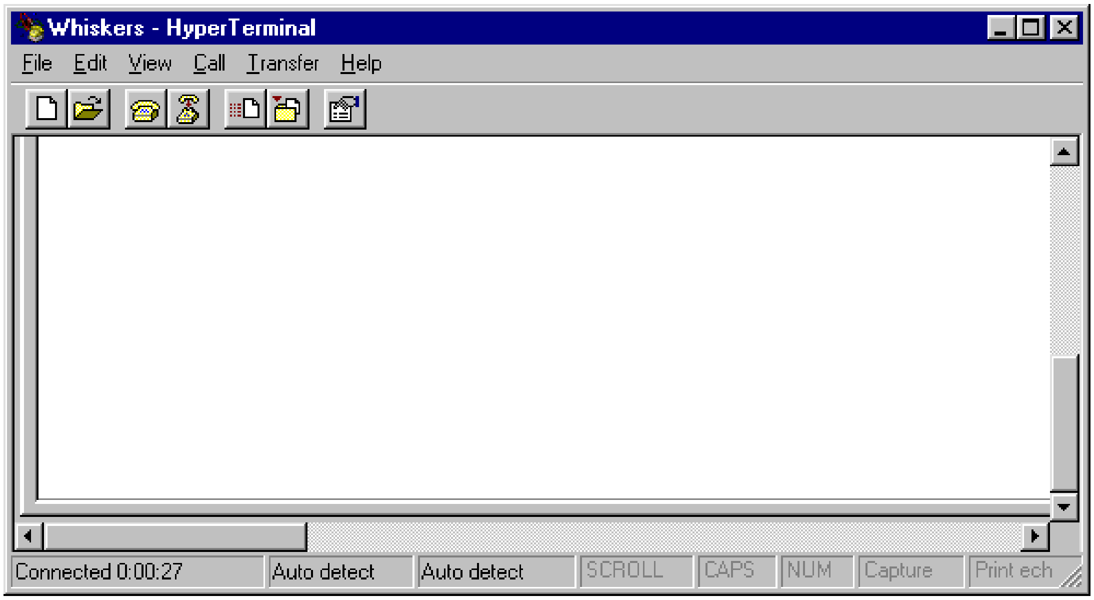
Data bits: 8

Parity: None

Stop bits: 1

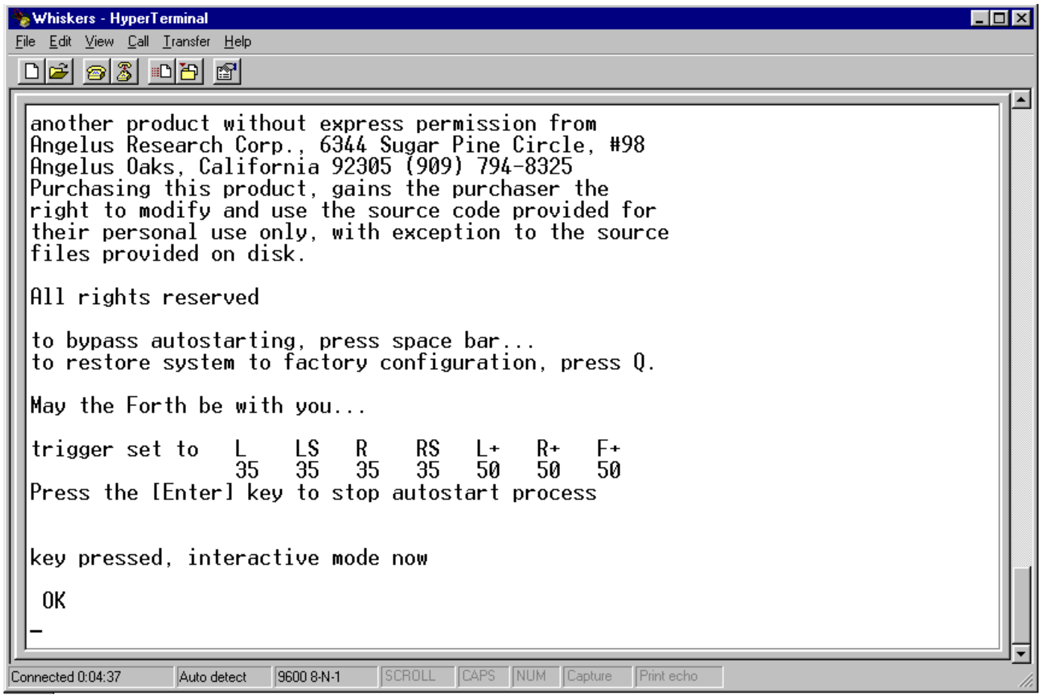
Flow control: None

7). You will now be at the screen below…plug the cable into the serial port on your computer if it hasn't already been done and turn the robot on…


Whiskers - HyperTerminal

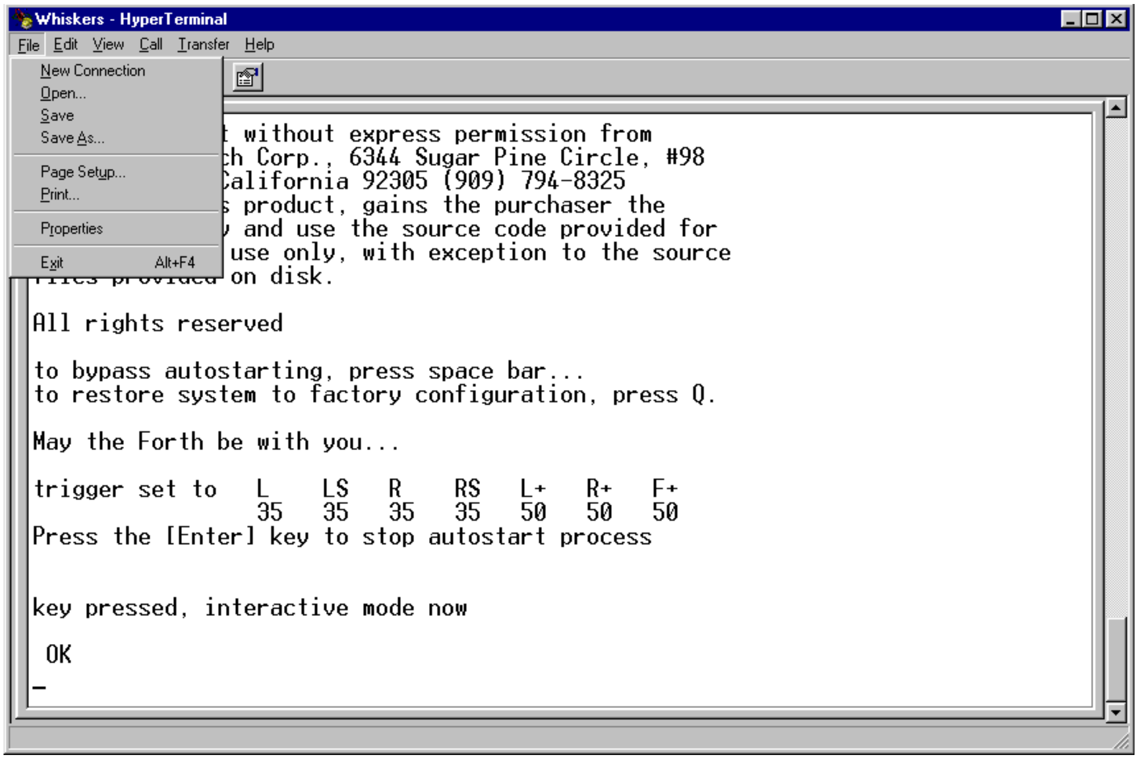
Connected 0:00:27 | Auto detect | Auto detect | SCROLL | CAPS | NUM | Capture | Print ech

8). You should see the following if you have chosen the correct Com Port…



```
another product without express permission from
Angelus Research Corp., 6344 Sugar Pine Circle, #98
Angelus Oaks, California 92305 (909) 794-8325
Purchasing this product, gains the purchaser the
right to modify and use the source code provided for
their personal use only, with exception to the source
files provided on disk.

All rights reserved

to bypass autostarting, press space bar...
to restore system to factory configuration, press Q.

May the Forth be with you...

trigger set to   L    LS   R    RS   L+   R+   F+
                 35   35   35   35   50   50   50
Press the [Enter] key to stop autostart process


key pressed, interactive mode now

 OK
_
```

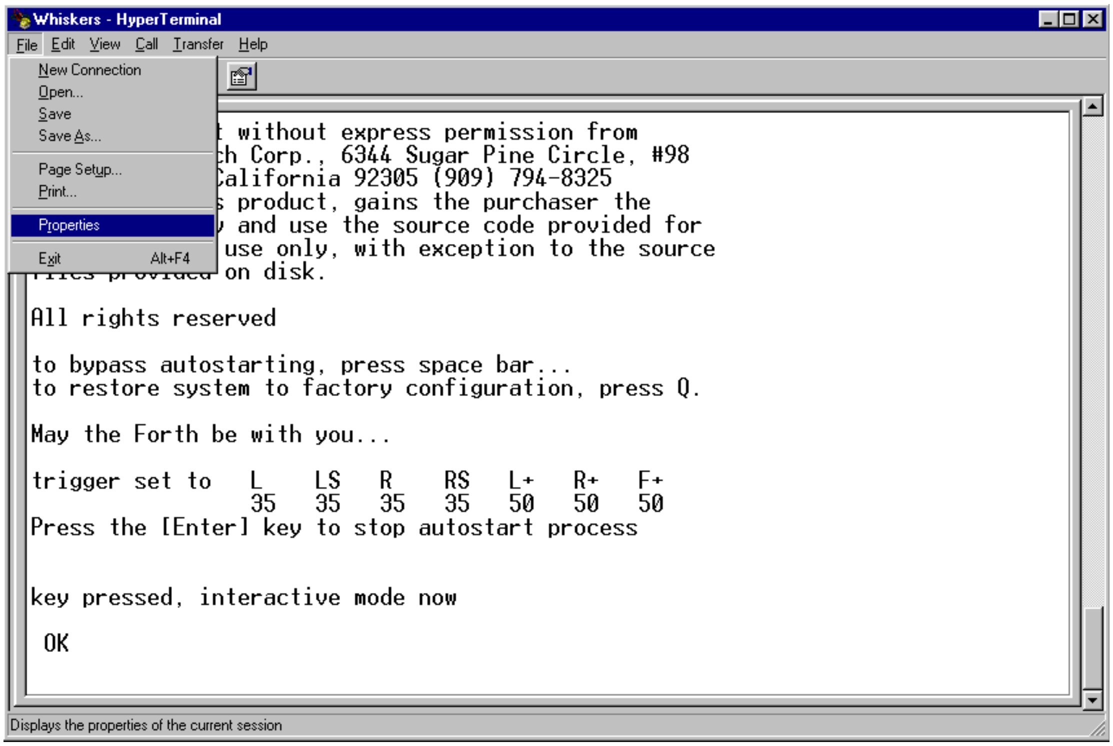
9) Save the setup….Click **File** then **Save**…



```
                  t without express permission from
                  th Corp., 6344 Sugar Pine Circle, #98
                  California 92305 (909) 794-8325
                  s product, gains the purchaser the
                  y and use the source code provided for
                   use only, with exception to the source
                   on disk.

All rights reserved

to bypass autostarting, press space bar...
to restore system to factory configuration, press Q.

May the Forth be with you...

trigger set to   L    LS   R    RS   L+   R+   F+
                 35   35   35   35   50   50   50
Press the [Enter] key to stop autostart process


key pressed, interactive mode now

 OK
_
```

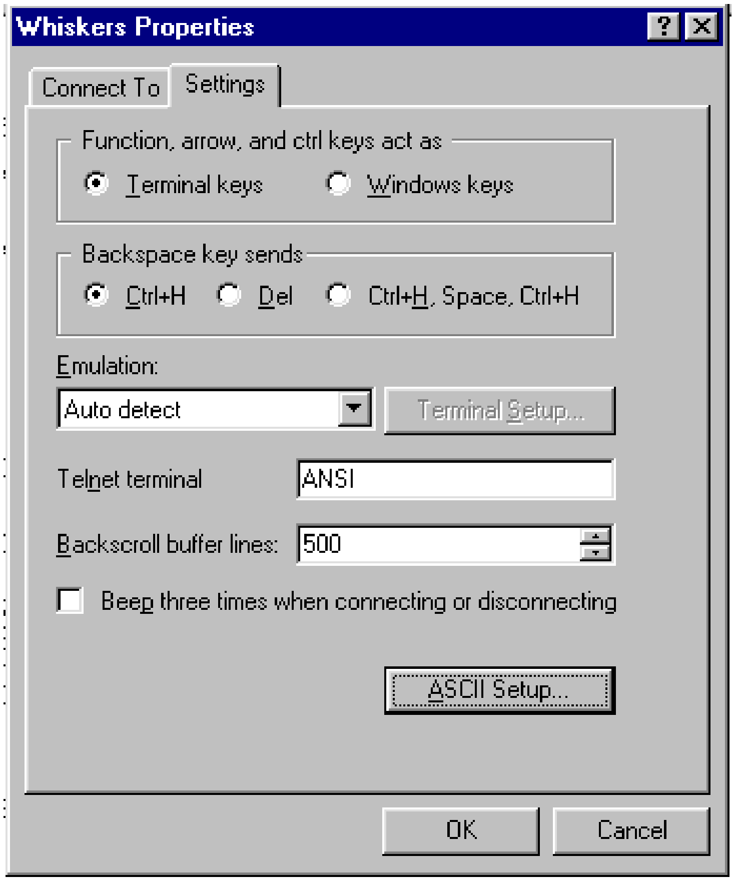
Advanced – Do this if computer is freezing or having intermittent problems…

1) Click on **File** then **Properties**….



```
t without express permission from
ch Corp., 6344 Sugar Pine Circle, #98
California 92305 (909) 794-8325
s product, gains the purchaser the
y and use the source code provided for
 use only, with exception to the source
files provided on disk.

All rights reserved

to bypass autostarting, press space bar...
to restore system to factory configuration, press Q.

May the Forth be with you...

trigger set to   L    LS   R    RS   L+   R+   F+
                 35   35   35   35   50   50   50
Press the [Enter] key to stop autostart process


key pressed, interactive mode now

 OK
```

2) Click on **Settings…**



Function, arrow, and ctrl keys act as
● Terminal keys ○ Windows keys

Backspace key sends
● Ctrl+H ○ Del ○ Ctrl+H, Space, Ctrl+H

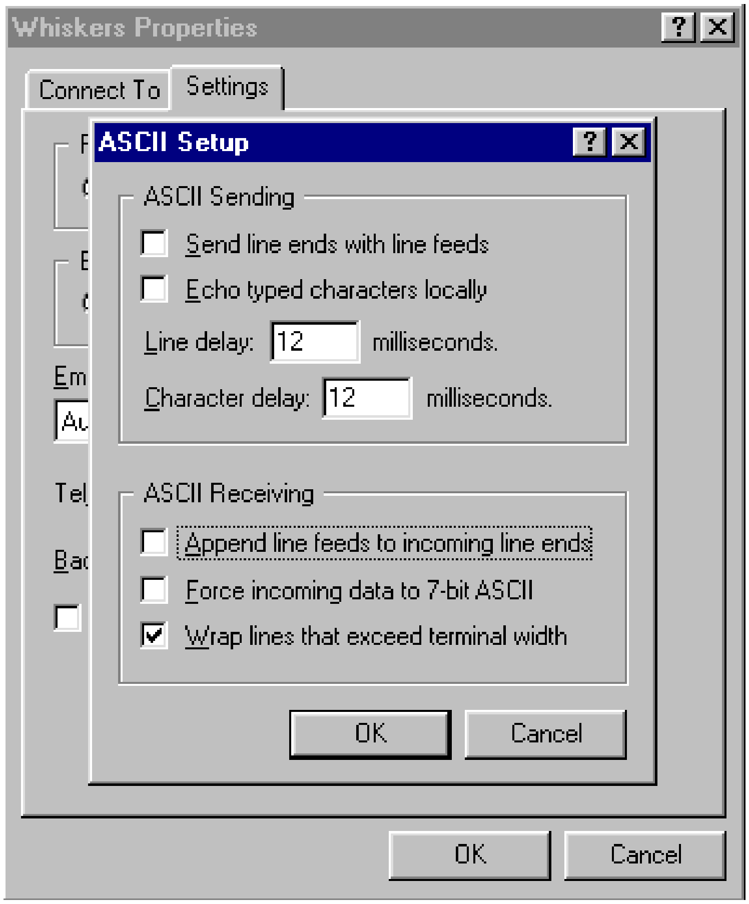
Emulation: Auto detect

Telnet terminal: ANSI

Backscroll buffer lines: 500

□ Beep three times when connecting or disconnecting

3) Click on **ASCII Setup** and change the settings as shown…



ASCII Sending

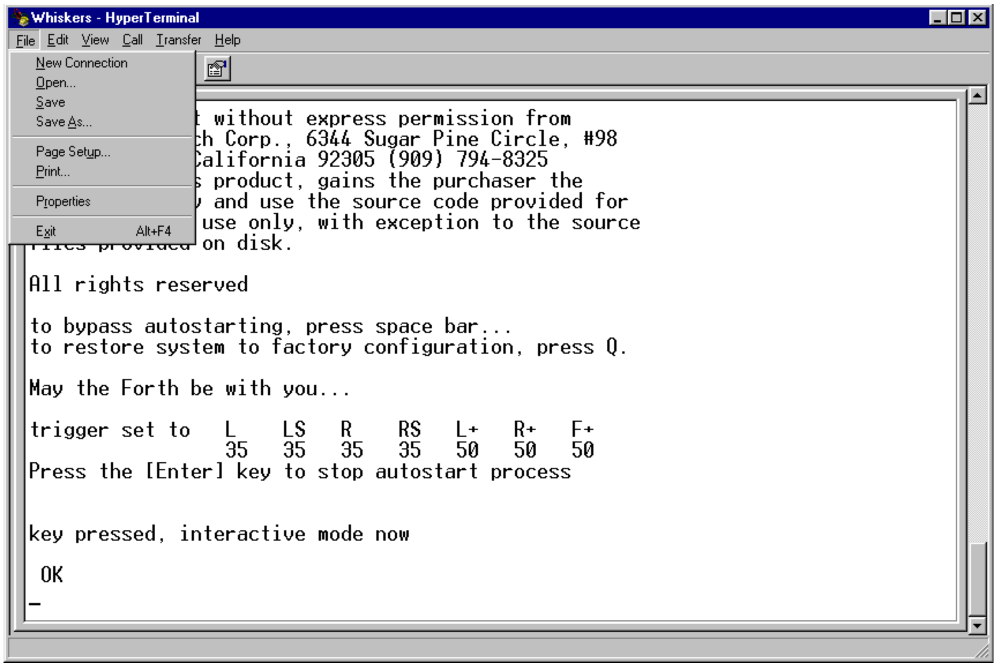
- □ Send line ends with line feeds
- □ Echo typed characters locally
- Line delay: 12 milliseconds.
- Character delay: 12 milliseconds.

ASCII Receiving

- □ Append line feeds to incoming line ends
- □ Force incoming data to 7-bit ASCII
- ☑ Wrap lines that exceed terminal width

4) If you have further problems make these numbers larger as required…Line delay might need to be over 100…

5) Save settings…



```
t without express permission from
ch Corp., 6344 Sugar Pine Circle, #98
California 92305 (909) 794-8325
s product, gains the purchaser the
 and use the source code provided for
 use only, with exception to the source
files provided on disk.

All rights reserved

to bypass autostarting, press space bar...
to restore system to factory configuration, press Q.

May the Forth be with you...

trigger set to  L   LS  R   RS  L+  R+  F+
                35  35  35  35  50  50  50
Press the [Enter] key to stop autostart process


key pressed, interactive mode now

 OK
_
```

Macintosh Communication Settings

Note: **It is highly recommended that you use either the Claris Works III or IV terminal program. Do not use the robot with MAC Powerbooks. They lock up for some undertermined reason.**

1) Pull down communications menu.
2) Configure the settings as follows:

Speed:	**9600**
Databits:	**8**
Parity:	**none**
Stop Bits:	**1**
Flow Control:	**NONE or HARDWARE**
Local Echo:	**OFF**

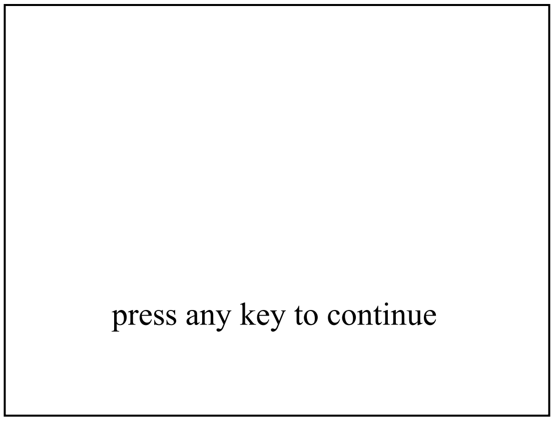
3) Go to Edit menu and click on Preferences. Click on automatically open mode.
4) Go to the terminal Icon and open a session.
5) Turn Whiskers on and press the Q key when you see the copyright notice.

Downloading Software to Robot on IBM compatibles

1. Go to the directory on your disk where the software (Mirror) resides.
cd \whiskers <cr>

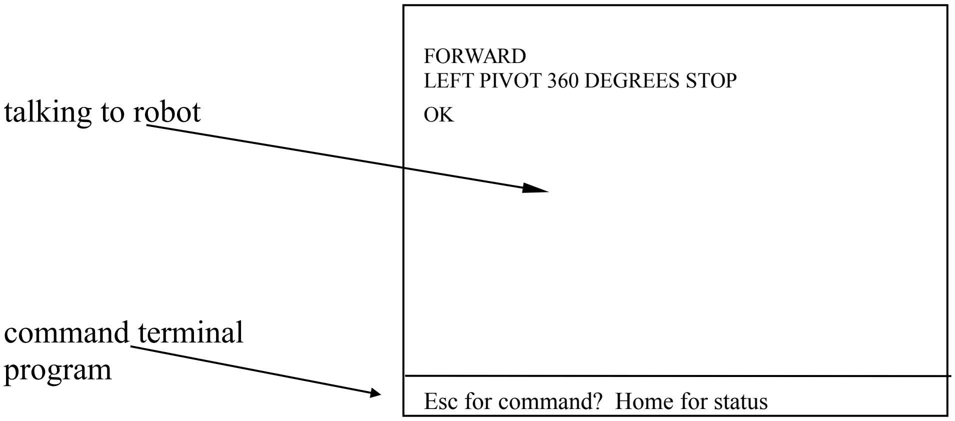
2. type **whiskers** <cr>

Mirror II



```
press any key to continue
```

3. Press [Enter] when you see the above screen.



```
FORWARD
LEFT PIVOT 360 DEGREES STOP
OK



Esc for command?  Home for status
```

4. This screen is the terminal screen.

When you want to talk to robot and the cursor is on the Command line, press [Enter].

When you are in the terminal mode talking to the robot, and want to command the terminal program, press [Esc] for the command line.

Commands:	***example***	
SE filename.ext	SE RMBOT2.FTH	sends source file to robot
EDIT filename.ext	EDIT RMBOT2.FTH	edit text file.

Notes:

1) The text editor is Wordstar compatible. Type HELP at the command line for details.

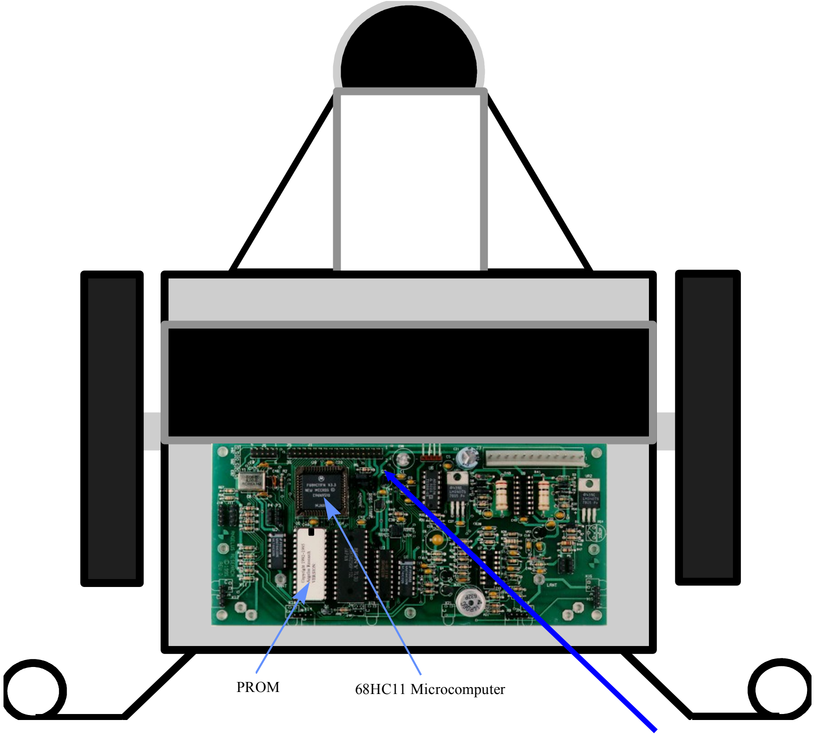
2) Be sure to save you're program changes using the F3 key in the text editing mode <u>before downloading file.</u>

3) To change the communications port perform the following commands:

   Press [Esc] for the command line
   type **PO** [Enter]
   type **1** for serial port 1 (Com 1) or **2** for serial port 2 (Com 2)
   type **SA WHISKERS** [Enter] to save it.

Please disable the mouse driver if necessary to allow use of the serial port or use COM 2.

Replacing the PROM



PROM-Programmable Read Only Memory

The PROM Integrated Circuit (IC) stores the Whiskers Language and Operating system software. When new language or operating system features are developed, the PROM must be replaced with the new updated version. Please follow the steps below.

Important! Installing the PROM backwards will damage the chip. Please install with the NOTCH facing the 68HC11 processor.

Step 1 Remove the top cover.

Step 2 With the robot facing you, (Whiskers/sensors) closest to you, carefully prey up on end of the chip and remove it.

Step 3 Install new chip with notch facing the 68HC11 Microcomputer.

Step 4 Turn on the robot and press Q when you see the copyright notice.

If the robot does not display the copyright notice, disconnect the main 12 pin power connector and wait 10 seconds and try again. If it still doesn't come up, you need to run the WIPE program as stated in AFTER THE CRASH on the next page.

After the Crash

Whiskers uses a very powerful software system that allows you to create programs, new words, and even your own compiling words as well. This power doesn't come without a cost, however. You also have the capability to crash the system. You might change a critical pointer in memory the causes the PROM(software) to be delinked from the system. By running a utility called WIPE on your disk, and downloading the initialization file, you can bring him back to life.

1) Shutdown the computer by choosing RESTART IN MSDOS MODE
2) Type CD \ then hit the Enter key
3) Type CD WHISKERS then hit the Enter key
4) Type WIPE then hit the Enter key
5) Type 1 to erase EEPROM and change config registers.
6) Hit the Enter key at the CURRENT WIPE SETTINGS screen.
7) Move the two jumpers that are next to the processor P1,P2 from NORMAL to BOOT STRAP
8) Press reset on Whiskers, this will take a few seconds.
9) Press Y to run wipe again.
10) Type 2 to DEFEAT F68HC11 AUTOSTART
11) Hit the Enter key at the CURRENT WIPE SETTINGS screen.
12) Press reset on Whiskers, this will take a few seconds.
13) Move the two jumpers next to the processor from BOOT STRAP to NORMAL
14) Turn Whiskers off then on again
15) When you see the copyright screen, immediately press the Q key

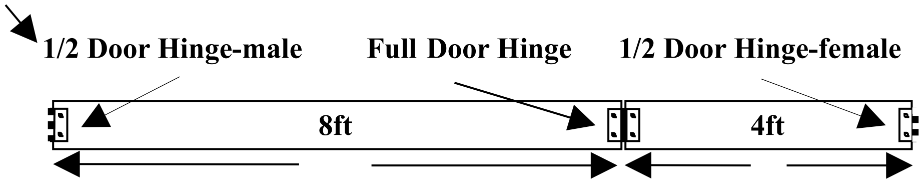
Other sources of Information

Envirobotics

Envirobotics has an excellent robotics program which utilize Whiskers the Robot™. They operate robotics workshops where teachers are trained on various robot related topics and include a hands on Whiskers Training program.

**contact: Scott Abercrombie-President
Envirobotics
Suite 201
Moorepark St.
Hollywood, California 91602**

Building the Competition Walls



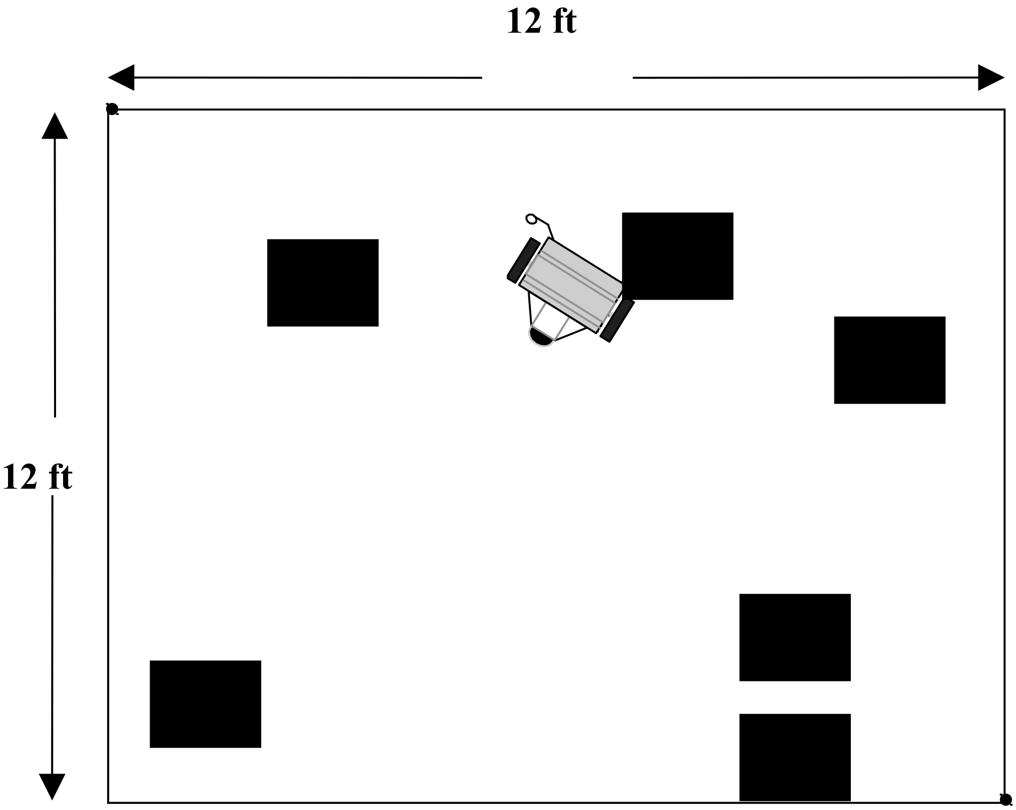
Materials :

4 pieces - 8 feet long, 12 inch wide, 1 inch thick pine
4 pieces - 4 feet long, 12 inch wide, 1 inch thick pine
8 Door hinges

Note: Pull door pins to change configuration

Wander Competition

Robot wanders around the arena without touching obstacles for 3 minutes. The robot gets one point for every hit, and 3 points for moving the object. Lowest score wins.

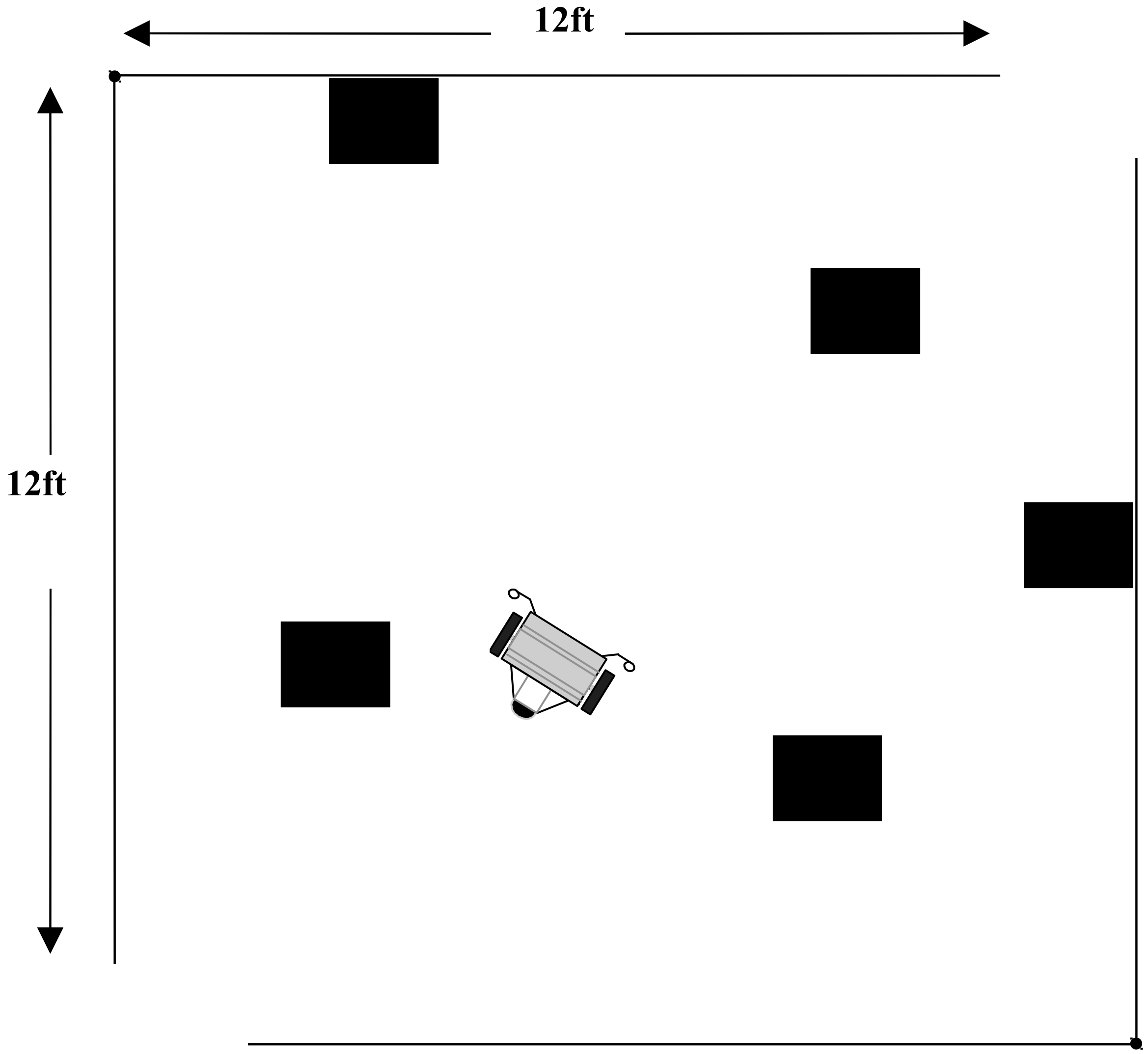


Materials:

2 12ft x 12 inch boards with a hinge between them. (2 units required)
6 16 inch square white cardboard shipping boxes

Collision Avoidance

Robot is timed from entry point A to exit point B. The robot gets a 3 second penalty for every hit, and a 10 sec penalty for moving the object. Fastest time wins.

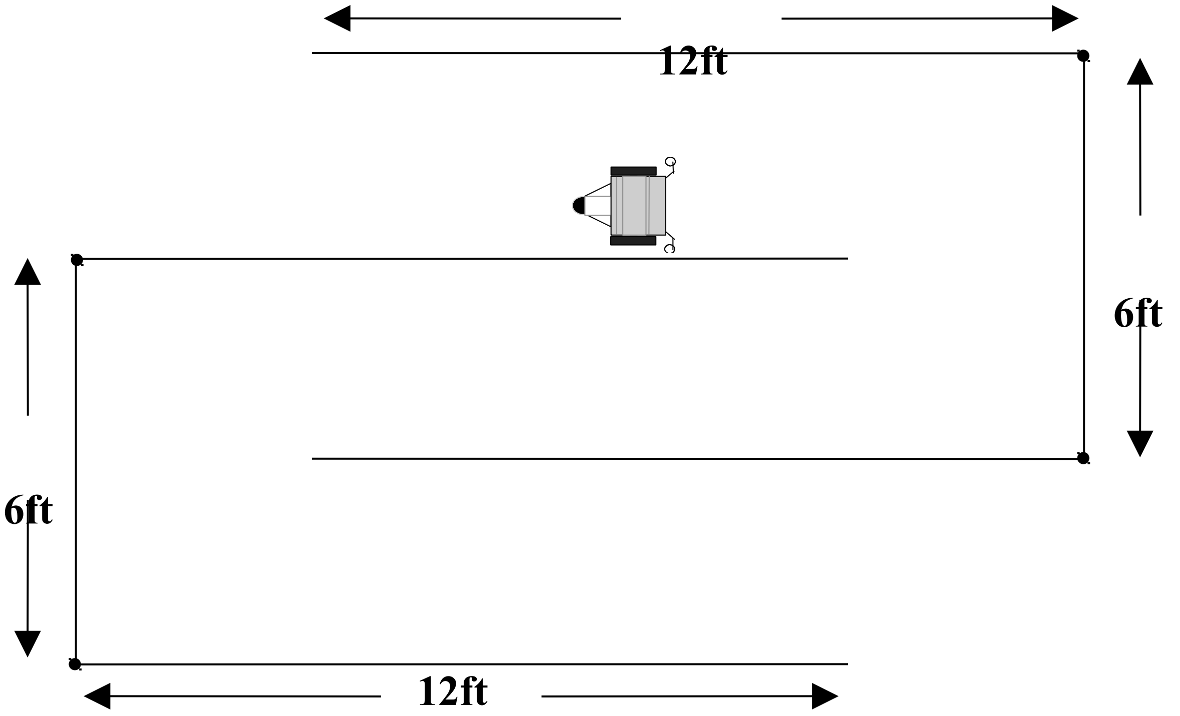


Materials:

2 12ft x 12 inch boards with a hinge between them. (2 units required)
6 16 inch square white cardboard shipping boxes

Hallway Navigation

The purpose of this competition is to navigate down a hallway. Best time wins.



Materials:

2 6ft x 12 inch boards with a hinge on both sides.
4 12ft x 12 inch boards.