Note to Teacher

In this investigation, students will learn the relationships between radio (RF) transmitter and receivers in a technological system. Students will use the Vex Robotics System in a laboratory setting and conduct scientific inquiry-based experiments to determine the effect of transmitter antenna length and position on signal strength relative to the receiver. Students will construct a basic model of a working system that includes a radio transmitter, receiver, controller and motor driven output. Students will gain an understanding of math and science concepts related to frequency and the time period of a sinusoidal signal (sine wave).

Students will apply engineering notation to frequency and time period calculation and demonstrate the ability to use a calculator programmed for engineering notation to easily determine the appropriate unit.

Activities

This investigation consists of 4 activities: three of which are lab based. These activities support robotics instruction and participation in competitive events.

- This investigation should take approximately 3-4, forty minute periods.
- Students will work in cooperative teams of 2 or 3.
- Managing a classroom when multiple investigations are being done using multiple Vex systems but only one crystal frequency is not recommended.
- Refer to Inventors Guide Unit Six (page 21)–Control and Appendix E–Control Configuration (page 11-18).
- Recommendation is to purchase addition crystal sets from Vex (see Unit 6 page 22 in the Inventors Guide).

Students will be able to:

1. Apply scientific process.
2. Identify and measure the maximum distance from transmitter to receiver at various antenna heights at a single position (pointed at receiver).
3. Use a fixed transmitter antenna height (4inches) and fixed transmitter distance from receiver to discover the optimal angle of the transmitter antenna.
4. Use a calculator with engineering exponential notation (such as CASIO fx-300sa or the TI 83, 86, 89) to determine the frequency and time period of a sinusoidal wave form.
5. Collect data from their investigation.
6. Apply and describe the various points of experimental procedure:
   - **a.** experimental hypothesis
   - **b.** measurement technique
   - **c.** multiple trials
   - **d.** systematic error
   - **e.** random error
7. Write a summary describing what they learned in the investigation.

Note to Teacher *continued*

Figure 1

Description of the investigation

To begin this investigation, students will work in teams of 2 or three and construct a simple test robot system that can be controlled by the supplied radio transmitter and has an observable output. The actual system can vary and students should be encouraged to make it simple. The system must include the following Vex components: (one 40 minute period).

- Transmitter with crystal and adequate battery power
- Receiver with matching crystal
- Antenna wire on the receiver should be arranged as shown in figure one. If the antenna is fully distended the reception distance becomes difficult to measure.(it will be too large)
- Vex controller
- Battery (adequate charge)
- One motor
- Visual demonstration of motor output (ex. wheel turning, fan blades spinning)

HORIZONTAL ANTENNA TEST / Lesson 1

Once the test system is complete the students can begin the investigation. In the first experiment, the team will explore the relationship between antenna height and signal strength. The hypothesis is that the transmission strength is a function of antenna height. Students will measure the distance from receiver at various antenna heights at a single position (with the transmitter antenna pointed at receiver) at signal failure.

1. The starting position is about 4 feet from receiver.
   - **a.** Antenna is set at 4 inches and pointed at receiver
2. Increase the distance from receiver (in a straight line) until the signal is lost.
   - **a.** Measure the distance from tip of the transmitting antenna to the receiver at signal failure (the motor stops).
3. Repeat steps one and two increasing the antenna height by 4 inches each time up to an antenna height of 34 inches.
4. Record data and graph results (antenna height verses failure distance) Students could use a variety of resources for generating the graphs. Using computer software such as Excel would be considered a plus.

VERTICAL ANTENNA TEST / Lesson 2

In the second experiment, the team will compare the relationship between the antenna position and the strength of the signal. The hypothesis is that pointing the antenna at the receiver will not result in the best signal performance. Students will measure the distance from receiver at various antenna heights at a single position (with the transmitter antenna in a vertical position) at signal failure.

1. The starting position is about 4 feet from receiver.
   - **a.** Antenna is set at 4 inches and vertical.
2. Increase the distance from receiver (in a straight line) until the signal is lost.
   - **a.** Measure the distance from tip of the transmitting antenna to the receiver at signal failure (the motor stops).
3. Repeat steps one, two and four (above) increasing the antenna height by 4 inches each time up to an antenna height of 34 inches.
4. Record data and graph results (antenna height verses failure distance) Students could use a variety of resources for generating the graphs. (Using computer software such as Excel would be considered a plus).

Note to Teacher *continued*

WAIST HIGH TEST / Lesson 3

$$T = \frac{1}{f}$$

In the final step of this investigation, the student will use a calculator with engineering notation (such as CASIO fx-300sa or the TI 83, 86, 89) to determine the frequency and time period of a sinusoidal wave form. In the first calculation the students are given a frequency and will calculate the time period given the following formula at left.

Where T is the time period and f is the frequency. The answer will be expressed in milliseconds, microseconds, or nanoseconds.

$$f = \frac{1}{T}$$

For the second calculation, the students are given a time period and will calculate the frequency given the equation at left.

Where T is the time period and f is the frequency. The answer will be expressed in kilohertz, megahertz, or gigahertz.

The students will then gain an understanding of the sensitivity of a crystal.

1. Given frequency of any two available Vex crystals, determine the difference between the 2 frequencies—express the answer in either megahertz or kilohertz.
2. Calculate the time period of any two available Vex crystals, determine the difference between the 2 time periods—express the answer in nanoseconds.

If students are not familiar with units in engineering notation a review will be necessary.

See helper page Engineering Notation.

Addition procedure sheets are included for further investigation.

Math versus science

As students complete the investigations they will begin to understand the relationship between mathematics and science. Mathematics is pure; when you plug numbers into equations you will get the same result every time. Science is dependent on multiple variables that may or may not be in control of the investigator. A good scientist will eliminate as many uncontrollable variables as possible so that they are able to analyze and measure the results of their investigation.

Note to Teacher *continued*

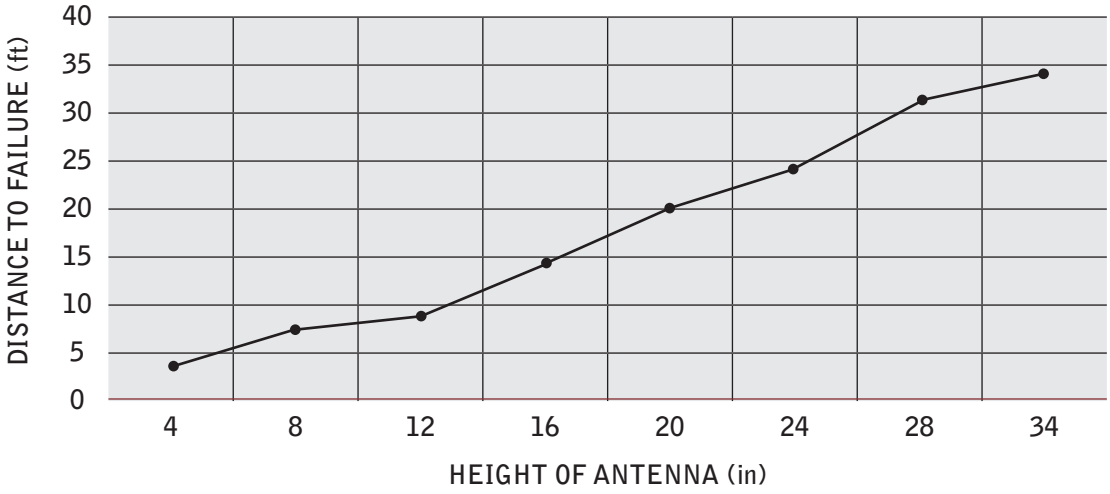
Experimental error

There are many things that can cause your experimentally measured numbers to fall off-target from the predicted values. Here are a few:

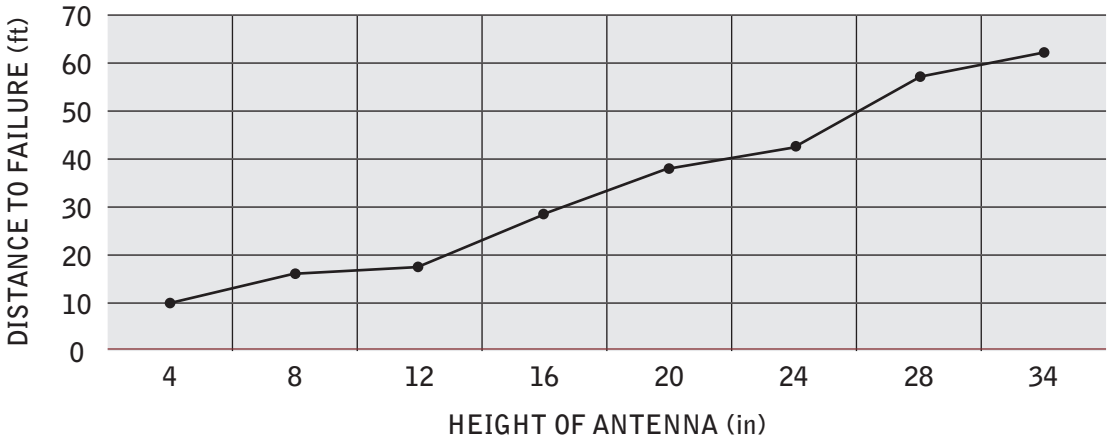
- ***Systematic error*** is something in the experiment that always throws off the data in the exact same way. Some examples of systematic errors are: dead battery, improperly connected components, defective motor.
- ***Random error*** is caused by small factors that constantly change and affect the experimental results. In this experiment, random error may be caused by varying starting points, sloppy measuring procedures, or battery level.

This investigation includes worksheets where students capture data and write conclusions. Below is some sample data presented in graph format using MS Excel.

EXPERIMENT 1



EXPERIMENT 2



Note to Teacher *continued*

How to use the lesson materials

1. Review the other lesson materials thoroughly.
2. Read "Overview/PowerPoint/Lesson Guide." It will serve as a general guide for the lesson content. It is also modifiable, but note that it is only modifiable if you use the "Save As" option or browse to it. (If you click on it in the lesson page, you will not be able to modify it.) To get a version you can modify, go to "File/Save As" to save a copy to your computer, or browse to Vex Curriculum/Content/Lessons/ remote_control/documents/teachernote.doc on the Vex curriculum, and copy it to your computer.
3. Read the remainder of this document. It will serve as a general guide for how to teach the lesson content. It is also modifiable, but note that it is only modifiable if you browse to it. (If you click on it in the lesson page, you will not be able to modify it.) To get a version you can modify, browse to Vex Curriculum/Content/Lessons/ remote_control/documents/teachernote.doc on your cd and copy it to your computer.
4. Have your students review all the materials in "Background." Under "Slide Shows", "Tacoma Bridge" provides a real world example of resonance, and "Signal Box" is a step-by-step guide to building the platform needed for the lesson. Under "Helper Links", "Engineering Notation" and "Scientific Notation" explain those forms of notation. Under "Resources," "Example Data for Student Exercise" provides a set of sample values resulting from the experiment. Note that you should choose whether to print and hand out this excel document and ask students to make a similar table, or whether you want to tell students to save the file to their own computer, and modify the document by adding data gathered from their own experiments. Lack of computers and potential technical problems may make printing the table and asking students to construct a similar table the easier option. "Remote Control Guide" is a slideshow with linked videos that you can use as a reference for advanced remote control use.
5. Modify and add to the lesson in the way that will best serve your classroom.
6. Teach the lesson, drawing on lesson materials where appropriate. You may wish to begin the lesson by having your students go through "Introduction for Students" and the PowerPoint Lesson Guide, as these link an explanation of resonance to the lesson procedures. Note that "Lesson/Multimedia/ Vex Controller and Resonance" provides an animated explanation of how resonance works in sending signals, while "Lesson/Printable PDFS" provide step-by-step procedures. "Multimedia/Vex Controller… " is designed to show the class before beginning the lesson. The printable PDFS should be printed and given to each lab group as a procedural guide.
7. Assign the "Checking for Understanding" Quiz.