Note to the Student

Overview

These notes will be your guide for this investigation. These notes cover the lessons, key concepts, and reference material.

Glossary

Resonance	The induction of vibrations on a physical object by a vibrating force having the same frequency
Oscillate	To swing back and forth with a steady, uninterrupted rhythm
Oscillator	A device or mechanism for producing or controlling oscillations
Amplify	To make larger; to increase
Amplifier	To amplify an electric signal; to increase an electric signal
Frequency	The measurement of the number of times that a repeated event occurs per unit time; measured in Hertz (1 / s)
Period	The interval taken to complete one cycle of a regular repeating phenomenon; measured in units of time
Sinusoid	A sine wave, like the one shown in Figure 1

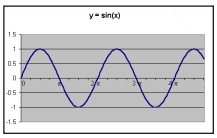

Figure 1

Introduction to Resonance

Resonance is the induction of vibrations on a physical object by a vibrating force having the same frequency.

For an example of resonance, consider a trumpet and a kettledrum, tuned to the note of “E”, placed in the same room. When the trumpet plays the “E” note, the sound wave leaves the trumpet and travels through the air. The air molecules vibrate against the surface of the kettledrum and, because the drum is tuned to the same frequency, the drum will vibrate with an audible sound.

Figure 2

Resonance may cause physical objects to behave strangely. A drastic demonstration can be seen in the video of the bridge constructed over the Puget Sound in the state of Washington seen in Figure 2. Every bridge is constructed to vibrate at some natural, or resonant frequency. However, the civil engineers who designed this bridge erred when they did not check to determine the value of the bridge’s resonant frequency. It turned out that the bridge’s natural frequency was equal to the frequency of the wind that flows from the Puget Sound and across the bridge. During resonant conditions, energy from the wind was transferred to the bridge and the amplitude of the bridge vibration became larger and larger until the maximum bridge forces were exceeded and the bridge was destroyed.

See “Background / Slide Shows / Tacoma Bridge” for a video.

Resonance in Electronic Circuits

The crystals in your Vex receiver and radio control transmitter exploit the resonance property in their circuits. They use resonance to transmit signals. Consider an example. How does the signal get sent from your radio control transmitter to your robot to turn on the right motor?

How is a signal sent from the radio control transmitter antenna?

First, a crystal is placed in the radio control transmitter as part of an oscillator circuit. This oscillator circuit sends electrons to vibrate the crystal. The crystal begins to vibrate at its resonant frequency. The oscillator circuit then sends this signal to an amplifier, which makes the signal larger. The amplified signal travels to the antenna

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where it is changed into an airborne electromagnetic wave. Refer to the "Lesson / Multimedia / Vex Controller and Resonance" slide show for a visual illustration of this.

How does the robot receiver the signal from the radio control transmitter?

While the radio control transmitter sends waves via its antenna, the Vex receiver on the robot is using an antenna to receive these electromagnetic waves. The receiver then changes these waves to an electrical signal. The signal is amplified and sent to the circuit containing the crystal. If the amplified signal is at the same frequency of the crystal in the receiver, then the crystal will generate a large sinusoidal signal. This will activate a circuit in the micro controller that will active that motor. Refer to the "Lesson / Multimedia / Vex Controller and Resonance" slide show for a visual illustration of this.

Figure 3

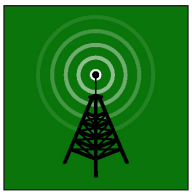

Figure 4

Antenna Transmission

There are two basic ways an electromagnetic wave leaves the transmitting antenna. The first is the axial method of transmission. Here the energy of the electromagnetic wave leaves the antenna in a manner that light leaves a flashlight as illustrated in Figure 3.

The second method of antenna transmission is the radial method. Here the energy of the electromagnetic wave radiates in a radial direction as shown in Figure 4.

Description of the Lessons

To begin this investigation, you will work in teams of 2 or 3 and construct a simple test robot system that can be controlled by a radio control transmitter and has an observable output. Your system must include the following Vex components:

- Radio control transmitter with crystal and adequate battery power
- Receiver with matching crystal
- Vex micro controller and charged battery
- One motor
- Visual demonstration of motor output (ex. wheel turning, fan blades spinning)

Once you have used "Background / Resources / Signal Box Construction Show" to construct your robotic system, you can begin the lessons.

HORIZONTAL ANTENNA TEST / Lesson 1

Goal of this Lesson: Your team will explore the relationship between antenna height and signal strength. The hypothesis is that transmission strength of the radio control transmitter is directly related to antenna height.

VERTICAL ANTENNA TEST / Lesson 2

Goal of this Lesson: Your team will explore the relationship between antenna height and signal strength. The hypothesis is that the transmission strength of the radio control transmitter is better when not directly pointing at the receiver.

TEST WITH OBSTACLES / Lesson 3

Goal of this Lesson: Your team will determine the effect of an obstructed receiver on the radio control transmitter signal strength. The hypothesis is that steel will interfere the most with your radio control transmitter.

SINUSOIDS, FREQUENCY AND PERIOD / Lesson 4

Goal of this Lesson: Your team will learn about sinusoids and the relationship between frequency and period.

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Math Versus Science

As you complete the investigation, you 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 your control. A good scientist will eliminate as many uncontrollable variables as possible so that they are able to analyze and measure the results of their investigations.

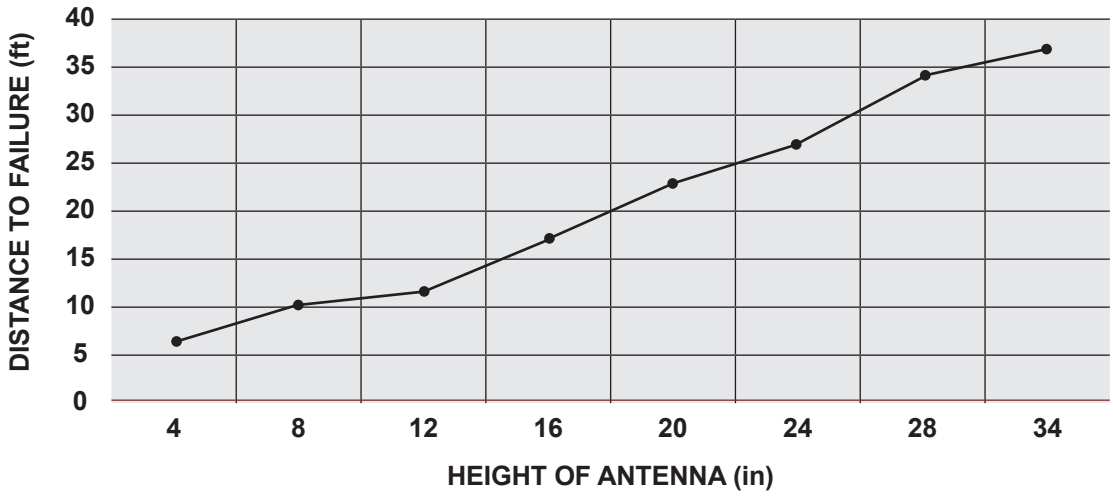
Experimental Error

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 include a dead battery, improperly connected components, or a 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 you will capture data and make conclusions. Below is some sample data presented in graph format using MS Excel.

EXPERIMENT 1



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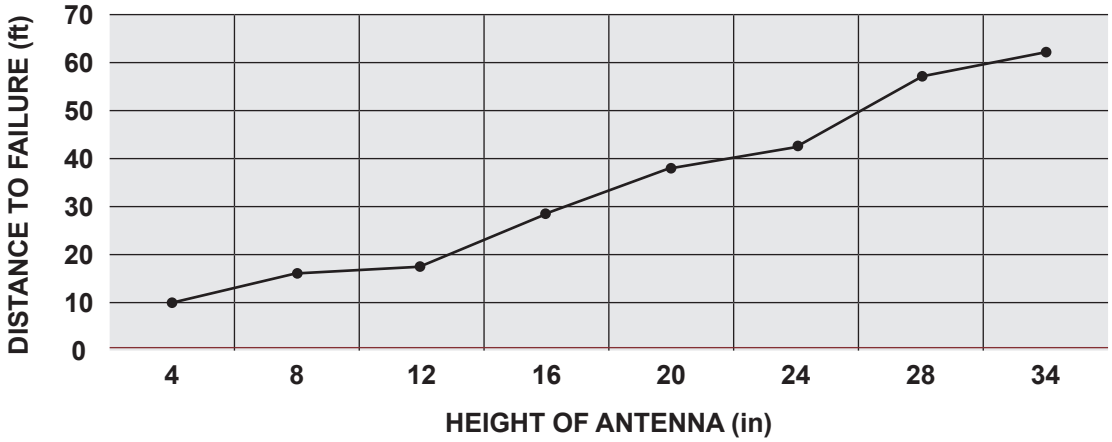
EXPERIMENT 2



References

Use the following resources:

- For a review of, or to learn about scientific and engineering notation, refer to "Background / Helper Links / Scientific and Engineering Notation"
- For a visual presentation of the lesson material, watch "Overview / Video / Video Preview"
- For information about resonance, refer to the "Background / Slide Shows / Tacoma Bridge" slide show, or the "Lesson / Multimedia / Vex Controller and Resonance" slide show
- For a template of the lesson datasheet, refer to the "Background / Resources / Lesson Datasheet"
- For advanced radio control transmitter functions, refer to "Background / Resources / Radio Control Transmitter Guide"
- For directions on how to assemble the robotic platform for your lessons, refer to "Background / Resources / Signal Box Construction"
- For detailed procedural guides of all the lessons, refer to the "Lesson / Printable PDF" section