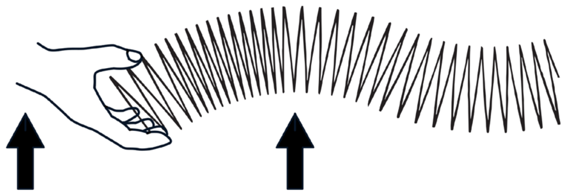
STUDENT ACTIVITY

Name: ______________________ Class: __________ Date: ____________

CRASH SCIENCE IN THE CLASSROOM

RADAR SLINKY



Key Question(s)

» What types of waves do crash avoidance sensors generate?

» How do vehicles use different types of sensors to avoid collisions?

» What is the range of different types of crash avoidance sensors?

Purpose

» Create transverse pulses and waves with a Slinky®.

» Analyze transverse pulses of different amplitudes.

» Describe the relationship between the amplitude and energy level of a transverse pulse.

» Label the parts of a transverse wave.

» Measure the wavelength of a transverse wave.

» Describe the relationship between the frequency of a wave and its wavelength.

» Calculate the maximum range of various crash avoidance sensors using a scale diagram.

» Determine which two types of crash avoidance technologies provide the greatest collision-reduction and safety benefits.

Did you know?

By utilizing electromagnetic wave technologies like radar, visible-light cameras, and LIDAR, crash avoidance sensors in vehicles can detect imminent collisions, erratic driving behavior, or obstacles in the vehicle's path thereby contributing significantly to reducing the severity and frequency of collisions and ultimately saving lives on the road (see Figure 1). In this activity, you will use a Slinky to simulate electromagnetic or transverse waves to explore how these types of crash avoidance sensors work.

Group Roles (switch roles at least once during the activity)

Students 1 and 2 – will firmly hold each end of the Slinky and generate pulses and waves.

Student 3 – will use a plastic or paper cup, meterstick or measuring tape, and digital camera to measure and record data and observations.

Safety Notes

» Firmly grip the Slinky and always hold it flat on the floor when it is stretched and moving.

» Do not release the Slinky while it is stretched, or it can become permanently tangled.

» Wear safety glasses while the Slinky is stretched.

» With your teacher's permission, use a tablet or phone camera to record video of the waves passing through the Slinky. Follow school rules when using the camera in the classroom. Do not record classmates' faces.

MATERIALS NEEDED

Per Group of Three Students

» 1 Slinky®

» 2-3 metersticks or measuring tape

» 1 roll of masking tape

» 1 plastic or paper cup (any size)

» 1 digital camera device (e.g., computer tablet or smart phone)

» 1 "Summary of Real-world Benefits of Crash Avoidance Technologies" (digital access or hard-copy – see Advance Preparation)

Per Student

» 1 "RADAR SLINKY" Student Activity Sheet

» 1 pair of safety glasses

» 1 centimeter ruler

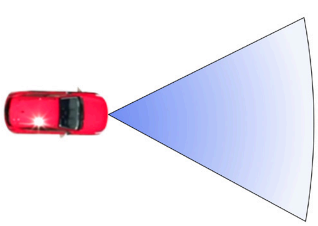


Figure 1. Crash Avoidance Sensor emitting waves

RADAR SLINKY

Procedure

Part 1 - Creating a Transverse Pulse

1. View the Introduction video for this activity at classroom.iihs.org to watch Dr. Griff Jones use a Slinky to create transverse pulses and waves with a Slinky.
2. Make a 2-3 m straight line on the floor with masking tape. The line will mark resting position of the Slinky.
3. Stretch the Slinky over the center of the line of masking tape. Don't over stretch the Slinky. Hold each end firmly, keep it flat on the floor, and do not let go. Keep the Slinky stretched out to the same length throughout the activity.
4. Take turns creating a single transverse pulse with your Slinky by quickly snapping your hand once to the right and then back to center. Let the Slinky return to its resting position before producing another pulse. Try creating pulses of different sizes.
    a. Closely observe one pulse traveling down and back to your hand.
    b. What happened to the pulse when it reached your partner's hand at the other end of the Slinky?

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5. Place a cup upside down and 3 cm away from the right side of the Slinky. See Figure 2 for an example.
    a. Send a pulse down the Slinky to hit the cup. Observe how far the cup travels after impact.
    b. Replace the cup in its original position and repeat with different size pulses.
    c. How does the size (amplitude) of the pulse hitting the cup affect how far the cup moves?

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6. The size or **amplitude** of a pulse is determined by measuring the maximum distance that the Slinky coils move away from the resting position. See Figure 2a.
    a. How does the **amplitude** of the pulse change as it travels down and back to your hand?

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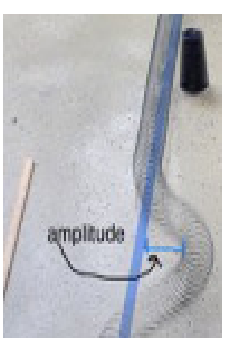

Figure 2. Cup placed upside down next to Slinky

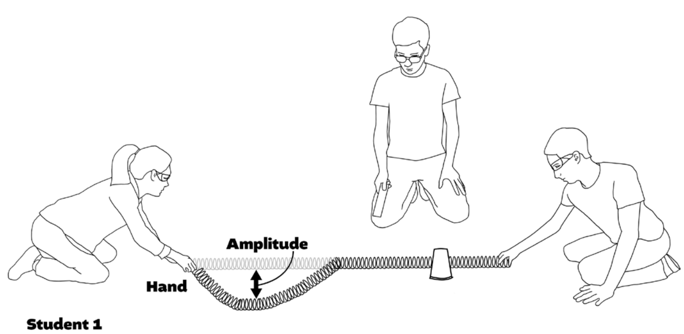

Figure 2a. Amplitude of a transverse pulse traveling towards the cup.

RADAR SLINKY

Part 2 – Creating and Measuring the Wavelengths of Transverse Waves

7. Create transverse waves by quickly and continually snapping your hand from side-to-side to generate a succession of transverse pulses. If needed, rewatch the Introduction video of Dr. Jones creating transverse waves.

8. Use Figure 3 to identify the parts of the wave.

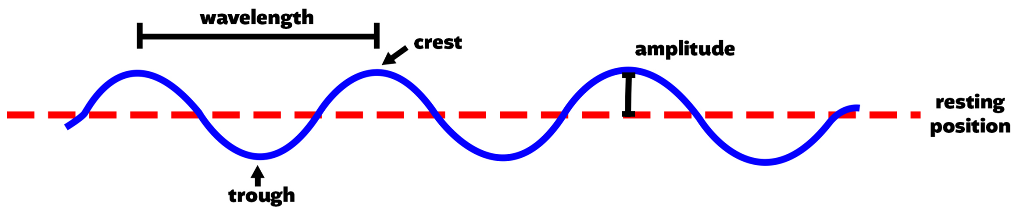

Figure 3. Parts of a transverse wave.

9. Take turns creating transverse waves and change how fast you snap your hand from side-to-side.

» The number of times your hand moves side-to-side in one second is the frequency at which you generate the wave. More hand movements per second = high wave frequency.

» Practice creating and observing the visible differences in transverse waves of different frequencies

10. Follow these steps to create and video transverse waves with different frequencies.

» Place two to three metersticks end-to-end alongside the Slinky to create a 200-300 cm meterstick (or stretch out a 200-300 cm length of measuring tape). See Figure 4 below.

» Create a low frequency transverse wave.

» Using a digital camera, record a video 5-10 seconds long of the lower frequency wave. Make sure that both the Slinky and the meter sticks or measuring tape next to the Slinky are clearly visible in the video.

» Replay and pause the video after a few seconds. With the video paused, you should be able to drag your finger along the bottom of the screen to slowly scroll through the video. (This may vary with different types of devices.) Slowly scroll until you find a good spot in the video that allows you to see the distance between two successive crests along Slinky and pause the video. See Figure 4 below.

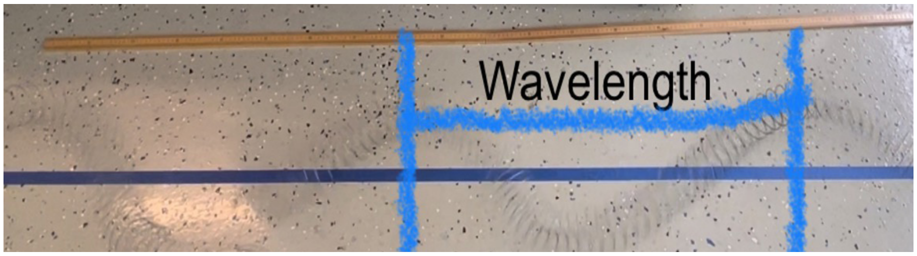

Figure 4. *The wavelength is the distance between two identical points along a wave (in this photo it is 90 cm between two crests).*

RADAR SLINKY

11. With the video paused, follow these steps to measure the wavelength of the wave in the Slinky:

» Look closely at the metersticks in the video and count the centimeters between the centers of two crests. Record the wavelength for the lower frequency wave in Table 1 below. (You may need to zoom in on the metersticks to better see the measurements. If the meterstick is out-of-focus, repeat Step 10 and focus the camera on the meterstick by tapping on the meterstick on the video display screen before videoing.)

» Next, create a higher frequency transverse wave and repeat the videoing and measuring steps above. Record the wavelength of the higher frequency wave in Table 1 below.

Table 1. Wavelengths of Lower and Higher Frequency Transverse Waves

Wave frequency	Wavelength (cm)
Low	
High	

Analysis Questions

1. Do you think a pulse with a larger amplitude transfers more energy, less energy, or about the same amount of energy as a pulse with a smaller amplitude? Why do you think so?

2. If the size (amplitude) indicates the amount of energy in a pulse, then why does amplitude decrease as the pulse travels down the Slinky and then back to your hand? In other words, where does the energy "go?"

3. In Table 2 on the next page, draw an example of a lower frequency transverse wave and an example of a higher frequency transverse wave. For each wave, label a crest, a trough, the amplitude, and the wavelength..

Table 2. Illustrating Parts of Lower and Higher Frequency Transverse Waves

Lower Frequency	---resting position
Higher Frequency	---resting position

4. As the frequency of a transverse wave increases, what happens to its wavelength?

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Crash Science Questions (Refer to Table 3 and Figure 5 on the next two pages to answer Crash Science Questions 1 and 2.)

1. Examine Table 3 and answer the following questions:

a. Which sensor type generates a completely different type of wave than the others? ____________

b. What type of wave does it generate? ____________________________

c. Does it travel as a longitudinal wave or a transverse wave? ____________________

2. Carefully study Figure 5 and complete the following tasks:

a. Using a ruler, measure the maximum range (in centimeters) for each type of sensor.

b. Using the scale of **1 cm = 15 meters,** calculate the maximum range (in meters) for each type of sensor.

c. Convert the maximum range from meters to feet by multiplying the value in meters by 3.28 ft.

- For example: converting 15 m into feet = 15 m x **3.28 ft.** = 49.2 ft.

d. Record your answers in Table 3.

3. Study the 1-page IIHS-HLDI 2025 Summary of Real-world Benefits of Crash Avoidance Technologies (provided by your teacher) and list the two types of technologies responsible for the two highest reduction rates of police-reported crashes and insurance claims.

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RADAR SLINKY

Table 3. Determining the Range of Crash Avoidance Sensors

Sensor type	Wave type	Crash avoidance system(s)	Measure-ment (cm)	Typical range* conversion to m (1 cm = 15 m)	Typical range* conversion to ft (m x 3.28 ft)
LIDAR	EM, transverse	All			
Long-range RADAR	EM, transverse	Adaptive Cruise Control			
Visible-light camera	EM, transverse	Forward Collision Warning, Automatic Emergency Braking, Lane Departure Warning/Prevention			
Medium-range RADAR	EM, transverse	Forward Collision Warning, Automatic Emergency Braking, Rear Cross Traffic Alert			
Short-range RADAR	EM, transverse	Blind Spot Warning/ Detection, Rear Cross Traffic Alert			
Ultrasonic	Sound, longitudinal	Parking, Rear Automatic Emergency Braking			

*These ranges are approximate and may vary among different vehicle models and manufacturers. Advancements in technology and the specific design of the collision avoidance system can influence the effective range.

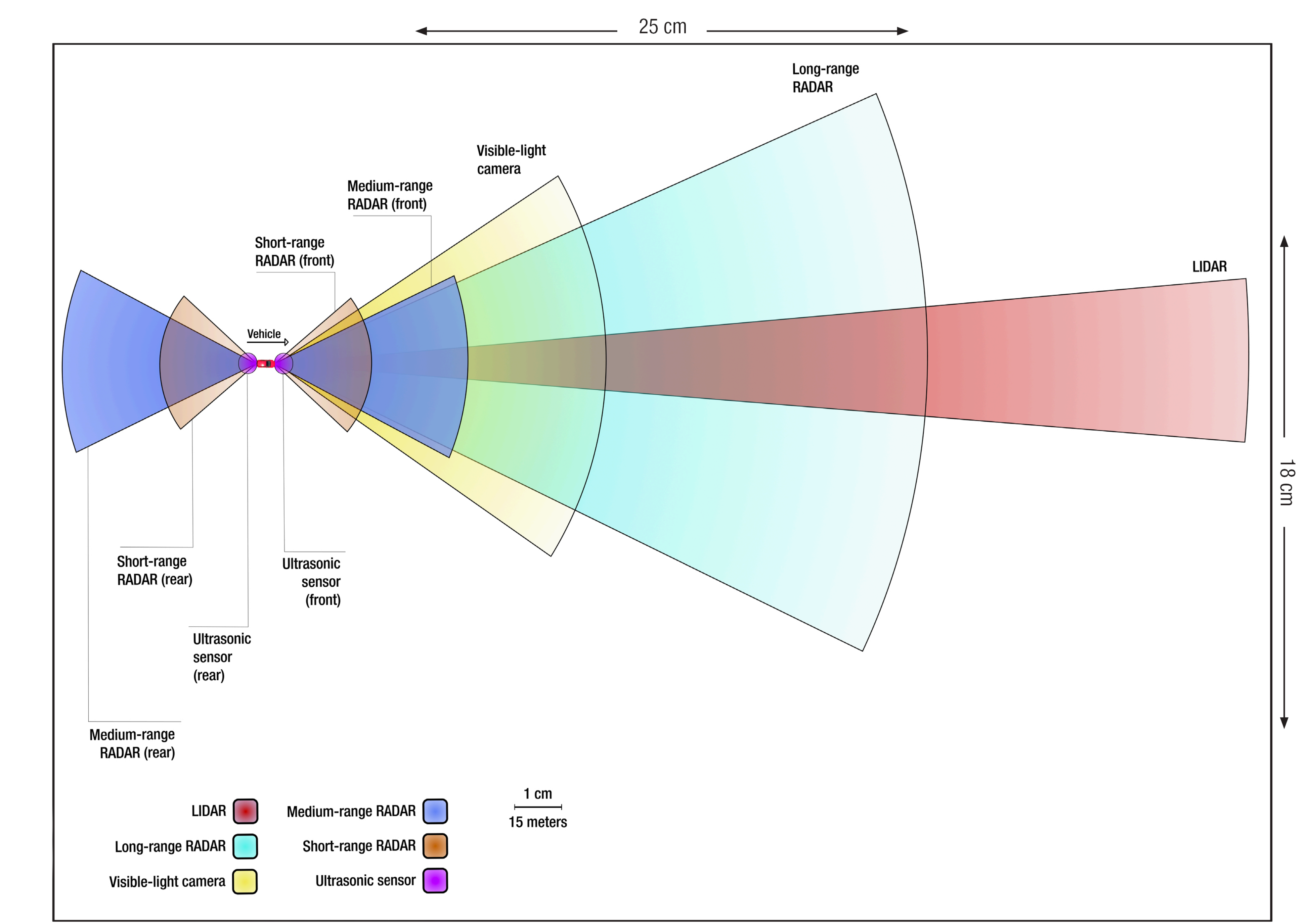


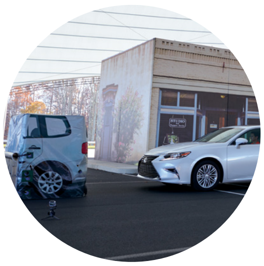
Figure 5. Determining the Range of Crash Avoidance Sensors

IIHS HLDI

CRASH AVOIDANCE TECHNOLOGIES

Real-world benefits

HLDI and IIHS study the effects of crash avoidance features by comparing rates of police-reported crashes and insurance claims for vehicles with and without the technologies. Results below are for passenger vehicles unless otherwise noted.



Automatic emergency braking

- ↓ **50%** Front-to-rear crashes
- ↓ **56%** Front-to-rear crashes with injuries
- ↓ **14%** Claim rates for damage to other vehicles
- ↓ **24%** Claim rates for injuries to people in other vehicles
- ↓ **41%** Large truck front-to-rear crashes

Automatic emergency braking with pedestrian detection

- ↓ **27%** Pedestrian crashes
- ↓ **30%** Pedestrian injury crashes

Lane departure warning

- ↓ **11%** Single-vehicle, sideswipe and head-on crashes
- ↓ **21%** Injury crashes of the same types

Blind spot detection

- ↓ **14%** Lane-change crashes
- ↓ **23%** Lane-change crashes with injuries
- ↓ **7%** Claim rates for damage to other vehicles
- ↓ **8%** Claim rates for injuries to people in other vehicles

Rear automatic braking

- ↓ **78%** Backing crashes (when combined with rearview camera and parking sensors)
- ↓ **9%** Claim rates for damage to the insured vehicle
- ↓ **29%** Claim rates for damage to other vehicles

Rearview cameras

- ↓ **17%** Backing crashes

Rear cross-traffic alert

- ↓ **22%** Backing crashes

Added costs

Lower crash rates are a clear benefit of these technologies, but some features can lead to higher repair costs in the crashes that do happen. That's because sensors and other components are often located on the vehicle's exterior. For example, in the case of forward collision warning without auto-brake, the average payment per claim for damage to the insured vehicle goes up $118 for vehicles equipped with the feature.