Math Xa Lab   Name _____
Laser Speed Gun   Collaborators _____
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How a Laser Speed Gun Works

(From howstuffworks.com)

A normal radar speed gun sends out a radio pulse and waits for the reflection. Then it measures the doppler shift in the signal and uses the shift to determine the speed.

The new laser speed guns use a more direct method that relies on the reflection time of light rather than doppler shift. You have probably experienced the reflection time of sound waves in the form of an echo. For example, if you shout down a well or across a canyon, the sound takes a noticeable amount of time to reach the bottom of the well and travel back to your ear. Sound travels at something like 1,000 feet (300 meters) per second, so a deep well or a wide canyon creates a very apparent round-trip time for the sound.

A laser speed gun measures the round-trip time for light to reach a car and reflect back. Light from a laser speed gun moves a lot faster than sound – about 984,000,000 feet per second (300,000,000 meters), or roughly 1 foot (30 cm) per nanosecond. A laser speed gun shoots a very short burst of infrared laser light and then waits for it to reflect off the vehicle. The gun counts the number of nanoseconds it takes for the round trip, and by dividing by 2 it can calculate the distance to the car. If the gun takes 1,000 samples per second, it can compare the change in distance between samples and calculate the speed of the car. By taking several hundred samples over the course of a third of a second or so, the accuracy can be very high.

Speeding Ticket

While you were vacationing in Canada, Officer Trapp aimed her laser speed gun at your car and pulled you over for driving too fast. She said that you were going 91 kilometers per hour in a 90 km/hr zone, and wrote you a ticket for 80 pounds. Officer Trapp was standing directly behind your car as she took her readings.

You are planning to contest the ticket, and you are able to obtain the table on the next page which lists the time that it took each pulse fired by the laser to return, and the corresponding distance from the laser gun to your car.

1. Find your average speed between $t = 0.015$ and $t = 0.020$.

2. Find your average speed between $t = 0.015$ and $t = 0.016$.

3. Find your average speed between $t = 0.010$ and $t = 0.015$.

Table 1: Data From Laser Speed Gun

Time Pulse Sent (in seconds)	Time Pulse Received (in thousands of sec)	Distance from car to gun (in meters)
0	0.0005005	150.0027
0.002	2.000001001	150.0593
0.004	4.000001002	150.1143
0.006	6.000001002	150.1677
0.008	8.000001002	150.2208
0.01	10.000001	150.2736
0.011	11.000001	150.2997
0.012	12.000001	150.3255
0.013	13.000001	150.3513
0.014	14.000001	150.3769
0.015	15.000001	150.4022
0.016	16.000001	150.4269
0.017	17.000001	150.4513
0.018	18.000001	150.4755
0.019	19.000001	150.4997
0.02	20.000001	150.5239
0.022	22.00000101	150.572
0.024	24.00000101	150.6198
0.026	26.00000101	150.667
0.028	28.00000101	150.7136
0.03	30.00000101	150.7598

4. Find your average speed between $t = 0.014$ and $t = 0.015$.

5. Using the above calculations, what are the best upper and lower bounds that you can find for the instantaneous velocity (in m/s)?

6. Convert these upper and lower bounds into kilometers per hour.

7. Write a one or two sentence argument about why you should *not* have to pay the speeding ticket based on your calculations.

8. In response to your letter contesting the ticket, Officer Trapp claims that you must have stepped hard on your brakes as soon as you saw the speed gun, and that actually you were going much faster than 91 km/hr. Does the data support Officer Trapp? Why or why not?

9. Which of the following graphs could be the graph of the function $d(t)$, where t is the time in seconds, and d is the distance between your car and the speed gun?
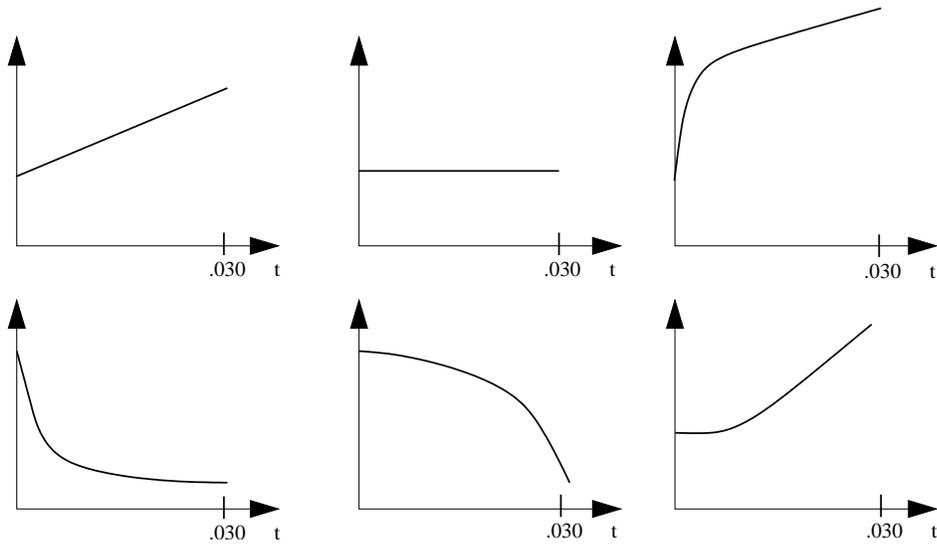
10. Which of the following graphs could be the graph of the function $s(t)$, where t is the time in seconds, and s is the speed of your car?