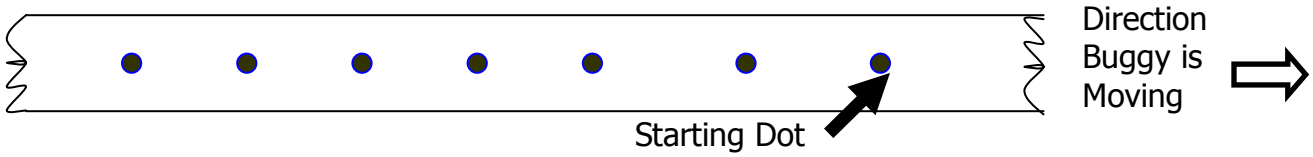
Investigating Motion using a Toy Dune Buggy

Question: What is the motion of a battery powered Dune Buggy?

A student says a battery powered Dune Buggy moves along at constant speed. Another thinks the motion changes. Let's see how we can investigate the buggy's motion.

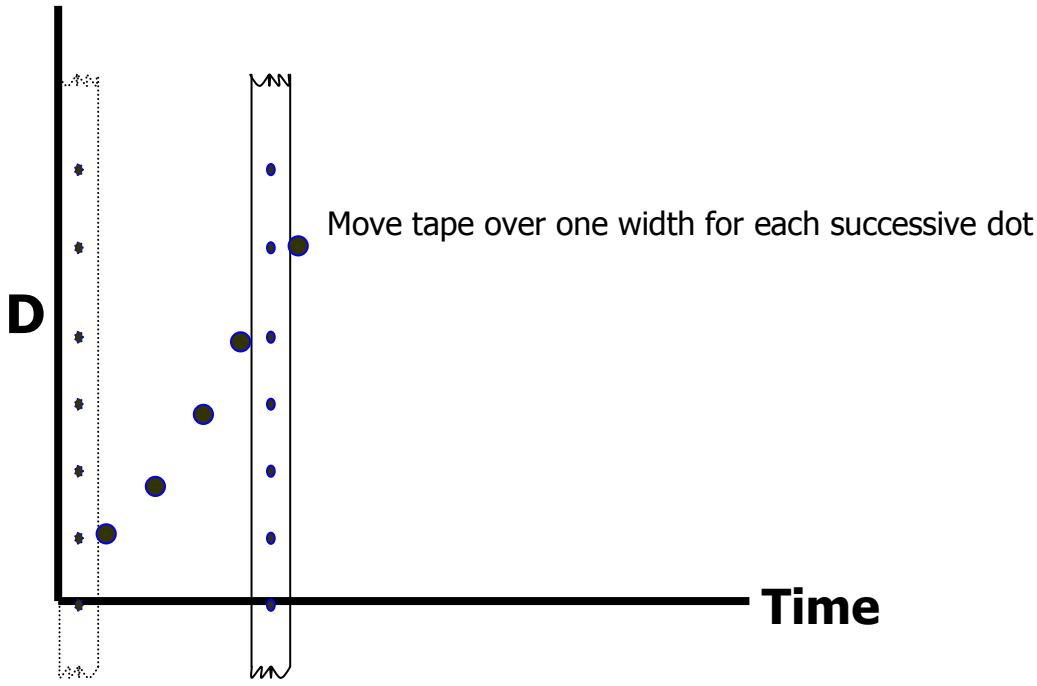
Investigation

1. Attach a strip of adding machine tape to the back of a toy Dune Buggy.
2. Students clap in time with the flashing lights.
3. As the Buggy pulls the adding machine tape past a student, she moves her hand in time to the clapping while holding a marking pen in her hand. The marking pen taps dots onto the moving tape strip as it passes by.
4. The tape then has a series of dots, recording the motion of the Buggy. (see below)



Creating a Distance Versus Time Graph

1. The tape can be used directly to make a graph.
2. Use a white board or large sheet of paper to create a graph. On the left hand side make a vertical line labeled D or Distance, and along the bottom, make a horizontal line marked Time.
3. Place the tape vertically with the starting point on the horizontal Time axis. The edge of the tape touches the vertical axis.
4. Along the right side of the tape place a mark at the same height as the next dot on the tape.
5. Move the tape to the right an amount equal to its width to represent the next time interval.
6. Mark the next higher dot on the graph.
7. Repeat to create the graph for the whole trip.! (See Below)



Looking at the Distance Time Graph

What is the shape of the graph you just made? Is it a straight line or is it curved?

- To understand the meaning of the shape of the graph, let's think about what is happening as we go from one dot on the graph to the next.
- Starting at the first dot we must go to the right along the Time axis, one unit of time.
- Then we go up to the next dot. The amount we go up is how far the Buggy went in that unit of time.
- Remember that we call the distance traveled for each unit of time the speed or velocity in that direction.

Graph Shapes

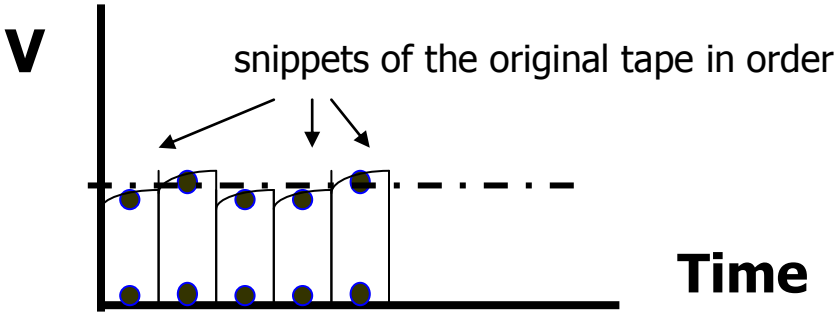
A straight sloping line says that for every unit you go to the right, the distance you go up will be the same. (This is like steps of a stair case. You would be able to place a long straight board along the steps, so that each corner of the stairs touches the bottom of the board. A straight line on a graph connects the "over" and "up" distances on a straight line graph.)

A curved line will have a different distance "up" for every unit you go across. If the "up" distance increases each time, the line will curve up. If the distances are less each time the line curves down.

Back to our Buggy's Tape

- We know that the distance between each dot is the actual distance traveled in that period of time. Also speed is defined to be the distance traveled for each unit of time (speed = D/T). In a straight line we can call the speed the velocity

  We can now use our tape to find the speed (velocity) of the Buggy as it moves.
- If you cut across the tapes at each dot, the length of the tape is the distance traveled during that time. It is the "distance per unit time" or speed of the Buggy.
- By numbering the spaces between the dots along the original tape and cutting the tape through the dots, we can line up the "snippets" along a graph as shown below. This makes an automatic Velocity (Speed) - Time graph!



Speed – Time Graphs for different types of motion

If an object moves at the same speed all the time, what would you notice about the lengths of the "snippets"

- Would they be about the same length or different lengths?
- Does having the same speed mean having the same length?
- We call same speed all the time, constant speed or constant velocity.

If the Buggy speeds up it will be going farther each unit of time.

- How would the lengths of the "snippets" compare each time?
- Going faster and faster is called acceleration.

If the Buggy was slows down it goes less distance for each next unit of time.

- How would the lengths of the "snippets" compare each time?

Your Buggies Speed – Time Graph

Go ahead and cut your Buggy's tape up into "snippets" and make a Speed time graph for its motion. Remember to number the intervals between dots before cutting the tape to keep the speeds in order.

What does your Buggy's graph tell you about its motion? How do you know this?

Some Practice

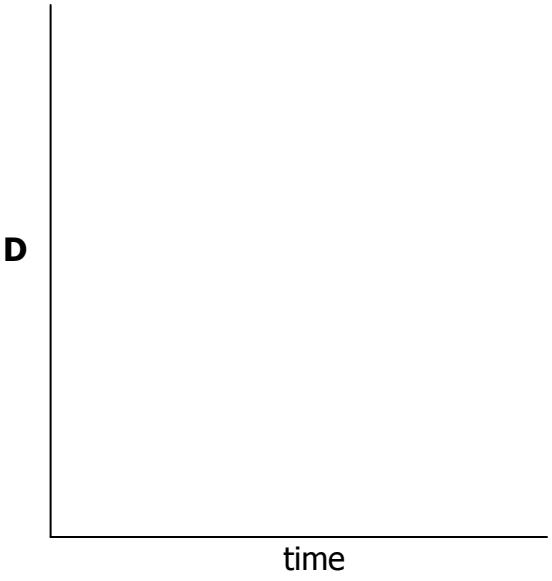
1. If a Buggy's speed is constant, how would the dots be spaced along the tape?

2. Mark dots on the tape below to show what it would look like if the object's speed were constant. The first 2 dots are made for you

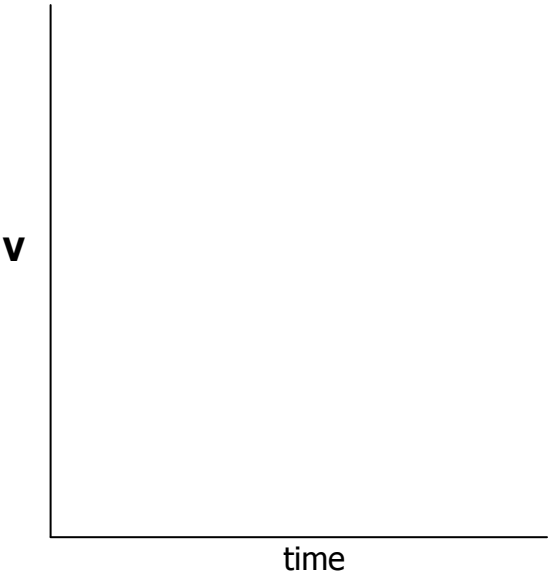
3. If a Buggy's speed keeps increasing, how would the dots be spaced along the tape?

4. Mark dots on the tape below to show what it would look like if the object's speed keeps increasing. The first 2 dots are made for you

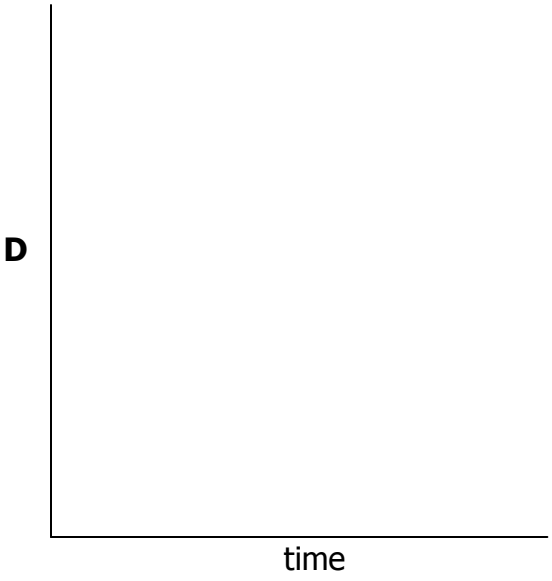
5. Use the space below to sketch the distance – time graph you might make using the tape of a car that moves at a constant speed.



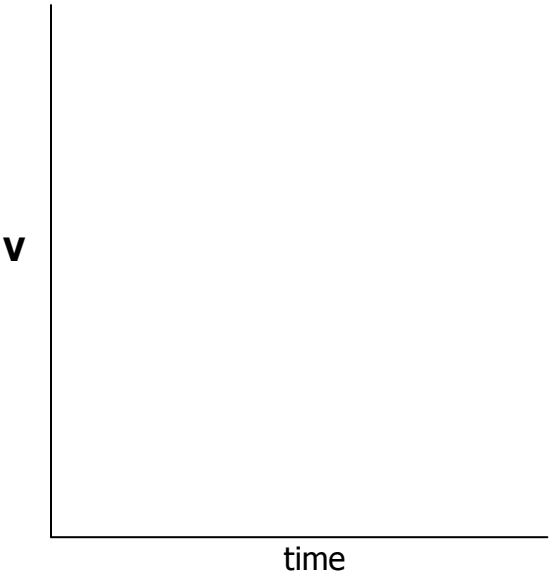
6. What would the "snippet" speed – time graph look like for Problem 5? Sketch it below



7. Use the space below to sketch the distance – time graph you might make using the tape of a car that moves at increasing speed

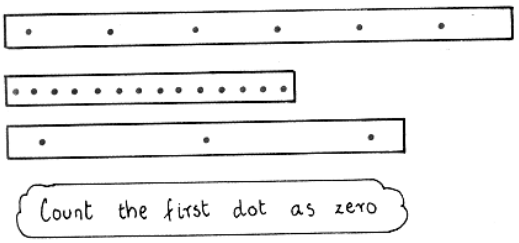


8. What would the "snippet" speed – time graph look like for Problem 7? Sketch it below



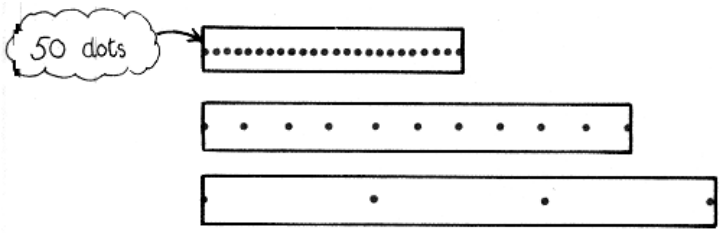
The following questions ask for calculation made from the sketches given. Assume the time between dots is one second.

1. For each tape below work out how long it took to print the dots.

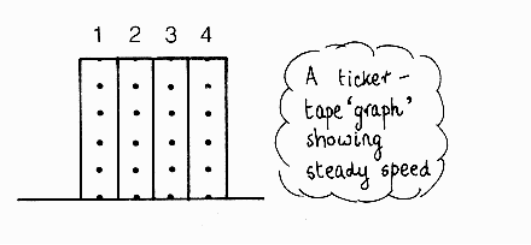


2. Which tape was pulled through the timer fastest? Explain your answer.

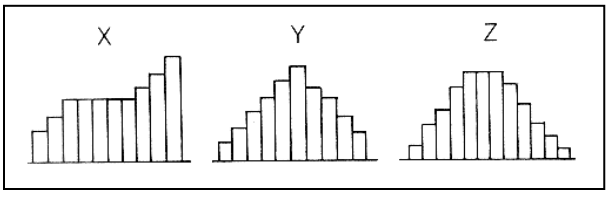
3. Work out the speeds of the 3 tapes below shown full size.



4. The ticker tape below shows steady speed, what is that speed if each tape is 2cm long.? Show your working out.



5. The diagrams below show ticker tape graphs of moving objects.



Which one fits these descriptions? (see drawing on previous page)

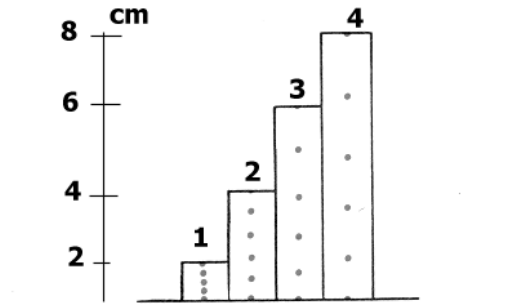
1. the object accelerates then decelerates
2. the object accelerates, travels at steady speed, then accelerates again.
3. the object accelerates, travels at steady speed, then decelerates.

6. Copy and complete this table.

Speed	Distance	Time
	100m	5s
5m/s		10s
8m/s	96m	
	36km	1hr

7. The ticker tapes below show acceleration.

a) How long did it take to make each tape?



Ticker-tape graph showing an acceleration (or increase in speed)

b) Calculate the

i) speed of tape 1 =

ii) speed of tape 2 =

iii) speed of tape 3 =

iv) speed of tape 4 =

The formula for acceleration is **Acceleration = $\frac{\text{change in speed}}{\text{time}}$**

c) What is the change in speed from tape 1 to tape 4?

d) What time interval did it take to change this speed?

e) What was the acceleration of the tape?