



student activity



Name: _____

Teacher: _____

Mathematics B Education Program

School: _____

Speed may be the ultimate quest of the daredevil, but clever thrill-seekers know that it is really acceleration that creates the ultimate rush. The Blue Ringed Octopus has no shortage of either, and in this activity you will investigate just how much speed and acceleration you experience. A stopwatch and radar gun may allow you to measure speed simply enough, but you will need to master the powerful tool of calculus to get a handle on your acceleration!

Syllabus Links

Rates of change - calculation of average rates of change in both practical and purely mathematical situations

Rates of change - interpretation of the derivative as an instantaneous rate of change

Rates of change - practical applications of instantaneous rates of change

Rates of change - determine average and instantaneous accelerations from a velocity–time graph

Introduction to integration - investigate the motion of a falling body in terms of its displacement and velocity as functions of time neglecting air resistance

Introduction to integration - from a velocity time function (or graph) determine a distance or displacement function (or graph); interpret the result

Equipment

Student activity sheets, pens/pencils, graphics calculators, stopwatches (with lap time), radar guns (supplied by WWW)



Activities with this symbol may be completed while you're having lunch or after you leave WhiteWater World.

Standard Achieved

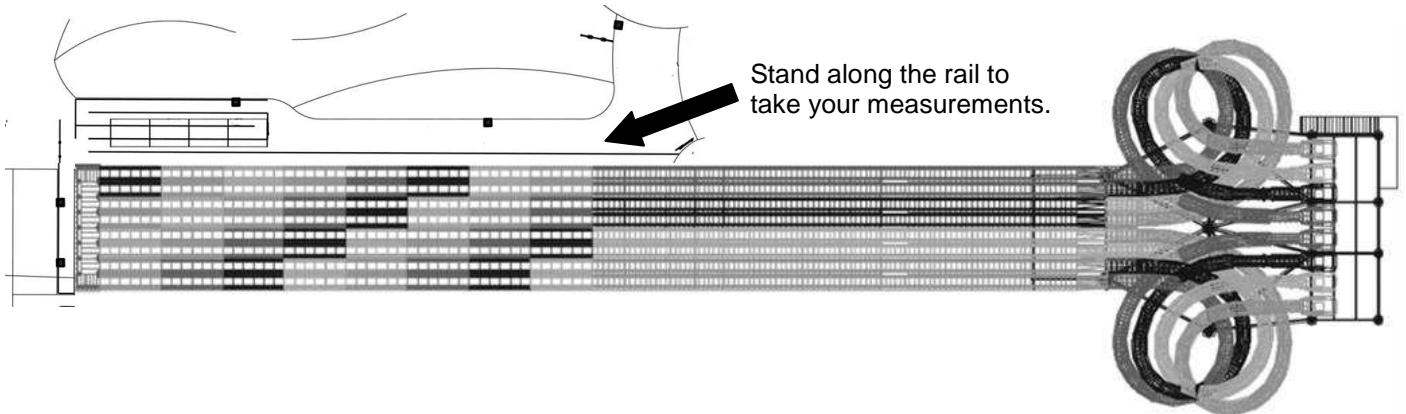
Knowledge & Procedures

Communication & Justification

Average Velocity

Your average velocity on the Blue Ringed Octopus is crucial because the person with the highest average velocity will win the race. To measure the average velocity of a racer, you need to measure the distance that they cover and the time that it takes.

The best location for taking measurements is from the rail that runs alongside the runout part of the slide, as in the diagram below. This will give you a good view of the riders to allow you to take time and distance measurements, as well as the best angle with the radar gun for measuring velocities. Be sure to stand close to the rail so as to stay out of the way of people using the path.



Question 1

From your observation point, use a stopwatch to time a racer on the Blue Ringed Octopus, from the moment that they get the signal from the starter until they come to a dead stop. It will be useful to position a friend on the launch level of the Blue Ringed Octopus, and arrange for them to signal to you to start the stopwatch the instant that the race begins. You will also need to note exactly where the rider comes to a stop (to answer Question 2).

Time = _____ s

Question 2

To find the average velocity, you will also need to know the distance covered by the rider. The total length of the track is 120m, but this is measured to the end of the runout and a rider will never reach this full distance. To estimate the distance that they cover, use the coloured modules that make up the track runout as a guide. Each of these is about 4.5m in length. By counting back from the end to the position at which the rider stops and then subtracting this from 120m, you should be able to record the distance that they have covered to the nearest metre.

Distance = _____ m

Question 3

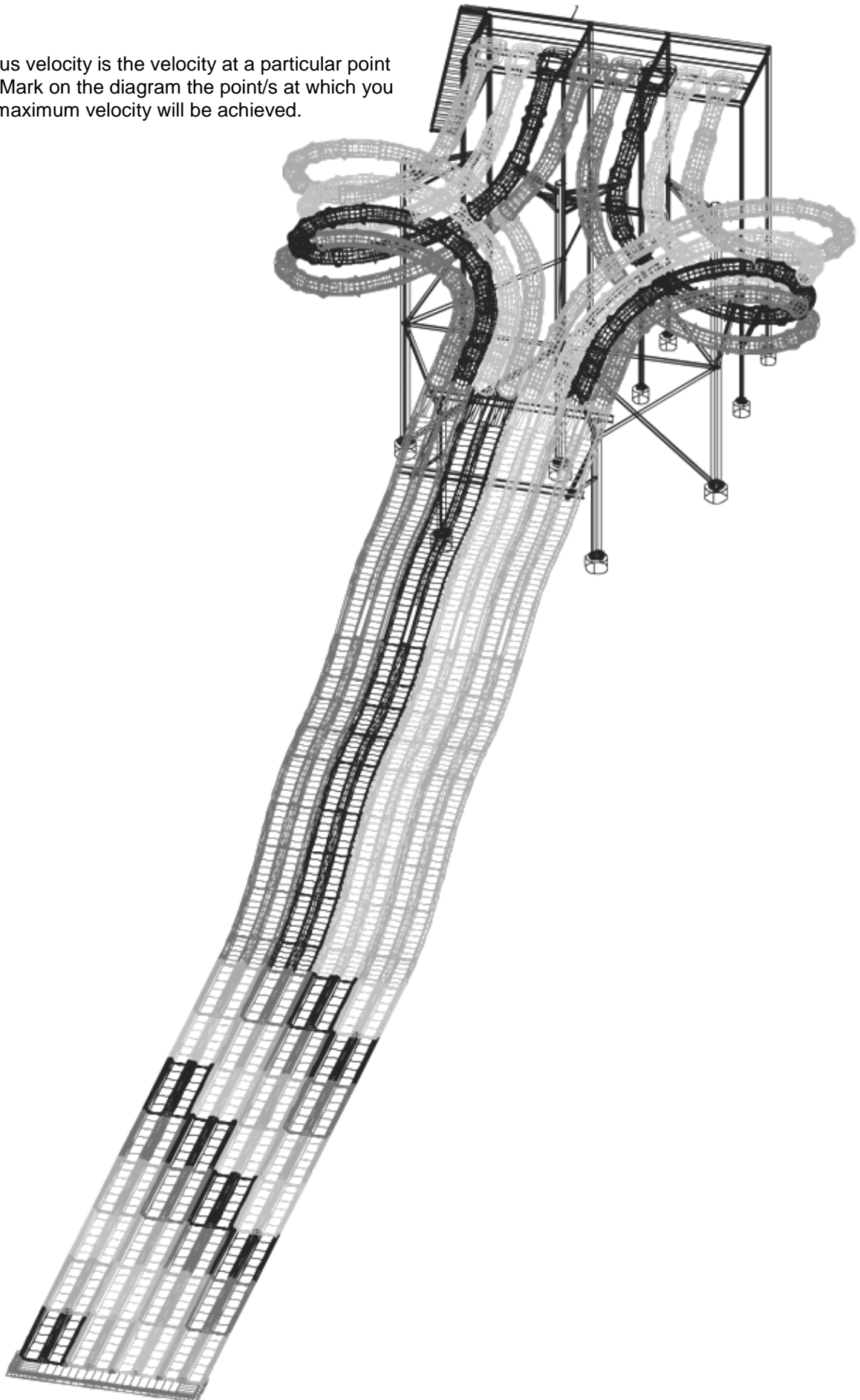
You're now ready to calculate their average velocity, using the equation $v = \frac{d}{t}$.

Average Velocity = _____ m/s

Instantaneous Velocity

Question 6

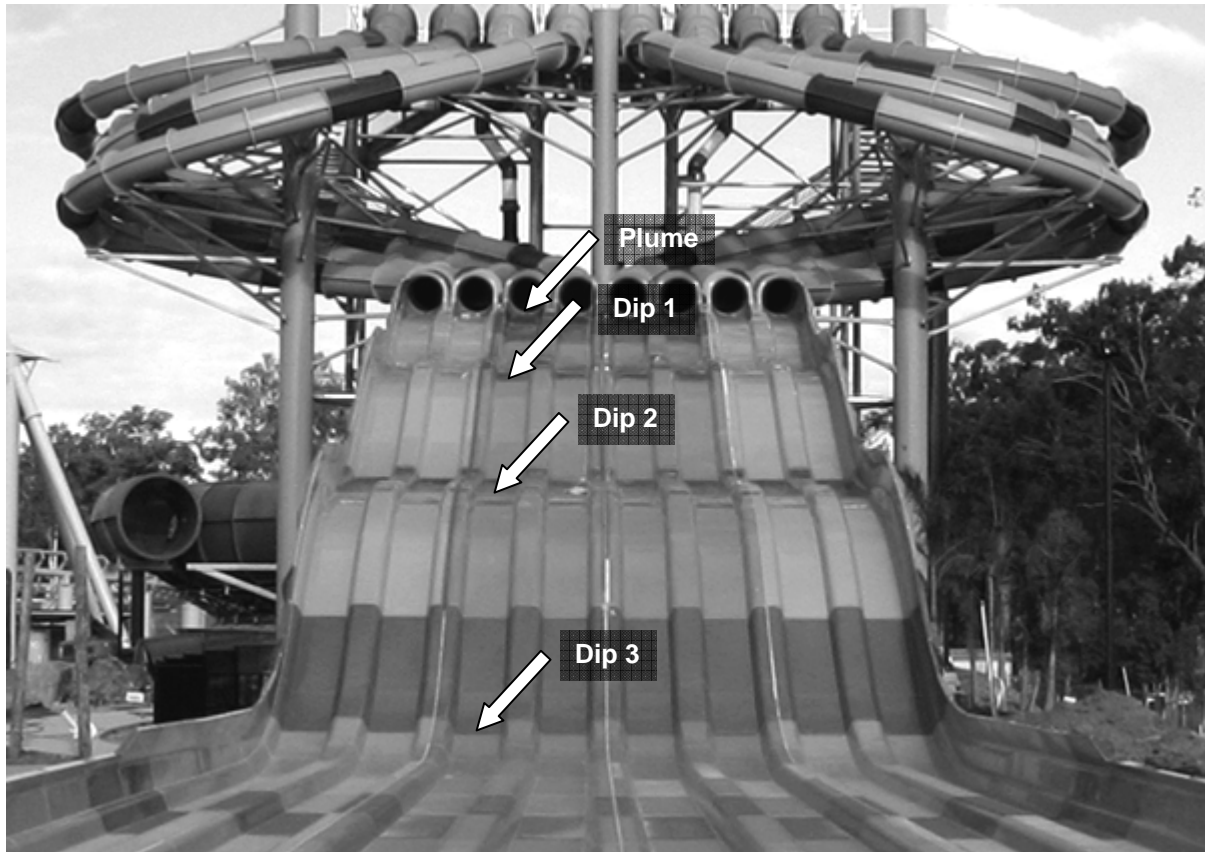
Instantaneous velocity is the velocity at a particular point in the race. Mark on the diagram the point/s at which you predict the maximum velocity will be achieved.



Question 7

Use the radar gun to measure the instantaneous velocity of a single rider at four points in the race: the moment they appear as they exit the plume and at the bottom of each of the next three dips (at the ends of the blue sections in the slide, as shown in the diagram below). At the same time, have a friend record the time that it takes them to reach each point, starting from the moment they appear. A stop watch with a lap time feature will be useful for this purpose. Repeat for another two riders.

You may choose a rider in any lane, but you are more likely to get an accurate result with the radar gun if you choose a lane closer to you.



	Plume velocity (m/s)	Dip 1 velocity (m/s)	Dip 2 velocity (m/s)	Dip 3 velocity (m/s)
Rider 1	_____	_____	_____	_____
Rider 2	_____	_____	_____	_____
Rider 3	_____	_____	_____	_____

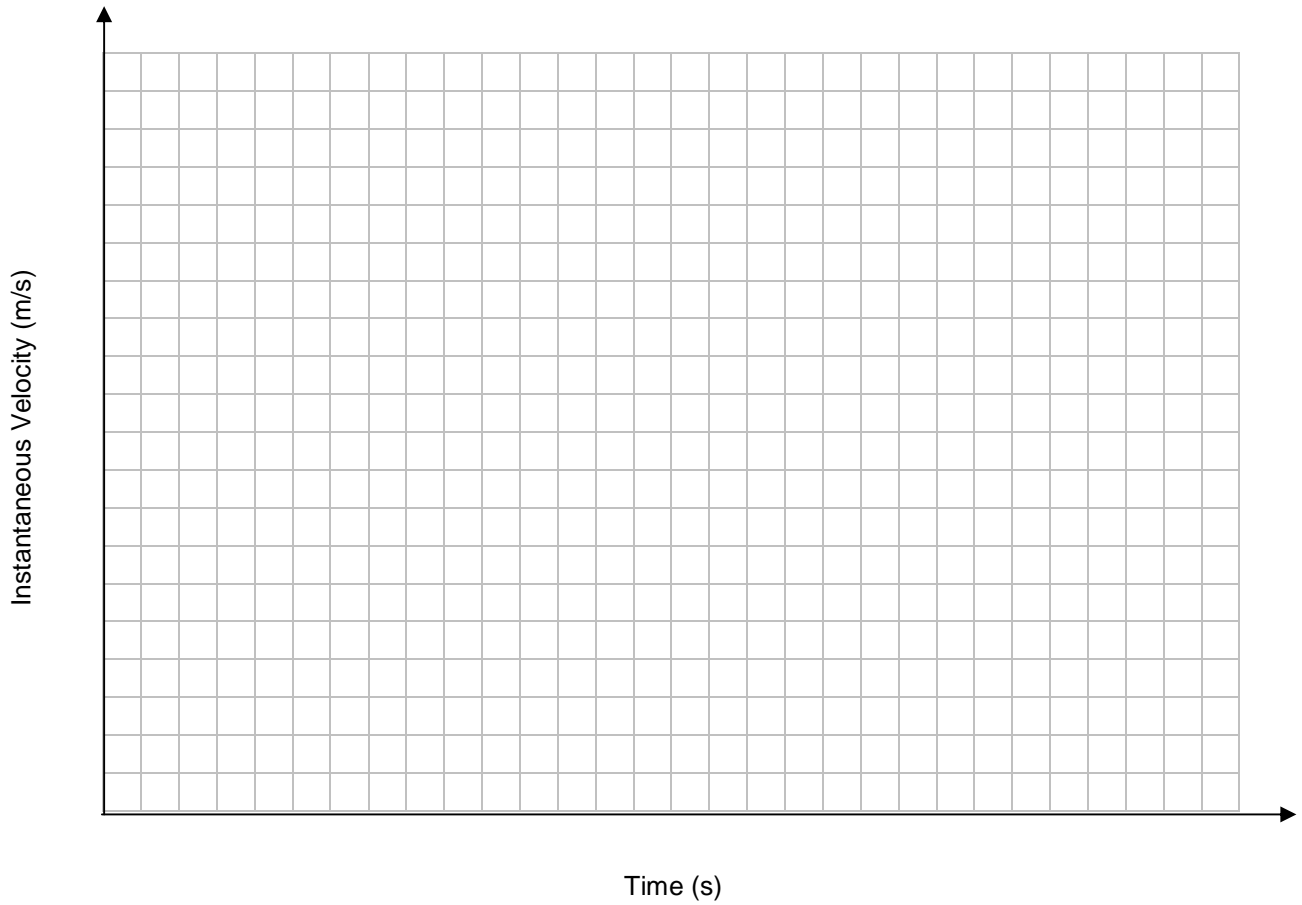
	Plume time (s)	Dip 1 time (s)	Dip 2 time (s)	Dip 3 time (s)
Rider 1	0	_____	_____	_____
Rider 2	0	_____	_____	_____
Rider 3	0	_____	_____	_____

How accurate were your predictions in Question 6?



Question 8

Choose the instantaneous velocities of one of your riders in Question 7 and sketch a graph of time versus instantaneous velocity. (Select your most reliable results.)



Question 9

Draw a curve of best fit on your graph in Question 8.



Question 10

Will the person with the highest instantaneous velocity always win the race? Comment.

Acceleration from Velocity-Time Graph

Acceleration is the first derivative of velocity with respect to time. That is, acceleration is the slope of the velocity-time graph.



Question 11

Average acceleration is the average slope across the graph. That is, the slope of a straight line from the instantaneous velocity at the plume to the instantaneous velocity at Dip 3.

Draw this straight line on your graph in Question 8 and calculate its slope to determine the average acceleration in m/s^2 .

Average acceleration = _____ m/s^2



Question 12

Instantaneous acceleration is the slope of the graph at a particular point.

Draw tangents to your curve of best fit on your graph in Question 8 at the points for Dip 1 and Dip 2. Calculate the slope of each of these tangents to determine the instantaneous accelerations at these two points.

Instantaneous acceleration at Dip 1 = _____ m/s^2

Instantaneous acceleration at Dip 2 = _____ m/s^2

Distance from Velocity-Time Graph

Distance is the integral of velocity with respect to time. That is, distance is the area under the velocity-time graph.



Question 13

Estimate the area under your velocity-time graph in Question 8 using a method such as counting squares or from the area of a triangle. Hence determine the distance travelled between exiting the plume and the bottom of Dip 3.

Distance = _____ m

Working space:



Question 14

Compare your result in Question 12 with the known distance of 45m for this part of the water slide. Suggest possible reasons for any discrepancies.
