Caught in a Rip!   Due: 4/13/2017

Background story

Swimming in the sea may seem similar to swimming in a pool, but there are hidden dangers. In particular, rip currents can put the lives of swimmers at risk. What may appear to be a calm inviting area between the breaking waves may in reality be very dangerous.

How would even a strong swimmer fare against a rip current travelling at 2.44m/s?

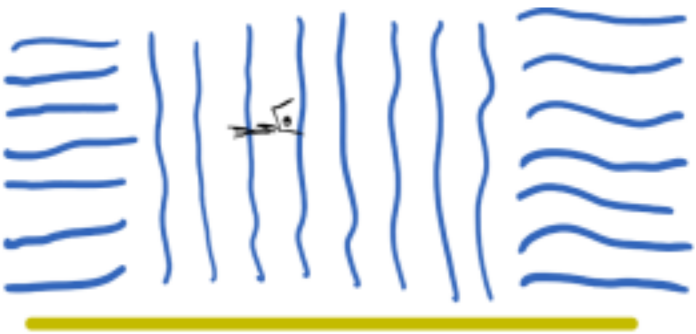
Part A: Through the water

You will be provided with a set of data in an Excel spreadsheet called swimming.xlsx. The dataset contains distances covered and the times taken by a strong freestyle swimmer over a five second period.

a) Using formulas in the spreadsheet, calculate the speed of the swimmer at twenty intervals over the five second period.
b) Produce an appropriately labelled graph that displays the swimmer's speed against time over the five second period.
c) Calculate the swimmer's average speed (over the entire five second time interval), and then draw a horizontal line on your graph representing this average speed.
d) With reference to your graph, identify the times when the swimmer's acceleration is positive, when it is negative, and when it is zero.
e) Explain these changes in acceleration in relation to the technique of freestyle swimming.
f) If this swimmer finds herself in a rip current travelling at 1.9 m/s what would happen if she tried to swim to safety by swimming directly to shore?

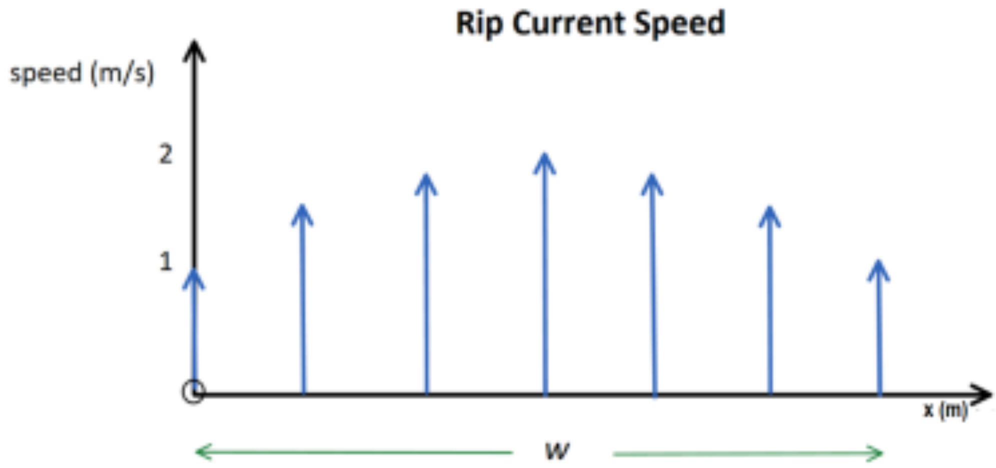
Part B: Under the waves

The swimmer finds herself 35 metres out from the shore and 4m to the left of the centre of the rip current when it surges towards her. She decides to swim parallel to the shore towards the right.



Adapted from exercises by Dr. Ian Thomson, Ormiston College

The speed of the rip current is 2 m/s down the middle and weakens to 1 m/s at its edges as illustrated below.



a) If the speed of the rip current varies according to a quadratic equation, show that the speed of the rip current can be found from the equation:

Speed (m/s) = $-\frac{4}{w^2}\left(x-\frac{w}{2}\right)^2+2$, where w is the width of the current in metres and x is the distance from the edge of the current in metres.

Assuming the swimmer swims constantly at her average speed:

b) Use a spreadsheet to calculate the following for time intervals of one tenth of a second:
   i. the distance travelled parallel to the shore (make this the x-coordinate of the path of the swimmer
   ii. the speed of the rip current
   iii. the average speed of the rip current over each time interval
   iv. the y-coordinate of the path of the swimmer
   (*Note*: assume the width of the rip current w is 26 meters)

c) Use a trendline to find a polynomial equation that represents the path of the swimmer from her starting position until she is out of the rip current.

d) Using calculus, find the instantaneous speed of the swimmer through the water after 2 seconds of swimming.

Part C: Between the flags

a) Describe qualitatively the strengths and limitations of the mathematical modelling you used in this investigation. Identify any significant assumptions you have used, and the reasonableness of your results with reference to real world data.

b) Write down a lesson plan if you were to adapt this activity to a school audience. Restrict your lesson plan to 2-3 pages in length. If you are looking for inspiration or a template, check out https://www.teachengineering.org/activities/view/nyu_linear_activity1

Note: You are allowed to work in 3-4 person groups while completing this assignment. Each group will turn in one report of their results and work (preferably typed up, with computed generated graphs) – please make sure to list all the group members.

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