1 Kite surfing is the sport of riding on a small surfboard, propelled forwards across water by a large kite. The surfer holds onto a bar that is attached to the lines. As the air moves over the kite an upwards and forwards force is produced, causing a tension in the lines of the kite.

Consider the board and the surfer to be a single object and the lines of the kite to be equivalent to a single line.

(a) (i) Complete the free body diagram for the forces acting on the surfer at the instant he starts to move along the water.

(2)

(ii) At maximum speed, the angle of the kite to the horizontal is 40° and the total tension in the lines is 1100 N.

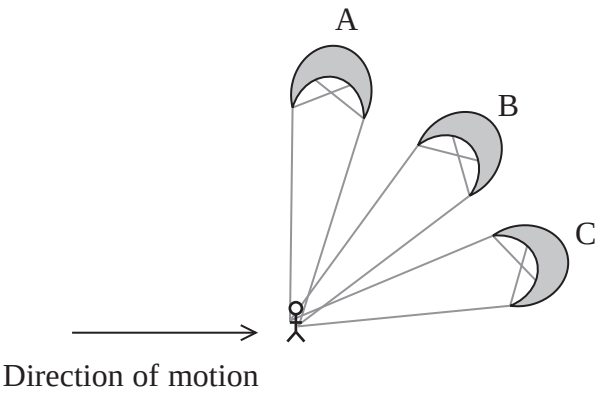
Show that the horizontal force from the kite on the surfer is about 800 N.

(2)

(iii) By considering the vertical forces acting on the surfer, explain why the mass of the surfer must be at least 72 kg.

(3)

*(b) The diagram shows three positions of the kite when pulling the surfer along.

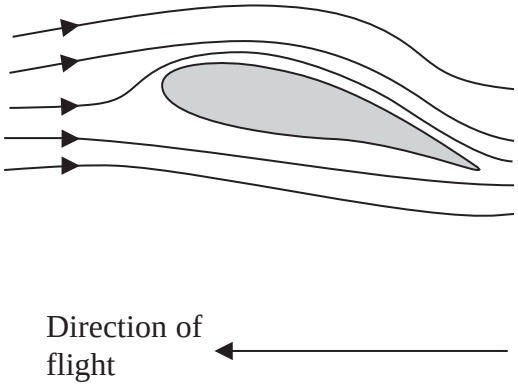


State and explain which position of the kite would supply the most power to the surfer. Assume that the tension in the kite lines is the same in each position.

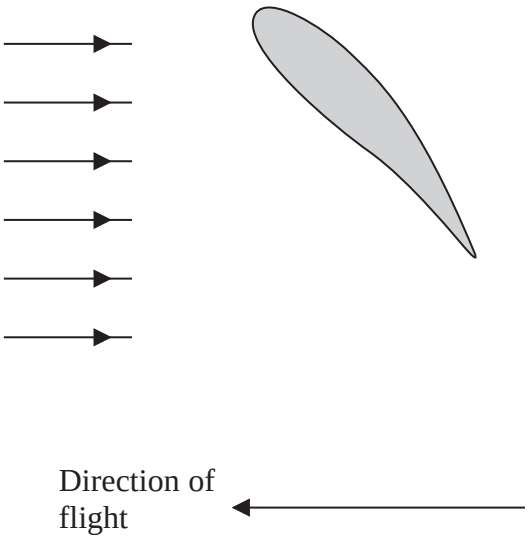
(4)

(Total for Question = 11 marks)

2 The cross section of the wing of a bird is an aerofoil shape.



In order to fly higher, a bird can tilt its wings more. If it tilts them too much, as shown in the diagram below, the air flow above the wing becomes turbulent.



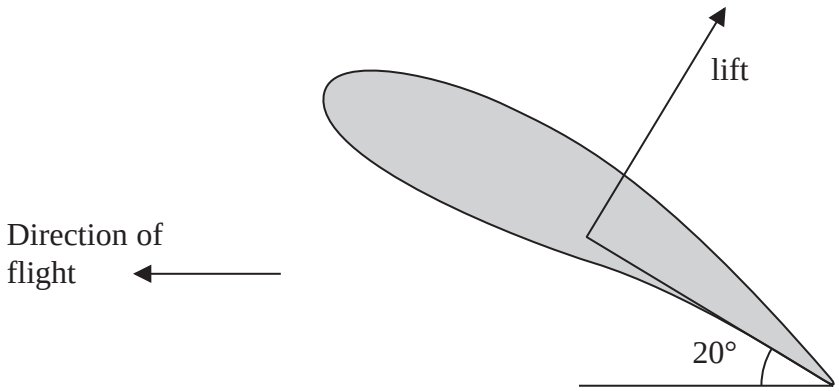
(a) Complete the diagram above to show the airflow around the wing.

(2)

(b) The tilting of the wing results in the air exerting a force on the wing which is called lift. The lift force acts perpendicular to the wing.

The total vertical component of the lift produced by both wings when tilted at an angle of 20° to the horizontal is enough to keep the bird flying at a constant height.

mass of bird = 0.063 kg



(i) Show that the total lift acting on the bird is about 1 N.

(3)

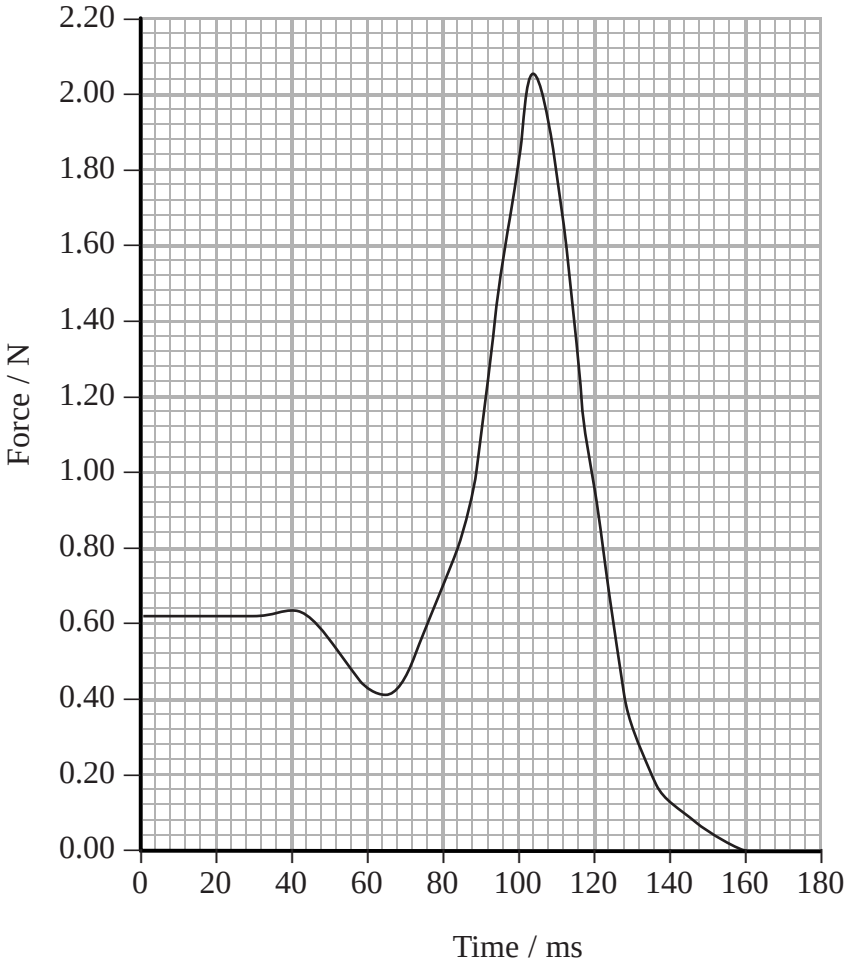
(ii) Assuming that the only forces acting on the bird are the weight and lift, calculate its acceleration at this instant.

(3)

Acceleration =

(c) When some birds take off from the ground there is no lift initially. These birds push off from the ground with their legs.

The following graph shows the downward force exerted by the leg on the ground during take off.



(i) With reference to Newton's laws explain how the downward force from the leg enables the bird to take off.

(4)

(ii) Use the graph to calculate the maximum acceleration of the bird during take off.

mass of bird = 0.063 kg

(3)

Maximum acceleration =

(Total for Question = 15 marks)

3 An exhibit in a science museum requires the observer to use a pump to create air bubbles in a column of liquid. The bubbles then rise through the liquid.

(a) (i) Complete the free-body force diagram for a bubble as it rises through the liquid.

(3)

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*(ii) It is observed that larger bubbles reach the top of the column of liquid in less time than smaller bubbles.

By considering the forces acting on a bubble as it rises, explain this observation.

(3)

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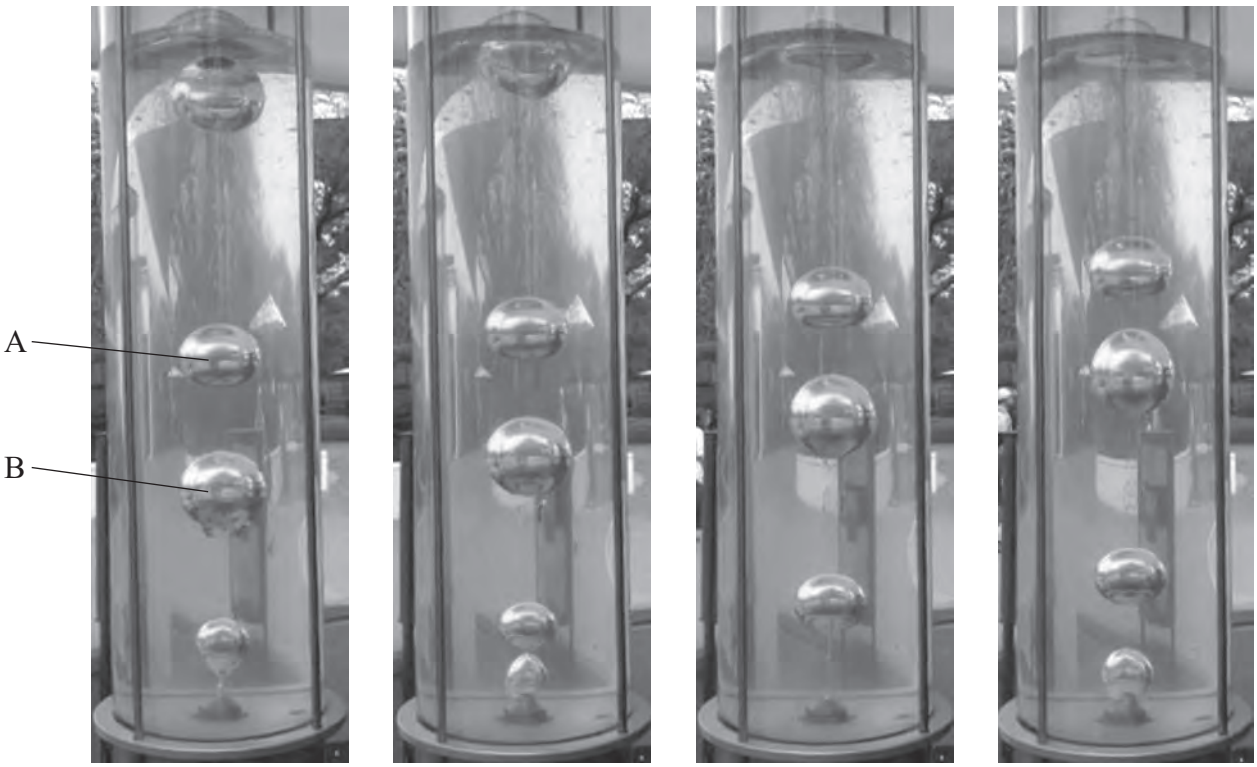
(b) The following photographs were taken at 0.33 s intervals.



Photograph 1
time 0

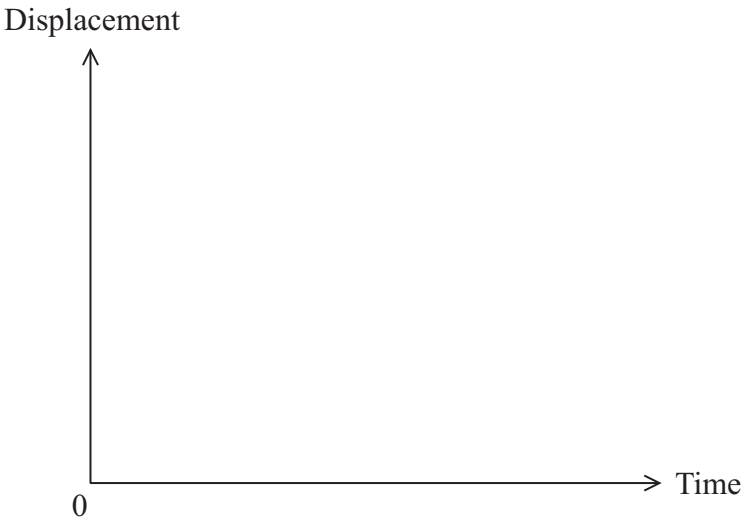
Photograph 2

Photograph 3

Photograph 4

(i) Sketch on the axes below two labelled lines to show how the displacements of the smaller bubble A and the larger bubble B vary with time over the four images.

(2)



(ii) The photographs are at a scale of 1 to 12. By using measurements from the photographs, calculate the speed of bubble B between photographs 2 and 3.

(4)

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Speed of bubble B .....

(c) A student wishes to determine the total drag force acting on a bubble.

(i) Explain why it might not be possible to use Stokes' law to calculate the drag force acting on a bubble.

(2)

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*(ii) Describe an additional measurement that would need to be taken from the photograph and how it could be used to determine the drag force, assuming that the bubble has reached its terminal velocity.

(4)

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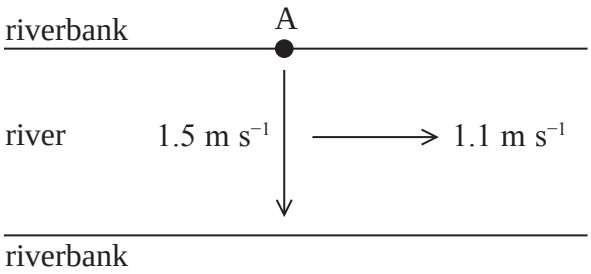
(Total for Question 18 marks)

4 A student rows across a river heading from point A. Her boat is headed in a direction at right angles to the bank and she rows through the water at a constant speed of 1.5 m s^{-1}. The river flows with a current of 1.1 m s^{-1}.



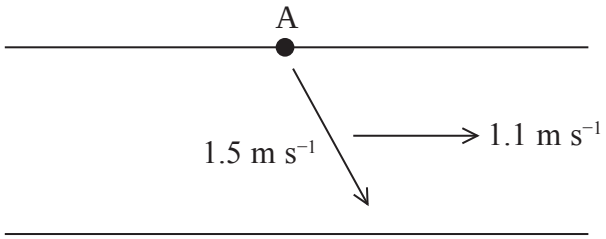
(a) Calculate the velocity of her boat relative to the riverbank.

(4)

Magnitude of velocity =

Angle of velocity to the riverbank =

(b) Another student also rows through the water at a constant speed of 1.5 m s^{-1} and heads their boat in a direction at 65° to the riverbank.



On the grid below draw a scaled vector diagram to determine the velocity of the boat.

(3)

Magnitude of velocity =

Angle of velocity to the riverbank =

(Total for Question = 7 marks)

5 A student entering a physics classroom sees the following sentences on the board. These sentences are being used as examples in an explanation of Newton's third law.

The car tyre exerts a frictional contact force of 300 N backwards on the road.

The road exerts a frictional contact force of 300 N forwards on the car tyre.

State Newton's third law.

Explain how the sentences provide a good example of a Newton's third law pair.

(5)

(Total for Question 5 marks)