Q1.(a) Indicate with ticks (✓) in the table below which of the quantities are vectors and which are scalars.

	Velocity	**Speed**	**Distance**	**Displacement**
vector				
scalar				

(2)

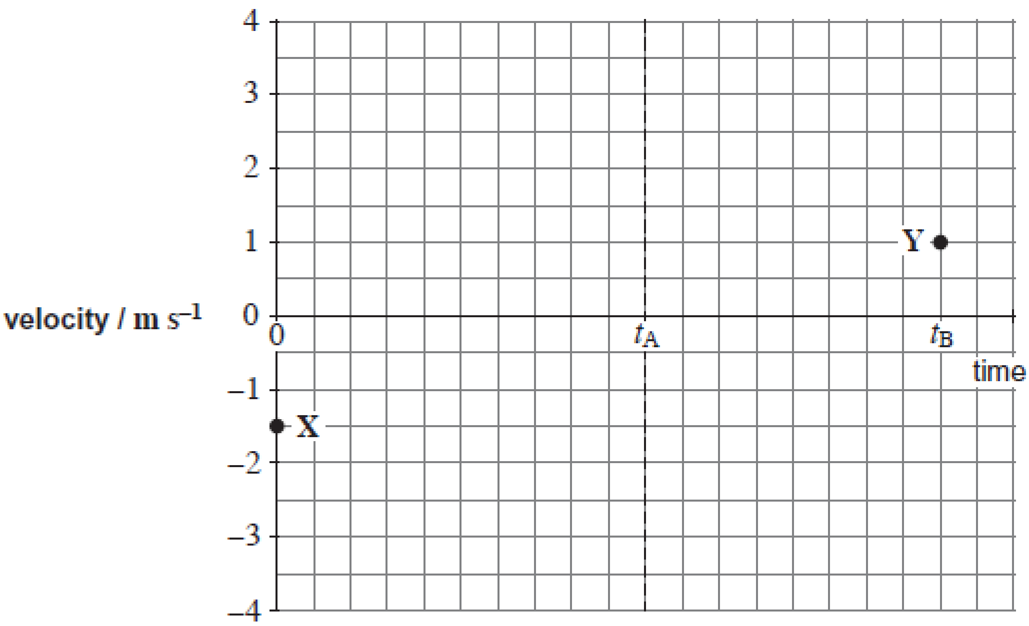
(b) A tennis ball is thrown vertically downwards and bounces on the ground. The ball leaves the hand with an initial speed of 1.5 m s^{-1} at a height of 0.65 m above the ground. The ball rebounds and is caught when travelling upwards with a speed of 1.0 m s^{-1}.

Assume that air resistance is negligible.

(i) Show that the speed of the ball is about 4 m s^{-1} just before it strikes the ground.

(3)

(ii) The ball is released at time t = 0. It hits the ground at time t_A and is caught at time t_B. On the graph, sketch a velocity−time graph for the vertical motion of the tennis ball from when it leaves the hand to when it returns. The initial velocity **X** and final velocity **Y** are marked.



(3)

(c) In a game of tennis, a ball is hit horizontally at a height of 1.2 m and travels a horizontal distance of 5.0 m before reaching the ground. The ball is at rest when hit.

Calculate the initial horizontal velocity given to the ball when it was hit.

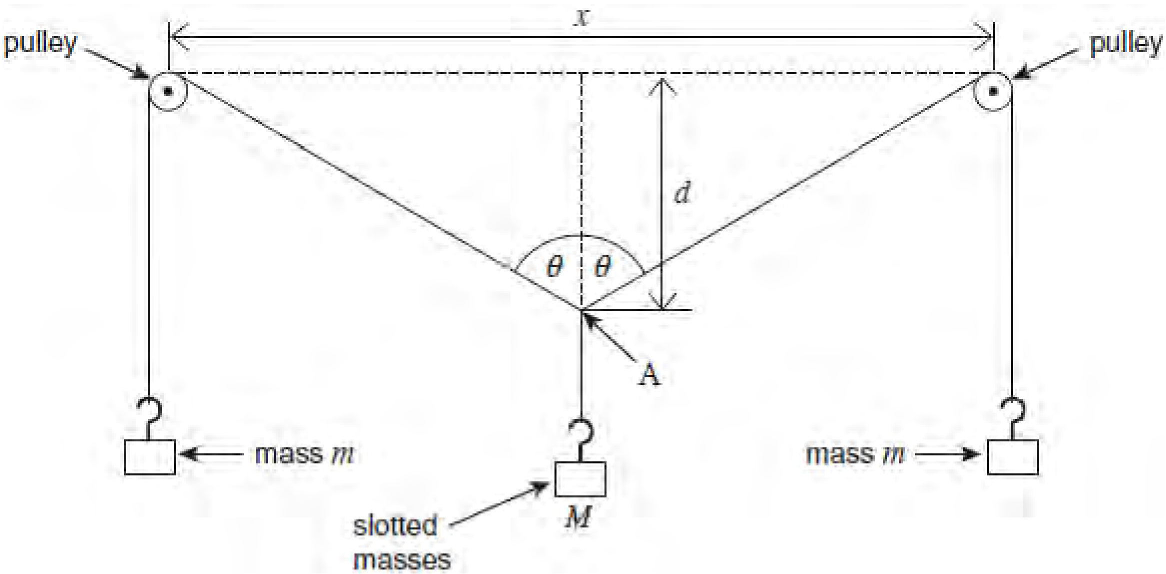
horizontal velocity = ... m s^{-1}

(3)

(Total 11 marks)

Q2.(a) **Figure 1** shows the arrangement of apparatus in an experiment to investigate the equilibrium of three forces.

Figure 1



The two pulleys are secured in a fixed position at the same height. The centres of the pulleys are separated by a horizontal distance x. Identical masses m are suspended by a continuous string which passes over both pulleys. A third mass M is suspended from the string at point A, equidistant from the pulleys. The strings that pass over the pulleys each make an angle θ to the vertical at point A, as shown in **Figure 1**.

When the forces are in equilibrium the vertical distance d is measured. Mass M is varied and the system is allowed to come into equilibrium. For each M, the corresponding distance d is measured.

The results are shown in the table below.

M / kg	d / m	$\frac{d}{\sqrt{d^2 + \frac{x^2}{4}}}$
0.100	0.035	0.087
0.200	0.066	0.163
0.300	0.105	0.254
0.400	0.139	0.328
0.500	0.183	
0.600	0.228	

(i) Given that x = 0.800 m, complete the table above.

(1)

(ii) Complete the graph in **Figure 2** by plotting the two remaining points and drawing a best fit straight line.

(2)

(iii) Determine the gradient of the graph in **Figure 2.**

gradient = ...

(3)

(iv) (1) Consider the forces that act at point A in **Figure 1**. By resolving these forces vertically, show that $M = 2m\cos\theta$.

Figure 2

(1)

(2) Express $\cos\theta$ in terms of d and x and hence show that the gradient of the graph is equal to $\frac{1}{2m}$.

(2)

(3) Determine the value of m using your value for the gradient from (iii).

m = ...

(2)

(v) A student obtains different results for d when M is increased compared with those obtained when M is decreased.

(1) Suggest why these two sets of results do not agree.

....

....

(1)

(2) State what the student should do with the results to take account of this problem.

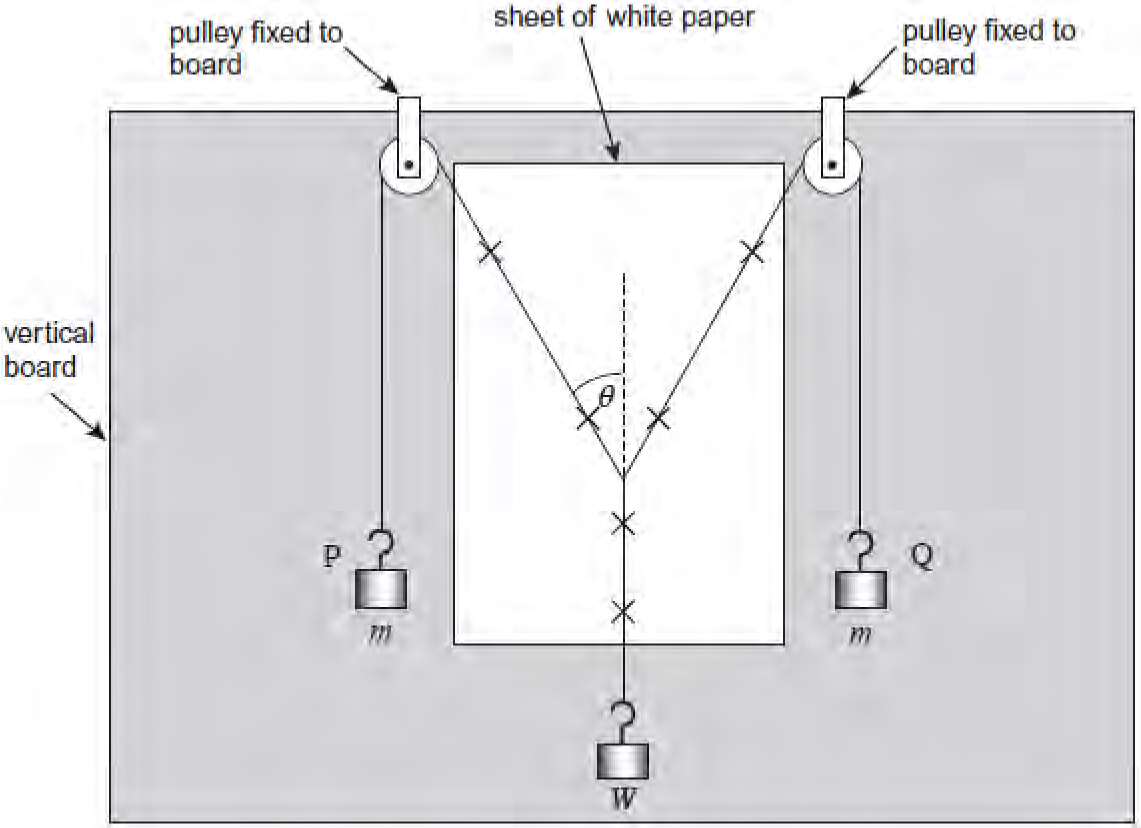
....

....

(1)

(b) An arrangement for investigating the equilibrium of forces is shown in **Figure 1**.

Figure 1



In the arrangement shown in **Figure 1**, P and Q are identical masses of mass m. A student uses this arrangement to investigate the relationship between m and θ when the system of forces is in equilibrium. Weight W is constant.
The student performs the investigation by marking the position of the strings when the forces are in equilibrium for different values of m. He does this by marking crosses on the sheet of white paper.

(i) The string is about 10 mm from the paper. Describe and explain a technique to mark accurately the string positions on the paper.

....

....

....

....

....

....

(2)

(ii) The crosses on the paper are used to determine the directions of the strings. The results are shown full scale in **Figure 2**.

(1) Use **Figure 2** and your protractor to measure θ as accurately as possible and calculate the percentage uncertainty in your answer. State the precision of the protractor you used.

precision of protractor = ...

θ = ...

percentage uncertainty = ... %

(3)

(2) Use **Figure 2** and a ruler to determine θ using trigonometry. Show on **Figure 2** the measurements you make.

θ = ...

(2)

(iii) Theory suggests that $W = 2mg\cos\theta$.

The student produces a set of results for different values of m and the corresponding values of θ.

Suggest and explain a graphical way of testing this relationship between m and θ.

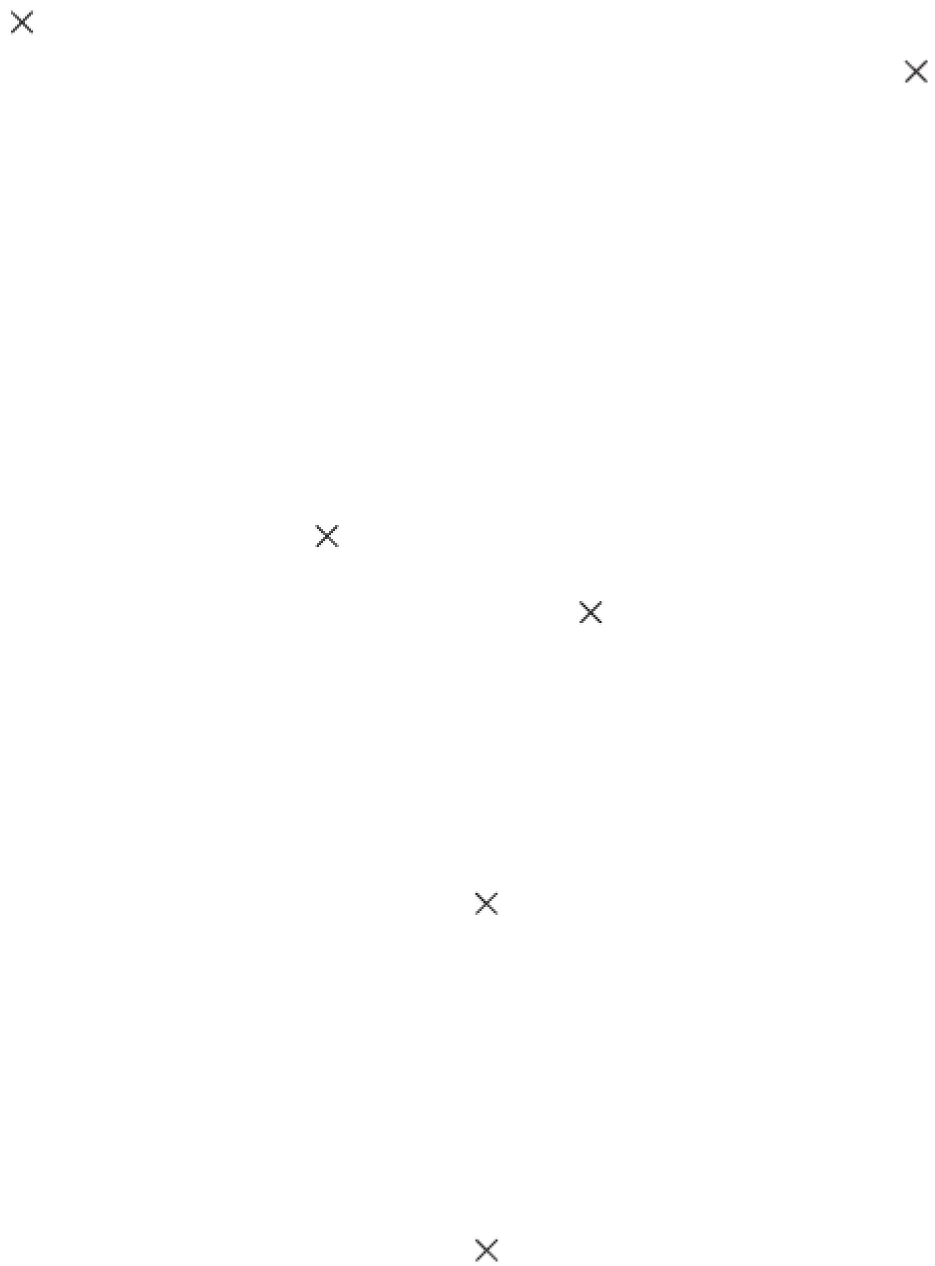
....

....

....

....

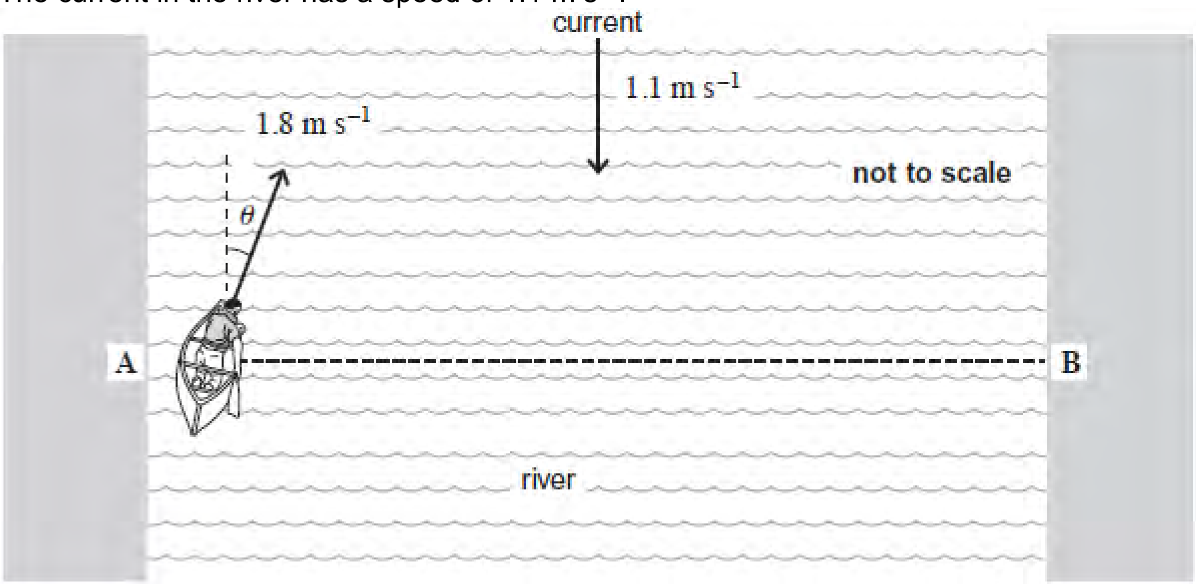
Figure 2



(1)
(Total 21 marks)

Q3. A canoeist wishes to cross a river in a straight line between two points labelled **A** and **B** as shown in the diagram below.
The canoeist can paddle the canoe at a speed of 1.8 m s^{-1} in still water.

The current in the river has a speed of 1.1 m s^{-1}.



To cross from **A** to **B** the canoeist has to paddle at an angle θ to the direction of the current, as shown above.

Determine θ using a scale drawing.

angle θ .... degrees

(Total 3 marks)

Q4. Which of the following is a scalar quantity?

A	velocity	☐
B	kinetic energy	☐
C	force	☐
D	momentum	☐

(Total 1 mark)

Q5. Two forces of 6 N and 10 N act at a point. Which of the following could **not** be the magnitude of the result?

A	16 N	☐
B	8 N	☐
C	5 N	☐
D	3 N	☐

(Total 1 mark)