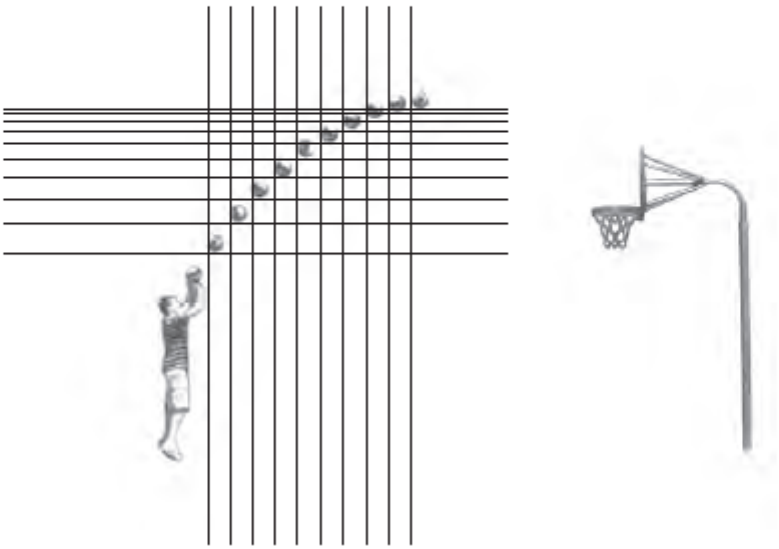
Kinematics QP 1

1

A basketball is thrown towards a basket. The position of the ball at equal time intervals is shown in the photograph.

Vertical and horizontal lines have been added to the photograph to help identify the ball's horizontal and vertical position.



Suggest a reason for each of the following observations:

(a) the vertical lines are evenly spaced,

(1)

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.....

(b) the horizontal lines become closer together.

(1)

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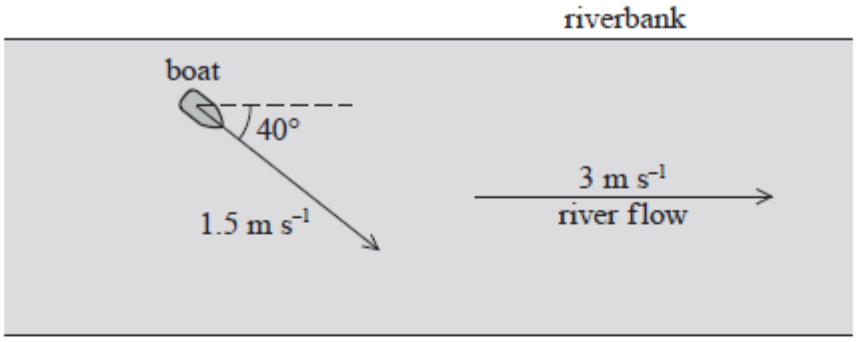
(Total for Question 11 = 2 marks)

2

The river is flowing at a speed of 3 m s^{-1}. A boat is pointed at an angle of 40° to the riverbank and paddled at a speed of 1.5 m s^{-1}, as shown in the diagram.



In the space below, draw a vector diagram to scale and use it to determine the magnitude of the actual velocity of the boat.

(3)

Magnitude of actual velocity = ...

3

During the 17th century, the physicist Galileo carried out a series of experiments to investigate how gravity affected acceleration.

There were no accurate methods to measure short times, so Galileo used an object on a smooth inclined plane to increase the time taken for the object's motion.

(a) An object is released from rest and slides a distance s down a smooth inclined plane, as shown in diagram 1. This will take longer than releasing the object from rest and allowing it to fall freely through the same distance s, as shown in diagram 2.

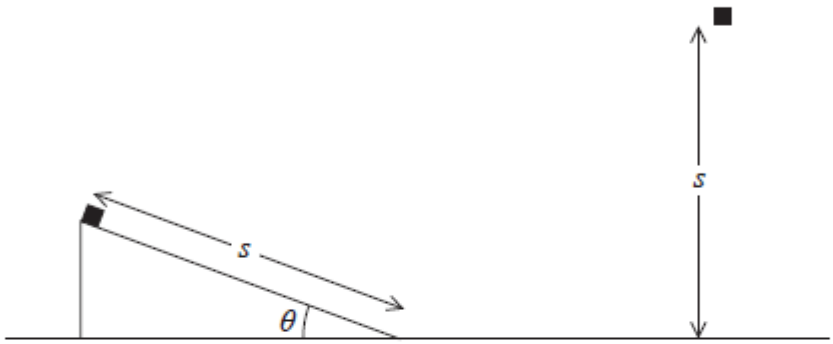


Diagram 1 Diagram 2

(i) Assuming that the frictional forces between the plane and the object are negligible, explain why the object in diagram 1 takes longer to travel distance s than the object in diagram 2.

(3)

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(ii) Calculate the acceleration of the object in diagram 1 when $\theta = 35°$.

(2)

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.....

.....

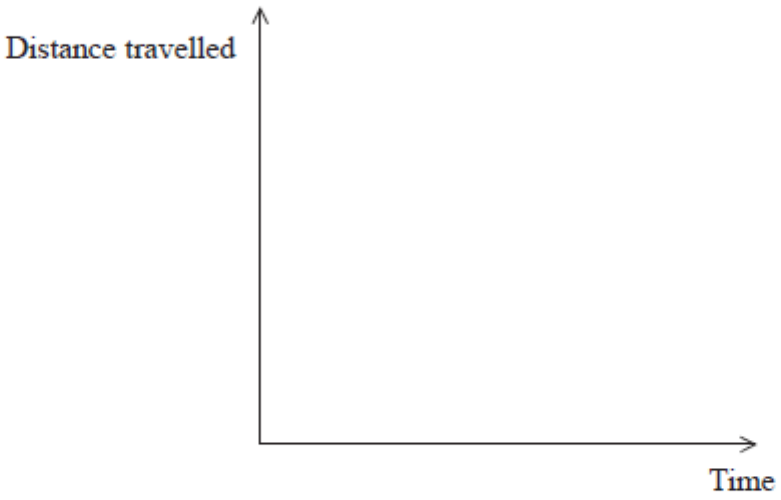
Acceleration = ...

3

(b) Galileo released a metal ball from rest so that it could roll down a smooth inclined plane. The time t taken to roll a distance s was measured. He repeated the experiment, each time recording the time taken to travel a different fraction of the distance s.

(i) On the axes below, sketch the distance-time graph that would be expected from these readings.

(2)



(ii) Write an expression for the time taken, in terms of t, for the ball to roll a distance $\frac{s}{2}$ from the top of the plane.

(1)

.....

.....

Time taken = ...

3

(c) Galileo repeated his measurements many times and obtained similar results on each occasion. He did not have a stopwatch and had to measure times using his pulse. A human pulse is about one beat per second.

Comment on Galileo's method.

(2)

(d) Today, the acceleration of free fall can be found accurately by dropping a metal ball vertically and using ICT to collect data.

Suggest the apparatus required to take the measurements needed to calculate a value for the acceleration of free fall.

(2)

4

A student investigated the physics of football.

(a) She used the equations of motion to model the behaviour of a ball when kicked at different angles to the horizontal. She predicted the height of the ball when it reached the goal, presuming it was kicked from the same place, with the same initial speed, each time. The results are shown in the table below.

Angle to the horizontal / °	Height of the ball when it reached the goal / m
10	–0.78
20	1.0
30	2.8
40	4.7

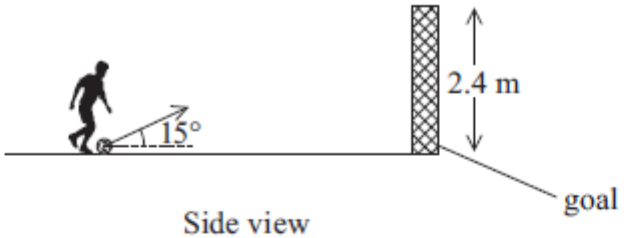
(i) State the significance of the negative value of height for an angle of 10°.

(1)

(ii) On the diagram below, sketch and label the predicted path of the ball for angles of 20° and 40°.

(2)

(b) (i) During a football match the ball is kicked towards the goal, at an angle of 15° to the horizontal, from a distance of 11 m as shown.



Side view

The ball has a diameter of 0.22 m and an initial speed of 26 m s^{-1}.

By means of a calculation, determine whether or not the ball will pass into the goal. You may ignore the effects of air resistance.

(6)

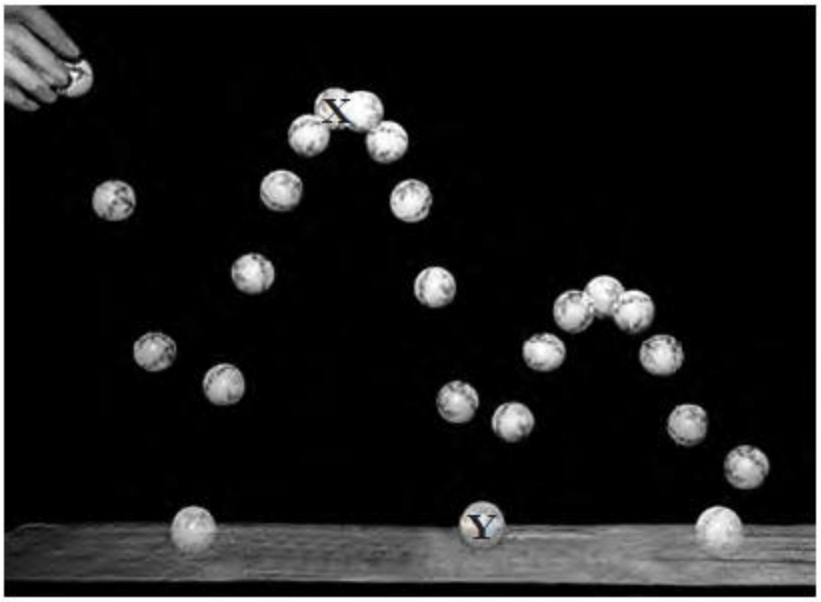
(ii) Air resistance would cause an additional force on the ball.

Explain the effect this would have on the ball's motion.

(2)

5

The photograph shows a sequence of images of a bouncing ball. 20 images were taken per second.



(a) (i) Show that the distance the ball fell between point X and point Y is about 0.4 m.

(3)

(ii) Use measurements from the photograph to calculate the horizontal velocity of the ball.

(4)

Horizontal velocity = ...

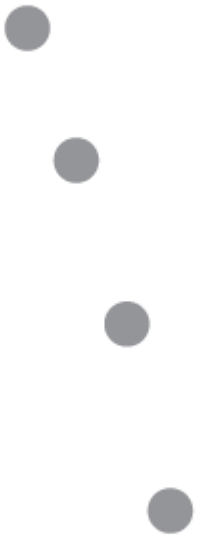
5

(b) The ball was released with a small horizontal velocity.

(i) The position of the ball in the first 4 images is shown below.

Draw in the first 4 positions of the ball had it been released with no horizontal velocity.

(2)



(ii) Explain why you have drawn the ball in these positions.

(2)

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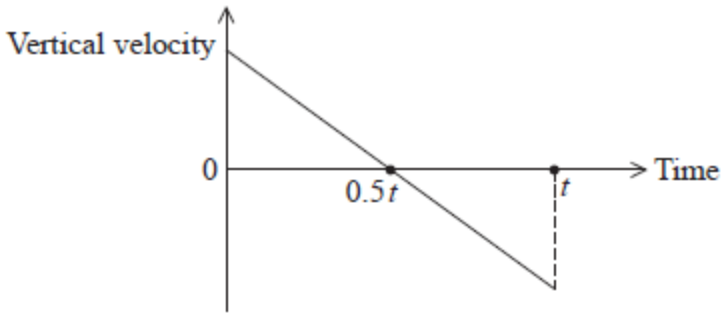
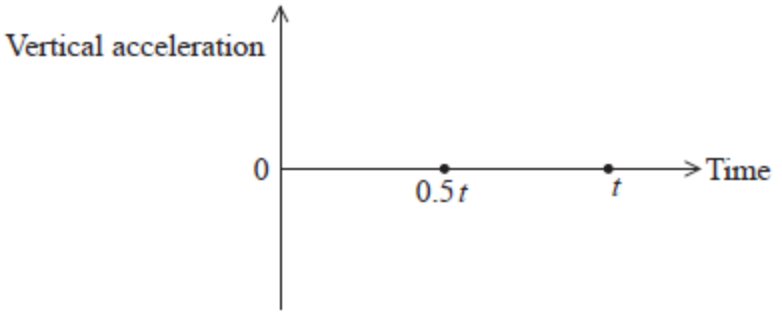
6

A cricket ball is hit and travels across a field where it is caught at a time t. A graph of vertical velocity against time is shown.



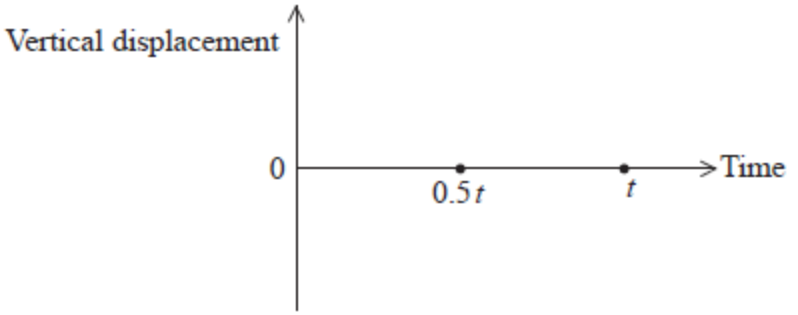
(a) On the axes below, sketch the corresponding graph of vertical acceleration against time for the motion of the cricket ball.

(2)



(b) On the axes below, sketch the corresponding graph of vertical displacement against time for the motion of the cricket ball.

(2)



(Total for Question 12 = 4 marks)