Q1. An apple and a leaf fall from a tree at the same instant. Both apple and leaf start at the same height above the ground but the apple hits the ground first.

You may be awarded marks for the quality of written communication in your answer.

Use Newton's laws of motion to explain why

(i) the leaf accelerates at first then reaches a terminal velocity,

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(ii) the apple hits the ground first.

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(Total 5 marks)

Q2. A supertanker of mass 4.0×10^8 kg, cruising at an initial speed of 4.5 m s^{-1}, takes one hour to come to rest.

(a) Assuming that the force slowing the tanker down is constant, calculate

(i) the deceleration of the tanker,

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(ii) the distance travelled by the tanker while slowing to a stop.

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(4)

(b)   Sketch, using the axes below, a distance-time graph representing the motion of the tanker
       until it stops.

distance

0

   0   time
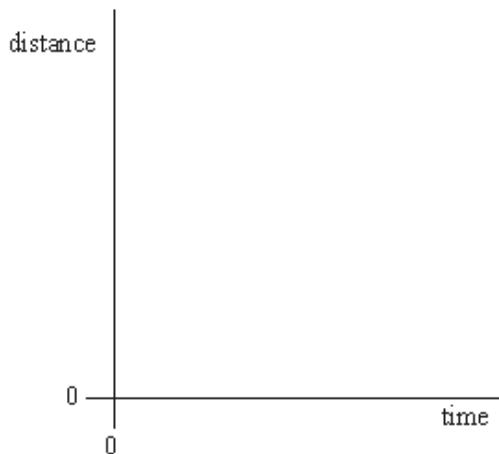
(2)

(c)   Explain the shape of the graph you have sketched in part (b).

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(2)
(Total 8 marks)

Q3.   In the 1969 Moon landing, the Lunar Module separated from the Command Module above the surface of the Moon when it was travelling at a horizontal speed of 2040 m ss^{-1}.
In order to descend to the Moon's surface the Lunar Module needed to reduce its speed using its rocket as shown in **Figure 1**.

Figure 1
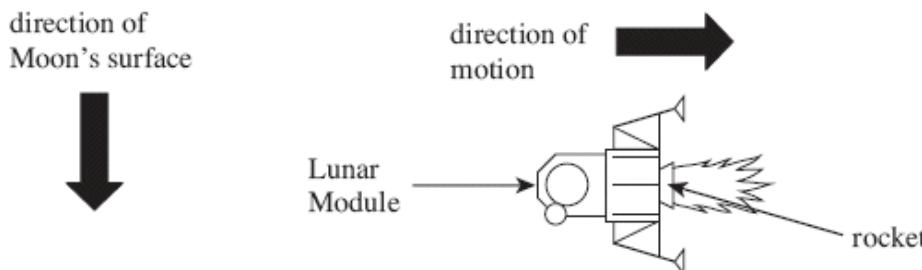
(a)   (i)   The average thrust from the rocket was 30 kN and the mass of the Lunar Module was 15100 kg. Calculate the horizontal deceleration of the Lunar Module.

answer = ... m s^{-2}

(2)

(ii)   Calculate the time for the Lunar Module to slow to the required horizontal velocity of 150 m s^{-1}. Assume the mass remained constant.

answer = ... s

(2)

(b)   The rocket was then used to control the velocity of descent so that the Lunar Module descended vertically with a constant velocity as shown in **Figure 2**. Due to the use of fuel during the previous deceleration, the mass of the Lunar Module had fallen by 53%.

Figure 2

direction of
Moon's surface
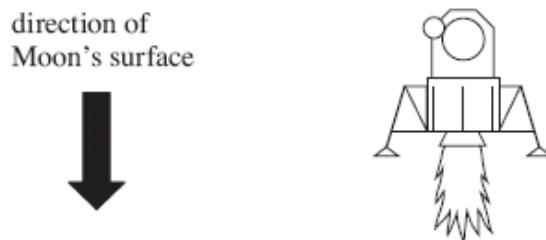
acceleration due to gravity near the Moon's surface = 1.61 m s^{-2}

(i)   Draw force vectors on **Figure 2** to show the forces acting on the Lunar Module at this time. Label the vectors.

(2)

(ii)   Calculate the thrust force needed to maintain a constant vertical downwards velocity.

answer = ... N

(2)

(c)   When the Lunar Module was 1.2 m from the lunar surface, the rocket was switched off.

At this point the vertical velocity was 0.80 m s^{-1}. Calculate the vertical velocity at which the Lunar Module reached the lunar surface.

answer = ... m s^{-1}

**(2)**
(Total 10 marks)

Q4.   A car accelerates from rest to a speed of 26 m s⁻¹. The table shows how the speed of the car varies over the first 30 seconds of motion.

time/ s	0	5.0	10.0	15.0	20.0	25.0	30.0
speed/ m s⁻¹	0	16.5	22.5	24.5	25.5	26.0	26.0

(a)   Draw a graph of speed against time on the grid provided.

speed/ m s⁻¹

time / s
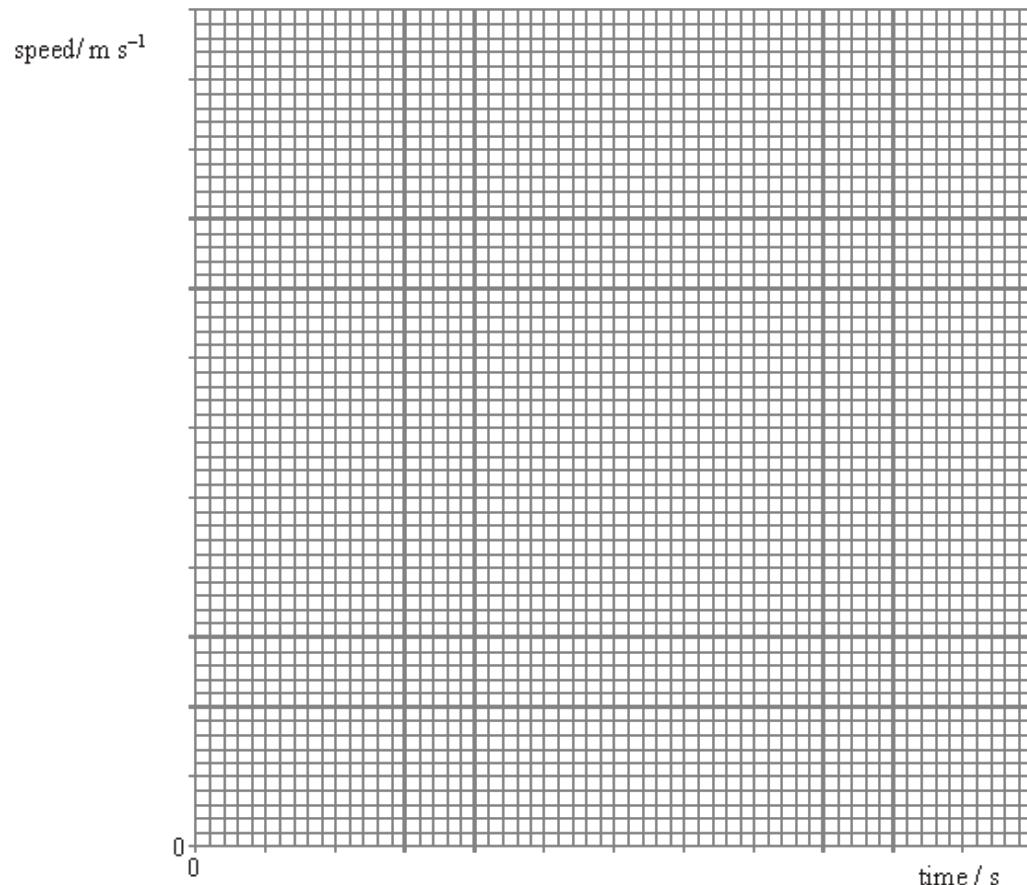
(3)

(b)   Calculate the average acceleration of the car over the first 25 s.

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(2)

(c)   Use your graph to estimate the distance travelled by the car in the first 25 s.

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(2)

(d) Using the axes below, sketch a graph to show how the resultant force acting on the car varies over the first 30 s of motion.

resultant force

0

0   time
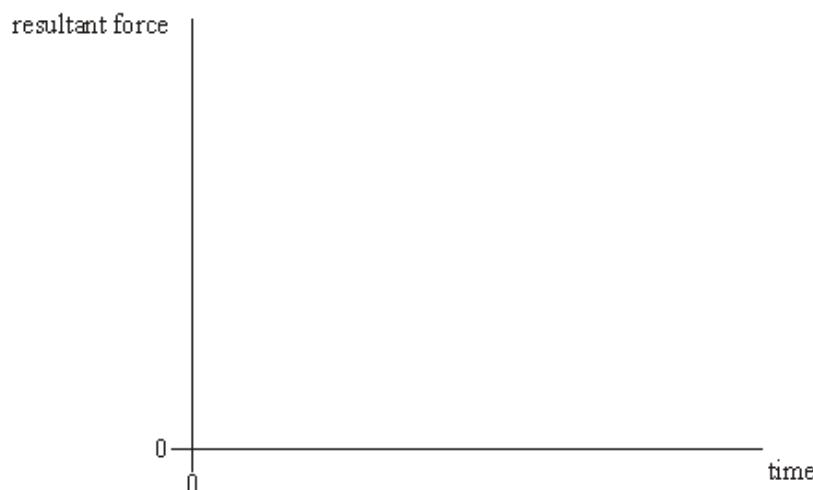
(2)

(e) Explain the shape of the graph you have sketched in part (d), with reference to the graph you plotted in part (a).

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(2)
(Total 11 marks)

Q5.   Galileo used an inclined plane, similar to the one shown in the figure below, to investigate the motion of falling objects.

(a) Explain why using an inclined plane rather than free fall would produce data which is valid when investigating the motion of a falling object.

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(2)

(b)   In a demonstration of Galileo's investigation, the number of swings of a pendulum was
       used to time a trolley after it was released from rest. A block was positioned to mark the
       distance that the trolley had travelled after a chosen whole number of swings.
       See the figure below.
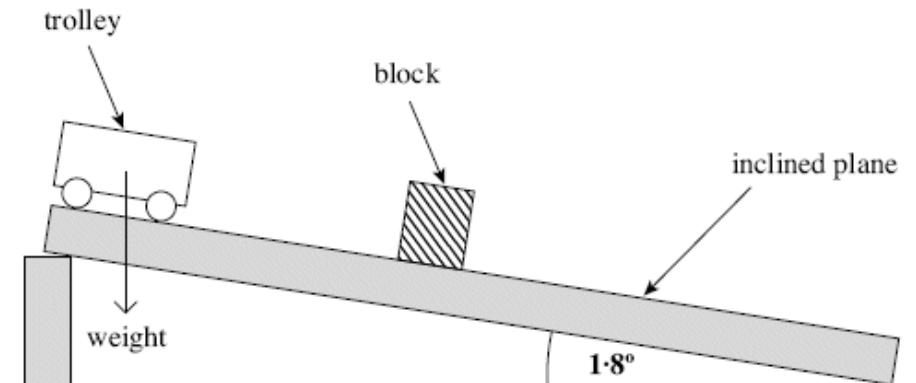
The mass of the trolley in the figure above is 0.20 kg and the slope is at an angle of 1·8⁰ to
the horizontal.

(i)   Show that the component of the weight acting along the slope is about 0.06 N.

(2)

(ii)   Calculate the initial acceleration down the slope.

answer = ... m s⁻²

(2)

(c) In this experiment, the following data was obtained. A graph of the data is shown below it.

time / pendulum swings	distance travelled /m
1	0.29
2	1.22
3	2.70
4	4.85
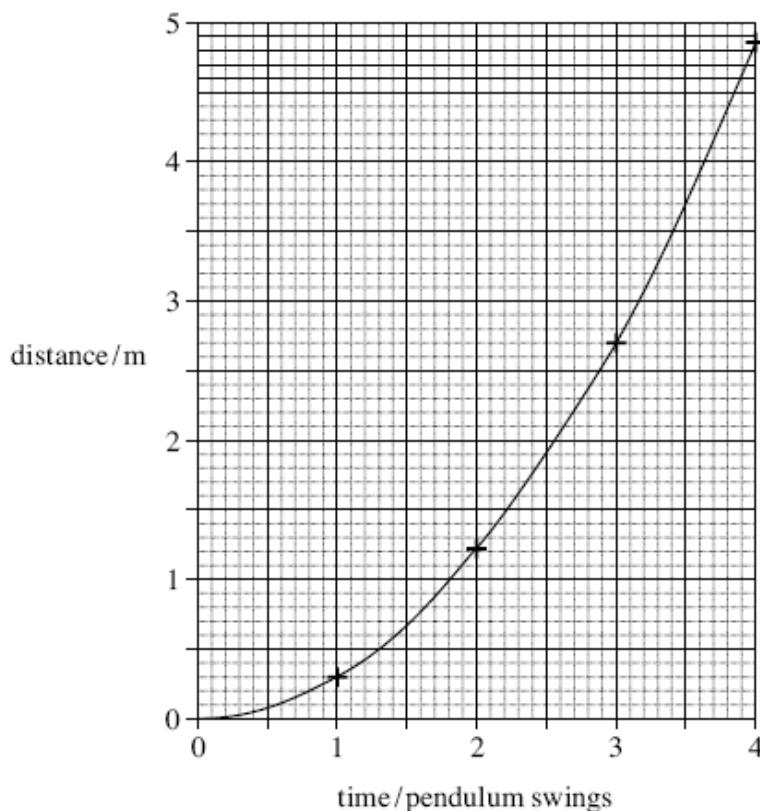
From the graph above, state what you would conclude about the motion of the trolley?
Give a reason for your answer.

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(2)

(d) Each complete pendulum swing had a period of 1.4 s. Use the graph above to find the speed of the trolley after it had travelled 3.0 m.

answer = ... m s^{-1}

(3)
(Total 11 marks)

Q6. A car accelerates from rest to a speed of 26 m s^{-1}. The table shows how the speed of the car varies over the first 30 seconds of motion.

time/s	0	5.0	10.0	15.0	20.0	25.0	30.0
speed/m s^{-1}	0	16.5	22.5	24.5	25.5	26.0	26.0

(a)   Draw a graph of speed against time on the grid below.

speed/m s^{-1}

0

0   time/s
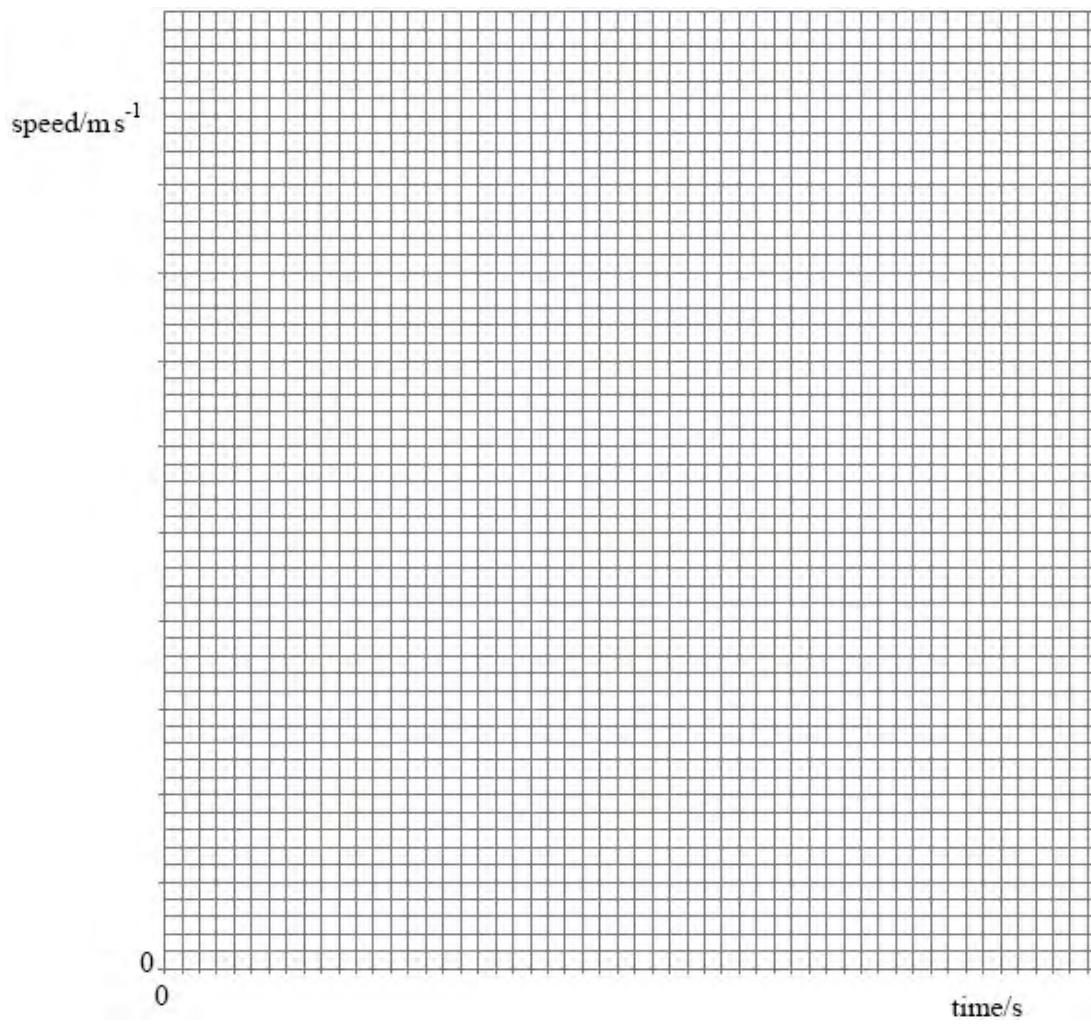
(5)

(b)   Calculate the average acceleration of the car over the first 25 s.

(2)

(c)   Use your graph to estimate the distance travelled by the car in the first 25 s.

(2)

(d)   Using the axes below, sketch a graph to show how the resultant force acting on the car varies over the first 30 s of motion.

resultant force

0

0   time
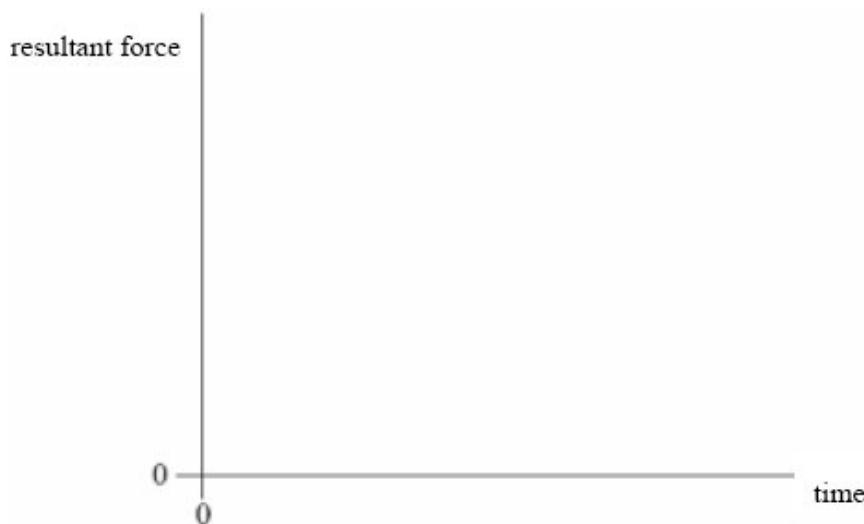
(3)

(e)   Explain the shape of the graph you have sketched in part (d), with reference to the graph you plotted in part (a).

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(2)
(Total 14 marks)