Mechanics 1: Kinematics in 1 Dimension

Past Paper Questions
2006 - 2013

Name:

6 A van moves from rest on a straight horizontal road.

(a) In a simple model, the first 30 seconds of the motion are represented by three separate stages, each lasting 10 seconds and each with a constant acceleration.

During the first stage, the van accelerates from rest to a velocity of $4\,\text{m s}^{-1}$.

During the second stage, the van accelerates from $4\,\text{m s}^{-1}$ to $12\,\text{m s}^{-1}$.

During the third stage, the van accelerates from $12\,\text{m s}^{-1}$ to $16\,\text{m s}^{-1}$.

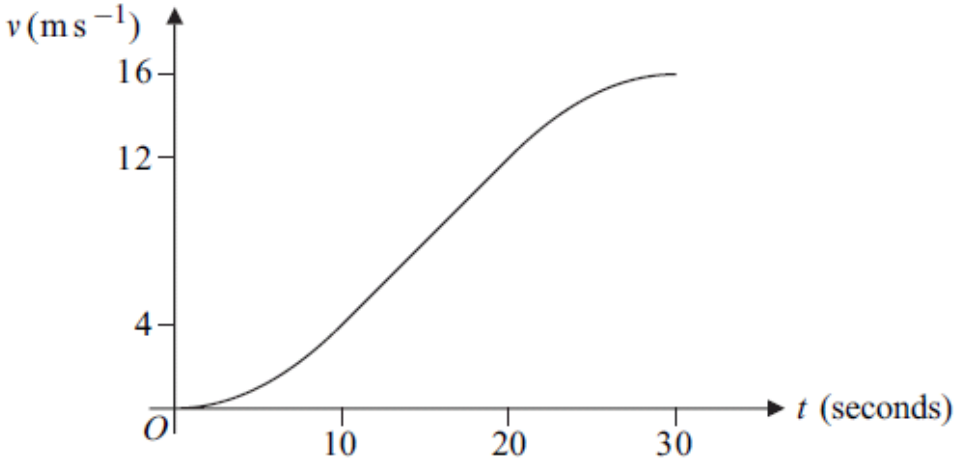
(i) Sketch a velocity–time graph to represent the motion of the van during the first 30 seconds of its motion. *(3 marks)*

(ii) Find the total distance that the van travels during the 30 seconds. *(4 marks)*

(iii) Find the average speed of the van during the 30 seconds. *(2 marks)*

(iv) Find the greatest acceleration of the van during the 30 seconds. *(2 marks)*

(b) In another model of the 30 seconds of the motion, the acceleration of the van is assumed to vary during the first and third stages of the motion, but to be constant during the second stage, as shown in the velocity–time graph below.



The velocity of the van takes the same values at the beginning and the end of each stage of the motion as in part (a).

(i) State, with a reason, whether the distance travelled by the van during the first 10 seconds of the motion in **this** model is greater or less than the distance travelled during the same time interval in the model in part (a). *(2 marks)*

(ii) Give one reason why **this** model represents the motion of the van more realistically than the model in part (a). *(1 mark)*

3 (a) A small stone is dropped from a height of 25 metres above the ground.

(i) Find the time taken for the stone to reach the ground. *(2 marks)*

(ii) Find the speed of the stone as it reaches the ground. *(2 marks)*

(b) A large package is dropped from the same height as the stone. Explain briefly why the time taken for the package to reach the ground is likely to be different from that for the stone. *(2 marks)*

June 2006

1 A stone is dropped from a high bridge and falls vertically.

(a) Find the distance that the stone falls during the first 4 seconds of its motion. *(3 marks)*

(b) Find the average speed of the stone during the first 4 seconds of its motion. *(2 marks)*

(c) State one modelling assumption that you have made about the forces acting on the stone during the motion. *(1 mark)*

3 A car travels along a straight horizontal road. The motion of the car can be modelled as three separate stages.

During the first stage, the car accelerates uniformly from rest to a velocity of $10\,\mathrm{m\,s^{-1}}$ in 6 seconds.

During the second stage, the car travels with a constant velocity of $10\,\mathrm{m\,s^{-1}}$ for a further 4 seconds.

During the third stage of the motion, the car travels with a uniform retardation of magnitude $0.8\,\mathrm{m\,s^{-2}}$ until it comes to rest.

(a) Show that the time taken for the **third** stage of the motion is 12.5 seconds. *(2 marks)*

(b) Sketch a velocity–time graph for the car during the three stages of the motion. *(4 marks)*

(c) Find the total distance travelled by the car during the motion. *(3 marks)*

(d) State one criticism of the model of the motion. *(1 mark)*

January 2007

2 A lift rises vertically from rest with a constant acceleration.

After 4 seconds, it is moving upwards with a velocity of $2\,\mathrm{m\,s^{-1}}$.

It then moves with a constant velocity for 5 seconds.

The lift then slows down uniformly, coming to rest after it has been moving for a total of 12 seconds.

(a) Sketch a velocity–time graph for the motion of the lift. *(4 marks)*

(b) Calculate the total distance travelled by the lift. *(2 marks)*

(c) The lift is raised by a single vertical cable. The mass of the lift is 300 kg. Find the maximum tension in the cable during this motion. *(4 marks)*

June 2007

1 A ball is released from rest at a height h metres above ground level. The ball hits the ground 1.5 seconds after it is released. Assume that the ball is a particle that does not experience any air resistance.

(a) Show that the speed of the ball is $14.7\,\mathrm{m\,s^{-1}}$ when it hits the ground. *(2 marks)*

(b) Find h. *(2 marks)*

(c) Find the distance that the ball has fallen when its speed is $5\,\mathrm{m\,s^{-1}}$. *(3 marks)*

January 2008

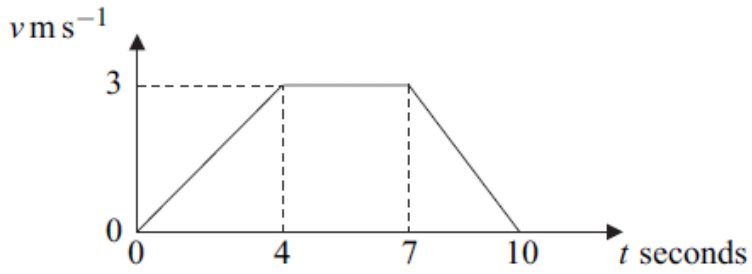
1 A crane is used to lift a crate, of mass 70 kg, vertically upwards. As the crate is lifted, it accelerates uniformly from rest, rising 8 metres in 5 seconds.

(a) Show that the acceleration of the crate is $0.64\,\mathrm{m\,s^{-2}}$. *(2 marks)*

(c) Calculate the average speed of the crate during these 5 seconds. *(1 mark)*

June 2008

1 The diagram shows a velocity–time graph for a lift.

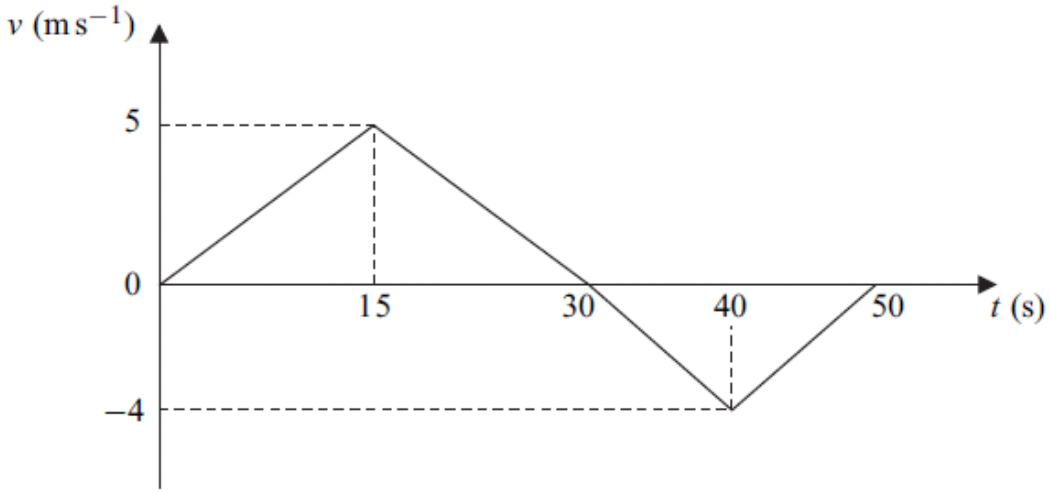


(a) Find the distance travelled by the lift. *(3 marks)*

(b) Find the acceleration of the lift during the first 4 seconds of the motion. *(1 mark)*

January 2009

2 The graph shows how the velocity of a particle varies during a 50-second period as it moves forwards and then backwards on a straight line.



(a) State the times at which the velocity of the particle is zero. *(2 marks)*

(b) Show that the particle travels a distance of 75 metres during the first 30 seconds of its motion. *(2 marks)*

(c) Find the total distance travelled by the particle during the 50 seconds. *(4 marks)*

(d) Find the distance of the particle from its initial position at the end of the 50-second period. *(2 marks)*

June 2009

2 A lift is travelling upwards and accelerating uniformly. During a 5 second period, it travels 16 metres and the speed of the lift increases from $u\,\mathrm{m\,s^{-1}}$ to $4.2\,\mathrm{m\,s^{-1}}$.

(a) Find u. *(3 marks)*

(b) Find the acceleration of the lift. *(3 marks)*

January 2010

2 A sprinter accelerates from rest at a constant rate for the first 10 metres of a 100-metre race. He takes 2.5 seconds to run the first 10 metres.

(a) Find the acceleration of the sprinter during the first 2.5 seconds of the race. *(3 marks)*

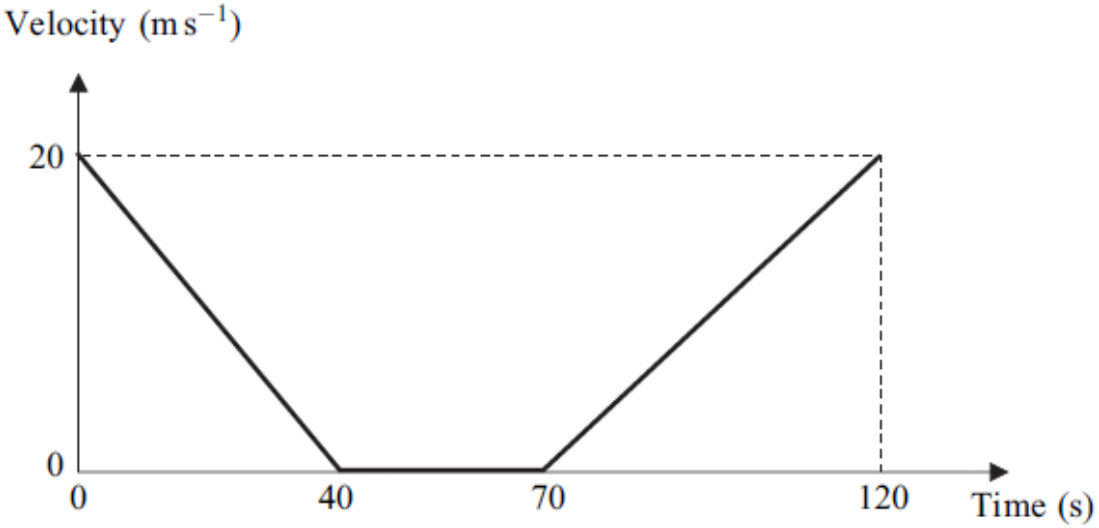
(b) Show that the speed of the sprinter at the end of the first 2.5 seconds of the race is $8\,\mathrm{m\,s^{-1}}$. *(2 marks)*

(c) The sprinter completes the 100-metre race, travelling the remaining 90 metres at a constant speed of $8\,\mathrm{m\,s^{-1}}$. Find the total time taken for the sprinter to travel the 100 metres. *(3 marks)*

(d) Calculate the average speed of the sprinter during the 100-metre race. *(2 marks)*

June 2010

1 A bus slows down as it approaches a bus stop. It stops at the bus stop and remains at rest for a short time as the passengers get on. It then accelerates away from the bus stop. The graph shows how the velocity of the bus varies.



Assume that the bus travels in a straight line during the motion described by the graph.

(a) State the length of time for which the bus is at rest. *(1 mark)*

(b) Find the distance travelled by the bus in the first 40 seconds. *(2 marks)*

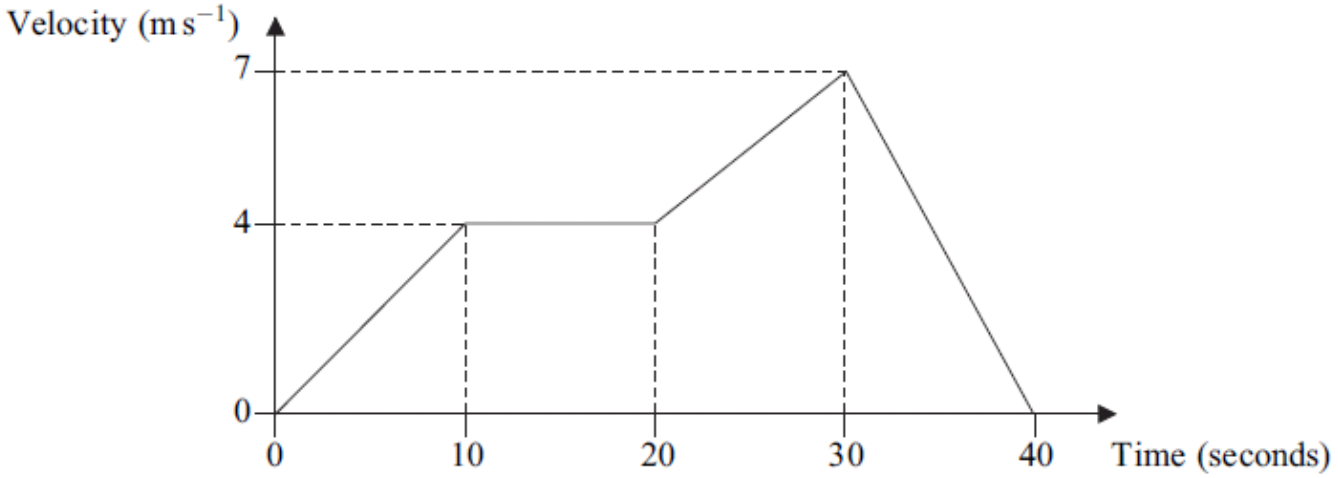
(c) Find the total distance travelled by the bus in the 120-second period. *(2 marks)*

(d) Find the average speed of the bus in the 120-second period. *(2 marks)*

(e) If the bus had not stopped but had travelled at a constant 20 m s^{-1} for the 120-second period, how much further would it have travelled? *(2 marks)*

January 2011

2 The graph shows how the velocity of a train varies as it moves along a straight railway line.



(a) Find the total distance travelled by the train. *(4 marks)*

(b) Find the average speed of the train. *(2 marks)*

(c) Find the acceleration of the train during the first 10 seconds of its motion. *(2 marks)*

June 2011

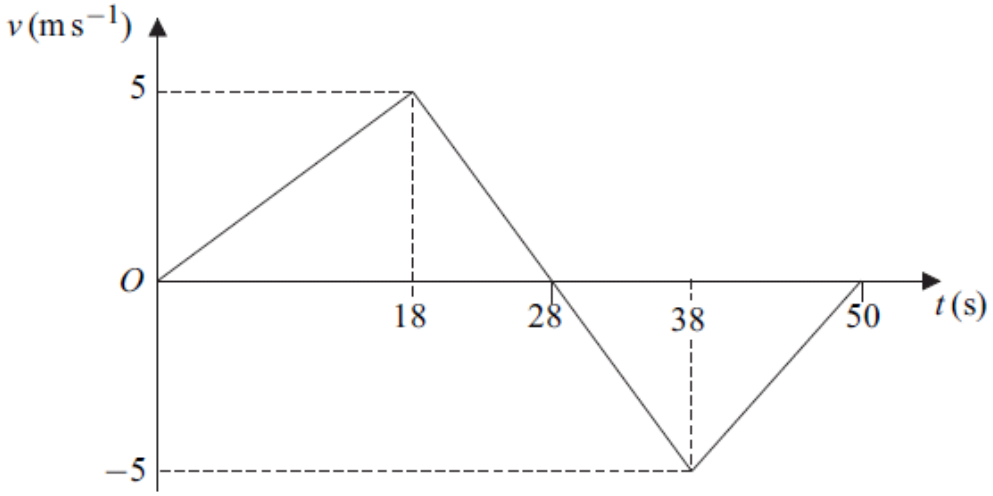
1 A crane is used to lift a load, using a single vertical cable which is attached to the load. The load accelerates uniformly from rest. When it has risen 0.9 metres, its speed is 0.6 m s^{-1}.

(a) (i) Show that the acceleration of the load is 0.2 m s^{-2}. *(3 marks)*

(ii) Find the time taken for the load to rise 0.9 metres. *(2 marks)*

January 2012

3 The diagram shows a velocity–time graph for a train as it moves on a straight horizontal track for 50 seconds.



(a) Find the distance that the train moves in the first 28 seconds. *(2 marks)*

(b) Calculate the total distance moved by the train during the 50 seconds. *(3 marks)*

(c) Hence calculate the average speed of the train. *(2 marks)*

(d) Find the displacement of the train from its initial position when it has been moving for 50 seconds. *(1 mark)*

(e) Hence calculate the average velocity of the train. *(2 marks)*

(f) Find the acceleration of the train in the first 18 seconds of its motion. *(1 mark)*

June 2012

3 A car is travelling at a speed of $20\,\text{m s}^{-1}$ along a straight horizontal road. The driver applies the brakes and a constant braking force acts on the car until it comes to rest.

(a) Assume that no other horizontal forces act on the car.

(i) After the car has travelled 75 metres, its speed has reduced to $10\,\text{m s}^{-1}$. Find the acceleration of the car. *(3 marks)*

(ii) Find the time taken for the speed of the car to reduce from $20\,\text{m s}^{-1}$ to zero. *(2 marks)*

January 2013

1 A car travels on a straight horizontal race track. The car decelerates uniformly from a speed of $20\,\text{m s}^{-1}$ to a speed of $12\,\text{m s}^{-1}$ as it travels a distance of 640 metres. The car then accelerates uniformly, travelling a further 1820 metres in 70 seconds.

(a) (i) Find the time that it takes the car to travel the first 640 metres. *(3 marks)*

(ii) Find the deceleration of the car during the first 640 metres. *(3 marks)*

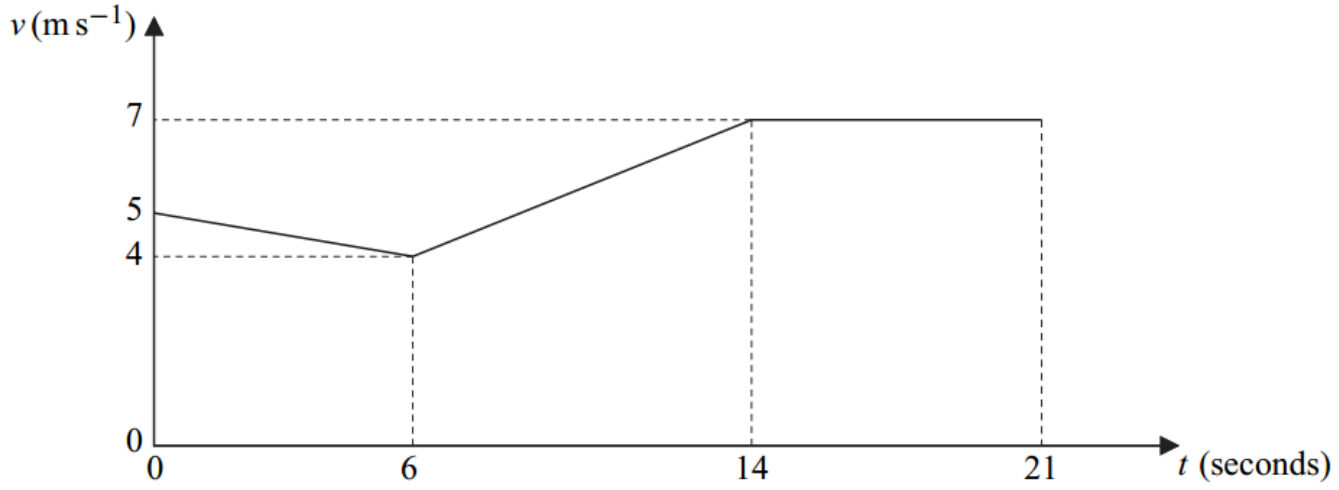
(b) (i) Find the acceleration of the car as it travels the further 1820 metres. *(3 marks)*

(ii) Find the speed of the car when it has completed the further 1820 metres. *(3 marks)*

(c) Find the average speed of the car as it travels the 2460 metres. *(2 marks)*

June 2013

2 The graph shows how the speed of a cyclist, Hannah, varies as she travels for 21 seconds along a straight horizontal road.



(a) Find the distance travelled by Hannah in the 21 seconds. *(4 marks)*

(b) Find Hannah's average speed during the 21 seconds. *(2 marks)*