Mechanics

TOPIC- Kinematics

Interpret graph

Kinematics-Interpret graph

0 1 A train travels from A to B, a distance of 20 000 m, taking 1000 s. The journey has three stages. In the first stage the train starts from rest at A and accelerates uniformly until its speed is $V\,\text{m s}^{-1}$. In the second stage the train travels at constant speed $V\,\text{m s}^{-1}$ for 600 s. During the third stage of the journey the train decelerates uniformly, coming to rest at B.

(i) Sketch the velocity-time graph for the train's journey. [2]

(ii) Find the value of V. [3]

(iii) Given that the acceleration of the train during the first stage of the journey is $0.15\,\text{m s}^{-2}$, find the distance travelled by the train during the third stage of the journey. [4]

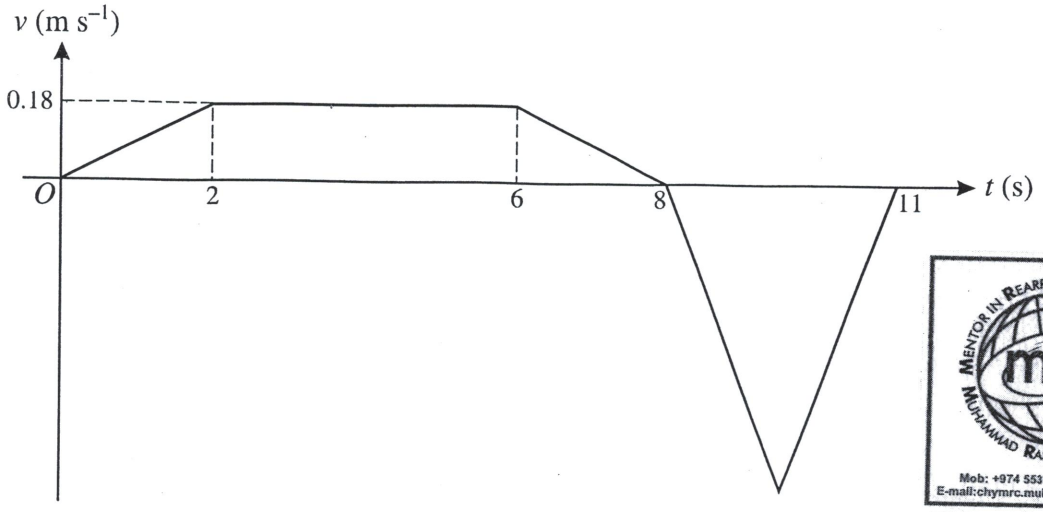
55258711

MENTOR IN REARRANGED & CLASSIFIED MUHAMMAD RASHED CHOWDHURY
mrc
Mob: +974 55373678 / 33787500
E-mail:chymrc.muhammad@gmail.com

rashed.saba@gmail.com

Kinematics-Interpret graph

2



The diagram shows the velocity-time graph for the motion of a machine's cutting tool. The graph consists of five straight line segments. The tool moves forward for 8 s while cutting and then takes 3 s to return to its starting position. Find

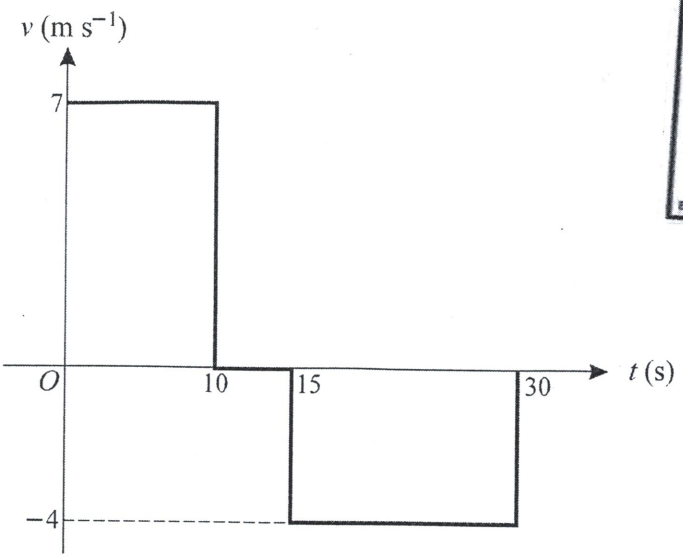
(i) the acceleration of the tool during the first 2 s of the motion, [1]

(ii) the distance the tool moves forward while cutting, [2]

(iii) the greatest speed of the tool during the return to its starting position. [2]

Kinematics-Interpret graph

3



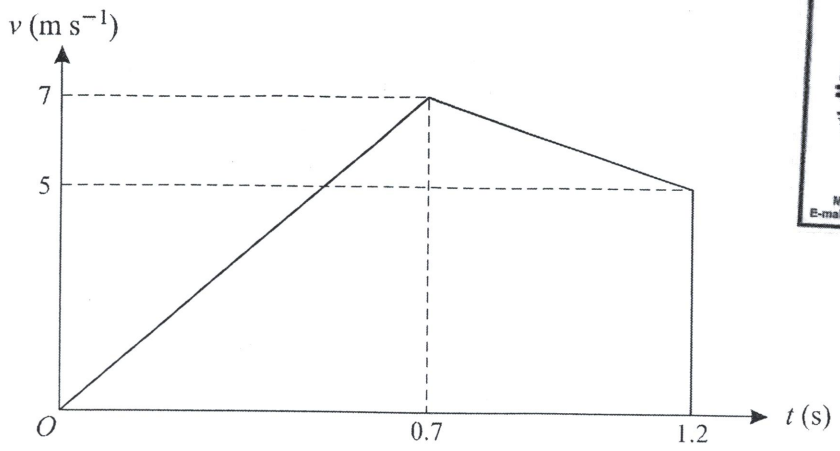
A boy runs from a point A to a point C. He pauses at C and then walks back towards A until reaching the point B, where he stops. The diagram shows the graph of v against t, where v m s^{-1} is the boy's velocity at time t seconds after leaving A. The boy runs and walks in the same straight line throughout.

(i) Find the distances AC and AB. [3]

(ii) Sketch the graph of x against t, where x metres is the boy's displacement from A. Show clearly the values of t and x when the boy arrives at C, when he leaves C, and when he arrives at B. [3]

Kinematics-Interpret graph

4



The diagram shows the velocity-time graph for the motion of a small stone which falls vertically from rest at a point A above the surface of liquid in a container. The downward velocity of the stone t s after leaving A is v m s^{-1}. The stone hits the surface of the liquid with velocity 7 m s^{-1} when $t = 0.7$. It reaches the bottom of the container with velocity 5 m s^{-1} when $t = 1.2$.

(i) Find

(a) the height of A above the surface of the liquid,

(b) the depth of liquid in the container.

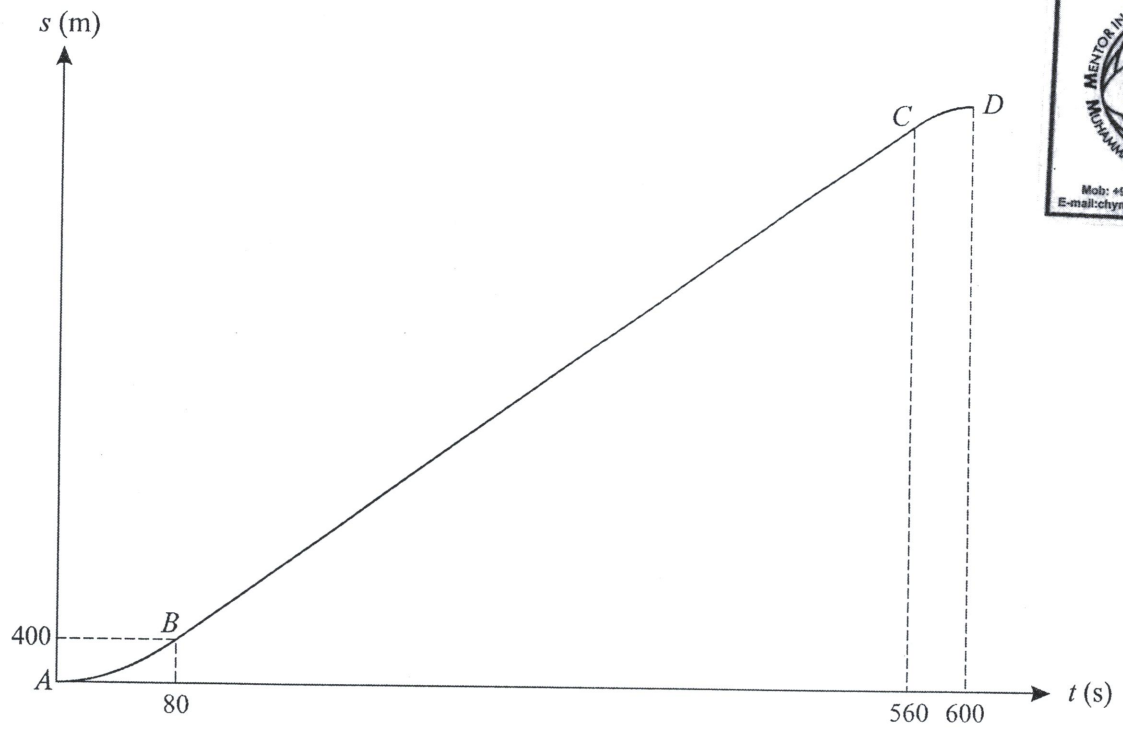
[3]

(ii) Find the deceleration of the stone while it is moving in the liquid. [2]

(iii) Given that the resistance to motion of the stone while it is moving in the liquid has magnitude 0.7 N, find the mass of the stone. [3]

Kinematics-Interpret graph

5



The diagram shows the displacement-time graph for a car's journey. The graph consists of two curved parts AB and CD, and a straight line BC. The line BC is a tangent to the curve AB at B and a tangent to the curve CD at C. The gradient of the curves at $t = 0$ and $t = 600$ is zero, and the acceleration of the car is constant for $0 < t < 80$ and for $560 < t < 600$. The displacement of the car is 400 m when $t = 80$.

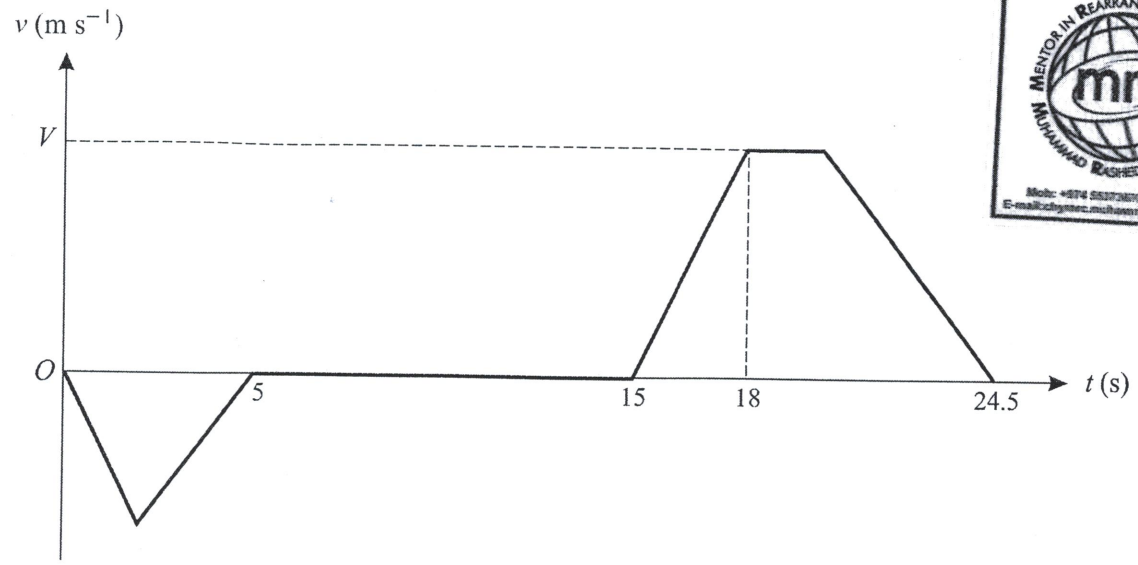
(i) Sketch the velocity-time graph for the journey. [3]

(ii) Find the velocity at $t = 80$. [2]

(iii) Find the total distance for the journey. [2]

(iv) Find the acceleration of the car for $0 < t < 80$. [2]

6



The diagram shows the velocity-time graph for a lift moving between floors in a building. The graph consists of straight line segments. In the first stage the lift travels downwards from the ground floor for 5 s, coming to rest at the basement after travelling 10 m.

(i) Find the greatest speed reached during this stage. [2]

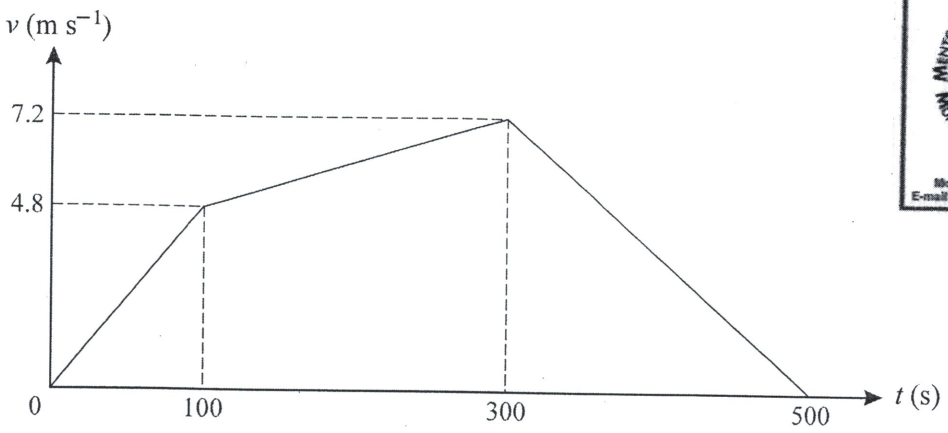
The second stage consists of a 10 s wait at the basement. In the third stage, the lift travels upwards until it comes to rest at a floor 34.5 m above the basement, arriving 24.5 s after the start of the first stage. The lift accelerates at $2\,\text{m s}^{-2}$ for the first 3 s of the third stage, reaching a speed of $V\,\text{m s}^{-1}$. Find

(ii) the value of V, [2]

(iii) the time during the third stage for which the lift is moving at constant speed, [3]

(iv) the deceleration of the lift in the final part of the third stage. [2]

7



A tractor A starts from rest and travels along a straight road for 500 seconds. The velocity-time graph for the journey is shown above. This graph consists of three straight line segments. Find

(i) the distance travelled by A, [3]

(ii) the initial acceleration of A. [2]

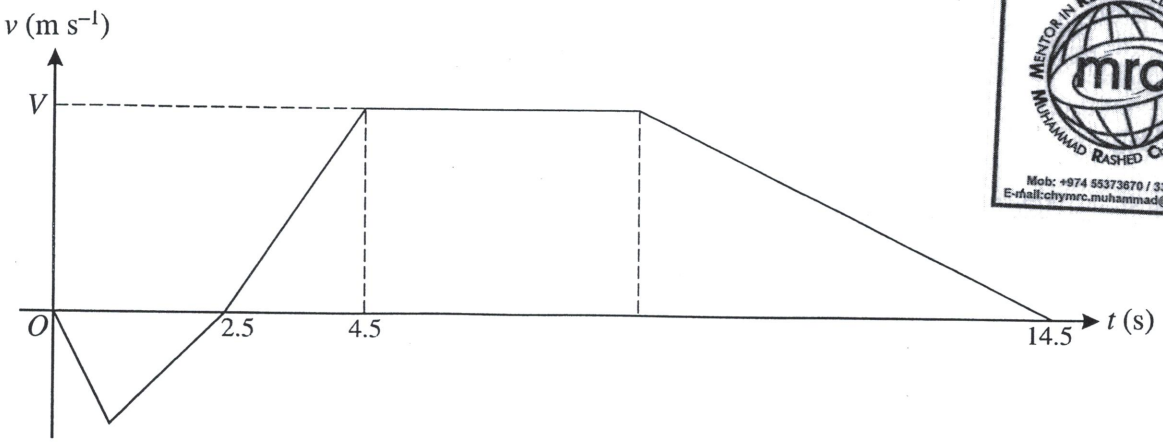
Another tractor B starts from rest at the same instant as A, and travels along the same road for 500 seconds. Its velocity t seconds after starting is $(0.06t - 0.00012t^2)$ m s^{-1}. Find

(iii) how much greater B's initial acceleration is than A's, [2]

(iv) how much further B has travelled than A, at the instant when B's velocity reaches its maximum. [6]

Kinematics-Interpret graph

0 8



The diagram shows the velocity-time graph for a particle P which travels on a straight line AB, where v m s^{-1} is the velocity of P at time t s. The graph consists of five straight line segments. The particle starts from rest when $t = 0$ at a point X on the line between A and B and moves towards A. The particle comes to rest at A when $t = 2.5$.

(i) Given that the distance XA is 4 m, find the greatest speed reached by P during this stage of the motion. [2]

In the second stage, P starts from rest at A when $t = 2.5$ and moves towards B. The distance AB is 48 m. The particle takes 12 s to travel from A to B and comes to rest at B. For the first 2 s of this stage P accelerates at 3 m s^{-2}, reaching a velocity of V m s^{-1}. Find

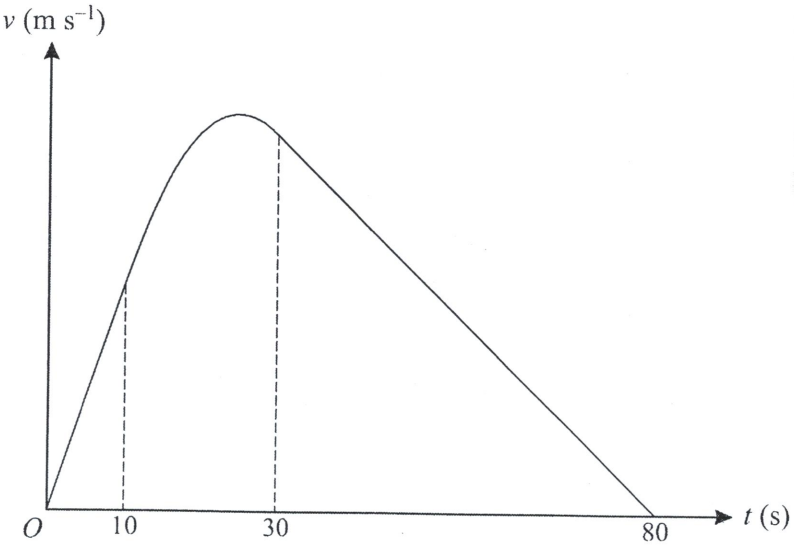
(ii) the value of V, [2]

(iii) the value of t at which P starts to decelerate during this stage, [3]

(iv) the deceleration of P immediately before it reaches B. [2]

Kinematics-Interpret graph

09



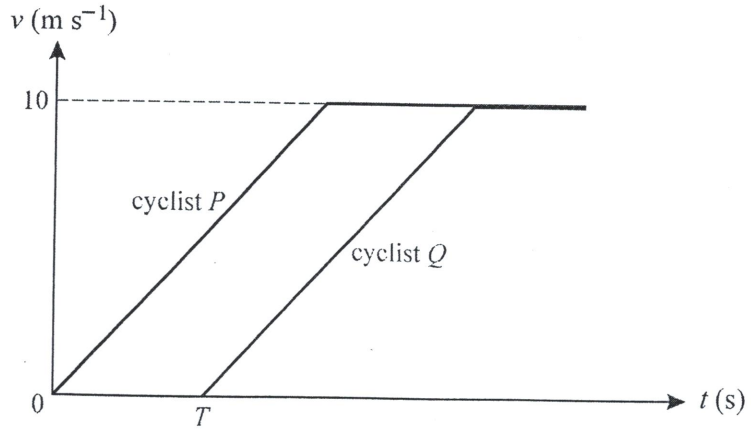
An object P travels from A to B in a time of 80 s. The diagram shows the graph of v against t, where v m s^{-1} is the velocity of P at time t s after leaving A. The graph consists of straight line segments for the intervals $0 \leqslant t \leqslant 10$ and $30 \leqslant t \leqslant 80$, and a curved section whose equation is $v = -0.01t^2 + 0.5t - 1$ for $10 \leqslant t \leqslant 30$. Find

(i) the maximum velocity of P, [4]

(ii) the distance AB. [9]

Kinematics-Interpret graph

10



The diagram shows the velocity-time graphs for the motion of two cyclists P and Q, who travel in the same direction along a straight path. Both cyclists start from rest at the same point O and both accelerate at $2\,\text{m s}^{-2}$ up to a speed of $10\,\text{m s}^{-1}$. Both then continue at a constant speed of $10\,\text{m s}^{-1}$. Q starts his journey T seconds after P.

(i) Show in a sketch of the diagram the region whose area represents the displacement of P, from O, at the instant when Q starts. [1]

Given that P has travelled 16 m at the instant when Q starts, find

(ii) the value of T, [3]

(iii) the distance between P and Q when Q's speed reaches $10\,\text{m s}^{-1}$. [2]

Kinematics-Interpret graph

1 A lift moves upwards from rest and accelerates at $0.9\,\text{m s}^{-2}$ for 3 s. The lift then travels for 6 s at constant speed and finally slows down, with a constant deceleration, stopping in a further 4 s.

(i) Sketch a velocity-time graph for the motion. [3]

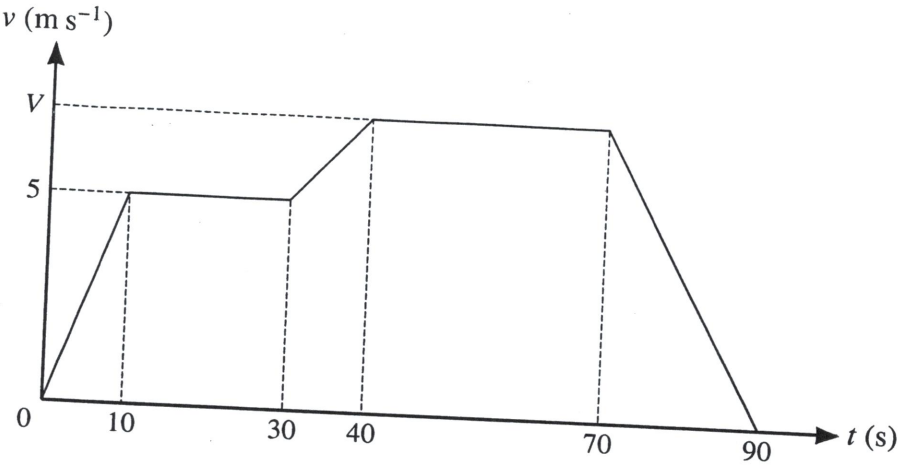
(ii) Find the total distance travelled by the lift. [2]

55258711

MENTOR IN REARRANGED & CLASSIFIED MUHAMMAD RASHED CHOWDHURY
mrc
Mob: +974 55373679 / 33787500
E-mail:chymrc.muhammad@gmail.com

rashed.saba@gmail.com

12



The diagram shows a velocity-time graph which models the motion of a cyclist. The graph consists of five straight line segments. The cyclist accelerates from rest to a speed of 5 m s^{-1} over a period of 10 s, and then travels at this speed for a further 20 s. The cyclist then descends a hill, accelerating to speed V m s^{-1} over a period of 10 s. This speed is maintained for a further 30 s. The cyclist then decelerates to rest over a period of 20 s.

(i) Find the acceleration of the cyclist during the first 10 seconds. [1]

(ii) Show that the total distance travelled by the cyclist in the 90 seconds of motion may be expressed as $(45V + 150)$ m. Hence find V, given that the total distance travelled by the cyclist is 465 m. [3]

(iii) The combined mass of the cyclist and the bicycle is 80 kg. The cyclist experiences a constant resistance to motion of 20 N. Use an energy method to find the vertical distance which the cyclist descends during the downhill section from $t = 30$ to $t = 40$, assuming that the cyclist does no work during this time. [4]

13

The velocity-time graph shown models the motion of a parachutist falling vertically. There are four stages in the motion:

- falling freely with the parachute closed,
- decelerating at a constant rate with the parachute open,
- falling with constant speed with the parachute open,
- coming to rest instantaneously on hitting the ground.

(i) Show that the total distance fallen is 1048 m. [2]

The weight of the parachutist is 850 N.

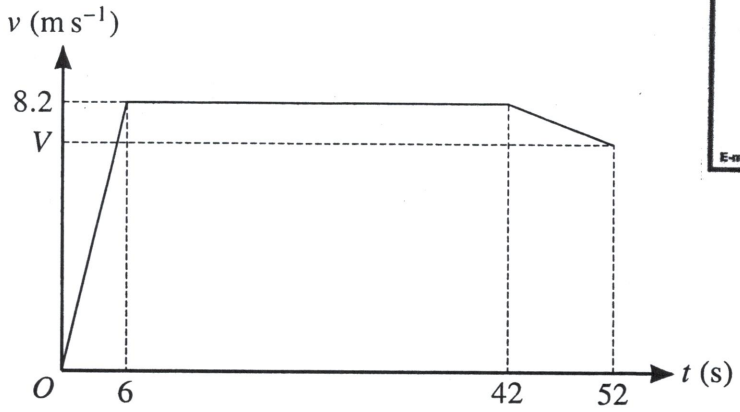
(ii) Find the upward force on the parachutist due to the parachute, during the second stage. [5]

55258711

MENTOR IN REARRANGED & CLASSIFIED MUHAMMAD RASHED CHOWDHURY
mrc
Mob: +974 55373670 / 33787500
E-mail:chymrc.muhammad@gmail.com

rashed.saba@gmail.com

14



A sprinter runs a race of 400 m. His total time for running the race is 52 s. The diagram shows the velocity-time graph for the motion of the sprinter. He starts from rest and accelerates uniformly to a speed of 8.2 m s^{-1} in 6 s. The sprinter maintains a speed of 8.2 m s^{-1} for 36 s, and he then decelerates uniformly to a speed of V m s^{-1} at the end of the race.

(i) Calculate the distance covered by the sprinter in the first 42 s of the race. [2]

(ii) Show that $V = 7.84$. [3]

(iii) Calculate the deceleration of the sprinter in the last 10 s of the race. [2]

Kinematics-Interpret graph

15 A train starts from rest at a station A and travels in a straight line to station B, where it comes to rest. The train moves with constant acceleration $0.025\ \text{m s}^{-2}$ for the first 600 s, with constant speed for the next 2600 s, and finally with constant deceleration $0.0375\ \text{m s}^{-2}$.

(i) Find the total time taken for the train to travel from A to B. [4]

(ii) Sketch the velocity-time graph for the journey and find the distance AB. [3]

(iii) The speed of the train t seconds after leaving A is $7.5\ \text{m s}^{-1}$. State the possible values of t. [1]

55258711

MENTOR IN REARRANGED & CLASSIFIED MUHAMMAD RASHED CHOWDHURY
mrc
Mob: +974 55373670 / 33787500
E-mail:chymrc.muhammad@gmail.com

rashed.saba@gmail.com

16

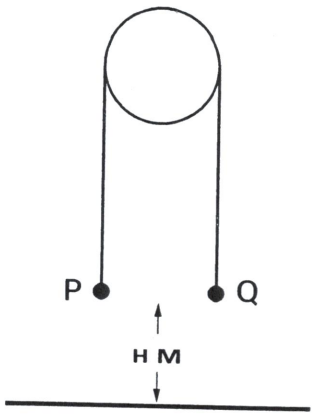


FIG. 1

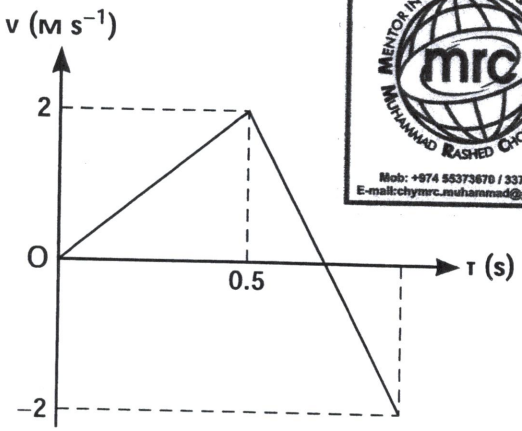


FIG. 2

Two particles P and Q have masses M kg and $(1 - M)$ kg respectively. The particles are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. P is held at rest with the string taut and both straight parts of the string vertical. P and Q are each at a height of H m above horizontal ground (see Fig. 1). P is released and Q moves downwards. Subsequently Q hits the ground and comes to rest. Fig. 2 shows the velocity-time graph for P while Q is moving downwards or is at rest on the ground.

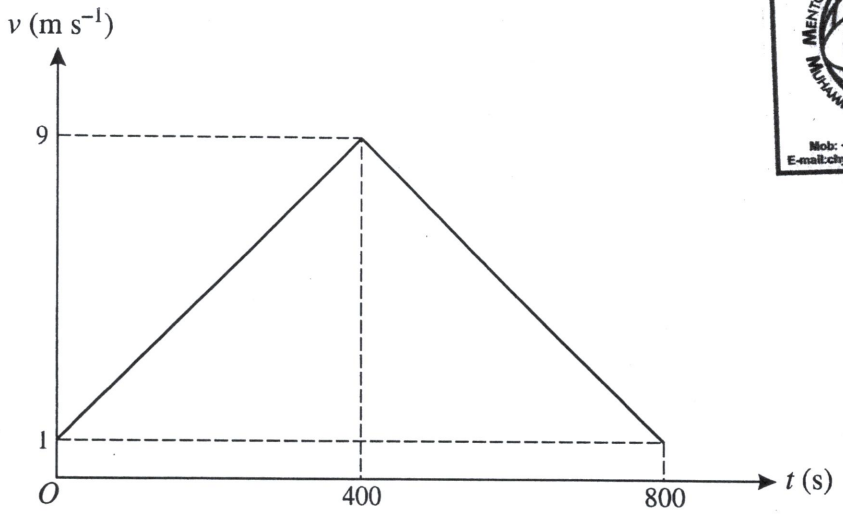
(i) Find the value of H. [2]

(ii) Find the value of M, and find also the tension in the string while Q is moving. [6]

(iii) The string is slack while Q is at rest on the ground. Find the total time from the instant that P is released until the string becomes taut again. [3]

17 A tractor travels in a straight line from a point A to a point B. The velocity of the tractor is v m s^{-1} at time t s after leaving A.

(i)



The diagram shows an approximate velocity-time graph for the motion of the tractor. The graph consists of two straight line segments. Use the graph to find an approximation for

(a) the distance AB, [2]

(b) the acceleration of the tractor for $0 < t < 400$ and for $400 < t < 800$. [2]

(ii) The actual velocity of the tractor is given by $v = 0.04t - 0.000\,05t^2$ for $0 \leqslant t \leqslant 800$.

(a) Find the values of t for which the actual acceleration of the tractor is given correctly by the approximate velocity-time graph in part **(i)**. [3]

For the interval $0 \leqslant t \leqslant 400$, the approximate velocity of the tractor in part **(i)** is denoted by v_1 m s^{-1}.

(b) Express v_1 in terms of t and hence show that $v_1 - v = 0.000\,05(t - 200)^2 - 1$. [2]

(c) Deduce that $-1 \leqslant v_1 - v \leqslant 1$. [2]

Kinematics-Interpret graph

18 A particle starts from rest at a point O and moves in a horizontal straight line. The velocity of the particle is v m s^{-1} at time t s after leaving O. For $0 \leqslant t < 60$, the velocity is given by

$$v = 0.05t - 0.0005t^2.$$

The particle hits a wall at the instant when $t = 60$, and reverses the direction of its motion. The particle subsequently comes to rest at the point A when $t = 100$, and for $60 < t \leqslant 100$ the velocity is given by

$$v = 0.025t - 2.5.$$

(i) Find the velocity of the particle immediately before it hits the wall, and its velocity immediately after its hits the wall. [2]

(ii) Find the total distance travelled by the particle. [4]

(iii) Find the maximum speed of the particle and sketch the particle's velocity-time graph for $0 \leqslant t \leqslant 100$, showing the value of t for which the speed is greatest. [4]

55258711

MENTOR IN REARRANGED & CLASSIFIED MUHAMMAD RASHED CHOWDHURY mrc
Mob: +974 55373670 / 33787500
E-mail:chymrc.muhammad@gmail.com

rashed.saba@gmail.com

19

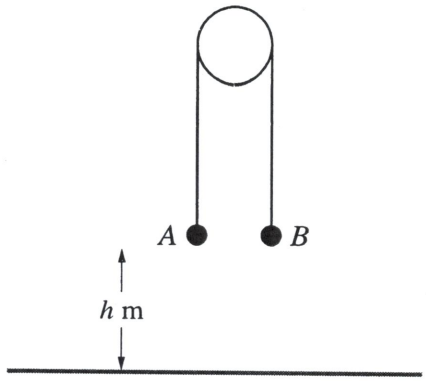


Fig. 1

Particles A of mass 0.25 kg and B of mass 0.75 kg are attached to opposite ends of a light inextensible string which passes over a fixed smooth pulley. The system is held at rest with the string taut and its straight parts vertical. Both particles are at a height of h m above the floor (see Fig. 1). The system is released from rest, and 0.6 s later, when both particles are in motion, the string breaks. The particle A does not reach the pulley in the subsequent motion.

(i) Find the acceleration of A and the distance travelled by A before the string breaks. [4]

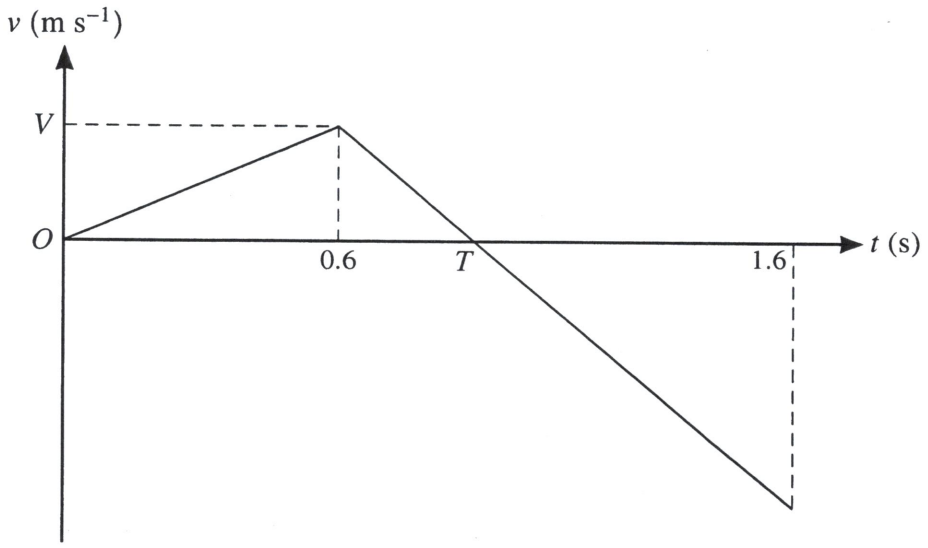


Fig. 2

The velocity-time graph shown in Fig. 2 is for the motion of particle A until it hits the floor. The velocity of A when the string breaks is V m s^{-1} and T s is the time taken for A to reach its greatest height.

(ii) Find the value of V and the value of T. [3]

(iii) Find the distance travelled by A upwards and the distance travelled by A downwards and hence find h. [3]

20 A cyclist starts from rest at point A and moves in a straight line with acceleration $0.5\,\text{m s}^{-2}$ for a distance of 36 m. The cyclist then travels at constant speed for 25 s before slowing down, with constant deceleration, to come to rest at point B. The distance AB is 210 m.

(i) Find the total time that the cyclist takes to travel from A to B. [5]

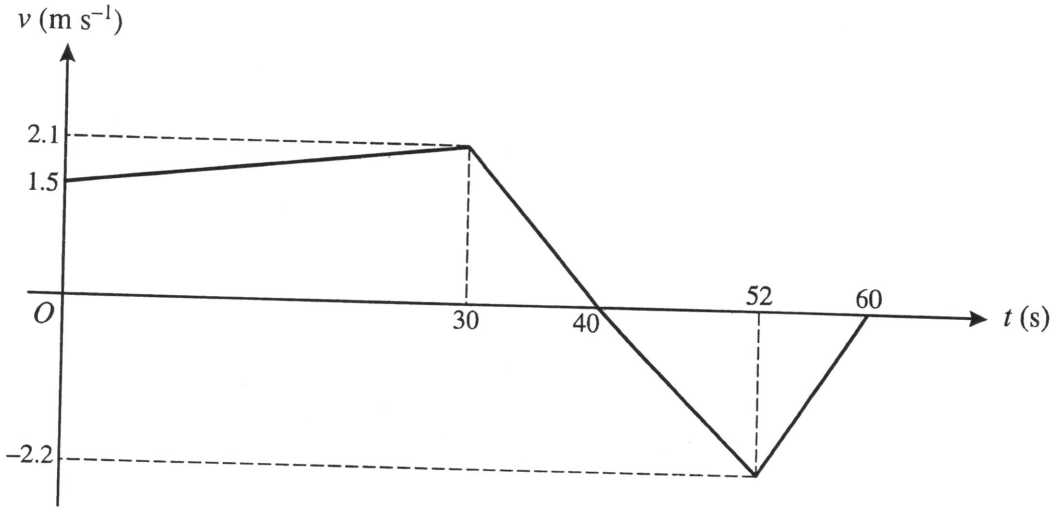
7-15-41 7

24 s after the cyclist leaves point A, a car starts from rest from point A, with constant acceleration $4\,\text{m s}^{-2}$, towards B. It is given that the car overtakes the cyclist while the cyclist is moving with constant speed.

(ii) Find the time that it takes from when the cyclist starts until the car overtakes her. [5]

Kinematics-Interpret graph

21



A woman walks in a straight line. The woman's velocity t seconds after passing through a fixed point A on the line is v m s^{-1}. The graph of v against t consists of 4 straight line segments (see diagram). The woman is at the point B when $t = 60$. Find

(i) the woman's acceleration for $0 < t < 30$ and for $30 < t < 40$, [3]

(ii) the distance AB, [2]

(iii) the total distance walked by the woman. [1]

55258711

MENTOR IN REARRANGED & CLASSIFIED
mrc
MUHAMMAD RASHED CHOWDHURY
Mob: +974 55373670 / 33787500
E-mail:chymrc.muhammad@gmail.com

rashed.saba@gmail.com

2 2 A car starts from rest and moves in a straight line from point A with constant acceleration $3\,\text{m s}^{-2}$ for 10 s. The car then travels at constant speed for 30 s before decelerating uniformly, coming to rest at point B. The distance AB is 1.5 km.

7-16-42-7

(i) Find the total distance travelled in the first 40 s of motion. [3]

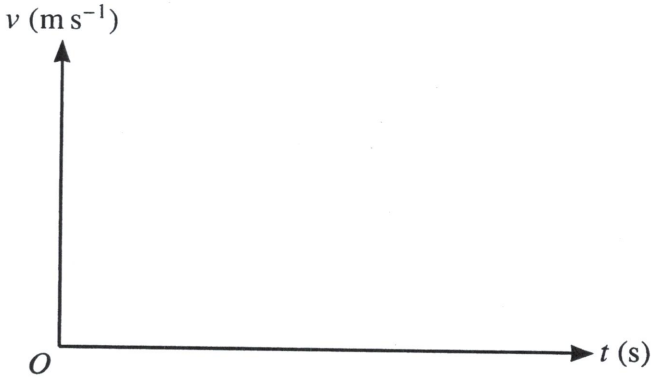
When the car has been moving for 20 s, a motorcycle starts from rest and accelerates uniformly in a straight line from point A to a speed $V\,\text{m s}^{-1}$. It then maintains this speed for 30 s before decelerating uniformly to rest at point B. The motorcycle comes to rest at the same time as the car.

(ii) Given that the magnitude of the acceleration $a\,\text{m s}^{-2}$ of the motorcycle is three times the magnitude of its deceleration, find the value of a. [6]

(iii) Sketch the displacement-time graph for the motion of the car. [3]

23 A train travels between two stations, A and B. The train starts from rest at A and accelerates at a constant rate for T s until it reaches a speed of $25\ \text{m s}^{-1}$. It then travels at this constant speed before decelerating at a constant rate, coming to rest at B. The magnitude of the train's deceleration is twice the magnitude of its acceleration. The total time taken for the journey is 180 s.

(i) Sketch the velocity-time graph for the train's journey from A to B. [1]



(ii) Find an expression, in terms of T, for the length of time for which the train is travelling with constant speed. [2]

.....

.....

.....

.....

.....

(iii) The distance from A to B is 3300 m. Find how far the train travels while it is decelerating. [3]

.....

.....

.....

.....

.....

.....

.....

.....

.....

rashed.saba@gmail.com

24

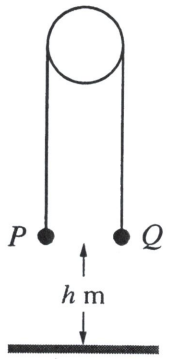


Fig. 1

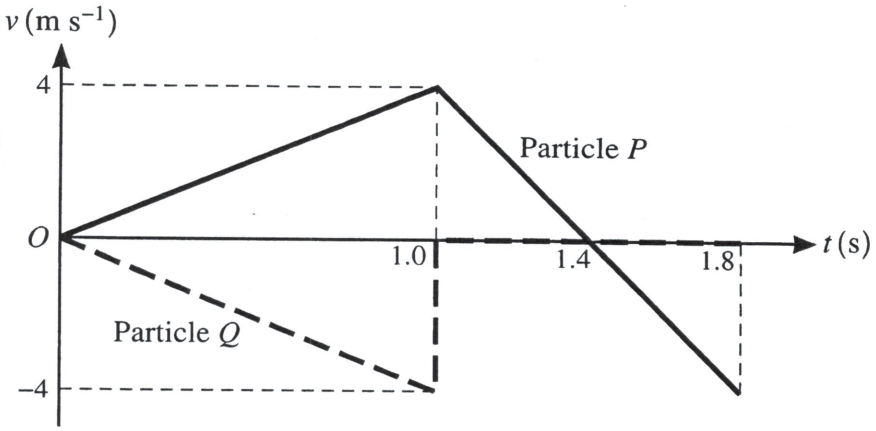


Fig. 2

Particles P and Q have a total mass of 1 kg. The particles are attached to opposite ends of a light inextensible string which passes over a smooth fixed pulley. P is held at rest and Q hangs freely, with both straight parts of the string vertical. Both particles are at a height of h m above the floor (see Fig. 1). P is released from rest and the particles start to move with the string taut. Fig. 2 shows the velocity-time graphs for P's motion and for Q's motion, where the positive direction for velocity is vertically upwards. Find

(i) the magnitude of the acceleration with which the particles start to move and the mass of each of the particles, [5]

(ii) the value of h, [1]

(iii) the greatest height above the floor reached by particle P. [2]

MENTOR IN REARRANGED & CLASSIFIED
mrc
MUHAMMAD RASHED CHOWDHURY
Mob: +974 55373670 / 33787580
E-mail:chymrc.muhammad@gmail.com

rashed.saba@gmail.com

25 A car travels in a straight line from A to B, a distance of 12 km, taking 552 seconds. The car starts from rest at A and accelerates for T_1 s at 0.3 m s^{-2}, reaching a speed of V m s^{-1}. The car then continues to move at V m s^{-1} for T_2 s. It then decelerates for T_3 s at 1 m s^{-2}, coming to rest at B.

(i) Sketch the velocity-time graph for the motion and express T_1 and T_3 in terms of V. [3]

(ii) Express the total distance travelled in terms of V and show that $13V^2 - 3312V + 72\,000 = 0$. Hence find the value of V. [5]

55258711

rashed.saba@gmail.com

26 A particle P moves in a straight line. It starts from rest at a point O and moves towards a point A on the line. During the first 8 seconds P's speed increases to $8\,\text{m s}^{-1}$ with constant acceleration. During the next 12 seconds P's speed decreases to $2\,\text{m s}^{-1}$ with constant deceleration. P then moves with constant acceleration for 6 seconds, reaching A with speed $6.5\,\text{m s}^{-1}$.

(i) Sketch the velocity-time graph for P's motion. [2]

The displacement of P from O, at time t seconds after P leaves O, is s metres.

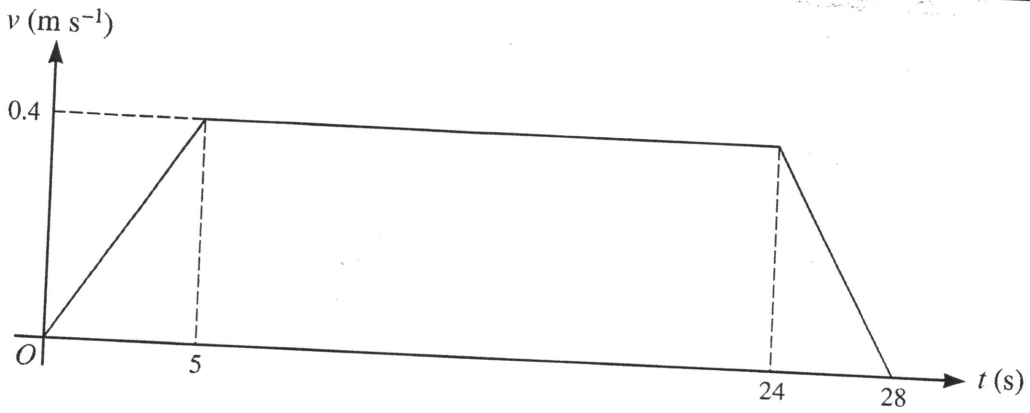
(ii) Shade the region of the velocity-time graph representing s for a value of t where $20 \leqslant t \leqslant 26$. [1]

(iii) Show that, for $20 \leqslant t \leqslant 26$,

$$s = 0.375t^2 - 13t + 202.$$

[6]

27



F 42-13 2

An elevator is pulled vertically upwards by a cable. The velocity-time graph for the motion is shown above. Find

(i) the distance travelled by the elevator, [2]

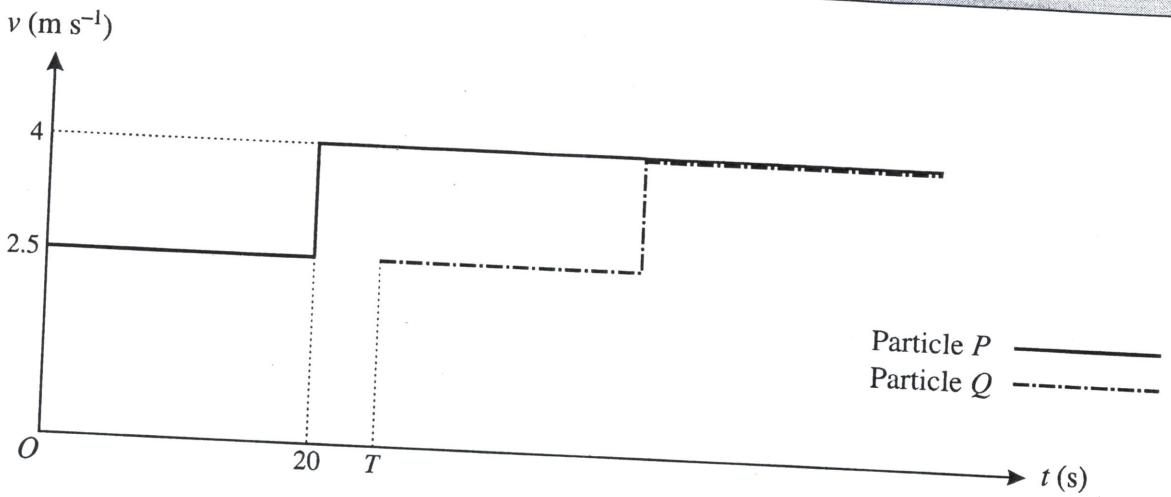
(ii) the acceleration during the first stage and the deceleration during the third stage. [2]

The mass of the elevator is 800 kg and there is a box of mass 100 kg on the floor of the elevator.

(iii) Find the tension in the cable in each of the three stages of the motion. [3]

(iv) Find the greatest and least values of the magnitude of the force exerted on the box by the floor of the elevator. [3]

28



The diagram shows the velocity-time graphs for the motion of two particles P and Q, which travel in the same direction along a straight line. P and Q both start at the same point X on the line, but Q starts to move T s later than P. Each particle moves with speed 2.5 m s^{-1} for the first 20 s of its motion. The speed of each particle changes instantaneously to 4 m s^{-1} after it has been moving for 20 s and the particle continues at this speed.

(i) Make a rough copy of the diagram and shade the region whose area represents the displacement of P from X at the instant when Q starts. [1]

It is given that P has travelled 70 m at the instant when Q starts.

(ii) Find the value of T. [2]

(iii) Find the distance between P and Q when Q's speed reaches 4 m s^{-1}. [2]

(iv) Sketch a single diagram showing the displacement-time graphs for both P and Q, with values shown on the t-axis at which the speed of either particle changes. [2]

29 A particle of mass 3 kg falls from rest at a point 5 m above the surface of a liquid which is in a container. There is no instantaneous change in speed of the particle as it enters the liquid. The depth of the liquid in the container is 4 m. The downward acceleration of the particle while it is moving in the liquid is $5.5\ \text{m s}^{-2}$.

(i) Find the resistance to motion of the particle while it is moving in the liquid. [2]

(ii) Sketch the velocity-time graph for the motion of the particle, from the time it starts to move until the time it reaches the bottom of the container. Show on your sketch the velocity and the time when the particle enters the liquid, and when the particle reaches the bottom of the container. [7]

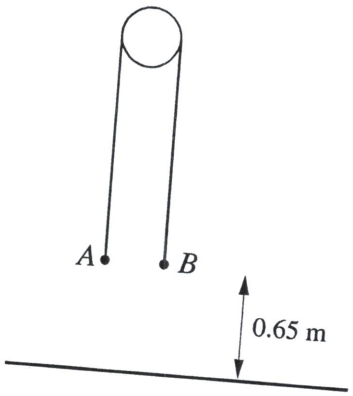
55258711

MENTOR IN REARRANGED & CLASSIFIED MUHAMMAD RASHED CHOWDHURY mrc

Mob: +974 55373670 / 33787500
E-mail:chymrc.muhammad@gmail.com

rashed.saba@gmail.com

30



Two particles A and B have masses 0.12 kg and 0.38 kg respectively. The particles are attached to the ends of a light inextensible string which passes over a fixed smooth pulley. A is held at rest with the string taut and both straight parts of the string vertical. A and B are each at a height of 0.65 m above horizontal ground (see diagram). A is released and B moves downwards. Find

(i) the acceleration of B while it is moving downwards, [2]

(ii) the speed with which B reaches the ground and the time taken for it to reach the ground. [3]

B remains on the ground while A continues to move with the string slack, without reaching the pulley. The string remains slack until A is at a height of 1.3 m above the ground for a second time. At this instant A has been in motion for a total time of T s.

(iii) Find the value of T and sketch the velocity-time graph for A for the first T s of its motion. [3]

(iv) Find the total distance travelled by A in the first T s of its motion. [2]