



Bronze Questions

Calculator

The total mark for this section is 35

Q1

A girl runs a 400 m race in a time of 84 s. In a model of this race, it is assumed that, starting from rest, she moves with constant acceleration for 4 s, reaching a speed of 5 m s^{-1} . She maintains this speed for 60 s and then moves with constant deceleration for 20 s, crossing the finishing line with a speed of $V \text{ m s}^{-1}$.

- (a) Sketch, in the space below, a speed-time graph for the motion of the girl during the whole race. (2)
- (b) Find the distance run by the girl in the first 64 s of the race. (3)
- (c) Find the value of V . (5)
- (d) Find the deceleration of the girl in the final 20 s of her race. (2)

(Total for Question 1 is 12 marks)

Q2

A car is moving along a straight horizontal road with constant acceleration.

There are three points A , B and C , in that order, on the road, where $AB = 22 \text{ m}$ and $BC = 104 \text{ m}$.

The car takes 2 s to travel from A to B and 4 s to travel from B to C .

Find

- (i) the acceleration of the car,
(ii) the speed of the car at the instant it passes A .

(Total for Question 2 is 7 marks)

Q3

A cyclist is moving along a straight horizontal road and passes a point A . Five seconds later, at the instant when she is moving with speed 10 ms^{-1} , she passes the point B . She moves with constant acceleration from A to B .

Given that $AB = 40\text{m}$, find

- (a) the acceleration of the cyclist as she moves from A to B , (4)
- (b) the time it takes her to travel from A to the midpoint of AB . (5)

(Total for Question 3 is 9 marks)

Q4

A small stone is projected vertically upwards from a point O with a speed of 19.6ms^{-1} .

Modelling the stone as a particle moving freely under gravity,

- (a) find the greatest height above O reached by the stone, (2)
- (b) find the length of time for which the stone is more than 14.7 m above O . (5)

(Total for Question 4 is 7 marks)

End of Questions



Silver Questions

Calculator

The total mark for this section is 36

Q1

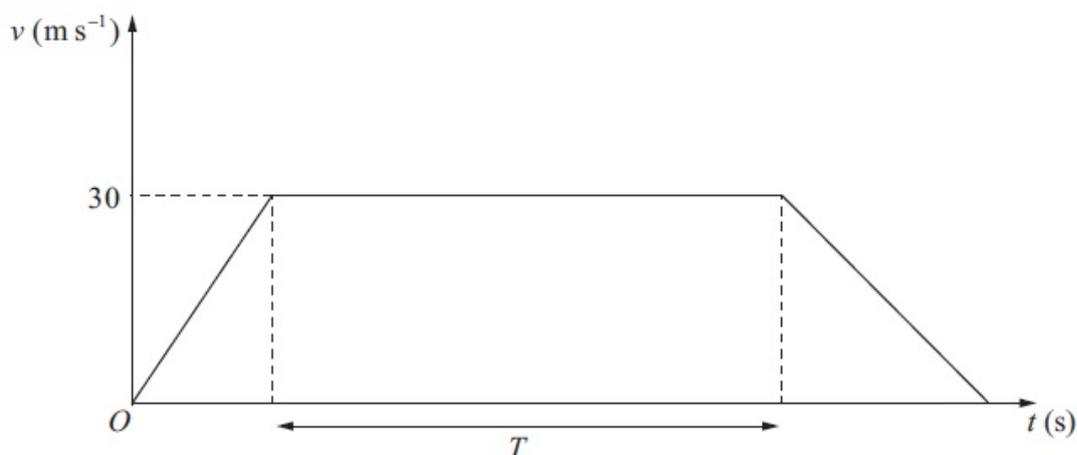


Figure 1

The velocity-time graph in Figure 1 represents the journey of a train P travelling along a straight horizontal track between two stations which are 1.5 km apart. The train P leaves the first station, accelerating uniformly from rest for 300 m until it reaches a speed of 30 m s^{-1} . The train then maintains this speed for T seconds before decelerating uniformly at 1.25 m s^{-2} , coming to rest at the next station.

(a) Find the acceleration of P during the first 300 m of its journey. (2)

(b) Find the value of T . (5)

A second train Q completes the same journey in the same total time. The train leaves the first station, accelerating uniformly from rest until it reaches a speed of $V \text{ m s}^{-1}$ and then immediately decelerates uniformly until it comes to rest at the next station.

(c) Sketch on the diagram above, a velocity-time graph which represents the journey of train Q . (2)

(d) Find the value of V . (6)

(Total for Question 1 is 15 marks)

Q2

A ball is projected vertically upwards with a speed of 14.7 m s^{-1} from a point which is 49 m above horizontal ground. Modelling the ball as a particle moving freely under gravity, find

- (a) the greatest height, above the ground, reached by the ball, (4)
- (b) the speed with which the ball first strikes the ground, (3)
- (c) the total time from when the ball is projected to when it first strikes the ground. (3)

(Total for Question 2 is 10 marks)

Q3

At time $t = 0$, a small ball is projected vertically upwards with speed $U \text{ m s}^{-1}$ from a point A that is 16.8 m above horizontal ground.

The speed of the ball at the instant immediately before it hits the ground for the first time is 19 m s^{-1}

The ball hits the ground for the first time at time $t = T$ seconds.

The motion of the ball, from the instant it is projected until the instant just before it hits the ground for the first time, is modelled as that of a particle moving freely under gravity.

The acceleration due to gravity is modelled as having magnitude 10 m s^{-2}

Using the model,

(a) show that $U = 5$ (2)

(b) find the value of T , (2)

(c) find the time from the instant the ball is projected until the instant when the ball is 1.2 m below A . (4)

(d) Sketch a velocity-time graph for the motion of the ball for $0 \leq t \leq T$, stating the coordinates of the start point and the end point of your graph. (2)

In a refinement of the model of the motion of the ball, the effect of air resistance on the ball is included and this refined model is now used to find the value of U .

(e) State, with a reason, how this new value of U would compare with the value found in part (a), using the initial unrefined model. (1)

(Total for Question 3 is 11 marks)

End of Questions



Gold Questions

Calculator

The total mark for this section is 35

Q1

A car is travelling along a straight horizontal road. The car takes 120 s to travel between two sets of traffic lights which are 2145 m apart. The car starts from rest at the first set of traffic lights and moves with constant acceleration for 30 s until its speed is 22 m s^{-1} . The car maintains this speed for T seconds. The car then moves with constant deceleration, coming to rest at the second set of traffic lights.

(a) Sketch, in the space below, a speed-time graph for the motion of the car between the two sets of traffic lights.

(2)

(b) Find the value of T .

(3)

A motorcycle leaves the first set of traffic lights 10 s after the car has left the first set of traffic lights. The motorcycle moves from rest with constant acceleration, $a \text{ m s}^{-2}$, and passes the car at the point A which is 990 m from the first set of traffic lights. When the motorcycle passes the car, the car is moving with speed 22 m s^{-1} .

(c) Find the time it takes for the motorcycle to move from the first set of traffic lights to the point A.

(4)

(d) Find the value of a .

(2)

(Total for Question 1 is 11 marks)

Q2

At time $t = 0$, two balls A and B are projected vertically upwards. The ball A is projected vertically upwards with speed 2 m s^{-1} from a point 50 m above the horizontal ground. The ball B is projected vertically upwards from the ground with speed 20 m s^{-1} . At time $t = T$ seconds, the two balls are at the same vertical height, h metres, above the ground. The balls are modelled as particles moving freely under gravity. Find

(a) the value of T ,

(5)

(a) the value of h ,

(2)

(Total for Question 2 is 7 marks)

Q3

At time $t = 0$, a parachutist falls vertically from rest from a helicopter which is hovering at a height of 550 m above horizontal ground.

The parachutist, who is modelled as a particle, falls for 3 seconds before her parachute opens.

While she is falling, and before her parachute opens, she is modelled as falling freely under gravity.

The acceleration due to gravity is modelled as being 10 m s^{-2} .

(a) Using this model, find the speed of the parachutist at the instant her parachute opens.

(1)

When her parachute is open, the parachutist continues to fall vertically.

Immediately after her parachute opens, she decelerates at 12 m s^{-2} for 2 seconds before reaching a constant speed and she reaches the ground with this speed.

The total time taken by the parachutist to fall the 550 m from the helicopter to the ground is T seconds.

(b) Sketch a speed–time graph for the motion of the parachutist for $0 \leq t \leq T$.

(2)

(c) Find, to the nearest whole number, the value of T .

(5)

In a refinement of the model of the motion of the parachutist, the effect of air resistance is included before her parachute opens and this refined model is now used to find a new value of T .

(d) How would this new value of T compare with the value found, using the initial model, in part (c)?

(1)

(Total for Question 3 is 9 marks)

Q4

At time $t = 0$, a particle is projected vertically upwards with speed u from a point A . The particle moves freely under gravity. At time T the particle is at its maximum height H above A .

(a) Find T in terms of u and g .

(2)

(b) Show that $H = \frac{u^2}{2g}$

(2)

The point A is at a height $3H$ above the ground.

(c) Find, in terms of T , the total time from the instant of projection to the instant when the particle hits the ground.

(4)

(4)

(Total for Question 4 is 8 marks)

End of Questions



Bronze Questions

Calculator

The total mark for this section is 24

Q1

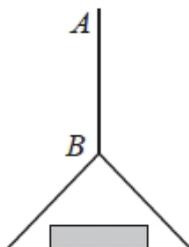


Figure 1

A vertical rope AB has its end B attached to the top of a scale pan. The scale pan has mass 0.5 kg and carries a brick of mass 1.5 kg, as shown in Figure 1. The scale pan is raised vertically upwards with constant acceleration 0.5 m s^{-2} using the rope AB . The rope is modelled as a light inextensible string.

(a) Find the tension in the rope AB .

(3)

(b) Find the magnitude of the force exerted on the scale pan by the brick.

(3)

(Total for Question 1 is 6 marks)

Q2

A car of mass 1000 kg is towing a caravan of mass 750 kg along a straight horizontal road. The caravan is connected to the car by a tow-bar which is parallel to the direction of motion of the car and the caravan. The tow-bar is modelled as a light rod. The engine of the car provides a constant driving force of 3200 N. The resistances to the motion of the car and the caravan are modelled as constant forces of magnitude 800 newtons and R newtons respectively.

Given that the acceleration of the car and the caravan is 0.88 m s^{-2} ,

(a) show that $R = 860$,

(3)

(b) find the tension in the tow-bar.

(3)

(Total for Question 2 is 6 marks)

Q3

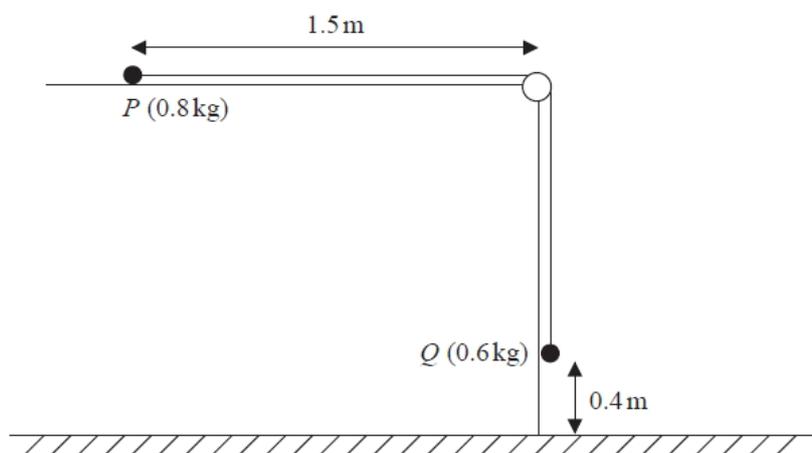


Figure 2

A small ball, P , of mass 0.8 kg , is held at rest on a smooth horizontal table and is attached to one end of a thin rope.

The rope passes over a pulley that is fixed at the edge of the table.

The other end of the rope is attached to another small ball, Q , of mass 0.6 kg , that hangs freely below the pulley.

Ball P is released from rest, with the rope taut, with P at a distance of 1.5 m from the pulley and with Q at a height of 0.4 m above the horizontal floor, as shown in Figure 1.

Ball Q descends, hits the floor and does not rebound.

The balls are modelled as particles, the rope as a light and inextensible string and the pulley as small and smooth.

Using this model,

- (a) show that the acceleration of Q , as it falls, is 4.2 m s^{-2} (5)
- (b) find the time taken by P to hit the pulley from the instant when P is released. (6)
- (c) State one limitation of the model that will affect the accuracy of your answer to part (a). (1)

(Total for Question 3 is 12 marks)

End of Questions



Silver Questions

Calculator

The total mark for this section is 35

Q1

A woman travels in a lift. The mass of the woman is 50 kg and the mass of the lift is 950 kg. The lift is being raised vertically by a vertical cable which is attached to the top of the lift. The lift is moving upwards and has constant deceleration of 2 m s^{-2} . By modelling the cable as being light and inextensible, find

- (a) the tension in the cable, (3)
- (b) the magnitude of the force exerted on the woman by the floor of the lift. (3)

(Total for Question 1 is 6 marks)

Q2

A car of mass 800 kg pulls a trailer of mass 200 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 200 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1200 N. Find

- (a) the acceleration of the car and trailer, (3)
- (b) the magnitude of the tension in the towbar. (3)

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 100 N,

- (c) find the value of F . (7)

(Total for Question 2 is 13 marks)

Q3

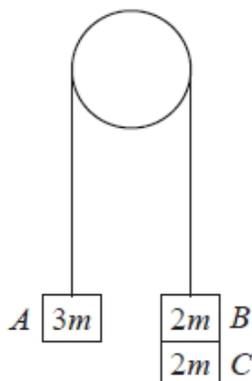


Figure 1

Three particles A , B and C have masses $3m$, $2m$ and $2m$ respectively. Particle C is attached to particle B . Particles A and B are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 1. The system is released from rest and A moves upwards.

(a) (i) Show that the acceleration of A is $\frac{g}{7}$

(ii) Find the tension in the string as A ascends.

(7)

At the instant when A is 0.7 m above its original position, C separates from B and falls away. In the subsequent motion, A does not reach the pulley.

(b) Find the speed of A at the instant when it is 0.7 m above its original position.

(2)

(c) Find the acceleration of A at the instant after C separates from B .

(4)

(d) Find the greatest height reached by A above its original position.

(3)

(Total for Question 3 is 16 marks)

End of Questions



Gold Questions

Calculator

The total mark for this section is 30

Q1

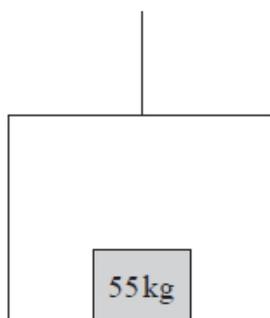


Figure 1

A lift of mass 200 kg is being lowered into a mineshaft by a vertical cable attached to the top of the lift. A crate of mass 55 kg is on the floor inside the lift, as shown in Figure 1. The lift descends vertically with constant acceleration. There is a constant upwards resistance of magnitude 150 N on the lift. The crate experiences a constant normal reaction of magnitude 473 N from the floor of the lift.

(a) Find the acceleration of the lift.

(3)

(b) Find the magnitude of the force exerted on the lift by the cable.

(4)

(Total for Question 1 is 7 marks)

Q2

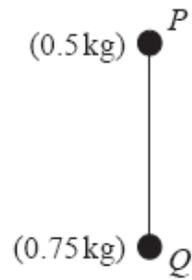
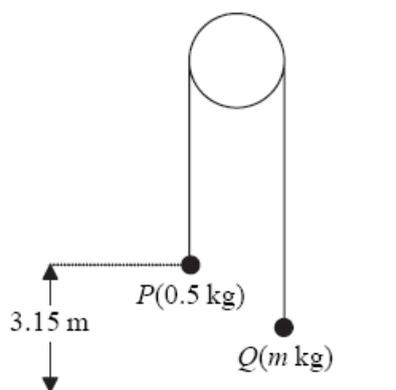


Figure 2

A vertical light rod PQ has a particle of mass 0.5 kg attached to it at P and a particle of mass 0.75 kg attached to it at Q , to form a system, as shown in Figure 2. The system is accelerated vertically upwards by a vertical force of magnitude 15 N applied to the particle at Q . Find the thrust in the rod.

(Total for Question 2 is 6 marks)

Q3**Figure 3**

Two particles P and Q have mass 0.5 kg and m kg respectively, where $m < 0.5$. The particles are connected by a light inextensible string which passes over a smooth, fixed pulley, as shown in Figure 3. Initially P is 3.15 m above horizontal ground. The particles are released from rest with the string taut and the hanging parts of the string vertical, as shown in Figure 4. After P has been descending for 1.5 s, it strikes the ground. Particle P reaches the ground before Q has reached the pulley.

- (a) Show that the acceleration of P as it descends is 2.8 m s⁻². (3)
- (b) Find the tension in the string as P descends. (3)
- (c) Show that $m = \frac{5}{18}$. (4)
- (d) State how you have used the information that the string is inextensible. (1)

When P strikes the ground, P does not rebound and the string becomes slack. Particle Q then moves freely under gravity, without reaching the pulley, until the string becomes taut again.

- (e) Find the time between the instant when P strikes the ground and the instant when the string becomes taut again. (6)

(Total for Question 3 is 17 marks)

End of Questions



Bronze Questions

Calculator

The total mark for this section is 30

Q1

A particle P moves along a straight line such that at time t seconds, $t \geq 0$, after leaving the point O on the line, the velocity, v m s⁻¹, of P is modelled as

$$v = (7 - 2t)(t + 2)$$

- (a) Find the value of t at the instant when P stops accelerating. (4)
- (b) Find the distance of P from O at the instant when P changes its direction of motion. (5)

In this question, solutions relying on calculator technology are not acceptable.

(Total for Question 1 is 9 marks)

Q2

At time $t = 0$ a particle P leaves the origin O and moves along the x -axis. At time t seconds the velocity of P is v m s⁻¹, where

$$v = 8t - t^2.$$

- (a) Find the maximum value of v . (4)
- (b) Find the time taken for P to return to O . (5)

(Total for Question 2 is 9 marks)

Q3

At time $t = 0$ a particle P leaves the origin O and moves along the x -axis. At time t seconds, the velocity of P is $v \text{ m s}^{-1}$ in the positive x direction, where

$$v = 3t^2 - 16t + 21$$

The particle is instantaneously at rest when $t = t_1$ and when $t = t_2$ ($t_1 < t_2$).

- (a) Find the value of t_1 and the value of t_2 . (2)
- (b) Find the magnitude of the acceleration of P at the instant when $t = t_1$. (3)
- (c) Find the distance travelled by P in the interval $t_1 \leq t \leq t_2$. (4)
- (d) Show that P does not return to O . (3)

(Total for Question 1 is 12 marks)

End of Questions



Silver Questions

Calculator

The total mark for this section is 26

Q1

A bird leaves its nest at time $t = 0$ for a short flight along a straight line.

The bird then returns to its nest.

The bird is modelled as a particle moving in a straight horizontal line.

The distance, s metres, of the bird from its nest at time t seconds is given by

$$s = \frac{1}{10}(t^4 - 20t^3 + 100t^2), \quad \text{where } 0 \leq t \leq 10$$

- (a) Explain the restriction, $0 \leq t \leq 10$ (3)
- (b) Find the distance of the bird from the nest when the bird first comes to instantaneous rest. (6)

(Total for Question 1 is 9 marks)

Q2

A particle P moves on the x -axis. The acceleration of P at time t seconds, $t \geq 0$, is $(3t + 5)$ m s^{-2} in the positive x -direction. When $t = 0$, the velocity of P is 2 m s^{-1} in the positive x -direction. When $t = T$, the velocity of P is 6 m s^{-1} in the positive x -direction. Find the value of T .

(Total for Question 2 is 6 marks)

Q3

A particle P moves on the x -axis. The acceleration of P at time t seconds is $(t - 4) \text{ m s}^{-2}$ in the positive x -direction. The velocity of P at time t seconds is $v \text{ m s}^{-1}$. When $t = 0$, $v = 6$.

Find

- (a) v in terms of t , **(4)**
- (b) the values of t when P is instantaneously at rest, **(3)**
- (c) the distance between the two points at which P is instantaneously at rest. **(4)**

(Total for Question 3 is 11 marks)

End of Questions



Gold Questions

Calculator

The total mark for this section is 30

Q1

A particle P moves along a straight line in such a way that at time t seconds its velocity v m s^{-1} is given by

$$v = \frac{1}{2}t^2 - 3t + 4$$

Find

(a) the times when P is at rest,

(4)

(b) the total distance travelled by P between $t = 0$ and $t = 4$.

(5)

(Total for Question 1 is 9 marks)

Q2

A particle P moves along a straight line. The speed of P at time t seconds ($t \geq 0$) is v m s^{-1} , where $v = (pt^2 + qt + r)$ and p , q and r are constants. When $t = 2$ the speed of P has its minimum value. When $t = 0$, $v = 11$ and when $t = 2$, $v = 3$

Find

(a) the acceleration of P when $t = 3$

(8)

(b) the distance travelled by P in the third second of the motion.

(5)

(Total for Question 2 is 13 marks)

Q3

A particle P moves along the x -axis in a straight line so that, at time t seconds, the velocity of P is v m s⁻¹, where

$$v = \begin{cases} 10t - 2t, & 0 \leq t \leq 6 \\ \frac{-432}{t^2}, & t > 6 \end{cases}$$

At $t = 0$, P is at the origin O . Find the displacement of P from O when

(a) $t = 6$, (3)

(b) $t = 10$. (5)

(Total for Question 3 is 8 marks)

End of Questions