

**1.** The point *A* is 1.8 m vertically above horizontal ground.

At time *t* = 0, a small stone is projected vertically upwards with speed *U* m s−1 from the

point *A*.

At time *t* = *T* seconds, the stone hits the ground.

The speed of the stone as it hits the ground is 10 ms−1

In an initial model of the motion of the stone as it moves from *A* to where it hits

the ground

• the stone is modelled as a particle moving freely under gravity

• **the acceleration due to gravity is modelled as having magnitude 10 m s−2**

Using the model,

(*a*)find the value of *U*,

**(3)**

(*b*)find the value of *T*.

**(2)**

(*c*)Suggest one refinement, apart from including air resistance, that would make the

model more realistic.

**(1)**

In reality the stone will not move freely under gravity and will be subject to air resistance.

(*d*)Explain how this would affect your answer to part (a).

**(1)**

**(Total for Question 1 is 7 marks)**

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**2.** A train travels along a straight horizontal track from station *P* to station *Q*.

In a model of the motion of the train, at time *t* = 0 the train starts from rest at *P*, and

moves with constant acceleration until it reaches its maximum speed of 25 ms−1

The train then travels at this constant speed of 25 ms−1 before finally moving with

constant deceleration until it comes to rest at *Q*.

The time spent decelerating is four times the time spent accelerating.

The journey from *P* to *Q* takes 700 s.

Using the model,

(*a*)sketch a speed-time graph for the motion of the train between the two stations *P* and *Q*.

**(1)**

The distance between the two stations is 15 km.

Using the model,

(*b*)show that the time spent accelerating by the train is 40 s,

**(3)**

(*c*)find the acceleration, in m s−2, of the train,

**(1)**

(*d*)find the speed of the train 572 s after leaving *P*.

**(2)**

(*e*)State one limitation of the model which could affect your answers to parts (*b*)and (c).

**(1)**

**(Total for Question 2 is 8 marks)**

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**3.** A fixed point *O* lies on a straight line.

A particle *P* moves along the straight line.

At time *t* seconds, *t* ≥ 0, the distance, *s* metres, of *P* from *O* is given by



(*a*)Find the acceleration of *P* at each of the times when *P* is at instantaneous rest.

**(6)**

(*b*)Find the total distance travelled by *P* in the interval 0 ≤ *t* ≤ 4

**(3)**

**(Total for Question 3 is 9 marks)**

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**4.**

Shape

Description automatically generated with medium confidence

A vertical rope *PQ* has its end *Q* attached to the top of a small lift cage.

The lift cage has mass 40 kg and carries a block of mass 10 kg, as shown in Figure 1.

The lift cage is raised vertically by moving the end *P* of the rope vertically upwards

with constant acceleration 0.2 m s−2

The rope is modelled as being light and inextensible and air resistance is ignored.

Using the model,

(*a*)find the tension in the rope *PQ*

**(3)**

(*b*)find the magnitude of the force exerted on the block by the lift cage.

**(3)**

**(Total for Question 4 is 6 marks)**

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**TOTAL FOR MECHANICS IS 30 MARKS**