Kinematics (Velocity and Displacement – Time Graphs) (Sheet 2)

Q1.

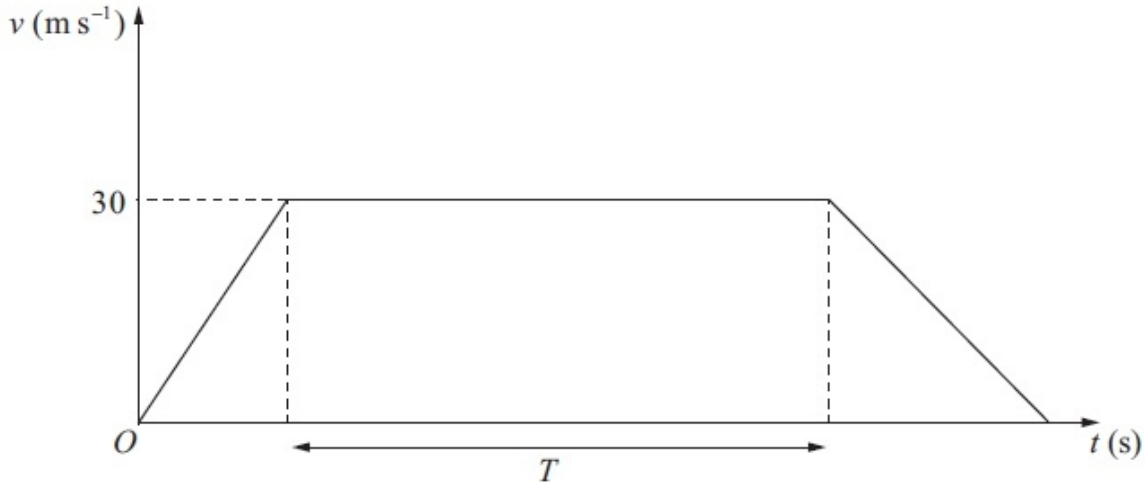

Figure 4

The velocity-time graph in Figure 4 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 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 15 marks)

Q2.
An athlete runs along a straight road. She starts from rest and moves with constant acceleration for 5 seconds, reaching a speed of 8 m s^{-1}. This speed is then maintained for T seconds. She then decelerates at a constant rate until she stops. She has run a total of 500 m in 75 s.
(a) In the space below, sketch a speed-time graph to illustrate the motion of the athlete.

(3)

(b) Calculate the value of T.

(5)

(Total 8 marks)

Q3.
A car accelerates uniformly from rest for 20 seconds. It moves at constant speed v m s^{-1} for the next 40 seconds and then decelerates uniformly for 10 seconds until it comes to rest.

(a) For the motion of the car, sketch

(i) a speed-time graph,
(ii) an acceleration-time graph.

(6)

Given that the total distance moved by the car is 880 m,

(b) find the value of v.

(4)

(Total 10 marks)

Q4.
A car is moving along a straight horizontal road. The speed of the car as it passes the point A is 25 m s^{-1} and the car maintains this speed for 30 s. The car then decelerates uniformly to a speed of 10 m s^{-1}. The speed of 10 m s^{-1} is then maintained until the car passes the point B. The time taken to travel from A to B is 90 s and AB = 1410 m.

(a) Sketch a speed-time graph to show the motion of the car from A to B.

(2)

(b) Calculate the deceleration of the car as it decelerates from 25 m s^{-1} to 10 m s^{-1}.

(7)

(Total 9 marks)

Q5.
A train travels along a straight horizontal track between two stations, A and B. The train starts from rest at A and moves with constant acceleration 0.5 m s^{-2} until it reaches a speed of V ms^{-1}, ($V < 50$). The train then travels at this constant speed before it moves with constant deceleration 0.25 m s^{-2} until it comes to rest at B.

(a) Sketch in the space below a speed–time graph for the motion of the train between the two stations A and B.

(2)

The total time for the journey from A to B is 5 minutes.

(b) Find, in terms of V, the length of time, in seconds, for which the train is

(i) accelerating,
(ii) decelerating,
(iii) moving with constant speed.

(5)

Given that the distance between the two stations A and B is 6.3 km,

(c) find the value of V.

(6)

(Total for question = 13 marks)

Q6.
A car starts from rest and moves with constant acceleration along a straight horizontal road. The car reaches a speed of V m s^{-1} in 20 seconds. It moves at constant speed V m s^{-1} for the next 30 seconds, then moves with constant deceleration $\frac{1}{2}$ m s^{-2} until it has speed 8 m s^{-1}. It moves at speed 8 m s^{-1} for the next 15 seconds and then moves with constant deceleration $\frac{1}{3}$ m s^{-2} until it comes to rest.

(a) Sketch, in the space below, a speed-time graph for this journey.

(3)

In the first 20 seconds of this journey the car travels 140 m.

Find

(b) the value of V,

(2)

(c) the total time for this journey,

(4)

(d) the total distance travelled by the car.

(4)

(Total 13 marks)

Q7.
Two cars P and Q are moving in the same direction along the same straight horizontal road. Car P is moving with constant speed 25 m s^{-1}. At time $t = 0$, P overtakes Q which is moving with constant speed 20 m s^{-1}. From $t = T$ seconds, P decelerates uniformly, coming to rest at a point X which is 800 m from the point where P overtook Q. From $t = 25$ s, Q decelerates uniformly, coming to rest at the same point X at the same instant as P.

(a) Sketch, on the same axes, the speed-time graphs of the two cars for the period from $t = 0$ to the time when they both come to rest at the point X.

(4)

(b) Find the value of T.

(8)

(Total 12 marks)

Q8.
A car moves along a horizontal straight road, passing two points A and B. At A the speed of the car is 15 m s^{-1}. When the driver passes A, he sees a warning sign W ahead of him, 120 m away. He immediately applies the brakes and the car decelerates with uniform deceleration, reaching W with speed 5 m s^{-1}. At W, the driver sees that the road is clear. He then immediately accelerates the car with uniform acceleration for 16 s to reach a speed of V m s^{-1} ($V > 15$). He then maintains the car at a constant speed of V m s^{-1}. Moving at this constant speed, the car passes B after a further 22 s.

(a) Sketch, in the space below, a speed-time graph to illustrate the motion of the car as it moves from A to B.

(3)

(b) Find the time taken for the car to move from A to B.

(3)

The distance from A to B is 1 km.

(c) Find the value of V.

(5)

(Total 11 marks)

Q9.

A car is moving along a straight horizontal road. At time $t = 0$, the car passes a point A with speed 25 m s^{-1}. The car moves with constant speed 25 m s^{-1} until $t = 10$ s. The car then decelerates uniformly for 8 s. At time $t = 18$ s, the speed of the car is V m s–1 and this speed is maintained until the car reaches the point B at time $t = 30$ s.

(a) Sketch, in the space below, a speed–time graph to show the motion of the car from A to B.

(3)

Given that $AB = 526$ m, find

(b) the value of V,

(5)

(c) the deceleration of the car between $t = 10$ s and $t = 18$ s.

(3)

(Total 11 marks)

Q10.

A car moves along a straight horizontal road from a point A to a point B, where $AB = 885$ m. The car accelerates from rest at A to a speed of 15 m s^{-1} at a constant rate a m s^{-2}. The time for which the car accelerates is $\frac{1}{3}T$ seconds. The car maintains the speed of 15 m s^{-1} for T seconds. The car then decelerates at a constant rate of 2.5 m s^{-2} stopping at B.

(a) Find the time for which the car decelerates.

(2)

(b) Sketch a speed-time graph for the motion of the car.

(2)

(c) Find the value of T.

(4)

(d) Find the value of a.

(2)

(e) Sketch an acceleration-time graph for the motion of the car.

(3)

(Total 13 marks)

Q11.

At time $t = 0$, a small ball is projected vertically upwards with speed U 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)

(f) Suggest one further refinement that could be made to the model, apart from including air resistance, that would make the model more realistic.

(1)

(Total for question = 12 marks)