Name:

Total Marks:

A level Applied Mathematics

Paper 3B Mechanics

Practice Paper M12

Time: 2 hours

Information for Candidates

- This practice paper is an adapted legacy old paper for the Edexcel GCE A Level Specifications
- There are 9 questions in this question paper
- The total mark for this paper is 104.
- The marks for **each** question are shown in brackets.
- Full marks may be obtained for answers to ALL questions

Advice to candidates:

- You must ensure that your answers to parts of questions are clearly labelled.
- You must show sufficient working to make your methods clear to the Examiner
- Answers without working may not gain full credit

Question 1

A car is moving on a straight horizontal road. At time $t = 0$, the car is moving with speed 20 m s^{-1} and is at the point A. The car maintains the speed of 20 m s^{-1} for 25 s. The car then moves with constant deceleration 0.4 m s^{-2}, reducing its speed from 20 m s^{-1} to 8 m s^{-1}. The car then moves with constant speed 8 m s^{-1} for 60 s. The car then moves with constant acceleration until it is moving with speed 20 m s^{-1} at the point B.

(a) Sketch a speed-time graph to represent the motion of the car from A to B. **(3)**

(b) Find the time for which the car is decelerating. **(2)**

Given that the distance from A to B is 1960 m,

(c) find the time taken for the car to move from A to B. **(8)**

(Total 13 marks)

Question 2

A particle P is projected vertically upwards from a point A with speed u m s^{-1}. The point A is 17.5 m above horizontal ground. The particle P moves freely under gravity until it reaches the ground with speed 28 m s^{-1}.

(a) Show that $u = 21$ **(3)**

At time t seconds after projection, P is 19 m above A.

(b) Find the possible values of t. **(5)**

The ground is soft and, after P reaches the ground, P sinks vertically downwards into the ground before coming to rest. The mass of P is 4 kg and the ground is assumed to exert a constant resistive force of magnitude 5000 N on P.

(c) Find the vertical distance that P sinks into the ground before coming to rest. **(4)**

(Total 12 marks)

Question 3

Figure 3

Two particles P and Q, of mass 0.3 kg and 0.5 kg respectively, are joined by a light horizontal rod. The system of the particles and the rod is at rest on a horizontal plane. At time $t = 0$, a constant force **F** of magnitude 4 N is applied to Q in the direction PQ, as shown in Figure 3. The system moves under the action of this force until $t = 6$ s. During the motion, the resistance to the motion of P has constant magnitude 1 N and the resistance to the motion of Q has constant magnitude 2 N.

Find

(a) the acceleration of the particles as the system moves under the action of **F**, **(3)**

(b) the speed of the particles at $t = 6$ s, **(2)**

(c) the tension in the rod as the system moves under the action of **F**. **(3)**

At $t = 6$ s, **F** is removed and the system decelerates to rest. The resistances to motion are unchanged. Find

(d) the distance moved by P as the system decelerates, **(4)**

(e) the thrust in the rod as the system decelerates. **(3)**

(Total 15 marks)

Question 4

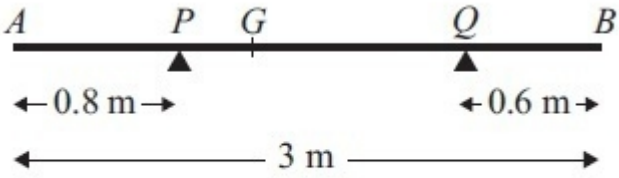

Figure 1

A non-uniform rod AB has length 3 m and mass 4.5 kg. The rod rests in equilibrium, in a horizontal position, on two smooth supports at P and at Q, where AP = 0.8 m and QB = 0.6 m, as shown in Figure 1. The centre of mass of the rod is at G. Given that the magnitude of the reaction of the support at P on the rod is twice the magnitude of the reaction of the support at Q on the rod, find

(a) the magnitude of the reaction of the support at Q on the rod, **(3)**

(b) the distance AG **(4)**

(Total 7 marks)

Question 5

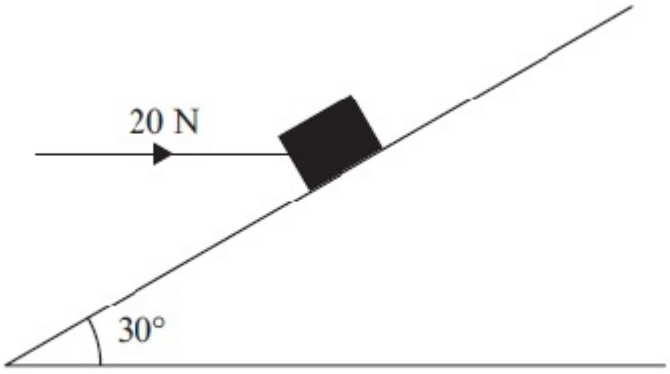

Figure 2

A box of mass 5 kg lies on a rough plane inclined at 30° to the horizontal. The box is held in equilibrium by a horizontal force of magnitude 20 N, as shown in Figure 2. The force acts in a vertical plane containing a line of greatest slope of the inclined plane. The box is in equilibrium and on the point of moving down the plane. The box is modelled as a particle.

Find

(a) the magnitude of the normal reaction of the plane on the box, **(4)**

(b) the coefficient of friction between the box and the plane. **(5)**

(Total 9 marks)

Question 6

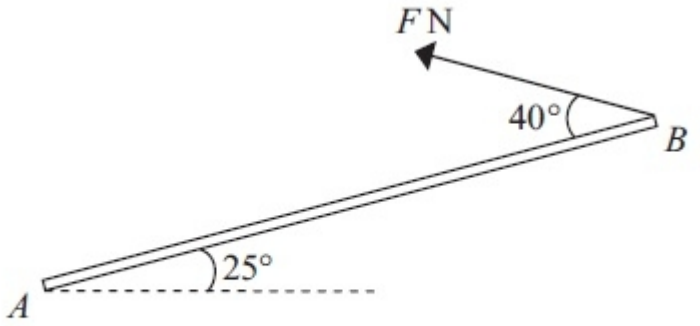

Figure 1

A uniform rod AB, of mass 5 kg and length 4 m, has its end A smoothly hinged at a fixed point. The rod is held in equilibrium at an angle of 25º above the horizontal by a force of magnitude F newtons applied to its end B. The force acts in the vertical plane containing the rod and in a direction which makes an angle of 40º with the rod, as shown in Figure 1.

(a) Find the value of F. **(4)**

(b) Find the magnitude and direction of the vertical component of the force acting on the rod at A. **(4)**

(Total 8 marks)

Question 7

[*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane.*]

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

$$\mathbf{v} = (3t^2 - 1)\mathbf{i} + (4t - t^2)\mathbf{j}$$ **(5)**

Given that, when $t = 0$, the position vector of P is $\mathbf{i}$ metres,

(b) find the position vector of P when $t = 3$ **(5)**

(Total 10 marks)

Question 8

[*In this question* **i** and **j** *are horizontal unit vectors due east and due north respectively and position vectors are given with respect to a fixed origin.*]

A ship S is moving with constant velocity $(-12\mathbf{i} + 7.5\mathbf{j})$ km h–1.

(a) Find the direction in which S is moving, giving your answer as a bearing. **(3)**

At time t hours after noon, the position vector of S is **s** km. When $t = 0$, **s** = 40**i** – 6**j**.

(b) Write down **s** in terms of t. **(2)**

A fixed beacon B is at the point with position vector $(7\mathbf{i} + 12.5\mathbf{j})$ km.

(c) Find the distance of S from B when $t = 3$ **(4)**

(d) Find the distance of S from B when S is due north of B. **(4)**

(Total 13 marks)

Question 9

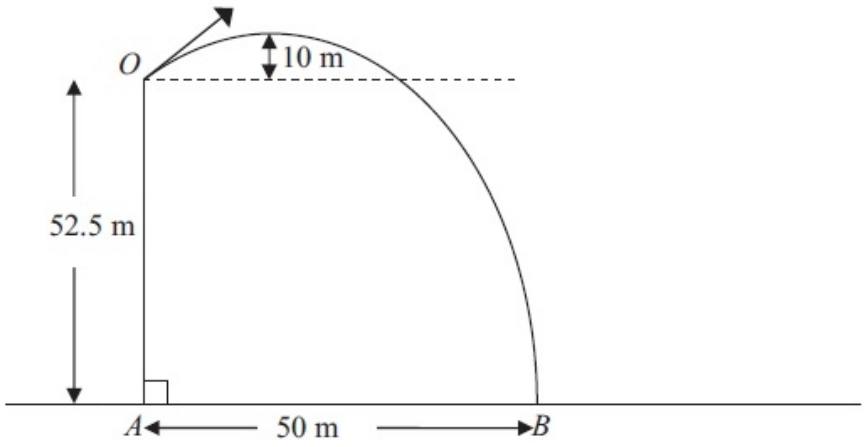

Figure 4

A small stone is projected from a point O at the top of a vertical cliff OA. The point O is 52.5 m above the sea. The stone rises to a maximum height of 10 m above the level of O before hitting the sea at the point B, where $AB = 50$ m, as shown in Figure 4. The stone is modelled as a particle moving freely under gravity.

(a) Show that the vertical component of the velocity of projection of the stone is 14 m s^{-1}. **(3)**

(b) Find the speed of projection. **(9)**

(c) Find the time after projection when the stone is moving parallel to OB. **(5)**

(Total 17 marks)

TOTAL FOR PAPER IS 104 MARKS