Name:

Total Marks:

A level Applied Mathematics

Paper 3B Mechanics

Practice Paper M9

Time: 2 hours

Information for Candidates

- This practice paper is an adapted legacy old paper for the Edexcel GCE A Level Specifications
- There are 10 questions in this question paper
- The total mark for this paper is 101.
- 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

Three posts P, Q and R, are fixed in that order at the side of a straight horizontal road. The distance from P to Q is 45 m and the distance from Q to R is 120 m. A car is moving along the road with constant acceleration a m s^{-2}. The speed of the car, as it passes P, is u m s−1. The car passes Q two seconds after passing P, and the car passes R four seconds after passing Q. Find

i) the value of u,

ii) the value of a. **(7)**

(Total 7 marks)

Question 2

A particle is acted upon by two forces $\mathbf{F_1}$ and $\mathbf{F_2}$, given by

$\mathbf{F_1} = (\mathbf{i} - 3\mathbf{j})$ N,

$\mathbf{F_2} = (p\mathbf{i} + 2p\mathbf{j})$ N, where p is a positive constant.

(a) Find the angle between $\mathbf{F_2}$ and $\mathbf{j}$. **(2)**

The resultant of $\mathbf{F_1}$ and $\mathbf{F_2}$ is $\mathbf{R}$. Given that $\mathbf{R}$ is parallel to $\mathbf{i}$,

(b) find the value of p. **(4)**

(Total 6 marks)

Question 3

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 13 marks)

Question 4

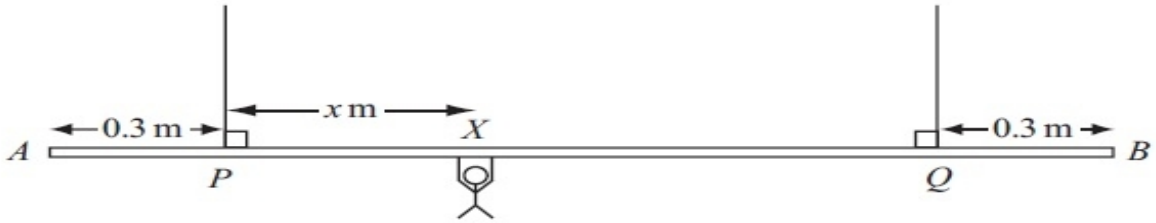

Figure 2

A beam AB is supported by two vertical ropes, which are attached to the beam at points P and Q, where $AP = 0.3$ m and $BQ = 0.3$ m. The beam is modelled as a uniform rod, of length 2 m and mass 20 kg. The ropes are modelled as light inextensible strings. A gymnast of mass 50 kg hangs on the beam between P and Q. The gymnast is modelled as a particle attached to the beam at the point X, where $PX = x$ m, $0 < x < 1.4$ as shown in Figure 2. The beam rests in equilibrium in a horizontal position.

(a) Show that the tension in the rope attached to the beam at P is $(588 - 350x)$ N. **(3)**

(b) Find, in terms of x, the tension in the rope attached to the beam at Q. **(3)**

(c) Hence find, justifying your answer carefully, the range of values of the tension which could occur in each rope. **(3)**

Given that the tension in the rope attached at Q is three times the tension in the rope attached at P,

(d) find the value of x. **(3)**

(Total 12 marks)

Question 5

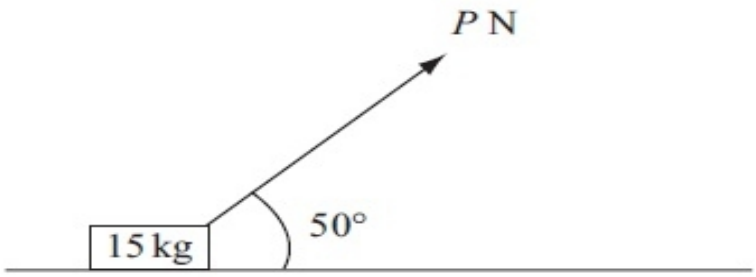

Figure 1

A small box of mass 15 kg rests on a rough horizontal plane. The coefficient of friction between the box and the plane is 0.2 . A force of magnitude P newtons is applied to the box at 50º to the horizontal, as shown in Figure 1. The box is on the point of sliding along the plane.

Find the value of P, giving your answer to 2 significant figures. **(9)**

(Total 9 marks)

Question 6

A small brick of mass 0.5 kg is placed on a rough plane which is inclined to the horizontal at an angle θ, where $\tan\theta = \frac{4}{3}$, and released from rest. The coefficient of friction between the brick and the plane is $\frac{1}{3}$.

Find the acceleration of the brick. **(9)**

(Total 9 marks)

Question 7

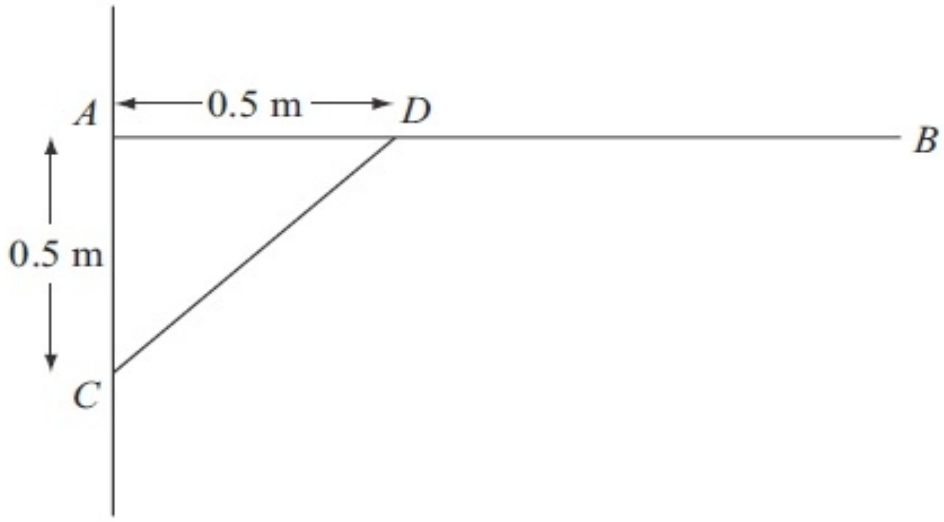

Figure 1

A uniform rod AB, of length 1.5 m and mass 3 kg, is smoothly hinged to a vertical wall at A. The rod is held in equilibrium in a horizontal position by a light strut CD as shown in Figure 1. The rod and the strut lie in the same vertical plane, which is perpendicular to the wall. The end C of the strut is freely jointed to the wall at a point 0.5 m vertically below A. The end D is freely joined to the rod so that AD is 0.5 m.

(a) Find the thrust in CD. **(4)**

(b) Find the magnitude and direction of the force exerted on the rod AB at A. **(7)**

(Total 11 marks)

Question 8

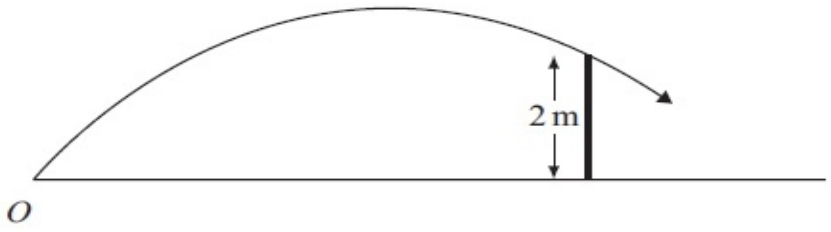

Figure 3

A child playing cricket on horizontal ground hits the ball towards a fence 10 m away. The ball moves in a vertical plane which is perpendicular to the fence. The ball just passes over the top of the fence, which is 2 m above the ground, as shown in Figure 3.

The ball is modelled as a particle projected with initial speed u m s^{-1} from point O on the ground at an angle a to the ground.

(a) By writing down expressions for the horizontal and vertical distances, from O of the ball t seconds after it was hit, show that

$$2 = 10\tan a - \frac{50g}{u^2 \cos^2 \alpha}$$ **(6)**

Given that $a = 45°$,

(b) find the speed of the ball as it passes over the fence. **(6)**

(Total 12 marks)

Question 9

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 9 marks)

Question 10

[*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively.*]

A hiker *H* is walking with constant velocity (1.2**i** − 0.9**j**) m s^{-1}.

(a) Find the speed of *H*.

(2)

Figure 3

A horizontal field *OABC* is rectangular with *OA* due east and *OC* due north, as shown in Figure 3. At twelve noon hiker *H* is at the point *Y* with position vector 100 **j** m, relative to the fixed origin *O*.

(b) Write down the position vector of *H* at time *t* seconds after noon. **(2)**

At noon, another hiker *K* is at the point with position vector (9**i** + 46**j**) m. Hiker *K* is moving with constant velocity (0.75**i** + 1.8**j**) m s^{-1}.

(c) Show that, at time *t* seconds after noon,

$$\overrightarrow{HK} = [(9 - 0.45t)\,\mathbf{i} + (2.7t - 54)\,\mathbf{j}] \text{ metres.}$$ **(4)**

Hence,

(d) show that the two hikers meet and find the position vector of the point where they meet. **(5)**

(Total 13 marks)

TOTAL FOR PAPER IS 101 MARKS