Name:

Total Marks:

A level Applied Mathematics

Paper 3B Mechanics

Practice Paper M11

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 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 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 12 marks)

Question 2

At time $t = 0$ a ball is projected vertically upwards from a point O and rises to a maximum height of 40 m above O. The ball is modelled as a particle moving freely under gravity.

(a) Show that the speed of projection is 28 m s^{-1}. **(3)**

(b) Find the times, in seconds, when the ball is 33.6 m above O. **(5)**

(Total 8 marks)

Question 3

A plank PQR, of length 8 m and mass 20 kg, is in equilibrium in a horizontal position on two supports at P and Q, where $PQ = 6$ m.

A child of mass 40 kg stands on the plank at a distance of 2 m from P and a block of mass M kg is placed on the plank at the end R. The plank remains horizontal and in equilibrium. The force exerted on the plank by the support at P is equal to the force exerted on the plank by the support at Q.

By modelling the plank as a uniform rod, and the child and the block as particles,

(a) (i) find the magnitude of the force exerted on the plank by the support at P,

(ii) find the value of M. **(10)**

(b) State how, in your calculations, you have used the fact that the child and the block can be modelled as particles. **(1)**

(Total 11 marks)

Question 4

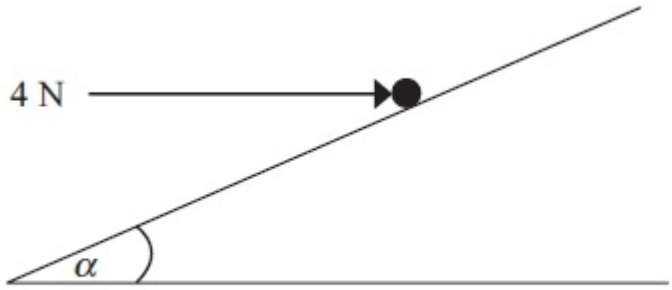

Figure 1

A particle of weight *W* newtons is held in equilibrium on a rough inclined plane by a horizontal force of magnitude 4 N. The force acts in a vertical plane containing a line of greatest slope of the inclined plane. The plane is inclined to the horizontal at an angle *a*, where tan *a* = $\frac{3}{4}$, as shown in Figure 1.

The coefficient of friction between the particle and the plane is $\frac{1}{2}$

Given that the particle is on the point of sliding down the plane,

(i) show that the magnitude of the normal reaction between the particle and the plane is 20 N,

(ii) find the value of *W*. **(9)**

(Total 9 marks)

Question 5

[*In this question* **i** and **j** *are unit vectors due east and due north respectively. Position vectors are given relative to a fixed origin O.*]

Two ships *P* and *Q* are moving with constant velocities. Ship *P* moves with velocity $(2\mathbf{i} - 3\mathbf{j})$ km h^{-1} and ship *Q* moves with velocity $(3\mathbf{i} + 4\mathbf{j})$ km h^{-1}.

(a) Find, to the nearest degree, the bearing on which *Q* is moving. **(2)**

At 2 pm, ship *P* is at the point with position vector **(i + j) km** and ship *Q* is at the point with position vector $(-2\mathbf{j})$ km.

At time *t* hours after 2 pm, the position vector of *P* is **p** km and the position vector of *Q* is **q** km.

(b) Write down expressions, in terms of *t*, for

(i) **p**,
(ii) **q**,
(iii) $\overrightarrow{PQ}$. **(5)**

(c) Find the time when

(i) *Q* is due north of *P*,
(ii) *Q* is north-west of *P*.

(4)

(Total 11 marks)

Question 6

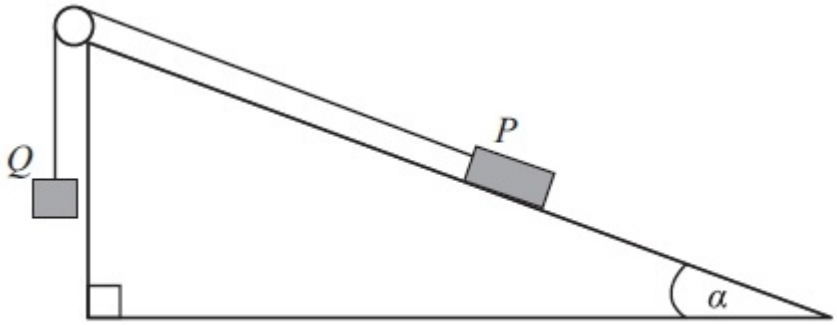

Figure 2

Two particles P and Q have masses 0.3 kg and m kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the top of a fixed rough plane. The plane is inclined to the horizontal at an angle a, where $\tan a = \frac{3}{4}$. The coefficient of friction between P and the plane is $\frac{1}{2}$.

The string lies in a vertical plane through a line of greatest slope of the inclined plane. The particle P is held at rest on the inclined plane and the particle Q hangs freely below the pulley with the string taut, as shown in Figure 2.

The system is released from rest and Q accelerates vertically downwards at 1.4 m s^{-2}.
Find

(a) the magnitude of the normal reaction of the inclined plane on P, **(2)**

(b) the value of m. **(8)**

When the particles have been moving for 0.5 s, the string breaks. Assuming that P does not reach the pulley,

(c) find the further time that elapses until P comes to instantaneous rest. **(6)**

(Total 16 marks)

Question 7

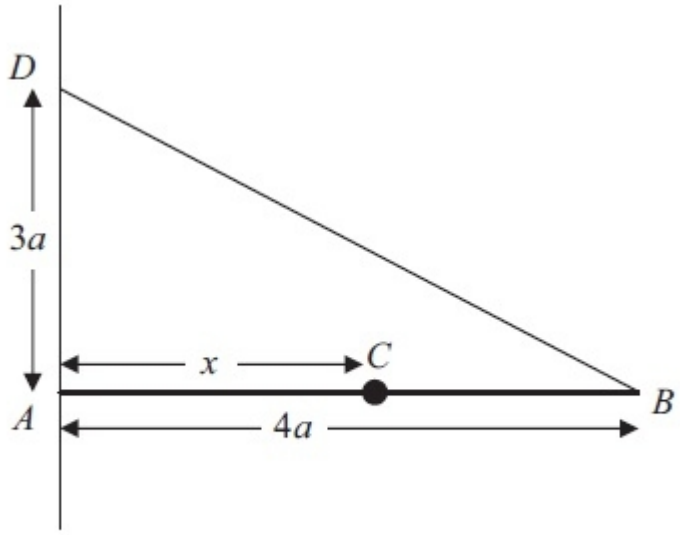

Figure 3

A uniform rod AB, of mass $3m$ and length $4a$, is held in a horizontal position with the end A against a rough vertical wall. One end of a light inextensible string BD is attached to the rod at B and the other end of the string is attached to the wall at the point D vertically above A, where $AD = 3a$. A particle of mass $3m$ is attached to the rod at C, where $AC = x$. The rod is in equilibrium in a vertical plane perpendicular to the wall as shown in Figure 3. The tension in the string is $\frac{25}{4}mg$.

Show that

(a) $x = 3a$, **(5)**

(b) the horizontal component of the force exerted by the wall on the rod has magnitude $5mg$. **(3)**

The coefficient of friction between the wall and the rod is μ. Given that the rod is about to slip,

(c) find the value of μ. **(5)**

(Total 13 marks)

Question 8

A particle P moves on the x-axis. The acceleration of P at time t seconds is $(t - 4)$ m s^{-2} in the positive x-direction. The velocity of P at time t seconds is v 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 11 marks)

Question 9

A particle is projected from a point O with speed u at an angle of elevation a above the horizontal and moves freely under gravity. When the particle has moved a horizontal distance x, its height above O is y.

(a) Show that

$$y = x\tan\alpha - \frac{gx^2}{2u^2\cos^2\alpha}$$

(4)

A girl throws a ball from a point A at the top of a cliff. The point A is 8 m above a horizontal beach. The ball is projected with speed 7 m s^{-1} at an angle of elevation of 45°. By modelling the ball as a particle moving freely under gravity,

(b) find the horizontal distance of the ball from A when the ball is 1 m above the beach. **(5)**

A boy is standing on the beach at the point B vertically below A. He starts to run in a straight line with speed v m s^{-1}, leaving B 0.4 seconds after the ball is thrown.

He catches the ball when it is 1 m above the beach.

(c) Find the value of v. **(4)**

(Total 13 marks)

TOTAL FOR PAPER IS 104 MARKS