Name:

Total Marks:

A level Applied Mathematics

Paper 3B Mechanics

Practice Paper M17

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 102.
- 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 cyclist is moving along a straight horizontal road and passes a point A. Five seconds later, at the instant when she is moving with speed 10 ms^{-1}, she passes the point B. She moves with constant acceleration from A to B.

Given that AB = 40m, find

(a) the acceleration of the cyclist as she moves from A to B, **(4)**

(b) the time it takes her to travel from A to the midpoint of AB. **(5)**

(Total for question = 9 marks)

Question 2

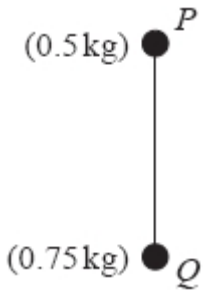

Figure 2

A vertical light rod PQ has a particle of mass 0.5kg attached to it at P and a particle of mass 0.75kg attached to it at Q, to form a system, as shown in Figure 2. The system is accelerated vertically upwards by a vertical force of magnitude 15N applied to the particle at Q. Find the thrust in the rod. **(6)**

(Total for question = 6 marks)

Question 3

A plank AB has length 6m and mass 30kg. The point C is on the plank with CB = 2m. The plank rests in equilibrium in a horizontal position on supports at A and C. Two people, each of mass 75kg, stand on the plank. One person stands at the point P of the plank, where $AP = x$ metres, and the other person stands at the point Q of the plank, where $AQ = 2x$ metres. The plank remains horizontal and in equilibrium with the magnitude of the reaction at C five times the magnitude of the reaction at A. The plank is modelled as a uniform rod and each person is modelled as a particle.

(a) Find the value of x. **(7)**

(b) State two ways in which you have used the assumptions made in modelling the plank as a uniform rod. **(2)**

(Total for question = 9 marks)

Question 4

Three forces, (15**i** + **j**) N, (5*q***i** − *p***j**) N and (−3*p***i** − *q***j**) N, where *p* and *q* are constants, act on a particle. Given that the particle is in equilibrium, find the value of *p* and the value of *q*. **(6)**

(Total for question = 6 marks)

Question 5

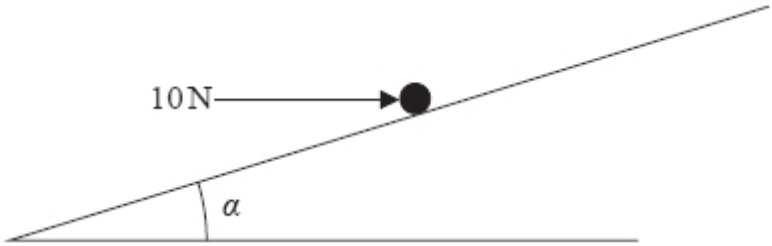

Figure 1

A particle *P* of mass 5kg is held at rest in equilibrium on a rough inclined plane by a horizontal force of magnitude 10N. The plane is inclined to the horizontal at an angle α where $\tan\alpha = \frac{3}{4}$, as shown in Figure 1. The line of action of the force lies in the vertical plane containing *P* and a line of greatest slope of the plane. The coefficient of friction between *P* and the plane is μ. Given that *P* is on the point of sliding down the plane, find the value of μ. **(9)**

(Total for question = 9 marks)

Question 6

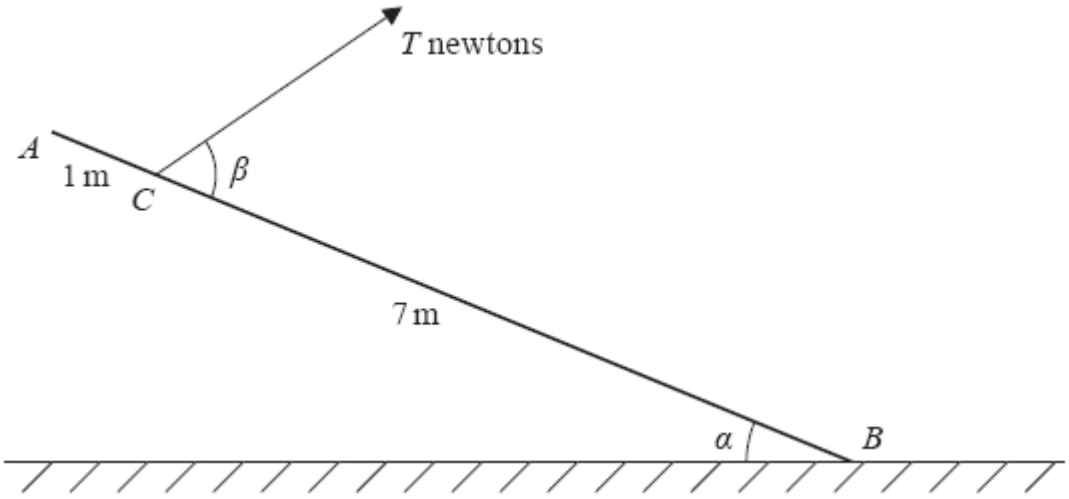

Figure 3

A uniform rod AB, of mass 5 kg and length 8 m, has its end B resting on rough horizontal ground. The rod is held in limiting equilibrium at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$, by a rope attached to the rod at C. The distance AC = 1 m. The rope is in the same vertical plane as the rod. The angle between the rope and the rod is β and the tension in the rope is T newtons, as shown in Figure 3. The coefficient of friction between the rod and the ground is $\frac{2}{3}$. The vertical component of the force exerted on the rod at B by the ground is R newtons.

(a) Find the value of R. **(6)**

(b) Find the size of angle β. **(5)**

(Total for question = 11 marks)

Question 7

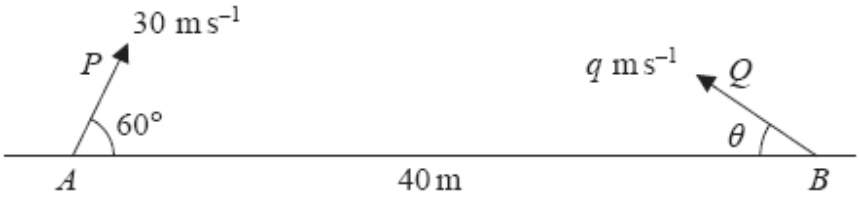

Figure 4

The points A and B lie 40 m apart on horizontal ground. At time $t = 0$ the particles P and Q are projected in the vertical plane containing AB and move freely under gravity. Particle P is projected from A with speed 30 m s^{-1} at 60° to AB and particle Q is projected from B with speed q m s^{-1} at angle θ to BA, as shown in Figure 4.

At $t = 2$ seconds, P and Q collide.

(a) Find

(i) the size of angle θ,

(ii) the value of q. **(6)**

(b) Find the speed of P at the instant before it collides with Q. **(5)**

(Total for question = 11 marks)

Question 8

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

Two ships, P and Q, are moving with constant velocities.

The velocity of P is $(9\mathbf{i} - 2\mathbf{j})$km h^{-1} and the velocity of Q is $(4\mathbf{i} + 8\mathbf{j})$ km h^{-1}

(a) Find the direction of motion of P, giving your answer as a bearing to the nearest degree. **(3)**

When $t = 0$, the position vector of P is $(9\mathbf{i} + 10\mathbf{j})$km and the position vector of Q is $(\mathbf{i} + 4\mathbf{j})$ km. At time t hours, the position vectors of P and Q are **p** km and **q** km respectively.

(b) Find an expression for

(i) **p** in terms of t,

(ii) **q** in terms of t. **(3)**

(c) Hence show that, at time t hours,

$\overrightarrow{QP} = (8 + 5t)\mathbf{i} + (6 - 10t)\mathbf{j}$ **(2)**

(d) Find the values of t when the ships are 10 km apart. **(6)**

(Total for question = 14 marks)

Question 9

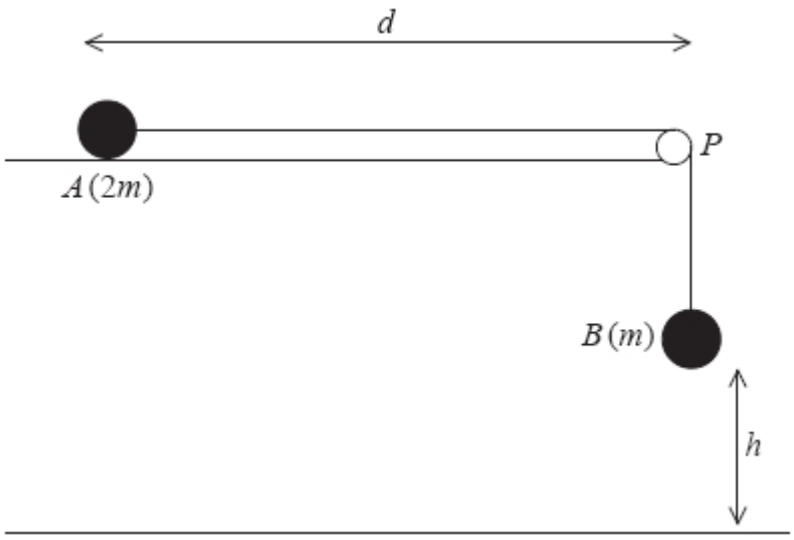

Figure 3

Two particles, A and B, have masses $2m$ and m respectively. The particles are attached to the ends of a light inextensible string. Particle A is held at rest on a fixed rough horizontal table at a distance d from a small smooth light pulley which is fixed at the edge of the table at the point P. The coefficient of friction between A and the table is μ, where $\mu < \frac{1}{2}$.

The string is parallel to the table from A to P and passes over the pulley. Particle B hangs freely at rest vertically below P with the string taut and at a height h, ($h < d$), above a horizontal floor, as shown in Figure 3. Particle A is released from rest with the string taut and slides along the table.

(a) (i) Write down an equation of motion for A.

(ii) Write down an equation of motion for B. **(4)**

(b) Hence show that, until B hits the floor, the acceleration of A is $\frac{g}{3}(1 - 2\mu)$. **(3)**

(c) Find, in terms of g, h and μ, the speed of A at the instant when B hits the floor. **(2)**

After B hits the floor, A continues to slide along the table. Given that $\mu = \frac{1}{3}$ and that A comes to rest at P,

(d) find d in terms of h. **(5)**

(e) Describe what would happen if $\mu = \frac{1}{2}$ **(1)**

(Total for question = 15 marks)

Question 10

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} in the positive x direction, where

$$v = 3t^2 - 16t + 21$$

The particle is instantaneously at rest when $t = t_1$ and when $t = t_2$ ($t_1 < t_2$).

(a) Find the value of t_1 and the value of t_2. **(2)**

(b) Find the magnitude of the acceleration of P at the instant when $t = t_1$. **(3)**

(c) Find the distance travelled by P in the interval $t_1 \leq t \leq t_2$. **(4)**

(d) Show that P does not return to O. **(3)**

(Total for question = 12 marks)

TOTAL FOR PAPER IS 102 MARKS