Name:

Total Marks:

A level Applied Mathematics

Paper 3B Mechanics

Practice Paper M16

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 106.
- 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

Two trains M and N are moving in the same direction along parallel straight horizontal tracks. At time $t = 0$, M overtakes N whilst they are travelling with speeds 40 m s^{-1} and 30 m s^{-1} respectively. Train M overtakes train N as they pass a point X at the side of the tracks.

After overtaking N, train M maintains its speed of 40 m s^{-1} for T seconds and then decelerates uniformly, coming to rest next to a point Y at the side of the tracks.

After being overtaken, train N maintains its speed of 30 m s^{-1} for 25 s and then decelerates uniformly, also coming to rest next to the point Y.

The times taken by the trains to travel between X and Y are the same.

(a) Sketch, on the same diagram, the speed-time graphs for the motions of the two trains between X and Y. **(4)**

Given that $XY = 975$ m,

(b) find the value of T. **(8)**

(Total for question = 12 marks)

Question 2

A non-uniform plank AB has length 6 m and mass 30 kg. The plank rests in equilibrium in a horizontal position on supports at the points S and T of the plank where $AS = 0.5$ m and $TB = 2$ m.

When a block of mass M kg is placed on the plank at A, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about S.

When the block is moved to B, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about T.

The distance of the centre of mass of the plank from A is d metres. The block is modelled as a particle and the plank is modelled as a non-uniform rod. Find

(i) the value of d,

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

(Total for question = 7 marks)

Question 3

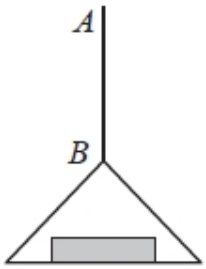

Figure 1

A vertical rope *AB* has its end *B* attached to the top of a scale pan. The scale pan has mass 0.5 kg and carries a brick of mass 1.5 kg, as shown in Figure 1. The scale pan is raised vertically upwards with constant acceleration 0.5 m s^{-2} using the rope *AB*. The rope is modelled as a light inextensible string.

(a) Find the tension in the rope *AB*. **(3)**

(b) Find the magnitude of the force exerted on the scale pan by the brick. **(3)**

(Total for question = 6 marks)

Question 4

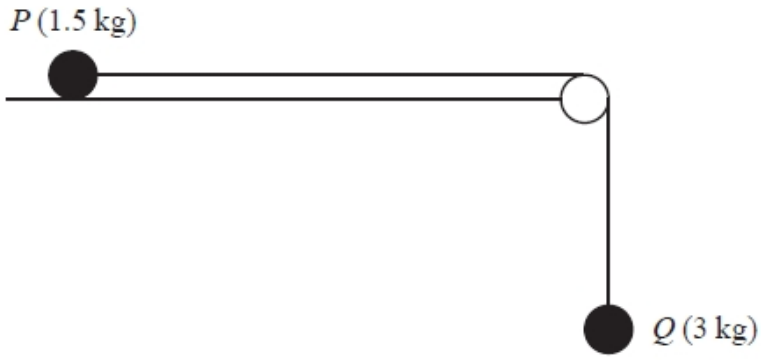

Figure 3

Two particles *P* and *Q* have masses 1.5 kg and 3 kg respectively. The particles are attached to the ends of a light inextensible string. Particle *P* is held at rest on a fixed rough horizontal table. The coefficient of friction between *P* and the table is $\frac{1}{5}$. The string is parallel to the table and passes over a small smooth light pulley which is fixed at the edge of the table. Particle *Q* hangs freely at rest vertically below the pulley, as shown in Figure 3. Particle *P* is released from rest with the string taut and slides along the table.

Assuming that *P* has not reached the pulley, find

(a) the tension in the string during the motion, **(8)**

(b) the magnitude and direction of the resultant force exerted on the pulley by the string. **(4)**

(Total for question = 12 marks)

Question 5

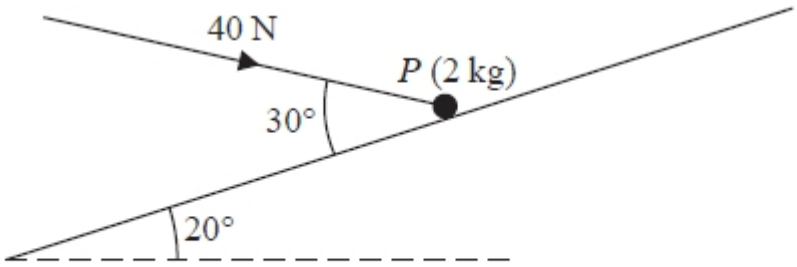

Figure 2

A particle P of mass 2 kg is held at rest in equilibrium on a rough plane by a constant force of magnitude 40 N. The direction of the force is inclined to the plane at an angle of 30°. The plane is inclined to the horizontal at an angle of 20°, as shown in Figure 2. 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 up the plane, find the value of μ **(10)**

(Total for question = 10 marks)

Question 6

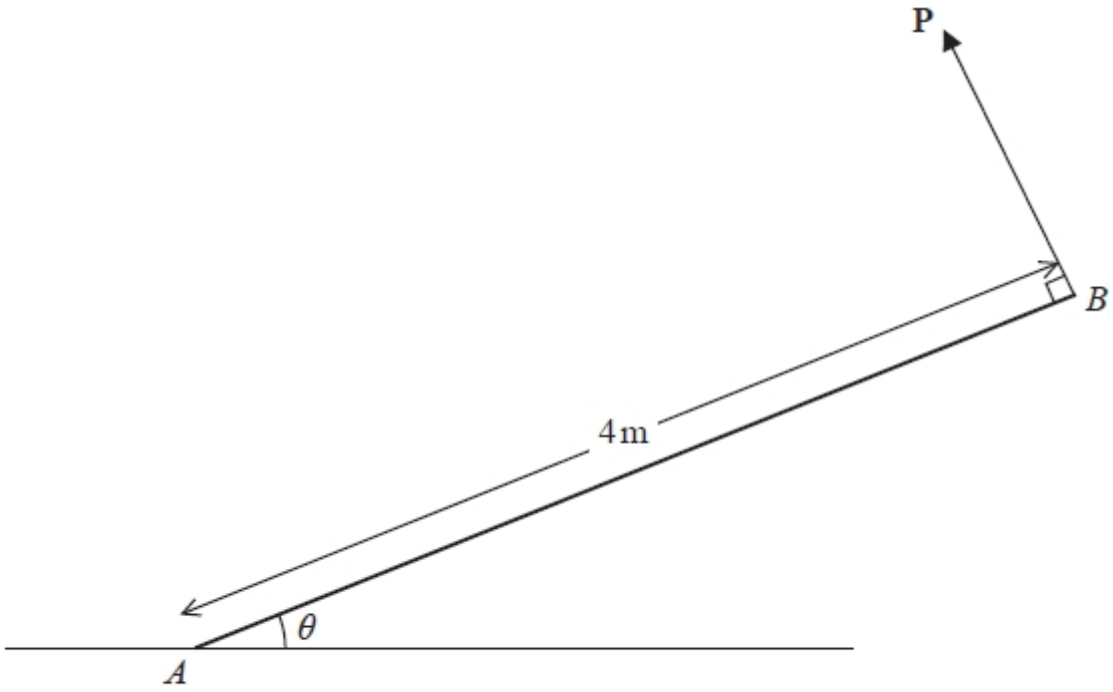

Figure 2

A non-uniform rod AB, of mass 5kg and length 4m, rests with one end A on rough horizontal ground. The centre of mass of the rod is d metres from A. The rod is held in limiting equilibrium at an angle θ to the horizontal by a force **P**, which acts in a direction perpendicular to the rod at B, as shown in Figure 2. The line of action of **P** lies in the same vertical plane as the rod.

(a) Find, in terms of d, g and θ,

(i) the magnitude of the vertical component of the force exerted on the rod by the ground,

(ii) the magnitude of the friction force acting on the rod at A. **(8)**

Given that $\tan\theta = \frac{5}{12}$ and that the coefficient of friction between the rod and the ground is $\frac{1}{2}$,

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

(Total for question = 12 marks)

Question 7

Two forces $\mathbf{F}_1$ and $\mathbf{F}_2$ act on a particle P.

The force $\mathbf{F}_1$ is given by $\mathbf{F}_1 = (-\mathbf{i} + 2\mathbf{j})$ N and $\mathbf{F}_2$ acts in the direction of the vector $(\mathbf{i} + \mathbf{j})$.

Given that the resultant of $\mathbf{F}_1$ and $\mathbf{F}_2$ acts in the direction of the vector $(\mathbf{i} + 3\mathbf{j})$,

(a) find $\mathbf{F}_2$ **(7)**

The acceleration of P is $(3\mathbf{i} + 9\mathbf{j})$ m s^{-2}. At time $t = 0$, the velocity of P is $(3\mathbf{i} - 22\mathbf{j})$ m s^{-1}

(b) Find the speed of P when $t = 3$ seconds. **(4)**

(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 cars P and Q are moving on straight horizontal roads with constant velocities. The velocity of P is $(15\mathbf{i} + 20\mathbf{j})$ m s^{-1} and the velocity of Q is $(20\mathbf{i} - 5\mathbf{j})$ m s^{-1}

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

At time $t = 0$, the position vector of P is $400\mathbf{i}$ metres and the position vector of Q is $800\mathbf{j}$ metres. At time t seconds, the position vectors of P and Q are $\mathbf{p}$ metres and $\mathbf{q}$ metres respectively.

(b) Find an expression for

(i) $\mathbf{p}$ in terms of t,

(ii) $\mathbf{q}$ in terms of t. **(3)**

(c) Find the position vector of Q when Q is due west of P. **(4)**

(Total for question = 10 marks)

Question 9

[*In this question,* **i** *is a horizontal unit vector and* **j** *is an upward vertical unit vector.*]
A particle P is projected from a fixed origin O with velocity $(3\mathbf{i} + 4\mathbf{j})$m s^{-1}. The particle moves freely under gravity and passes through the point A with position vector $\lambda(\mathbf{i} - \mathbf{j})$m, where λ is a positive constant.

(a) Find the value of λ. **(6)**

(b) Find

(i) the speed of P at the instant when it passes through A,
(ii) the direction of motion of P at the instant when it passes through A. **(7)**

(Total for question = 13 marks)

Question 10

A particle P moves along a straight line. The speed of P at time t seconds ($t \geq 0$) is v m s^{-1}, where $v = (pt^2 + qt + r)$ and p, q and r are constants. When $t = 2$ the speed of P has its minimum value. When $t = 0$, $v = 11$ and when $t = 2$, $v = 3$

Find

(a) the acceleration of P when $t = 3$ **(8)**

(b) the distance travelled by P in the third second of the motion. **(5)**

(Total for question = 13 marks)

TOTAL FOR PAPER IS 106 MARKS