Name:

Total Marks:

A level Applied Mathematics

Paper 3B Mechanics

Practice Paper M15

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

A small stone is projected vertically upwards from a point O with a speed of 19.6ms^{-1}.
Modelling the stone as a particle moving freely under gravity,

(a) find the greatest height above O reached by the stone, **(2)**

(b) find the length of time for which the stone is more than 14.7 m above O. **(5)**

(Total for question = 7 marks)

Question 2

A train travels along a straight horizontal track between two stations, A and B. The train starts from rest at A and moves with constant acceleration 0.5 m s^{-2} until it reaches a speed of $V \text{ ms}^{-1}$, ($V < 50$). The train then travels at this constant speed before it moves with constant deceleration 0.25 m s^{-2} until it comes to rest at B.

(a) Sketch in the space below a speed–time graph for the motion of the train between the two stations A and B. **(2)**

The total time for the journey from A to B is 5 minutes.

(b) Find, in terms of V, the length of time, in seconds, for which the train is

(i) accelerating,

(ii) decelerating,

(iii) moving with constant speed. **(5)**

Given that the distance between the two stations A and B is 6.3 km,

(c) find the value of V. **(6)**

(Total for question = 13 marks)

Question 3

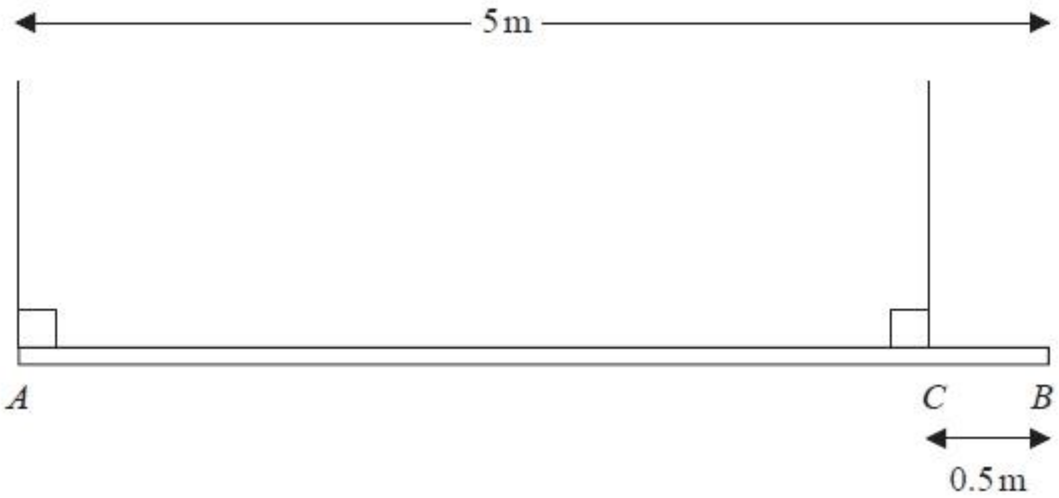

Figure 3

A beam AB has length 5 m and mass 25 kg. The beam is suspended in equilibrium in a horizontal position by two vertical ropes. One rope is attached to the beam at A and the other rope is attached to the point C on the beam where $CB = 0.5$ m, as shown in Figure 3. A particle P of mass 60 kg is attached to the beam at B and the beam remains in equilibrium in a horizontal position. The beam is modelled as a uniform rod and the ropes are modelled as light strings.

(a) Find

(i) the tension in the rope attached to the beam at A,

(ii) the tension in the rope attached to the beam at C. **(6)**

Particle P is removed and replaced by a particle Q of mass M kg at B. Given that the beam remains in equilibrium in a horizontal position,

(b) Find

(i) the greatest possible value of M,

(ii) the greatest possible tension in the rope attached to the beam at C. **(6)**

(Total for question = 12 marks)

Question 4

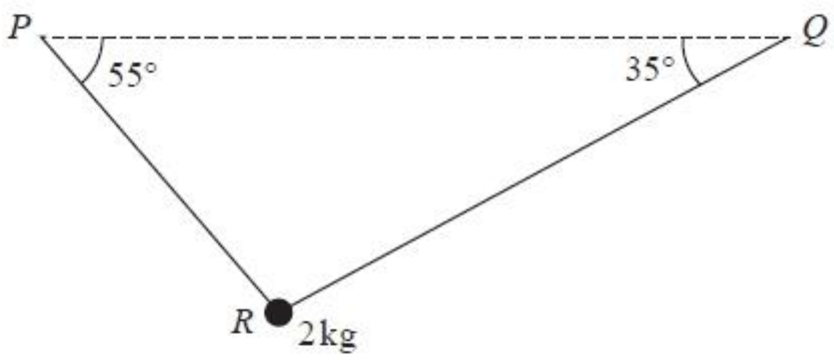

Figure 1

A particle of mass 2 kg is suspended from a horizontal ceiling by two light inextensible strings, *PR* and *QR*. The particle hangs at *R* in equilibrium, with the strings in a vertical plane. The string *PR* is inclined at 55° to the horizontal and the string *QR* is inclined at 35° to the horizontal, as shown in Figure 1.

Find

(i) the tension in the string *PR*,

(ii) the tension in the string *QR*. **(7)**

(Total for question = 7 marks)

Question 5

A particle *P* moves on the positive *x*–axis. The velocity of *P* at time *t* seconds is $(2t^2 - 9t + 4)$ m s^{-1}. When $t = 0$, *P* is 15 m from the origin *O*.

Find

(a) the values of *t* when *P* is instantaneously at rest, **(3)**

(b) the acceleration of *P* when $t = 5$ **(3)**

(c) the total distance travelled by *P* in the interval $0 \leq t \leq 5$ **(5)**

(Total for question = 11 marks)

Question 6

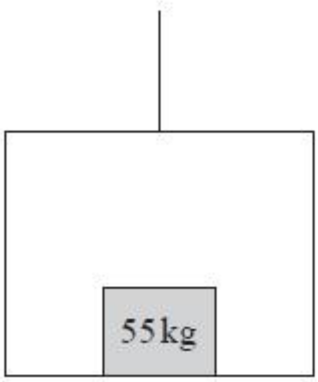

Figure 2

A lift of mass 200 kg is being lowered into a mineshaft by a vertical cable attached to the top of the lift. A crate of mass 55 kg is on the floor inside the lift, as shown in Figure 2. The lift descends vertically with constant acceleration. There is a constant upwards resistance of magnitude 150 N on the lift. The crate experiences a constant normal reaction of magnitude 473 N from the floor of the lift.

(a) Find the acceleration of the lift. **(3)**

(b) Find the magnitude of the force exerted on the lift by the cable. **(4)**

(Total for question = 7 marks)

Question 7

A particle P is moving with constant velocity. The position vector of P at time t seconds ($t \geqslant 0$) is $\mathbf{r}$ metres, relative to a fixed origin O, and is given by

$$\mathbf{r} = (2t - 3)\mathbf{i} + (4 - 5t)\mathbf{j}$$

(a) Find the initial position vector of P. **(1)**

The particle P passes through the point with position vector $(3.4\mathbf{i} - 12\mathbf{j})$m at time T seconds.

(b) Find the value of T. **(3)**

(c) Find the speed of P. **(4)**

(Total for question = 8 marks)

Question 8

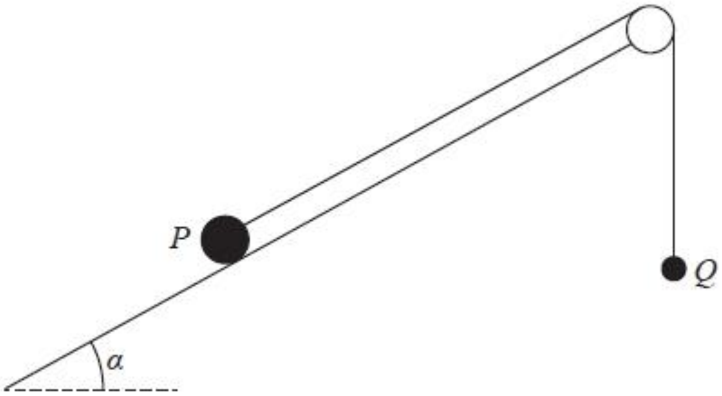

Figure 4

Two particles P and Q have mass 4 kg and 0.5 kg respectively. The particles are attached to the ends of a light inextensible string. Particle P is held at rest on a fixed rough plane, which is inclined to the horizontal at an angle α where $\tan \alpha = \frac{4}{3}$. The coefficient of friction between P and the plane is 0.5. The string lies along the plane and passes over a small smooth light pulley which is fixed at the top of the plane. Particle Q hangs freely at rest vertically below the pulley. The string lies in the vertical plane which contains the pulley and a line of greatest slope of the inclined plane, as shown in Figure 4. Particle P is released from rest with the string taut and slides down the plane.

Given that Q has not hit the pulley, find

(a) the tension in the string during the motion, **(11)**

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

(Total for question = 15 marks)

Question 9

A ladder AB, of weight W and length $2l$, has one end A resting on rough horizontal ground. The other end B rests against a rough vertical wall. The coefficient of friction between the ladder and the wall is $\frac{1}{3}$. The coefficient of friction between the ladder and the ground is μ. Friction is limiting at both A and B. The ladder is at an angle θ to the ground, where $\tan \theta = \frac{5}{3}$. The ladder is modelled as a uniform rod which lies in a vertical plane perpendicular to the wall.

Find the value of μ. **(9)**

(Total for question = 9 marks)

Question 10

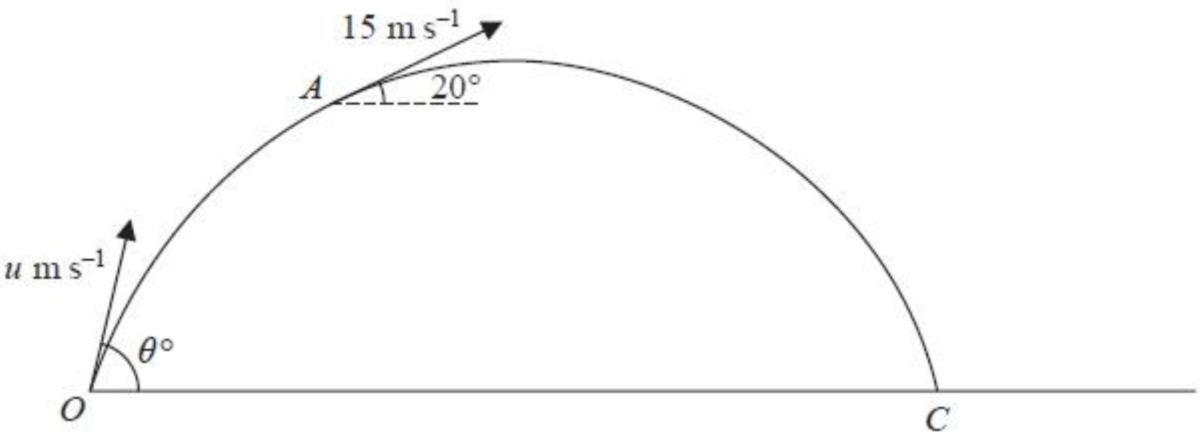

Figure 3

At time $t = 0$, a particle is projected from a fixed point O on horizontal ground with speed u m s^{-1} at an angle θ° to the horizontal. The particle moves freely under gravity and passes through the point A when $t = 4$ s. As it passes through A, the particle is moving upwards at 20° to the horizontal with speed 15 m s^{-1}, as shown in Figure 3.

(a) Find the value of u and the value of θ. **(7)**

At the point B on its path the particle is moving downwards at 20° to the horizontal with speed 15 m s^{-1}.

(b) Find the time taken for the particle to move from A to B. **(2)**

The particle reaches the ground at the point C.

(c) Find the distance OC. **(3)**

(Total for question = 12 marks)

TOTAL FOR PAPER IS 101 MARKS