Name:

Total Marks:

A level Applied Mathematics

Paper 3B Mechanics

Practice Paper M14

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 108.
- 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 ball of mass 0.3 kg is released from rest at a point which is 2 m above horizontal ground. The ball moves freely under gravity. After striking the ground, the ball rebounds vertically and rises to a maximum height of 1.5 m above the ground, before falling to the ground again. The ball is modelled as a particle.

(a) Find the speed of the ball at the instant before it strikes the ground for the first time. **(2)**

(b) Find the speed of the ball at the instant after it rebounds from the ground for the first time. **(2)**

(c) Find the magnitude of the impulse on the ball in the first impact with the ground. **(2)**

(d) Sketch, in the space provided, a velocity-time graph for the motion of the ball from the instant when it is released until the instant when it strikes the ground for the second time. **(3)**

(e) Find the time between the instant when the ball is released and the instant when it strikes the ground for the second time. **(4)**

(Total 13 marks)

Question 2

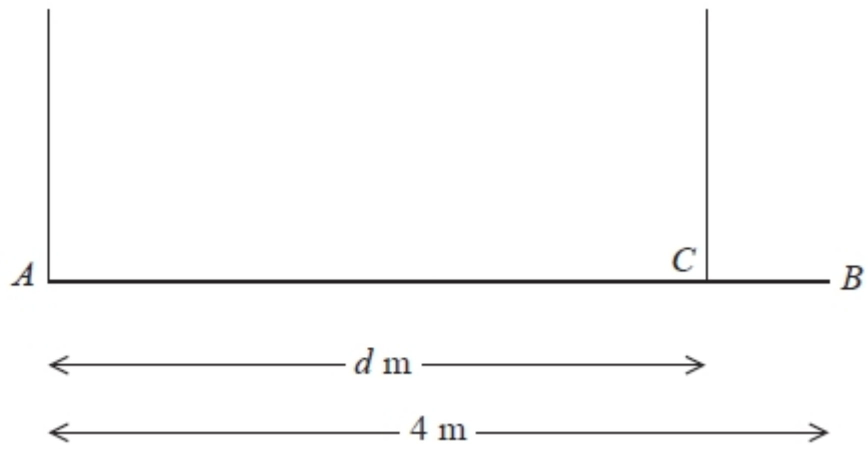

Figure 3

A beam AB has weight W newtons and length 4 m. The beam is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. One rope is attached to A and the other rope is attached to the point C on the beam, where $AC = d$ metres, as shown in Figure 3. The beam is modelled as a uniform rod and the ropes as light inextensible strings. The tension in the rope attached at C is double the tension in the rope attached at A.

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

A small load of weight kW newtons is attached to the beam at B. The beam remains in equilibrium in a horizontal position. The load is modelled as a particle. The tension in the rope attached at C is now four times the tension in the rope attached at A.

(b) Find the value of k. **(6)**

(Total 12 marks)

Question 3

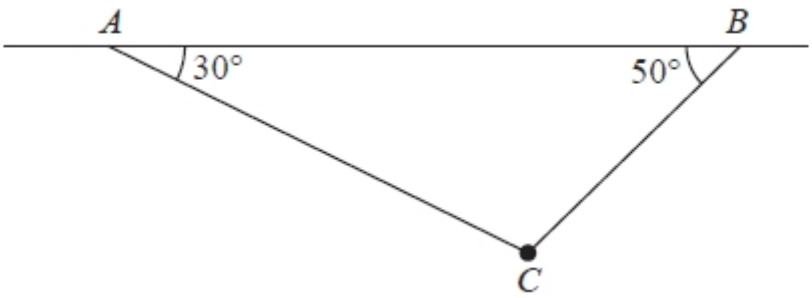

Figure 1

A particle of weight W newtons is attached at C to two light inextensible strings AC and BC. The other ends of the strings are attached to fixed points A and B on a horizontal ceiling. The particle hangs in equilibrium with AC and BC inclined to the horizontal at 30° and 50° respectively, as shown in Figure 1.

Given that the tension in BC is 6 N, find

(a) the tension in AC, **(3)**

(b) the value of W. **(3)**

(Total 6 marks)

Question 4

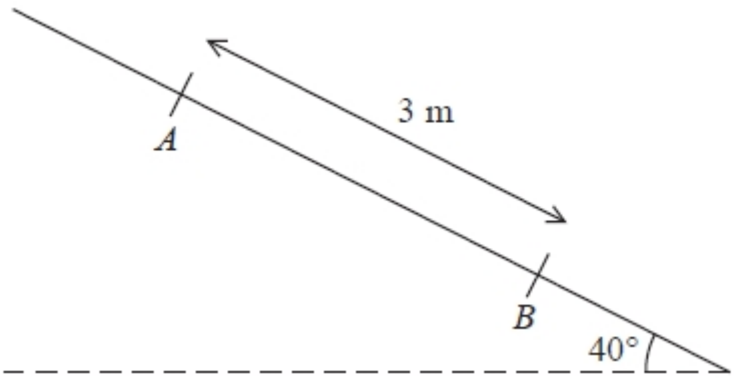

Figure 2

A rough plane is inclined at 40° to the horizontal. Two points A and B are 3 metres apart and lie on a line of greatest slope of the inclined plane, with A above B, as shown in Figure 2. A particle P of mass m kg is held at rest on the plane at A. The coefficient of friction between P and the plane is $\frac{1}{2}$. The particle is released.

(a) Find the acceleration of P down the plane. **(5)**

(b) Find the speed of P at B. **(2)**

(Total 7 marks)

Question 5

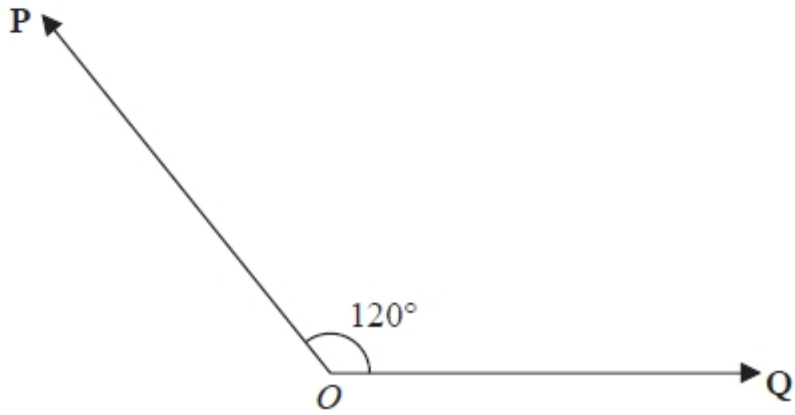

Figure 4

Two forces **P** and **Q** act on a particle at *O*. The angle between the lines of action of **P** and **Q** is 120° as shown in Figure 4. The force **P** has magnitude 20 N and the force **Q** has magnitude *X* newtons. The resultant of **P** and **Q** is the force **R**.

Given that the magnitude of **R** is 3*X* newtons, find, giving your answers to 3 significant figures

(a) the value of *X*, **(5)**

(b) the magnitude of (**P** − **Q**). **(4)**

(Total 9 marks)

Question 6

A particle *P* of mass 0.5 kg is moving under the action of a single force (3**i** − 2**j**) N.

(a) Show that the magnitude of the acceleration of *P* is $2\sqrt{13}$ m s^{-2}. **(4)**

At time $t = 0$, the velocity of *P* is (**i** + 3**j**) m s^{-1}.

(b) Find the velocity of *P* at time $t = 2$ seconds. **(3)**

Another particle *Q* moves with constant velocity **v** = (2**i** − **j**) m s^{-1}.

(c) Find the distance moved by *Q* in 2 seconds. **(2)**

(d) Show that at time $t = 3.5$ seconds both particles are moving in the same direction. **(3)**

(Total 12 marks)

Question 7

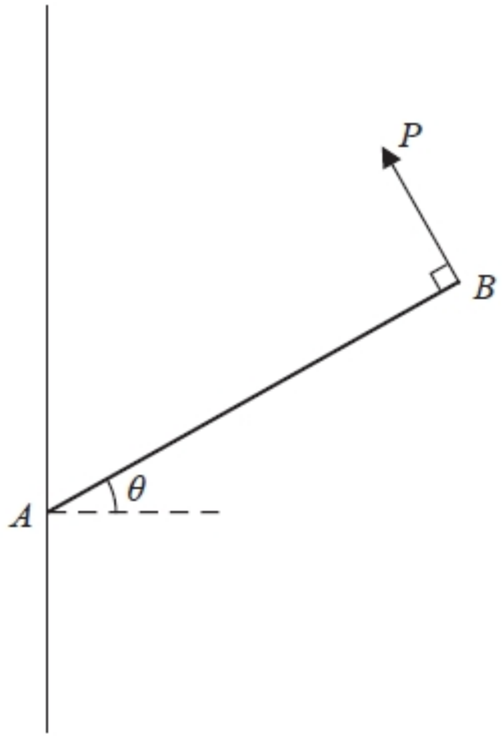

Figure 3

A uniform rod AB of weight W has its end A freely hinged to a point on a fixed vertical wall. The rod is held in equilibrium, at angle θ to the horizontal, by a force of magnitude P. The force acts perpendicular to the rod at B and in the same vertical plane as the rod, as shown in Figure 3. The rod is in a vertical plane perpendicular to the wall. The magnitude of the vertical component of the force exerted on the rod by the wall at A is Y.

(a) Show that $Y = \frac{W}{2}(2 - \cos^2\theta)$. **(6)**

Given that $\theta = 45°$

(b) find the magnitude of the force exerted on the rod by the wall at A, giving your answer in terms of W. **(6)**

(Total 12 marks)

Question 8

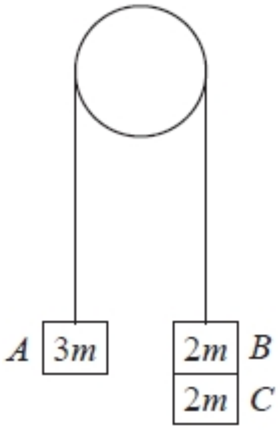

Figure 5

Three particles A, B and C have masses $3m$, $2m$ and $2m$ respectively. Particle C is attached to particle B. Particles A and B are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 5. The system is released from rest and A moves upwards.

(a) (i) Show that the acceleration of A is $\frac{g}{7}$

(ii) Find the tension in the string as A ascends. **(7)**

At the instant when A is 0.7 m above its original position, C separates from B and falls away. In the subsequent motion, A does not reach the pulley.

(b) Find the speed of A at the instant when it is 0.7 m above its original position. **(2)**

(c) Find the acceleration of A at the instant after C separates from B. **(4)**

(d) Find the greatest height reached by A above its original position. **(3)**

(Total 16 marks)

Question 9

At time t seconds, where $t \geq 0$, a particle P is moving on a horizontal plane with acceleration $[(3t^2 - 4t)\mathbf{i} + (6t - 5)\mathbf{j}]$ m s^{-2}.

When $t = 3$ the velocity of P is $(11\mathbf{i} + 10\mathbf{j})$ m s^{-1}.

Find

(a) the velocity of P at time t seconds, **(5)**

(b) the speed of P when it is moving parallel to the vector $\mathbf{i}$. **(4)**

(Total 9 marks)

Question 10

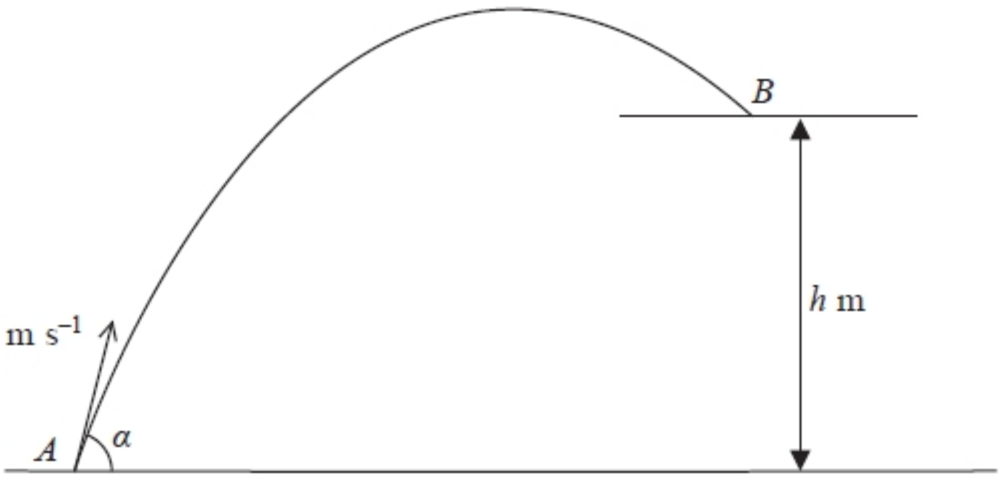

Figure 2

A small ball is projected with speed 14 m s^{-1} from a point *A* on horizontal ground. The angle of projection is α above the horizontal. A horizontal platform is at height *h* metres above the ground. The ball moves freely under gravity until it hits the platform at the point *B*, as shown in Figure 2. The speed of the ball immediately before it hits the platform at *B* is 10 m s^{-1}.

(a) Find the value of *h*. **(4)**

Given that $\sin \alpha = 0.85$,

(b) find the horizontal distance from *A* to *B*. **(8)**

(Total 12 marks)

TOTAL FOR PAPER IS 108 MARKS