OXFORD

INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

INTERNATIONAL A-LEVEL

MATHEMATICS

(9660/MA05) Unit M2 − Mechanics

Specimen 2018 Morning Time allowed: 1 hour 30 minutes

Materials

- For this paper you must have the booklet of formulae and statistical tables.
- You may use a graphics calculator.

Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer each question in the space provided for that question. If you require extra space, use a supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box or around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- Unless otherwise stated, use $g = 9.8$ ms^{-2}

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

Answer **all** questions in the spaces provided.

1 In an Olympic diving competition, Kim, who has mass 58 kg, dives from a fixed platform 10 metres above the surface of the pool. She leaves the platform with a speed of 2 ms^{-1}.

Assume that Kim's weight is the only force that acts on her after she leaves the platform. Kim is to be modelled as a particle which is initially 1 m above the platform.

(a) Calculate Kim's initial kinetic energy.

[2 marks]

Answer _____ J

(b) By using conservation of energy, find Kim's speed when she is 6 m below the platform.

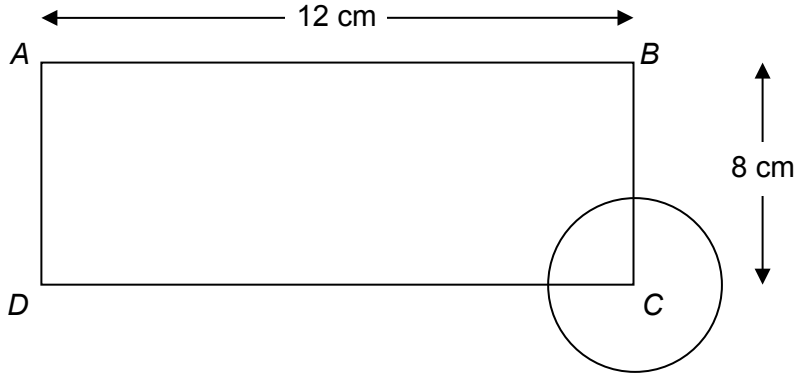
[5 marks]

Answer _____ m s^{-1}

2 A uniform rectangular lamina *ABCD*, of mass 1.6 kg, has side *AB* of length 12 cm and side *BC* of length 8 cm.

To create a logo, a uniform circular lamina, of mass 0.4 kg, is attached.

The centre of the circular lamina is at the point *C*, as shown in the diagram.



(a)(i) Find the distance of the centre of mass of the logo from the line *AB*.

[3 marks]

Answer _____ cm

(ii) Find the distance of the centre of mass of the logo from the line *AD*.

[3 marks]

Answer _____ cm

(b) The logo is suspended in equilibrium, with *AB* horizontal, by two vertical strings.
One string is attached at the point *A* and the other string is attached at the point *B*.

Find the tensions in each of these two strings.

[5 marks]

3 A particle moves in a horizontal plane under the action of a single force, **F** newtons. The unit vectors **i** and **j** are directed east and north respectively.

At time t seconds, the velocity of the particle, **v** ms^{-1}, is given by

$$\mathbf{v} = 4e^{-2t}\,\mathbf{i} + (6t - 3t^2)\mathbf{j}$$

(a) Find an expression for the acceleration of the particle at time t.

[3 marks]

Answer _____

(b) The mass of the particle is 5 kg.

(i) Find an expression for the force, **F**, acting on the particle at time t.

[2 marks]

Answer _____

(ii) Find the magnitude of **F** when $t = 0$

[2 marks]

Answer _____

(c) Find the value of t when **F** acts due west.

[2 marks]

Answer _____

(d) When $t = 0$, the particle is at the point with position vector $(6\mathbf{i} + 5\mathbf{j})$ m.

Find the position vector, $\boldsymbol{r}$ metres, of the particle at time t.

[5 marks]

Answer _____

4 A van, of mass 1500 kg, travels at a constant speed of 22 ms^{-1} up a slope inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{25}$

The van experiences a resistance force of 8000 N.

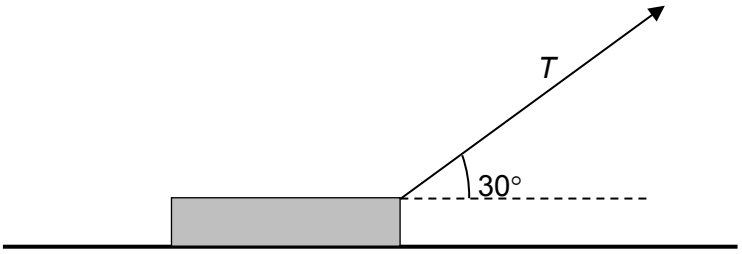
Find the power output of the van's engine, giving your answer in kilowatts.

[5 marks]

Answer _____

5 A man pulls a small block, of mass 8 kg, along a rough horizontal surface, using a rope.

The coefficient of friction between the block and the ground is 0.3. The tension in the rope is T newtons. The rope is kept at an angle of 30° to the horizontal, as shown in the diagram.



(a) Draw a diagram to show all of the forces acting on the block. **[1 mark]**

(b) Find the magnitude of the normal reaction force in terms of T.

[3 marks]

Answer _____

(c) Given that the block accelerates at 0.05 ms^{-2}, find the value of T.

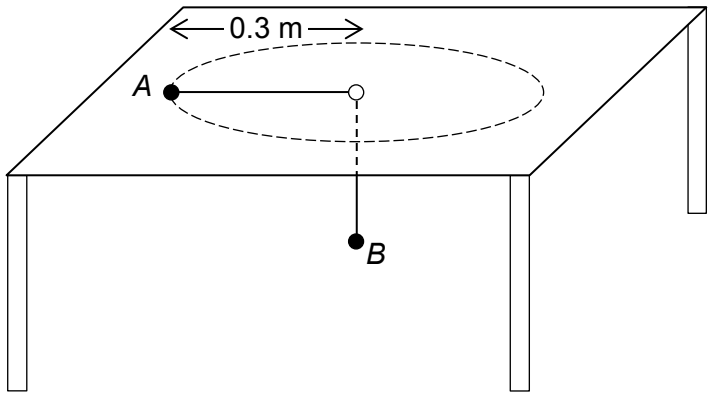
[6 marks]

Answer _____

6 Two particles, *A* and *B*, are connected by a light inextensible string which passes through a hole in a smooth horizontal table. The edges of the hole are also smooth.

Particle *A*, of mass 1.4 kg, moves, on the table, with constant speed in a circle of radius 0.3 m around the hole.

Particle *B*, of mass 2.1 kg, hangs in equilibrium under the table, as shown in the diagram.



(a) Find the angular speed of particle *A*.

[4 marks]

Answer _____

(b) Find the speed of particle *A*.

[2 marks]

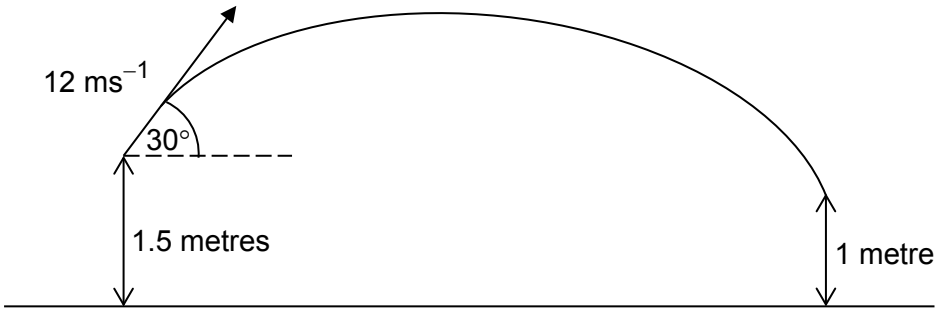
Answer _____

(c) Find the time taken for particle *A* to complete one full circle around the hole.

[2 marks]

Answer _____

7 An arrow is fired from a point at a height of 1.5 metres above horizontal ground. It has an initial velocity of 12 ms^{-1} at an angle of 30° above the horizontal. The arrow hits a target at a height of 1 metre above horizontal ground. The path of the arrow is shown in the diagram.



Model the arrow as a particle.

(a) Show that the time it takes for the arrow to travel to the target is 1.30 seconds, correct to three significant figures.

[5 marks]

(b) Find the horizontal distance between the point where the arrow is fired and the target.

[2 marks]

Answer _____ m

(c) Find the speed of the arrow when it hits the target.

[4 marks]

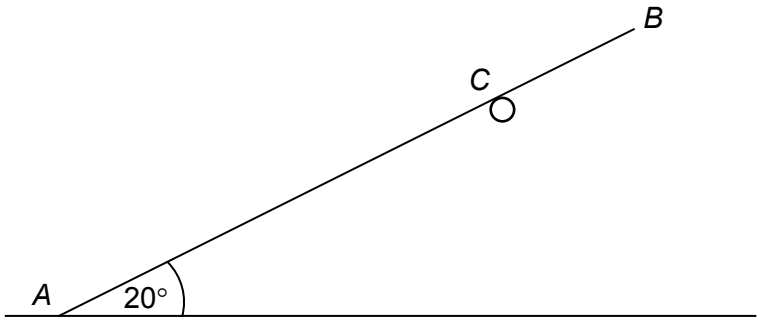
Answer _____ m s^{-1}

(d) Find the angle between the velocity of the arrow and the horizontal when the arrow hits the target.

[2 marks]

Answer _____

8 A uniform rod AB, of length 4 m and mass 6 kg, rests in equilibrium with one end A on smooth horizontal ground . The rod rests on a rough horizontal peg at the point C, where AC is 3 m. The rod is inclined at an angle of 20° to the horizontal.



(a) Draw a diagram to show the forces acting on the rod.

[2 marks]

(b) Find the magnitude of the normal reaction force between the rod and the ground.

[3 marks]

Answer _____

(c) (i) Find the normal reaction force acting on the rod at *C*.

[3 marks]

Answer _____

(c) (ii) Find the friction force acting on the rod at *C*.

[2 marks]

Answer _____

(d) In this position, the rod is on the point of slipping.

Calculate the coefficient of friction between the rod and the peg.

[2 marks]

Answer _____

END OF QUESTIONS