OXFORD
INTERNATIONAL
AQA EXAMINATIONS

Please write clearly, in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

INTERNATIONAL A-LEVEL
FURTHER MATHEMATICS

(FM05) Unit FM2 − 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 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.

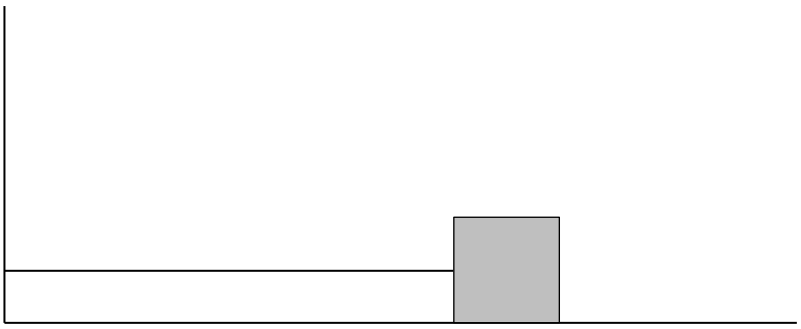
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

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 A block, of mass 5 kg, is attached to one end of a length of elastic string. The other end of the string is fixed to a vertical wall. The block is placed on a horizontal surface.

The elastic string has natural length 1.2 m and modulus of elasticity 180 N. The block is pulled so that it is 2 m from the wall and is then released from rest. Whilst taut, the string remains horizontal. It may be assumed that, after the string becomes slack, it does not interfere with the movement of the block.



(a) Calculate the elastic potential energy when the block is 2 m from the wall.

[2 marks]

Answer _____ J

(b) If the horizontal surface is smooth, find the speed of the block when it hits the wall.

[3 marks]

Answer _____ m s^{-1}

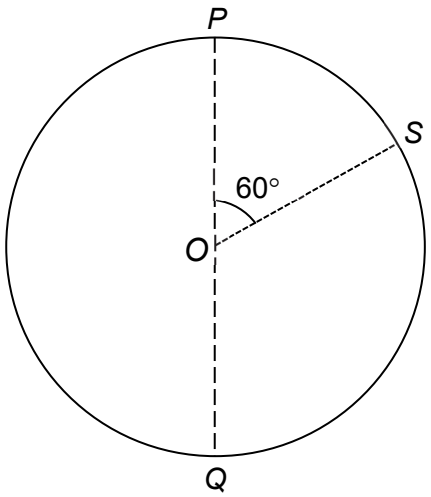
(c) The surface is in fact rough and the coefficient of friction between the block and the surface is μ.

Find the value of μ if the block comes to rest just as it reaches the wall.

[7 marks]

Answer _____

2 A bead, of mass m, moves on a smooth circular ring, of radius a and centre O, which is fixed in a vertical plane, as shown in the diagram below. At P, the highest point on the ring, the speed of the bead is $2u$ and at Q, the lowest point on the ring, the speed of the bead is $5u$.



(a) Show that $u = \sqrt{\frac{4ag}{21}}$

[4 marks]

(b) *S* is a point on the ring so that angle *POS* is 60°, as shown on the diagram.

Find, in terms of m and g, the magnitude of the reaction of the wire on the bead when the bead is at *S*.

[5 marks]

Answer _____

3 A ball of mass 0.2 kg is thrown vertically upwards from a fixed point with an initial speed of 10 ms^{-1}. In the ball's subsequent motion, when it has a speed of v ms^{-1}, it experiences a resistance of $0.01v^2$ newtons.

(a) Show that $\dfrac{\mathrm{d}v}{\mathrm{d}t} = -\left(\dfrac{20g + v^2}{20}\right)$

[2 marks]

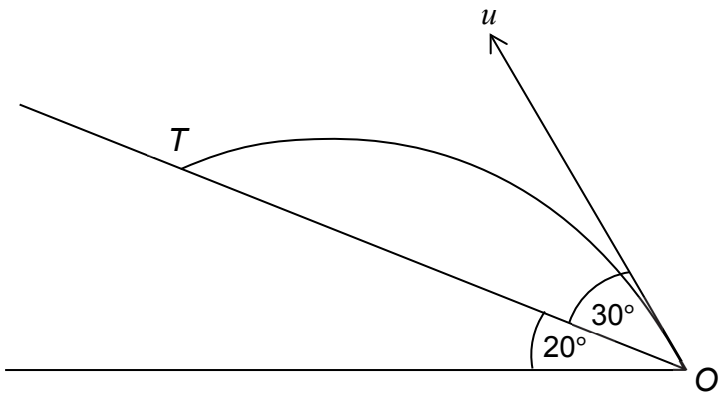
(b) Find the time it takes for the ball to reach its maximum height, giving your answer to two significant figures.

[6 marks]

Answer _____

4 A projectile is fired from a point O on a plane which is inclined at an angle of 20° to the horizontal. The projectile is fired up the plane with velocity u ms^{-1} at an angle of 30° to the inclined plane. The projectile travels in a vertical plane containing a line of greatest slope of the inclined plane.

The projectile hits a target T on the inclined plane.



(a) Given that $OT = 200$ m, determine the value of u.

[7 marks]

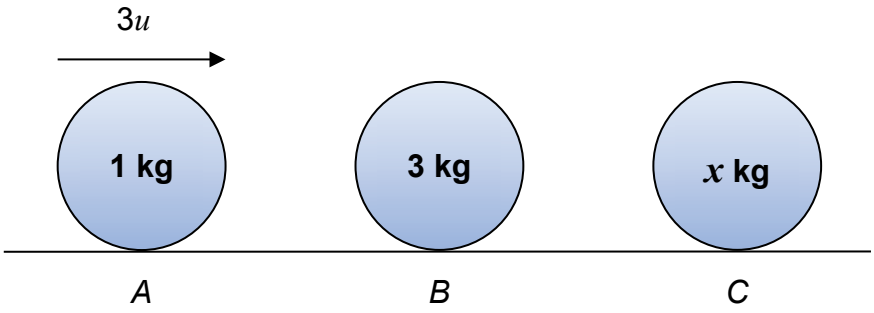
Answer _____

(b) Find the greatest perpendicular distance of the projectile from the plane.

[4 marks]

Answer _____ metres

5 Three smooth spheres, *A, B* and *C,* of equal radii have masses 1 kg, 3 kg and x kg respectively. The spheres lie at rest in a straight line on a smooth horizontal surface with *B* between *A* and *C*. The sphere *A* is projected with speed $3u$ ms^{-1} directly towards *B* and collides with it.



The coefficient of restitution between each pair of spheres is $\frac{1}{3}$

(a) Show that *A* is brought to rest by the impact, and find the speed of *B* immediately after the collision in terms of u.

[6 marks]

Speed of *B* = _____ m s^{-1}

(b) Subsequently, *B* collides with *C*.

Find the speed of *B* immediately after the collision in terms of u and x. **[6 marks]**

Answer _____ m s^{-1}

(c) Show that *B* will collide with *A* again if $x > 9$

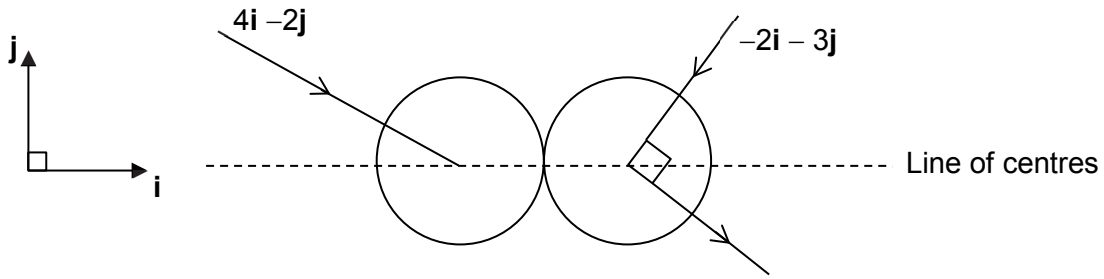
[2 marks]

(d) Given that $x = 5$, find the magnitude of the impulse exerted on *C* by *B* in terms of u.

[2 marks]

Answer _____ N s

6 Two smooth spheres, *A* and *B*, have equal radii and masses 4 kg and 2 kg respectively. The sphere *A* is moving with velocity $(4\mathbf{i} - 2\mathbf{j})$ ms^{-1} and the sphere *B* is moving with velocity $(-2\mathbf{i} - 3\mathbf{j})$ ms^{-1} on the same smooth horizontal surface. The spheres collide when their line of centres is parallel to unit vector **i**. The direction of motion of *B* is changed through 90° by the collision, as shown in the diagram.



(a) Show that the velocity of *B* immediately after the collision is $\left(\frac{9}{2}\mathbf{i} - 3\mathbf{j}\right)$ m s^{-1}

[4 marks]

(b) Find the coefficient of restitution between the spheres.

[5 marks]

Answer _____

(c) Find the impulse exerted on *B* during the collision.

State the units of your answer.

[3 marks]

Answer _____

Units _____

7 A particle *P*, of mass 0.4 kg, is attached to one end of a light elastic string, and the other end of the string is attached to a fixed point *A*.

(a) The particle *P* hangs in equilibrium at a point *E*, vertically below *A*, where the extension of the string is 0.1 metres. Calculate the stiffness of the string.

[3 marks]

Answer _____

(b) The particle *P* is pulled vertically downwards from the point *E* by a distance of 0.2 metres, and released from rest. The displacement of *P* from *E* at time t seconds after being released is x metres.

(b) (i) Show that, during the subsequent motion,

$$\ddot{x} = hx$$

where h is a constant to be determined.

[4 marks]

(b) (ii) Hence deduce that the motion of *P* is simple harmonic.

[1 mark]

(b) (iii) Show that the period of this motion is 0.63 seconds, correct to two significant figures.

[2 marks]

(b) (iv) Calculate the maximum speed of *P* during its motion.

[2 marks]

Answer _____ m s^{-1}

END OF QUESTIONS

There are no questions printed on this page

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