physicsandmathstutor.com

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

MATHEMATICS **4730**

Mechanics 3

Candidates answer on the answer booklet.

OCR supplied materials:
- 8 page answer booklet
  (sent with general stationery)
- List of Formulae (MF1)

Other materials required:
- Scientific or graphical calculator

Monday 20 June 2011
Morning

Duration: 1 hour 30 minutes

* 4 7 3 0 *

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by g m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a scientific or graphical calculator in this paper.

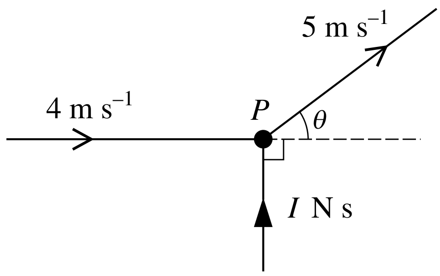
INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- This document consists of **4** pages. Any blank pages are indicated.

© OCR 2011 [T/102/2703]
2R–0K10 OCR is an exempt Charity

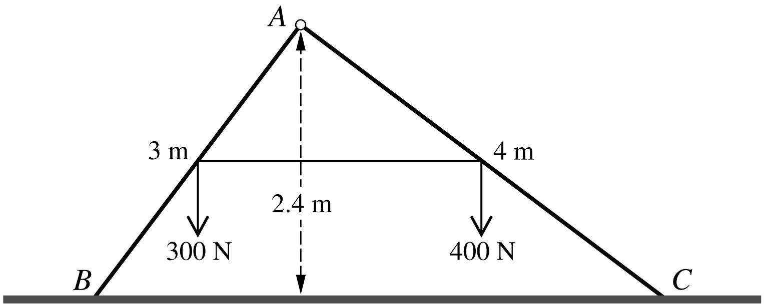
physicsandmathstutor.com

1



A particle P of mass 0.3 kg is moving in a straight line with speed 4 m s^{-1} when it is deflected through an angle θ by an impulse of magnitude I N s. The impulse acts at right angles to the initial direction of motion of P (see diagram). The speed of P immediately after the impulse acts is 5 m s^{-1}. Show that $\cos\theta = 0.8$ and find the value of I. **[4]**

2



Two uniform rods AB and AC, of lengths 3 m and 4 m respectively, have weights 300 N and 400 N respectively. The rods are freely jointed at A. The mid-points of the rods are joined by a light inextensible string. The rods are in equilibrium in a vertical plane with the string taut and B and C in contact with a smooth horizontal surface. The point A is 2.4 m above the surface (see diagram).

(i) Show that the force exerted by the surface on AB is 374 N and find the force exerted by the surface on AC. **[4]**

(ii) Find the tension in the string. **[3]**

(iii) Find the horizontal and vertical components of the force exerted on AB at A and state their directions. **[3]**

3 A particle P of mass 0.25 kg is projected horizontally with speed 5 m s^{-1} from a fixed point O on a smooth horizontal surface and moves in a straight line on the surface. The only horizontal force acting on P has magnitude $0.2v^2$ N, where v m s^{-1} is the velocity of P at time t s after it is projected from O. This force is directed towards O.

(i) Find an expression for v in terms of t. **[5]**

The particle P passes through a point X with speed 0.2 m s^{-1}.

(ii) Find the average speed of P for its motion between O and X. **[5]**

4 One end of a light inextensible string of length 2 m is attached to a fixed point O. A particle P of mass 0.2 kg is attached to the other end of the string. P is held at rest with the string taut so that OP makes an angle of 0.15 radians with the downward vertical. P is released and t seconds afterwards OP makes an angle of θ radians with the downward vertical.

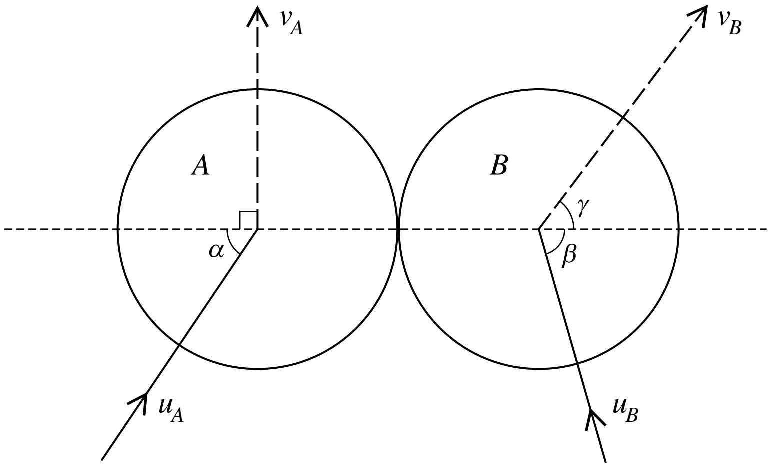
(i) Show that $\frac{d^2\theta}{dt^2} = -4.9\sin\theta$ and give a reason why the motion is approximately simple harmonic. **[3]**

Using the simple harmonic approximation,

(ii) obtain an expression for θ in terms of t and hence find the values of t at the first and second occasions when $\theta = -0.1$, **[5]**

(iii) find the angular speed of OP and the linear speed of P when $t = 0.5$. **[3]**

5



Two uniform smooth identical spheres A and B are moving towards each other on a horizontal surface when they collide. Immediately before the collision A and B are moving with speeds u_A m s^{-1} and u_B m s^{-1} respectively, at acute angles α and β, respectively, to the line of centres. Immediately after the collision A and B are moving with speeds v_A m s^{-1} and v_B m s^{-1} respectively, at right angles and at acute angle γ, respectively, to the line of centres (see diagram).

(i) Given that $\sin\beta = 0.96$ and $\frac{v_B}{u_B} = 1.2$, find the value of $\sin\gamma$. **[2]**

(ii) Given also that, before the collision, the component of A's velocity parallel to the line of centres is 2 m s^{-1}, find the values of u_B and v_B. **[5]**

(iii) Find the coefficient of restitution between the spheres. **[3]**

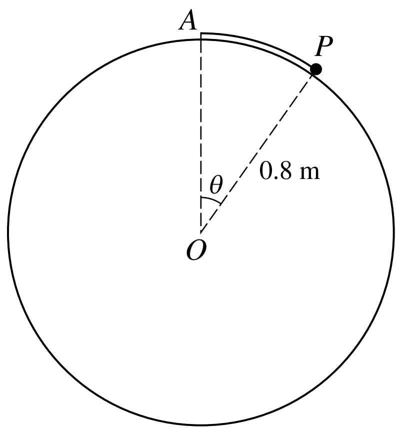
(iv) Given that the kinetic energy of A immediately before the collision is $6.5m$ J, where m kg is the mass of A, find the value of v_A. **[2]**

[Questions 6 and 7 are printed overleaf.]

© OCR 2011

physicsandmathstutor.com

6



A particle P of weight 6 N is attached to the highest point A of a fixed smooth sphere by a light elastic string. The sphere has centre O and radius 0.8 m. The string has natural length $\frac{1}{10}\pi$ m and modulus of elasticity 9 N. P is released from rest at a point X on the sphere where OX makes an angle of $\frac{1}{4}\pi$ radians with the upwards vertical. P remains in contact with the sphere as it moves upwards to A. At time t seconds after the release, OP makes an angle of θ radians with the upwards vertical (see diagram). When $\theta = \frac{1}{6}\pi$, P passes through the point Y.

(i) Show that as P moves from X to Y its gravitational potential energy increases by $2.4(\sqrt{3} - \sqrt{2})$ J and the elastic potential energy in the string decreases by 0.4π J. **[5]**

(ii) Verify that the transverse acceleration of P is zero when $\theta = \frac{1}{6}\pi$, and hence find the maximum speed of P. **[6]**

7 One end of a light inextensible string of length 0.8 m is attached to a fixed point O. A particle P of mass 0.3 kg is attached to the other end of the string. P is projected horizontally from the point 0.8 m vertically below O with speed 5.6 m s^{-1}. P starts to move in a vertical circle with centre O. The speed of P is v m s^{-1} when the string makes an angle θ with the downward vertical.

(i) While the string remains taut, show that $v^2 = 15.68(1 + \cos\theta)$, and find the tension in the string in terms of θ. **[7]**

(ii) For the instant when the string becomes slack, find the value of θ and the value of v. **[3]**

(iii) Find, in either order, the speed of P when it is at its greatest height after the string becomes slack, and the greatest height reached by P above its point of projection. **[4]**

OCR
RECOGNISING ACHIEVEMENT

Copyright Information

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact the Copyright Team, First Floor, 9 Hills Road, Cambridge CB2 1GE.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

© OCR 2011