Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						6 6 8 0 / 0 1	Signature	

Paper Reference(s)

6680/01

Edexcel GCE

Mechanics M4

Advanced/Advanced Subsidiary

Tuesday 18 June 2013 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
Total	

Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink)	Nil

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation or symbolic differentation/integration, or have retrievable mathematical formulae stored in them.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initials and signature.
Check that you have the correct question paper.
Answer ALL the questions.
You must write your answer to each question in the space following the question.
Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 7 questions in this question paper. The total mark for this paper is 75.
There are 28 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You should show sufficient working to make your methods clear to the Examiner.
Answers without working may not gain full credit.

Printer's Log. No.
P41819A
W850/R6680/57570 5/5/5/5/6/
P 4 1 8 1 9 A 0 1 2 8

Turn over

PEARSON

Leave blank

1. A particle P of mass 0.5 kg falls vertically from rest. After t seconds it has speed v m s^{-1}. A resisting force of magnitude $1.5v$ newtons acts on P as it falls.

(a) Show that $3v = 9.8(1 - e^{-3t})$.

(8)

(b) Find the distance that P falls in the first two seconds of its motion.

(5)

2.

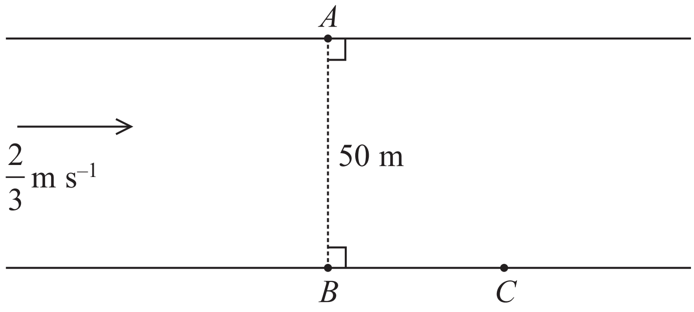

Figure 1

A river is 50 m wide and flows between two straight parallel banks. The river flows with a uniform speed of $\frac{2}{3}$ m s^{-1} parallel to the banks. The points A and B are on opposite banks of the river and AB is perpendicular to both banks of the river, as shown in Figure 1.

Keith and Ian decide to swim across the river. The speed relative to the water of both swimmers is $\frac{10}{9}$ m s^{-1}.

Keith sets out from A and crosses the river in the least possible time, reaching the opposite bank at the point C. Find

(a) the time taken by Keith to reach C,

(2)

(b) the distance BC.

(2)

Ian sets out from A and swims in a straight line so as to land on the opposite bank at B.

(c) Find the time taken by Ian to reach B.

(4)

Leave blank

Leave blank

Question 2 continued

P 4 1 8 1 9 A 0 5 2 8

Turn over

Leave blank

3.

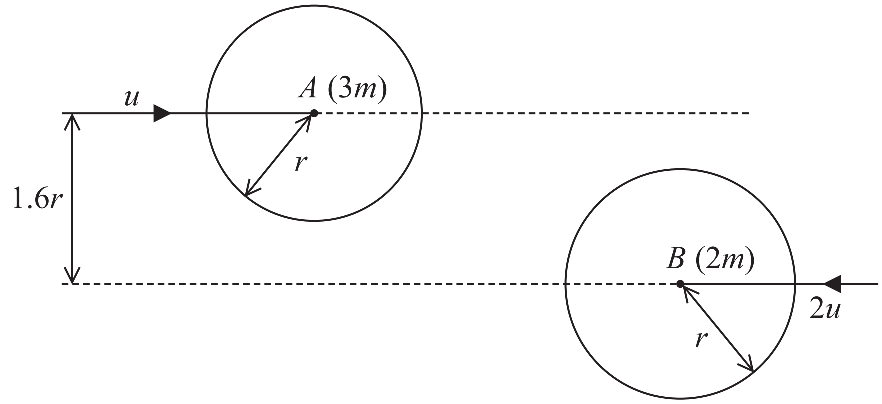

Figure 2

Two smooth uniform spheres A and B, of equal radius r, have masses $3m$ and $2m$ respectively. The spheres are moving on a smooth horizontal plane when they collide. Immediately before the collision they are moving with speeds u and $2u$ respectively. The centres of the spheres are moving towards each other along parallel paths at a distance $1.6r$ apart, as shown in Figure 2.

The coefficient of restitution between the two spheres is $\frac{1}{6}$.

Find, in terms of m and u, the magnitude of the impulse received by B in the collision.
(10)

P 4 1 8 1 9 A 0 8 2 8

Leave blank

Question 3 continued

Turn over

Leave blank

4.

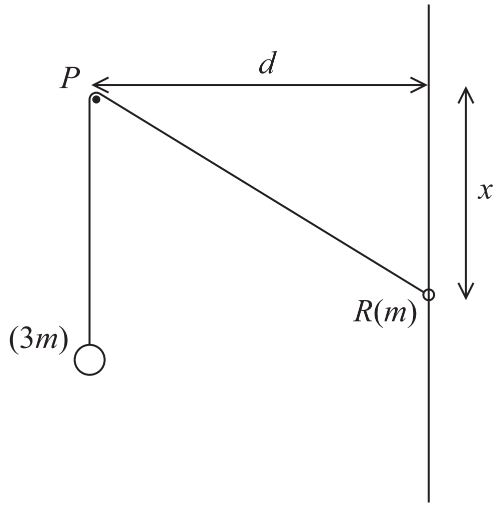

Figure 3

A small smooth peg P is fixed at a distance d from a fixed smooth vertical wire. A particle of mass $3m$ is attached to one end of a light inextensible string which passes over P. The particle hangs vertically below P. The other end of the string is attached to a small ring R of mass m, which is threaded on the wire, as shown in Figure 3.

(a) Show that when R is at a distance x below the level of P the potential energy of the system is

$$3mg\sqrt{(x^2 + d^2)} - mgx + \text{constant}$$

(4)

(b) Hence find x, in terms of d, when the system is in equilibrium.

(3)

(c) Determine the stability of the position of equilibrium.

(3)

Leave blank

Question 4 continued

Leave blank

5. A coastguard ship C is due south of a ship S. Ship S is moving at a constant speed of 12 km h^{-1} on a bearing of 140°. Ship C moves in a straight line with constant speed $V \text{ km h}^{-1}$ in order to intercept S.

(a) Find, giving your answer to 3 significant figures, the minimum possible value for V.

(3)

It is now given that $V = 14$

(b) Find the bearing of the course that C takes to intercept S.

(5)

Leave blank

Question 5 continued

Leave blank

6. A particle P of mass m kg is attached to the end A of a light elastic string AB, of natural length a metres and modulus of elasticity $9ma$ newtons. Initially the particle and the string lie at rest on a smooth horizontal plane with $AB = a$ metres. At time $t = 0$ the end B of the string is set in motion and moves at a constant speed U m s^{-1} in the direction AB. The air resistance acting on P has magnitude $6mv$ newtons, where v m s^{-1} is the speed of P. At time t seconds, the extension of the string is x metres and the displacement of P from its initial position is y metres.

Show that, while the string is taut,

(a) $x + y = Ut$

(2)

(b) $\dfrac{d^2x}{dt^2} + 6\dfrac{dx}{dt} + 9x = 6U$

(5)

You are given that the general solution of the differential equation in (b) is

$$x = (A + Bt)Ue^{-3t} + \frac{2U}{3}$$

where A and B are arbitrary constants.

(c) Find the value of A and the value of B.

(5)

(d) Find the speed of P at time t seconds.

(2)

Leave blank

Question 6 continued

P 4 1 8 1 9 A 0 2 1 2 8

Leave blank

7. [*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane*]

A small smooth ball of mass m kg is moving on a smooth horizontal plane and strikes a fixed smooth vertical wall. The plane and the wall intersect in a straight line which is parallel to the vector $2\mathbf{i} + \mathbf{j}$. The velocity of the ball immediately before the impact is $b\mathbf{i}$ m s^{-1}, where b is positive. The velocity of the ball immediately after the impact is $a(\mathbf{i} + \mathbf{j})$ m s^{-1}, where a is positive.

(a) Show that the impulse received by the ball when it strikes the wall is parallel to $(-\mathbf{i} + 2\mathbf{j})$.

(1)

Find

(b) the coefficient of restitution between the ball and the wall,

(8)

(c) the fraction of the kinetic energy of the ball that is lost due to the impact.

(3)

Leave blank

Question 7 continued