

Please write clearly in block capitals.			
Centre number		Candidate number	
Surname			
Forename(s)			
Candidate signature	·		

A-level MATHEMATICS

Unit Mechanics 5

Friday 16 June 2017

Afternoon

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

• the blue AQA 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.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box 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.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8 \text{ m s}^{-2}$, unless stated otherwise.

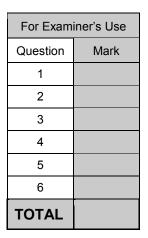
Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

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.	
	Answer each question in the space provided for that question.	
1	1 A simple pendulum consists of a light string of length 2.45 metres and a small spherical bob. The pendulum is released from rest with the string taut. When it is released, the	
	angle between the string and the vertical is $\frac{\pi}{10}$.	
(a)	Find the period of the motion of the pendulum.	[2 marks]
(b)	Find the average speed of the spherical bob during one complete oscillation.	[3 marks]
(c)	Find the angle between the string and the vertical when the speed of the sphe 1.2 m s^{-1} .	rical bob is
		[5 marks]
QUESTION PART REFERENCE	Answer space for question 1	



QUESTION PART REFERENCE	Answer space for question 1



The points A and B are on a vertical line and 2 metres apart, with A above B.

		Two identical elastic springs have natural length 0.5 metres and modulus of elasticity 49 N. One end of each spring is attached to a particle of mass 0.4 kg . The other ends of the springs are attached to the points <i>A</i> and <i>B</i> .
(a))	Find the distance of the particle from A when it is in equilibrium. [4 marks]
(b))	The particle is then pulled down below its equilibrium position and released. Show that the period of the subsequent motion is $\frac{\pi\sqrt{10}}{35}$ seconds.
		$\frac{35}{35}$ seconds. [5 marks]
(c))	Given that the particle is released from rest at a point 0.05 metres below the equilibrium point:
	(i)	find the maximum speed of the particle; [2 marks]
	(ii)	find the speed of the particle when it is midway between the equilibrium position and the point of release.
		[3 marks]
QUESTION PART REFERENCE	Ans	swer space for question 2



2

QUESTION PART	Answer space for question 2
REFERENCE	



QUESTION PART REFERENCE	Answer space for question 2
REFERENCE	



QUESTION PART	Answer space for question 2
REFERENCE	



3	A smooth wire is in the shape of the curve $y = 4 - x^2$. The wire is fixed in a vertical plane with the <i>y</i> -axis vertical. A small ring, of mass <i>m</i> , is threaded onto this wire elastic string has modulus of elasticity $4mg$ and natural length 1. One end of the fixed to the point with coordinates $(0, 0)$ and the other to the ring.	re. An
	Gravitational potential energy is taken to be zero at the level of the <i>x</i> -axis.	
(a)	Show that the total potential energy, V , of this system is given by	
	$V = mg\left(38 - 15x^2 + 2x^4 - 4\sqrt{16 - 7x^2 + x^4}\right)$	
	where <i>x</i> is the <i>x</i> -coordinate of the position of the ring.	[5 marks]
(b)	Find $\frac{\mathrm{d}V}{\mathrm{d}x}$ and show that the system has a position of equilibrium when $x = 2$.	[4 marks]
(c)	Determine the nature of this equilibrium position.	[3 marks]
QUESTION PART	Answer space for question 3	
REFERENCE		
I		



QUESTION PART REFERENCE	Answer space for question 3



4	A particle moves on a curve and at time <i>t</i> has polar coordinates (r, θ) , where <i>n</i> and $\theta = 2t$.	$r = \sin \theta$
(a)	Show that, when $r = 1$, the transverse component of the acceleration of the pazero.	rticle is [5 marks]
(b)) Find an expression for the times when the radial component of the acceleration	
(c)	Show that, when the radial component of the acceleration is zero, the transverse component of the velocity is also zero.	se [2 marks]
QUESTION PART REFERENCE	Answer space for question 4	



QUESTION PART	Answer space for question 4
REFERENCE	



5 A particle, of mass m kg, is attached to one end of an elastic string which has modulus of elasticity 2.5m newtons. The natural length of the string is 0.5 metres. The other end of the string is attached to a fixed point O.

There is a container of fluid below O, where the surface of the fluid is 0.5 metres below O. The particle is released from rest at a point vertically below O, on the surface of the fluid. As it moves through the fluid, the particle experiences a resistance force of magnitude 2mv newtons, where v is the speed of the particle.

At time *t* seconds after the particle is released from rest, the displacement of the particle below the surface of the fluid is *x* metres.

Find the maximum length of the elastic string during the subsequent motion.

[15 marks]

	• •
QUESTION	Answer space for question 5
QUESTION PART REFERENCE	



QUESTION PART REFERENCE	Answer space for question 5
REFERENCE	



QUESTION PART REFERENCE	Answer space for question 5
REFERENCE	



QUESTION PART REFERENCE	Answer space for question 5
REFERENCE	



IB/G/Jun17/MM05

A spacecraft is descending towards the surface of a planet and fires its rockets to prepare for landing. The initial mass of the spacecraft, including fuel, is M kg and 10% of this is fuel. The fuel is expelled at a rate of $\lambda \text{ kg s}^{-1}$ and at a speed of $U \text{ m s}^{-1}$ relative to the spacecraft.

All the motion takes place near to the surface of the planet and the acceleration due to gravity on the planet is a constant $g \text{ m s}^{-2}$ throughout the motion. When the rockets are fired, the speed of the space craft is $\frac{U}{20} \text{ m s}^{-1}$. At time *t* seconds after the rockets start to fire, the velocity of the space craft is $v \text{ m s}^{-1}$.

Assume that no air-resistance forces act on the spacecraft as it moves.

(a) Show that

6

$$\frac{\mathrm{d}v}{\mathrm{d}t} = g - \frac{\lambda U}{M - \lambda t}$$

[5 marks]

(b) Given that the spacecraft slows down at the time that the rockets are fired, show that

$$U > \frac{Mg}{\lambda}$$

[3 marks]

(c) Given that $U = \frac{3Mg}{2\lambda}$, find the speed of the spacecraft when all the fuel has been used up, giving your answer in terms of g, M and λ .

[5 marks]

QUESTION PART	Answer space for question 6
REFERENCE	



QUESTION PART REFERENCE	Answer space for question 6
REFERENCE	

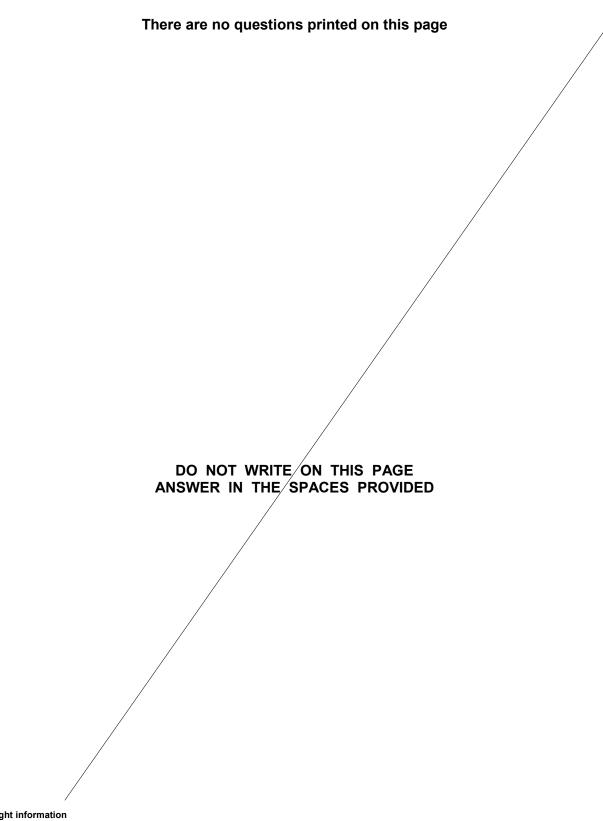


QUESTION PART	Answer space for question 6
REFERENCE	





QUESTION	Anower encode for question 6	
PART REFERENCE	Answer space for question 6	
	END OF QUESTIONS	



Copyright information

For confidentiality purposes, from the November 2015 examination series, acknowledgements of third party copyright material will be published in a separate booklet rather than including them on the examination paper or support materials. This booklet is published after each examination series and is available for free download from www.aqa.org.uk after the live examination series.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team, AQA, Stag Hill House, Guildford, GU2 7XJ.

Copyright © 2017 AQA and its licensors. All rights reserved.

