Mechanics 1

Advanced Subsidiary

Challenge Paper 1

April 2016

Time allowed: 1 hour 30 minutes

Candidates may use any calculator EXCEPT those with the facility for symbolic algebra, differentiation and/or integration.

Information to candidates:

- This paper is based on the Edexcel syllabus for the Mechanics 1 module.
- This paper is scored out of 75 marks.
- You have 1 hour and 30 minutes to complete this paper.
- Answer all questions in the spaces provided.
- No mathematical formulae are provided for this examination.
- None of the diagrams in this document are to scale.
- There are 7 questions on this paper.
- This document consists of 23 pages.

For examiner's use only

Question	Marks	Total Marks
1		7
2		11
3		11
4		11
5		13
6		10
7		12
Total		75

1) A train of mass 120000kg travels with a velocity of $1ms^{-1}$ along a smooth track and collides with a carriage of mass $d$kg that travels with a velocity of $0.1ms^{-1}$. As a result of the collision the train and the carriage coalesce and travel with a velocity of $0.64ms^{-1}$.

a) Define the term coalesce.

[1]

b) Show that $d = 80000$

[3]

c) The train and the carriage now collide with a stationary carriage of mass 56000kg and coalesce with it. Find the velocity of the train after the collision.

[3]

[Q1: 7 marks]

2) A ball is projected vertically upwards from the ground at a speed of $u$ms^{-1}. At the same time a second ball is dropped from 40m above the ground. They collide after T seconds at a height S. Just before the collision both balls are travelling at the same speed.

a) Show that $T = \frac{10}{7}$

[6]

b) Hence find values for

i) The speed of projection of the first ball.

[2]

ii) The height at which the balls collide.

[2]

c) State a modelling assumption that you have made.

[1]

[Q2: 11 marks]

3) A ship sets sail from a port at 1200hrs and has a position vector r, measured in km, after t hours, relative to a fixed origin, of

$$r = (2t - 1)i + (8 - 3t)j$$

a) State the ship's initial position vector.

[1]

b) Find the speed of the ship.

[2]

c) At 1300hrs the ship is 5km from a lighthouse and at 1400hrs the lighthouse is northeast of the ship.

i) Find the position vector of the lighthouse.

[6]

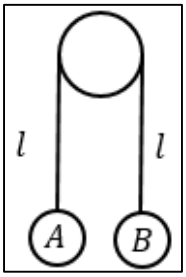
ii) Find the distance of the ship from the lighthouse at 1400hrs.

[2]

[Q3: 11 marks]

4) Two masses A and B are connected by a light, inextensible string. The string is of length $2l$ metres and the string is put over a smooth pulley so A and B hang vertically downwards, with each of them l metres from the pulley. The system is suspended such that the pulley is $1.5l$ metres above the ground. B has a mass of $2m$, which is twice the mass of A. The system is then released from rest.

You may assume that the length of the string around the pulley is negligible in comparison to the length of the string.



a) Show that the acceleration of the system is $\frac{1}{3}g$

[3]

b) Find the velocity of system at the instance that B hits the ground in terms of l and g.

[3]

c) Given that the highest height that A reaches is 1.4m above the ground. Find the length of the string.

[5]

[Q4: 11 marks]

5) A recovery vehicle is towing a car up a road that is inclined at α to the horizontal, where $\sin\alpha = \frac{1}{40}$. The recovery vehicle is of mass 2000kg and the car is of mass 800kg. The car is towed using a light, inextensible cable. The resistance due to non-gravitational forces is 350N for the car and 400N for the recovery vehicle. The recovery vehicle tows the car at a constant speed of $7.18ms^{-1}$.

a) Find the driving force produced by the recovery vehicle.

[3]

b) Find the tension in the cable.

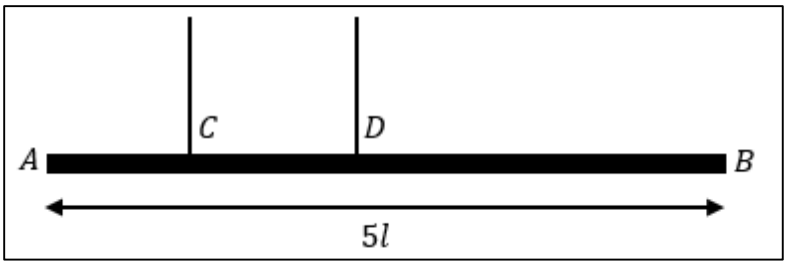
[5]

c) The recovery driver then turns off the engine of the recovery vehicle. Given that the resistance to motion of non-gravitational forces remains the same, find how far the recovery vehicle and the car travel up the road before coming to a rest.

[5]

[Q5: 13 marks]

6) A smooth, non-uniform rod AB of length $5l$ and mass $2m$ is supported by two light, inextensible cables at the points C and D, where $AC = l$ and $BD = 3l$.



a) When no other forces act on the rod, the tension in the cable at C is twice that of the cable at D.

i) Find the tension in the cable at D in terms of m.

[1]

ii) Hence find the distance of the centre of mass of the rod from A in terms of l.

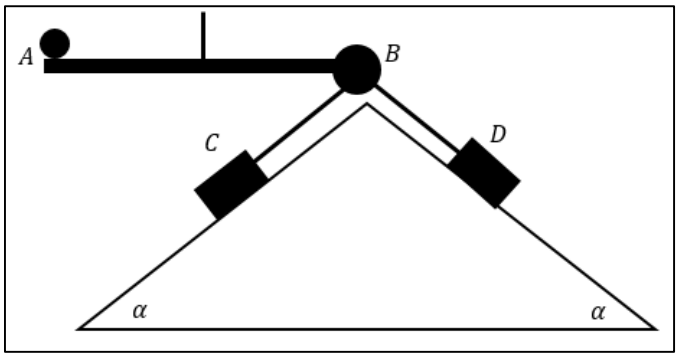
[4]

b) A ball of mass m now is rolled along the rod from A with velocity $\frac{1}{3}l\text{s}^{-1}$. Find the time at which the rod begins to tilt about D.

[5]

[Q6: 10 marks]

7) A uniform rod AB has a pulley attached to it at B and a ball of mass m on it at A. The rod is held in position by a light, inextensible string that attached at the rod's centre of mass. The pulley is smooth and is used to connect blocks C and D. Block C is of mass 6kg and block D is of mass 1kg and they are on separate sides of a rough isosceles triangle with base angles α. Both blocks have a coefficient of friction of 0.5 with their respective planes and $\sin\alpha = \frac{3}{4}$.



The rod remains horizontal when the system is released from rest.

a) Find tension in the string that connects the blocks.

[6]

b) Find the force exerted on the pulley by the string.

[4]

c) Hence find the value of m.

[2]

[Q7: 12 marks]

END OF QUESTIONS

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