Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	6	7	7	/	0	1	Signature	

Paper Reference(s)

6677/01

Examiner's use only

Team Leader's use only

Edexcel GCE

Mechanics M1

Advanced/Advanced Subsidiary

Monday 24 May 2010 – Afternoon

Time: 1 hour 30 minutes

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
8	
Total	

Materials required for examination
Mathematical Formulae (Pink)

Items included with question papers
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, differentiation and 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 8 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.

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Turn over

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1. A particle P is moving with constant velocity $(-3\mathbf{i}+2\mathbf{j})\ \text{m s}^{-1}$. At time $t=6$ s P is at the point with position vector $(-4\mathbf{i}-7\mathbf{j})$ m. Find the distance of P from the origin at time $t=2$ s.

(5)

1/ $r = r_0 + vt$

$r = (-4i - 7j) - 4(-3i + 2j)$

$= -4i - 7j + 12i - 8j$

$= 8i - 15j$

distance $= \sqrt{8^2 + 15^2}$

$= 17$ m

Leave blank

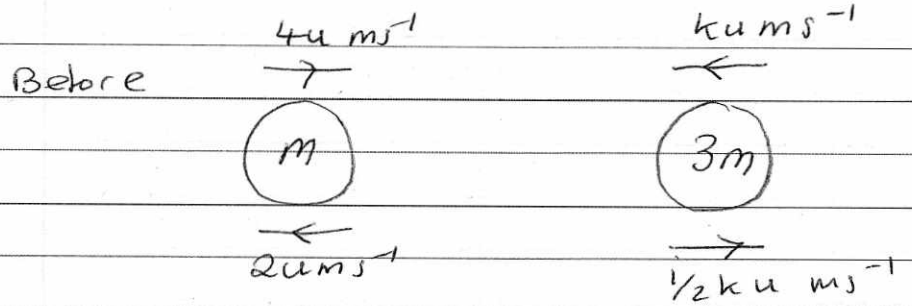
2. Particle P has mass m kg and particle Q has mass $3m$ kg. The particles are moving in opposite directions along a smooth horizontal plane when they collide directly. Immediately before the collision P has speed $4u$ m s^{-1} and Q has speed ku m s^{-1}, where k is a constant. As a result of the collision the direction of motion of each particle is reversed and the speed of each particle is halved.

(a) Find the value of k.

(4)

(b) Find, in terms of m and u, the magnitude of the impulse exerted on P by Q.

(3)



$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$m(4u) + 3m(-ku) = m(-2u) + 3m(\tfrac{1}{2}ku)$$

$$4m - 3km = -2m + \tfrac{3}{2}km$$

$$4 - 3k = -2 + \tfrac{3}{2}k$$

$$6 = \tfrac{9}{2}k$$

$$k = \frac{4}{3}$$

b/

$$I = |mv - mu|$$
$$= |m(-2u) - m(4u)|$$
$$= |-2mu - 4mu|$$
$$= |-6mu|$$
$$= 6mu$$

Leave blank

3.

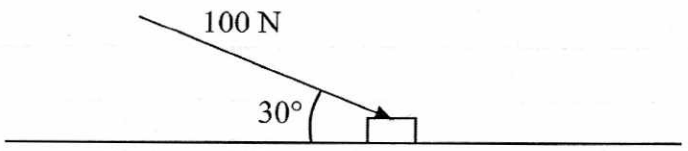
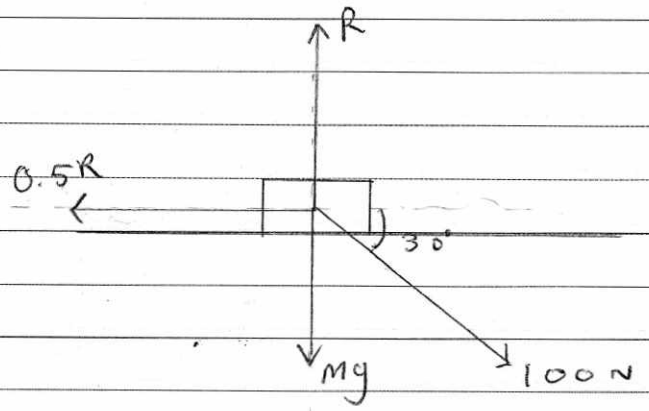


Figure 1

A small box is pushed along a floor. The floor is modelled as a rough horizontal plane and the box is modelled as a particle. The coefficient of friction between the box and the floor is $\frac{1}{2}$. The box is pushed by a force of magnitude 100 N which acts at an angle of 30° with the floor, as shown in Figure 1.

Given that the box moves with constant speed, find the mass of the box.

(7)



Resolving ↑ :

$R = 100 \sin 30 + mg$

$= 50 + mg$

constant speed so no acceleration.

Resolving → :

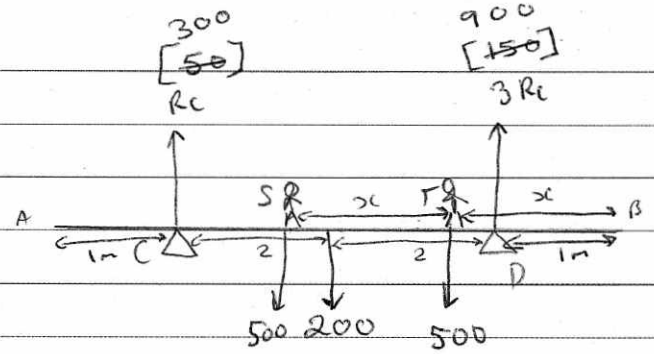
$100 \cos 30 = 0.5(50 + mg)$

$m = 12.6$ kg (3SF)

Leave blank

4. A beam AB has length 6 m and weight 200 N. The beam rests in a horizontal position on two supports at the points C and D, where $AC = 1$ m and $DB = 1$ m. Two children, Sophie and Tom, each of weight 500 N, stand on the beam with Sophie standing twice as far from the end B as Tom. The beam remains horizontal and in equilibrium and the magnitude of the reaction at D is three times the magnitude of the reaction at C. By modelling the beam as a uniform rod and the two children as particles, find how far Tom is standing from the end B.

(7)



$4R_c = 1200$

$R_c = 300$

Taking moments about B:

$1(900) + 5(300) = x(500) + 2x(500) + 3(200)$

$900 + 1500 = 500x + 1000x + 600$

$1800 = 1500x$

$x = \frac{18}{15} = \frac{6}{5}$ m

$= 1.2$ m

Leave blank

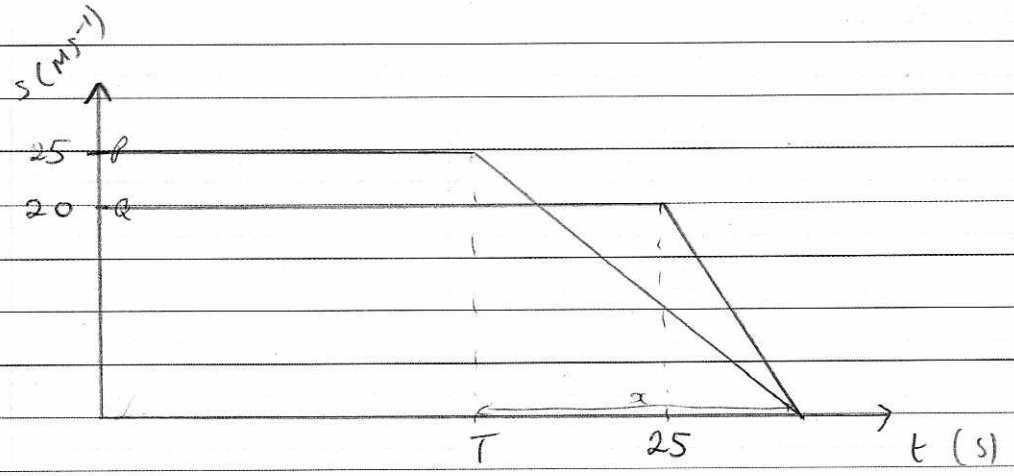
5. Two cars P and Q are moving in the same direction along the same straight horizontal road. Car P is moving with constant speed $25\ \text{m s}^{-1}$. At time $t = 0$, P overtakes Q which is moving with constant speed $20\ \text{m s}^{-1}$. From $t = T$ seconds, P decelerates uniformly, coming to rest at a point X which is $800\ \text{m}$ from the point where P overtook Q. From $t = 25\ \text{s}$, Q decelerates uniformly, coming to rest at the same point X at the same instant as P.

(a) Sketch, on the same axes, the speed-time graphs of the two cars for the period from $t = 0$ to the time when they both come to rest at the point X.

(4)

(b) Find the value of T.

(8)



b) distance = 800 m

P: $25T + \frac{1}{2}25x = 800$ (1)

Q: $20(25) + \frac{1}{2}20(T + x - 25) = 800$

$500 + 10T + 10x - 250 = 800$

$10T + 10x = 550$

$T + x = 55$

(1) $2T + x = 64$

$T = 9$

Leave blank

6. A ball is projected vertically upwards with a speed of $14.7\ \text{m s}^{-1}$ from a point which is 49 m above horizontal ground. Modelling the ball as a particle moving freely under gravity, find

(a) the greatest height, above the ground, reached by the ball,

(4)

(b) the speed with which the ball first strikes the ground,

(3)

(c) the total time from when the ball is projected to when it first strikes the ground.

(3)

$s = ?$
$u = 14.7$
$v = 0$
$a = -9.8$
t

a/ $v^2 = u^2 + 2as$
$0 = (14.7)^2 + 2(-9.8)s$
$s = 11.0$ (3sf)

$11.0 + 49 = 60.0\ \text{m}$ 3sf

b/ $s = -60$
$u = 0$
$v = ?$
$a = -9.8$
$t =$

$v^2 = u^2 + 2as$
$v^2 = 2(-9.8)(-60)$
$v = 34.3\ \text{ms}^{-1}$ (3sf)

Leave blank

Question 6 continued

e/ $s = -49$

$u = 14.7$

$v = -34.3$

$a = -9.8$

$t = ?$

$v = u + at$

$-34.3 = 14.7 - 9.8t$

$t = 5$ seconds

Leave blank

7.

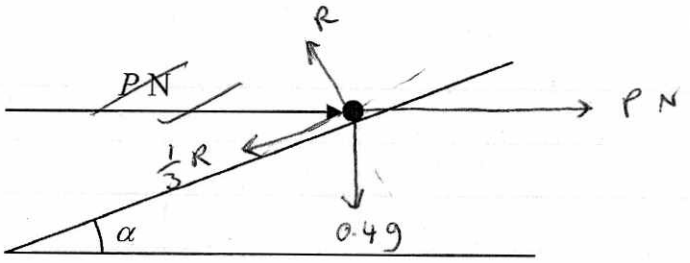


Figure 2

A particle of mass 0.4 kg is held at rest on a fixed rough plane by a horizontal force of magnitude P newtons. The force acts in the vertical plane containing the line of greatest slope of the inclined plane which passes through the particle. The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$, as shown in Figure 2.

The coefficient of friction between the particle and the plane is $\frac{1}{3}$.

Given that the particle is on the point of sliding up the plane, find

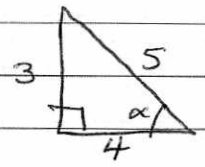
(a) the magnitude of the normal reaction between the particle and the plane,

(5)

(b) the value of P.

(5)

$\tan\alpha = \frac{3}{4}$



$\cos\alpha = 4/5$

$\sin\alpha = 3/5$

resolving ↑

$R = 0.4g\cos\alpha + P\sin\alpha$

$= \frac{8}{25}g + \frac{3}{5}P$

resolving ↗

$P\cos\alpha = 0.4g\sin\alpha + \frac{1}{3}R$

$\frac{4}{5}P = \frac{6}{25}g + \frac{1}{3}\left(\frac{8}{25}g + \frac{3}{5}P\right)$

$\frac{4}{5}P = \frac{6}{25}g + \frac{8}{75}g + \frac{3}{15}P$

$\frac{3}{5}P = \frac{1274}{375}$

$P = 5.66$ N (3sf)

Leave blank

Question 7 continued

$$R = \frac{8}{25}g + \frac{3}{5}(5.66)$$

$$= 6.53 \text{ N } (3\text{sf})$$

Leave blank

8.

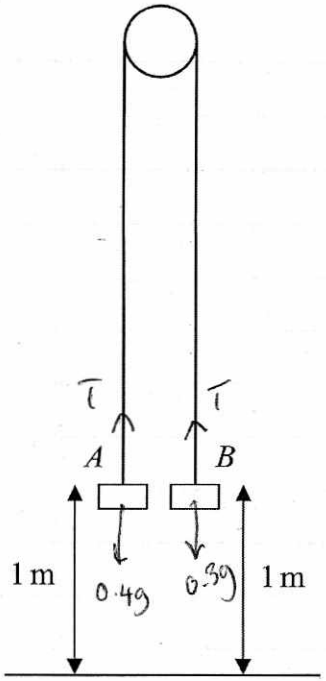


Figure 3

Two particles A and B have mass 0.4 kg and 0.3 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed above a horizontal floor. Both particles are held, with the string taut, at a height of 1 m above the floor, as shown in Figure 3. The particles are released from rest and in the subsequent motion B does not reach the pulley.

(a) Find the tension in the string immediately after the particles are released.

(6)

(b) Find the acceleration of A immediately after the particles are released.

(2)

When the particles have been moving for 0.5 s, the string breaks.

(c) Find the further time that elapses until B hits the floor.

(9)

a) $0.4g - T = 0.4a$ (1)

$T - 0.3g = 0.3a$ (2)

$1.2g - 3T = 1.2a$ (1) × 3

$4T - 1.2g = 1.2a$ (2) × 4

(1) − (2) $2.4g - 7T = 0$

$7T = 2.4g$

$T = 3.36$ N

Question 8 continued

$T - 0.3g = 0.3a$

$3.36 - 0.3g = 0.3a$

$a = 1.4\ ms^{-2}$

c) until string breaks

$s =$

$u = 0$

$v = ?$

$a = 1.4$

$t = 0.5$

$v = u + at$

$= 1.4 \times 0.5$

$= 0.7$

$s = ut + \frac{1}{2}at^2$

$s = \frac{1}{2}(1.4)(0.5)^2$

$= 0.175$

after string breaks

~~$v =$~~ $s = -1.175$

~~$a =$~~ $u = 0.7$

~~$a =$~~ $v =$

$a = -9.8$

$t = ?$

$s = ut + \frac{1}{2}at^2$

$-1.175 = 0.7t + \frac{1}{2}(-9.8)t^2$

$4.9t^2 - 0.7t - 1.175 = 0$

$a = 4.9$

$b = -0.7$

$c = -1.175$

~~$x =$~~ $t = \frac{-(-0.7) \pm \sqrt{(-0.7)^2 - 4(4.9)(-1.175)}}{2(4.9)}$

$t = 0.566$ or $t = -0.423$

$t = 0.566$ seconds 3sf