| Centre No. | | | | | | Paper Reference | | | | | | Surname | | Initial(s) |

Paper Reference

6 6 7 7 / 0 1

Candidate No.

Signature

Edexcel GCE

Mechanics M1

Advanced/Advanced Subsidiary

Monday 13 May 2013 – Afternoon

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	
8	

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 differentiation/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.

| Total | |

Turn over

P 4 1 8 2 8 A 0 1 2 8

PEARSON

1. Particle *P* has mass 3 kg and particle *Q* has mass *m* kg. The particles are moving in opposite directions along a smooth horizontal plane when they collide directly. Immediately before the collision, the speed of *P* is 4 m s^{-1} and the speed of *Q* is 3 m s^{-1}. In the collision the direction of motion of *P* is unchanged and the direction of motion of *Q* is reversed. Immediately after the collision, the speed of *P* is 1 m s^{-1} and the speed of *Q* is 1.5 m s^{-1}.

   (a) Find the magnitude of the impulse exerted on *P* in the collision.

   (3)

   (b) Find the value of *m*.

   (3)

4 ms^{-1} 3 ms^{-1}

P (3 kg)   *Q* (m kg)

1 ms^{-1} 1.5 ms^{-1}

a/ $I = mv - mu$

$= |(3)(1) - 3(4)|$

$= 9$ Ns
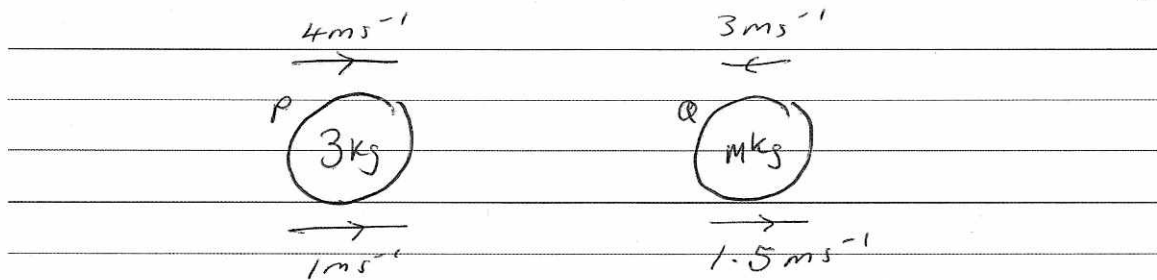
b/ $M_1 U_1 + M_2 U_2 = M_1 V_1 + M_2 V_2$

$3(4) + m(-3) = 3(1) + m(1.5)$

$12 - 3m = 3 + 1.5m$

$9 = 4.5m$

$m = 2$

2. A woman travels in a lift. The mass of the woman is 50 kg and the mass of the lift is 950 kg. The lift is being raised vertically by a vertical cable which is attached to the top of the lift. The lift is moving upwards and has constant deceleration of 2 m s^{-2}. By modelling the cable as being light and inextensible, find

(a) the tension in the cable,

(3)

(b) the magnitude of the force exerted on the woman by the floor of the lift.

(3)
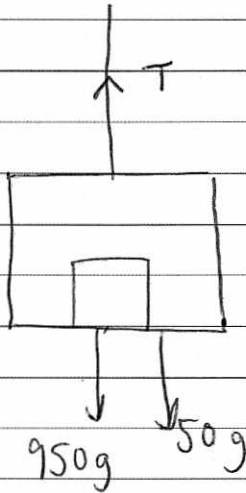
$$a = -2$$

whole system:

$$F = ma$$
$$T - 1000g = 1000(-2)$$
$$T = -2000 + 1000g$$
$$= 7800 \text{ N}$$

b/ woman:

$$F = ma$$
$$R - 50g = 50(-2)$$
$$R = -100 + 50g$$
$$= 390 \text{ N}$$

3.
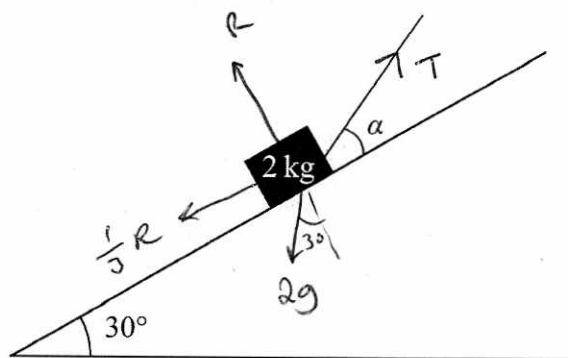
Figure 1

A box of mass 2 kg is held in equilibrium on a fixed rough inclined plane by a rope. The rope lies in a vertical plane containing a line of greatest slope of the inclined plane. The rope is inclined to the plane at an angle α, where $\tan \alpha = \frac{3}{4}$, and the plane is at an angle of $30°$ to the horizontal, as shown in Figure 1. The coefficient of friction between the box and the inclined plane is $\frac{1}{3}$ and the box is on the point of slipping up the plane. By modelling the box as a particle and the rope as a light inextensible string, find the tension in the rope.

(8)

Resolving ↑

$$R + T \sin \alpha = 2g \cos 30$$
$$R + \frac{3}{5} T = 2g \cos 30$$

$$\tan \alpha = \frac{3}{4}$$
$$\cos \alpha = \frac{4}{5}$$
$$\sin \alpha = \frac{3}{5}$$

$$R + \frac{3}{5} T = \sqrt{3} \, g$$
$$R = \sqrt{3} g - \frac{3}{5} T$$

Resolving ↗

$$T \cos \alpha = 2g \sin 30 + \frac{1}{3} R$$
$$\frac{4}{5} T = g + \frac{1}{3} R$$

$$\frac{4}{5} T - g = \frac{1}{3} R$$

$$\frac{12}{5} T - 3g = R$$

$$\frac{12}{5} T - 3g = \sqrt{3} \, g - \frac{3}{5} T$$

$$3T = \sqrt{3} g + 3g$$
$$T = 15.5 \quad N \quad (3sf)$$

6

4. A lorry is moving along a straight horizontal road with constant acceleration. The lorry passes a point A with speed u m s^{-1}, $(u < 34)$, and 10 seconds later passes a point B with speed 34 m s^{-1}. Given that $AB = 240$ m, find

(a) the value of u,

(3)

(b) the time taken for the lorry to move from A to the mid-point of AB.

(6)

$s = 240$

$u = u$

$v = 34$

a

$t = 10$

$$S = \left(\frac{u+v}{2}\right) t$$

$$240 = \left(\frac{u+34}{2}\right) 10$$

$$48 = u + 34$$

$$u = 14$$

b/ $s = 120$

$u = 14$

$v =$

$a = 2$

$t = ?$

Original Motion

$A \rightarrow B$

$v = u + at$

$34 = 14 + a(10)$

$20 = 10a$

$a = 2$

$$S = ut + \tfrac{1}{2}at^2$$

$$120 = 14t + \tfrac{1}{2}(2)t^2$$

$$120 = 14t + t^2$$

$$t^2 + 14t - 120 = 0$$

$$(t + 20)(t - 6) = 0$$

$$t = -20 \qquad t = 6$$

6 seconds

5. A car is travelling along a straight horizontal road. The car takes 120 s to travel between
    two sets of traffic lights which are 2145 m apart. The car starts from rest at the first set of
    traffic lights and moves with constant acceleration for 30 s until its speed is 22 m s⁻¹. The
    car maintains this speed for T seconds. The car then moves with constant deceleration,
    coming to rest at the second set of traffic lights.

    (a) Sketch, in the space below, a speed-time graph for the motion of the car between the
        two sets of traffic lights.
                                                                                            (2)

    (b) Find the value of T.
                                                                                            (3)

    A motorcycle leaves the first set of traffic lights 10 s after the car has left the first set of
    traffic lights. The motorcycle moves from rest with constant acceleration, a m s⁻², and
    passes the car at the point A which is 990 m from the first set of traffic lights. When the
    motorcycle passes the car, the car is moving with speed 22 m s⁻¹.

    (c) Find the time it takes for the motorcycle to move from the first set of traffic lights to
        the point A.
                                                                                            (4)

    (d) Find the value of a.
                                                                                            (2)
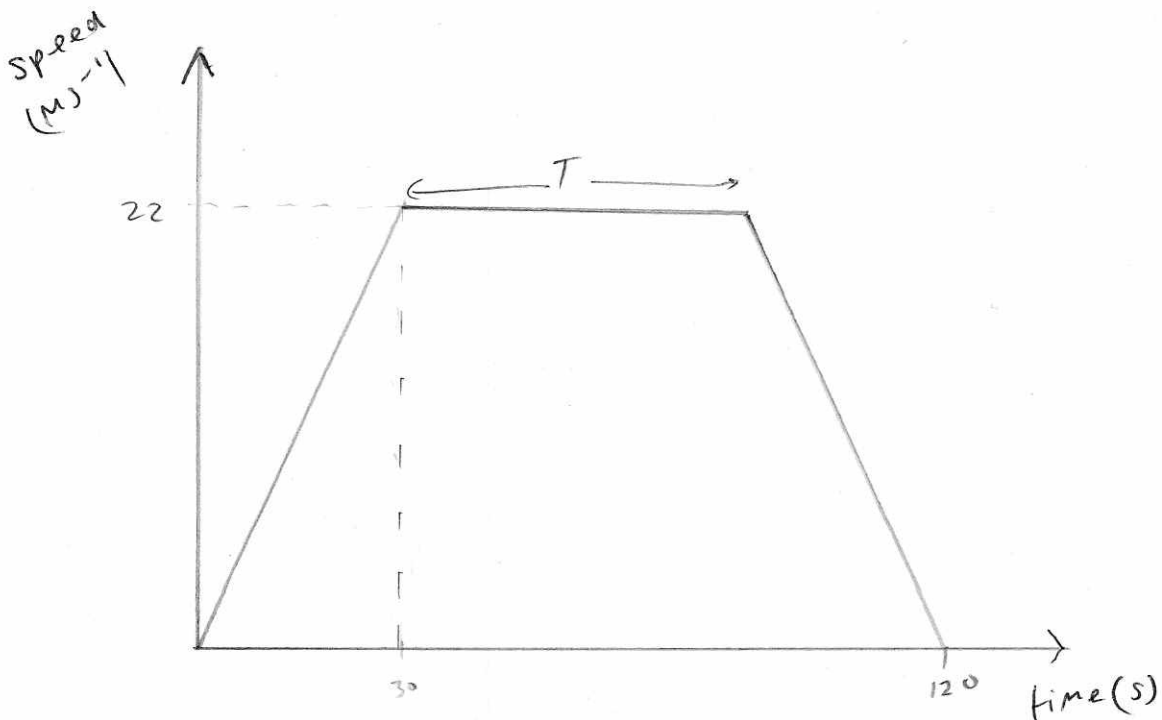
Question 5 continued

b/ $\dfrac{120 + T}{2}(22) = 2145$

$\qquad$ $120 + T = 195$

$\qquad$ $T = \underline{75 \text{ seconds}}$

c/
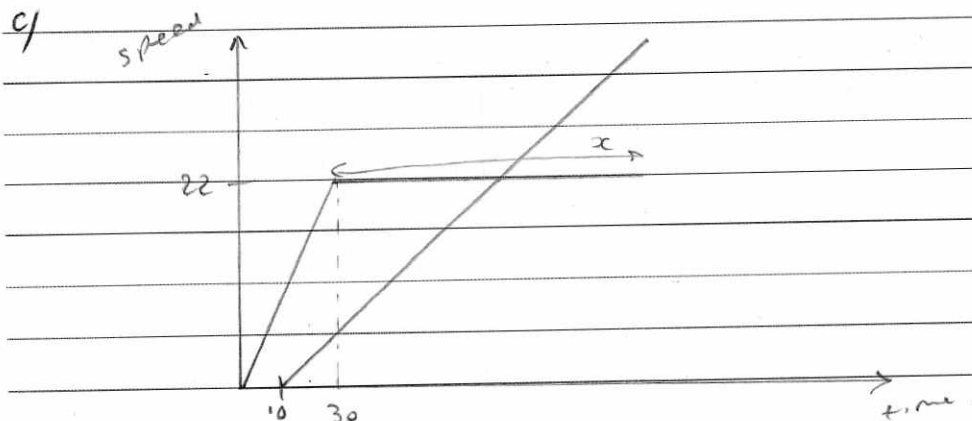
Car: $\dfrac{x + x + 30}{2}(22) = 990$

$\qquad$ $2x + 30 = 90$

$\qquad$ $2x = 60$

$\qquad$ $x = 30$

$30 + 20 = \underline{50 \text{ seconds}}$

d/ $s = 990$
$u = 0$ $\qquad$ $s = ut + \frac{1}{2}at^2$
$v =$ $\qquad$ $990 = 0(50) + \frac{1}{2}a(50)^2$
$a =$ $\qquad$ $990 = 1250\,a$
$t = 50$ $\qquad$ $a = \dfrac{990}{1250}$

$\qquad\qquad\qquad = 0.792 \text{ ms}^{-2}$

6. A beam AB has length 15 m. The beam rests horizontally in equilibrium on two smooth supports at the points P and Q, where $AP = 2$ m and $QB = 3$ m. When a child of mass 50 kg stands on the beam at A, the beam remains in equilibrium and is on the point of tilting about P. When the same child of mass 50 kg stands on the beam at B, the beam remains in equilibrium and is on the point of tilting about Q. The child is modelled as a particle and the beam is modelled as a non-uniform rod.

(a) (i) Find the mass of the beam.

   (ii) Find the distance of the centre of mass of the beam from A.

(8)

When the child stands at the point X on the beam, it remains horizontal and in equilibrium. Given that the reactions at the two supports are equal in magnitude,

(b) find AX.

(6)
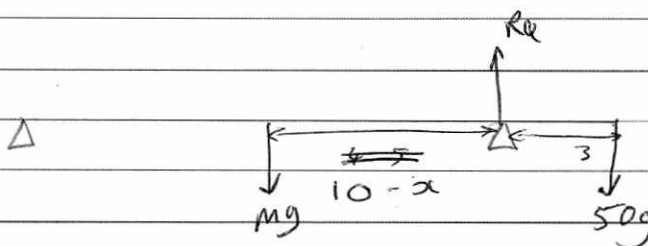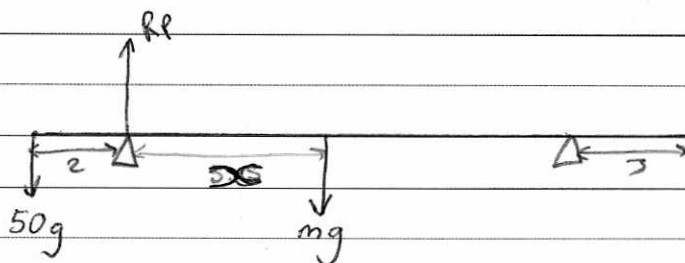
Child at A:

Taking moments about P:

$$5.5mg = 100g$$
$$5.5m = 100$$
$$m = 200$$

$$xmg = 100g$$
$$xm = 100$$

Child at B:

Taking moments about Q:

$$3(50g) = (10-x)mg$$
$$150g = 10mg - xmg$$
$$150 = 10m - xm$$

Question 6 continued

$$xm = 100$$

$$x = \frac{100}{m}$$

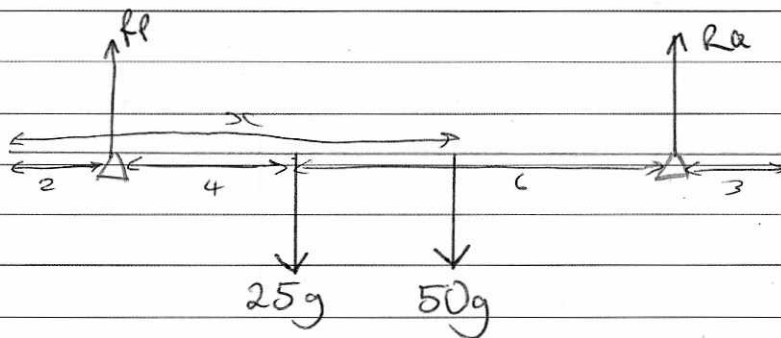$$150 = 10m - m\left(\frac{100}{m}\right)$$

$$150 = 10m - 100$$

$$250 = 10m$$

$$m = 25 \, kg$$

$$x = \frac{100}{25}$$

$$= 4$$

Distance from A: $2 + 4 = \underline{6 \, m}$

b)

Forces up = Forces down

$$2R = 75g$$

$$R = 37.5g$$

Taking moments about A:

$$6(25g) + x(50g) = 2(37.5g) + 12(37.5g)$$

$$150g + x(50g) = 525g$$

$$x(50g) = 375g$$

$$x = \underline{7.5 \, m}$$

7. *[In this question, the horizontal unit vectors **i** and **j** are directed due east and due north respectively.]*

The velocity, **v** m s⁻¹, of a particle P at time t seconds is given by

$$\mathbf{v} = (1 - 2t)\mathbf{i} + (3t - 3)\mathbf{j}$$

(a) Find the speed of P when $t = 0$

(3)

(b) Find the bearing on which P is moving when $t = 2$

(2)

(c) Find the value of t when P is moving

(i) parallel to **j**,

(ii) parallel to $(-\mathbf{i} - 3\mathbf{j})$.

(6)

a) $v = (1 - 2(0))i + (3(0) - 3)j$

$= i - 3j$

$speed = \sqrt{1^2 + 3^2}$

$= \sqrt{10} \text{ ms}^{-1}$

b) when $t = 2$

$v = (1 - 2(2))i + (3(2) - 3)j$

$= -3i + 3j$
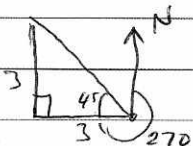
$270 + 45 = 315°$

c) i) parallel to j ∴ $i = 0$

$1 - 2t = 0$

$t = 0.5 \text{ seconds}$

Question 7 continued

ii/ iii/ $1 - 2t = x \; (-1)$ ①

iii/ $3t - 3 = x \, (-3)$ ②

$$1 - 2t = -x \qquad ①$$
$$x = 2t - 1$$

① into ②

$$3t - 3 = -3(2t - 1)$$
$$3t - 3 = -6t + 3$$
$$9t = 6$$
$$t = \tfrac{2}{3} \text{ seconds}$$
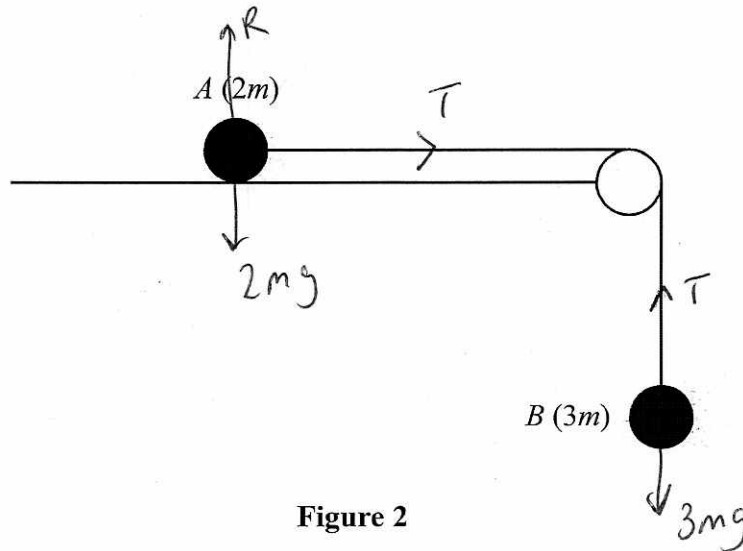
8.

Figure 2

Two particles A and B have masses $2m$ and $3m$ respectively. The particles are attached to the ends of a light inextensible string. Particle A is held at rest on a smooth horizontal table. The string passes over a small smooth pulley which is fixed at the edge of the table. Particle B hangs at rest vertically below the pulley with the string taut, as shown in Figure 2. Particle A is released from rest. Assuming that A has not reached the pulley, find

(a) the acceleration of B,

(5)

(b) the tension in the string,

(1)

(c) the magnitude and direction of the force exerted on the pulley by the string.

(4)

$$F = ma$$

a/ A: $T = 2ma$

B: $3mg - T = 3ma$

$$T = 3mg - 3ma$$

$$2ma = 3mg - 3ma$$
$$2a = 3g - 3a$$
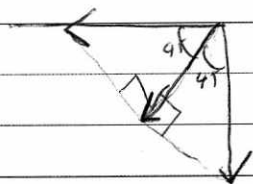$$5a = 3g$$

$$a = \frac{3}{5}g \quad ms^{-2}$$

b/ $T = 2m\left(\frac{3}{5}g\right)$

$$= \frac{6}{5}mg \quad ms^{-2}$$

c/

$$F = 2T \cos 45$$

$$= 2\left(\frac{6}{5} mg\right) \cos 45$$

$$= \frac{6}{5} \sqrt{2} \, mg \quad N \qquad 16.6 \, m \quad (3sf)$$

at a $45°$ Angle