

Paper Reference(s)

**6677**

# **Edexcel GCE**

## **Mechanics M1**

### **Advanced Subsidiary**

**Wednesday 23 January 2013 – Morning**

**Time: 1 hour 30 minutes**

**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 formulas stored in them.**

#### **Instructions to Candidates**

---

In the boxes on the answer book, write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M1), the paper reference (6677), your surname, other name and signature.

Whenever a numerical value of  $g$  is required, take  $g = 9.8 \text{ m s}^{-2}$ .

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.

There are 7 questions in this question paper.

The total mark for this paper is 75.

#### **Advice to Candidates**

---

You must ensure that your answers to parts of questions are clearly labelled.

You must show sufficient working to make your methods clear to the Examiner.

Answers without working may not gain full credit.

1. Two particles  $P$  and  $Q$  have masses  $4m$  and  $m$  respectively. The particles are moving towards each other on a smooth horizontal plane and collide directly. The speeds of  $P$  and  $Q$  immediately before the collision are  $2u$  and  $5u$  respectively. Immediately after the collision, the speed of  $P$  is  $\frac{1}{2}u$  and its direction of motion is reversed.

(a) Find the speed and direction of motion of  $Q$  after the collision.

(4)

(b) Find the magnitude of the impulse exerted on  $P$  by  $Q$  in the collision.

(3)

2. A steel girder  $AB$ , of mass  $200$  kg and length  $12$  m, rests horizontally in equilibrium on two smooth supports at  $C$  and at  $D$ , where  $AC = 2$  m and  $DB = 2$  m. A man of mass  $80$  kg stands on the girder at the point  $P$ , where  $AP = 4$  m, as shown in Figure 1.

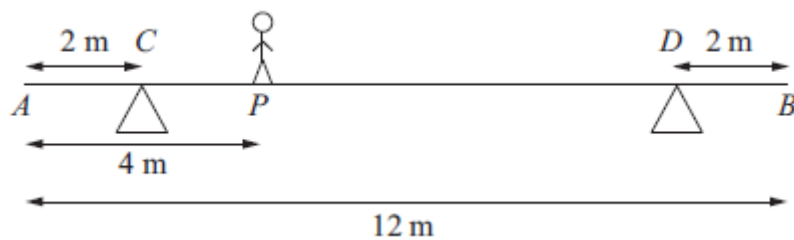


Figure 1

The man is modelled as a particle and the girder is modelled as a uniform rod.

(a) Find the magnitude of the reaction on the girder at the support at  $C$ .

(3)

The support at  $D$  is now moved to the point  $X$  on the girder, where  $XB = x$  metres. The man remains on the girder at  $P$ , as shown in Figure 2.

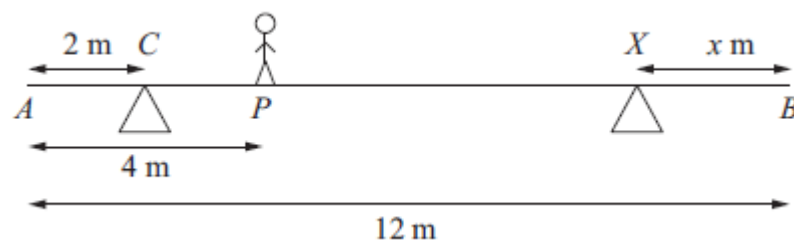


Figure 2

Given that the magnitudes of the reactions at the two supports are now equal and that the girder again rests horizontally in equilibrium, find

(b) the magnitude of the reaction at the support at  $X$ ,

(2)

(c) the value of  $x$ .

(4)

3. A particle  $P$  of mass 2 kg is attached to one end of a light string, the other end of which is attached to a fixed point  $O$ . The particle is held in equilibrium, with  $OP$  at  $30^\circ$  to the downward vertical, by a force of magnitude  $F$  newtons. The force acts in the same vertical plane as the string and acts at an angle of  $30^\circ$  to the horizontal, as shown in Figure 3.

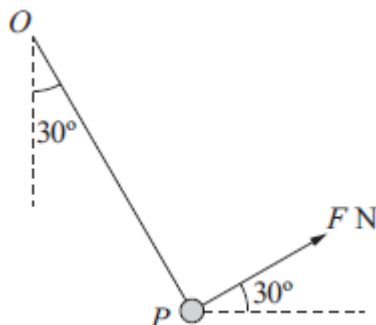


Figure 3

Find

- (i) the value of  $F$ ,
- (ii) the tension in the string.

(8)

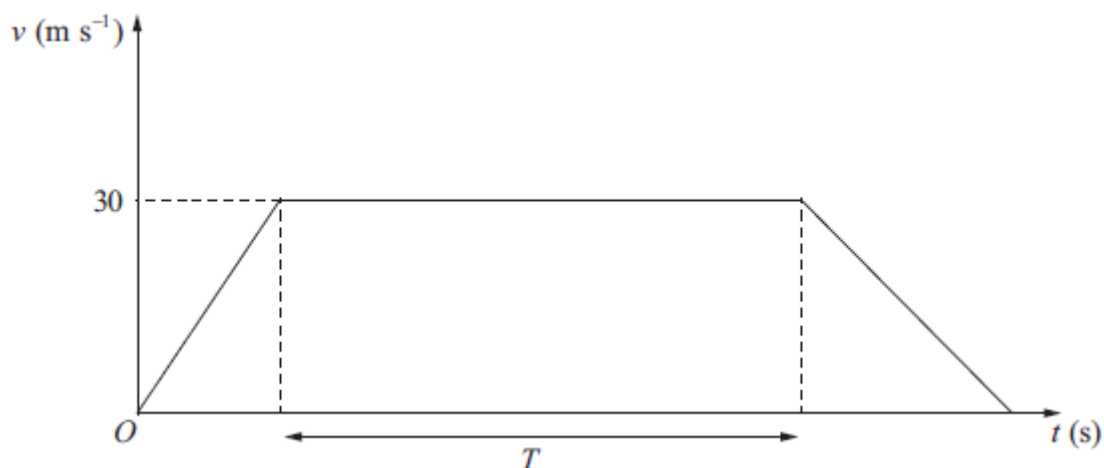
---

4. A lifeboat slides down a straight ramp inclined at an angle of  $15^\circ$  to the horizontal. The lifeboat has mass 800 kg and the length of the ramp is 50 m. The lifeboat is released from rest at the top of the ramp and is moving with a speed of  $12.6 \text{ m s}^{-1}$  when it reaches the end of the ramp. By modelling the lifeboat as a particle and the ramp as a rough inclined plane, find the coefficient of friction between the lifeboat and the ramp.

(9)

---

5.



**Figure 4**

The velocity-time graph in Figure 4 represents the journey of a train  $P$  travelling along a straight horizontal track between two stations which are 1.5 km apart. The train  $P$  leaves the first station, accelerating uniformly from rest for 300 m until it reaches a speed of  $30 \text{ m s}^{-1}$ . The train then maintains this speed for  $T$  seconds before decelerating uniformly at  $1.25 \text{ m s}^{-2}$ , coming to rest at the next station.

(a) Find the acceleration of  $P$  during the first 300 m of its journey. (2)

(b) Find the value of  $T$ . (5)

A second train  $Q$  completes the same journey in the same total time. The train leaves the first station, accelerating uniformly from rest until it reaches a speed of  $V \text{ m s}^{-1}$  and then immediately decelerates uniformly until it comes to rest at the next station.

(c) Sketch on the diagram above, a velocity-time graph which represents the journey of train  $Q$ . (2)

(d) Find the value of  $V$ . (6)

---

6. [In this question, the unit vectors  $\mathbf{i}$  and  $\mathbf{j}$  are due east and due north respectively. Position vectors are relative to a fixed origin  $O$ .]

A ship sets sail at 9 a.m. from a port  $P$  and moves with constant velocity. The position vector of  $P$  is  $(4\mathbf{i} - 8\mathbf{j})$  km. At 9.30 a.m. the ship is at the point with position vector  $(\mathbf{i} - 4\mathbf{j})$  km.

- (a) Find the speed of the ship in  $\text{km h}^{-1}$ . (4)

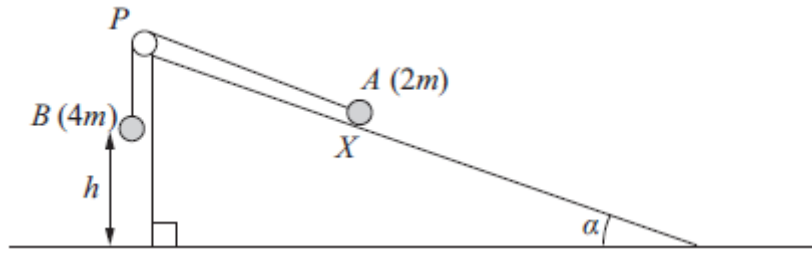
- (b) Show that the position vector  $\mathbf{r}$  km of the ship,  $t$  hours after 9 a.m., is given by

$$\mathbf{r} = (4 - 6t)\mathbf{i} + (8t - 8)\mathbf{j}. \quad (2)$$

At 10 a.m. a passenger on the ship observes that a lighthouse  $L$  is due west of the ship. At 10.30 a.m. the passenger observes that  $L$  is now south-west of the ship.

- (c) Find the position vector of  $L$ . (5)
-

7.



**Figure 5**

Figure 5 shows two particles  $A$  and  $B$ , of mass  $2m$  and  $4m$  respectively, connected by a light inextensible string. Initially  $A$  is held at rest on a rough inclined plane which is fixed to horizontal ground. The plane is inclined to the horizontal at an angle  $\alpha$ , where  $\tan \alpha = \frac{3}{4}$ . The coefficient of friction between  $A$  and the plane is  $\frac{1}{4}$ . The string passes over a small smooth pulley  $P$  which is fixed at the top of the plane. The part of the string from  $A$  to  $P$  is parallel to a line of greatest slope of the plane and  $B$  hangs vertically below  $P$ . The system is released from rest with the string taut, with  $A$  at the point  $X$  and with  $B$  at a height  $h$  above the ground.

For the motion until  $B$  hits the ground,

(a) give a reason why the magnitudes of the accelerations of the two particles are the same, (1)

(b) write down an equation of motion for each particle, (4)

(c) find the acceleration of each particle. (5)

Particle  $B$  does not rebound when it hits the ground and  $A$  continues moving up the plane towards  $P$ . Given that  $A$  comes to rest at the point  $Y$ , without reaching  $P$ ,

(d) find the distance  $XY$  in terms of  $h$ . (6)

**TOTAL FOR PAPER: 75 MARKS**

**END**

Question Number	Scheme	Marks		
1. (a)	$4m.2u - m.5u = -4m.\frac{1}{2}u + mv$ $3mu = -2mu + mv$ $v = 5u, \text{ opposite direction}$	M1 A1 A1, A1 <b>cso</b> (4)		
		(b)	$I = 4m(\frac{1}{2}u - -2u) \quad \text{OR} \quad I = m(5u - -5u)$ $= 10mu \quad \quad \quad = 10mu$	M1 A1 A1 (3) <b>7</b>
2. (a)	$M(D), \quad 8R = (80g \times 6) + (200g \times 4)$ $R = 160g, 1600, 1570$	M1 A1 A1 (3)		
		(b)	$(\uparrow), \quad 2S = 80g + 200g$ $S = 140g, 1400, 1370$	M1 A1 (2)
		(c)	$M(B), \quad Sx + (S \times 10) = (80g \times 8) + (200g \times 6)$ $140x + 1400 = 640 + 1200$ $140x = 440$ $x = \frac{22}{7}$	M1 A2 A1 (4) <b>9</b>
3.	$(\uparrow), \quad T \cos 30 + F \cos 60 = 2g$ $(\rightarrow), \quad T \cos 60 - F \cos 30 = 0$ $F = g = 9.8$ $T = \sqrt{3}g = 17 \text{ or } 17.0$	M1 A1 M1 A1 M1 A1 M1 A1 <b>8</b>		
	OR:	$(\square), \quad F = 2g \cos 60$ $(\square), \quad T = 2g \cos 30$ $F = g = 9.8$ $T = \sqrt{3}g = 17 \text{ or } 17.0$	M1 A1 M1 A1 M1 A1 M1 A1 <b>8</b>	

<p>4.</p>	$12.6^2 = 2a.50 \quad (\Rightarrow a = 1.5876)$ $800g\sin 15 - F = 800a$ $R = 800g\cos 15$ $F = mR$ $800g\sin 15 - m800g\cos 15 = 800 \times 1.5876$ $m = 0.1, 0.10, 0.100$	<p>M1 A1 M1 A1 M1 A1 B1  M1 A1</p> <p style="text-align: right;"><b>9</b></p>
<p>5. (a)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p>	$30^2 = 2a.300$ $a = 1.5$ $0^2 = 30^2 - 2 \times 1.25s \quad \text{OR} \quad 0 = 30 - 1.25t_2$ $s = 360 \quad t_2 = 24$ $300 + 30T + 360 = 1500 \quad \frac{(20 + T + 24 + T)}{2} \times 30 = 1500$ $T = 28 \quad T = 28$ <p>triangle, <i>drawn on the diagram</i>, with base coinciding with base of trapezium, top vertex above line <math>v = 30</math> and meeting trapezium at least once</p> <p><math>V</math> marked correctly</p> $30 = 1.5t_1 \Rightarrow t_1 = 20$ $30 = 1.25t_2 \Rightarrow t_2 = 24$ $\frac{1}{2}(20 + 28 + 24)V = 1500$ $V = \frac{750}{18} = 41.67$ $= \frac{125}{3} \text{ (oe) 0r 42 (or$ <p>better)</p>	<p>M1 A1 (2)</p> <hr/> <p>M1 A1 M1 A1 A1 (5)</p> <hr/> <p>B1 DB1 (2)</p> <hr/> <p>M1 A1 A1 M1 A1 A1 (6)</p> <p style="text-align: right;"><b>15</b></p>



<p>6. (a)</p> <p>(b)</p> <p>(c)</p>	$\frac{(\mathbf{i} - 4\mathbf{j}) - (4\mathbf{i} - 8\mathbf{j})}{0.5}; (\pm 6\mathbf{i} \pm 8\mathbf{j})$ $\sqrt{(\pm 6)^2 + (\pm 8)^2} = 10$ $\mathbf{r} = (4\mathbf{i} - 8\mathbf{j}) + t(-6\mathbf{i} + 8\mathbf{j})$ $= (4\mathbf{i} - 8\mathbf{j}) - 6t\mathbf{i} + 8t\mathbf{j}$ $= (4 - 6t)\mathbf{i} + (8t - 8)\mathbf{j} \quad *$ <p>At 10 am, <math>\mathbf{r} = -2\mathbf{i}</math></p> <p>At 10.30 am, <math>\mathbf{r} = -5\mathbf{i} + 4\mathbf{j}</math></p> $\mathbf{l} = k\mathbf{i}, k < -2$ $k = -5 - 4 = -9$ $\mathbf{l} = -9\mathbf{i}$	<p>M1 A1</p> <p>M1 A1 (4)</p> <p>M1</p> <p>A1 (2)</p> <p>M1 A1</p> <p>A1</p> <p>DM1</p> <p>A1 (5)</p> <p><b>11</b></p>
<p>7. (a)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p>	<p>Inextensible string</p> $4mg - T = 4ma$ $T - 2mg \sin \alpha - F = 2ma$ $F = 0.25R$ $R = 2mg \cos \alpha$ <p><math>\cos \alpha = 0.8</math> or <math>\sin \alpha = 0.6</math></p> <p>Eliminating <math>R, F</math> and <math>T</math></p> $a = 0.4g = 3.92$ $v^2 = 2 \times 0.4gh$ $-2mg \sin \alpha - F = 2ma'$ $a' = -0.8g$ $0^2 = 0.8gh - 2 \times 0.8g \times s$ $s = 0.5h$ $XY = 0.5h + h = 1.5h$	<p>B1 (1)</p> <p>M1A1</p> <p>M1A1 (4)</p> <p>B1</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>A1 (5)</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>A1</p> <p>(6)</p> <p><b>16</b></p>