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

Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Advanced/Advanced Subsidiary

Friday 15 January 2010 – 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	
Total	

Materials required for examination
Mathematical Formulae (Pink or Green)

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.
If you need more space to complete your answer to any question, use additional answer sheets.
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 7 questions in this question paper. The total mark for this paper is 75.
There are 24 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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1. A particle A of mass 2 kg is moving along a straight horizontal line with speed $12\,\text{m}\,\text{s}^{-1}$. Another particle B of mass m kg is moving along the same straight line, in the opposite direction to A, with speed $8\,\text{m}\,\text{s}^{-1}$. The particles collide. The direction of motion of A is unchanged by the collision. Immediately after the collision, A is moving with speed $3\,\text{m}\,\text{s}^{-1}$ and B is moving with speed $4\,\text{m}\,\text{s}^{-1}$. Find

(a) the magnitude of the impulse exerted by B on A in the collision,

(2)

(b) the value of m.

(4)

M35104A0224

January 2010
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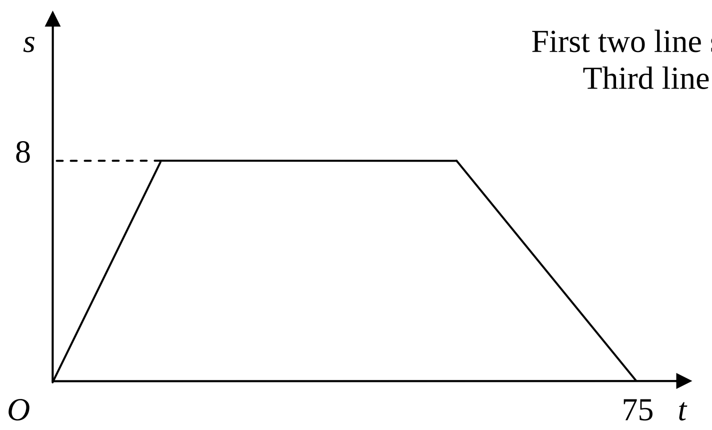
Mark Scheme

Question Number	Scheme	Marks
Q1.	(a) $I = 2\times 12 - 2\times 3 = 18 \ (\text{N s})$	M1 A1 (2)
	(b) LM $2\times 12 - 8m = 2\times 3 + 4m$	M1 A1
	Solving to $m = 1.5$	DM1 A1 (4)
		[6]
	Alternative to (b)	
	$I = m(4-(-8)) = 18$	M1 A1
	Solving to $m = 1.5$	DM1 A1 (4)
Q2.	(a)  First two line segments	B1
	Third line segment	B1
	8, 75	B1 (3)
	(b) $\frac{1}{2}\times 8\times(T+75) = 500$	M1 A2 (1,0)
	Solving to $T = 50$	DM1 A1 (5)
		[8]

Leave blank

2. An athlete runs along a straight road. She starts from rest and moves with constant acceleration for 5 seconds, reaching a speed of $8\,\mathrm{m\,s^{-1}}$. This speed is then maintained for T seconds. She then decelerates at a constant rate until she stops. She has run a total of 500 m in 75 s.

(a) In the space below, sketch a speed-time graph to illustrate the motion of the athlete.
(3)

(b) Calculate the value of T.
(5)

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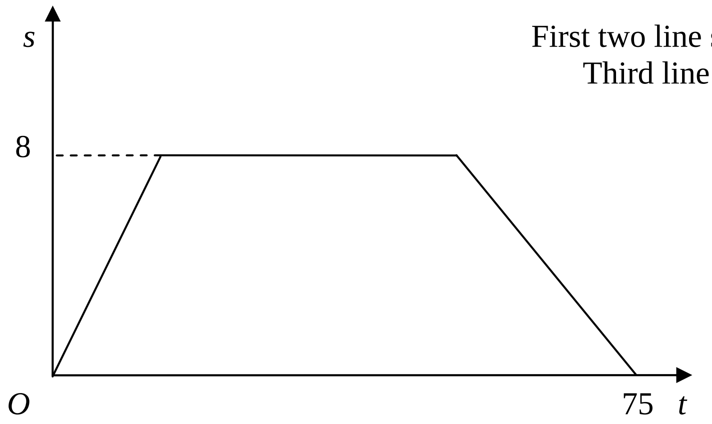
Mark Scheme

Question Number	Scheme	Marks
Q1.	(a) $I = 2\times12-2\times3=18\ (\text{N s})$	M1 A1 (2)
	(b) LM $2\times12-8m=2\times3+4m$	M1 A1
	Solving to $m=1.5$	DM1 A1 (4)
		[6]
	Alternative to (b)	
	$I=m\big(4-(-8)\big)=18$	M1 A1
	Solving to $m=1.5$	DM1 A1 (4)
Q2.	(a)  First two line segments	B1
	Third line segment	B1
	8, 75	B1 (3)
	(b) $\frac{1}{2}\times8\times(T+75)=500$	M1 A2 (1,0)
	Solving to $T=50$	DM1 A1 (5)
		[8]

Leave blank

3.

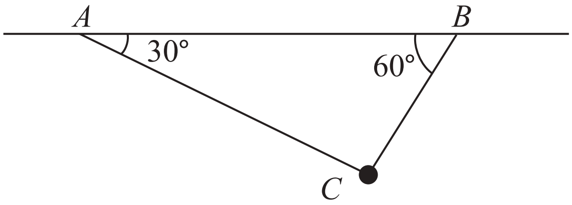


Figure 1

A particle of mass m kg is attached at C to two light inextensible strings AC and BC. The other ends of the strings are attached to fixed points A and B on a horizontal ceiling. The particle hangs in equilibrium with AC and BC inclined to the horizontal at 30° and 60° respectively, as shown in Figure 1.

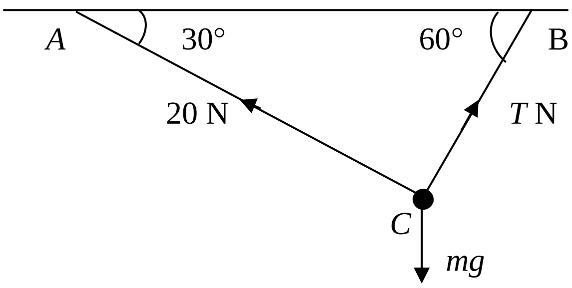
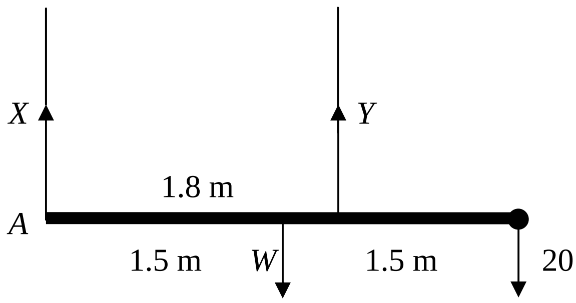
Given that the tension in AC is 20 N, find

(a) the tension in BC,

(4)

(b) the value of m.

(4)

Question Number	Scheme	Marks
Q3.		
	(a) R(→) $20\cos 30° = T\cos 60°$	M1 A2 (1,0)
	$T = 20\sqrt{3}$, 34.6, 34.64,…	A1 (4)
	(b) R(↑) $mg = 20\sin 30° + T\sin 60°$	M1 A2 (1,0)
	$m = \frac{40}{g}(\approx 4.1)$,4.08	A1 (4)
		[8]
Q4.	(a) 	
	M (A) $W\times 1.5 + 20\times 3 = Y\times 1.8$	M1 A2 (1, 0)
	$Y = \frac{5}{6}W + \frac{100}{3}$ $*$ cso	A1 (4)
	(b) ↑ $X + Y = W + 20$ or equivalent	M1 A1
	$X = \frac{1}{6}W - \frac{40}{3}$	A1 (3)
	(c) $\frac{5}{6}W + \frac{100}{3} = 8\left(\frac{1}{6}W - \frac{40}{3}\right)$	M1 A1 ft
	$W = 280$	A1 (3) **[10]**
	Alternative to (b) M(C) $X\times 1.8 + 20\times 1.2 = W\times 0.3$ $X = \frac{1}{6}W - \frac{40}{3}$	M1 A1 A1

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4.

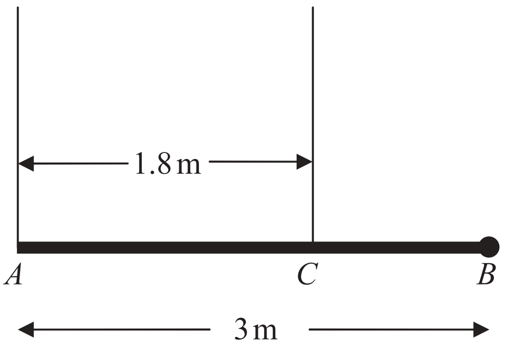


Figure 2

A pole AB has length 3 m and weight W newtons. The pole is held in a horizontal position in equilibrium by two vertical ropes attached to the pole at the points A and C where $AC = 1.8$ m, as shown in Figure 2. A load of weight 20 N is attached to the rod at B. The pole is modelled as a uniform rod, the ropes as light inextensible strings and the load as a particle.

(a) Show that the tension in the rope attached to the pole at C is $\left(\frac{5}{6}W + \frac{100}{3}\right)$ N.

(4)

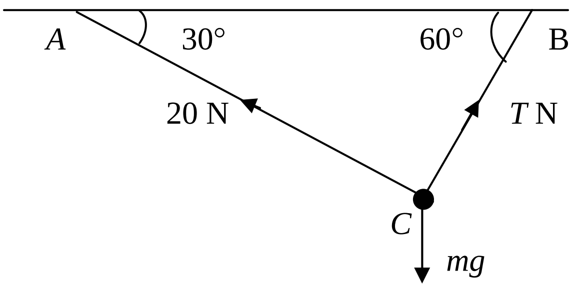
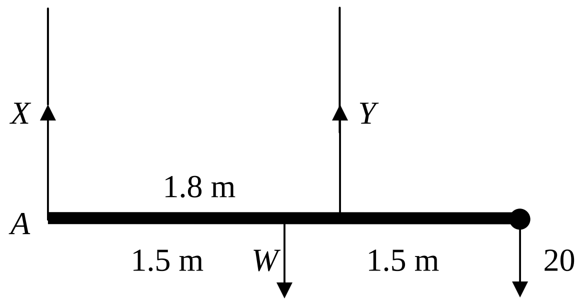
(b) Find, in terms of W, the tension in the rope attached to the pole at A.

(3)

Given that the tension in the rope attached to the pole at C is eight times the tension in the rope attached to the pole at A,

(c) find the value of W.

(3)

Question Number	Scheme	Marks
Q3.		
	(a) R($\rightarrow$) $20\cos 30° = T\cos 60°$	M1 A2 (1,0)
	$T = 20\sqrt{3}$, 34.6, 34.64,…	A1 (4)
	(b) R($\uparrow$) $mg = 20\sin 30° + T\sin 60°$	M1 A2 (1,0)
	$m = \frac{40}{g} (\approx 4.1)$,4.08	A1 (4)
		[8]
Q4.	(a) 	
	M (A) $W \times 1.5 + 20 \times 3 = Y \times 1.8$	M1 A2 (1, 0)
	$Y = \frac{5}{6}W + \frac{100}{3}$ ∗ cso	A1 (4)
	(b) $\uparrow$ $X + Y = W + 20$ or equivalent	M1 A1
	$X = \frac{1}{6}W - \frac{40}{3}$	A1 (3)
	(c) $\frac{5}{6}W + \frac{100}{3} = 8\left(\frac{1}{6}W - \frac{40}{3}\right)$	M1 A1 ft
	$W = 280$	A1 (3)
		[10]
	Alternative to (b)	
	M(C) $X \times 1.8 + 20 \times 1.2 = W \times 0.3$	M1 A1
	$X = \frac{1}{6}W - \frac{40}{3}$	A1

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5. A particle of mass 0.8 kg is held at rest on a rough plane. The plane is inclined at 30° to the horizontal. The particle is released from rest and slides down a line of greatest slope of the plane. The particle moves 2.7 m during the first 3 seconds of its motion. Find

(a) the acceleration of the particle,

(3)

(b) the coefficient of friction between the particle and the plane.

(5)

The particle is now held on the same rough plane by a horizontal force of magnitude X newtons, acting in a plane containing a line of greatest slope of the plane, as shown in Figure 3. The particle is in equilibrium and on the point of moving up the plane.

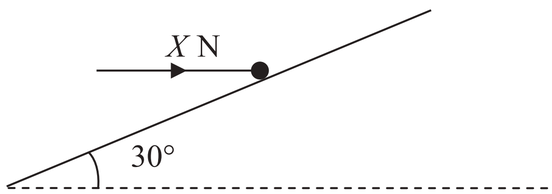
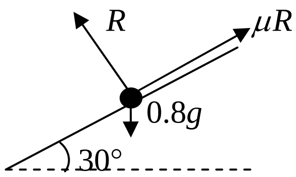
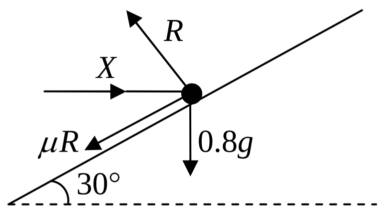


Figure 3

(c) Find the value of X.

(7)

Question Number	Scheme	Marks
Q5.	(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 2.7 = \frac{1}{2}a \times 9$	M1 A1
	$a = 0.6 \left(\text{m s}^{-2}\right)$	A1 (3)
	(b) 	
	↖ $R = 0.8g\cos 30° \left(\approx 6.79\right)$	B1
	Use of $F = \mu R$	B1
	↙ $0.8g\sin 30° - \mu R = 0.8 \times a$	M1 A1
	$\left(0.8g\sin 30° - \mu 0.8g\cos 30° = 0.8 \times 0.6\right)$	
	$\mu \approx 0.51$ accept 0.507	A1 (5)
	(c) 	
	↑ $R\cos 30° = \mu R\cos 60° + 0.8g$	M1 A2 (1,0)
	$\left(R \approx 12.8\right)$	
	→ $X = R\sin 30° + \mu R\sin 60°$	M1 A1
	Solving for X, $X \approx 12$ accept 12.0	DM1 A1 (7)
		[15]
	Alternative to (c)	
	↖ $R = X\sin 30° + 0.8 \times 9.8\sin 60°$	M1 A2 (1,0)
	↙ $\mu R + 0.8g\cos 60° = X\cos 30°$	M1 A1
	$X = \dfrac{\mu 0.8g\sin 60° + 0.8g\cos 60°}{\cos 30° - \mu\sin 30°}$	
	Solving for X, $X \approx 12$ accept 12.0	DM1 A1 (7)

Leave blank

6.

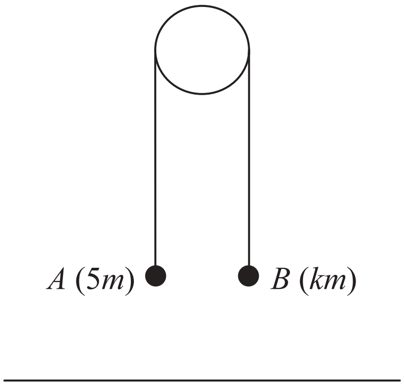


Figure 4

Two particles A and B have masses $5m$ and km respectively, where $k < 5$. The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut, the hanging parts of the string vertical and with A and B at the same height above a horizontal plane, as shown in Figure 4. The system is released from rest. After release, A descends with acceleration $\frac{1}{4}g$.

(a) Show that the tension in the string as A descends is $\frac{15}{4}mg$.

(3)

(b) Find the value of k.

(3)

(c) State how you have used the information that the pulley is smooth.

(1)

After descending for 1.2 s, the particle A reaches the plane. It is immediately brought to rest by the impact with the plane. The initial distance between B and the pulley is such that, in the subsequent motion, B does not reach the pulley.

(d) Find the greatest height reached by B above the plane.

(7)

Question Number	Scheme	Marks	
Q6.	(a) N2L A: $5mg - T = 5m \times \frac{1}{4}g$	M1 A1	
	$T = \frac{15}{4}mg$ ∗ cso	A1	(3)
	(b) N2L B: $T - kmg = km \times \frac{1}{4}g$	M1 A1	
	$k = 3$	A1	(3)
	(c) The tensions in the two parts of the string are the same	B1	(1)
	(d) Distance of *A* above ground $s_1 = \frac{1}{2} \times \frac{1}{4}g \times 1.2^2 = 0.18g\ (\approx 1.764)$	M1 A1	
	Speed on reaching ground $v = \frac{1}{4}g \times 1.2 = 0.3g\ (\approx 2.94)$	M1 A1	
	For *B* under gravity $(0.3g)^2 = 2gs_2 \Rightarrow s_2 = \frac{(0.3)^2}{2}g\ (\approx 0.441)$	M1 A1	
	$S = 2s_1 + s_2 = 3.969 \approx 4.0$ (m)	A1	(7) **[14]**

Leave blank

7. [*In this question,* **i** *and* **j** *are horizontal unit vectors due east and due north respectively and position vectors are given with respect to a fixed origin*.]

A ship S is moving along a straight line with constant velocity. At time t hours the position vector of S is $\mathbf{s}$ km. When $t = 0$, $\mathbf{s} = 9\mathbf{i} - 6\mathbf{j}$. When $t = 4$, $\mathbf{s} = 21\mathbf{i} + 10\mathbf{j}$. Find

(a) the speed of S,

(4)

(b) the direction in which S is moving, giving your answer as a bearing.

(2)

(c) Show that $\mathbf{s} = (3t + 9)\,\mathbf{i} + (4t - 6)\,\mathbf{j}$.

(2)

A lighthouse L is located at the point with position vector $(18\mathbf{i} + 6\mathbf{j})$ km. When $t = T$, the ship S is 10 km from L.

(d) Find the possible values of T.

(6)

Question Number	Scheme	Marks
Q7.	(a)	
	$\mathbf{v} = \dfrac{21\mathbf{i} + 10\mathbf{j} - (9\mathbf{i} - 6\mathbf{j})}{4} = 3\mathbf{i} + 4\mathbf{j}$	M1 A1
	speed is $\sqrt{(3^2 + 4^2)} = 5\ (\text{km h}^{-1})$	M1 A1 (4)
	(b) $\tan\theta = \dfrac{3}{4}\ (\Rightarrow \theta \approx 36.9°)$	M1
	bearing is 37, 36.9, 36.87, …	A1 (2)
	(c) $\mathbf{s} = 9\mathbf{i} - 6\mathbf{j} + t(3\mathbf{i} + 4\mathbf{j})$	M1
	$= (3t + 9)\mathbf{i} + (4t - 6)\mathbf{j}$ ∗ cso	A1 (2)
	(d) Position vector of *S* relative to *L* is	
	$(3T + 9)\mathbf{i} + (4T - 6)\mathbf{j} - (18\mathbf{i} + 6\mathbf{j}) = (3T - 9)\mathbf{i} + (4T - 12)\mathbf{j}$	M1 A1
	$(3T - 9)^2 + (4T - 12)^2 = 100$	M1
	$25T^2 - 150T + 125 = 0$ or equivalent	DM1 A1
	$(T^2 - 6T + 5 = 0)$	
	$T = 1, 5$	A1 (6)
		[14]