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

Paper Reference(s)

6677/01R

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	
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 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 32 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. Two particles A and B, of mass 2 kg and 3 kg respectively, are moving towards each other in opposite directions along the same straight line on a smooth horizontal surface. The particles collide directly. Immediately before the collision the speed of A is 5 m s^{-1} and the speed of B is 6 m s^{-1}. The magnitude of the impulse exerted on B by A is 14 N s. Find

(a) the speed of A immediately after the collision,

(3)

(b) the speed of B immediately after the collision.

(3)

Question Number	Scheme	Marks
1(a)		
	$2v+10=14$ $v=2\ \text{m s}^{-1}$	M1A1 A1 **(3)**
(b)	$3w+18=14$ $w=\frac{4}{3}\ \text{m s}^{-1}$	M1A1 A1 **(3)** **[6]**
	Notes for Question 1	
Q1(a)	M1 for attempt at Impulse = difference in momenta for particle *A*, (must be considering *one* particle) (M0 if g is included or if mass omitted). First A1 for $-14=2(\pm v-5)$ Second A1 for 2 (Must be positive). Allow change of sign at end to obtain speed.	
Q1(b)	**EITHER** M1 for attempt at Impulse = difference in momenta for particle *B*, (must be considering *one* particle) (M0 if g is included or if mass omitted). First A1 $14=3(\pm w--6)$ Second A1 for 4/3, 1.3 or better (Must be positive). Allow change of sign at end to obtain speed. **OR** M1 for attempt at CLM equation, with correct no. of terms, dimensionally correct. Allow consistent extra g's and sign errors. First A1 (**Not f.t.**) for a correct equation e.g. 2 x 5 - 3 x 6 = -2 x 2 + 3*w* Second A1 for speed is 4/3; 1.3 or better N.B. They may find the speed of *B* first and then use CLM to find the speed of *A*. It must be clear which speed is which, in order to gain the A marks for the answers	

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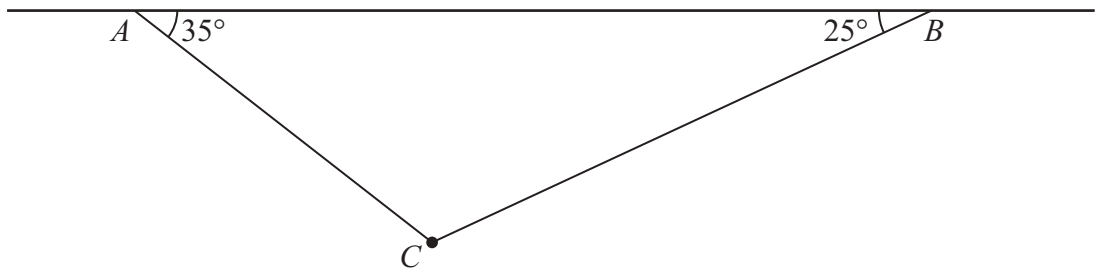


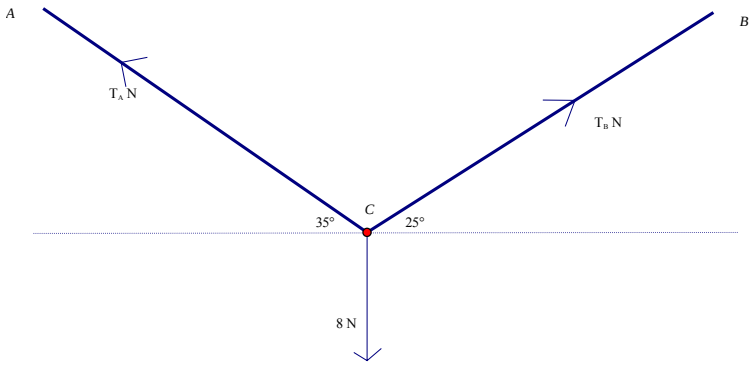
Figure 1

A particle of weight 8 N is attached at C to the ends of two light inextensible strings AC and BC. The other ends, A and B, are attached to a fixed horizontal ceiling. The particle hangs at rest in equilibrium, with the strings in a vertical plane. The string AC is inclined at 35° to the horizontal and the string BC is inclined at 25° to the horizontal, as shown in Figure 1. Find

(i) the tension in the string AC,

(ii) the tension in the string BC.

(8)

Question Number	Scheme	Marks
2.		
	Resolve horizontally: $T_A \cos 35° = T_B \cos 25°$	M1A1
	Resolve vertically: $T_A \sin 35° + T_B \sin 25° = 8$	M1A1
	Equation in one unknown: $T_B \dfrac{\cos 25°}{\cos 35°} \sin 35° + T_B \sin 25° = 8$	**DM1**A1
	or $T_A \sin 35° + T_A \dfrac{\cos 35°}{\cos 25°} \sin 25° = 8$	
	T_A = 8.4, 8.37, 8.372 (N) or better	A1
	T_B = 7.6, 7.57, 7.567 (N) or better	A1 **(8)**
2alt	**OR**	
	Using Sine Rule on triangle of forces: $\dfrac{8}{\sin 60°} = \dfrac{T_A}{\sin 65°} = \dfrac{T_B}{\sin 55°}$	M1A1
	$\dfrac{8 \times \sin 65°}{\sin 60°} = T_A$, = 8.4, 8.37, 8.372 (N) or better	M1A1, A1
	$\dfrac{8 \times \sin 55°}{\sin 60°} = T_B$, = 7.6, 7.57, 7.567 (N) or better	M1A1, A1

Notes for Question 2		
2	First M1 for resolving horizontally with correct no. of terms and both T_A and T_B terms resolved. First A1 for a correct equation. Second M1 for resolving vertically with correct no. of terms and both T_A and T_B terms resolved. Second A1 for a correct equation. Third M1, dependent on first two M marks, for eliminating T_A or T_B Third A1 for a correct equation in one unknown Fourth A1 for T_A = 8.4 (N) or better. Fifth A1 for T_B = 7.6 (N) or better. N.B. The first two M marks can be for two resolutions in any two directions. N.B. If the two tensions are taken to be equal, can score max M1A0 for vertical resolution.	
2 alt 1	See **Alternative 1** using a Triangle of Forces and the Sine Rule.	
2 alt 2	**Alternative 2** is to resolve perpendicular to each string: The scheme is similar to Alt 1 and gives the same expressions for T_A and T_B M1A1 resolving perp to *both* strings as a complete method. M1A1A1 for finding T_A M1A1A1 for finding T_B	

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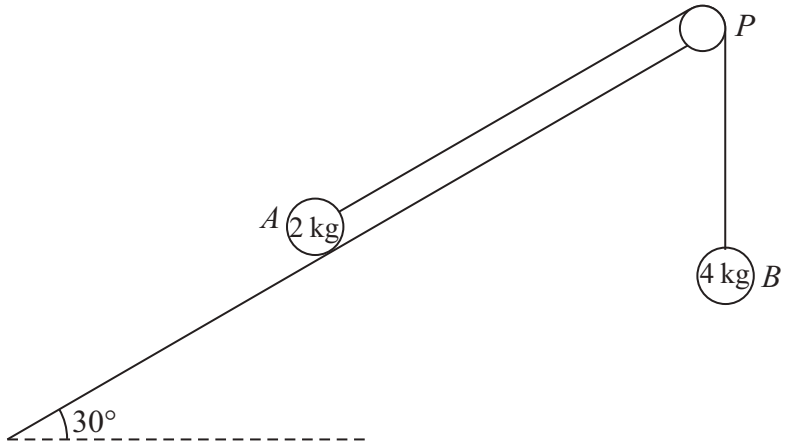
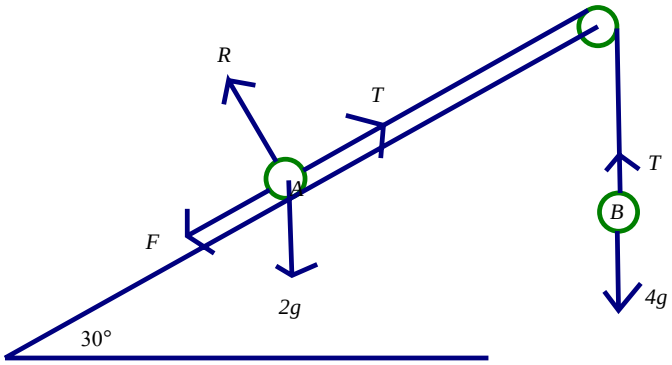


Figure 2

A fixed rough plane is inclined at 30° to the horizontal. A small smooth pulley P is fixed at the top of the plane. Two particles A and B, of mass 2 kg and 4 kg respectively, are attached to the ends of a light inextensible string which passes over the pulley P. The part of the string from A to P is parallel to a line of greatest slope of the plane and B hangs freely below P, as shown in Figure 2. The coefficient of friction between A and the plane is $\frac{1}{\sqrt{3}}$. Initially A is held at rest on the plane. The particles are released from rest with the string taut and A moves up the plane.

Find the tension in the string immediately after the particles are released.

(9)

Question Number	Scheme	Marks
3.		
	Equation of motion of B: $4g - T = 4a$	M1A1
	Equation of motion of A: $T - F - 2g\sin 30 = 2a$	M1A2
	OR: $4g - F - 2g\sin 30 = 6a$	
	Resolve perpendicular to the plane at A: $R = 2g\cos 30$	B1
	Use of $F = \mu R$: $F = \frac{1}{\sqrt{3}} \times 2g\cos 30 (= g)$	M1
	$T - g - g = T - 2g = 2a$	
	$2T - 4g = 4g - T$, $3T = 8g$, $T = \frac{8g}{3} (\approx 26)$ 26.1(N)	**DM1**A1
		(9) **[9]**
	Notes for Question 3	
3	First M1 for resolving vertically (up or down) for B, with correct no. of terms. First A1 for a correct equation. Second M1 for resolving parallel to the plane (up or down) for A, with correct no. of terms. A2 for a correct equation (-1 each error) **OR**: M2 A3 for the whole system equation - any method error loses all the marks. B1 for perpendicular resolution Third M1 for sub for R in $F = \mu R$ Fourth DM1, dependent on first and second M marks, for eliminating a. Fourth A1 for 8g/3, 26.1 or 26 (N). (392/15 oe is A0)	

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4. At time $t = 0$, two balls A and B are projected vertically upwards. The ball A is projected vertically upwards with speed 2 m s^{-1} from a point 50 m above the horizontal ground. The ball B is projected vertically upwards from the ground with speed 20 m s^{-1}. At time $t = T$ seconds, the two balls are at the same vertical height, h metres, above the ground. The balls are modelled as particles moving freely under gravity. Find

(a) the value of T,

(5)

(b) the value of h.

(2)

Question Number	Scheme	Marks
4. **(a)**	Use of $s = ut + \frac{1}{2}at^2$	M1
	$-2t + \frac{1}{2}gt^2$ (+ or – 50)	A1
	$20t - \frac{1}{2}gt^2$ (+ or – 50)	A1
	$50 = -2T + \frac{1}{2}gT^2 + 20T - \frac{1}{2}gT^2 = 18T$	M1
	$T = \frac{50}{18} = 2.777.... = 2.8$ or better	A1 **(5)**
(b)	$h = 20 \times T - 4.9 \times T^2 = 17.74.... \approx 17.7$ (18 to 2 s.f.) (use of 2.8 gives 17.584)	M1A1 **(2)** **[7]**
	Notes on Question 4	
Q4(a)	First M1 for use of $s = ut + 1/2at^2$ (or use of 2 *suvat* formulae AND eliminating *v*, to give an equation in *s* and *t*). N.B. M0 if they use $s = 50$ or $u = 0$ or $v = 0$) First A1 with $u = 2$ and $a = -g$ or -9.8 to obtain a distance, possibly with 50 added or subtracted. (2 and 4.9 must have *opposite* signs) Second A1 with $u = 20$ and $a = -g$ or -9.8 to obtain a distance, possibly with 50 added or subtracted. (2 and 4.9 must have *opposite* signs) Second M1 dependent on first M1 for a *correct* equation obtained correctly in *T* only. Third A1 for 25/9 oe, 2.8 or better	
Q4(b)	First M1 for substituting their *T* value (allow –ve changed to +ve but A mark is then unavailable) into an appropriate equation First A1 for 17.7 or 18 (m). (A0 if they then add 50)	

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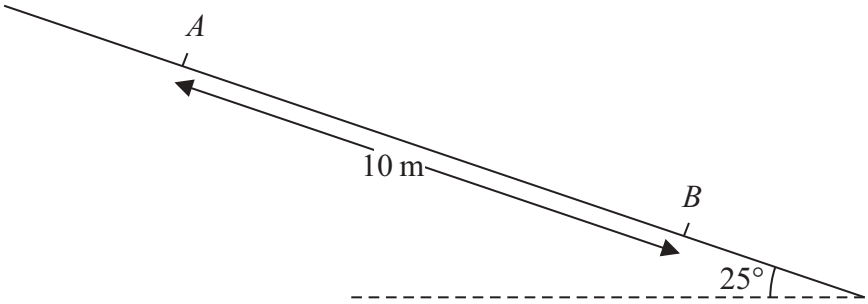

Figure 3

A particle P of mass 0.6 kg slides with constant acceleration down a line of greatest slope of a rough plane, which is inclined at 25° to the horizontal. The particle passes through two points A and B, where $AB = 10$ m, as shown in Figure 3. The speed of P at A is 2 m s^{-1}. The particle P takes 3.5 s to move from A to B. Find

(a) the speed of P at B,

(3)

(b) the acceleration of P,

(2)

(c) the coefficient of friction between P and the plane.

(5)

Question Number	Scheme	Marks
5. **(a)**	$s = \frac{u+v}{2}t \qquad 10 = \frac{2+v}{2} \times 3.5$ $v = \frac{20}{3.5} - 2 = \frac{26}{7} = 3.71 \ \ (\text{m s}^{-1})$	M1A1 A1 **(3)**
(b)	$a = \frac{v-u}{t} = \frac{\frac{26}{7} - 2}{3.5} = \frac{24}{49} = 0.490 \ \ (\text{m s}^{-2})$	M1A1 **(2)**
(c)	Normal reaction : $R = 0.6g\cos 25°$ Resolve parallel to the slope : $0.6g\sin 25° - \mu \times R = 0.6 \times a$ $\mu = 0.41$ or 0.411	B1 M1A2 A1 **(5)** **[10]**
	Notes for Question 5	
Q5(a)	First M1 for producing an equation in *v only.* First A1 for a correct equation Second A1 for 26/7 oe, 3.7 or better (ms^{-1})	
Q5(b)	M1 for producing an equation in *a only.* A1 for 24/49, 0.49 or better (ms^{-2})	
Q5(c)	B1 for $R = 0.6g\cos 25^{o}$ M1 for resolving along the plane, correct no. of terms etc. A2 (-1 each error) *R* and *a* do not need to be substituted Third A1 for 0.41 or 0.411	

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

A ship S is moving with constant velocity $(3\mathbf{i} + 3\mathbf{j})$ km h^{-1}. At time $t = 0$, the position vector of S is $(-4\mathbf{i} + 2\mathbf{j})$ km.

(a) Find the position vector of S at time t hours.

(2)

A ship T is moving with constant velocity $(-2\mathbf{i} + n\mathbf{j})$ km h^{-1}. At time $t = 0$, the position vector of T is $(6\mathbf{i} + \mathbf{j})$ km. The two ships meet at the point P.

(b) Find the value of n.

(5)

(c) Find the distance OP.

(4)

Question Number	Scheme	Marks
6. **(a)**	Use of $\mathrm{r} = \mathrm{r}_0 + \mathrm{v}t$ $(-4\mathrm{i} + 2\mathrm{j}) + (3\mathrm{i} + 3\mathrm{j})t = (-4 + 3t)\mathrm{i} + (2 + 3t)\mathrm{j}$	M1 A1 **(2)**
(b)	$(6\mathrm{i} + \mathrm{j}) + (-2\mathrm{i} + n\mathrm{j})t = (6 - 2t)\mathrm{i} + (1 + nt)\mathrm{j}$ Position vectors identical $\Rightarrow -4 + 3t = 6 - 2t$ **AND** $5t = 10$, Either equation $2 + 3 \times 2 = 1 + 2n$, $n = 3.5$	B1 M1 A1 **DM1** A1 **(5)**
(c)	Position vector of P is $(-4 + 6)\mathrm{i} + (2 + 6)\mathrm{j} = 2\mathrm{i} + 8\mathrm{j}$ Distance OP $= \sqrt{2^2 + 8^2} = \sqrt{68} = 8.25\,(\mathrm{km})$	M1A1 M1A1 **(4)** **[11]**

Notes for Question 6

Q6(a)	M1 for clear attempt to use $\mathbf{r}_0 + t\mathbf{v}$ (M0 if $\mathbf{r}_0$ and $\mathbf{v}$ reversed) A1 for answer in any form.
Q6(b)	B1 for $(6\mathbf{i} + \mathbf{j}) + (-2\mathbf{i} + n\mathbf{j})t$ seen or implied First M1 for equating their **i**- cpts *and* their **j**- cpts. (must have *both* equations in terms of *same t*) First A1 for a correct equation (either) Second M1 dependent on first M1 for producing an equation in *n* only. Second A1 for $n = 3.5$ oe
Q6(c)	First M1 for clear attempt to find pv of *P*, using their *t* and/or *n* value(s) First A1 for $2\mathbf{i} + 8\mathbf{j}$ Second M1 for attempt to find magnitude of their **p** Second A1 for $\sqrt{68}$, $2\sqrt{17}$, 8.2 or better (km)

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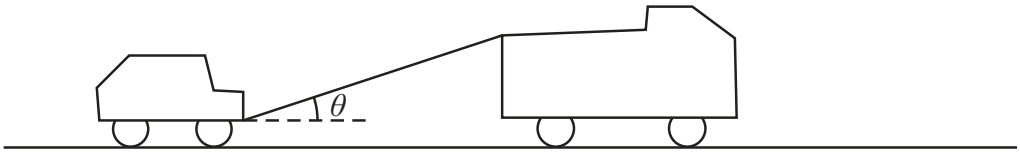

Figure 4

A truck of mass 1750 kg is towing a car of mass 750 kg along a straight horizontal road. The two vehicles are joined by a light towbar which is inclined at an angle θ to the road, as shown in Figure 4. The vehicles are travelling at 20 m s^{-1} as they enter a zone where the speed limit is 14 m s^{-1}. The truck's brakes are applied to give a constant braking force on the truck. The distance travelled between the instant when the brakes are applied and the instant when the speed of each vehicle is 14 m s^{-1} is 100 m.

(a) Find the deceleration of the truck and the car.

(3)

The constant braking force on the truck has magnitude R newtons. The truck and the car also experience constant resistances to motion of 500 N and 300 N respectively. Given that $\cos\theta = 0.9$, find

(b) the force in the towbar,

(4)

(c) the value of R.

(4)

Question Number	Scheme	Marks
7 **(a)**	Use of $v^2 = u^2 + 2as$ $14^2 = 20^2 - 2a \times 100$ Deceleration is $1.02(\text{m s}^{-2})$	M1 A1 A1 **(3)**
(b)	Horizontal forces on the car: $\pm T\cos\theta - 300 = 750 \times -1.02 = -765$ $T = -1550/3$ The force in the tow-bar is 1550/3, 520 (N) or better (allow –ve answer)	M1A2 **f.t.** A1 **(4)**
(c)	Horizontal forces on the truck: $\pm T\cos\theta - 500 - R = 1750 \times -1.02$ Braking force $R =$ 1750 (N)	M1A2 **f.t.** A1 **(4)** **[11]**
	ALT: Whole system: $800 + R = 2500 \times 1.02$ $R = 1750$	M1A2 **f.t.** A1
	Notes for Question 7	
Q7(a)	M1 for a complete method to produce an equation in *a* only. First A1 for a correct equation. Second A1 for 1.02 (ms^{-2}) oe. must be POSITIVE.	
Q7(b)	M1 for considering *the car ONLY* horizontally to produce an equation in *T* only, with usual rules. i.e. correct no. of terms AND *T* resolved: $\pm T\cos\theta - 300 = 750$ x -1.02 A2 **ft** on their *a* for a correct equation (300 and *a* must have *same* sign); -1 each error (treat cos 0.9 as an A error) A1 for 1550/3 oe, 520 or better (N) N.B. Allow a negative answer.	
Q7(c)	M1 for considering *the truck ONLY* horizontally to produce an equation, with usual rules. i.e. correct no. of terms AND *T* resolved: $\pm T\cos\theta - 500 - R = 1750$ x -1.02 A2 **ft** on their *T* and *a* for a correct equation (500, *a* and *R* must have *same* sign); -1 each error (treat cos 0.9 as an A error) A1 for 1750 (N). **OR** M1 for considering *the whole system* to produce an equation in *R* only, with usual rules. i.e. correct no. of terms. A2 **ft** on their *a* for a correct equation (*a* and *R* must have *same* sign) -1 each error A1 for 1750 (N). N.B. If 300 and 500 are given separately, penalise any sign errors only ONCE.	

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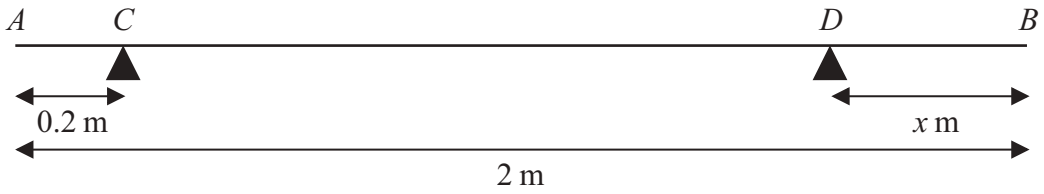


Figure 5

A uniform rod AB has length 2 m and mass 50 kg. The rod is in equilibrium in a horizontal position, resting on two smooth supports at C and D, where $AC = 0.2$ metres and $DB = x$ metres, as shown in Figure 5. Given that the magnitude of the reaction on the rod at D is twice the magnitude of the reaction on the rod at C,

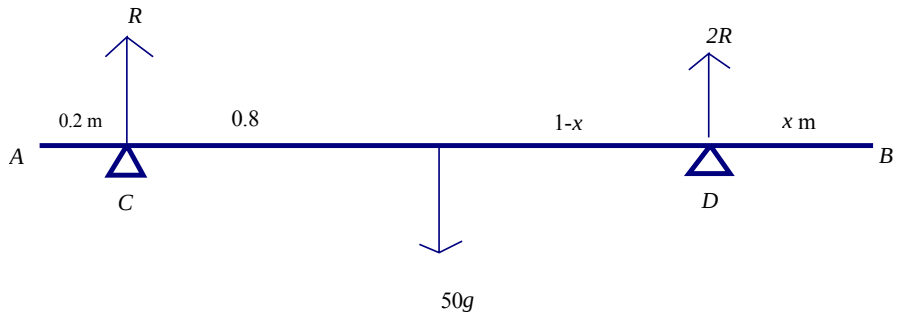
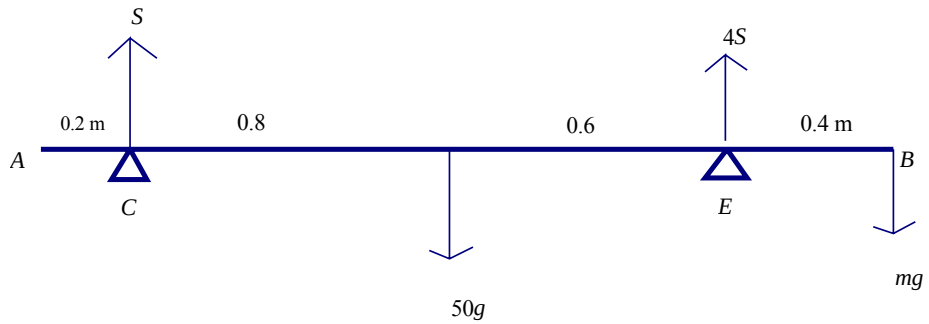
(a) find the value of x.

(6)

The support at D is now moved to the point E on the rod, where $EB = 0.4$ metres. A particle of mass m kg is placed on the rod at B, and the rod remains in equilibrium in a horizontal position. Given that the magnitude of the reaction on the rod at E is four times the magnitude of the reaction on the rod at C,

(b) find the value of m.

(7)

Question Number	Scheme	Marks
8. **(a)**		
	Vertical equilibrium: $R+2R=50g$,	M1A1
	Moments about C: $50g\times0.8=(1.8-x)\times2\times R$	M1A1
	$3\times0.8=3.6-2x$, $x=0.6$	**DM1**A1
		(6)
(b)		
	S, $4S$	B1
	Vertical equilibrium: $S+4S=(50+m)g=5S$	M1A1
	Moments about B: $50g\times1=4S\times0.4+S\times1.8=3.4S$	M1A1
	$50\times\frac{5}{3.4}=(50+m)$	**DM1**
	$m=400/17$, 24, 23.5 or better	A1
		(7)
		[13]

Notes for Question 8		
Q8(a)	**In both parts consistent omission of g's can score all the marks.** First M1 for vertical resolution or a moments equation, with usual rules. (allow R and N at this stage) First A1 for a correct equation (with $N = 2R$ substituted) Second M1 for a moments equation in R and one unknown length with usual rules. Second A1 for a correct equation. Third M1, dependent on first and second M marks, for solving for x Third A1 for $x = 0.6$. S.C. Moments about centre of rod: $R \times 0.8 = 2R(1 - x)$ M2 A2	
Q8(b)	B1 for S and $4S$ placed correctly. First M1 for vertical resolution or a moments equation, with usual rules. (allow S and $4S$ reversed) First A1 for a correct equation. Second M1 for a moments equation in S (and m) with usual rules. Second A1 for a correct equation. Third M1, dependent on first and second M marks, for *eliminating S* to give an equation in *m only.* Third A1 for $m = 400/17$ oe or 24 or better. N.B. SC If they use the reaction(s) found in part (a) in their equations, can score max B1M1A0M1A0DM0A0.	