

ADVANCED SUBSIDIARY GCE MATHEMATICS (MEI)

Mechanics 1

4761

Candidates answer on the Answer Booklet

OCR Supplied Materials:

- 8 page Answer Booklet
- Graph paper
- MEI Examination Formulae and Tables (MF2)

Other Materials Required:

None

Wednesday 27 January 2010 Afternoon

Duration: 1 hour 30 minutes



INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer all the questions.
- Do **not** write in the bar codes.
- You are permitted to use a graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $g \, \text{m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use g = 9.8.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- You are advised that an answer may receive no marks unless you show sufficient detail of the working to
 indicate that a correct method is being used.
- The total number of marks for this paper is 72.
- This document consists of **8** pages. Any blank pages are indicated.

Section A (36 marks)

1 A ring is moving up and down a vertical pole. The displacement, s m, of the ring above a mark on the pole is modelled by the displacement-time graph shown in Fig. 1. The three sections of the graph are straight lines.

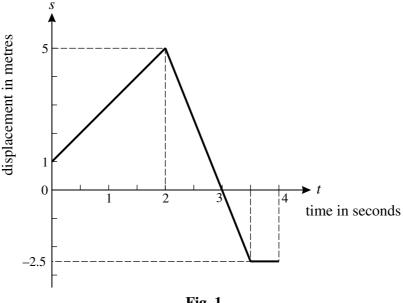


Fig. 1

- (i) Calculate the velocity of the ring in the interval 0 < t < 2 and in the interval 2 < t < 3.5. [2]
- (ii) Sketch a velocity-time graph for the motion of the ring during the 4 seconds. [2]
- (iii) State the direction of motion of the ring when
 - (A) t = 1,
 - (*B*) t = 2.75,

(C)
$$t = 3.25$$
.

- A particle of mass 5 kg has constant acceleration. Initially, the particle is at $\binom{-1}{2}$ m with velocity 2 $\binom{2}{-3}$ m s⁻¹; after 4 seconds the particle has velocity $\binom{12}{9}$ m s⁻¹.
 - (i) Calculate the acceleration of the particle. [2]
 - (ii) Calculate the position of the particle at the end of the 4 seconds. [3]
 - (iii) Calculate the force acting on the particle. [2]

© OCR 2010 4761 Jan10 3 In this question, **i** is a horizontal unit vector and **j** is a unit vector pointing vertically upwards.

A force \mathbf{F} is $-\mathbf{i} + 5\mathbf{j}$.

(i) Calculate the magnitude of **F**.

Calculate also the angle between **F** and the upward vertical.

[4]

Force **G** is $2a\mathbf{i} + a\mathbf{j}$ and force **H** is $-2\mathbf{i} + 3b\mathbf{j}$, where a and b are constants. The force **H** is the resultant of forces $4\mathbf{F}$ and \mathbf{G} .

A box of mass 2.5 kg is on a smooth horizontal table, as shown in Fig. 4. A light string AB is attached to the table at A and the box at B. AB is at an angle of 50° to the vertical. Another light string is attached to the box at C; this string is inclined at 15° above the horizontal and the tension in it is 20 N. The box is in equilibrium.

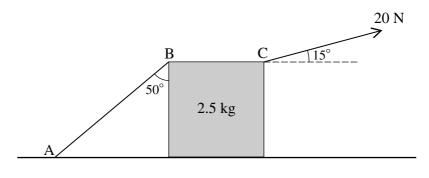


Fig. 4

- (i) Calculate the horizontal component of the force exerted on the box by the string at C. [1]
- (ii) Calculate the tension in the string AB.

[2]

(iii) Calculate the normal reaction of the table on the box.

[4]

The string at C is replaced by one inclined at 15° below the horizontal with the same tension of 20 N.

(iv) Explain why this has no effect on the tension in string AB.

[1]

5 The velocity, $v \,\mathrm{m}\,\mathrm{s}^{-1}$, of a particle moving along a straight line is given by

$$v = 3t^2 - 12t + 14$$
.

where *t* is the time in seconds.

(i) Find an expression for the acceleration of the particle at time t.

[2]

- (ii) Find the displacement of the particle from its position when t = 1 to its position when t = 3. [4]
- (iii) You are *given* that v is always positive. Explain how this tells you that the distance travelled by the particle between t = 1 and t = 3 has the same value as the displacement between these times.

[2]

Section B (36 marks)

6

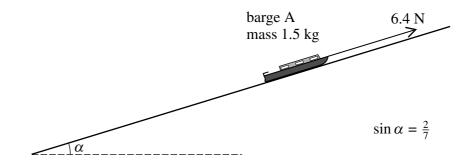


Fig. 6.1

Fig. 6.1 shows a toy barge A of mass 1.5 kg on a rough plane. The plane is at an angle α to the horizontal where $\sin \alpha = \frac{2}{7}$.

(i) Show that the component of the weight of the barge down the slope is 4.2 N. [2]

The barge is held in equilibrium by a force of 6.4 N acting up and parallel to the plane.

(ii) Determine the frictional force on the barge and state whether it acts up or down the plane. [2]

The force of $6.4 \,\mathrm{N}$ is removed and the barge now slides down the plane with acceleration $1.2 \,\mathrm{m \, s^{-2}}$.

- (iii) Calculate the new frictional force on the barge. [4]
- (iv) Determine how far the barge travels while its speed increases from $0.8 \,\mathrm{m \, s^{-1}}$ to $2 \,\mathrm{m \, s^{-1}}$. [3]

Fig. 6.2 shows barge A on the same slope with a second barge B of mass 2 kg attached to it by means of a light rigid coupling parallel to the plane. The frictional force on barge B is 0.7 N and the frictional force on barge A is now 2.3 N. At one stage of the motion the two barges are being pulled up the plane by a force of 10 N parallel to the plane.

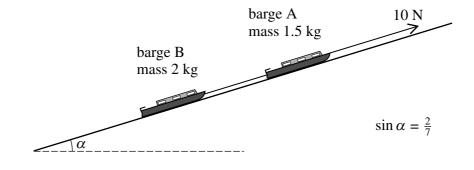


Fig. 6.2

(v) Draw diagrams showing the forces acting on each barge.

Calculate the acceleration of the barges and clearly indicate its direction.

Find the force in the coupling, stating whether this is a tension or a thrust (compression). [7]

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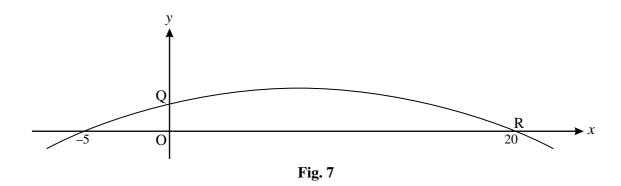


Fig. 7 shows the graph of $y = \frac{1}{100}(100 + 15x - x^2)$.

For $0 \le x \le 20$, this graph shows the trajectory of a small stone projected from the point Q where y m is the height of the stone above horizontal ground and x m is the horizontal displacement of the stone from O. The stone hits the ground at the point R.

- (i) Write down the height of Q above the ground. [1]
- (ii) Find the horizontal distance from O of the highest point of the trajectory and show that this point is 1.5625 m above the ground. [5]
- (iii) Show that the time taken for the stone to fall from its highest point to the ground is 0.565 seconds, correct to 3 significant figures. [3]
- (iv) Show that the horizontal component of the velocity of the stone is 22.1 m s⁻¹, correct to 3 significant figures. Deduce the time of flight from Q to R. [5]
- (v) Calculate the speed at which the stone hits the ground. [4]

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1 (i)	0 < t < 2, v = 2 $2 < t < 3.5, v = -5$	B1 B1	Condone '5 downwards' and ' – 5 downwards'	
(ii)	$\begin{array}{c} S \\ 2 \\ \hline $		Condone intent – e.g. straight lines free-hand and scales not labelled; accept non-vertical sections at $t = 2 \& 3.5$.	2
	\ 	B1	Only horizontal lines used and 1 st two parts present. BOD <i>t</i> -axis section. One of 1 st 2 sections correct. FT (i) and allow if answer correct with (i) wrong All correct. Accept correct answer with (i) wrong. FT (i) only if 2 nd section –ve in (i)	2
(iii)	(A) upwards; (B) and (C) downwards	E1	All correct. Accept +/- ve but not towards/away from O Accept forwards/backwards. Condone additional wrong statements about position.	1
2 (i)		M1 A1	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ If vector \mathbf{a} seen, isw.	5
(ii)	either $\mathbf{r} = \begin{pmatrix} -1 \\ 2 \end{pmatrix} + \begin{pmatrix} 2 \\ -3 \end{pmatrix} \times 4 + \frac{1}{2}\mathbf{a} \times 4^{2}$ $\mathbf{r} = \begin{pmatrix} 27 \\ 14 \end{pmatrix} \text{ so } \begin{pmatrix} 27 \\ 14 \end{pmatrix} \text{ m}$ or	M1 A1 A1	For use of $\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ with their a. Initial position may be omitted. FT their a. Initial position may be omitted. cao. Do not condone magnitude as final answer. Use of $\mathbf{s} = 0.5t(\mathbf{u} + \mathbf{v})$ Initial position may be omitted.	
		A1 A1	Correct substitution. Initial position may be omitted. cao Do not condone mag as final answer. SC2 for $\binom{28}{12}$	3

(iii)	Using N2L			
	$\mathbf{F} = 5\mathbf{a} = \begin{pmatrix} 12.5 \\ 15 \end{pmatrix} \text{ so } \begin{pmatrix} 12.5 \\ 15 \end{pmatrix} \text{ N}$	M1	Use of $\mathbf{F} = m\mathbf{a}$ or $\mathbf{F} = mg\mathbf{a}$.	
		F1	FT their a only. Do not accept magnitude as final ans.	
				7
				,
3 (i)		M1	Accept $\sqrt{-1^2 + 5^2}$ even if taken to be $\sqrt{24}$	
	$=\sqrt{26} = 5.0990 = 5.10 (3 \text{ s. f.})$	A1		
	Angle with \mathbf{j} is $\arctan(0.2)$	M1	accept $arctan(p)$ where $p = \pm 0.2$ or ± 5 o.e.	
	so 11.309 so 11.3° (3 s. f.)	A1	cao	4
(;;)	(2) (1) (2a)			
(ii)	$ \begin{pmatrix} -2 \\ 3b \end{pmatrix} = 4 \begin{pmatrix} -1 \\ 5 \end{pmatrix} + \begin{pmatrix} 2a \\ a \end{pmatrix} $	M1	$\mathbf{H} = 4\mathbf{F} + \mathbf{G}$ soi	
		M1	Formulating at least 1 scalar equation from their	
	a = 1, b = 7	A1	vector equation soi a correct or G follows from their wrong a	
	so $\mathbf{G} = \begin{pmatrix} 2 \\ 1 \end{pmatrix}$ and $\mathbf{H} = \begin{pmatrix} -2 \\ 21 \end{pmatrix}$	A1	Н сао	
	or $\mathbf{G} = 2\mathbf{i} + \mathbf{j}$ and $\mathbf{H} = -2\mathbf{i} + 21\mathbf{j}$			
	,			4
				8
4(i)	20cos 15 = 19.3185 so 19.3 N (3 s. f.) in direction BC	B1	Accept no direction. Must be evaluated	1
(ii)	Let the tension be T $T \sin 50 = 19.3185$	M1	Accept $\sin \leftrightarrow \cos$ but not (i) $\times \sin 50$	
	so $T = 25.2185$ so 25.2 N (3 s. f.)	F1	FT their 19.3 only. cwo	2
				2
(iii)	$R + 20 \sin 15 - 2.5g - 25.2185 \times \cos 50 = 0$	M1	Allow 1 force missing or 1 tension not resolved. FT <i>T</i> .	
			No extra forces. Accept mass used.	
		B1	Accept sin ↔ cos. Weight correct	
	R = 35.5337 so 35.5 N (3 s. f.)	A1 A1	All correct except sign errors. FT their <i>T</i> cao. Accept 35 or 36 for 2. s.f.	
		A1	- Cao. Accept 55 of 50 for 2. s.i.	4
(iv)	The horizontal resolved part of the 20 N	E1	Accept no reference to vertical component but do	
	force is not changed.		not accept 'no change' to both components. No need to be explicit that value of tension in AB	
			depends only on horizontal component of force at C	
				8
	•		•	

		1		
5(i)	a=6t-12	M1	Differentiating	
3(1)	<i>u</i> = 0 <i>t</i> 12	A1	cao	
				2
(ii)	We need $\int_{1}^{3} (3t^2 - 12t + 14) dt$	M1	Integrating. Neglect limits.	
	$= \left[t^3 - 6t^2 + 14t\right]^3$	A1	At least two terms correct. Neglect limits.	
	either			
	= (27 - 54 + 42) - (1 - 6 + 14)	M1	Dep on 1 st M1. Use of limits with attempt at subtraction seen.	
	= 15 - 9 = 6 so 6 m	A1	cao	
	or			
	$s = t^3 - 6t^2 + 14t + C$			
	s = 0 when $t = 1$ gives	M1	Dep on 1 st M1. An attempt to find C using $s(1) = 0$	
	0 = 1 - 6 + 14 + C so $C = -9$		and then evaluating $s(3)$.	
	Put $t = 3$ to give s = 27 - 54 + 42 - 9 = 6 so 6 m.	A1	cao	
	3 27 34 42 7 0 30 0 III.	711	cao	4
(iii)	v > 0 so the particle always travels in the			
(111)	same (+ve) direction	E1	Only award if explicit	
	As the particle never changes direction,	E1	Complete argument	
	the final distance from the starting point			
	is the displacement.			
				8
6 (i)	Component of weight down the plane is			
	$1.5 \times 9.8 \times \frac{2}{7} = 4.2 \text{ N}$	M1	Use of mgk where k involves an attempt at	
		E1	resolution	
		EI	Accept $1.5 \times 9.8 \times \frac{2}{7} = 4.2$ or $14.7 \times \frac{2}{7} = 4.2$ seen	2
				-=
(ii)	Down the plane. Take F down the			
	plane. $4.2 - 6.4 + F = 0$	M1	Allow sign errors. All forces present. No extra	
	1.2 0.1 1	1711	forces.	
	so $F = 2.2$. Friction is 2.2 N down the	A1	Must have direction. [Award 1 for 2.2 N seen and	
	plane		2 for 2.2 N down plane seen]	2
(iii)	F up the plane			
` '	N2L down the plane	M1	N2L. $F = ma$. No extra forces. Allow weight term	
	$4.2 - F = 1.5 \times 1.2$		missing or wrong	
	5 F - 42 19 - 24	A1	Allow only sign errors	
	so $F = 4.2 - 1.8 = 2.4$ Friction is 2.4 N up the plane	A1 A1	± 2.4 cao. Accept no reference to direction if $F = 2.4$.	
	1 Henon 15 2.7 IV up the plane	AI	cao. Accept no reference to uncertoil if $r=2.4$.	4
(iv)	$2^2 = 0.8^2 + 2 \times 1.2 \times s$	M1	Use of $v^2 = u^2 + 2as$ or sequence	
		A1	All correct in 1 or 2-step method	
	s = 1.4 so 1.4 m	A1		2
		J	J	3

either Up the planeM1N2L. $F = ma$. No extra forces. Condone sign errors. All with arrows. All forces present and properly labelled with arrows. $10-3.5\times9.8\times^2_7-(2.3+0.7)=3.5a$ M1N2L. $F = ma$. No extra forces. Condone sign errors. Allow total/part weight or total/part friction omitted (but not both). Allow mass instead of weight and mass/weight not or wrongly resolved. $a=-0.8$ so 0.8 m s $^{-2}$. down the plane $T-2\times9.8\times^2_7-0.7=2\times(-0.8)$ M1N2L on one barge with their $\pm a$ (\pm 1.2 or 0). All forces present and weight component attempted. No extra forces. Condone sign errors. $T=4.7$ so 4.7 N. Tension or (separate equations of motion)A1N2L on one barge with their $\pm a$ (\pm 1.2 or 0). All forces present and weight component attempted. No extra forces. Condone sign errors.Barge AM1N2L on one barge with their $\pm a$ (\pm 1.2 or 0). All forces present and weight component attempted. No extra forces. Condone sign errors.Barge BM1N2L on one barge with their $\pm a$ (\pm 1.2 or 0). All forces present and weight component attempted and with a row of weight and was sused instead of weight and was sused ins	(v)	Diagrams	B1	Frictions and coupling force correctly labelled	
either Up the planeM1N2L. $F = ma$. No extra forces. Condone sign errors. Allow total/part weight or total/part friction omitted (but not both). Allow mass instead of weight and mass/weight not or wrongly resolved. $a = -0.8 \text{ so } 0.8 \text{ m s}^2$. down the plane $For barge B$ up the plane $T = 2 \times 9.8 \times \frac{2}{7} - 0.7 = 2 \times (-0.8)$ A1Clear description or diagram $T = 4.7 \text{ so } 4.7 \text{ N. Tension}$ or (separate equations of motion)M1N2L on one barge with their $\pm a$ ($\pm 1.2 \text{ or } 0$). All forces present and weight component attempted. No extra forces. Condone sign errors.Barge AM1N2L on one barge with their $\pm a$ ($\pm 1.2 \text{ or } 0$). All forces present and weight or friction missing and also allow mass used instead of weight and wt not or wrongly resolved. In other equa weight component attempted and friction term present. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors.Barge BM1N2L. Do not allow $F = mga$. No extra forces. Condone sign errors.M1N2L. Do not allow $F = mga$. No extra forces. Condone sign errors.M1N2L. Do not allow $F = mga$. No extra forces. Condone sign errors.M1V2L. Do not allow $F = mga$. No extra forces. Condone sign errors.M1V2L. Do not allow $F = mga$. No extra forces.Condone sign errors.Solving a pair of equns in a and T 4A1Clear description or diagram cao cwoT(i) $y(0) = 1$ B1Either (ii) $\frac{1}{2}(20+5) - 5 = 7.5$ M1Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 $1.2.5$ o.e. seen A1 $1.2.5$ o.e. seen A1 $1.2.5$					
either Up the plane 10-3.5×9.8× $\frac{2}{7}$ -(2.3+0.7)=3.5a M1 N2L. $F = ma$. No extra forces. Condone sign errors. Allow total/part weight or total/part friction omitted (but not both). Allow mass instead of weight and mass/weight not or wrongly resolved. B1 Correct overall mass and friction A1 Clear description or diagram For barge B up the plane $T - 2 \times 9.8 \times \frac{2}{7} - 0.7 = 2 \times (-0.8)$ M1 N2L on one barge with their $\pm a \neq 1.2$ or 0). All forces present and weight component attempted. No extra forces. Condone sign errors. T = 4.7 so 4.7 N. Tension or (separate equations of motion) A1 Barge A Barge A Barge B M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. A1 Clear description or diagram and also allow mass used instead of weight and we not or wrongly resolved. In other equn weight component attempted and friction term present. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. A1 Clear description or diagram and T Clear description or diagram cao ewo T(i) $y(0) = 1$ B1 Either $\frac{1}{2}(20+5) - 5 = 7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 A1 Clear description or diagram cao ewo T(i) $\frac{1}{2}(20+5) - 5 = 7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 A1 A1 A1 A1 A1 A1 Clear description or diagram cao ewo			B1	All forces present and properly labelled with	
Up the plane $10-3.5 \times 9.8 \times \frac{3}{7} - (2.3 + 0.7) = 3.5a$ $10-3.5 \times 9.8 \times \frac{3}{7} - (2.3 + 0.7) = 3.5a$ $10-3.5 \times 9.8 \times \frac{3}{7} - (2.3 + 0.7) = 3.5a$ $10-3.5 \times 9.8 \times \frac{3}{7} - (2.3 + 0.7) = 3.5a$ B1 $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. down the plane For barge B up the plane For barge B up the plane $T - 2 \times 9.8 \times \frac{3}{7} - 0.7 = 2 \times (-0.8)$ T= 4.7 so 4.7 N. Tension or (separate equations of motion) B1 $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. down the plane T= 4.7 so 4.7 N. Tension or (separate equations of motion) A1 Barge A Barge B M1 M2L. On one barge with their $\pm a \neq 1.2 \text{ or } 0$). All forces present and weight component attempted. No extra forces. Condone sign errors. M1 M2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 M2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 M2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 M2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 Clear description or diagram a = -0.8 so 0.8 m s ⁻² . down the plane T = 4.7 so 4.7 N. Tension T = 4.7 so 4.7 N.				1 1 2	
errors. Allow total/part weight or total/part friction omitted (but not both). Allow mass instead of weight and mass/weight not or wrongly resolved. B1 Correct overall mass and friction A1 Clear description or diagram For barge B up the plane $T-2\times9.8\times^2-0.7=2\times(-0.8)$ M1 N2L on one barge with their $\pm a$ ($\neq 1.2$ or 0). All forces present and weight component attempted. No extra forces. Condone sign errors. A1 cao In eom for A or B allow weight or friction missing and also allow mass used instead of weight and wt not or wrongly resolved. In other equn weight component attempted and friction term present. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 Solving a pair of equns in a and a Clear description or diagram cao cwo 7 (i) $y(0) = 1$ B1 Either $\frac{1}{2}(20+5)-5=7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 $\frac{12.5}{2.5}$ o.e. seen A1 $\frac{7}{2.5}$ cao. M1 Attempt at y' and to solve $y' = 0$ A1 $\frac{12.5}{2.5}$ o.e. seen as final answer FT their $\frac{7}{2.5}$ their $\frac{7}{2.5}$ os so 1.5625 m E1 AG		either			
$a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}.$ $down the plane$ For barge B up the plane $T - 2 \times 9.8 \times \frac{2}{7} - 0.7 = 2 \times (-0.8)$ $T = 4.7 \text{ so } 4.7 \text{ N. Tension}$ or (separate equations of motion) $A1$ $B1$ $T = 4.7 \text{ so } 4.7 \text{ N. Tension}$ or (separate equations of motion) $A1$ $A1$ $A2$ $A3$ $A4$ $A4$ $A4$ $A5$ $A5$ $A5$ $A5$ $A6$ $A6$ $A7$ $A8$ $A8$ $A8$ $A8$ $A9$ $A9$ $A9$ $A9$ $A9$ $A9$ $A9$ $A9$		Up the plane	M1		
$a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}.$ $down the plane$ For barge B up the plane $T - 2 \times 9.8 \times \frac{2}{3} - 0.7 = 2 \times (-0.8)$ M1 N2L. on one barge with their $\pm a$ (\pm 1.2 or 0). All forces present and weight component attempted. No extra forces. Condone sign errors. $T = 4.7 \text{ so } 4.7 \text{ N. Tension}$ or (separate equations of motion) Barge A Barge B M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 Clear description or diagram T=4.7 so 4.7 N. Tension T(i) $y(0) = 1$ B1 Either (ii) $\frac{1}{2}(20+5)-5=7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 12.5 o.e. seen A1		$10 - 3.5 \times 9.8 \times \frac{2}{7} - (2.3 + 0.7) = 3.5a$		omitted (but not both). Allow mass instead of weight and mass/weight not or wrongly resolved.	
For barge B up the plane $T-2\times 9.8\times \frac{2}{7}-0.7=2\times (-0.8)$ M1 N2L on one barge with their $\pm a$ (\pm 1.2 or 0). All forces present and weight component attempted. No extra forces. Condone sign errors. A1 cao In eom for A or B allow weight or friction missing and also allow mass used instead of weight and wt not or wrongly resolved. In other equn weight component attempted and friction term present. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. Barge B M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. Solving a pair of equns in a and a and a and a and a cao evo T(i) $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. down the plane $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. down the plane $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. down the plane $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. M1 Either $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. M1 Use of symmetry e.g. use of $a = 0.8 \text{ so } 0.8 \text{ m s}^{-2}$. A1 12.5 o.e. seen 7.5 cao M1 A1 T2.5 o.e. seen 7.5 cao A1 A1 T2.5 cao, seen as final answer M1 T3.5 cao, seen as final answer M1 T3.5 cao, seen as final answer T4 their 7.5 E1 A6		$a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$.	B1	Correct overall mass and friction	
For barge B up the plane $T-2\times 9.8\times \frac{2}{7}-0.7=2\times (-0.8)$ M1 N2L on one barge with their $\pm a$ (\pm 1.2 or 0). All forces present and weight component attempted. No extra forces. Condone sign errors. A1 cao In eom for A or B allow weight or friction missing and also allow mass used instead of weight and wt not or wrongly resolved. In other equn weight component attempted and friction term present. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. Barge B M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. Solving a pair of equns in a and a and a and a cao evo T(i) $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. down the plane $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. down the plane $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. down the plane $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. A1 Clear description or diagram cao evo T(i) $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. M1 Use of symmetry e.g. use of $a = 0.8 \text{ so } 0.8 \text{ m s}^{-2}$. A1 12.5 o.e. seen 7.5 cao M1 A1 N2L no none barge with their $a = 0.8 \text{ so } 0.8 \text{ m}$ and with their $a = 0.8 \text{ so } 0.8 \text{ m}$ in the plane $a = 0.8 \text{ so } 0.8 \text{ m}$ in the plane $a = 0.8 \text{ so } 0.8 \text{ m}$ in $a = 0$			A1	Clear description or diagram	
$T-2\times9.8\times^2_7-0.7=2\times(-0.8)$ $T-2\times9.8\times^2_7-0.7=2\times(-0.8)$ $T=4.7 \text{ so } 4.7 \text{ N. Tension}$ or (separate equations of motion) $T=4.7 \text{ so } 4.7 \text{ N. Tension}$ or (separate equations of motion) $T=4.7 \text{ so } 4.7 \text{ N. Tension}$ $T=4.7 \text{ so } 4.7 N. Tensio$		<u> </u>			
or (separate equations of motion) In eom for A or B allow weight or friction missing and also allow mass used instead of weight and wt not or wrongly resolved. In other equn weight component attempted and friction term present. Barge A M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 Solving a pair of equns in a and a Clear description or diagram cao cwo 7 (i) $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. M1 Use of symmetry e.g. use of $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Use of symmetry e.g. use of $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Use of symmetry e.g. use of $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Use of symmetry e.g. use of $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M2 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M3 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M4 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M5 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M6 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M1 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M2 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M3 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M4 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M5 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M6 Attempt at $a = 0.8 \text{ so } 0.8 \text{ m}^{-2}$. M7 So cao, seen as final answer. M8 Attempt at $a $			M1	forces present and weight component attempted.	
and also allow mass used instead of weight and wt not or wrongly resolved. In other equn weight component attempted and friction term present. M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 Solving a pair of equns in a and a Clear description or diagram cao cwo To iv $y(0) = 1$ B1 Either (ii) $y(0) = 1$ B1 Either (iii) $y(0) = 1$ B1 Use of symmetry e.g. use of $\frac{1}{2}(20 + 5)$ A1 $y(0) = 1$ B1 Tightharpoonup in $y(0) = 1$ A1 $y(0) = 1$ A2 $y(0) = 1$ A3 $y(0) = 1$ A4 $y(0) = 1$ A5 $y(0) = 1$ A6 $y(0) = 1$ A6 $y(0) = 1$ A7 $y(0) = 1$ A8 $y(0) = 1$ A9 $y(0) = 1$ A1 $y(0) = 1$ A1 $y(0) = 1$ A2 $y(0) = 1$ A3 $y(0) = 1$ A4 $y(0) = 1$ A5 $y(0) = 1$ A6 $y(0) = 1$ A7 $y(0) = 1$ A8 $y(0) = 1$ A9 $y(0) = 1$ A1 $y(0) = 1$ A1 $y(0) = 1$ A2 $y(0) = 1$ A3 $y(0) = 1$ A4 $y(0) = 1$ A5 $y(0) = 1$ A6 $y(0) = 1$ A7 $y(0) = 1$ A8 $y(0) = 1$ A9 $y(0) = 1$ A1 $y(0) = 1$ A1 $y(0) = 1$ A2 $y(0) = 1$ A3 $y(0) = 1$ A4 $y(0) = 1$ A5 $y(0) = 1$ A6 $y(0) = 1$ A7 $y(0) = 1$ A8 $y(0) = 1$ A9 $y(0) = 1$ A1 $y(0) = 1$ A1 $y(0) = 1$ A2 $y(0) = 1$ A3 $y(0) = 1$ A4 $y(0) = 1$ A5 $y(0) = 1$ A7 $y(0) = 1$ A8 $y(0) = 1$ A9 $y(0) = 1$ A1 $y(0) = 1$ A1 $y(0) = 1$ A2 $y(0) = 1$ A3 $y(0) = 1$ A4 $y(0) = 1$ A5 $y(0) = 1$ A7 $y(0) = 1$ A8 $y(0) = 1$ A9 $y(0) = 1$ A1		T = 4.7 so 4.7 N. Tension	A1	cao	
Barge A Barge B M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. Solving a pair of equns in a and a and a and a and a clear description or diagram cao cwo 7 (i) $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. M1 Clear description or diagram cao cwo 8 Either (ii) $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. M1 Use of symmetry e.g. use of $a = -0.8 \text{ so } 0.8 \text{ m}^{-2}$. A1 12.5 o.e. seen A1 A1 A1 Clear description or diagram cao cwo A1 A2 A1 A2 A3 A3 A4 A4 A4 A4 A4 A5 A5 A6 A7 A7 A7 A7 A7 A8 A8 A8 A8 A8		or (separate equations of motion)		not or wrongly resolved. In other equn weight	
Barge B M1 N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. Solving a pair of equns in a and T $a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$. down the plane $T = 4.7 \text{ so } 4.7 \text{ N}$. Tension A1 Clear description or diagram cao cwo T(i) $y(0) = 1$ B1 Either $\frac{1}{2}(20+5)-5=7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 12.5 o.e. seen A1 7.5 cao M1 Attempt at y ' and to solve y ' = 0 A1 A1 A1 A1 T.5 cao, seen as final answer $y(7.5) = \frac{1}{100}(100+15\times7.5-7.5^2)$ $y(7.5) = \frac{25}{16}(1.5625) \text{ so } 1.5625 \text{ m}$ E1 AG		Barge A	M1	N2L. Do not allow $F = mga$. No extra forces.	
M1 Solving a pair of equns in a and T Clear description or diagram A1 Clear description or diagram Cao cwo 7 (i) $y(0) = 1$ B1 B1 Either $\frac{1}{2}(20+5)-5=7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 12.5 o.e. seen A1 7.5 cao A1 Attempt at y ' and to solve y ' = 0 A1 $k(15-2x)$ where $k=1$ or $\frac{1}{100}$ A1 7.5 cao, seen as final answer $y(7.5) = \frac{1}{100}(100+15\times7.5-7.5^2)$ A1 AG AG AG AG		Barge B	M1	N2L. Do not allow $F = mga$. No extra forces.	
down the plane $T = 4.7$ so 4.7 N. Tension A1 A1 Clear description or diagram cao cwo 7 (i) $y(0) = 1$ B1 Either $\frac{1}{2}(20+5)-5=7.5$ M1 A1 A1 A1 A2.5 o.e. seen A1 A2.9 where $k = 1$ or $\frac{1}{100}$ A1 A1 A2.5 cao, seen as final answer A1 A2.5 cao, seen as final answer A3 A4 A5 A6			M1		
$T = 4.7$ so 4.7 N. Tension A1 cao cwo $T = 4.7$ so 4.7 N. Tension A1 cao cwo $T = 4.7$ so 4.7 N. Tension B1 $T = 4.7$ so 4.7 N. Tension M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 A1 cao cwo A1 cao cwo $T = 4.7$ so 4.7 N. Tension M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 A1 cao cwo A2 cao cwo $T = 4.7$ so 1.7 cao. A2 cao cwo A3 cao cwo $T = 4.7$ so 1.7 cao. A3 cao cwo A4 cao cwo A4 cao cwo A5 cao cwo A5 cao cwo A6 cao cwo A7 cao cwo A1 cao cwo		$a = -0.8 \text{ so } 0.8 \text{ m s}^{-2}$.			
7 (i) $y(0) = 1$ B1 Either $\frac{1}{2}(20+5) - 5 = 7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 12.5 o.e. seen A1 7.5 cao M1 Attempt at y' and to solve $y' = 0$ A1 $k(15-2x)$ where $k = 1$ or $\frac{1}{100}$ A1 7.5 cao, seen as final answer $y(7.5) = \frac{1}{100}(100+15\times7.5-7.5^2)$ A1 y' A1		down the plane	A 1	Clear description or diagram	
(ii) Either $\frac{1}{2}(20+5)-5=7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 12.5 o.e. seen A1 7.5 cao M1 Attempt at y' and to solve y' = 0 A1 $k(15-2x)$ where $k=1$ or $\frac{1}{100}$ A1 7.5 cao, seen as final answer $y(7.5) = \frac{1}{100}(100+15\times7.5-7.5^2)$ $= \frac{25}{16}(1.5625)$ so 1.5625 m E1 AG		T = 4.7 so 4.7 N. Tension	A1	cao cwo	
(ii) Either $\frac{1}{2}(20+5)-5=7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 12.5 o.e. seen A1 7.5 cao M1 Attempt at y' and to solve y' = 0 A1 $k(15-2x)$ where $k=1$ or $\frac{1}{100}$ A1 7.5 cao, seen as final answer $y(7.5) = \frac{1}{100}(100+15\times7.5-7.5^2)$ $= \frac{25}{16}(1.5625)$ so 1.5625 m E1 AG					7
(ii) Either $\frac{1}{2}(20+5)-5=7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 12.5 o.e. seen A1 7.5 cao M1 Attempt at y' and to solve y' = 0 A1 $k(15-2x)$ where $k=1$ or $\frac{1}{100}$ A1 7.5 cao, seen as final answer $y(7.5) = \frac{1}{100}(100+15\times7.5-7.5^2)$ $= \frac{25}{16} (1.5625) \text{ so } 1.5625 \text{ m}$ EI AG					18
(ii) $\frac{1}{2}(20+5)-5=7.5$ M1 Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ A1 12.5 o.e. seen A1 7.5 cao M1 Attempt at y' and to solve $y'=0$ A1 $k(15-2x)$ where $k=1$ or $\frac{1}{100}$ A1 7.5 cao, seen as final answer FT their 7.5 E1 AG	7 (i)	y(0) = 1	B1		1
or $ \begin{array}{ccccccccccccccccccccccccccccccccccc$		Either			
or $ \begin{array}{ccccccccccccccccccccccccccccccccccc$	(ii)	$\frac{1}{2}(20+5)-5=7.5$	M1	Use of symmetry e.g. use of $\frac{1}{2}(20+5)$	
or $ \begin{array}{ccccccccccccccccccccccccccccccccccc$			A1		
or $ M1 Attempt at y' and to solve y' = 0 A1 k(15-2x) where k = 1 or \frac{1}{100} A1 7.5 cao, seen as final answer y(7.5) = \frac{1}{100} (100 + 15 \times 7.5 - 7.5^{2}) = \frac{25}{16} (1.5625) \text{ so } 1.5625 \text{ m} A1 7.5 cao, seen as final answer FT their 7.5 E1 AG $					
$y(7.5) = \frac{1}{100} (100 + 15 \times 7.5 - 7.5^2)$ $= \frac{25}{16} (1.5625) \text{ so } 1.5625 \text{ m}$ A1 A1 T.5 cao, seen as final answer FT their 7.5 E1 AG		or		Attempt at y' and to solve $y' = 0$	
$y(7.5) = \frac{1}{100} (100 + 15 \times 7.5 - 7.5^2)$ $= \frac{25}{16} (1.5625) \text{ so } 1.5625 \text{ m}$ A1 A1 A2 T.5 cao, seen as final answer FT their 7.5 E1 AG			A1	1 7	
$y(7.5) = \frac{1}{100} (100 + 15 \times 7.5 - 7.5^2)$ M1 FT their 7.5 = $\frac{25}{16}$ (1.5625) so 1.5625 m E1 AG			A 1	100	
		$y(7.5) = \frac{1}{100} (100 + 15 \times 7.5 - 7.5^2)$			
		$=\frac{25}{16}$ (1.5625) so 1.5625 m	E1	AG	
[SC2 only showing 1.3623 leads to $x = 7.3$]				[SC2 only showing 1.5625 leads to $x = 7.5$]	5

(iii)	$4.9t^2 = \frac{25}{16} (1.5625)$	M1	Use of $s = ut + 0.5at^2$ with $u = 0$. Condone use of	
(111)	$1.5t - \frac{1}{16} (1.5025)$	1.11	± 10 , ± 9.8 , ± 9.81 . If sequence of <i>suvat</i> used,	
			complete method required.	
		A1	In any method only error accepted is sign error	
	$t^2 = 0.31887$ so $t = \pm 0.56469$			
	Hence 0.565 s (3 s. f.)	E1	AG. Condone no reference to –ve value. www.	
			0.565 must be justified as answer to 3 s. f.	3
(iv)	. 12.5 22.1250	M1	or 25 / (2×0.56469)	
	$\dot{x} = \frac{12.5}{0.56469} = 22.1359$			
		B1	Use of 12.5 or equivalent	
	so 22.1 m s ⁻¹ (3 s. f.))	E1	22.1 must be justified as answer to 3 s. f. Don't	
	Either		penalise if penalty already given in (iii).	
		M1		
	Time is $\frac{20}{12.5} \times 0.56469$ s			
	so 0.904 s (3 s. f.)	A1	cao Accept 0.91 (2 s. f.)	
	or	M1		
	Time is $\frac{20}{22 \cdot 1359}$ s	IVII		
	= 0.903507 so 0.904 s (3 s. f.)	A1	cao Accept 0.91 (2 s. f.)	
	or		(-2.2.)	
	$(iii) + \frac{7.5}{\text{their } \dot{x}}$	M1		
	so 0.904 s (3 s. f.)	A1	cao Accept 0.91 (2 s. f.)	_
				5
(v)	$v = \sqrt{\dot{x}^2 + \dot{y}^2}$	M1	Must have attempts at both components	
	$\dot{y}^2 = 0^2 + 2 \times 9.8 \times \frac{25}{16}$ or	M1	Or equiv. $u = 0$. Condone use of	
	$\dot{y} = 0 + 9.8 \times 0.5646$		$\pm 10, \pm 9.8, \pm 9.81.$	
			Accept wrong s (or t in alternative method)	
	$=\frac{245}{8}$ (30.625) or $\dot{y} = \pm 5.539$	A1	Or equivalent. May be implied. Could come from	
			(iii) if $v^2 = u^2 + 2as$ used there. Award marks again.	
	so $v = \sqrt{490 + 30.625} = 22.8172 \text{ m s}^{-1}$			
	so 22.8 m s ⁻¹ (3 s. f.)	A1	cao. www	
				4
				18