OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

MATHEMATICS (MEI) 4761

Mechanics 1

QUESTION PAPER

Candidates answer on the printed answer book.

OCR supplied materials:
- Printed answer book 4761
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Wednesday 26 January 2011
Afternoon

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the printed answer book and the question paper.

- The question paper will be found in the centre of the printed answer book.
- Write your name, centre number and candidate number in the spaces provided on the printed answer book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the printed answer book.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure 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 scientific or 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 m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

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- The number of marks is given in brackets **[ ]** at the end of each question or part question on the question paper.
- 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**.
- The printed answer book consists of **12** pages. The question paper consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this question paper for marking; it should be retained in the centre or destroyed.

Section A (36 marks)

1 An object C is moving along a vertical straight line. Fig. 1 shows the velocity-time graph for part of its motion. Initially C is moving upwards at $14\,\text{m s}^{-1}$ and after 10 s it is moving downwards at $6\,\text{m s}^{-1}$.

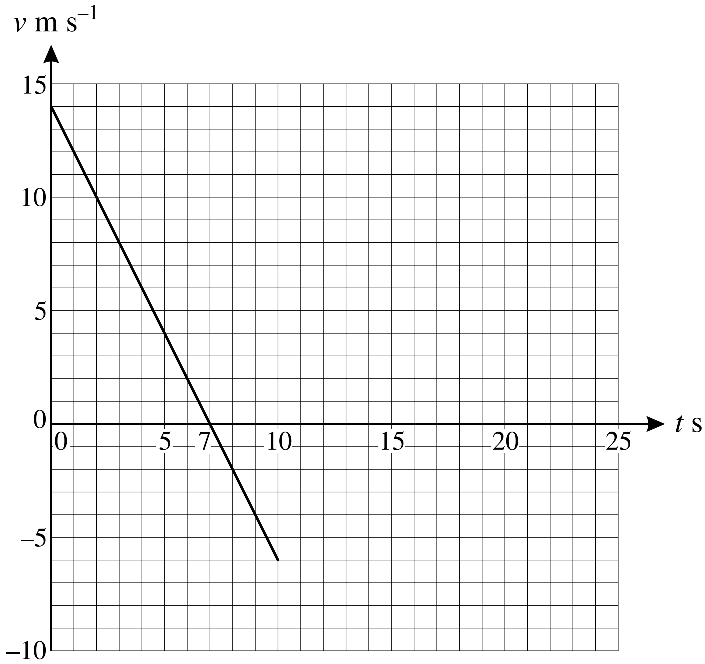

Fig. 1

C then moves as follows.

- In the interval $10 \leqslant t \leqslant 15$, the velocity of C is constant at $6\,\text{m s}^{-1}$ downwards.
- In the interval $15 \leqslant t \leqslant 20$, the velocity of C increases uniformly so that C has zero velocity at $t = 20$.

(i) Complete the velocity-time graph for the motion of C in the time interval $0 \leqslant t \leqslant 20$. **[2]**

(ii) Calculate the acceleration of C in the time interval $0 < t < 10$. **[2]**

(iii) Calculate the displacement of C from $t = 0$ to $t = 20$. **[4]**

2 Fig. 2 shows two forces acting at A. The figure also shows the perpendicular unit vectors **i** and **j** which are respectively horizontal and vertically upwards.

The resultant of the two forces is **F** N.

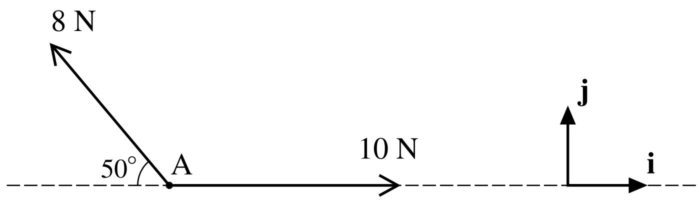

Fig. 2

(i) Find **F** in terms of **i** and **j**, giving your answer correct to three significant figures. **[3]**

(ii) Calculate the magnitude of **F** and the angle that **F** makes with the upward vertical. **[3]**

3 Two cars, P and Q, are being crashed as part of a film 'stunt'.

At the start

- P is travelling directly towards Q with a speed of $8\,\text{m s}^{-1}$,
- Q is instantaneously at rest and has an acceleration of $4\,\text{m s}^{-2}$ directly towards P.

P continues with the same velocity and Q continues with the same acceleration. The cars collide T seconds after the start.

(i) Find expressions in terms of T for how far each of the cars has travelled since the start. **[2]**

At the start, P is 90 m from Q.

(ii) Show that $T^2 + 4T - 45 = 0$ and hence find T. **[5]**

4 At time t seconds, a particle has position with respect to an origin O given by the vector

$$\mathbf{r} = \begin{pmatrix} 8t \\ 10t^2 - 2t^3 \end{pmatrix},$$

where $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$ are perpendicular unit vectors east and north respectively and distances are in metres.

(i) When $t = 1$, the particle is at P. Find the bearing of P from O. **[2]**

(ii) Find the velocity of the particle at time t and show that it is never zero. **[3]**

(iii) Determine the time(s), if any, when the acceleration of the particle is zero. **[3]**

5 Fig. 5 shows two boxes, A of mass 12 kg and B of mass 6 kg, sliding in a straight line on a rough horizontal plane. The boxes are connected by a light rigid rod which is parallel to the line of motion. The only forces acting on the boxes in the line of motion are those due to the rod and a constant force of F N on each box.

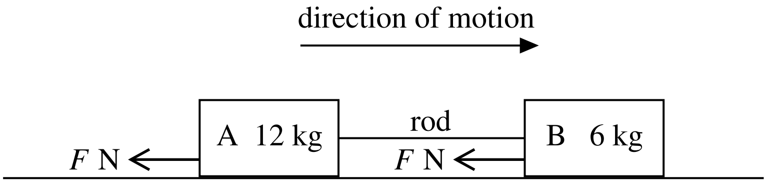

Fig. 5

The boxes have an initial speed of $1.5\,\text{m}\,\text{s}^{-1}$ and come to rest after sliding a distance of 0.375 m.

(i) Calculate the deceleration of the boxes and the value of F. **[4]**

(ii) Calculate the magnitude of the force in the rod and state, with a reason, whether it is a tension or a thrust (compression). **[3]**

Section B (36 marks)

6 A toy sledge of mass 4 kg is being pulled in a straight line by a light string. The resistance to its motion is 6 N.

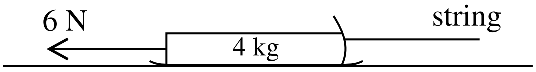

Fig. 6.1

At one time, the string is horizontal and the sledge is on horizontal ground, as shown in Fig. 6.1. The acceleration of the sledge is $3\,\mathrm{m\,s^{-2}}$ forwards.

(i) Calculate the tension in the string. **[3]**

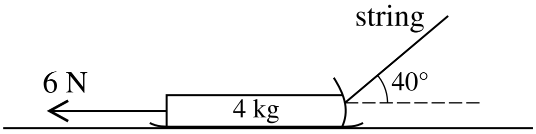

Fig. 6.2

At another time, the sledge is again on horizontal ground but the string is now at 40° to the horizontal, as shown in Fig. 6.2. The tension in the string is 25 N.

(ii) Calculate the acceleration of the sledge. **[3]**

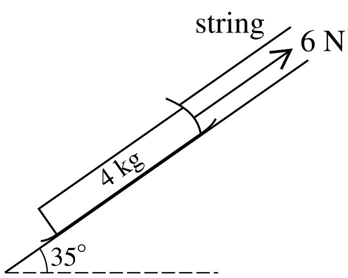

Fig. 6.3

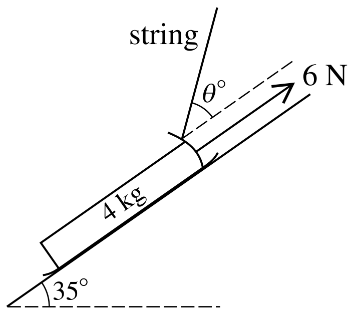

Fig. 6.4

In another situation the sledge is on a slope inclined at 35° to the horizontal, as shown in Fig. 6.3. It is held in equilibrium by the light string parallel to the slope. The resistance to motion of 6 N acts up the slope.

(iii) Calculate the tension in the string. **[3]**

The sledge is now held in equilibrium with the light string inclined at $\theta°$ to the slope, as shown in Fig. 6.4. The tension in the string is 25 N and the resistance to motion remains 6 N acting up the slope.

(iv) (*A*) Show all the forces acting on the sledge. **[2]**

(*B*) Calculate the angle θ. **[3]**

(*C*) Calculate the normal reaction of the slope on the sledge. **[3]**

7

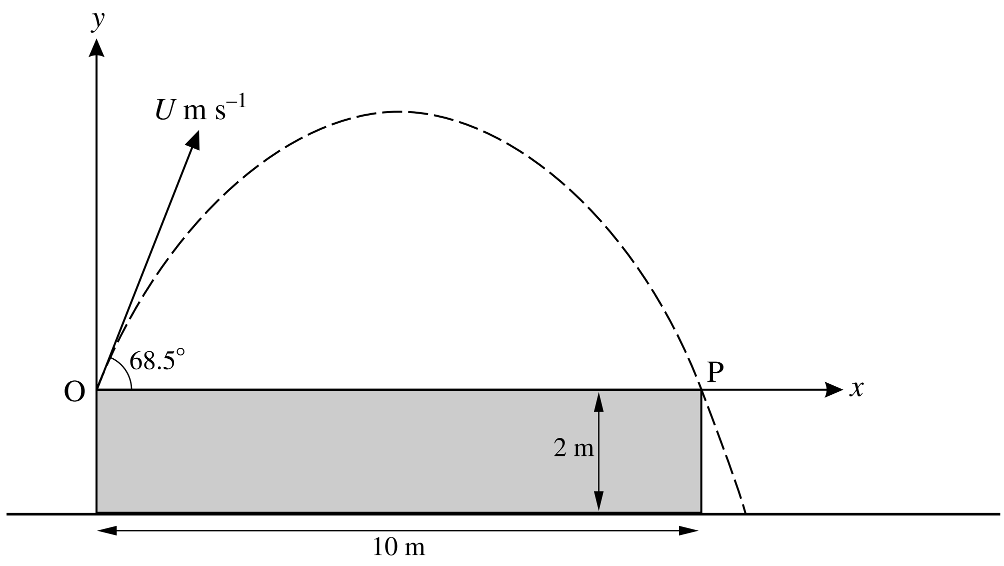

Fig. 7

Fig. 7 shows a platform 10 m long and 2 m high standing on horizontal ground. A small ball projected from the surface of the platform at one end, O, just misses the other end, P. The ball is projected at 68.5° to the horizontal with a speed of U m s^{-1}. Air resistance may be neglected.

At time t seconds after projection, the horizontal and vertical displacements of the ball from O are x m and y m.

(i) Obtain expressions, in terms of U and t, for

(A) x,

(B) y. **[3]**

(ii) The ball takes T s to travel from O to P.

Show that $T = \dfrac{U \sin 68.5°}{4.9}$ and write down a second equation connecting U and T. **[4]**

(iii) Hence show that $U = 12.0$ (correct to three significant figures). **[3]**

(iv) Calculate the horizontal distance of the ball from the platform when the ball lands on the ground. **[5]**

(v) Use the expressions you found in part **(i)** to show that the cartesian equation of the trajectory of the ball in terms of U is

$$y = x \tan 68.5° - \frac{4.9x^2}{U^2(\cos 68.5°)^2}.$$

Use this equation to show again that $U = 12.0$ (correct to three significant figures). **[4]**

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MATHEMATICS (MEI) 4761

Mechanics 1

PRINTED ANSWER BOOK

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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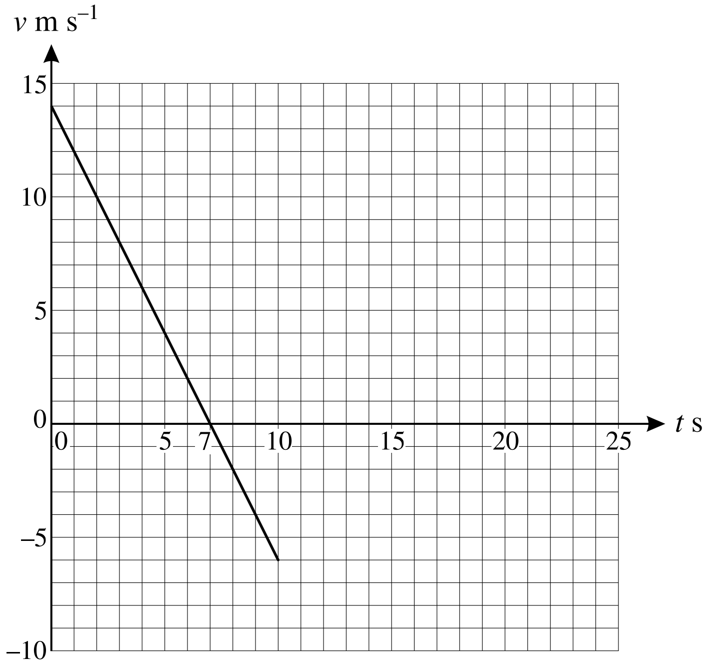
1 (i)



1 (ii)

1 (iii)

2 (i)	
2 (ii)	

3 (i)	
3 (ii)	

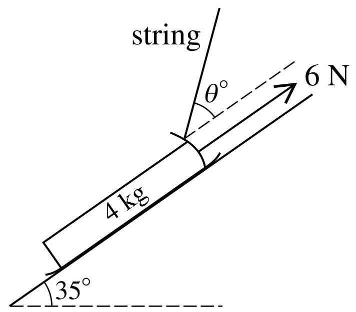
4 (i)	
4 (ii)	
4 (iii)	

5 (i)	

5 (ii)

Section B (36 marks)

6 (i)	
6 (ii)	
6 (iii)	

6(iv)(A)	
6(iv)(B)	
6(iv)(C)	

7 (i) (*A*)	
7 (i) (*B*)	
7 (ii)	
7 (iii)	

7 (iv)	
7 (v)	

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GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4761:** Mechanics 1

Mark Scheme for January 2011

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comment
You should expect to follow through from one part to another unless the scheme says otherwise but not follow through within a part unless the scheme specifies this. Each script must be viewed as a whole at some stage so that (i) a candidate's writing of letters, digits, symbols on diagrams etc can be better interpreted; (ii) repeated mistakes can be recognised (e.g. calculator in wrong angle mode throughout – penalty 1 in the script and FT except given answers). You are advised to 'set width' for most questions but to 'set height' for the following:

Q 1		mark	note
(i)		B1 B1 2	Section from t = 10 to t = 15 Section from t = 15 to t = 20. FT connecting from their point when t = 15. Ignore graph outside $0 \le t \le 20$.
(ii)	$\frac{-6-14}{10} = -2$ so – 2 m s^{-2}	M1 A1 2	Attempt at $\frac{\Delta v}{\Delta t}$
(iii)	**either** Displacement is $\frac{14}{2}\times 7 - \frac{13+5}{2}\times 6$ or $\frac{14}{2}\times 7 - \frac{3\times 6}{2} - 5\times 6 - \frac{5\times 6}{2}$ = –5 so 5 m downwards	 M1 B1 B1 A1	FT misread from graph or graphing error to all but final A1 cao Attempt at whole area. Condone 'overlap' but not 'gaps'. 'Positive' area expression correct. Condone sign error. 'Negative' area expression correct. Condone overall sign error. Accept –5 m cao

	or Displacement is $14\times10+\frac{1}{2}\times(-2)\times10^2 -\ 5\times 6 + \frac{-6+0}{2}\times5$ = 140 – 100 – 30 –15 = –5 so 5 m downwards	M1 A1 B1 A1 4	Using *suvat* from 0 to 10 or 15 to 20. Condone 'overlap' but not 'gaps' Subtracting 30 or 15 or 45 Accept –5 m cao
		8	

Q 2		mark	notes
(i)	**F** = (10 – 8cos50)**i** + 8sin50**j** = 4.85769…**i** + 6.128355… **j** so 4.86**i** + 6.13**j** (3 s. f.)	M1 A1 A1 3	Resolution. Accept $s \leftrightarrow c$. Condone resolution in only one direction. Award for a vector with either component correct or consistent $s \leftrightarrow c$ error is only mistake in the vector. Need not be evaluated. cao. Must be in a**i** + b**j** or column format. Must be correct to 3 s. f.
(ii)	$\lvert\mathbf{F}\rvert = \sqrt{4.85769...^2 + 6.12835...^2} = 7.820101...$ so 7.82 (3 s. f.) angle is $\arctan\frac{4.857...}{6.128...}$ = 38.40243… so 38.4° (3 s. f.)	 B1 M1 F1 3	 FT **their F** Or equivalent. FT **their F.** Accept $\arctan\frac{6.128...}{4.857...}$. Accept complementary angle and ± signs FT only **their** *F*.
		6	

Q 3		mark	notes
(i)	For P: the distance is $8T$	B1	Allow – ve. Allow any form.
	For Q: the distance is $\frac{1}{2}\times 4\times T^2$	B1	Allow – ve. Allow any form.
		2	
(ii)	Require $8T+\frac{1}{2}\times 4\times T^2=90$	M1	For linking correct expressions or **their** expressions from (i) with 90. Condone sign errors and use of displacement instead of distance. Condone '= 0'implied.
		A1	The expression is correct or correctly derived from **their** (i). Reason not required.
	so $8T + 2T^2 - 90 = 0$		
	so $T^2 + 4T - 45 = 0$	E1	Must be established. Do not award if **their** 'correct expression' comes from incorrect manipulation.
	This gives		
	$(T - 5)(T + 9) = 0$	M1	Solving to find +ve root. Accept $(T + 5)(T - 9)$.
	so $T = 5$ since $T > 0$	A1	Condone 2nd root not found/discussed but not both roots given.
		5	
		7	

Q 4		mark	notes
(i)	When $t = 1$, $\mathbf{r} = \begin{pmatrix} 8 \\ 10-2 \end{pmatrix} = \begin{pmatrix} 8 \\ 8 \end{pmatrix}$ [8**i** +(10 – 2)**j** = 8**i** + 8**j**] Bearing OP is 045°	 B1 F1 2	Accept column or a**i** + b**j** notation May be implied Accept 45°. Accept NE and northeast. Condone $\lvert\mathbf{r}\rvert$ given as well.
(ii)	$\mathbf{v} = \begin{pmatrix} 8 \\ 20t-6t^2 \end{pmatrix}$ [8**i** + (20t – 6t^2)**j**] The **i** cpt is always 8 so $\mathbf{v} \neq \mathbf{0}$ for any t	M1 A1 E1 3	Differentiating both components. Condone 1 error if clearly attempting differentiation. Must be a vector answer. Accept any correct argument e.g. based on **i** cpt never 0.
(iii)	$\mathbf{a} = \begin{pmatrix} 0 \\ 20-12t \end{pmatrix}$ [(20 – 12t)**j**] $\mathbf{a} = \mathbf{0}$ when $t = \frac{20}{12} = \frac{5}{3}$ so $\frac{5}{3}$ s (1.67 s (3 s. f.))	M1 F1 B1 3	Differentiating as a vector. Condone 1 error if clearly attempting differentiation of **their v**. FT **their v**. cao. Condone obtained from scalar equation.
		8	

Q5		mark	notes
(i)	In direction $\rightarrow$ $0^2 = 1.5^2 + 2 \times a \times 0.375$ so $a = -3$ and deceleration is 3 m s^{-2}	M1 A1	Use of $v^2 = u^2 + 2as$ or complete sequence of *suvat.* CWO. Accept ± 3 and ignore accel or decal.
	N2L on both boxes $\rightarrow$ $-2F = (12+6) \times (-3)$	M1	N2L. Correct mass. Condone $F = mga$. Allow F on LHS. FT **their** a. Accept sign errors. No extra terms.
	so $F = 27$	A1 4	cao Condone this obtained from an equation with consistent signs not justified.
(ii)	Suppose the force in the rod is a tension T N2L gives box A $\rightarrow$ $T - 27 = 12 \times (-3)$ [box B $\rightarrow$ $-T - 27 = 6 \times (-3)$]	M1	N2L. $F = ma$. Correct mass. The ‘27’ and the ‘3’ must have the same sign. Ignore the sign of ‘T’. FT only for mod(their 27) in place of ‘27’ and/or mod(their 3) in place of ‘3’ in this sign pattern. No extra terms.
	so $T = -9$ and the force has magnitude 9 N	F1	Accept $T = \pm 9$. FT only for mod(their 27) in place of ‘27’ and/or mod(their 3) in place of ‘3’.
	It is a thrust (tension is +ve).	E1 3	cao Only accept thrust with $T = \pm 9$ and a sound argument.
		7	

Q 6		mark	notes
(i)	Let tension be T N N2L $\rightarrow T - 6 = 4 \times 3$ T = 18 so 18 N	 M1 A1 A1 3	 Condone $F = mga$. Condone resistance omitted or an extra force. Allow only sign error(s). cao
(ii)	Let acceleration be a m s^{-2} $25\cos 40 - 6 = 4a$ a = 3.28777.. so 3.29 m s^{-2} (3 s. f.)	 M1 M1 A1 3	 Attempt at resolution of 25 N. Allow $s \leftrightarrow c$. Allow $F = mga$ and sign error(s). No extra forces. Both forces present. cao
(iii)	Let tension be T N up the slope $T + 6 - 4 \times 9.8 \times \sin 35 = 0$ T = 16.48419… so 16.5 N (3 s. f.)	 M1 B1 A1 3	 Resolving along slope. Allow 6 N omitted. If different direction used all required forces present (except 6 N). Allow $s \leftrightarrow c$. No extra forces. Allow sign errors. Condone g omitted. If resolution is along plane, weight term correct. If resolution in another direction, one resolution correct.
(iv) (A)		 B1 B1 2	 At least two of tension, weight and NR marked correctly with arrows and labels (accept mg, W, T and words etc). All correct. No extra forces. Accept mg, W, T and words etc. Condone resolved parts as well only if clearly indicated as such by e.g. using dotted lines.
(B)	**continued**		

Q6 (iv) (B)	up the slope $25\cos\theta + 6 - 4g\sin 35 = 0$ so $25\cos\theta = 16.48414...$ so $\theta = 48.7483....$ so 48.7° (3 s. f.)	M1 A1 A1 3	No extra forces. Allow $s \leftrightarrow c$. All forces present and required resolutions attempted. Allow sign errors. Condone g omitted. Condone g omitted. cao [If they use **their** (iii): M1 Equating **their** (iii) to an attempt at resolving 25. Allow $s \leftrightarrow c$. No extra forces. A1 FT **their** T from (iii) A1 cao]
(C)	Resolve perp to slope $R + 25\sin\theta - 4\times 9.8\times\cos 35 = 0$ R = 13.315248.. so 13.3 N (3 s. f.)	M1 A1 A1 3	All forces present and resolutions attempted. No extra forces. Allow $s \leftrightarrow c$. FT their angle. Condone g omitted. FT their angle. Condone g omitted. cao
		17	

Q7		mark	notes
(i) (A)	$x = Ut\cos 68.5°$	B1 1	
(i) (B)	$y = Ut\sin 68.5° - 4.9\times t^2$	M1 A1 2	Allow ‘u’ = U. Allow $s \leftrightarrow c$. Allow g as g, ±9.8, ±9.81, ±10. Allow +2. Accept not ‘shown’. Do not allow +2. Allow e.g + 0.5 × (- 9.8) × t^2 instead of – 4.9t^2. Accept g not evaluated
	continued		

Q7 (ii)	**either** At D, $y = 0$ so $U\sin 68.5° T - 4.9 \times T^2 = 0$ $\Rightarrow T\left(U\sin 68.5° - 4.9T\right) = 0$ so $T = 0$ (at C) or $T = \dfrac{U\sin 68.5°}{4.9}$ (at D) **or** Use (i)(A) and put $x = 10$ with $t = T$ to get $UT\cos 68.5° = 10$	 M1 M1 E1 M1 M1 E1 B1 4	 Equating correct y to 0 or **their** y to correct value. Attempting to factorise (or solve). Allow ÷ T without comment. Properly shown. Accept no ref to $T = 0$. Accept $T = 0$ given as well without comment. Find time to top Double time to the top
(iii)	Eliminating T from the results in (ii) gives $U\cos 68.5° \times \dfrac{U\sin 68.5°}{4.9} = 10$ so $U = 11.98729\ldots$ so 12.0 (3 s. f.)	 M1 M1 E1 3	 Substituting, using correct expressions or **their** expressions from (ii). Attempt to solve for U^2 or U. Some evidence seen. e.g. $142.8025.. < U^2 < 145.2025...$ with clear statement, or 11.9… seen with clear statement or 11.98… seen. Accept 11.98… seen for full marks.
(iv)	**continued**		

(iv)	Require $Ut\sin 68.5° - 4.9t^2 = -2$ Solving $4.9t^2 - Ut\sin 68.5° - 2 = 0$ $t = -\ 0.1670594541\ldots , 2.4431591\ldots$ (Using 12: – 0.1669052502.. , 2.445478886..) Require $U\cos 68.5° \times 2.44\ldots - 10$ = 0.7336…. so 0.734 m (3 s. f.) (Using 12 consistently, 0.7552… so 0.755 (3 s. f.))	M1 M1 A1 M1 A1 5	Equating correct y to – 2 or **their** y to correct value. Allow use of U, 11.987… or 12. Allow implicit '= 0' Dep on 1st M1. Attempt to solve a 3 term quadratic to find at least the +ve root. Allow if two correct roots seen WW. Accept only + ve root given Alternative method of e.g. finding time to highest point and then time to the ground. M1 all times attempted, at least one by a sound method. M1 both methods sound and complete. A1. Dep on first M1. Allow **their** expression for x. Allow ' – 10' omitted. cao. Accept $0.73 \le x \le 0.76$
(v)	Eliminate t from (i) (B) using $t = \frac{x}{U\cos 68.5°}$ from (i)(A) so $y = x\tan 68.5° - \frac{4.9x^2}{U^2(\cos 68.5°)^2}$ We require $y = 0$ when $x = 10$ so $U = 11.98729\ldots$ so 12.0 (3 s. f.)	 M1 E1 M1 E1 4	 May be implied. FT their (i). Clearly shown. Must see attempt to solve. Or use $x = 10.73\ldots$ when $y = -2$. Must see evidence of fresh calculation or statement that they have now got the same expression for evaluation.
		19	

4761 Mechanics 1

General Comments

Most of the candidates were able to make some progress with every question and many made excellent attempts at all of them. Even the strongest candidates were challenged by answers that required an account of the reasoning used; for instance, many candidates failed to convince when attempting to justify their claim that the force in the rod in Q5 was a thrust. It was pleasing to see many candidates able to argue convincingly in Q4(ii) that the velocity was never zero.

The great majority of the candidates showed that they had covered the syllabus thoroughly and many demonstrated the ability to apply their knowledge and skills effectively.

Candidates should either write their answers in the space provided in the Printed Answer Book or write them clearly labelled on supplementary sheets.

Comments on Individual Questions

1 **(i)** Almost all of the candidates completed the graph correctly.

(ii) Many of the candidates had a clear idea of what to do to find the acceleration. A higher proportion of those who tried to find the gradient of the line were successful than those who tried to use the suvat results, but a common mistake was to give 2 instead of – 2 as the answer. A surprisingly large number of candidates took the initial speed to be 15 m s -1, despite the value being given in the text as well as on the graph.

(iii) Quite a few candidates got this wrong but most knew what they were doing. Those who tried to find the signed area under the graph were more likely to get the right answer than those who used the suvat results. Some candidates clearly did not know what 'the area under the graph' means. Common errors were: taking the lowest velocity to be – 5 instead of – 6 m s -1; not counting the areas below the time axis as negative and so finding the distance travelled instead of the displacement; finding the displacement from t = 0 to t = 10 correctly using suvat results and then subtracting the areas 'under' the graph from t = 7 to t = 20.

2 **(i)** Most candidates knew what to do but quite a few got into a muddle with the signs of the components of the force of magnitude 8 N. A few candidates failed to give their answers correct to 3 significant figures.

(ii) Many perfect answers, the most common error being to find the angle with the horizontal instead of the upward vertical.

3 **(i)** A few candidates could not do this; quite a few gave expressions that were not distances or displacements.

(ii) It seems that most candidates had no problem with visualising the situation and formulating the required (and given) quadratic equation. Some argued using distance and others using displacement. However, quite a few candidates got themselves into a muddle and, having found that the two cars had travelled distances 8T m and $2T^2$ m towards each other from positions 90 m apart when they collided after T s, could not write down $8T + 2T^2 = 90$ or an equivalent expression; some gave up after several tries and others made no attempt. I can only think that this was due to their not being used to formulating equations from given information. Most candidates correctly solved the quadratic but a few lost the final mark as they gave both the positive and the negative roots as answers.

4 In this question as well as Q2, a few candidates seemed unaware of the meaning of a vector expression and the comments below refer only to the candidates who did. Some candidates showed awareness in only one of these questions.

(i) Almost all candidates found the position vector of P and its bearing from O.

(ii) Only a very few candidates failed to use calculus in some way and most obtained the correct vector. Many candidates correctly stated that the vector could not be zero as its i component was always 8 and so it must always have a speed of at least 8 m s -1. A few candidates only claimed that the vector was not zero when t = 0, which is not a complete argument.

(iii) Most candidates knew they should differentiate their velocity vector and did this accurately. Almost all of these candidates then found the required value of t. Some candidates who did not write down the acceleration in vector form (which was acceptable) then made no reference at all to the i component (which was not).

5 **(i)** Almost all of the candidates knew how to find the deceleration correctly. Most did this directly and accurately using $v^2 = u^2 + 2as$ but some went via finding the time and falsely used the zero acceleration result s = ut.

More candidates tried to find F, used Newton's second law on the complete system with mass 18 kg than considered separate equations of motion. In both methods candidates made sign errors. Many using the complete system method used F instead of 2F but on the whole those using this method made fewer mistakes than those producing two equations.

(ii) There were some excellent answers to this part but not many candidates produced a correct solution. The most common problem was with sign errors. The arguments used to establish whether the rod was in tension or compression were often falsely based on wrong general principles (for example, the boxes are decelerating so the rod is in compression) or incomplete arguments.

6 There were many excellent solutions to all or almost all parts of this question. Unusually, some good answers came from candidates who had not done particularly well overall. It seemed that there were fewer instances than in recent series of incorrect resolution, confusion of mass and weight, and misunderstanding of the term normal reaction. Apart from the small number of candidates who took Newton's second law to be F = mga or F – mg = ma, wrong answers mostly came from sign errors made either in the formulation of the equations or during manipulation or from omitted forces.

(i) Most candidates knew what to do and obtained the correct answer.

(ii) Again, most candidates knew they should resolve horizontally and did so accurately.

(iii) The few candidates who resolved other than parallel to the plane usually omitted the component of the normal reaction.

(iv)(A) A lot of candidates failed to produce a correct diagram. The most common errors were: omitting the normal reaction; omitting an arrow or label; introducing another friction force down the plane; putting in a force and its components (without indicating in some way that the components were not additional forces).

(iv)(B) Most candidates started this part from first principles but a pleasing number saw the short cut and wrote down □cos□= their answer to (iii).

(iv)(C) I thought that, compared with recent examination series, fewer candidates did not use a proper definition of 'normal reaction'; however, this remained the most common error, especially using the false definition of normal reaction as being the component of the weight perpendicular to the plane.

7 A fairly common mistake was to take the origin to be at ground instead of platform level; this mistake made it harder to establish some of the results and impossible to find the given cartesian trajectory equation in part (v).

(i) Most candidates correctly wrote down the components of displacement at time t.

(ii) Many of the candidates saw what to do. Many who had the origin on the ground in (i)(B) used correct their equations in this part. Candidates who argued that y = 0 when t = T tended to do better than those who argued that T is twice the time it takes for the ball to reach its highest point. Quite a few candidates fudged the result by using v = u + at with a stated to be 4.9 instead of t = ½ T. Quite a few candidates did not use the horizontal displacement to obtain their second equation but instead simply gave a different form of the equation obtained by considering the vertical displacement (this was often different from the first equation because of a derivation or manipulation error).

(iii) Many candidates attempted to do the right thing, many producing the correct horizontal displacement equation in this part when they had no equation or the wrong equation in part (ii). A common error was for candidates to fail to show that their answers agreed with the correct answer to 3 significant figures. No candidate who tried to show that the use of u = 12.0 gave consistent results in the two equations could establish the accuracy of the result. There were many good answers to this part.

(iv) Many candidates made mistakes in this part which required, perhaps, the clearest thinking on the paper. A common mistake was to equate y to 0 or even + 2 instead of – 2. Most candidates who got started on this part realized that they should use the quadratic formula and did so accurately. There were many clear, concise and correct solutions.

(v) Most candidates who attempted this part knew how to establish the cartesian equation of the trajectory and did so well. The last request defeated many candidates, who didn't realize that they just need to use the result y = 0 when x = 10 (or y = – 2 when x takes the value 10 + their answer to part (iv)). There were many nice, concise answers.

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