OCR
Oxford Cambridge and RSA

Friday 15 June 2018 – Afternoon

AS GCE MATHEMATICS (MEI)

4761/01 Mechanics 1

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4761/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

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 inside 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. HB 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 barcodes.
- 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 $g\,\text{m}\,\text{s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- 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 **16** 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 recycled. Please contact OCR Copyright should you wish to re-use this document.

Section A (36 marks)

1 Fig. 1 shows a block of mass 10 kg on a rough horizontal table.

One end of a string is attached to the block. The string passes over a smooth pulley and the other end is attached to a sphere of mass 5 kg which is hanging freely. The string makes an angle of 30° with the vertical. The string is light and inextensible.

The system is in equilibrium.

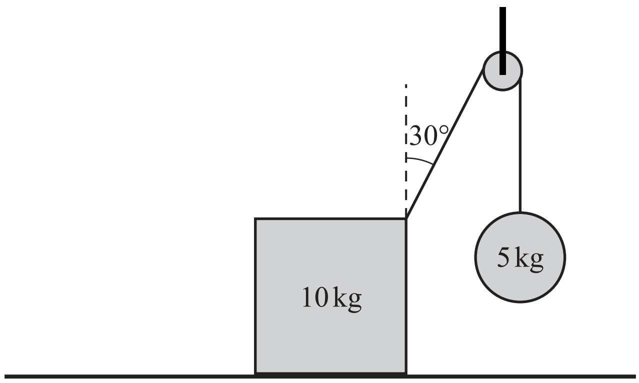

Fig. 1

(i) Draw a diagram showing all the forces acting on the block. **[3]**

(ii) Calculate the normal reaction of the table on the block.

Calculate also the frictional force acting on the block. **[3]**

(iii) Find the magnitude of the resultant of the forces that the table exerts on the block. **[2]**

2 In this question you should use the standard projectile model with $g = 9.8\,\mathrm{m\,s^{-2}}$.

Fig. 2 illustrates a situation in a cricket match.

A batsman has hit the ball in the air from the point B, 1 metre above the ground at P, towards the boundary at Q. The ground is horizontal and the distance PQ is 70 m. A fielder is standing at Q.

The initial velocity of the ball is $28\,\mathrm{m\,s^{-1}}$ at 30° to the horizontal.

Not to scale

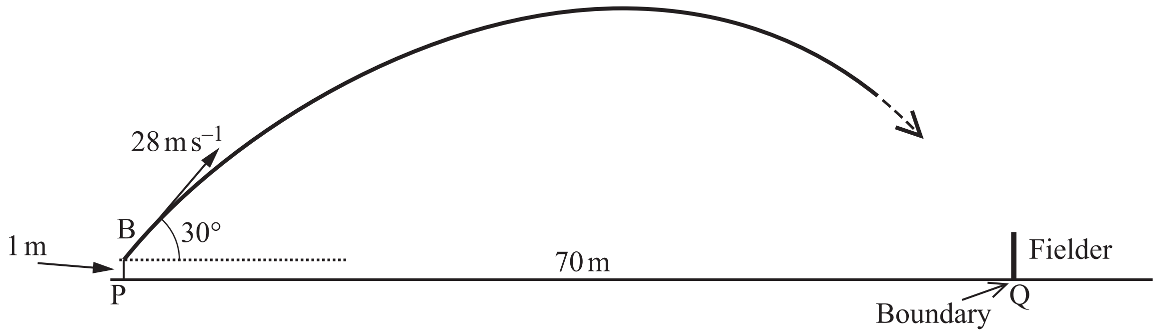

Fig. 2

(i) Find the greatest height of the ball above the ground during its flight. **[4]**

The height of the ball above the ground when it reaches the boundary at Q is denoted by h metres.

- If $h > 2.2$, the batsman will score 6 runs.
- If $0 \leqslant h \leqslant 2.2$, the fielder will catch the ball and the batsman will be out.
- If the ball hits the ground before it reaches Q, the fielder will stop it, and the batsman will score 1 run.

(ii) Determine what happens. **[4]**

3 Fig. 3 illustrates a car towing a trailer. They are connected by a light horizontal tow-bar and are travelling in a straight line along a horizontal road.

- The mass of the car is 1000 kg and the mass of the trailer is 600 kg.
- The resistance to motion is 300 N for the car and 100 N for the trailer.
- The driving force exerted by the car is D N.

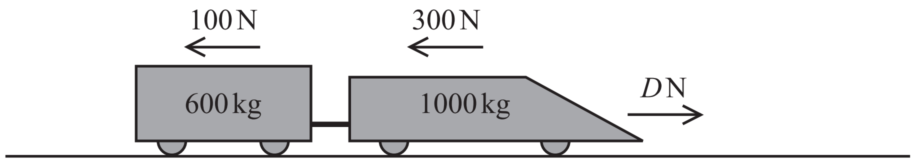

Fig. 3

(i) Initially $D = 1200$.

Find the acceleration of the car and the tension in the tow-bar. **[4]**

(ii) After some time the driving force is removed so that $D = 0$.

Find the new force in the tow-bar, stating whether it is a tension or a thrust. **[4]**

4 Salome takes a lift from the ground floor of a building vertically upwards to the floor where her office is situated. Her velocity, v, at time t is shown in Fig. 4. She stands still in the lift.

Salome's mass is 50 kg.

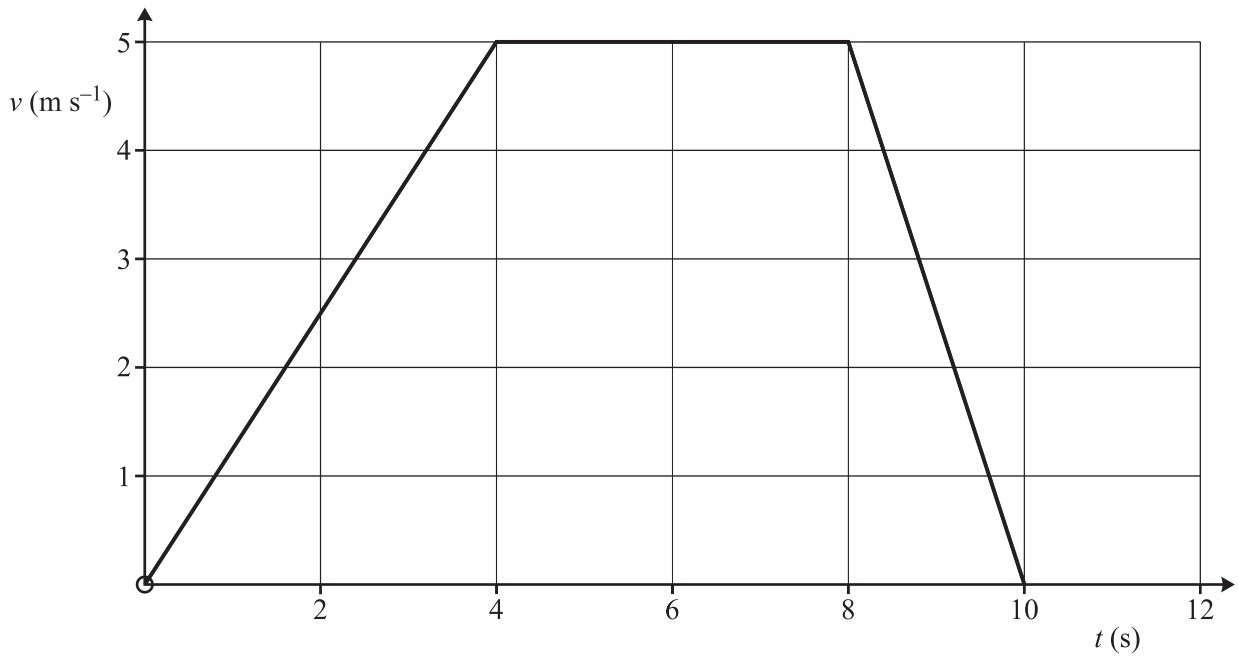

Fig. 4

(i) Find Salome's acceleration in each of the three phases of her motion. **[2]**

(ii) Find the greatest force that the floor of the lift exerts on Salome. **[2]**

5 Alice is driving along a straight narrow country road when she sees that a tree has fallen across the road in front of her. She applies the car's brakes with ever increasing firmness as she approaches the tree.

- The car's initial speed is $21\,\mathrm{m\,s^{-1}}$.
- The tree is 75 m from the front of Alice's car when she first applies the brakes.
- The car's acceleration, $a\,\mathrm{m\,s^{-2}}$, is given by $a = -2 - \frac{1}{2}t$ where t s is the time since Alice first applies the brakes.

Does Alice's car hit the tree? **[8]**

Section B (36 marks)

6 Two beetles, A and B, are on a large patio which is modelled as a flat horizontal surface.

Cartesian axes are defined relative to an origin near the middle of the patio; the direction of the x-axis is East and the direction of the y-axis is North.

The unit vectors $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$ are in the x- and y- directions.

The unit for distance is 1 metre. Time, t, is measured in seconds and $0 \leqslant t \leqslant 5$.

The position vector, $\mathbf{r}_\mathbf{A}$ m, of beetle A at time t is given by $\mathbf{r}_\mathbf{A} = \begin{pmatrix} t-1 \\ t^2-2 \end{pmatrix}$.

(i) Write down A's velocity and acceleration at time t. **[3]**

Beetle B is initially at the point $(-1, 10)$ and is initially moving with velocity $\begin{pmatrix} 1 \\ -4 \end{pmatrix}$ $\mathrm{m\,s^{-1}}$. It has constant acceleration $\begin{pmatrix} 0 \\ 2 \end{pmatrix}$ $\mathrm{m\,s^{-2}}$.

(ii) Find the velocity and position vector of beetle B at time t. **[4]**

(iii) Show that the two beetles meet once and give the coordinates of the place where this happens. **[4]**

(iv) Show that the directions of travel of the two beetles are never parallel. **[4]**

(v) Prove that there is one, and only one, time at which the speeds of the two beetles are the same. Find the speed at that time. **[3]**

7 This question is about a place where there is a steep cliff with flat horizontal ground at the bottom of it. A railway line runs along this flat ground. The railway line is parallel to the bottom of the cliff and at a distance of 100 m from it.

Hari is surveying the situation to see if stones falling down the cliff present any danger to the trains. Fig. 7 is his illustration of the place. He uses it for three models of a stone sliding down from the top of the cliff and across the flat horizontal ground towards the railway.

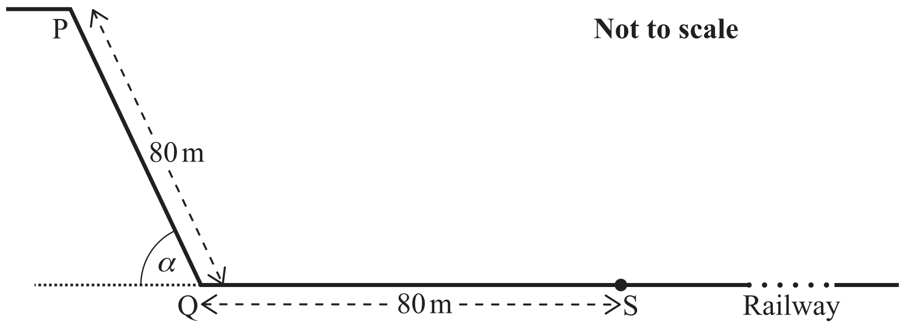

Fig. 7

He makes the following assumptions in all three models.

- The cliff PQ is a uniform plane making an angle α with the horizontal where $\sin \alpha = 0.8$.
- A stone loses no speed at the bottom of the cliff when it changes direction at Q.
- The mass of a stone is 5 kg.

To test his models, Hari places a flat stone at P and observes its motion sliding down the cliff and along the ground. After 11.4 seconds it comes to rest at S, 80 metres from Q.

In **Model A**, it is also assumed that all the surfaces are smooth.

(i) Show that Model A predicts that the speed of the stone at Q will be $35.4\,\text{m s}^{-1}$. Write down the predicted speed of the stone when it is at S.

Give one reason why Model A is not suitable. **[6]**

In **Model B**, it is assumed that the stone is subject to a constant resistance force throughout the motion.

(ii) Show that, if the resistance force is 19.6 N, Model B predicts that the stone will come to rest at S. **[4]**

Hari calculates the stone's time from P to S based on Model B and a resistance of 19.6 N. He finds it is not the same as the observed time and so he refines the model further.

In **Model C** it is assumed that the resistance forces are different, but constant, during each of the two stages of the motion: F_1 N between P and Q; F_2 N between Q and S. As a result of a further experiment Hari estimates that $F_2 = 24.5$ N and this value is assumed in Model C.

(iii) Given that Model C predicts that the stone stops at S, find the value of F_1. **[4]**

(iv) Find the time taken for the stone to travel from P to S as predicted by Model C. **[3]**

(v) Give one reason why the trains might not be as safe as Model C suggests. **[1]**

END OF QUESTION PAPER

OCR
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Friday 15 June 2018 – Afternoon

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4761/01 Mechanics 1

PRINTED ANSWER BOOK

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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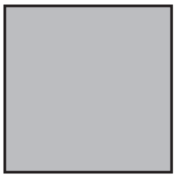
1 (i)



1 (ii)

1 (iii)	

2 (i)	

2 (ii)

3 (i)	
3 (ii)	

4 (i)	
4 (ii)	

5	
	(answer space continued on next page)

5	(continued)

6 (i)	
6 (ii)	

6 (iii)	
6 (iv)	

6 (v)

7 (i)	

7 (ii)	
7 (iii)	

7 (iv)	
7 (v)	

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Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4761**: Mechanics 1

Advanced Subsidiary GCE

Mark Scheme for June 2018

Annotations and abbreviations

Annotation in scoris	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

Subject-specific Marking Instructions for GCE Mathematics (MEI) Mechanics strand

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)

We are usually quite flexible about the accuracy to which the final answer is expressed and we do not penalise over-specification.

When a value is given in the paper
Only accept an answer correct to at least as many significant figures as the given value. This rule should be applied to each case.

When a value is not given in the paper
Accept any answer that agrees with the correct value to 2 s.f.

ft should be used so that only one mark is lost for each distinct error made in the accuracy to which working is done or an answer given. Refer cases to your Team Leader where the same type of error (e.g. errors due to premature approximation leading to error) has been made in different questions or parts of questions.

There are some mistakes that might be repeated throughout a paper. If a candidate makes such a mistake, (eg uses a calculator in wrong angle mode) then you will need to check the candidate's script for repetitions of the mistake and consult your Team Leader about what penalty should be given.

There is no penalty for using a wrong value for *g*. E marks will be lost except when results agree to the accuracy required in the question.

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

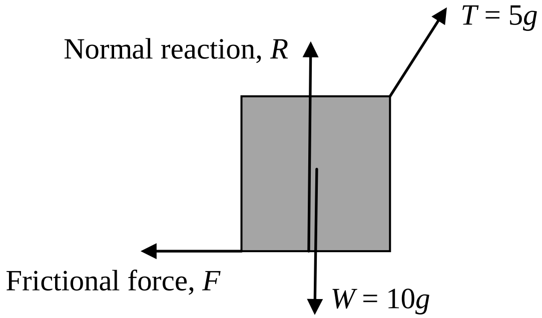
'Fresh starts' will not affect an earlier decision about a misread.

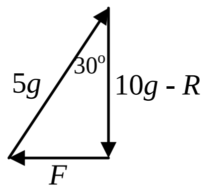
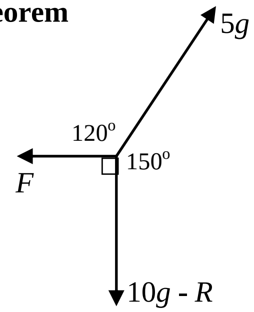
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j If in any case the scheme operates with considerable unfairness consult your Team Leader.

SECTION A

Qu	Part	Answer	Mark	Guidance
1	(i)		B1	Four correct forces. If one force is missing, or there is one extra force, the marks for labels and arrows may still be obtained.
			B1	Labels (any correct descriptions)
			B1	Arrows
				The force T may be replaced by vertical and horizontal components. Allow if both the force and components are given, only if the components are presented differently from other forces.
			[3]	
	(ii)	$R + 5g\cos 30° = 10g$	M1	Attempt at vertical equation; 3 relevant terms must be seen. Allow sin-cos interchange and omission of g for this mark.
		$R = 55.564... = 55.6$ to 3 sf	A1	
		$F = 5g\sin 30° = 24.5$	B1	Allow 2.5 if g is missing throughout this part.
			[3]	
	(iii)	Resultant = $\sqrt{55.564...^2 + 24.5^2}$	M1	FT from part (ii) but the figures must be consistent with those answers.
		= 60.726, so 60.7 to 3 sf	A1	cao
			[2]	

Qu	Part	Answer	Mark	Guidance
1	(ii)	**Alternative: Using triangle of forces** 		
		$10g - R = 5g\cos 30°$	M1	
		$R = 55.6$	A1	
		$F = 5g\sin 30° = 24.5$	B1	
			[4]	
1	(ii)	**Alternative: Using Lami's theorem** 		
		$\frac{F}{\sin 150°} = \frac{5g}{(\sin 90°)} = \frac{10g - R}{\sin 120°}$	M1	Allow M1 for $\frac{5g}{(\sin 90°)} = \frac{10g - R}{\sin 120°}$
		$R = 55.6$	A1	
		$F = 5g\sin 30° = 24.5$	B1	
			[4]	

Qu	Part	Answer	Mark	Guidance
2	(i)	Vertical motion Initial velocity = 28sin30° =14 m s^{-1}	B1	Award for 14 or 28sin30° seen.
		$v^2 - u^2 = 2as \Rightarrow 0^2 - 14^2 = 2\times(-9.8)\times y$	M1	A valid attempt to find y when the vertical component of velocity is 0
		$y = 10$	A1	
		Maximum height = 10 + 1 = 11 m	B1	This mark should be given retrospectively if y_0 has been introduced earlier. FT from their answer for y for this mark only. Only penalise omission of initial height once in the whole question.
			[4]	
	(ii)	Horizontal motion Initial velocity = 28cos30° (=24.25) m s^{-1}		
		To reach Q, $28\cos 30°\times t = 70$	M1	A valid attempt to find t when the ball reaches Q
		$\Rightarrow t = \left(\frac{5\sqrt{3}}{3}\right) = 2.886...$	A1	
		Height at Q = $1 + 14\times 2.886... - \frac{1}{2}\times 9.8\times 2.886...^2$	M1	A valid attempt to find the height of the ball at Q Allow their value of t
		Height = 0.58 m so the ball is caught and the batsman is out.	A1	Height and conclusion required. If the initial height has been omitted, give this mark for a height of -0.42 and the batsman scoring 1 run. Allow answer 0.53 following rounding t to 2.89.
			[4]	

Qu	Part	Answer	Mark	Guidance
2	(i)	**Alternative: 2-stage use of *suvat* equations**		
		Vertical motion Initial velocity = $28\sin 30^{\circ} = 14\text{ m s}^{-1}$	B1	
		$v = u + at \Rightarrow 0 = 14 - 9.8t \Rightarrow t = \frac{14}{9.8} (= 1.428...)$		
		$s = ut + \frac{1}{2}at^2 \Rightarrow y = 14 \times (1.428...) - 4.9 \times (1.428...)^2$	M1	This mark is for a valid 2 (or more) stage method that should lead to the correct height.
		$y = 10$	A1	
		Maximum height = 10 + 1 = 11 m	B1	This mark should be given retrospectively if y_0 has been introduced earlier. FT from their answer for y for this mark only. Only penalise omission of initial height once.
			[4]	
	(ii)	**Special case: Finding where the ball lands**		This is not a complete method and so only 3 marks are available
		Either The ball lands when $1 + 14t - 4.9t^2 = 0 \Rightarrow t = 2.926...$ **Or** The ball lands when $14t - 4.9t^2 = 0 \Rightarrow t = 2.857...$	SC M1	A valid attempt to find t when the ball hits the ground,
		Either $t = 2.926... \Rightarrow x = 70.97$ **Or** $t = 2.857... \Rightarrow x = 69.28...$	SC A1	A valid attempt to find x when the ball hits the ground.
		Either The ball is above the ground when it passes Q **Or** The ball bounces before Q so the batsman scores 1 run	SC A1	
			[3]	

Qu	Part	Answer	Mark	Guidance
2		**Alternative method: Using the equation of the trajectory**		
	(i)	$y=(y_0)+x\tan\alpha-\frac{gx^2}{2u^2\cos^2\alpha}$ $y=(1)+\frac{x}{\sqrt{3}}-\frac{9.8x^2}{2\times\left(\frac{\sqrt{3}}{2}\right)^2\times 28^2}$ $y=(1)+\frac{x}{\sqrt{3}}-0.008\dot{3}x^2$	B1	Or equivalent
		$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{1}{\sqrt{3}}-0.01\dot{6}x$	M1	
		$\frac{\mathrm{d}y}{\mathrm{d}x}=0 \Rightarrow x=34.64...$ $x=34.64...\Rightarrow y=(1)+\frac{34.64...}{\sqrt{3}}-0.008\dot{3}\times(34.64...)^2=(1)+10$	A1	
		Maximum height = 10 + 1 = 11 m	B1	This mark should be given retrospectively if y_0 has been introduced earlier. FT from their answer for y for this mark only. Only penalise omission of initial height once.
			[4]	

Qu	Part	Answer	Mark	Guidance
2	(ii)	When x = 70,	M1	For using the equation of the trajectory with x = 70
		$y=(1)+\frac{70}{\sqrt{3}}-0.008\dot{3}\times 70^2$	A1	
		Height at Q = 0.581... m	M1	
		So the ball is caught and the batsman is out.	A1	If the initial height has been omitted, give this mark for a height of -0.42 and the batsman scoring 1 run.
			[4]	

Qu	Part	Answer	Mark	Guidance
3	(i)	For whole system, $F = ma$		Or equivalent
		$D-(300+100)=(1000+600)\times a$	M1	Use of Newton's 2nd Law with correct elements on whole system.
		$D=1200 \Rightarrow a=0.5$; (the acceleration is 0.5 m s^{-2})	A1	
		For trailer, $T-100=600\times 0.5$	M1	Use of Newton's 2nd Law on the trailer
		(The tension is) 400 N	A1	FT from their value for *a*
		Alternative: Using the car		
		For car 1200 - 300 - T = 1000 × 0.5	M1	Use of Newton's 2nd Law on the car
		(The tension is) 400 N	A1	FT from their value for *a*
			[4]	
	(ii)	For whole system , → $-400=1600\times a$	M1	Use of Newton's 2nd Law on whole system in the new situation. Give no marks for part (ii) if a new acceleration is not used.
		$\Rightarrow a=-0.25$; (the acceleration is -0.25 m s^{-2})	A1	
		For trailer → $T-100=600\times(-0.25)$	M1	Or equivalently for the car
		$T=-50$		
		There is thrust of 50 N (or the rod is in compression)	A1	FT from their value for *a* but only if different from that in part (i)
			[4]	

Qu	Part	Answer	Mark	Guidance
3	(i)	**Alternative: Using simultaneous equations**		
		For car, 1200 - 300 - T = 1000a	**M1**	Use of Newton's 2nd Law on the car
		For trailer $T - 100 = 600a$	**M1**	Use of Newton's 2nd Law on the trailer
		Solving simultaneously		
		$a = 0.5$; (the acceleration is 0.5 m s^{-2})	**A1**	Dependent on both M marks
		$T = 400$; (the tension is 400 N)	**A1**	Dependent on both M marks
			[4]	
	(ii)	**Alternative: Using simultaneous equations**		
		For car - 300 - T = 1000a	**M1**	Use of Newton's 2nd Law on both the car and the trailer in the new situation
		For trailer $T - 100 = 600a$		
		Solving simultaneously	**M1**	Dependent on previous M mark
		$a = -0.25$; (the acceleration is -2.5 m s^{-2})	**A1**	
		$T = -50$		
		There is thrust of 50 N	**A1**	
			[4]	

Qu	Part	Answer	Mark	Guidance
4	(i)	$1.25\ \text{m s}^{-2}$, $0\ \text{m s}^{-2}$, $-2.5\ \text{m s}^{-2}$	B1	One correct non-zero value
			B1	All three values correct
			[2]	
	(ii)	$R - mg = m \times 1.25$	M1	FT from part (i) for the positive acceleration. Do not penalise calculations for more than one phase of the motion for this mark.
		The force is 552.5 N	A1	cao with no FT for the acceleration
			[2]	

Qu	Part	Answer	Mark	Guidance
5		Alice's velocity at time t s is given by	M1	Attempt to find the velocity at time t
		$v = \left(\int a\,dt\right) = \int\left(-2 - \frac{t}{2}\right)dt = -2t - \frac{t^2}{4}(+c)$	A1	Condone missing constant of integration for this mark
		When t = 0, v = 21 $\Rightarrow c = 21$ and so $v = 21 - 2t - \frac{t^2}{4}$	A1	For finding $c = 21$
		When v =0, $t^2 + 8t - 84 = 0$	M1	Attempt to find t when v = 0
		So t = 6 (or -14)	A1	
		Distance travelled	M1	Attempt to find distance travelled when v = 0
		$= \int_0^6\left(21 - 2t - \frac{t^2}{4}\right)dt = \left[21t - t^2 - \frac{t^3}{12}\right]_0^6 = 72$	A1	Cao for 72 m. This answer may be obtained using a constant of integration with value 0; condone this not being seen.
		Since 72 < 75, Alice's car does not hit the tree.	B1	cao
			[8]	

Qu	Part	Answer	Mark	Guidance
		Special case for the last 5 marks		
		Attempt to find distance travelled	**SC M1**	
		$s=\int\left(21-2t-\frac{t^2}{4}\right)\mathrm{d}t=21t-t^2-\frac{t^3}{12}(+c)$	**SC A1**	
		The car would hit the tree when $s=75$	**SC M1**	
		$21t-t^2-\frac{t^3}{12}=75\Rightarrow t^3+12t^2-252+900=0$	**SC A1**	
		This equation has no positive roots so the car does not hit the tree	**SC B1**	
			[8]	

Qu	Part	Answer	Mark	Guidance
5		**Possible limited credit for those using suvat equations** The three M marks are available to those candidates who (incorrectly) use constant acceleration formulae but do address the problem solving aspects of this question. The A marks may not be given nor may the final B mark. So the maximum possible mark for such candidates is 3.		
		Attempt to find the velocity at time t	M1	$v = u + at$ is written as $v = 21 + \left(-2 - \frac{1}{2}t\right)t$
		Attempt to find t when $v = 0$	M1	$0 = 21 - 2t - \frac{1}{2}t^2 \Rightarrow t^2 + 4t - 42 = 0$ $t = 4.78...$ $(\text{or} -8.78...)$
		Attempt to find distance travelled when $v = 0$	M1	$s = ut + \frac{1}{2}at^2 \Rightarrow s = 21t + \frac{1}{2}\left(-2 - \frac{1}{2}t\right)t^2$ $t = 4.78... \Rightarrow s = 50.21...$ Notice $-2 + \sqrt{46} = 4.78...$
			[3]	
		Special case		
		Using $s = 75$ to form an equation in t	SC M1	$s = ut + \frac{1}{2}at^2 \Rightarrow 75 = 21t + \frac{1}{2}\left(-2 - \frac{1}{2}t\right)t^2$
		Showing this equation has no positive roots	SC M1	$t^3 + 4t^2 - 84t + 300 = 0$ is shown to have no positive roots
			[2]	
		Caution		
		No credit should be given for assuming $v = 0$ when $s = 75$		eg $v^2 = u^2 + 2as \Rightarrow 0 = 21^2 - 2\left(2 + \frac{1}{2}t\right) \times 75$ gets 0 marks.

SECTION B

Qu	Part	Answer	Mark	Guidance
6	(i)	Differentiate $\mathbf{r_A}$	M1	Either calculus or constant acceleration formulae may be used. This mark should be awarded automatically if the two answers that follow are correct.
		$\mathbf{v_A} = \begin{pmatrix} 1 \\ 2t \end{pmatrix}$	A1	
		$\mathbf{a_A} = \begin{pmatrix} 0 \\ 2 \end{pmatrix}$	B1	
			[3]	
	(ii)	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ or integration of $\mathbf{a_B}$	M1	
		$\mathbf{v_B} = \begin{pmatrix} 1 \\ -4 \end{pmatrix} + \begin{pmatrix} 0 \\ 2 \end{pmatrix} t = \begin{pmatrix} 1 \\ -4+2t \end{pmatrix}$	A1	
		Use of $\mathbf{r} = \mathbf{r_0} + \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ or integration of $\mathbf{v_B}$	M1	
		$\mathbf{r_B} = \begin{pmatrix} -1 \\ 10 \end{pmatrix} + \begin{pmatrix} 1 \\ -4 \end{pmatrix} t + \frac{1}{2}\begin{pmatrix} 0 \\ 2 \end{pmatrix} t^2 = \begin{pmatrix} -1+t \\ 10-4t+t^2 \end{pmatrix}$	A1	
			[4]	

Qu	Part	Answer	Mark	Guidance
6	(iii)	If they meet $\mathbf{r_A} = \mathbf{r_B}$, so $t^2 - 2 = 10 - 4t + t^2$	M1	Equating the *y*-components. FT from (ii).
		They meet when $t = 3$	A1	No FT from (ii).
		The *x*-components are also be equal: $t - 1 = -1 + t$	B1	Only award this mark if the *x*-components are considered
		Position is (2, 7)	B1	This may be given in vector form. Allow from trial and error.
			[4]	
	(iv)	If their motions are parallel, $\mathbf{v_B} = k\mathbf{v_A}$	M1	For considering the velocities of the two beetles. FT from (i). *k* may be implied,
		$\begin{pmatrix} 1 \\ -4+2t \end{pmatrix} = k\begin{pmatrix} 1 \\ 2t \end{pmatrix}$		
		x-component $\Rightarrow k = 1$	A1	This may be implied by stating that the *x*-components are equal.
		y-component $\Rightarrow -4 + 2t = 2t$	A1	
		No solution so their motions are never parallel	A1	Cao and from correct working with no FT.
			[4]	
	(v)	$1^2 + (-4+2t)^2 = 1^2 + (2t)^2$	M1	This mark is for equating speeds. Since the *x*-components are both equal to 1 it may be given for the squared *y*-components only.
		$\Rightarrow \quad t = 1$ (only)	A1	Accept correct argument for only one time (with *t* =1 not stated)
		At *t* = 1, $v = \sqrt{5}$, (so speed is 2.236 m s^{-2})	B1	
			[3]	

Qu	Part	Answer	Mark	Guidance
6	(iii)	**Alternative: Using equations of paths**		
		Equation of beetle A: $y=x^2+2x-1$		
		Equation of beetle B: $y=x^2-2x+7$		
		Solving these equations gives their meeting point(s)	**M1**	Complete method must be indicated
		They meet where $x^2+2x-1=x^2-2x+7$ $(=y)$	**A1**	Correct equations
		Solving gives $x=2$	**A1**	
		They meet at (2, 7)	**B1**	
			[4]	
	(iv)	**Alternative: Comparing gradients**		
		Comparing gradients	**M1**	A valid attempt to use calculus to equate their gradients
		For beetle A, $\frac{dy}{dx}=2x+2$	**A1**	Or $\tan\theta_A=\frac{2t}{1}$
		For beetle B, $\frac{dy}{dx}=2x-2$	**A1**	$\tan\theta_B=\frac{2t-4}{1}$
		There is no value of x for which $2x+2=2x-2$, so their motions are never parallel	**A1**	Cao and from correct working with no FT.
			[4]	

Qu	Part	Answer	Mark	Guidance
7	Much of this question can be answered using energy methods which are beyond the specification for this unit. Full marks should be given for fully correct answers using such methods but no credit should be given for incorrect working.			
	(i)	Component of weight parallel to the slope $= 5g\sin\alpha \ (= 4g)$	**M1**	For a valid method to find the acceleration down the slope, Allow sin-cos interchange for this mark only.
		Newton's 2nd law $\Rightarrow\ a = 0.8g = 7.84$	**A1**	
				Special case Give **M0 A0 + SC B1** for a=0.8g without adequate explanation
		$v^2 - u^2 = 2as$: $v^2 - 0^2 = 2\times 7.84\times 80$	**M1**	For an attempt to find the speed at Q Accept $v^2 = 2\times 9.8\times 80\times 0.8$ for this mark only.
		$v = 35.4$	**A1**	Correct working required for this given answer
		Predicted speed at S is 35.4 m s^{-1}	**B1**	cao
		Model A predicts the stone will never stop	**B1**	Allow any comment that it is still moving, also that no friction is unrealistic
			[6]	

Qu	Part	Answer	Mark	Guidance
	(ii)	The motion is in 2 stages	M1	For considering motion down the slope and horizontally separately
		Motion down the slope $5a = 4g - 19.6 \Rightarrow a = 3.92$		
		At the bottom of the slope $v^2 = 627.2\ (= 64g)$, (v = 25.04)	A1	Accept $v = 25$ here and subsequently.
		Along the horizontal $5a = -19.6 \Rightarrow a = -3.92$	M1	Dependent on the previous M mark. Consideration of the horizontal motion with $u = 25.0...(\text{FT}), v = 0$ and $a = \pm 3.92$
		$v^2 - u^2 = 2as$: $0^2 - 627.2 = 2 \times (-3.92) \times s$		
		$s = 80$ as required	A1	
			[4]	
	(iii)	The answers for the first three B marks may be implied by subsequent correct answers following correct working.		
		Along the horizontal, $5a = -24.5 \Rightarrow a = -4.9$	B1	For the (negative) acceleration during the horizontal motion
		$v^2 - u^2 = 2as$: $0^2 - u^2 = 2 \times (-4.9) \times 80$		
		$u^2 = 784$, (u = 28)	B1	For the initial speed of the horizontal motion.
		Along the slope, $v^2 - u^2 = 2as$: $784 - 0^2 = 2 \times a \times 80$		
		$\Rightarrow a = 4.9$	B1	For the acceleration down the slope
		$5a = 4g - F_1$, $F_1 = 4 \times 9.8 - 5 \times 4.9$		
		$F_1 = 14.7$	B1	For the value of F_1
			[4]	

Qu	Part	Answer	Mark	Guidance
7	(iv)	Using $v = u + at$		
		Along the slope $\sqrt{784} = 0 + 4.9t \Rightarrow t = 5.714...$	B1	FT for $\sqrt{784}$ from part (iii)
		Along the horizontal $0 = \sqrt{784} - 4.9t \Rightarrow t = 5.714...$	B1	FT for $\sqrt{784}$ from part (iii)
		Total time is 11.4 seconds	B1	cao
			[3]	
	(v)	A stone might bounce and not slide and possibly travel further.	B1	Any plausible comment, eg friction is not constant. Do not allow statements that heavier stones travel faster but do allow statements that heavier stones require greater resistance forces.
			[1]	

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Contents

Introduction

Our examiners’ reports are produced to offer constructive feedback on candidates’ performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates’ performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects, which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 4761/01 series overview

This paper covers the first of the four mechanics modules in the MEI AS and A Level Mathematics and Further Mathematics.

Successful candidates have a good understanding of the whole content of this module and are able to answer questions that combine the different topics in the specification, as well as drawing on relevant pure mathematics. In addition to being competent with the various techniques, candidates are expected to be able to use the mechanics to model real world situations and to answer questions that involve problem solving.

The specification content for Mechanics 1 covers the following topics:

- Modelling
- Vectors
- Kinematics
- Force
- Newton's laws of motion
- Projectiles

The examination paper has two 36 mark sections. Section A has a number of short questions no more than 8 marks each. Section B has two long questions each carrying about 18 marks. Most, but not all, of the questions are split into a number of parts.

In this examination, many candidates scored more highly on the questions in Section A than on those in Section B.

Section A overview

Many candidates obtained nearly all the marks on the five questions in Section A.

Questions 1, 3 and 4 could be described as "routine" and many candidates provided succinct correct answers to them.

Questions 2 and, particularly, 5 both involved some problem solving and so candidates needed to devise strategies for solving them.

AfL Questions 2 and 5 showed that some candidates did not have good examination techniques for problem solving questions. Instead of thinking first and analysing the situations, they seem to have rushed into the questions and only later realised that they were not getting anywhere. It was common to see a lot of crossing out of work for these questions, which was then replaced by correct work. Even though such candidates may have obtained the marks for these questions, many of them seem to have run out of time for the Section B questions. Advice to future candidates might be: "If a question involves problem solving, pause and think it through first before answering the question."

Question 1 (i)

1 Fig. 1 shows a block of mass 10 kg on a rough horizontal table.

One end of a string is attached to the block. The string passes over a smooth pulley and the other end is attached to a sphere of mass 5 kg which is hanging freely. The string makes an angle of 30° with the vertical. The string is light and inextensible.

The system is in equilibrium.

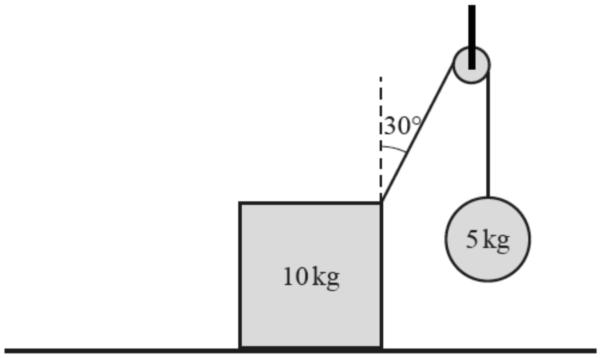


Fig. 1

(i) Draw a diagram showing all the forces acting on the block. **[3]**

Question 1 was about the forces acting on a block in equilibrium. Part (i) involved drawing a force diagram and was generally well answered. The most common mistake was to omit the frictional force. The three marks were given for correct forces, labels and arrows.

Question 1 (ii)

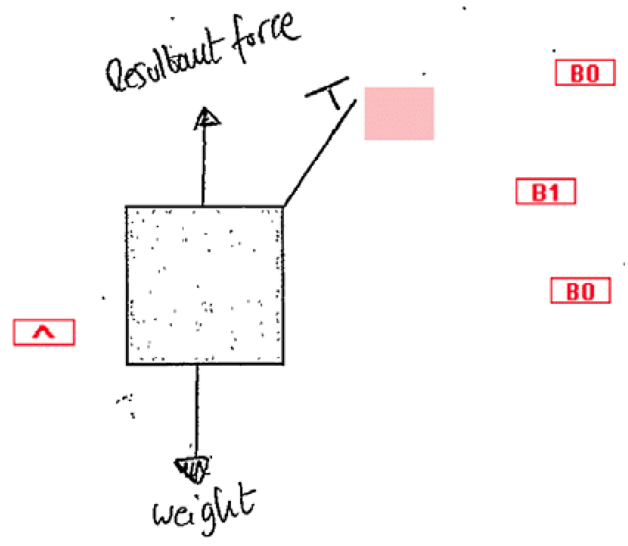
(ii) Calculate the normal reaction of the table on the block.

Calculate also the frictional force acting on the block. **[3]**

In part (ii) candidates were asked to find the normal reaction and the frictional force acting on the block. Most candidates got full marks for this part. There were quite a few mistakes over the normal reaction; a common error was to omit the vertical component of the tension in the string and so equate the normal reaction with the weight of the block.

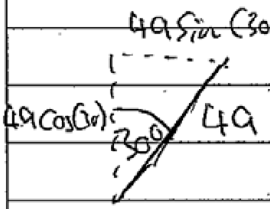
Exemplar 1 and 2

1 (i)



1 (ii)

$5 \times 9.8 = 49\text{N}$ $T = 49\text{N}$



frictional force is $49\sin(30) = 24.5\text{ N}$ B1

$10 \times 9.8 = 98\text{ N}$ weight $= 98\text{ N}$

M1

$R + 49\cos(60) = 98$

$R = 98 - 49\cos(30)$ $R = 55.565\text{N}$ – normal reaction force A1

AfL The exemplar shows a common situation in which the candidate has omitted the frictional force from the diagram in part (i) and then found its value in part (ii). This suggests that such candidates may not fully appreciate how useful a force diagram is as a tool for solving mechanics problems.

Question 1 (iii)

(iii) Find the magnitude of the resultant of the forces that the table exerts on the block. **[2]**

In the final part of the question, candidates were required to find the resultant of the two forces they had found in the previous part. These forces were at right angles, and so a Pythagoras-type calculation was required. While most candidates were successful, a few seemed to be unfamiliar with this technique.

Question 2 (i)

2 In this question you should use the standard projectile model with $g = 9.8\,\text{m}\,\text{s}^{-2}$.

Fig. 2 illustrates a situation in a cricket match.

A batsman has hit the ball in the air from the point B, 1 metre above the ground at P, towards the boundary at Q. The ground is horizontal and the distance PQ is 70 m. A fielder is standing at Q.

The initial velocity of the ball is $28\,\text{m}\,\text{s}^{-1}$ at 30° to the horizontal.

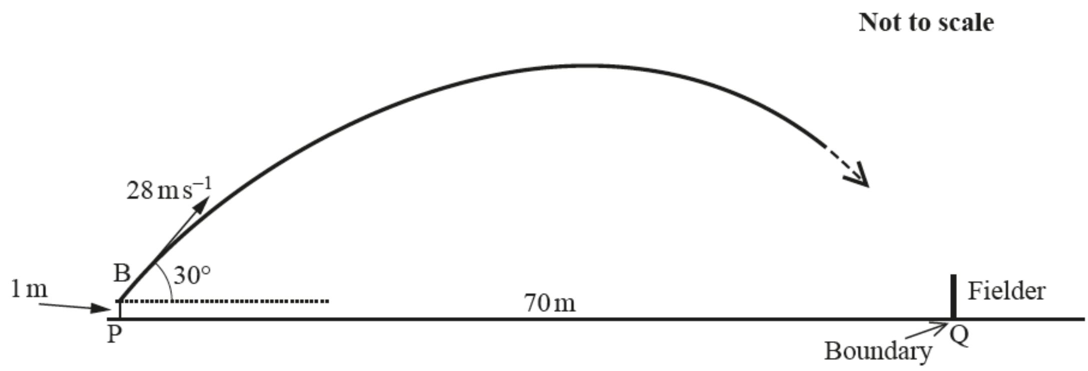


Fig. 2

(i) Find the greatest height of the ball above the ground during its flight. **[4]**

Question 2 was about projectiles, using the flight of a cricket ball as a context. In the first part, candidates were asked to find the greatest height of the ball. It was well answered with many candidates obtaining all 4 marks. The most common mistake was to omit the initial height of the ball, an error that was only penalised once across both parts of the question.

Question 2 (ii)

The height of the ball above the ground when it reaches the boundary at Q is denoted by h metres.

- If $h > 2.2$, the batsman will score 6 runs.
- If $0 \leqslant h \leqslant 2.2$, the fielder will catch the ball and the batsman will be out.
- If the ball hits the ground before it reaches Q, the fielder will stop it, and the batsman will score 1 run.

(ii) Determine what happens. **[4]**

The second part of this question involved some problem solving. Candidates had to realise that it was effectively asking for the height of the ball when it had travelled 70 metres horizontally. This part too was well answered. However, some candidates found where the ball would have landed, and so did not actually address the problem they were being asked to solve.

Question 3 (i)

3 Fig. 3 illustrates a car towing a trailer. They are connected by a light horizontal tow-bar and are travelling in a straight line along a horizontal road.

- The mass of the car is 1000 kg and the mass of the trailer is 600 kg.
- The resistance to motion is 300 N for the car and 100 N for the trailer.
- The driving force exerted by the car is D N.

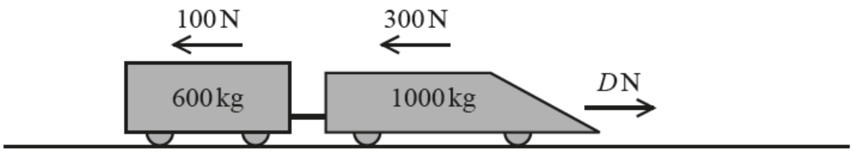


Fig. 3

(i) Initially $D = 1200$.

Find the acceleration of the car and the tension in the tow-bar. **[4]**

Question 3 was about connected particles. The context involved a car and a trailer on a straight horizontal road. In part (i) the car was exerting a driving force and candidates were asked to find the acceleration and the force in the tow-bar. It was well answered with most candidates obtaining all 4 marks.

Question 3 (ii)

(ii) After some time the driving force is removed so that $D = 0$.

Find the new force in the tow-bar, stating whether it is a tension or a thrust. **[4]**

In part (ii) the driving force was removed and the new force in the tow-bar was to be found. This part too was well answered. There were different ways the question could be approached but most candidates started by finding the acceleration which turned out to be negative. Perhaps therefore, sign errors were quite common when they went on to find the force in the tow-bar. Another common mistake occurred when candidates did not realise that in this new situation the acceleration they had found in part (i) was no longer relevant.

Question 4 (i)

4 Salome takes a lift from the ground floor of a building vertically upwards to the floor where her office is situated. Her velocity, v, at time t is shown in Fig. 4. She stands still in the lift.

Salome's mass is 50 kg.

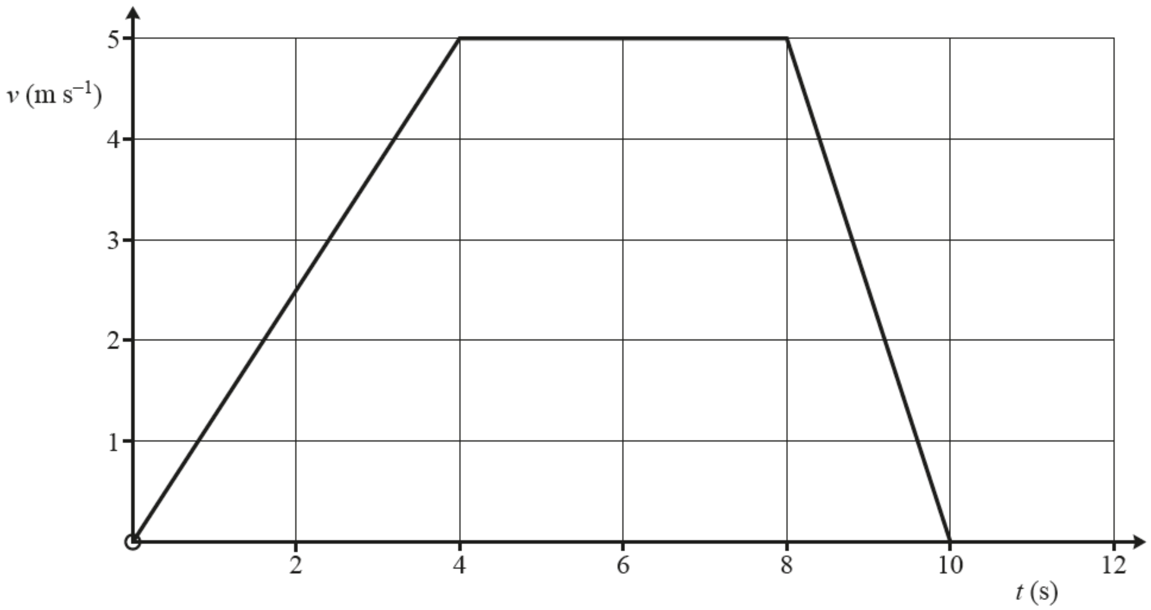


Fig. 4

(i) Find Salome's acceleration in each of the three phases of her motion. **[2]**

This question was about the forces acting on a person in a lift. Part (i) was based on the velocity-time graph for the lift and candidates were asked to use it to find the acceleration in each phase of the motion. Nearly all candidates answered it correctly.

Question 4 (ii)

(ii) Find the greatest force that the floor of the lift exerts on Salome. **[2]**

In part (ii) candidates were asked to find the greatest force that the lift exerted on the person. This was not well answered with only a minority of candidates giving the correct answer. The most common mistake was to forget about the weight of the person in the lift when applying Newton's second law.

Question 5

5 Alice is driving along a straight narrow country road when she sees that a tree has fallen across the road in front of her. She applies the car's brakes with ever increasing firmness as she approaches the tree.

- The car's initial speed is $21\,\mathrm{m\,s^{-1}}$.
- The tree is 75 m from the front of Alice's car when she first applies the brakes.
- The car's acceleration, $a\,\mathrm{m\,s^{-2}}$, is given by $a = -2 - \frac{1}{2}t$ where t s is the time since Alice first applies the brakes.

Does Alice's car hit the tree? **[8]**

This question involved a considerable amount of problem solving, in a context that involved motion with variable acceleration.

There were many right answers but these included those from some candidates who spent a long time doing unsuccessful work, which they then crossed out and replaced by a correct solution. Some of these candidates then ran short of time towards the end of the paper.

The most common mistake was to use the constant acceleration formulae instead of calculus. Candidates who did this within a correct problem solving structure could receive up to 3 method marks for taking the following steps:

- finding the velocity at time *t*
- finding the time when the velocity is zero
- finding the distance the car has travelled at that time.

However, candidates who used constant acceleration formulae did not receive any other marks.

Exemplar 3 shows a fully correct answer and Exemplar 4 shows an incorrect one based on constant acceleration formulae.

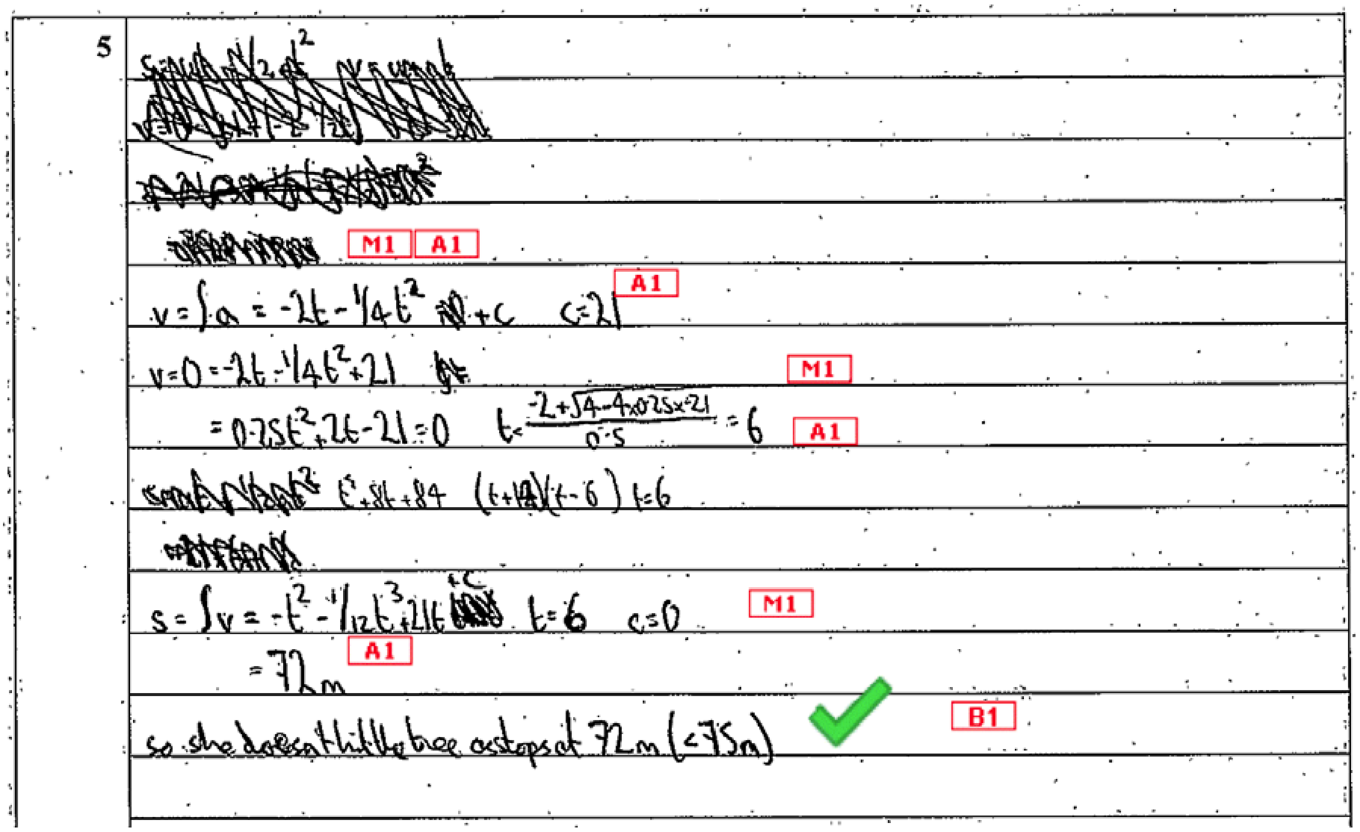
OCR support

Support from OCR and MEI is available for teachers wanting to address problem solving in their mathematics classes.

OCR support pack
http://www.ocr.org.uk/Images/83327-problem-solving-support-pack.pdf

MEI problem solving guide
http://mei.org.uk/problem-solving-guide.

Exemplar 3


5
M1 A1
$v = \int a = -2t - \frac{1}{4}t^2 + c \quad c = 21$
A1
$v = 0 = -2t - \frac{1}{4}t^2 + 21$
M1
$= 0.25t^2 + 2t - 21 = 0 \quad t = \frac{-2 + \sqrt{4 - 4 \times 0.25 \times -21}}{0.5} = 6$
A1
$t^2 + 8t + 84 \quad (t+14)(t-6) \quad t = 6$
$s = \int v = -t^2 - \frac{1}{12}t^3 + 21t + c \quad t = 6 \quad c = 0$
M1
$= 72\text{m}$
A1
so she doesn't hit the tree as stops at 72m (<75m)
B1

Exemplar 4

5

s u v a t

21 0 $-2-\frac{1}{2}t$?

$v = u + at$ [✗] M1

$0 = 21 + (-2-\frac{1}{2}t)t$

$21 - 2t - \frac{1}{2}t^2 = 0$ M1

$t = 4.78$

s u v a t

21 0 4.78

?

$s = \frac{u+v}{2}t$

$s = \frac{21}{2} \times 4.78$ M1

$s = 50.21$

$50.21 < 75$ ∴ She doesn't hit the tree. B0

Section B overview

Those candidates who spent longer than necessary on the problem solving questions in Section A appeared to have run short on time when answering the questions in Section B. There were many no responses, particularly to parts (ii), (iii) and (iv) of Question 7.

Question 6 (i)

6 Two beetles, A and B, are on a large patio which is modelled as a flat horizontal surface.

Cartesian axes are defined relative to an origin near the middle of the patio; the direction of the x-axis is East and the direction of the y-axis is North.

The unit vectors $\begin{pmatrix}1\\0\end{pmatrix}$ and $\begin{pmatrix}0\\1\end{pmatrix}$ are in the x- and y- directions.

The unit for distance is 1 metre. Time, t, is measured in seconds and $0 \leqslant t \leqslant 5$.

The position vector, $\mathbf{r}_\mathbf{A}$ m, of beetle A at time t is given by $\mathbf{r}_\mathbf{A} = \begin{pmatrix}t-1\\t^2-2\end{pmatrix}$.

(i) Write down A's velocity and acceleration at time t. **[3]**

Question 6 was about motion of two beetles in two dimensions and the use of vectors was required throughout. The first part involved using a given position vector to find velocity and acceleration of one beetle. The acceleration turned out to be constant and so the answers could be obtained using either calculus or constant acceleration formulae. It was well answered by almost all candidates.

Question 6 (ii)

Beetle B is initially at the point $(-1, 10)$ and is initially moving with velocity $\begin{pmatrix}1\\-4\end{pmatrix}$ m s^{-1}. It has constant acceleration $\begin{pmatrix}0\\2\end{pmatrix}$ m s^{-2}.

(ii) Find the velocity and position vector of beetle B at time t. **[4]**

Part (ii) involved finding expression for velocity and position at time *t* of the other beetle. Its acceleration, which was constant, and the initial conditions were given. It was well answered. The most common mistake was to miss out the initial conditions.

Question 6 (iii)

(iii) Show that the two beetles meet once and give the coordinates of the place where this happens. **[4]**

In this part candidates were required to investigate if and when the two beetles met. Most candidates knew how to go about it, equating the position vectors of the two beetles. However, many did not realised that both the *x*- and *y*- components had to be considered.

Question 6 (iv)

(iv) Show that the directions of travel of the two beetles are never parallel. **[4]**

In the last two parts candidates were asked about times when the two beetles were moving in parallel directions (part (iv)) and had the same speed (part (v)) Neither of these parts were well answered. Quite a lot of candidates missed out part (iv) completely. A common mistake was to compare the position vectors of the two beetles rather than their velocities. Among the responses from those who did compare the velocities, invalid arguments were common.

Question 6 (v)

(v) Prove that there is one, and only one, time at which the speeds of the two beetles are the same. Find the speed at that time. **[3]**

This question tested the relationship between velocities, expressed as vectors, and speeds. While there were some good answers most candidates were not successful.

Question 7 (i)

7 This question is about a place where there is a steep cliff with flat horizontal ground at the bottom of it. A railway line runs along this flat ground. The railway line is parallel to the bottom of the cliff and at a distance of 100 m from it.

Hari is surveying the situation to see if stones falling down the cliff present any danger to the trains. Fig. 7 is his illustration of the place. He uses it for three models of a stone sliding down from the top of the cliff and across the flat horizontal ground towards the railway.

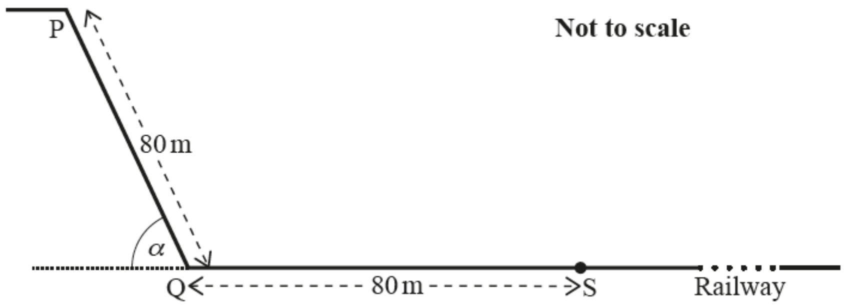


Fig. 7

He makes the following assumptions in all three models.

- The cliff PQ is a uniform plane making an angle α with the horizontal where $\sin\alpha = 0.8$.
- A stone loses no speed at the bottom of the cliff when it changes direction at Q.
- The mass of a stone is 5 kg.

To test his models, Hari places a flat stone at P and observes its motion sliding down the cliff and along the ground. After 11.4 seconds it comes to rest at S, 80 metres from Q.

In **Model A**, it is also assumed that all the surfaces are smooth.

(i) Show that Model A predicts that the speed of the stone at Q will be $35.4\,\mathrm{m\,s^{-1}}$. Write down the predicted speed of the stone when it is at S.

Give one reason why Model A is not suitable. **[6]**

Question 7 involved modelling in the context of motion in two stages, down a slope and along the horizontal. Three models of increasing complexity were considered in the course of the various parts of the question.

Part (i) was based on the simplest model in which friction was negligible. While there were many fully correct answers to this part, there were a significant number that demonstrated little, if any, understanding of the mechanics of motion down a slope. Candidates were asked to show that a stone starting at rest and sliding down a smooth slope of given length and angle reached the bottom with a particular speed. Many did not show a knowledge of the underlying mechanics, failing to find the component of the stone's weight down the slope and then apply Newton's second law.

AfL In this question, candidates were asked to show a given answer: that the speed of the stone at the bottom of the slope is $35.4\,\mathrm{m\,s^{-1}}$. In a large number of responses various numbers were manipulated to produce the given number 35.4 but without any explanation or any clear logical path. Candidates should be made aware that when an answer is given, a high standard of explanation or argument is needed to obtain the marks. Coming out with the right number will not be sufficient.

Question 7 (ii)

In **Model B**, it is assumed that the stone is subject to a constant resistance force throughout the motion.

(ii) Show that, if the resistance force is 19.6 N, Model B predicts that the stone will come to rest at S. **[4]**

In part (ii), the question then went on to consider a different model for the motion of the stone, in which there was a given constant frictional force. Many of those candidates who had been successful in part (i) had realised the two-stage nature of the motion in this question and used that understanding to proceed to answer this part well. Those who did not demonstrate an understanding that the motion involved two stages received no credit in this part.

Question 7 (iii)

Hari calculates the stone's time from P to S based on Model B and a resistance of 19.6 N. He finds it is not the same as the observed time and so he refines the model further.

In **Model C** it is assumed that the resistance forces are different, but constant, during each of the two stages of the motion: F_1 N between P and Q; F_2 N between Q and S. As a result of a further experiment Hari estimates that $F_2 = 24.5$ N and this value is assumed in Model C.

(iii) Given that Model C predicts that the stone stops at S, find the value of F_1. **[4]**

In part (iii), the model involved different resistance forces acting on the stone on the slope and on the horizontal. Those candidates who had been successful in part (ii) were usually also successful in this part. However, there were many others who offered no response at all.

Question 7 (iv)

(iv) Find the time taken for the stone to travel from P to S as predicted by Model C. **[3]**

This part continued with the same model as part (iii) and asked about the times taken on the two stages of the motion. Many of the candidates who had been successful in parts (ii) and (iii) were also successful in this part. However, many others provided no response.

Question 7 (v)

(v) Give one reason why the trains might not be as safe as Model C suggests. **[1]**

Question 7 involved three simple models for a real situation on the railway network. The last part invited candidates to consider the limitations of the third, and most sophisticated, of the models. Candidates produced a variety of acceptable answers, including the fact that stones are likely to bounce as well as slide, and so be liable to less resistance and travel further.

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Unit level raw mark and UMS grade boundaries June 2018 series

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AS GCE / Advanced GCE / AS GCE Double Award / Advanced GCE Double Award

AS & Advanced GCE Mathematics											
				Max Mark	a	b	c	d	e	u
4721	01	C1 Core mathematics 1 (AS)	Raw	72	61	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4722	01	C2 Core mathematics 2 (AS)	Raw	72	55	49	43	37	31	0
			UMS	100	80	70	60	50	40	0
4723	01	C3 Core mathematics 3 (A2)	Raw	72	55	48	41	34	28	0
			UMS	100	80	70	60	50	40	0
4724	01	C4 Core mathematics 4 (A2)	Raw	72	54	47	40	34	28	0
			UMS	100	80	70	60	50	40	0
4725	01	FP1 Further pure mathematics 1 (AS)	Raw	72	56	50	45	40	35	0
			UMS	100	80	70	60	50	40	0
4726	01	FP2 Further pure mathematics 2 (A2)	Raw	72	59	53	47	41	35	0
			UMS	100	80	70	60	50	40	0
4727	01	FP3 Further pure mathematics 3 (A2)	Raw	72	47	41	36	31	26	0
			UMS	100	80	70	60	50	40	0
4728	01	M1 Mechanics 1 (AS)	Raw	72	60	51	42	34	26	0
			UMS	100	80	70	60	50	40	0
4729	01	M2 Mechanics 2 (A2)	Raw	72	53	46	39	32	26	0
			UMS	100	80	70	60	50	40	0
4730	01	M3 Mechanics 3 (A2)	Raw	72	50	42	34	27	20	0
			UMS	100	80	70	60	50	40	0
4731	01	M4 Mechanics 4 (A2)	Raw	72	59	53	47	42	37	0
			UMS	100	80	70	60	50	40	0
4732	01	S1 – Probability and statistics 1 (AS)	Raw	72	57	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4733	01	S2 – Probability and statistics 2 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4734	01	S3 – Probability and statistics 3 (A2)	Raw	72	59	50	41	32	24	0
			UMS	100	80	70	60	50	40	0
4735	01	S4 – Probability and statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4736	01	D1 – Decision mathematics 1 (AS)	Raw	72	55	48	42	36	30	0
			UMS	100	80	70	60	50	40	0
4737	01	D2 – Decision mathematics 2 (A2)	Raw	72	58	53	48	44	40	0
			UMS	100	80	70	60	50	40	0

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AS & Advanced GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – Introduction to advanced mathematics (AS)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – Concepts for advanced mathematics (AS)	Raw	72	53	47	41	36	31	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) Methods for Advanced Mathematics (A2): Written Paper	Raw	72	61	56	51	46	40	0
4753	02	(C3) Methods for Advanced Mathematics (A2): Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) Methods for Advanced Mathematics (A2): Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – Applications of advanced mathematics (A2)	Raw	90	63	56	49	43	37	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – Further concepts for advanced mathematics (AS)	Raw	72	55	51	47	43	40	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – Further methods for advanced mathematics (A2)	Raw	72	48	42	36	31	26	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – Further applications of advanced mathematics (A2)	Raw	72	63	56	49	42	35	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) Differential Equations (A2): Written Paper	Raw	72	61	54	48	42	35	0
4758	02	(DE) Differential Equations (A2): Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) Differential Equations (A2): Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – Mechanics 1 (AS)	Raw	72	51	44	37	31	25	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – Mechanics 2 (A2)	Raw	72	59	53	47	41	35	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – Mechanics 3 (A2)	Raw	72	61	54	48	42	36	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – Mechanics 4 (A2)	Raw	72	59	51	44	37	30	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – Statistics 1 (AS)	Raw	72	59	53	47	42	37	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – Statistics 2 (A2)	Raw	72	54	47	41	35	29	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – Statistics 3 (A2)	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – Decision mathematics 1 (AS)	Raw	72	50	44	38	32	26	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – Decision mathematics 2 (A2)	Raw	72	55	51	47	43	39	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) Numerical Methods (AS): Written Paper	Raw	72	57	52	48	44	39	0
4776	02	(NM) Numerical Methods (AS): Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) Numerical Methods (AS): Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – Numerical computation (A2)	Raw	72	55	47	39	32	25	0
			UMS	100	80	70	60	50	40	0
4798	01	FPT - Further pure mathematics with technology (A2)	Raw	72	57	49	41	33	26	0
			UMS	100	80	70	60	50	40	0

AS GCE Statistics (MEI)

				Max Mark	a	b	c	d	e	u
G241	01	Statistics 1 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0
G242	01	Statistics 2 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0
G243	01	Statistics 3 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0

AS GCE Quantitative Methods (MEI)

				Max Mark	a	b	c	d	e	u
G244	01	Introduction to Quantitative Methods (Written Paper)	Raw	72	58	50	43	36	28	0
G244	02	Introduction to Quantitative Methods (Coursework)	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
G245	01	Statistics 1	Raw	72	61	55	49	43	37	0
			UMS	100	80	70	60	50	40	0
G246	01	Decision Mathematics 1	Raw	72	50	44	38	32	26	0
			UMS	100	80	70	60	50	40	0

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Level 3 Certificate Mathematics - Quantitative Methods (MEI)

					Max Mark	a	b	c	d	e	u
G244	A	01	Introduction to Quantitative Methods with Coursework (Written Paper)	Raw	72	58	50	43	36	28	0
G244	A	02	Introduction to Quantitative Methods with Coursework (Coursework)	Raw	18	14	12	10	8	7	0
				UMS	100	80	70	60	50	40	0
				Overall	90	72	62	53	44	35	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI)

				Max Mark	a	b	c	d	e	u
H866	01	Introduction to quantitative reasoning	Raw	72	56	49	42	35	28	0
H866	02	Critical maths	Raw	60	44	39	34	29	24	0
		*To create the overall boundaries, component 02 is weighted to give marks out of 72	Overall	144	109	96	83	70	57	0

Level 3 Certificate Mathematics - Quantitative Problem Solving (MEI)

				Max Mark	a	b	c	d	e	u
H867	01	Introduction to quantitative reasoning	Raw	72	56	49	42	35	28	0
H867	02	Statistical problem solving	Raw	60	40	36	32	28	24	0
		*To create the overall boundaries, component 02 is weighted to give marks out of 72	Overall	144	104	92	80	69	57	0

Advanced Free Standing Mathematics Qualification (FSMQ)

				Max Mark	a	b	c	d	e	u
6993	01	Additional Mathematics	Raw	100	56	50	44	38	33	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

				Max Mark	a	b	c	d	e	u
6989	01	Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0