OCR
Oxford Cambridge and RSA

Friday 16 June 2017 – 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 $g\,\mathrm{m\,s^{-2}}$. 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 **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 5 kg on a rough plane inclined at an angle α to the horizontal.

The block is in equilibrium.

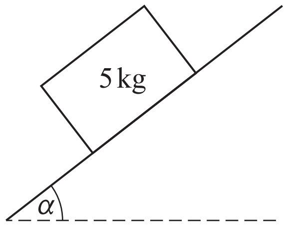

Fig. 1

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

(ii) The normal reaction of the plane on the block is 37.5 N.

Find α, giving your answer to the nearest degree.

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

2 In this question, $\begin{pmatrix}1\\0\end{pmatrix}$ and $\begin{pmatrix}0\\1\end{pmatrix}$ are unit vectors in the x- and y-directions.

A bird is flying in the vertical plane defined by these directions.

The origin is a point on the ground.

The position vector, $\mathbf{r}$ m, of the bird at time t seconds, where $t \geqslant 0$, is given by

$$\mathbf{r} = \begin{pmatrix}0\\8\end{pmatrix} + \begin{pmatrix}2\\-4\end{pmatrix}t + \begin{pmatrix}0\\1\end{pmatrix}t^2.$$

(i) Find the velocity of the bird when $t = 2.5$. **[3]**

(ii) Find the time at which the speed of the bird is $10\,\mathrm{m\,s^{-1}}$. **[3]**

(iii) Find the times at which the bird is flying at an angle of 45° to the horizontal. **[2]**

3 Olga and Petya are using light ropes to pull a sledge across rough snow.

- The surface of the snow is horizontal.
- The mass of the sledge and its load is 430 kg.
- Both ropes are horizontal.
- Olga pulls with a force of 120 N at an angle of 20° to the line of motion of the sledge.
- Petya also pulls with a force of 120 N at an angle of 20° to the line of motion of the sledge.

This is illustrated in a plan view in Fig. 2.

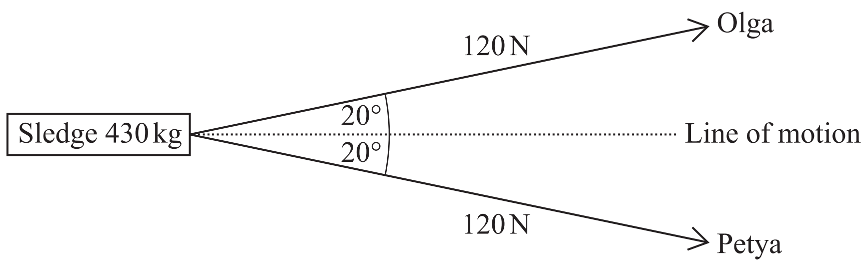

Fig. 2

(i) The sledge has acceleration $0.05\,\mathrm{m\,s^{-2}}$ in the direction of its line of motion.

Find the frictional force acting on the sledge. **[3]**

Olga and Petya then change to walking side by side. Their ropes, which are still horizontal, are now along the line of motion of the sledge. They maintain the forces on their ropes at 120 N and the frictional force remains the same.

(ii) Find the percentage increase in the acceleration of the sledge. **[4]**

4 Fig. 4 shows two small blocks, Q of mass 8 kg and R of mass 6 kg. They are connected by a light string which passes over a pulley.

The pulley is light and smooth. It is rigidly suspended from the ceiling.

The system is released from rest with the two blocks at the same height.

Initially the blocks are 2 m above the floor and 3 m below the pulley.

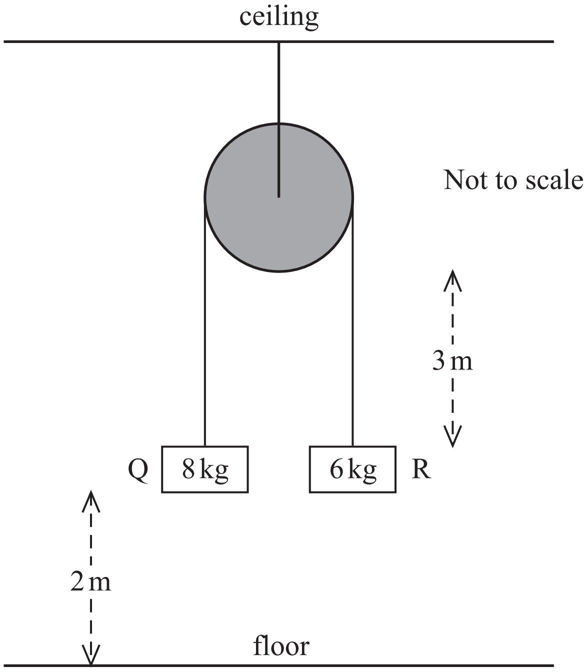

Fig. 4

(i) Draw diagrams showing the forces acting on each of the blocks Q and R. **[1]**

(ii) Write down the equations of motion of each of the blocks Q and R. **[2]**

(iii) Find the time between the system being released and one of the blocks reaching the floor. **[4]**

5 Two cars, A and B, are travelling in different lanes in the same direction along a straight road.

The initial situation is illustrated in Fig. 5.

- At this time, A is stationary at traffic lights at O. The lights have just turned green and A is on the point of moving off.
- B is travelling towards O with speed $20\,\text{m s}^{-1}$. B is 75 m behind A.

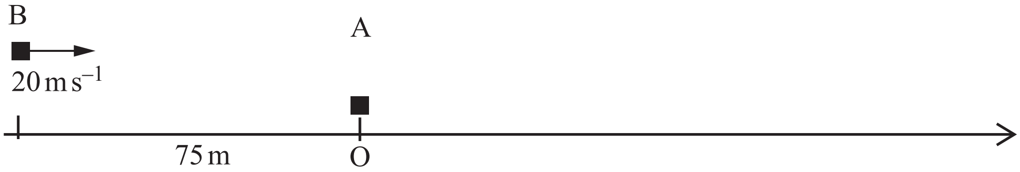

Fig. 5

During the subsequent motion,

- A has constant acceleration $2\,\text{m s}^{-2}$,
- the traffic lights remain green and B maintains a constant speed $20\,\text{m s}^{-1}$.

In order to model the subsequent motion you should make two assumptions.

- The cars can overtake each other with no interference from other traffic.
- The position of a car is defined by a point at its front and so the length of the car need not be considered.

(i) Find the times at which the two cars are side by side. **[4]**

(ii) Find the distance A travels while it is behind B. **[2]**

(iii) There is a speed camera 400 m from O.
How fast is A travelling when it passes the speed camera? **[2]**

Section B (36 marks)

6 A train is travelling along a straight test track. It starts from rest and reaches its maximum speed after a time of 2 minutes and 21 seconds. During that time it travels 5 km.

Two models, A and B, are considered for its motion.

In Model A, it is assumed that the train has constant acceleration.

(i) Find the acceleration of the train and its maximum speed according to Model A. **[5]**

In Model B, it is assumed that the acceleration, a m s^{-2} at time t seconds after starting, is given by

$$a = 0.6 - 3 \times 10^{-5} \times t^2.$$

(ii) Show that, according to Model B, the time taken for the train to reach its maximum speed is 2 minutes 21.42 seconds (to the nearest 0.01 s). **[2]**

(iii) Find expressions for the speed of the train and the distance that it has travelled at time t, according to Model B. **[4]**

(iv) Hence show that Model B is consistent with the train travelling a distance of 5 km to attain maximum speed.

Find the maximum speed of the train according to this model. **[3]**

(v) When the train reaches its maximum speed it continues at that speed.
Draw the speed-time graphs for both models on the grid provided, labelling them A and B. **[4]**

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

Fig. 7 illustrates the trajectory of a tennis ball which has been served by a player. It is not drawn to scale.

- The ball must pass over the net and land in the service court.
- The player hits the ball at an angle of α above the horizontal.

Three junior members of a tennis club take turns to serve a tennis ball. They are Hamish (a beginner), Oscar (of medium standard) and Tara (a good player). They each stand at the same point and hit the ball in the same vertical plane at the same point P. The following figures apply to their serves.

- The player hits the ball from a height of 2.22 m.
- The height of the net is 0.995 m.
- The player is 12.5 m from the net.
- The ball must bounce within 6.5 m of the net.

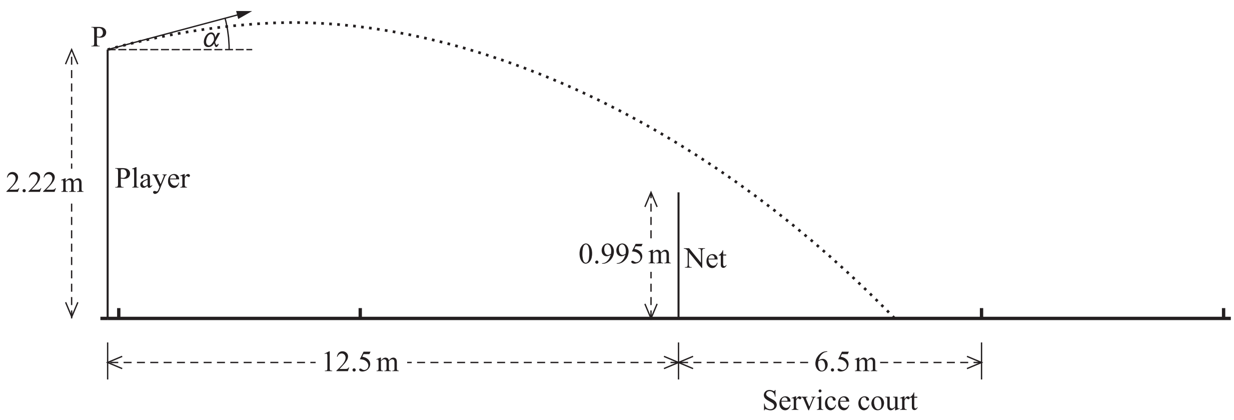

Fig. 7

Hamish serves the ball with components of velocity $10\,\text{m s}^{-1}$ horizontally and $5.5\,\text{m s}^{-1}$ vertically upwards.

(i) Find the speed of Hamish's serve and the value of α. **[2]**

(ii) Show that Hamish's serve passes over the net. **[3]**

(iii) Find the time at which Hamish's serve hits the ground.
Does it land in the service court? **[4]**

Oscar hits the ball horizontally, so $\alpha = 0$. The initial speed of the ball is $u\,\text{m s}^{-1}$.

(iv) Find the range of possible values of u for which the ball lands in the service court. **[6]**

Tara serves the ball at an angle of 2° below the horizontal. The ball clears the net and bounces after 0.57 seconds.

(v) Find the initial speed of Tara's serve. **[3]**

END OF QUESTION PAPER

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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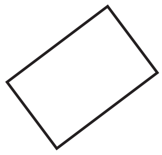
1 (i)



1 (ii)

2 (i)	
2 (ii)	
2 (iii)	

3 (i)	

3 (ii)	

4 (i)	
4 (ii)	

4 (iii)

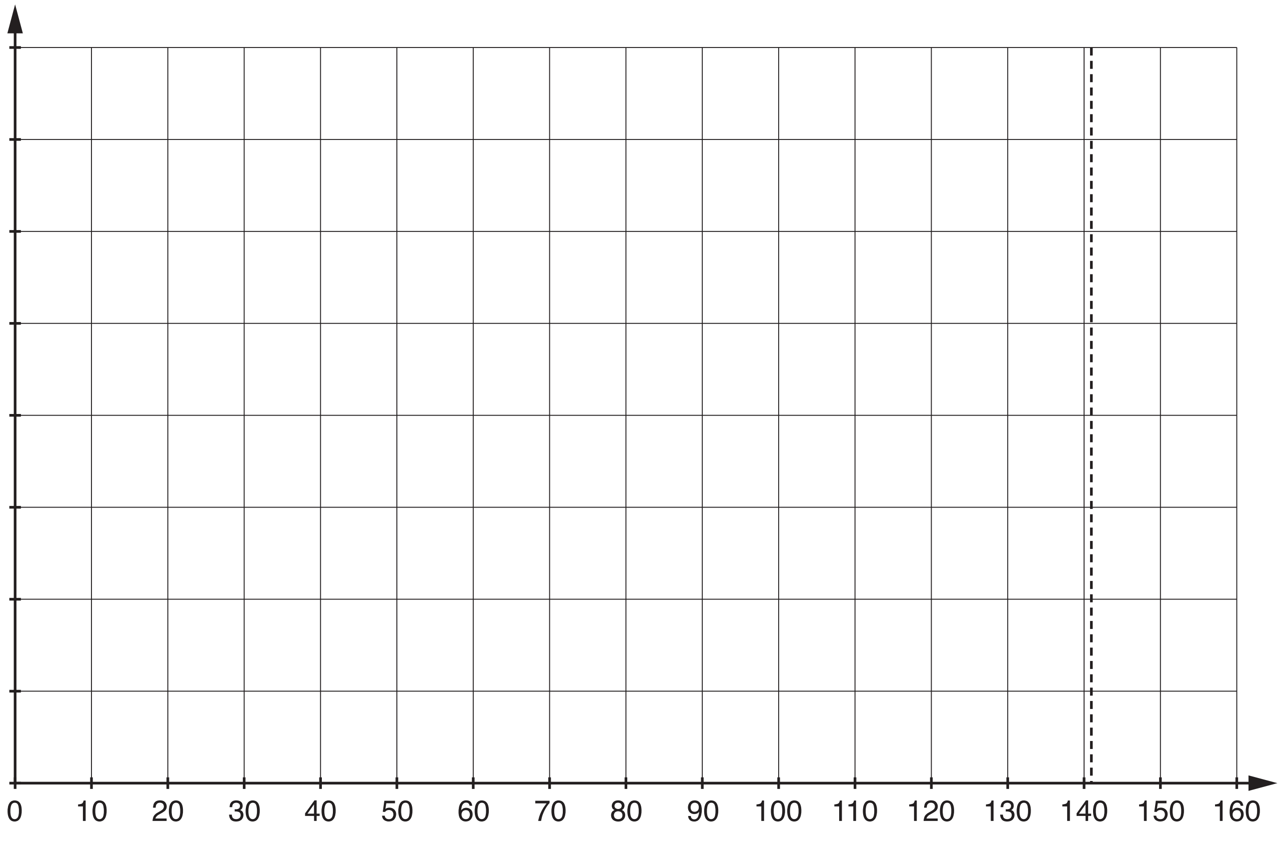
5 (i)	

5 (ii)	
5 (iii)	

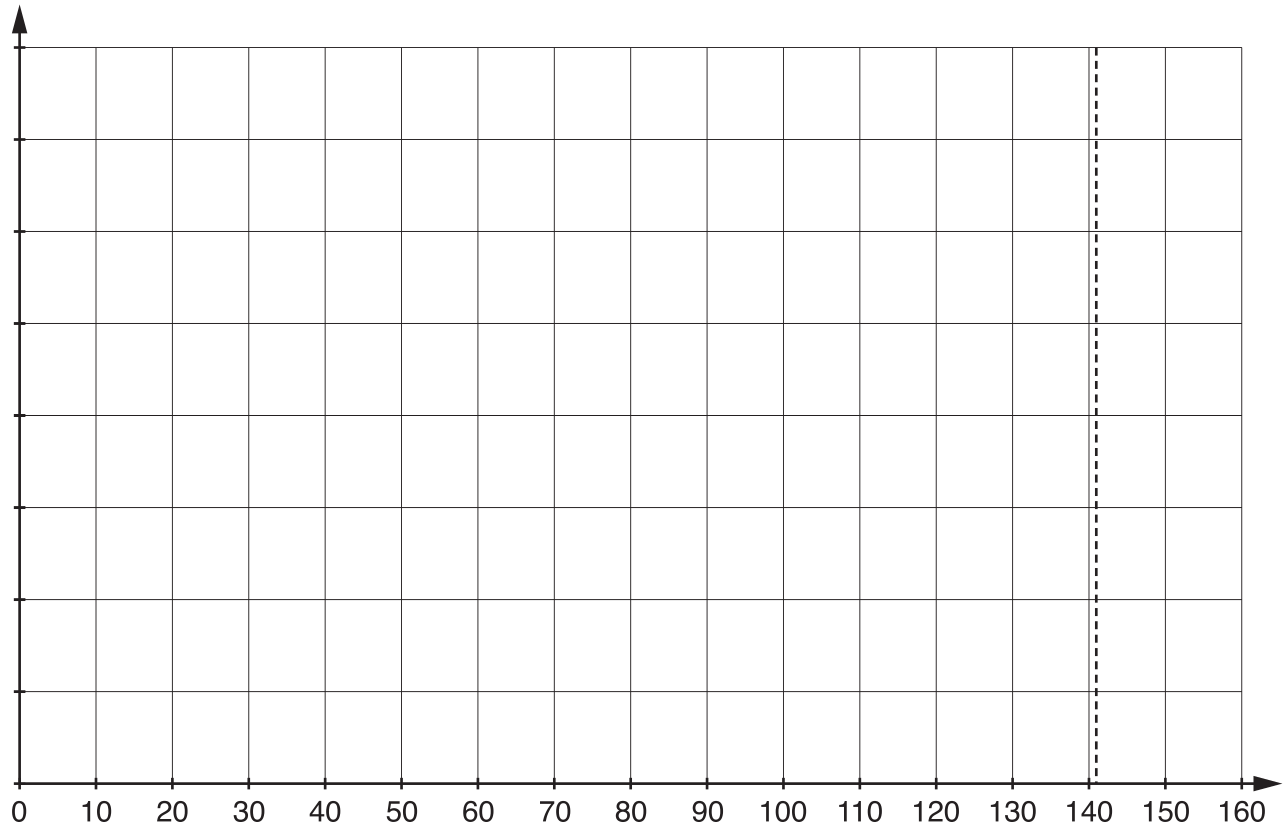
6 (i)	
6 (ii)	

6 (iii)	
6 (iv)	

6 (v)



Spare copy of the grid for 6 (v)



7 (i)	
7 (ii)	
7 (iii)	

7 (iv)	

7 (v)	

GCE

Mathematics (MEI)

Unit **4761**: Mechanics 1

Advanced Subsidiary GCE

Mark Scheme for June 2017

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.

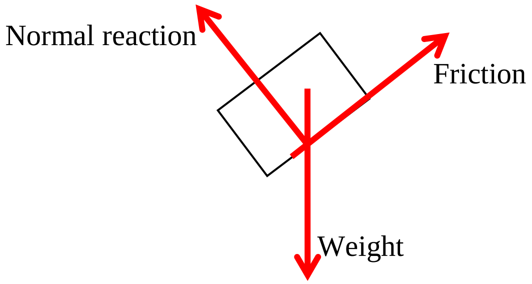
'Fresh starts' will not affect an earlier decision about a misread.

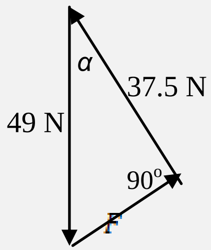
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

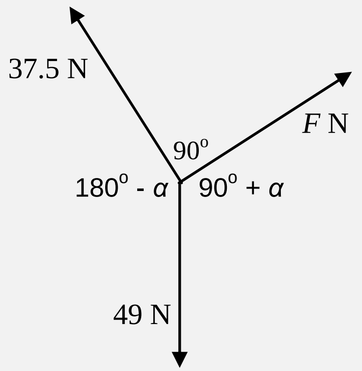
i If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is 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

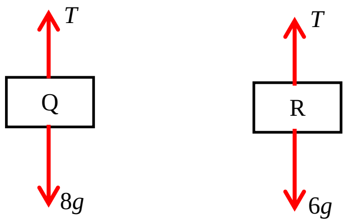
Qu	Part	Answer	Mark	Guidance
1	(i)		B1 B1 B1	**Forces** 3 correct forces. **Labels** Accept 5*g* and *mg* for weight. **Arrows** **Missing force(s)** If at least one of the 3 forces is missing, allow **SC1** for each fully correct force (ie including label and arrow) and ignore any additional forces that may be present. **Extra force(s)** Allow **B0** for **Forces** and up to **B1** for each of **Labels** and **Arrows** based on the correct forces and ignoring any extra(s). **Components of weight** Allow weight resolved into components parallel and perpendicular to the slope Accept **both** the weight and its components if the components are shown to be clearly different from the other forces (eg drawn with broken lines). Do not accept both the weight and its components if they all look the same; mark this as detailed under **Extra force(s)**.
			[3]	

1	**(ii)**	$N = 5g\cos\alpha$ (or $37.5 = 5g\cos\alpha$) $\cos\alpha = \frac{37.5}{49}$ $\alpha = 40.065...°$ so $40°$ to the nearest degree Frictional force = component of weight down the slope $= 5g\sin 40.065...°$ $(= 31.539...)$ so 31.5 N	**M1** **A1** **B1**	Do not allow sin-cos interchange Must be rounded to 40^{o} Allow any answer that rounds to 31.5 N Allow answer 31.5 N following two consistent sin-cos interchanges.
			[3]	
		Alternative Using a triangle of forces  $\cos\alpha = \frac{37.5}{49} \Rightarrow \alpha = 40°$ $= 5g\sin 40.065...°$ $(= 31.539...)$ so 31.5 N	**M1** **A1** **B1**	Condone no arrows. Do not allow sin-cos interchange Must be rounded to 40^{o} Allow any answer that rounds to 31.5 N Allow answer 31.5 N following two consistent sin-cos interchanges.

1.	(ii)	**Alternative Using Lami's theorem** 		
		$\frac{F}{\sin(180°-\alpha)} = \frac{37.5}{\sin(90°+\alpha)} = \frac{49}{\sin 90°}$	**M1**	
		$\alpha = 40°$	**A1**	Must be rounded to 40°
		$F = 31.5\text{ N}$	**B1**	Allow any answer that rounds to 31.5 N

2	(i)	Differentiating **r**	M1	Attempt at differentiation must be seen
		$\mathbf{v}=\begin{pmatrix}2\\-4\end{pmatrix}+\begin{pmatrix}0\\2\end{pmatrix}t$	A1	
		$\mathbf{v}=\begin{pmatrix}2\\1\end{pmatrix}$	B1	Apply ISW for speed = $\sqrt{5}$ providing $\begin{pmatrix}2\\1\end{pmatrix}$ is seen.
			[3]	
	(ii)	$\sqrt{2^2+(-4+2t)^2}=10$	M1	Attempt at formulation of the given information using their vector **v** from part (i). Must involve both components. e.g. $-4+2t=\sqrt{96}$ Accept drawing triangle of velocities
		$t^2-4t-20=0$		
		$t=\dfrac{4\pm\sqrt{4^2-4\times1\times-20}}{2}$ $(=6.898\ldots \text{ or } -2.898\ldots)$	M1	Attempted solution of an equation for *t*. Dependent on previous M mark
		$t=6.9$ (or -2.9) (to 2 sf)	A1	Allow FT from their vector expression for **v** in part (i). Else CAO. Condone not giving the negative value of *t* as well as the correct value. Dependent on both M marks.
			[3]	
	(iii)	Either 2 = -4 +2*t* $\Rightarrow t=3$	B1	FT from their vector expression for **v** in part (i).
		Or $-2=-4+2t \Rightarrow t=1$	B1	FT from their vector expression for **v** in part (i).
			[2]	

3	**(i)**	$2\times120\times\cos20°-F=430\times0.05$	**M1**	Newton's 2nd law, including *ma* term, friction and resolved force(s); allow sin-cos interchange for this mark only.
			A1	All terms and signs correct
		F = 204(.026 ...)	**A1**	
			[3]	
	(ii)	$430\times a=240-204.026...$	**M1**	Apply FT from their F from part (i) throughout this part. All forces present
		$a=0.08366...$	**A1**	Condone 0.08 for this mark
		Percentage increase is $\dfrac{0.0836...-0.05}{0.05}\times100\quad(=67.32...)$	**M1**	There must be evidence of a complete method for finding percentage change. The denominator must be the original acceleration and the original value must be subtracted from the new value at some stage.
		Percentage increase is 67.3% (to nearest 0.1)	**A1**	To allow for rounding and truncation, allow answers between 66% and 68% inclusive following otherwise correct working.
			[4]	

4	(i)		B1	The same symbol for T must be used in both diagrams.
			[1]	
	(ii)	Q: $8g - T = 8a$	B1	Allow the equivalent equations with the direction of a reversed
		R: $T - 6g = 6a$	B1	
			[2]	
	(iii)	Adding the equations of motion $2g = 14a$	M1	Eliminating one variable from the two equations. May be implied by subsequent working.
		$a = \frac{2g}{14}$ $\left(= 1.4 \text{ m s}^{-2}\right)$	A1	This answer must be consistent with the direction of a used in part (ii)
		For Q: $s = ut + \frac{1}{2}at^2$		Or an equivalent sequence of constant acceleration formulae
		$2 = \frac{1}{2} \times 1.4 \times t^2$	M1	Dependent on previous M mark. FT for their a but do not allow if it is g
		$\Rightarrow t = 1.690...$ so the time is 1.69 s	A1	CAO
			[4]	

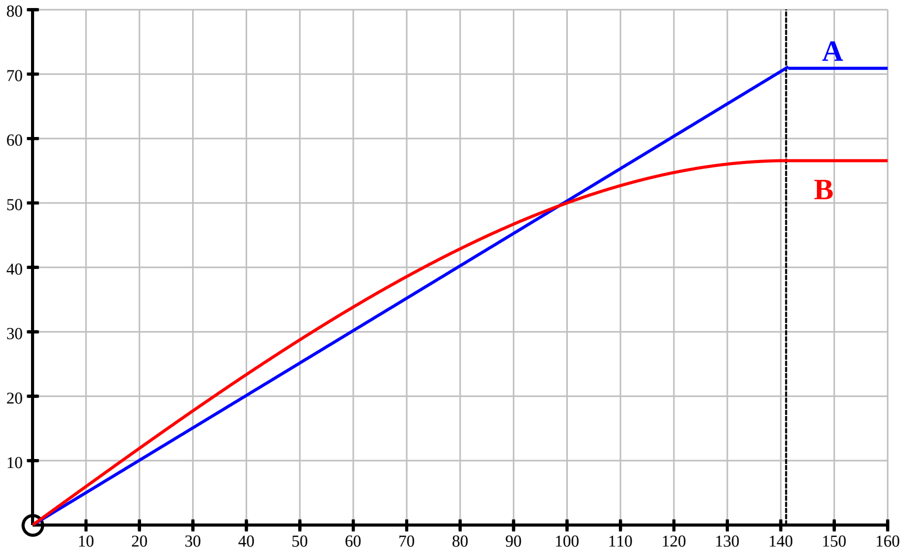
5	(i)	A: $x = t^2$	B1	Or displacements from B's start point: $x = t^2 + 75$ and $x = 20t$
		B: $x = -75 + 20t$	B1	Must be consistent
		When the cars are side by side, $t^2 = -75 + 20t$	M1	For equating two distances even if inconsistent
		$t^2 - 20t + 75 = 0$		
		$(t-5)(t-15) = 0$		
		The times are 5 seconds and 15 seconds	A1	
			[4]	
	(ii)	For A, $s = 225$ when $t = 15$		FT for two positive times from part (i) for the M mark only
		$s = 25$ when $t = 5$	M1	Both values of s attempted
		So A is behind B for 200 m	A1	CAO
			[2]	
		Alternative Using motion of B		
		Speed of B is (constant at) 20 m s^{-1}		
		So between $t = 5$ and $t = 15$, B travels 20 × (15- 5) (= 200 m)	M1	Or equivalent, eg using $s = ut + \frac{1}{2}at^2$ with $a = 0$
		So A is behind B for 200 m	A1	

5.	(ii)	**Alternative Using motion of A with the clock re-set** When the cars are first level, the motion of A is defined by $u = 10$ and $a = 2$. If the clock is re-set at this moment, $t = 0$ In this case, when they are next level, $t = 10$ $s = ut + \frac{1}{2}at^2 \Rightarrow s = 10\times10 + \frac{1}{2}\times2\times10^2$ $\Rightarrow s = 200$	 **M1** **A1**	 Or $v = u + at \Rightarrow v = 10 + 2\times10 = 30$ followed by use of $v^2 - u^2 = 2as$
5	(iii)	For A $v^2 - u^2 = 2as$ $v^2 = 2\times2\times400$ $v = 40$, (so speed 40 m s^{-1}).	 **M1** **A1**	 There must be an attempt to use the formula
			[2]	
		Alternative finding the time first For A $s = 400 \Rightarrow t = 20$ $v = u + at$ $\Rightarrow v = 40$ so 40 m s^{-1}	 **M1** **A1**	 There must be evidence of a complete method that can lead to the value of v

SECTION B

6	(i)	2 minutes 21 seconds is 141 seconds	B1	
		$s = ut + \frac{1}{2}at^2$		
		$5000 = 0 + 0.5 \times a \times 141^2$	M1	
		$a = 0.503 \quad (\text{m s}^{-2})$	A1	Allow 0.50 but not 0.5
		$v = u + at$	M1	Or equivalent, eg $v^2 - u^2 = 2as$
		$v = 0.503 \times 141 = 70.9$ so 70.9 m s^{-1}	A1	CAO (including 70.5 m s^{-1})
			[5]	
		Alternative using $s = \frac{1}{2}(u+v)t$		
		$5000 = \frac{1}{2} \times (0 + v) \times 141$	M1	
		$v = \frac{10000}{141} = 70.9...$ so 70.9 m s^{-1}	A1	CAO

6	(ii)	At maximum speed the acceleration is zero $t=\sqrt{\dfrac{0.6}{3\times10^{-5}}}\ \left(=\sqrt{20\,000}\right)\ =141.421...$ So 2 minutes 21.42 seconds	M1 A1	Setting a = 0 in the given equation for a. Accept answer in seconds
			[2]	
6	(iii)	Integrating $v=0.6t-0.000\,01t^3\ (+c)$, $(t=0,\ v=0\ \Rightarrow\ c=0)$ $s=0.3t^2-0.000\,0025t^4\ (+k)$ $t=0,\ s=0\ \Rightarrow\ k=0$	M1 A1 A1 A1	Attempt at integration. Or equivalent, eg $v=0.6t-10^{-5}\times t^3\ (+c)$ Coefficients do not need to be simplified in either integral. FT from v. Integration must be attempted. Or equivalent, eg $s=0.3t^2-2.5\times10^{-6}\times t^4\ (+k)$ Use of mechanics and not assertion to show k = 0
			[4]	
	(iv)	Substituting t = 141.42... in $s=0.3t^2-0.000\,0025t^4$ $s=5000$ so consistent with 5 km Substituting t = 141.42... in $v=0.6t-0.000\,01t^3$ $v=56.57\ \text{m}\,\text{s}^{-1}$	M1 A1 B1	Allow substituting s = 5000 to show that t =141.42... Notice that $141.42....=\sqrt{20\ 000}$ and so the answer of 5000 is exact
			[3]	

6	(v)		B1	Vertical scale from 0 that ensures that at least half the height is used.
				For the remaining marks do not allow FT from earlier parts.
			B1	A: A straight line from (0, 0) to (141, 70.9)
			B1	B: A curve from (0, 0) to (141, 56.6); the curvature must be in the right sense.
			B1	Both A from (141, 70.9) to (160, 70.9) and B from (141, 56.6) to (160, 56.6). CAO.
			[4]	

7.	(i)	Initial speed = $\sqrt{10^2+5.5^2}=11.412...$ so 11.4 m s-1 (to 1 dp)	B1	
		$\alpha=\arctan\left(\frac{5.5}{10}\right)=28.810...$ so 28.8^{o} (to the nearest 0.1^{o})	B1	
			[2]	
	(ii)	Horizontal motion: Time to net $10t$ = 12.5 so 1.25 s	B1	
		Vertical motion $s=s_0+ut+\frac{1}{2}at^2$		
		$y=2.22+5.5\times1.25-4.9\times1.25^2$	M1	A complete method for finding the height of the ball when it crosses the net. With the point of projection as the origin for vertical motion, the distance fallen in 1.25 s is 0.78125 m and 2.22 - 0.78125 =1.43875
		= 1.43875		
		This is greater than 0.995 so the ball goes over the net.	A1	Conclusion stated
			[3]	
		Alternative using time to net level and horizontal distance		
		$0.995=2.22+5.5t-4.9t^2 \Rightarrow t=1.313$	B1	
		Horizontal distance $10\times1.313=13.13$	M1	A complete method for finding the position of the ball when it is at the height of the top of the net.
		13.13 > 12.5 so the ball passes over the net	A1	Conclusion stated.

	(iii)	Vertical motion $s = s_0 + ut + \frac{1}{2}at^2$		
		$0 = 2.22 + 5.5t - 4.9t^2$	M1	Setting up an equation for vertical motion containing the right elements. (Vertical velocity on landing = 8.59 m s^{-1})
		$t = \frac{5.5 \pm \sqrt{5.5^2 + 4 \times 4.9 \times 2.22}}{2 \times 4.9} = 1.437...$ $\left(\text{or } -0.315...\right)$	A1	
		Horizontal motion $x = 10 \times 1.437... = 14.37...$	M1	Allow for 10 × their time. This may be implied.
		14.37... < 19 so the ball does land in the service court	A1	Conclusion stated. FT for their value of *t*.
			[4]	

7	(iv)	**Clearing the net**		
		The ball falls 2.22 - 0.995 = 1.225 m to the height of the net	M1	
		Time taken is given by $1.225 = 4.9t^2$		
		So $t = 0.5$	A1	The value of t can be implied and need not be seen.
		Speed must be greater than $\frac{12.5}{0.5} = 25 \text{ m s}^{-1}$	A1	
		Not going too far		
		Time to fall to the ground is given by $2.22 = 4.9t^2$	M1	
		So $t = 0.673...$	A1	The value of t can be implied and need not be seen.
		Horizontal distance must not exceed 19 m		
		Maximum speed = $\frac{19}{0.673...} = 28.227... \text{ m s}^{-1}$	A1	
		(Overall)		
		(So the ball's speed must be between 25 and 28.2 m s^{-1}.)		
			[6]	

Question		Answer	Marks	Guidance
7	(v)	Vertical motion $s = s_0 + ut + \frac{1}{2}at^2$		
		Using *u* to be the initial speed $0 = 2.22 - u \times \sin 2° \times 0.57 - 4.9 \times 0.57^2$	M1	An equation for vertical motion which could be used to find *u*. It must contain all three elements. No sin-cos interchange. If sin2° is not seen use the alternative method.
			A1	The equation must be correct including signs.
		$u = \frac{2.22 - 4.9 \times 0.57^2}{0.57 \times \sin 2°}$		
		$u = 31.568...$ so the speed of Tara's serve is 31.6 m s^{-1}	A1	CAO
			[3]	
		Alternative Using *U* as the initial vertical component downwards		Or equivalent for vertical motion upwards
		$0 = 2.22 - U \times 0.57 - 4.9 \times 0.57^2$	M1	
		$U = \frac{2.22 - 4.9 \times 0.57^2}{0.57} = 1.10173...$	A1	The value of *U* is calculated correctly. It should be negative if the direction of U is upwards.
		Speed = $\frac{U}{\sin 2°} = 31.568...$ So the speed of Tara's serve is 31.6 m s^{-1}	A1	

7. Alternative mark schemes for parts (ii), (iii) and (iv) using the equation of the trajectory

7.	**(ii)**	$y = y_0 + x\tan\alpha - \dfrac{gx^2}{2u^2\cos^2\alpha}$		
		$y = 2.22 + 0.55x - 0.049x^2$	**B1**	
		$x = 12.25$	**M1**	
		$\Rightarrow y = 1.438... > 0.995$	**A1**	
			[3]	
	(iii)	$y = 2.22 + 0.55x - 0.049x^2$	**M1**	
		$x = 19$ / Or $y = 0$	**M1**	
		$\Rightarrow y = -5.019$ / $x = 14.376...\ (\text{or} -3.151...)$	**A1**	Dependent on both M marks
		So the ball lands in the service court	**A1**	
			[4]	

7	(iv)	$y = 2.22 - 0.049\left(\frac{x}{u}\right)^2$		
		Clearing the net		
		To clear the net $2.22 - 4.9\left(\frac{12.5}{u}\right)^2 > 0.995$	M1	
		$\Rightarrow \left(\frac{u}{12.5}\right)^2 > \left(\frac{4.9}{1.225}\right)$	A1	
		Speed must be greater than $\frac{12.5}{0.5} = 25 \text{ m s}^{-1}$	B1	
		Not going too far		
		To land inside the service court, horizontal distance must not exceed 19 m $\Rightarrow$ $2.22 - 4.9 \times \left(\frac{19}{u}\right)^2 < 0$	M1	
		$\frac{u}{19} < \sqrt{\frac{4.9}{2.22}}$	A1	
		$u < 28.227$		
		Maximum speed = $28.227... \text{ m s}^{-1}$	A1	
		(So the ball's speed must be between 25 and 28.2 m s^{-1}.)		
			[6]	

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4761 Mechanics 1

General

This paper was answered with a pleasing level of confidence. Most candidates knew what techniques were appropriate to the various questions and were usually able to apply them. They had clearly been well prepared.

The majority of candidates were able to find questions that allowed them to show what they knew. There were also many candidates who scored highly across all the questions, even on the most demanding parts of the paper.

There was no evidence of candidates being under time pressure. Although there were some who did not complete the final question, they were almost entirely those who had not correctly completed all the previous questions.

Individual questions

Sections A

1. Equilibrium of a block on a rough slope

Part (i) of this question involved drawing a diagram for the forces acting on a block in equilibrium on a rough slope. While on the whole this was well answered, there were some surprising errors, such as showing the weight acting perpendicular to the slope or the normal reaction acting vertically. Some candidates showed the components of the weight as well as the weight itself; this is accepted if the components are presented differently from the other forces, for example using broken lines, but not if they all look the same.

In part (ii) candidates were required to use the given information to find the angle of the slope and the frictional force. Most did this successfully. However, the question asked for the angle to be given to the nearest degree and many lost a mark by giving it to some other level of accuracy.

2. Using vectors to describe the flight of a bird

This question was about vectors, using the context of the flight of a bird. The position vector of the bird was given in term of the time.

In part (i) candidates were asked about the velocity of the bird and this was well answered using vectors.

In part (ii), the time was to be found at which the bird had a given speed. This involved using a vector expression to form a scalar equation. Many candidates did not know how to go about this. Others obtained the right answer but their explanations were not always the most elegant. However there were very good answers written by some candidates.

In part (iii), candidates were asked to find the times when the bird was flying at an angle of 45^{o} to the horizontal. Correct answers to this were somewhat uncommon. One common mistake was to equate the components of the position vector rather than the velocity; most of those who did use the velocity considered only the case when the bird was flying above the horizon and not when it was flying below it.

3. Newton's 2nd law applied to the motion of a sledge

In part (i) the forces acting on a sledge and its acceleration were given and the question asked for the force of resistance. This was answered correctly by nearly everyone.

In part (ii) candidates were asked to find the new acceleration and the percentage increase when the forces were applied in a different manner. Almost all found the new acceleration correctly but there were quite a lot of errors working out the percentage, for example using the wrong denominator and forgetting to subtract the original value. Teachers using this question in the classroom may like to compare the percentage increases in the forward force on the sledge (6.4%) and the acceleration (67.3%) and consider why there is such a large difference between them.

4. Particles connected by a string passing over a pulley

Part (i) asked for force diagrams for the two connected particles, in this case blocks. A minority of candidates failed to get this right; the most common error was to mark different tensions for the different parts of the string.

Part (ii) followed on from part (i) with a request for the equations of motion of the two blocks. This was not universally well answered; sign errors were common.

In part (iii) the blocks were released and candidates were asked to find the time taken for one of them to reach the floor. This involved finding the acceleration of the system. Many, including those who has made mistakes in the earlier parts, did this using a whole system approach rather than working from the equations of motion.

5. Constant acceleration formulae based on the motion of two cars

This question involved the motion of two cars in parallel lanes on a road. One had constant acceleration and the other travelled at constant speed. One car was initially behind the other.

In part (i) candidates were asked to find the times when the cars were side by side. While there were many fully correct answers to this, there were also plenty of sign errors involving the 75 m difference in starting position. A few candidates did not realise that answering this question involved setting up an equation for the time t.

In part (ii) the question for the distance for which one particular car was ahead of the other. This was lower scoring than the other parts of the question.

In part (iii) they were asked to find the speed of one of the cars after it had travelled 400 m and this was very well answered, even by those who had made mistakes on earlier parts.

Section B

6. Modelling using the motion of a train

This was the first of the two long questions. It was based on two different models for the motion of a train from rest to maximum speed. It involved both constant and variable acceleration. On the whole this question was well answered with many high marks.

Part (i) was based on a constant acceleration model. It was very well answered with most candidates obtaining all the five available marks. However, many candidates lost one mark by giving the acceleration to only one significant figure.

The question then moved on to a model with variable acceleration. Part (ii) required candidates to recognise that when the train reached maximum speed its acceleration is zero and so obtain a given value for the time taken. While most candidates were successful in this, a substantial number did not recognise the significance of zero acceleration and tried other unsuccessful approaches, often involving a lot of fruitless work.

Part (iii) required candidates to integrate the acceleration to find the speed and then to integrate again to find the distance travelled by the train. Many candidates did not consider the constants of integration, or just declared them to be zero without any reason, and this was penalised.

In part (iv) candidates were expected to use the time given in part (ii) and their expression for the distance travelled from part (iii) to verify the distance the train had travelled in attaining maximum speed. Many knew just what to do and were successful. Some tried to do the question in reverse, substituting the distance and forming a quartic equation for the time; this was a viable approach and a few candidates realised that their equation could be written as a quadratic in t^2 and went on to solve it.
The question continued to ask for the maximum speed and this was well answered, even by those who had not been successful with the distance.

The final part (v) required the two models to be shown on a speed-time graph. This produced a wide spread of marks. Most candidates knew what they were trying to do but made errors. Some lost a mark by not showing the motion after the train had reached maximum speed and many others drew a straight line rather than a curve for the variable acceleration model.

7. Projectiles

This was the second of the two long questions. It was based on the context of tennis players serving. There were several points that candidates had to take into account: the ball was served from a given height; it had to pass over the net; it had to land in the service court. In addition the three players served with different speeds and at different angles to the horizontal. All of this meant that a significant amount of analysis was required and as a result some candidates were not successful on the later parts of the question.

In parts (i) to (iii) the serve was modelled as a projectile with given horizontal and vertical speeds. Most candidates were reasonably successful on all three parts: finding the speed and angle of projection in part (i), showing the ball passed over the net in part (ii) and finding out whether the ball landed in the service court in part (iii). The most common mistake was confusing horizontal and vertical components of the motion; there were also many sign errors.

In part (iv) a different player was serving, this time horizontally. The question asked candidates to find the range of possible values of the initial speed for the serve to land in the service court. This involved essentially the same work as parts (i) to (iii) although the situation was actually simpler with no vertical component of the initial velocity. However, no guidance was given and so candidates were required to analyse the situation; a substantial minority of candidates failed to do so and scored no marks. Among those candidates who did come to terms with the situation, some obtained both limits for the initial speed but many made a mistake with the lower limit, finding the minimum initial speed for the ball to reach the net without bouncing rather than to pass over the net.

In part (v) a third player served with initial direction below the horizontal. Only a minority of candidates scored any marks on this question and, among those who did, sign errors were quite common.

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Unit level raw mark and UMS grade boundaries June 2017 series

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

GCE Mathematics (MEI)											
				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	58	53	49	45	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	55	49	44	39	34	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	54	49	45	41	36	0
4753	02	(C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – MEI Applications of advanced mathematics (A2)	Raw	90	67	61	55	49	43	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	57	52	47	42	38	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	65	58	52	46	40	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	64	56	48	41	34	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	63	56	50	44	37	0
4758	02	(DE) MEI Differential Equations with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – MEI Mechanics 1 (AS)	Raw	72	57	49	41	34	27	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	56	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	58	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	53	45	38	31	24	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	61	55	49	43	37	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	56	50	45	40	35	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	63	57	51	46	41	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – MEI Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – MEI Decision mathematics 1 (AS)	Raw	72	52	46	41	36	31	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	53	48	43	39	35	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – MEI Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) MEI Numerical Methods with Coursework: Written Paper	Raw	72	58	53	48	43	37	0
4776	02	(NM) MEI Numerical Methods with Coursework: Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – MEI Numerical computation (A2)	Raw	72	55	48	41	34	27	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

GCE Statistics (MEI)

			Max Mark	a	b	c	d	e	u
G241	01 Statistics 1 MEI (Z1)	Raw	72	61	55	49	43	37	0
		UMS	100	80	70	60	50	40	0
G242	01 Statistics 2 MEI (Z2)	Raw	72	55	48	41	34	27	0
		UMS	100	80	70	60	50	40	0
G243	01 Statistics 3 MEI (Z3)	Raw	72	56	48	41	34	27	0
		UMS	100	80	70	60	50	40	0

GCE Quantitative Methods (MEI)

			Max Mark	a	b	c	d	e	u
G244	01 Introduction to Quantitative Methods MEI	Raw	72	58	50	43	36	28	0
G244	02 Introduction to Quantitative Methods MEI	Raw	18	14	12	10	8	7	0
		UMS	100	80	70	60	50	40	0
G245	01 Statistics 1 MEI	Raw	72	61	55	49	43	37	0
		UMS	100	80	70	60	50	40	0
G246	01 Decision 1 MEI	Raw	72	52	46	41	36	31	0
		UMS	100	80	70	60	50	40	0

Level 3 Certificate and FSMQ raw mark grade boundaries June 2017 series

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Level 3 Certificate Mathematics for Engineering

				Max Mark	a*	a	b	c	d	e	u
H860	01	Mathematics for Engineering		This unit has no entries in June 2017							
H860	02	Mathematics for Engineering									

Level 3 Certificate Mathematical Techniques and Applications for Engineers

				Max Mark	a*	a	b	c	d	e	u
H865	01	Component 1	Raw	60	48	42	36	30	24	18	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI) (GQ Reform)

				Max Mark	a	b	c	d	e	u
H866	01	Introduction to quantitative reasoning	Raw	72	54	47	40	34	28	0
H866	02	Critical maths	Raw	60*	48	42	36	30	24	0
		*Component 02 is weighted to give marks out of 72	Overall	144	112	97	83	70	57	0

Level 3 Certificate Mathematics - Quantitive Problem Solving (MEI) (GQ Reform)

				Max Mark	a	b	c	d	e	u
H867	01	Introduction to quantitative reasoning	Raw	72	54	47	40	34	28	0
H867	02	Statistical problem solving	Raw	60*	41	36	31	27	23	0
		*Component 02 is weighted to give marks out of 72	Overall	144	103	90	77	66	56	0

Advanced Free Standing Mathematics Qualification (FSMQ)

				Max Mark	a	b	c	d	e	u
6993	01	Additional Mathematics	Raw	100	72	63	55	47	39	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