OCR
Oxford Cambridge and RSA

Friday 17 June 2016 – 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

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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 bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $g\,\text{m s}^{-2}$. 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 M kg being pushed over level ground by means of a light rod. The force, T N, this exerts on the block is along the line of the rod.

The ground is rough.

The rod makes an angle α with the horizontal.

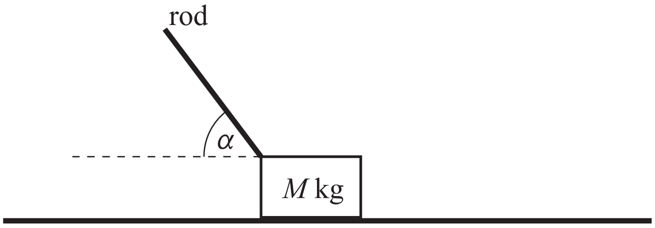

Fig. 1

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

(ii) You are given that $M = 5, \alpha = 60°, T = 40$ and the acceleration of the block is $1.5\,\text{m}\,\text{s}^{-2}$.

Find the frictional force.

[3]

2

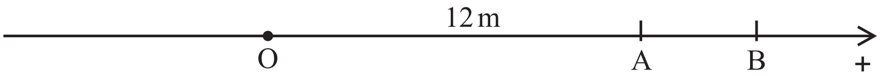

Fig. 2

A particle moves on the straight line shown in Fig. 2. The positive direction is indicated on the diagram.

The time, t, is measured in seconds. The particle has constant acceleration, $a\,\text{m}\,\text{s}^{-2}$.

Initially it is at the point O and has velocity $u\,\text{m}\,\text{s}^{-1}$.

When $t = 2$, the particle is at A where OA is 12 m. The particle is also at A when $t = 6$.

(i) Write down two equations in u and a and solve them. **[4]**

(ii) The particle changes direction when it is at B.

Find the distance AB. **[3]**

3 Fig. 3.1 shows a block of mass 8 kg on a smooth horizontal table.

This block is connected by a light string passing over a smooth pulley to a block of mass 4 kg which hangs freely. The part of the string between the 8 kg block and the pulley is parallel to the table.

The system has acceleration $a\,\mathrm{m\,s^{-2}}$.

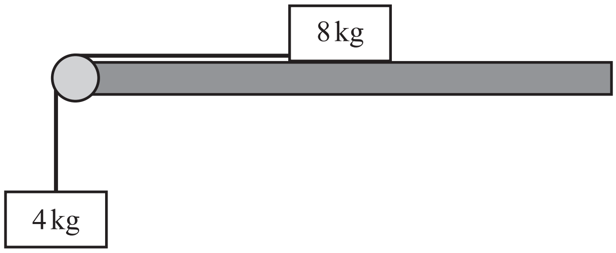

Fig. 3.1

(i) Write down two equations of motion, one for each block. **[2]**

(ii) Find the value of a. **[2]**

The table is now tilted at an angle of θ to the horizontal as shown in Fig. 3.2. The system is set up as before; the 4 kg block still hangs freely.

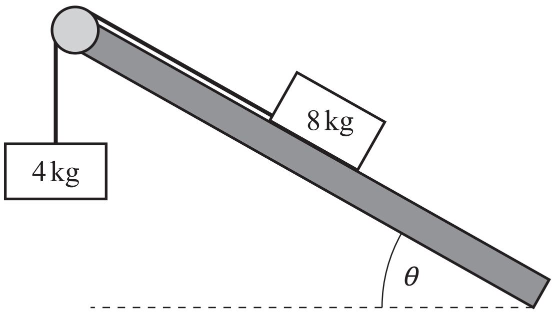

Fig. 3.2

(iii) The system is now in equilibrium. Find the value of θ. **[4]**

4 A particle is initially at the origin, moving with velocity **u**. Its acceleration **a** is constant.

At time t its displacement from the origin is $\mathbf{r} = \begin{pmatrix} x \\ y \end{pmatrix}$, where $\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 2 \\ 6 \end{pmatrix} t - \begin{pmatrix} 0 \\ 4 \end{pmatrix} t^2$.

(i) Write down **u** and **a** as column vectors. **[2]**

(ii) Find the speed of the particle when $t = 2$. **[3]**

(iii) Show that the equation of the path of the particle is $y = 3x - x^2$. **[3]**

5 Mr McGregor is a keen vegetable gardener. A pigeon that eats his vegetables is his great enemy.

One day he sees the pigeon sitting on a small branch of a tree. He takes a stone from the ground and throws it. The trajectory of the stone is in a vertical plane that contains the pigeon. The same vertical plane intersects the window of his house. The situation is illustrated in Fig. 5.

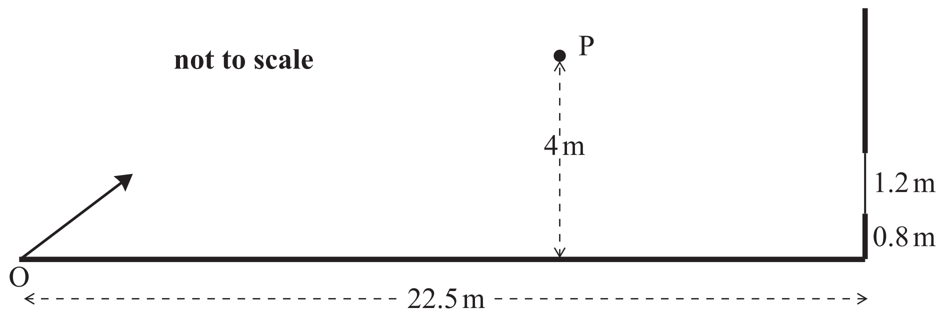

Fig. 5

- The stone is thrown from point O on level ground. Its initial velocity is $15\,\mathrm{m\,s^{-1}}$ in the horizontal direction and $8\,\mathrm{m\,s^{-1}}$ in the vertical direction.
- The pigeon is at point P which is 4 m above the ground.
- The house is 22.5 m from O.
- The bottom of the window is 0.8 m above the ground and the window is 1.2 m high.

Show that the stone does not reach the height of the pigeon.

Determine whether the stone hits the window. **[7]**

Section B (36 marks)

6 In this question you should take g to be $10\,\mathrm{m\,s^{-2}}$.

Piran finds a disused mineshaft on his land and wants to know its depth, d metres.

Local records state that the mineshaft is between 150 and 200 metres deep.

He drops a small stone down the mineshaft and records the time, T seconds, until he hears it hit the bottom. It takes 8.0 seconds.

Piran tries three models, A, B and C.

In model A, Piran uses the formula $d = 5T^2$ to estimate the depth.

(i) Find the depth that model A gives and comment on whether it is consistent with the local records.

Explain how the formula in model A is obtained. **[4]**

In model B, Piran uses the speed-time graph in Fig. 6.

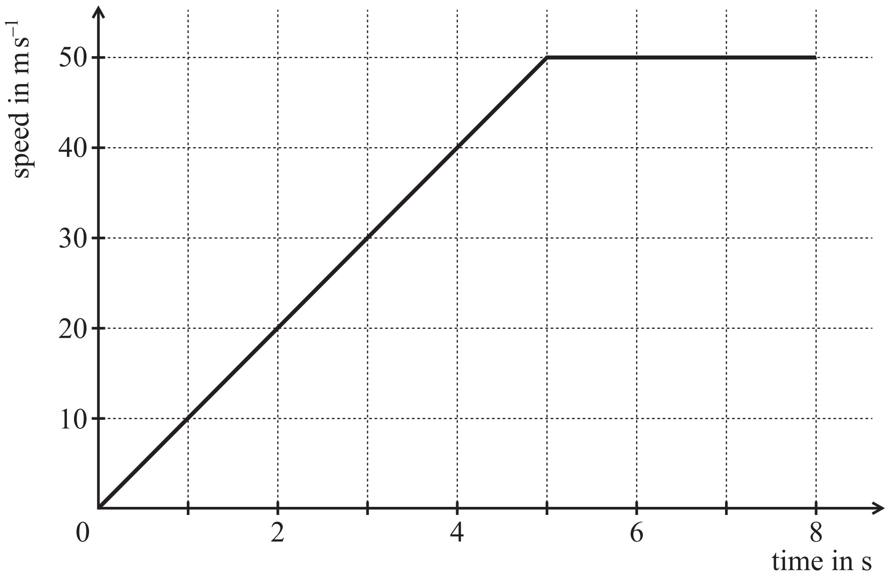

Fig. 6

(ii) Calculate the depth of the mineshaft according to model B.

Comment on whether this depth is consistent with the local records. **[4]**

(iii) Describe briefly one respect in which model B is the same as model A and one respect in which it is different. **[2]**

Piran then tries model C in which the speed, $v\,\mathrm{m\,s^{-1}}$, is given by

$$v = 10t - t^2 \text{ for } 0 \leqslant t \leqslant 5,$$

$$v = 25 \text{ for } 5 < t \leqslant 8\,.$$

(iv) Calculate the depth of the mineshaft according to model C.

Comment on whether this depth is consistent with the local records. **[6]**

(v) Describe briefly one respect in which model C is similar to model B and one respect in which it is different. **[2]**

7 Fig. 7 illustrates a situation on a building site. An unexploded bomb is being lifted by light ropes that pass over smooth pulleys. The ropes are attached to winches V and W.

- The weight of the bomb is 7500 N.
- The winches are on horizontal ground and are at the same level.
- The sloping parts of the ropes from V and W are at angles α and β to the horizontal.
- The point P is level with the horizontal sections of the ropes and is 16 m and 9 m from the two pulleys, as shown.
- The winches are controlled so that the bomb moves in a vertical line through P. The tension in the rope attached to winch W is kept constant at 8000 N. The tension, T N, in the rope attached to winch V is varied.
- The distance between the top of the bomb, B, and the point P is d metres.

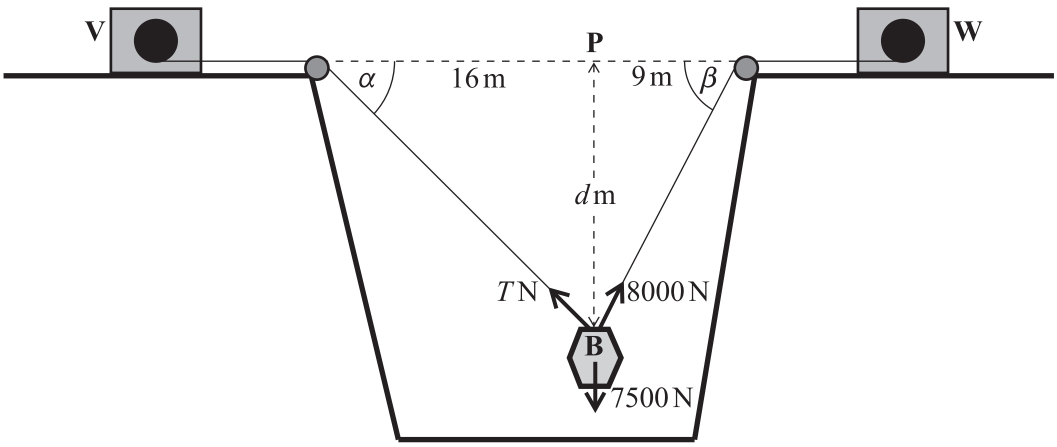

Fig. 7

At a particular stage in the lift, $d = 12$ and $T = 6000$.

(i) Find the values of $\cos\alpha$ and $\cos\beta$ at this stage. **[1]**

(ii) Verify that, at this stage, the horizontal component of the bomb's acceleration is zero. Find the vertical component of its acceleration. **[7]**

At a later stage, the bomb is higher up and so the values of d, T, α and β have all changed.

(iii) Show that $T = \dfrac{8000\cos\beta}{\cos\alpha}$.

Hence show that $T = \dfrac{4500\sqrt{d^2 + 256}}{\sqrt{d^2 + 81}}$. **[4]**

(iv) Find the acceleration of the bomb when $d = 6.75$. **[4]**

(v) Explain briefly why it is not possible for the bomb to be in equilibrium with B at P.

What could you say about the acceleration of the bomb if B were at P and the tensions in the two ropes were equal? **[2]**

END OF QUESTION PAPER

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4761/01 Mechanics 1

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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Turn over

1 (i)	
1 (ii)	

2 (i)	
2 (ii)	

3 (i)

3 (ii)

3 (iii)	

4 (i)

4 (ii)

4 (iii)	

5

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5	(continued)

6 (i)	
6 (ii)	

6 (iii)	
6 (iv)	

6 (v)	

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7 (i)	
7 (ii)	
	(answer space continued on next page)

7 (ii)	**(continued)**
7 (iii)	

7 (iv)	
7 (v)	

Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4761**: Mechanics 1

Advanced Subsidiary GCE

Mark Scheme for June 2016

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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

1. **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.

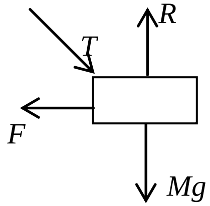
'Fresh starts' will not affect an earlier decision about a misread.

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.

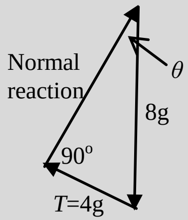
SECTION A

Qu	Part	Answer	Mark	Guidance
1.	(i)		B1 B1 B1	Forces **B0** if one force missing or an extra force present Labels Arrows **B0** if T in tension Allow T given in components provided it is clear they are not additional forces. Allow sin-cos interchange in this case. Give **B0 B0 B0** if 2 or more forces missing
			[3]	
	(ii)			Notice that the same solution applies if the direction of T was wrong in part (i), and full marks are available for part (ii) in this case.
		$T\cos\alpha - F = ma$	M1	Horizontal equation of motion with the right 3 elements
		$40\cos\alpha - F = 5\times 1.5$	A1	A0 if sin-cos interchange
		$F = 12.5$ Frictional force of 12.5 N.	A1	CAO
			[3]	

Qu	Part	Answer	Mark	Guidance
2.	(i)	$s = ut + \frac{1}{2}at^2$		The final mark scheme will include commonly used alternative methods.
		$t = 2 \Rightarrow 2u + 2a = 12$	B1	Allow one equation with $v = 0$ and $t = 4$
		$t = 6 \Rightarrow 6u + 18a = 12$	B1	
		Solving the simultaneous equations	M1	Attempt to solve non-trivial simultaneous equations in u and a
		$u = 8, \quad a = -2$	A1	CAO
			[4]	
	(ii)	At B, $v^2 - u^2 = 2as$		Follow through for their values of u and a.
		$\Rightarrow 0^2 - 8^2 = 2 \times -2 \times s$	M1	Allow the use of $s = ut + \frac{1}{2}at^2$ with $t = 4$.
		$s = 16$	A1	
		AB is 4 m.	A1	CAO
			[3]	

Qu	Part	Answer	Mark	Guidance
3.	(i)	$T = 8a$	B1	
		$4g - T = 4a$	B1	Allow if a is in the upwards direction but the two equations must be consistent in this.
			[2]	
	(ii)	Adding the two equations $\Rightarrow$ $4g = 12a$	M1	Or equivalent method. No FT from part (i).
		$a = \frac{g}{3}$ (-3.27 m s^{-2})	A1	CAO but allow 3.26 .
			[2]	
	(iii)	Equilibrium equations $T - 4g = 0$ $T - 8g\sin\theta = 0$ $4g$ - $8g\sin\theta = 0$	M1 M1 A1	Vertical equation Award if $8g\sin\theta$ seen. Do not allow sin-cos interchange Correct equation with $T = 4g$ substituted
				Note Award **M1 M1 A1** for going straight to $4g = 8g\sin\theta$ oe Allow **M1 M1 A0** for 4 = 8sinθ with no previous work
		$\Rightarrow$ $\theta = 30°$	A1	CAO
			[4]	

4761 June 2016 Addition to Mark scheme Alternative method for 3(iii)

3.	**(iiii)**	**Alternative**		
		$T - 4g = 0$	**M1**	
		Triangle of forces for the 8 kg block 	**M1**	Dependent on the other M mark There must be an attempt to use the triangle for this mark to be awarded. The triangle must be labelled with $4g$, $8g$ and θ . The right angle must be drawn close to 90^{o}.
		$\sin\theta = \frac{4g}{8g}$	**A1**	Dependent on both M marks.
		$\theta = 30°$	**A1**	CAO

Qu	Part	Answer	Mark	Guidance
4.	(i)	$\mathbf{u} = \begin{pmatrix} 2 \\ 6 \end{pmatrix}$	B1	
		$\mathbf{a} = \begin{pmatrix} 0 \\ -8 \end{pmatrix}$	B1	
			[2]	
	(ii)	$\mathbf{v} = \mathbf{u} + \mathbf{a}t$		
		$t = 2 \Rightarrow \mathbf{v} = \begin{pmatrix} 2 \\ 6 \end{pmatrix} + \begin{pmatrix} 0 \\ -8 \end{pmatrix} \times 2$ $= \begin{pmatrix} 2 \\ -10 \end{pmatrix}$	M1 A1	Or equivalent. FT for their **u** and **a** Continue the FT for this mark
		Speed $= \sqrt{2^2 + (-10)^2} = 10.2\,\text{m s}^{-1}$ (to 3 sf)	B1	FT from their **v**
			[3]	
	(iii)	$x = ut \Rightarrow x = 2t \Rightarrow t = \frac{x}{2}$	M1	This mark may also be obtained for substituting x for $2t$ in the expression for y.
		$y = 6t - 4t^2$	B1	
		$y = 6 \times \frac{x}{2} - 4 \times \left(\frac{x}{2}\right)^2 = 3x - x^2$	A1	
			[3]	

Qu	Part	Answer	Mark	Guidance
4.	(iii)	**Alternative**		
		$x = 2t$		
		Substitute for x in given answer	**M1**	
		$y = 3x - x^2 \Rightarrow y = 6t - 4t^2$	**A1**	
		This is the given expression for y	**B1**	

Qu	Part	Answer	Mark	Guidance
5.		At maximum height	M1	For considering maximum height
		$v^2 - u^2 = 2as \Rightarrow 0^2 - 8^2 = 2\times(-9.8)\times h$	M1	Use of suitable *suvat* equation(s) eg finding and using *t* for maximum height (0.816 s). Allow for use of calculus.
		$h = 3.265...$	A1	CAO but allow 3.26 as well as 3.27
		($3.265... < 4$) so the stone misses the pigeon	A1	Dependent on previous mark
		Alternative		
		Substitute y = 4 in $y = 8t - 4.9t^2$	M1	
		Attempt to solve $4.9t^2 - 8t + 4 = 0$	M1	
		Discriminant (= 64 - 4 × 4.9 × 4 = - 14.4) < 0	A1	
		No value of *t* so the stone does not reach height 4 m	A1	
		Time to house is $\frac{22.5}{15} = 1.5$ s	B1	
		Height at house $= 8\times1.5 - \frac{1}{2}\times9.8\times1.5^2 = 0.975$ m	B1	Allow answers from essentially correct working that round to 0.96, 0.97 or 0.98, eg 0.96375 from g = 9.81
		0.8 < 0.975 < 2.0 so it hits the window.	B1	A 2-sided inequality must be given, either in figures or in words. Condone 0.8 < 0.975 < 1.2 Dependent on previous mark
			[7]	

SECTION B

Qu	Part	Answer	Mark	Guidance
6.	(i)	$d = 5\times 8^2 = 320$, so 320 m	**B1**	
		This value is too great. It is not between 150 and 200 m.	**B1**	Accept "inconsistent". Dependent on previous mark.
		$s = ut + \frac{1}{2}at^2$ with $s = d$, $(u = 0)$, $a = 10$ and $t = T$	**M1**	
		Giving $d = \frac{1}{2}\times 10\times T^2 = 5T^2$	**A1**	
			[4]	
	(ii)	Depth = Area under the graph	**M1**	oe
		$= \frac{1}{2}\times 5\times 50 + 3\times 50$	**A1**	
		= 275 m	**A1**	
		Outside the 150 to 200 m interval so inconsistent	**B1**	A numerical comparison is required for this mark but may refer to values for it stated in part (i). Dependent on previous mark.
				Special Case Allow up to M1 A0 A1 B1 for a response in which the time at which v becomes constant is near but not equal to 5 (eg 4 or 4.5).
			[4]	
	(iii)	The same: initial constant acceleration (of 10 $\mathrm{m\,s^{-2}}$)	**B1**	Do not allow statements about the initial speed or the time taken
		Different: two part motion with constant speed at end	**B1**	
			[2]	

Qu	Part	Answer	Mark	Guidance
6.	(iv)	For $0 \le t \le 5$, the distance travelled is $\int_0^5 (10t - t^2)\mathrm{d}t$	**M1**	Or equivalent using indefinite integration
		$= \left[5t^2 - \frac{t^3}{3}\right]_0^5$	**A1**	Limits not required for this mark
		$5 \times 5^2 - \frac{5^3}{3}\ (= 83\frac{1}{3})$	**A1**	A $\Rightarrow$ M
		For $5 < t \le 8$, the distance travelled is 25 × 3 (= 75)	**B1**	Seen or implied
		$d = 83\frac{1}{3} + 75 = 158\frac{1}{3}$	**A1**	CAO
		This is within the given interval.	**B1**	Dependent on previous mark
			[6]	
	(v)	Similar: constant speed for $5 < t \le 8$	**B1**	
		Different: acceleration is not constant for $0 \le t \le 5$.	**B1**	
			[2]	

Qu	Part	Answer	Mark	Guidance
7.	(i)	$\cos\alpha = 0.8,\ \cos\beta = 0.6$	B1	Or equivalent statements
			[1]	
	(ii)	Horizontal forces → $8000\cos\beta$ - $6000\cos\alpha$	M1	Do not allow sin-cos interchange
		4800 - 4800 = 0 So the horizontal component of acceleration is 0	A1	Must state acceleration is zero
		Vertical forces ↑ $T\sin\alpha$ + 8000 $\sin\beta$ – 7500	M1	Do not allow if the weight is missing Allow $T\cos\beta$ + 8000 $\cos\alpha$ – 7500
		$\sin\alpha$ (= $\cos\beta$) =0.6 and $\sin\beta$ (= $\cos\alpha$) = 0.8	B1	o.e. CAO May be seen or implied in the working
		6400 + 3600 -7500 = 2500	A1	CAO
		Mass of bomb $\frac{7500}{9.8}$ (= 765.3) kg	M1	
		$a = \frac{2500}{765.3} = 3.27$ The acceleration is 3.27 m s^{-1} upwards	A1	CAO Allow 3.26
			[7]	

Qu	Part	Answer	Mark	Guidance
7.	(iii)	No horizontal acceleration ⇒ Resultant = 0		
		Horizontal forces → $8000\cos\beta - T\cos\alpha = 0$	M1	Horizontal must be indicated
		$T = \dfrac{8000\cos\beta}{\cos\alpha}$	A1	
		$\cos\alpha = \dfrac{16}{\sqrt{d^2+16^2}}, \quad \cos\beta = \dfrac{9}{\sqrt{d^2+9^2}}$	M1	
		$T = 8000\times\dfrac{\frac{9}{\sqrt{d^2+81}}}{\frac{16}{\sqrt{d^2+256}}} = \dfrac{4500\sqrt{d^2+256}}{\sqrt{d^2+81}}$	A1	
			[4]	

Qu	Part	Answer	Mark	Guidance
	(iv)	When $d = 6.75$, $T = 4500 \times \frac{\sqrt{6.75^2 + 256}}{\sqrt{6.75^2 + 81}}$ $(= 6946.2 \ldots)$	B1	May be implied by subsequent working Note In this situation α = 22.9°, β = 36.9°
		Vertical forces ↑ $6946.2\sin\alpha + 8000\sin\beta - 7500$	M1	Their α and β. No sin-cos interchange . Note The forces are 2700 N and 4800N
		= 0	A1	Condone any resultant force that rounds to 0 to the nearest integer.
		So the (vertical) acceleration is zero.	A1	CAO
			[4]	
		Alternative		
		Vertical forces ↑ $T\sin\alpha + 8000\sin\beta - 7500$		
		$4500 \times \frac{\sqrt{6.75^2 + 256}}{\sqrt{6.75^2 + 81}} \times \frac{6.75}{\sqrt{6.75^2 + 256}} + 8000 \times \frac{6.75}{\sqrt{6.75^2 + 81}} - 7500$	M1 B1	
		$12500 \times \frac{6.75}{11.25} - 7500 = 0$	A1	
		So the (vertical) acceleration is zero.	A1	CAO
7.	(v)	When at P there would be no vertical components of the tensions to counteract the weight.	B1	
		The acceleration would be g vertically downwards .	B1	The acceleration must be stated to be g
			[2]	

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4761 Mechanics 1

General Comments:

This paper was well answered. Almost all candidates found questions that allowed them to demonstrate their knowledge and the techniques with which they were confident. There were very few really low marks.

There was a noticeable improvement over previous years in certain particular areas: 2-stage motion; connected particles; extracting the cartesian equation of the path of a particle from its position vector at a general time.

Comments on Individual Questions:

Q1(i) In this question candidates were asked to draw a force diagram and many did this successfully. The most common mistake was to reverse the direction the thrust applied to the block, making it into a tension instead; a few candidates omitted the normal reaction. Some candidates replaced the thrust by its vertical and horizontal components and that was entirely acceptable provided that they were not presented as extra forces in addition to the actual thrust.

Q1(ii) In part (ii) candidates were expected to apply Newton's 2nd law to the block and to deduce the frictional force acting on it. Most candidates got this right but there were a few sign errors.
Answer 12.5 N

Q2(i) This question was about the movement of a particle along a straight line with constant acceleration. In part (i) candidates were asked to use the given information to find two equations for the initial velocity and the acceleration and to solve them. Most candidates got this right. Only a few failed to find the equations and there were also some careless mistakes when it came to solving them.
Answer $u = 8$, $a = -2$

Q2(ii) The question then went on to ask for a distance AB where B was the point where the particle was instantaneously at rest. Most candidates successfully found the distance OB but a common mistake was to fail to subtract OA to find the distance requested.
Answer 4 m

Q3(i) Question 3 involved two connected particles in two different situations. In part (i) candidates were asked to write down the equation of motion of each particle. Most did this correctly but a common mistake was to introduce the weight of the block that was on a smooth horizontal table as an extra force.

Q3(ii) The question then went on to ask candidates to solve the equations to find the acceleration of the system. Those who got the right equations in the previous part were almost entirely successful. By contrast those who made a mistake on one or both equations in part (i) were almost entirely unsuccessful. No follow through was allowed from wrong equations in part (i).
Answer 3.27 m s^{-2}

Q3(iii) In part (iii) the table was titled and the system was in equilibrium. Candidates were asked to find the angle of the table. There were many correct answers. The most common mistake was to try to work with the weight of the block on the table rather than its resolved component down the slope. A few candidates lost a mark by missing *g* out altogether.
Answer 30^{o}

Q4(i) In this question the position of a particle at time *t* was given as a column vector. In part (i) candidates were asked to write down **u** and **a** as column vectors. Most were successful in this but a common mistake was to give **v** instead of **u**.

Answer $\begin{pmatrix} 2 \\ 6 \end{pmatrix}, \begin{pmatrix} 0 \\ -8 \end{pmatrix}$

Q4(ii) In the next part candidates were asked to find the speed at a certain time and this was well answered with many recovering from errors in part (i). Follow through was allowed for the values of **u** and **a** that they found in part (i). Common mistakes were sign errors and not distinguishing between speed and velocity.

Answer $\begin{pmatrix} 2 \\ -10 \end{pmatrix}$, 10.2 m s^{-2}

Q4(iii) In the final part candidates were asked to show that the position vector at time *t* led to a given cartesian equation for the path of the particle. This was answered confidently and almost entirely successfully.

Q5 This question was on projectiles. It involved Mr McGreggor throwing a stone at a pigeon, missing it and hitting the window of his house instead. It was extremely well answered.

Although presented as a single question for 7 marks, it actually broke down into two parts: showing that the stone did not go high enough to hit the pigeon and then showing that it did hit the window. Most candidates found the maximum height of the stone and showed that it was less than the height of the pigeon. However, a considerable number substituted the height of the pigeon in the quadratic equation for the height of the stone at time *t* and then showed that this equation had no real roots; this showed considerable mathematical understanding. Full marks were available for either method and for any correct variant on them, for example working with the equation of the stone's trajectory.

Most candidates found the correct height of the stone when it reached the house but many lost a mark by failing to give a convincing argument that this height was within the interval for the window.

Answers Max height of stone = 3.27 m, Height at the house = 0.975 m

Q6 Question 6 was about modelling. It involved building up a model in three stages of increasing sophistication. At each stage candidates were asked to comment on which aspects of the model had changed and which had remained the same. The context was estimating the depth of a mine shaft from the time it took a stone to reach the bottom. Throughout the model was checked against local records. This question was very well answered.

Q6(i) The question started with applying a simple model given by a formula and comparing the depth it gave to local records. It then went on to ask for an explanation of the model. Almost all candidates answered this fully correctly.
Answer 320 m

Q6(ii) The question then moved on to the second model which was given by a velocity time graph. Nearly all candidates obtained the correct distance but many lost a mark by not making a numerical comparison of their result with the local records.
Answer 275 m

Q6(iii) In this part candidates were asked to identify one respect in which the two models (so far) were the same and one in which they were different. Many candidates gave good answers. In both models the stone has acceleration of *g* for the first 5 second but then in model B it has constant velocity while in A it continues to accelerate. No marks were given for answers that referred to the conditions given in the question, such as that it takes 8 seconds, nor for answers that compared the mathematical presentation, for example algebra against a graph.

Q6(iv) The question then moved on to Model C where there was variable acceleration and so calculus had to be used. This was very well answered. Only a handful of candidates tried to use constant acceleration formulae. Most carried out the integration and did the appropriate substitution to find the distance covered in the first 5 seconds successfully, and then went on to add on the distance covered at constant velocity. All but few candidates handled the two stage motion correctly.

The final mark required the distance found to be related to the local records and in this case it was necessary to identify the interval within which it lay. Many candidates did not do so and so scored 5 out of 6.

Answer $158\frac{1}{3}$ m

Q6(v) This part was similar to part (iii) asking about how the model had developed. Those who had done well in part (iii) tended to do well here too. Both models involved terminal velocity but its value was different. In the new model the acceleration was variable for the first 5 seconds whereas it had been constant in the previous model.

Q7 This was the second of the long questions on the paper, worth 18 marks. It was set in the context of raising an unexploded bomb from a hole on a building site. This question was quite challenging and many candidates were unsuccessful on the later parts.

Q7(i) The question started with a straightforward piece of trigonometry for 1 mark, and almost all candidates were successful.
Answers 0.8 and 0.6.

Q7(ii) The question then went on to consider the horizontal and vertical components of acceleration in a particular situation. The first demand was to show that the horizontal component is zero. Most candidates got this right but some lost a mark by failing to take the step of going from zero resultant force to zero acceleration; this was a given result and so a high standard of argument was expected. The question then went on to find the vertical component of acceleration and this elicited many good answers. A few candidates failed to convert the weight of the bomb to its mass, and some missed it out completely.
There were fewer sin-cos interchanges than might have been the case a few years ago.
Answer 3.27 m s^{-2}.

Q7(iii) The question then went on to consider a general situation during the lift. The first request was derive a given result for *T*. Many candidates lost marks here by not relating it to the horizontal direction. Some candidates may not have been aware that because this was a given result a high standard of argument was expected.

Candidates were then asked to show that the given result for *T* could be written in a different form. While there were plenty of correct answers, there were also many that appeared to conjure the given result out of incorrect working.

Q7(iv) In this part of the question, the bomb was at the height at which its vertical acceleration was zero and candidates were expected to use the result given at the end of part (iii) to discover this. Only the stronger candidates were successful. Many of those who attempted to find the equation of motion used the wrong angles or the wrong tensions, or forgot about the weight completely.
Answer Acceleration = 0 m s^{-2}

Q7(v) In part (ii) the bomb was in a position where it was accelerating upwards. In part (iv) it was in a position where equilibrium was possible but there could be no upwards acceleration. The final part of the question considered the hypothetical situation where the bomb was at the top and so was at the same level as the winches. Candidates were asked to explain why equilibrium was impossible in this situation and to state the acceleration. While there were some excellent explanations many were garbled or wrong. Many candidates said there would be zero acceleration. Answer $g\,\mathrm{m\,s^{-2}}$ vertically downwards.

GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	57	52	47	42	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	49	42	35	29	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	58	52	47	42	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	64	57	51	45	39	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	59	53	48	43	38	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	60	54	48	43	38	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	60	54	49	44	39	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	67	61	55	49	43	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	58	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	59	53	47	41	36	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	60	53	46	40	34	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	55	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	59	52	46	40	34	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	60	54	48	42	37	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	48	43	38	34	30	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	55	50	45	40	36	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	55	49	44	39	33	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	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

GCE Statistics (MEI)

			Max Mark	a	b	c	d	e	u
G241	01 Statistics 1 MEI (Z1)	Raw	72	59	52	46	40	34	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	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
G246	01 Decision 1 MEI	Raw	72	48	43	38	34	30	0
		UMS	100	80	70	60	50	40	0

Level 3 Certificate and FSMQ raw mark grade boundaries June 2016 series

For more information about results and grade calculations, see www.ocr.org.uk/ocr-for/learners-and-parents/getting-your-results

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 2016							
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	55	47	39	31	23	0
H866	02 Critical maths	Raw	60	47	41	35	29	23	0
		Overall	132	111	96	81	66	51	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	55	47	39	31	23	0
H867	02 Statistical problem solving	Raw	60	40	34	28	23	18	0
		Overall	132	103	88	73	59	45	0

Advanced Free Standing Mathematics Qualification (FSMQ)

			Max Mark	a	b	c	d	e	u
6993	01 Additional Mathematics	Raw	100	59	51	44	37	30	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

Version	Details of change
1.1	Correction to Overall grade boundaries for H866
	Correction to Overall grade boundaries for H867