OCR

Thursday 12 June 2014 – 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 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 $g\,\mathrm{m\,s^{-2}}$. 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 the velocity-time graph of a cyclist travelling along a straight horizontal road between two sets of traffic lights. The velocity, v, is measured in metres per second and the time, t, in seconds. The distance travelled, s metres, is measured from when $t = 0$.

Fig. 1

(i) Find the values of s when $t = 4$ and when $t = 18$. **[3]**

(ii) Sketch the graph of s against t for $0 \leqslant t \leqslant 18$. **[3]**

2 The unit vectors **i** and **j** shown in Fig. 2 are in the horizontal and vertically upwards directions.

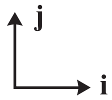

Fig. 2

Forces **p** and **q** are given, in newtons, by $\mathbf{p} = 12\mathbf{i} - 5\mathbf{j}$ and $\mathbf{q} = 16\mathbf{i} + 1.5\mathbf{j}$.

(i) Write down the force $\mathbf{p} + \mathbf{q}$ and show that it is parallel to $8\mathbf{i} - \mathbf{j}$. **[3]**

(ii) Show that the force $3\mathbf{p} + 10\mathbf{q}$ acts in the horizontal direction. **[2]**

(iii) A particle is in equilibrium under forces $k\mathbf{p}$, $3\mathbf{q}$ and its weight **w**.

Show that the value of k must be –4 and find the mass of the particle. **[3]**

3 Fig. 3 shows a smooth ball resting in a rack. The angle in the middle of the rack is 90°. The rack has one edge at angle α to the horizontal.

The weight of the ball is W N. The reaction forces of the rack on the ball at the points of contact are R N and S N.

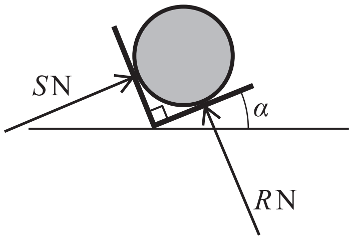

Fig. 3

(i) Draw a fully labelled triangle of forces to show the forces acting on the ball. Your diagram must indicate which angle is α. **[3]**

(ii) Find the values of R and S in terms of W and α. **[2]**

(iii) On the same axes draw sketches of R against α and S against α for $0^\circ \leqslant \alpha \leqslant 90^\circ$.

For what values of α is $R < S$? **[3]**

4 Fig. 4 illustrates a situation in which a film is being made. A cannon is fired from the top of a vertical cliff towards a ship out at sea. The director wants the cannon ball to fall just short of the ship so that it appears to be a near-miss. There are actors on the ship so it is important that it is not hit by mistake.

The cannon ball is fired from a height 75 m above the sea with an initial velocity of $20\,\text{m}\,\text{s}^{-1}$ at an angle of 30° above the horizontal. The ship is 90 m from the bottom of the cliff.

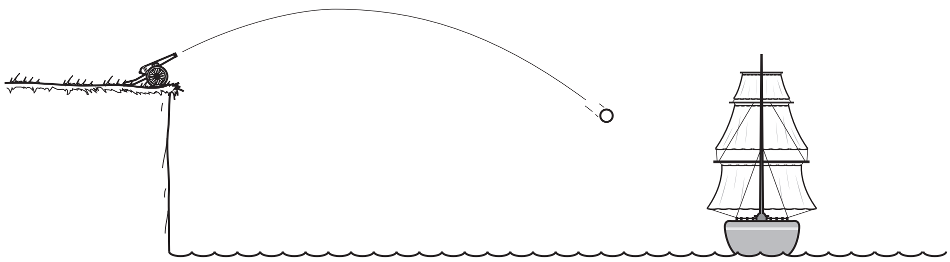

Fig. 4

(i) The director calculates where the cannon ball will hit the sea, using the standard projectile model and taking the value of g to be $10\,\text{m}\,\text{s}^{-2}$.

Verify that according to this model the cannon ball is in the air for 5 seconds. Show that it hits the water less than 5 m from the ship. **[6]**

(ii) Without doing any further calculations state, with a brief reason, whether the cannon ball would be predicted to travel further from the cliff if the value of g were taken to be $9.8\,\text{m}\,\text{s}^{-2}$. **[1]**

5 In a science fiction story a new type of spaceship travels to the moon. The journey takes place along a straight line. The spaceship starts from rest on the earth and arrives at the moon's surface with zero speed. Its speed, v kilometres per hour at time t hours after it has started, is given by

$$v = 37500(4t - t^2).$$

(i) Show that the spaceship takes 4 hours to reach the moon. **[1]**

(ii) Find an expression for the distance the spaceship has travelled at time t.

Hence find the distance to the moon. **[4]**

(iii) Find the spaceship's greatest speed during the journey. **[2]**

Section B (36 marks)

6 In this question the origin is a point on the ground. The directions of the unit vectors $\begin{pmatrix}1\\0\\0\end{pmatrix}$, $\begin{pmatrix}0\\1\\0\end{pmatrix}$ and $\begin{pmatrix}0\\0\\1\end{pmatrix}$ are east, north and vertically upwards.

Alesha does a sky-dive on a day when there is no wind. The dive starts when she steps out of a moving helicopter. The dive ends when she lands gently on the ground.

- During the dive Alesha can reduce the magnitude of her acceleration in the vertical direction by spreading her arms and increasing air resistance.
- During the dive she can use a power unit strapped to her back to give herself an acceleration in a horizontal direction.
- Alesha's mass, including her equipment, is 100 kg.
- Initially, her position vector is $\begin{pmatrix}-75\\90\\750\end{pmatrix}$ m and her velocity is $\begin{pmatrix}-5\\0\\-10\end{pmatrix}$ m s^{-1}.

(i) Calculate Alesha's initial speed, and the initial angle between her motion and the downward vertical. **[4]**

At a certain time during the dive, forces of $\begin{pmatrix}0\\0\\-980\end{pmatrix}$ N, $\begin{pmatrix}0\\0\\880\end{pmatrix}$ N and $\begin{pmatrix}50\\-20\\0\end{pmatrix}$ N are acting on Alesha.

(ii) Suggest how these forces could arise. **[3]**

(iii) Find Alesha's acceleration at this time, giving your answer in vector form, and show that, correct to 3 significant figures, its magnitude is 1.14 m s^{-2}. **[3]**

One suggested model for Alesha's motion is that the forces on her are constant throughout the dive from when she leaves the helicopter until she reaches the ground.

(iv) Find expressions for her velocity and position vector at time t seconds after the start of the dive according to this model. Verify that when $t = 30$ she is at the origin. **[6]**

(v) Explain why consideration of Alesha's landing velocity shows this model to be unrealistic. **[2]**

7 Fig. 7 illustrates a train with a locomotive, L, pulling two trucks, A and B.

The locomotive has mass 90 tonnes and is subject to a resistance force of 2000 N.

Each of the trucks A and B has mass 30 tonnes and is subject to a resistance force of 500 N.

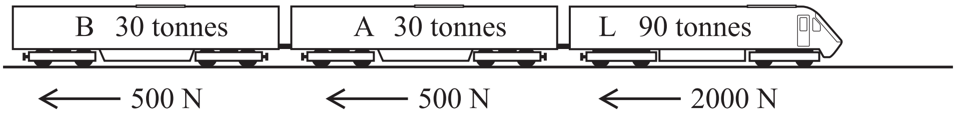

Fig. 7

Initially the train is travelling along a straight horizontal track. The locomotive is exerting a driving force of 12 000 N.

(i) Find the acceleration of the train. **[3]**

(ii) Find the tension in the coupling between trucks A and B. **[3]**

When the train is travelling at $10\,\text{m}\,\text{s}^{-1}$, a fault occurs with truck A and the resistance to its motion changes from 500 N to 5000 N.

The driver reduces the driving force to zero and allows the train to slow down under the resistance forces and come to a stop.

(iii) Find the distance the train travels while slowing down and coming to a stop.

Find also the force in the coupling between trucks A and B while the train is slowing down, and state whether it is a tension or a thrust. **[7]**

The fault in truck A is repaired so that the resistance to its motion is again 500 N. The train continues and comes to a place where the track goes up a uniform slope at an angle of $\alpha°$ to the horizontal.

(iv) When the train is on the slope, it travels at uniform speed. The driving force remains at 12 000 N. Find the value of α. **[3]**

(v) Show that the force in the coupling between trucks A and B has the same value that it had in part **(ii)**. **[2]**

END OF QUESTION PAPER

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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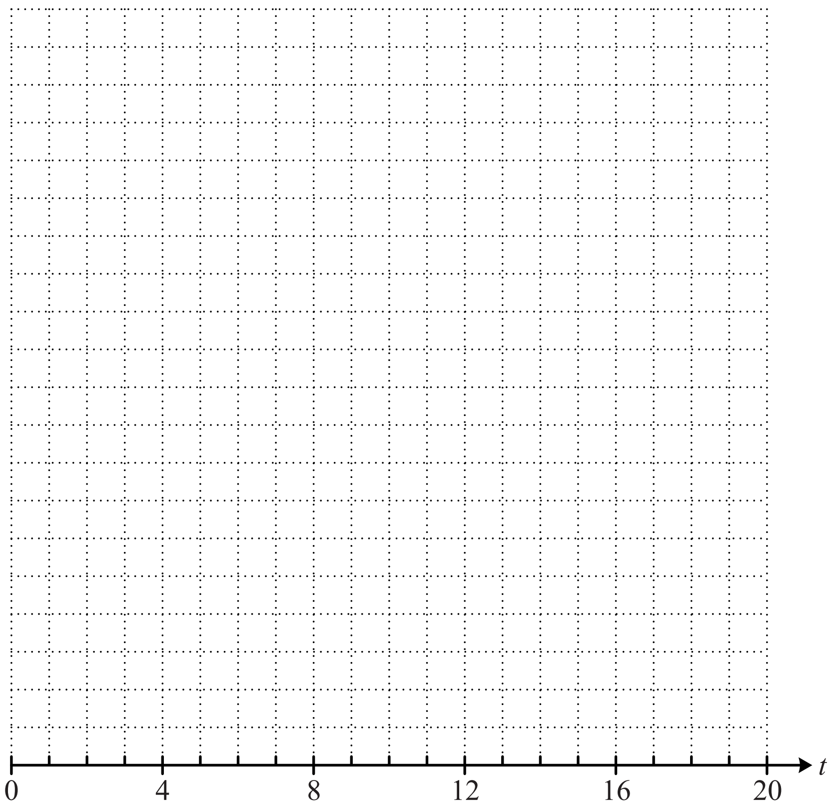
Turn over

Section A (36 marks)

1 (i)

1 (ii)



2 (i)	
2 (ii)	

2 (iii)	
3 (i)	

3 (ii)

3 (iii)

4 (i)

(answer space continued on next page)

4 (i)	**(continued)**
4 (ii)	

5 (i)	
5 (ii)	
5 (iii)	

Section B (36 marks)

6 (i)	
6 (ii)	

6 (iii)

6 (iv)

(answer space continued on next page)

6 (iv)	(continued)
6 (v)	

7 (i)

7 (ii)

7 (iii)	
	(answer space continued on next page)

7 (iii)	(continued)

7 (iv)	

7 (v)	

Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4761**: Mechanics 1

Advanced Subsidiary GCE

Mark Scheme for June 2014

1. Annotations and abbreviations

Annotation in scoris	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
✓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

2. 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.

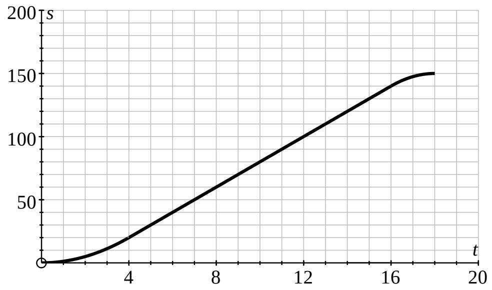
Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working.

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

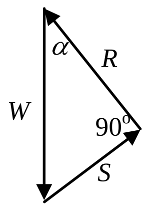
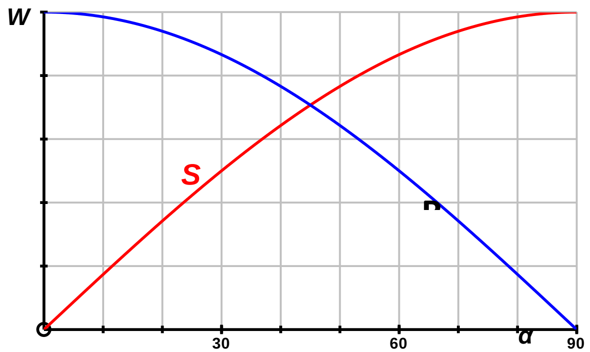
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

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.

Question		Answer	Marks	Guidance
1	(i)	When $t = 4$, $s = \frac{1}{2} \times 4 \times 10$		Finding the area of the triangle or equivalent.
		$s = 20$	B1	
		When $t = 18$, $s = \frac{1}{2} \times (18 + 12) \times 10$	M1	A complete method of finding the area of the trapezium or equivalent.
		$s = 150$	A1	CAO
			[3]	
1	(ii)			
		Graph joining (0,0), (4,20) and (18, 150)	B1	Allow FT for their (4,20) and (18, 150) Condone extension to (20, 150) with a horizontal line.
		The graph goes through (16, 140)	B1	
				Allow SC1 for the first two marks if there is a consistent displacement from a correct scale, eg plotting (18,150) at (19, 150)
		Curves at both ends	B1	The sections from $t = 0$ to $t = 4$ and from $t = 16$ to $t = 18$ are both curves
			[3]	

Question			Answer	Marks	Guidance
2	(i)		$\mathbf{p} + \mathbf{q} = 28\mathbf{i} - 3.5\mathbf{j}$	B1	
			$28\mathbf{i} - 3.5\mathbf{j} = k(8\mathbf{i} - \mathbf{j})$ $k = 3.5$	M1 A1	Or equivalent. k may be implied by going straight to 3.5
			(So they are parallel)		
			Alternative		
			$\mathbf{p} + \mathbf{q} = 28\mathbf{i} - 3.5\mathbf{j}$	B1	
			$\mathbf{p} + \mathbf{q}$: $\tan\theta = \frac{-3.5}{28} \Rightarrow \theta = -7.13°$		
			$8\mathbf{i} - \mathbf{j}$: $\tan\theta = \frac{-1}{8} \Rightarrow \theta = -7.13°$	M1	Comparing the ratio of the components in each of the two vectors is sufficient, using any consistent sign convention. The angle does not need to be worked out, nor does tan have to be seen.
			So they are parallel	A1	Both ratios the same and correct
				[3]	
2	(ii)		$3\mathbf{p} + 10\mathbf{q} = (36 + 160)\mathbf{i} + (-15 + 15)\mathbf{j}$		
			$= 196\mathbf{i}$	B1	
			Zero $\mathbf{j}$ component so horizontal	B1	Or equivalent explanation. May be shown on a diagram
				[2]	
2	(iii)		The horizontal component must be zero		
			So $12k + 3\times16 = 0 \Rightarrow k = -4$	B1	Substituting $k = -4$ and showing $\mathbf{i}$ component is zero is acceptable
			$\mathbf{w} = -24.5\mathbf{j}$	B1	Award for 24.5 seen
			$mg = 24.5 \Rightarrow m = 2.5$ The mass is 2.5 kg	B1	Award for 2.5 seen. FT from their weight.
				[3]	

Question			Answer	Marks	Guidance
3	(i)			B1 B1 B1 **[3]**	Closed triangle with cycling arrows. Accept any consistent orientation. All forces labelled. Correct angles. The 90° may be implied. α may be shown between S and the horizontal (ie outside the triangle). SC1 Award for a force diagram with no extra forces and all labels and directions correct.
3	(ii)		$R = W\cos\alpha$ $S = W\sin\alpha$	B1 B1 **[2]**	Allow FT for sin-cos interchange following the wrong angle in the triangle being marked α in part (i) for both marks. SC1 if both S and R are given negative signs
3	(iii)		Sketch graph of R against α Correct sketch graph of S against α $45° < \alpha \quad (\leq 90°)$	B1 B1 B1 **[3]**	The answers in part (iii) must - either be fully correct - or they must all be consistent with those in part (ii) where the marks in part (ii) are FT from part (i). No credit should be given to forms other than $W\cos\alpha$ and $W\sin\alpha$. The curves must have the correct end points and lie within the correct range; no credit should be given for straight lines. Graphs must be correctly labelled. Unlabelled graphs get B0 B0. Condone no explicit vertical scale. Do not accept straight lines. Must be consistent with graph of R Condone $45° \leq \alpha$

Question			Answer	Marks	Guidance	
4	(i)		Vertical component of initial velocity $= 20\sin 30°$ $(=10)$	B1		
			Vertical motion $s = s_0 + ut + \frac{1}{2}at^2$	M1	Substitution required. The sign of g must be correct. Condone no s_0	
			When it hits the sea $0 = 75 + 10t - 5t^2$	A1		
			$75 + 10\times 5 - 5\times 5^2 = 0$ As required		Or equivalent, eg solving the quadratic equation.	
			This is satisfied when $t = 5$	E1		
			Alternative			
			Vertical component of initial velocity $= 20\sin 30°$ $(=10)$	B1		
			Vertical motion $v = u + at$	M1	Complete method for finding t = 5 required.	
			At the top $0 = 10 - 10t \Rightarrow t = 1$			
			It takes another 1 second to reach the level of the cliff top			
			At that point its speed is 10 m s^{-1} downwards			
			When it hits the sea $-75 = -10t - 5t^2$		Or equivalent finding the time (4 seconds) from the top (height 80 m) to hitting the sea	
			$t^2 + 2t - 15 = 0 \Rightarrow t = 3$	A1		
			Total time = 1 + 1 + 3 = 5 seconds	E1		
			Horizontal motion $x = 20\times\cos 30°\times t$	M1		
			$t = 5 \Rightarrow 86.6$			
			It is 3.4 m from the ship so within 5 m	E1	Condone 3.5 m	
				[6]		
4	(ii)		It is longer in the air so it goes further	B1 **[1]**	Justification for travelling further is required for this mark.	

Question			Answer	Marks	Guidance	
5	(i)		$v = 0$ when it arrives $150\ 000(t - \frac{1}{4}t^2) = 0$ $\Rightarrow$ $t = 4$ (on arrival)	B1 **[1]**	Award this mark for substituting $t = 4$ to obtain $v = 0$ Condone omission of $t = 0$	
5	(ii)		Distance travelled $s = \int v\,dt$ $s = 150\ 000\left[\frac{1}{2}t^2 - \frac{1}{12}t^3\right]$ $(+c)$ When $t = 4$, $s = 400\ 000$ The journey is 400 000 km	M1 A1 M1 A1 **[4]**	Do not accept multiplication by t. Substituting their $t = 4$. This mark is dependent on the previous M mark. If 400 000 seen award the previous mark	
5	(iii)		For maximum speed $a = \frac{dv}{dt} = 0$ $\frac{dv}{dt} = 150\ 000(1 - \frac{1}{2}t)$ $\Rightarrow t = 2$ $v = 150\ 000(2 - \frac{1}{4} \times 2^2) = 150\ 000$ Maximum speed is 150 000 km h^{-1}	B1 B1 **[2]**	$t = 2$ seen Accept a trial and error method CAO	

Question			Answer	Marks	Guidance	
6	(i)		Speed = $\sqrt{(-5)^2+0^2+(-10)^2}$	M1	For use of Pythagoras. Accept $\sqrt{5^2+10^2}$.	
			$= 11.2\ \text{m s}^{-1}$ (11.18)	A1	Accept $\sqrt{125}$ or $5\sqrt{5}$	
			$\tan\theta = \frac{5}{10}$	M1	Complete method for correct angle; may use $\sin\theta = \frac{5}{11.2}$, $\cos\theta = \frac{10}{11.2}$.	
			$\theta = 26.6°$	A1	Allow 153.4°, 206.6°	
				[4]		
6	(ii)		$\begin{pmatrix}0\\0\\-980\end{pmatrix}$ her weight	B1	The descriptions should be linked to the forces, either by the layout of the answer or by suitable text. If not, assume that the forces they refer to are in the order given here (which is the same as the question).	
			$\begin{pmatrix}0\\0\\880\end{pmatrix}$ resistance to her vertical motion	B1	Accept "Air resistance", "Arms stretched out" and similar statements. Condone mention of a parachute.	
			$\begin{pmatrix}50\\-20\\0\end{pmatrix}$ force from the power unit	B1		
				[3]		
6	(iii)		Resultant force = $\begin{pmatrix}50\\-20\\-100\end{pmatrix}$	B1	May be implied	
			Acceleration = $\begin{pmatrix}0.5\\-0.2\\-1\end{pmatrix}$	B1	Newton's 2nd Law	
			Magnitude = $\sqrt{0.5^2+(-0.2)^2+1^2} = 1.1357...$ So 1.14 to 3 s.f.	B1	Answer given. Allow FT from sign errors. Accept $\lvert\mathbf{F}\rvert \div 100$	
				[3]		

Question			Answer	Marks	Guidance	
6	(iv)		$\mathbf{v} = \mathbf{u} + \mathbf{a}t$	M1	FT their **a** for the first 5 marks of this part. Vectors must be seen or implied. Accept valid integration.	
			$\mathbf{v} = \begin{pmatrix} -5 \\ 0 \\ -10 \end{pmatrix} + \begin{pmatrix} 0.5 \\ -0.2 \\ -1 \end{pmatrix} t$	A1		
			$\mathbf{r} = \mathbf{r_0} + \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$	M1	Vectors must be seen or implied. Accept valid integration. Condone no $\mathbf{r_0}$ for this M mark	
			$\mathbf{r} = \begin{pmatrix} -75 \\ 90 \\ 750 \end{pmatrix} + \begin{pmatrix} -5 \\ 0 \\ -10 \end{pmatrix} t + \frac{1}{2}\begin{pmatrix} 0.5 \\ -0.2 \\ -1 \end{pmatrix} t^2$	A1		
			When $t = 30$	M1	Vectors must be seen or implied.	
			$\mathbf{r} = \begin{pmatrix} -75 - 150 + 225 \\ 90 + 0 - 90 \\ 750 - 300 - 450 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$, as required	E1	CAO	
					SC1 to replace the first 4 marks of this section if the acceleration is taken to be **g** but the answer is otherwise correct.	
				[6]		
6	(v)		When $t = 30$, $\mathbf{v} = \begin{pmatrix} 10 \\ -6 \\ -40 \end{pmatrix}$	M1	There must be an attempt to work out at least the vertical component of the velocity at t = 30. This mark is not dependent on a correct answer.	
			The vertical component of the velocity is too fast for a safe landing	A1	Accept an argument based on speed derived from a vector.	
				[2]		

Question			Answer	Marks	Guidance	
7	(i)		Whole train: mass = 150 tonnes Total Resistance = 3000 N	B1	Both totals required.	
			$12000 - 3000 = 150000a$	M1	Correct elements must be present	
			$a = 0.06$ The acceleration is 0.06 m s^{-2}	A1	CAO. Errors with units (eg not converting tonnes to kilograms) are penalised here but condoned where possible for the remainder of the question.	
				[3]		
7	(ii)		Truck B: $T - 500 = 30000a$	M1	Correct elements must be present	
			$T - 500 = 30000 \times 0.06$	A1	Allow FT for *a* from part (i) if units are used consistently, for all the marks in this part	
			$T = 2300$ Between A and B, tension of 2300 N	A1		
				[3]		
			Alternative			
			Rest of train: 12 000 – 2500 – T = 120 000a	M1	Correct elements must be present	
			T = 12 000 –2500 – 120 000 × 0.06	A1		
			T = 2300	A1		
7	(iii)		Treating the train as a whole – 2000 – 5000 – 500 = 150 000a	M1		
			$a = -0.05$	A1	Allow FT for the remaining A marks in part (iii) from an error in *a*	
			$v^2 - u^2 = 2as$	M1		
			$0^2 - 10^2 = 2 \times (-0.05) \times s$			
			$s = 1000$ Stopping distance is 1000 m	A1		
			B: $T - 500 = 30000a$	M1	Correct elements must be present. Alternative for rest of train: – T – 5000 –2000 = 120 000 × – 0.05	
			$T = -1000$	A1	The sign of 1000 must be consistent with the direction of *T*.	
			Between A and B, thrust of 1000 N	A1	Dependent on previous M and A marks. Accept "compression".	
				[7]		

Question			Answer	Marks	Guidance	
7	(iv)		Equilibrium parallel to the slope	M1	Correct elements must be present and there must be an attempt to resolve the weight. Condone omission of *g* for this mark.	
			$150000 \times 9.8 \times \sin\alpha + 3000 = 12000$	A1		
			$\alpha = 0.35°$	A1	CAO	
				[3]		
7	(v)		B: $T_2 - 500 - 30000 \times 9.8 \times \sin 0.35...° = 0$	M1	Correct elements must be present. Condone omission of g for this mark. Do not accept 1800 N for the component of the weight without justification. Alternative for rest of train: 12 000 = T + 2500 + 120 000 × 9.8 × sin0.35°	
			$T_2 = 2300$ Between A and B, tension of 2300 N, as in part (ii)	A1	This mark can only be awarded if the angle found in (iv) is correct.	
				[2]		

4761 Mechanics 1

General Comments:

This paper produced a satisfactory mark distribution. Candidates of all abilities were able to show what they could do but there were places where even the most able were challenged.

A common weakness shown by many candidates was a reluctance to draw good diagrams to guide their work.

Comments on Individual Questions:

Section A

1) This question, about interpreting a velocity-time graph, was well answered. It ended with a request to draw the equivalent distance-time graph, parts of which were curves; many candidates did not realise this and so lost the final mark.

2) This question was about vectors defined using **i**, **j** notation. It was well answered with many candidates obtaining full marks. Most of the errors that did occur were in part (iii) where candidates were required to interpret the vectors as forces on a particle in equilibrium, with its weight now introduced. Some did not interpret the equilibrium conditions sufficiently rigorously, failing to recognise that both the horizontal and vertical components of the resultant had to be zero. The question ended with a request for the mass of the particle and some candidates confused this with its weight.

3) This was a statics question involving three forces. In the first part candidates were asked to draw a triangle of forces and many dropped some of the marks for this; lack of arrows, incorrect or missing labels and errors in the directions were all quite common. A number of candidates drew a force diagram instead and at most only one of the three marks was available for this.

   The final part of the question required candidates to draw graphs of $W\sin a$ and $W\cos a$; many candidates found this difficult and a significant number made no attempt at an answer.

4) This question was about projectiles and was well answered with many candidates gaining all the marks. Virtually all candidates knew what they were trying to do but many made sign errors in the vertical motion equation.

   The most straightforward approach to this question involved treating the motion in a single stage. A few candidates considered it in two, or even three, stages; this increased the scope for errors and consequently most such responses were less than perfect.

   The question ended by asking candidates to comment on the effect of taking a different value for g. This produced a pleasing number of highly articulate responses.

5) This question involved motion with non-uniform acceleration. It was set in the context of a science fiction flight to the moon. It was well answered with many candidates obtaining full marks. Only a few candidates made the mistake of attempting to use constant acceleration formulae. There were some mistakes in the integration to go from speed to distance; an extraneous t appeared in some scripts.

Section B

6) This question was about motion in three dimensions described using vectors. It was also about modelling. The context was a sky-dive.

In part (i), candidates were asked to use the given (vector) initial velocity to find the initial speed and direction. Nearly all candidates found the speed but there were many mistakes with the direction, particularly finding the wrong angle or using the initial displacement instead of the initial velocity.

In part (ii), candidates were asked to account for the three forces acting on the sky-diver. This involved interpreting the information given in the question. Many did this correctly but there were also candidates who dropped marks here.

In part (iii), candidates were asked to find the acceleration of the sky-diver as a vector and to verify its magnitude. While this was on the whole well answered, a number of candidates omitted to find the vector form and so lost a mark.

Part (iv) carried 6 marks and many candidates obtained all of them. Candidates were asked to find expressions for the velocity and position vector at time t, and then to show that at a given time the sky-diver was at the origin. The commonest mistake among those who otherwise answered this part well was to omit the initial displacement from the position vector. However, several candidates used *g* for the acceleration instead of the acceleration they should have found in part (iii).

Part (v) was not well answered. Candidates were asked to show that a consideration of the sky-diver's landing velocity showed the model to be unrealistic. This was part of the overall modelling process; they had considered the landing position in part (iv) and were now required to consider the velocity on landing. So they needed to calculate the velocity on landing, or at least its vertical component. Most candidates failed to do this and made comments that were not based on evidence obtained from the question.

7) This question was a good source of marks for many candidates. It was about the motion of a train and the forces in one of the couplings. Most candidates were able to answer the parts that involved considering the train as a whole. Fewer were successful when it came to working with part of the train to find the force in a particular coupling.

In part (i) candidates were asked find the acceleration of the whole train and most were successful. A number failed to convert the mass of the train from tonnes into kilograms. This was penalised here but follow-through was then applied for all the marks in the next two parts and for the first two marks in part (iv).

In part (ii) candidates were asked to find the tension in the coupling between the two trucks. Most candidates answered this correctly but some introduced extraneous forces.

Part (iii) carried 7 marks. The first four of these involved the motion of the train as a whole in a new situation and many candidates obtained all of these marks. The last three marks were for finding the new force in the coupling between the trucks. Most of those candidates who had been successful in part (ii) obtained these marks but others were unable to identify which forces were relevant and which were not.

Part (iv) involved a new situation in which the train was on a slope. Candidates were asked to find the angle of the slope. While there were plenty of correct answers, many of them were not very well explained. Good force diagrams were something of a rarity.

Part (v) provided the last two marks on the paper. It exemplified the interesting (and little known) result that the tensions between trucks when the train is going up a slope at constant speed are the same as those when it is accelerating on level ground, under the same driving force. In this part candidates were asked to do no more than find the same numerical answer as they had obtained in part (ii). Stronger candidates were successful on this but many others had failed to find the correct earlier results (the tension in part (ii) and the angle in part (iv)) that were needed here.

Unit level raw mark and UMS grade boundaries June 2014 series
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	Raw	72	61	56	51	46	42	0
	UMS	100	80	70	60	50	40	0
4752/01 (C2) MEI Concepts for Advanced Mathematics	Raw	72	57	51	45	39	33	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
4753 (C3) MEI Methods for Advanced Mathematics with Coursework	UMS	100	80	70	60	50	40	0
4754/01 (C4) MEI Applications of Advanced Mathematics	Raw	90	68	61	54	47	41	0
	UMS	100	80	70	60	50	40	0
4755/01 (FP1) MEI Further Concepts for Advanced Mathematics	Raw	72	63	57	51	45	40	0
	UMS	100	80	70	60	50	40	0
4756/01 (FP2) MEI Further Methods for Advanced Mathematics	Raw	72	60	54	48	42	36	0
	UMS	100	80	70	60	50	40	0
4757/01 (FP3) MEI Further Applications of Advanced Mathematics	Raw	72	57	51	45	39	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
4758 (DE) MEI Differential Equations with Coursework	UMS	100	80	70	60	50	40	0
4761/01 (M1) MEI Mechanics 1	Raw	72	57	49	41	34	27	0
	UMS	100	80	70	60	50	40	0
4762/01 (M2) MEI Mechanics 2	Raw	72	57	49	41	34	27	0
	UMS	100	80	70	60	50	40	0
4763/01 (M3) MEI Mechanics 3	Raw	72	55	48	42	36	30	0
	UMS	100	80	70	60	50	40	0
4764/01 (M4) MEI Mechanics 4	Raw	72	48	41	34	28	22	0
	UMS	100	80	70	60	50	40	0
4766/01 (S1) MEI Statistics 1	Raw	72	61	53	46	39	32	0
	UMS	100	80	70	60	50	40	0
4767/01 (S2) MEI Statistics 2	Raw	72	60	53	46	40	34	0
	UMS	100	80	70	60	50	40	0
4768/01 (S3) MEI Statistics 3	Raw	72	61	54	47	41	35	0
	UMS	100	80	70	60	50	40	0
4769/01 (S4) MEI Statistics 4	Raw	72	56	49	42	35	28	0
	UMS	100	80	70	60	50	40	0
4771/01 (D1) MEI Decision Mathematics 1	Raw	72	51	46	41	36	31	0
	UMS	100	80	70	60	50	40	0
4772/01 (D2) MEI Decision Mathematics 2	Raw	72	46	41	36	31	26	0
	UMS	100	80	70	60	50	40	0
4773/01 (DC) MEI Decision Mathematics Computation	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	54	48	43	38	32	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
4776 (NM) MEI Numerical Methods with Coursework	UMS	100	80	70	60	50	40	0
4777/01 (NC) MEI Numerical Computation	Raw	72	55	47	39	32	25	0
	UMS	100	80	70	60	50	40	0
4798/01 (FPT) Further Pure Mathematics with Technology	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 (Z1) Statistics 1	Raw	72	61	53	46	39	32	0
	UMS	100	80	70	60	50	40	0
G242/01 (Z2) Statistics 2	Raw	72	55	48	41	34	27	0
	UMS	100	80	70	60	50	40	0
G243/01 (Z3) Statistics 3	Raw	72	56	48	41	34	27	0
	UMS	100	80	70	60	50	40	0