OCR
RECOGNISING ACHIEVEMENT

Friday 1 June 2012 – Morning

AS GCE MATHEMATICS (MEI)

4761 Mechanics 1

QUESTION PAPER

Candidates answer on the Printed Answer Book.

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

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found in the centre of the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book**. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- 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

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

- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **16** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

Section A (36 marks)

1 Fig. 1 shows the speed-time graph of a runner during part of his training.

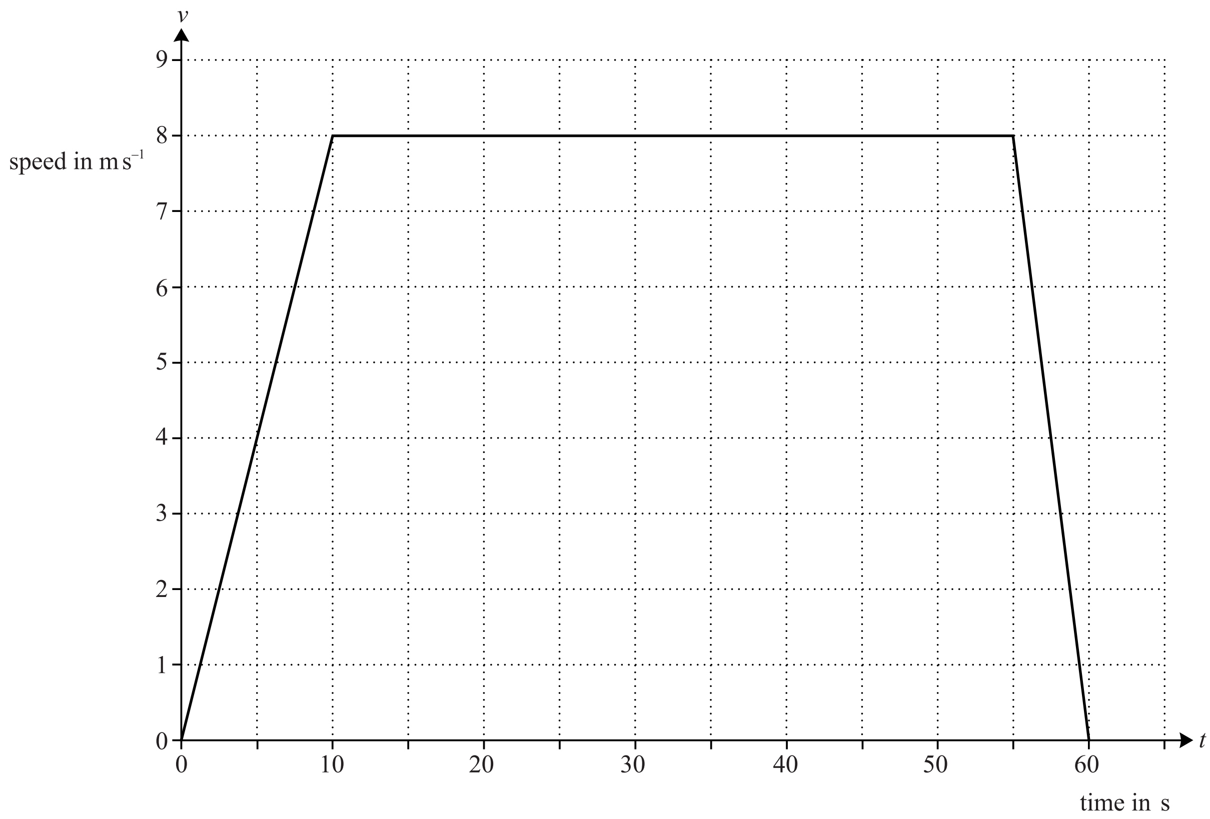

Fig. 1

For each of the following statements, say whether it is true or false. If it is false give a brief explanation.

(*A*) The graph shows that the runner finishes where he started.

(*B*) The runner's maximum speed is $8\,\mathrm{m\,s^{-1}}$.

(*C*) At time 58 seconds, the runner is slowing down at a rate of $1.6\,\mathrm{m\,s^{-2}}$.

(*D*) The runner travels 400 m altogether. **[6]**

2 A particle is moving along a straight line and its position is relative to an origin on the line. At time t s, the particle's acceleration, $a\,\mathrm{m\,s^{-2}}$, is given by

$$a = 6t - 12\,.$$

At $t = 0$ the velocity of the particle is $+9\,\mathrm{m\,s^{-1}}$ and its position is -2 m.

(i) Find an expression for the velocity of the particle at time t s and verify that it is stationary when $t = 3$. **[4]**

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

3 The vectors **P**, **Q** and **R** are given by

$$\mathbf{P} = 5\mathbf{i} + 4\mathbf{j}, \quad \mathbf{Q} = 3\mathbf{i} - 5\mathbf{j}, \quad \mathbf{R} = -8\mathbf{i} + \mathbf{j}.$$

(i) Find the vector **P** + **Q** + **R**. **[1]**

(ii) Interpret your answer to part **(i)** in the cases

(*A*) **P**, **Q** and **R** represent three forces acting on a particle, **[1]**

(*B*) **P**, **Q** and **R** represent three stages of a hiker's walk. **[1]**

4 Fig. 4 illustrates points A, B and C on a straight race track. The distance AB is 300 m and AC is 500 m.

A car is travelling along the track with uniform acceleration.

Fig. 4

Initially the car is at A and travelling in the direction AB with speed $5\,\mathrm{m\,s^{-1}}$. After 20 s it is at C.

(i) Find the acceleration of the car. **[2]**

(ii) Find the speed of the car at B and how long it takes to travel from A to B. **[3]**

5 Fig. 5 shows a block of mass 10 kg at rest on a rough horizontal floor. A light string, at an angle of 30° to the vertical, is attached to the block. The tension in the string is 50 N.

The block is in equilibrium.

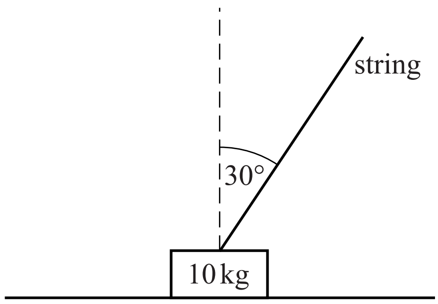

Fig. 5

(i) Show all the forces acting on the block. **[2]**

(ii) Show that the frictional force acting on the block is 25 N. **[2]**

(iii) Calculate the normal reaction of the floor on the block. **[2]**

(iv) Calculate the magnitude of the total force the floor is exerting on the block. **[2]**

6 A football is kicked with speed $31\,\mathrm{m\,s^{-1}}$ at an angle of $20°$ to the horizontal. It travels towards the goal which is 50 m away. The height of the crossbar of the goal is 2.44 m.

(i) Does the ball go over the top of the crossbar? Justify your answer. **[6]**

(ii) State one assumption that you made in answering part **(i)**. **[1]**

Section B (36 marks)

7 A train consists of a locomotive pulling 17 identical trucks.

The mass of the locomotive is 120 tonnes and the mass of each truck is 40 tonnes. The locomotive gives a driving force of 121 000 N.

The resistance to motion on each truck is R N and the resistance on the locomotive is $5R$ N.

Initially the train is travelling on a straight horizontal track and its acceleration is $0.11\,\mathrm{m\,s^{-2}}$.

(i) Show that $R = 1500$. **[4]**

(ii) Find the tensions in the couplings between

(A) the last two trucks, **[4]**

(B) the locomotive and the first truck. **[3]**

The train now comes to a place where the track goes up a straight, uniform slope at an angle α with the horizontal, where $\sin\alpha = \frac{1}{80}$.

The driving force and the resistance forces remain the same as before.

(iii) Find the magnitude and direction of the acceleration of the train. **[4]**

The train then comes to a straight uniform downward slope at an angle β to the horizontal.

The driver of the train reduces the driving force to zero and the resistance forces remain the same as before.

The train then travels at a constant speed down the slope.

(iv) Find the value of β. **[3]**

8 In this question, positions are given relative to a fixed origin, O. The x-direction is east and the y-directic north; distances are measured in kilometres.

Two boats, the *Rosemary* and the *Sage*, are having a race between two points A and B.

The position vector of the *Rosemary* at time t hours after the start is given by

$$\mathbf{r} = \begin{pmatrix} 3 \\ 2 \end{pmatrix} + \begin{pmatrix} 6 \\ 8 \end{pmatrix} t, \text{ where } 0 \leqslant t \leqslant 2 .$$

The *Rosemary* is at point A when $t = 0$, and at point B when $t = 2$.

(i) Find the distance AB. **[3]**

(ii) Show that the *Rosemary* travels at constant velocity. **[1]**

The position vector of the *Sage* is given by

$$\mathbf{r} = \begin{pmatrix} 3(2t + 1) \\ 2(2t^2 + 1) \end{pmatrix} .$$

(iii) Plot the points A and B.

Draw the paths of the two boats for $0 \leqslant t \leqslant 2$. **[3]**

(iv) What can you say about the result of the race? **[1]**

(v) Find the speed of the *Sage* when $t = 2$. Find also the direction in which it is travelling, giving your answer as a compass bearing, to the nearest degree. **[6]**

(vi) Find the displacement of the *Rosemary* from the *Sage* at time t and hence calculate the greatest distance between the boats during the race. **[4]**

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AS GCE MATHEMATICS (MEI)

4761 Mechanics 1

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Candidate forename		Candidate surname	

Centre number						Candidate number				

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Section A (36 marks)

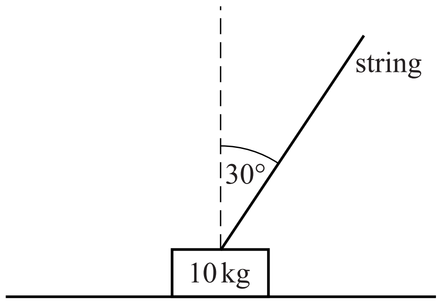
1 (*A*)	
1 (*B*)	
1 (*C*)	
1 (*D*)	

2 (i)	
2 (ii)	

3 (i)	
3 (ii)(A)	
3 (ii)(B)	
4 (i)	

4 (ii)

5 (i)



5 (ii)

5 (iii)	
5 (iv)	

6 (i)	
	(answer space continued on next page)

6 (i)	(continued)
6 (ii)	

Section B (36 marks)

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

7 (ii)(A)	**(continued)**
7 (ii)(B)	

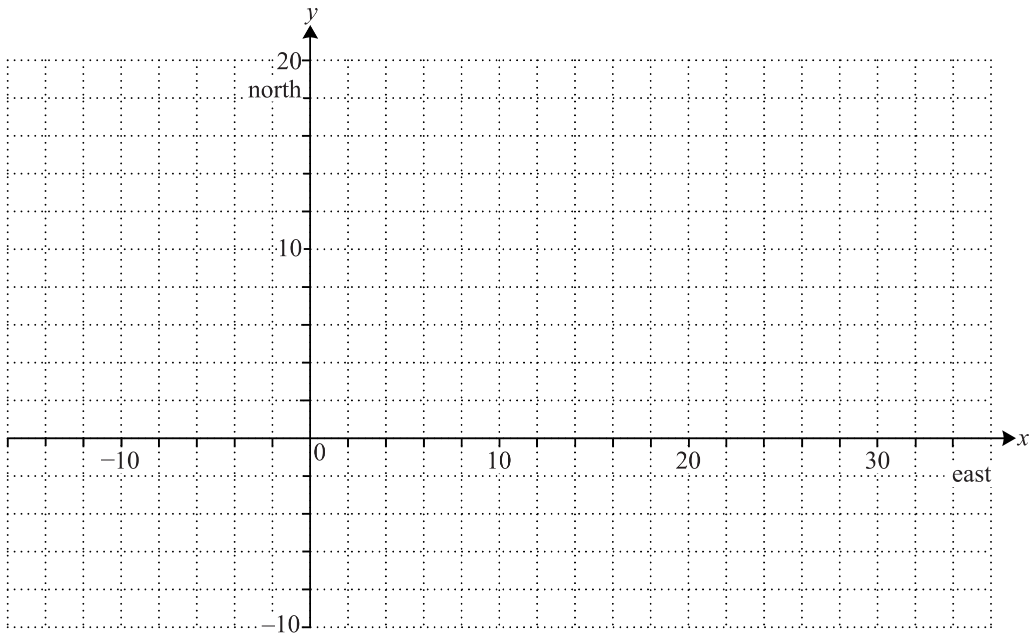
7 (iii)

7 (iv)

(answer space continued on next page)

7 (iv)	(continued)
8 (i)	
8 (ii)	

8 (iii)



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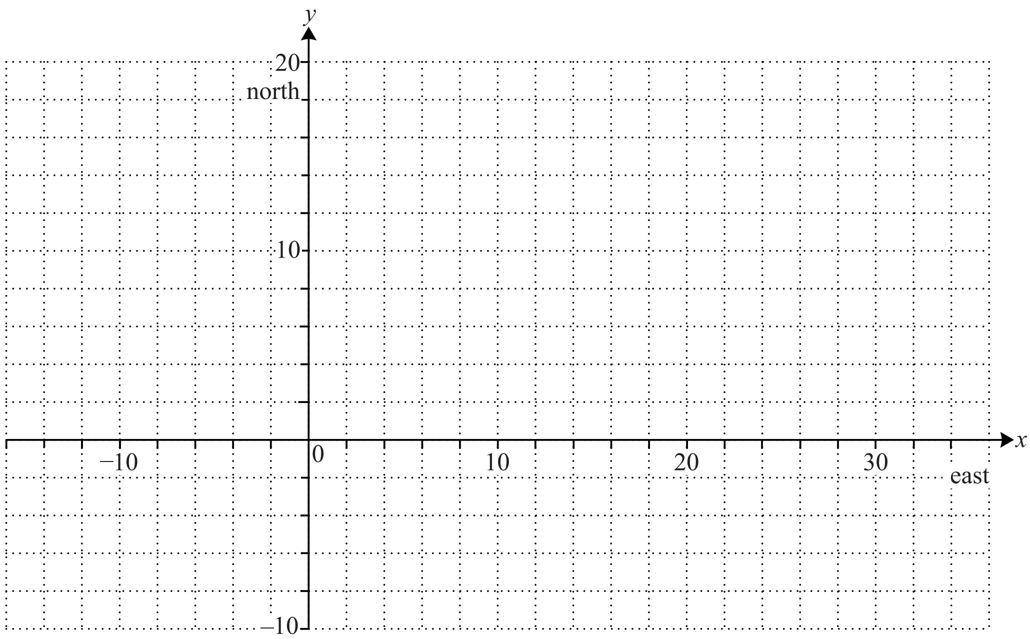

8 (iv)

8 (v)

8 (vi)	

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GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4761:** Mechanics 1

Mark Scheme for June 2012

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, OCR Nationals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

Any enquiries about publications should be addressed to:

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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. 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 entire 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.

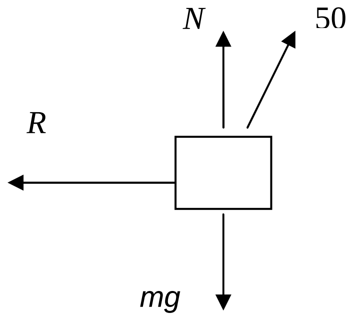
i. If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is 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	*(A)*		False This is a speed-time graph not one for displacement-time	M1 A1	**Notice** that the runner may have returned to his starting place or may not; the graph does not contain the information to tell you which is the case. **Accept** statements only if they are true and relevant, e.g.: There is no information about direction of travel There is no evidence to suggest he has turned round Distance is given by the area under the graph but this is not the same as displacement Speed is not a vector and so the area under the graph says nothing about the direction travelled It just (or only) shows speed-time **Do not accept** statements that are, or may be, untrue: eg The particle moves only in the positive direction **Do not accept** statements that are true but irrelevant: eg The distance travelled is the area under the graph **Condone** This is a speed time graph not one for distance-time
1	*(B)*		True	B1	Ignore subsequent working
1	*(C)*		True	B1	Ignore subsequent working
1	*(D)*		False The area under the graph is 420 not 400	M1 A1 **[6]**	Accept area up to time 55 s is 400 m The calculation in the false example must be correct

Question			Answer	Marks	Guidance
2	(i)		$v=\int(6t-12)\,\mathrm{d}t$	M1	Attempt to integrate
			$v=3t^2-12t+c$	A1	Condone no c if implied by subsequent working (eg adding 9 to the expression)
			$c=9$	A1	
			$t=3\Rightarrow v=3\times3^2-12\times3+9=0$	E1	Or by showing that $(t-3)$ is a factor of $3t^2-12t+9$
				[4]	
2	(ii)		$s=\int(3t^2-12t+9)\,\mathrm{d}t$	M1	Attempt to integrate Ft from part (i)
			$s=t^3-6t^2+9t-2$	A1	A correct value of c is required. Ft from part (i).
			When $t=2$, $s=0$. (It is at the origin.)	B1	Cao
				[3]	
3	(i)		**P** + **Q** + **R** = 0**i** + 0**j**	B1	Accept answer zero (ie condone it not being in vector form)
				[1]	
3	(ii)	*(A)*	The particle is in equilibrium	B1	If "equilibrium" is seen give B1 and ignore whatever else is written. Allow, instead, "acceleration is zero", "the particle has constant velocity" and other equivalent statements. Do not allow "The forces are balanced", "The particle is stationary" as complete answers
		(B)	The hiker returns to her starting point	B1	Do not allow "The hiker's displacement is zero"
				[2]	

Question			Answer	Marks	Guidance
4	(i)		At C: $s = ut + \frac{1}{2}at^2$		
			$500 = 5\times 20 + 0.5\times a \times 20^2$	M1	M1 for a method which if correctly applied would give a.
			$a = 2$ (ms^{-2})	A1	Cao
					Special case If 800 is used for s instead of 500, giving $a = 3.5$, treat this as a misread. Annotate it as SC SC and give M1 A0 in this part
				[2]	
4	(ii)		At B: $v^2 - u^2 = 2as$	M1	M1 for a method which if correctly applied would give either v or t Apply FT from incorrect a from part (i) for the M mark only
			$v^2 - 5^2 = 2\times 2\times 300$		
			$v = 35$ Speed is 35 m s^{-1}	A1	Cao. No FT from part (i) except for SC1 for 46.2 following $a = 3.5$ after the use of $s = 800$.
			At B: $v = u + at$		
			$35 = 5 + 2\times t$		
			$t = 15$ Time is 15 s	A1	Cao. No FT from part (i) except for SC1 for 11.7 following $a = 3.5$ after the use of $s = 800$.
				[3]	

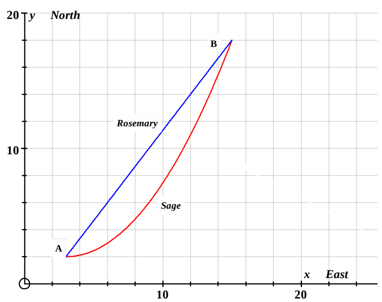
Question			Answer	Marks	Guidance
5	(i)			B2 **[2]**	Subtract one mark for each error, omission or addition down to a minimum of zero. Each force must have a label and an arrow. Accept T for 50 N. Units not required. If a candidate gives the tension in components: Accept if the components are a replacement for the tension Treat as an error if the components duplicate the tension However, accept dotted lines for the components as not being duplication
5	(ii)		Horizontal equilibrium : $R = 50\sin 30° = 25$	M1 A1 **[2]**	May be implied. Allow sin-cos interchange for this mark only Award both marks for a correct answer after a mistake in part (i) (eg omission of R)
5	(iii)		Vertical equilibrium $N + 50\cos 30° = 10g$ $N = 54.7$ to 3 s.f.	 M1 A1 **[2]**	 Relationship must be seen and involve all 3 elements. No credit given in the case of sin-cos interchange Cao
5	(iv)		Resultant $= \sqrt{25^2 + 54.7^2}$ Resultant is 60.1 N	M1 A1 **[2]**	Use of Pythagoras. Components must be correct but allow ft from both (ii) and (iii) for this mark only Cao

Question			Answer	Marks	Guidance
6	(i)		**Either**		
			Both components of initial speed Horiz $31\cos 20°\ (29.1)$ Vert $31\sin 20°\ (10.6)$	B1	No credit if sin-cos interchanged The components may be found anywhere in the question
			Time to goal $= \dfrac{50}{31\cos 20°}$	M1	Attempt to use horizontal distance ÷ horizontal speed
			$= 1.716\ ...\ \text{s}$	A1	
			$h = 31 \times \sin 20° \times 1.716 + 0.5 \times (-9.8) \times (1.716)^2$	M1	Use of one (or more) formula(e) to find the required result(s) relating to vertical motion within a correct complete method. Finding the maximum height is not in itself a complete method.
			$h = 3.76\ \text{(m)}$	A1	Allow 3.74 or other answers that would round to 3.7 or 3.8 if they result from premature rounding
			So the ball goes over the crossbar	E1	Dependent on both M marks. Allow follow through from previous answer
			Or		
			Both components of initial speed	B1	May be found anywhere in the question. No credit if sin-cos interchange
			$h = 31\sin 20° \times t - 4.9t^2$	M1	
			Substitute $h = 2.44 \Rightarrow t = (0.26 \text{ or})\ 1.90$	A1	If only 0.26 is given, award A0
			Substitute $t = 1.90$ in $x = 31\cos 20° \times t$	M1	Allow this mark for substituting $t = 0.26$
			$x = 55.4$	A1	Allow $x = 7.6$ following on from $t = 0.26$
			Since $55.4 > 50$ the ball goes over the crossbar	E1	Dependent on both M marks. Allow FT from their value for 55.4.
			Or		
			Both components of initial speed	B1	May be found anywhere in the question. No credit if sin-cos interchanged
			$h = 31\sin 20° \times t - 4.9t^2$	M1	
			Substitute $h = 2.44 \Rightarrow t = (0.26 \text{ or})\ 1.90$	A1	
			Time to goal $= \dfrac{50}{31\cos 20°}$	M1	Attempt to use horizontal distance ÷ horizontal speed
			$= 1.716\ ...\ \text{s}$	A1	
			Since $1.90 > 1.72$ the ball goes over the crossbar	E1	Dependent on both M marks. Allow follow through from previous answer

Question			Answer	Marks	Guidance
			Or		
			Use of the equation of the trajectory	M1	
			$y = x\tan 20° - \dfrac{9.8x^2}{2\times 31^2 \times \cos^2 20°}$	A1 A1	Correct substitution of $\alpha = 20°$ Fully correct
			Substituting $x = 50$	M1	
			$\Rightarrow y = 3.76$	A1	
			So the ball goes over the crossbar	E1	Dependent on both M marks. Follow through from previous answer
6	(ii)		Any one reasonable statement	B1 **[1]**	**Accept** The ground is horizontal The ball is initially on the ground Air resistance is negligible Horizontal acceleration is zero The ball does not swerve There is no wind The particle model is being used The value of g is 9.8 **Do not accept** g is constant

Question			Answer	Marks	Guidance
7	(i)		Total mass of train $=800\ 000$ kg	B1	Allow 800 (tonnes)
			Total resistance $=5R+17R(=22R)$	B1	
			Newton's 2nd Law in the direction of motion	M1	The right elements must be present, consistent with the candidate's answers above for total resistance and mass . No extra forces.
			$121\ 000-22R=800\ 000\times 0.11$		
			$22R=121\ 000-88\ 000 \quad R=1500$	E1	Perfect answer required
				[4]	
7	(ii)	(*A*)	**Either** (Last truck)		
			Resultant force on last truck $=40\ 000\times 0.11$	B1	Award this mark for $40\ 000\times 0.11$ (= 4400) or 40×0.11 seen
			Use of Newton's 2nd Law	M1	The right elements must be present and consistent with the answer above; no extra forces.
			$T-1500=40\ 000\times 0.11$	A1	Fully correct equation, or equivalent working
			$T=5900$ The tension is 5900 N.	A1	Cao
					Special case Award SC2 to a candidate who, instead, provides a perfect argument that the tension in the penultimate coupling is 11 800 N.
			Or (Rest of the train)		
			Resultant force on rest of train $=760\ 000\times 0.11$	B1	Award this mark for $760\ 000\times 0.11$ (= 83 600) or 760×0.11 seen
			Use of Newton's 2nd Law	M1	The right elements must be present consistent with the answer above; no extra forces.
			$121000-31500-T=760000\times 0.11$	A1	Fully correct equation, or equivalent working
			$T=5900$ The tension is 5900 N.	A1	Cao
				[4]	

Question			Answer	Marks	Guidance
7	(ii)	(*B*)	**Either** (Rest of the train)		
			Newton's 2nd Law is applied to the trucks	M1	The right elements must be present; no extra forces
			$S - 25\ 500 = 680\ 000 \times 0.11$	A1	
			$S = 100\ 300$ The tension is 100 300 N.	A1	Cao
			Or (Locomotive)		
			Newton's 2nd Law is applied to the locomotive	M1	The right elements must be present; no extra forces
			$121\ 000 - S - 5 \times 1500 = 120\ 000 \times 0.11$	A1	
			$S = 100\ 300$ The tension is 100 300 N.	A1	Cao
			Or (By argument)		
			Each of the 17 trucks has the same mass, resistance and acceleration.	M1	
			So the tension in the first coupling is 17 times that in the last coupling	A1	
			$T = 17 \times 5900 = 100\ 300$	A1	Cao. For this statement on its own with no supporting argument allow SC2
				[3]	
7	(iii)		Resolved component of weight down slope		
			$= 800\ 000 \times 9.8 \times \frac{1}{80}$	B1	$m \times 9.8 \times \frac{1}{80}$ where m is the mass of the object the candidate is considering. Do not award if g is missing. Evaluation need not be seen
			$= 98\ 000$ N		
			Let the acceleration be a m s^{-2} up the slope.		
			Newton's 2nd Law to the whole train,	M1	The right elements must be present consistent with the candidate's component of the weight down the slope. No extra forces allowed
			$121\ 000 - 33\ 000 - 98\ 000 = 800\ 000a$	A1	
			$a = -0.0125$ Magnitude 0.0125 m s^{-2}, down the slope	A1	Cao but allow an answer rounding to –0.012 or -0.013 following earlier premature rounding. The negative sign must be interpreted so "Down the slope" or "decelerating" must be seen
				[4]	

Question			Answer	Marks	Guidance
7	(iv)		Taking the train as a whole, Force down the slope = Resistance force $800\ 000 \times 9.8 \times \sin\beta = 33\ 000$ $\beta = 0.24°$	M1 A1 A1 **[3]**	Equilibrium of whole train required The evidence for this mark may be obtained from a correct force diagram Allow missing *g* for this mark only
8	(i)		A: $t = 0,\ \mathbf{r} = \begin{pmatrix} 3 \\ 2 \end{pmatrix}$, B: $t = 2,\ \mathbf{r} = \begin{pmatrix} 15 \\ 18 \end{pmatrix}$ $\begin{pmatrix} 15 \\ 18 \end{pmatrix} - \begin{pmatrix} 3 \\ 2 \end{pmatrix} = \begin{pmatrix} 12 \\ 16 \end{pmatrix}$ $\sqrt{12^2 + 16^2} = 20$ The distance AB is 20 km.	B1 B1 B1 **[3]**	Award this mark automatically if the displacement is correct Finding the displacement. Follow through from position vectors for A and B Cao
8	(ii)		$\mathbf{v} = \frac{d\mathbf{r}}{dt} = \begin{pmatrix} 6 \\ 8 \end{pmatrix}$ which is constant	B1 **[1]**	Any valid argument. Accept $\begin{pmatrix} 6 \\ 8 \end{pmatrix}$ with no comment. Do not accept $a = 0$ without explanation.
8	(iii)			B1 B1 B1 **[3]**	Points A and B plotted correctly, with no FT from part (i), and the line segment AB for the *Rosemary*. No extra lines or curves. For the *Sage*, a curve between A and B. B0 for two line segments. Nothing extra. No FT from part (i). Passes through (9, 6) Condone no labels

Question			Answer	Marks	Guidance
8	(iv)		The race is a draw.	B1 **[1]**	Cao. Accept "Both arrive at B at $t=2$."
8	(v)		For the *Sage*, $\mathbf{v}=\frac{\mathrm{d}\mathbf{r}}{\mathrm{d}t}=\begin{pmatrix}6\\8t\end{pmatrix}$	M1	Attempt to differentiate **r**
			When $t=2$, $\mathbf{v}=\begin{pmatrix}6\\16\end{pmatrix}$	A1	Substitution
			Speed $=\sqrt{6^2+16^2}$	M1	Use of Pythagoras Must be on components of velocity. Allow FT from their **v** but not from displacement (etc)
			Speed $=17.1$ (km h^{-1})	A1	
			$\tan\theta=\frac{6}{16}$	M1	Use of trig on components of their **v**
			$\Rightarrow \theta=20.556...°$ The bearing is 21° to the nearest degree	A1 **[6]**	Condone no rounding
8	(vi)		Displacement $=\begin{pmatrix}3+6t\\2+8t\end{pmatrix}-\begin{pmatrix}3(2t+1)\\2(2t^2+1)\end{pmatrix}$	M1	Use of subtraction to find displacement
			$=\begin{pmatrix}0\\8t-4t^2\end{pmatrix}$	A1	
			Distance, $s=8t-4t^2$ $\quad \frac{\mathrm{d}s}{\mathrm{d}t}=8-8t$		
			For maximum s, $\frac{\mathrm{d}s}{\mathrm{d}t}=0$,		
			giving $t=1$ (and $s=4$)	B1	Valid method for maximising s. $t=1$ must be seen. Allow an argument based on the graph.
			Greatest distance between the boats is 4 (km)	B1 **[4]**	Correct answer only but no preceding working need be seen The answer must be given as a scalar (ie distance and not displacement)

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4761 Mechanics 1

General Comments

Most candidates were successful on much of this paper. There were very few really low scores and many in the 50s and 60s (out of 72); few, however, scored full marks.

The questions in section A tended to be higher scoring than those in section B, which proved somewhat more demanding.

Comments on Individual Questions

1) This question involved interpretation of a speed-time graph. Virtually all candidates scored highly on it. Many, however, lost a mark in part *A*; typically they knew that the statement that the graph showed the runner had returned to his starting point was false but were unable to explain why, not distinguishing between distance and displacement.

2) This question involved motion with non-constant acceleration and so required the use of calculus. Most candidates recognised this and scored highly but some lost marks by omitting the arbitrary constants from the integrations or by failing to evaluate them correctly. A more common mistake, however, was to attempt to use constant acceleration formulae; no credit was given for this.

3) This question involved adding three vectors together to obtain a zero sum. This result then had to be interpreted in two different possible contexts. It was well answered with most candidates scoring all three marks. In part (ii)(*A*), some candidates, however, stated that when the three vectors were forces acting on a particle, the zero sum indicated that it was stationary (instead of being in equilibrium or moving with constant velocity).

4) This question involved the use of constant acceleration formulae and it was well answered by a large majority of candidates. The commonest mistake was to misread the given information and conclude that the distance AC is 800m and not 500m (candidates who worked correctly following this error lost only 1 mark).

5) This question was about the forces acting on a block which was in equilibrium on a rough horizontal plane.

   In part (i) candidates were asked to mark in the forces on a diagram; only a small minority got this right. Common reasons for losing marks were: missing out forces; including extra forces; not labelling forces; omitting the arrows. Some candidates gave both the tension, T, and its resolved components $T\cos 30^{\circ}$ and $T\sin 30^{\circ}$. The convention used for marking this duplication is that it counts as an extra force unless the components are shown in a different style (eg with broken lines) from the other forces; candidates should be warned that similar colours (eg blue and black) will be indistinguishable when their scripts have been scanned for marking.

   Many candidates who had made mistakes on the force diagram nonetheless continued with the question correctly; almost all got part (ii) right.

   A common mistake in part (iii) was to forget the vertical component of the string's tension and so say that the normal reaction was equal to the weight of the block.

   In part (iv) many candidates simply added the horizontal and vertical components of the force instead of using a Pythagoras-type calculation to find their resultant.

6) This projectiles question was set in a slightly unconventional style with the modelling assumptions not stated in the initial stem, but made the subject of part (ii) instead.

Part (i) was well answered and many candidates obtained full marks for it. There were a variety of possible approaches. However, some candidates wasted time finding the coordinates of the highest point of the trajectory, and the time at which it was attained, all of which was irrelevant to the question; many such candidates then recovered, either by effectively starting again, or by using the maximum point as a staging post and considering what happened next.

Part (ii) asked for one modelling assumption. Most candidates correctly said that air resistance had been neglected; other possible correct answers included the ground being horizontal, the ball starting on the ground, there being no wind, etc. This part, too, was well answered.

7) Many candidates found parts of this question difficult. It was about a train and in parts (i), (iii) and (iv) it was easiest to consider the whole train but in (ii)(*A*) and (*B*) the tensions in couplings were required and so it was necessary to consider the relevant sections of the train. Those candidates who understood this mostly found the question straightforward and many of them obtained full marks. By contrast, many others produced jumbled answers with attempts at equations of motion that were internally inconsistent as to what section of the train they applied to.

Most candidates were successful in obtaining the given answer to part (i). To do so they needed find the mass of the whole train and to express it in kilograms rather than tonnes. A few, however, reverted to tonnes for later parts of the question.

In part (ii)(*A*), candidates needed the equation of motion of the last truck but many incorrectly included the driving force from the locomotive. In part (*B*), they were asked for the tension in the coupling between the locomotive and the rest of the train and this was better answered, most considering the equation of motion of the locomotive (which requires its driving force).

Parts (iii) and (iv) involved the motion of the train on a slope and they were well answered by those who realised that the whole train needed to be considered.

8) Question 8 was about the motion of two boats, described by their position vectors. Most candidates obtained all or most of the marks on parts (i) to (iv) but many did not go on to score well on the last two parts, (v) and (vi).

Part (v) required them to find the velocity of one of the boats and then its speed and direction of motion at a given time. However, many did not take the first step of differentiating the position vector and among those who did, a common mistake was to think that the direction of motion is found from the position vector rather than the velocity vector.

The last part, (vi), involved finding the maximum displacement of one boat from the other. Only the higher achieving candidates answered well.

GCE Mathematics (MEI)

			Max Mark	a	b	c	d	e	u
4751/01	(C1) MEI Introduction to Advanced Mathematics	Raw	72	57	50	44	38	32	0
		UMS	100	80	70	60	50	40	0
4752/01	(C2) MEI Concepts for Advanced Mathematics	Raw	72	54	48	42	36	31	0
		UMS	100	80	70	60	50	40	0
4753/01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	60	53	47	41	34	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	65	57	50	43	36	0
		UMS	100	80	70	60	50	40	0
4755/01	(FP1) MEI Further Concepts for Advanced Mathematics	Raw	72	63	56	49	42	35	0
		UMS	100	80	70	60	50	40	0
4756/01	(FP2) MEI Further Methods for Advanced Mathematics	Raw	72	61	53	46	39	32	0
		UMS	100	80	70	60	50	40	0
4757/01	(FP3) MEI Further Applications of Advanced Mathematics	Raw	72	54	47	40	34	28	0
		UMS	100	80	70	60	50	40	0
4758/01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	63	57	51	45	39	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	58	50	42	34	27	0
		UMS	100	80	70	60	50	40	0
4762/01	(M2) MEI Mechanics 2	Raw	72	58	51	44	38	32	0
		UMS	100	80	70	60	50	40	0
4763/01	(M3) MEI Mechanics 3	Raw	72	63	56	50	44	38	0
		UMS	100	80	70	60	50	40	0
4764/01	(M4) MEI Mechanics 4	Raw	72	56	49	42	35	29	0
		UMS	100	80	70	60	50	40	0
4766/01	(S1) MEI Statistics 1	Raw	72	54	46	38	30	23	0
		UMS	100	80	70	60	50	40	0
4767/01	(S2) MEI Statistics 2	Raw	72	61	55	49	43	38	0
		UMS	100	80	70	60	50	40	0
4768/01	(S3) MEI Statistics 3	Raw	72	58	51	44	38	32	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	53	47	42	37	32	0
		UMS	100	80	70	60	50	40	0
4772/01	(D2) MEI Decision Mathematics 2	Raw	72	56	50	44	39	34	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	50	44	38	33	27	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