OCR RECOGNISING ACHIEVEMENT

Wednesday 25 January 2012 – Afternoon

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 two blocks of masses 3 kg and 5 kg connected by a light string which passes over a smooth, fixed pulley.

Initially the blocks are held at rest but then they are released.

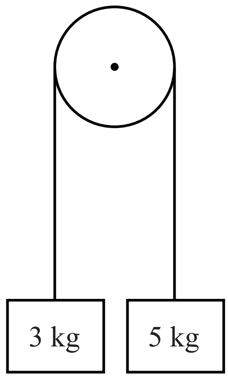

Fig. 1

Find the acceleration of the blocks when they start to move, and the tension in the string. **[5]**

2 Fig. 2 shows a small object, P, of weight 20 N, suspended by two light strings. The strings are tied to points A and B on a sloping ceiling which is at an angle of 60^{o} to the upward vertical. The string AP is at 60^{o} to the downward vertical and the string BP makes an angle of 30^{o} with the ceiling.

The object is in equilibrium.

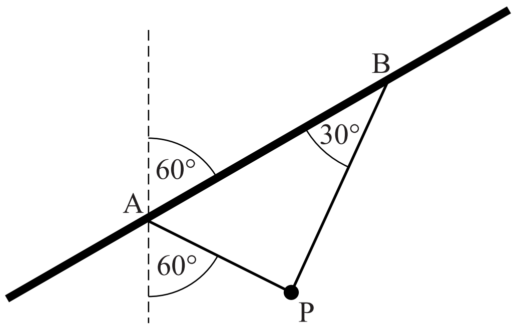

Fig. 2

(i) Show that $\angle APB = 90°$. **[1]**

(ii) Draw a labelled triangle of forces to represent the three forces acting on P. **[3]**

(iii) Hence, or otherwise, find the tensions in the two strings. **[3]**

3 Two girls, Marie and Nina, are members of an Olympic hockey team. They are doing fitness training.

Marie runs along a straight line at a constant speed of $6\,\text{m}\,\text{s}^{-1}$.

Nina is stationary at a point O on the line until Marie passes her. Nina immediately runs after Marie until she catches up with her.

The time, t s, is measured from the moment when Nina starts running. So when $t = 0$, both girls are at O.

Nina's acceleration, $a\,\text{m}\,\text{s}^{-2}$, is given by

$$a = 4 - t \quad \text{for } 0 \leqslant t \leqslant 4,$$
$$a = 0 \quad \text{for } t > 4.$$

(i) Show that Nina's speed, $v\,\text{m}\,\text{s}^{-1}$, is given by

$$v = 4t - \tfrac{1}{2}t^2 \quad \text{for } 0 \leqslant t \leqslant 4,$$
$$v = 8 \quad \text{for } t > 4.$$ **[3]**

(ii) Find an expression for the distance Nina has run at time t, for $0 \leqslant t \leqslant 4$.

Find how far Nina has run when $t = 4$ and when $t = 5\tfrac{1}{3}$. **[4]**

(iii) Show that Nina catches up with Marie when $t = 5\tfrac{1}{3}$. **[1]**

4 A projectile P travels in a vertical plane over level ground. Its position vector $\mathbf{r}$ at time t seconds after projection is modelled by

$$\mathbf{r} = \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 0 \\ 5 \end{pmatrix} + \begin{pmatrix} 30 \\ 40 \end{pmatrix} t - \begin{pmatrix} 0 \\ 5 \end{pmatrix} t^2,$$

where distances are in metres and the origin is a point on the level ground.

(i) Write down

(A) the height from which P is projected,

(B) the value of g in this model. **[2]**

(ii) Find the displacement of P from $t = 3$ to $t = 5$. **[2]**

(iii) Show that the equation of the trajectory is

$$y = 5 + \frac{4}{3}x - \frac{x^2}{180}.$$ **[4]**

5 The vectors **p** and **q** are given by

$$\mathbf{p} = 8\mathbf{i} + \mathbf{j} \text{ and } \mathbf{q} = 4\mathbf{i} - 7\mathbf{j}.$$

(i) Show that **p** and **q** are equal in magnitude. **[3]**

(ii) Show that **p** + **q** is parallel to 2**i** – **j**. **[2]**

(iii) Draw **p** + **q** and **p** – **q** on the grid.

Write down the angle between these two vectors. **[3]**

Section B (36 marks)

6 Robin is driving a car of mass 800 kg along a straight horizontal road at a speed of $40\,\text{m}\,\text{s}^{-1}$.

Robin applies the brakes and the car decelerates uniformly; it comes to rest after travelling a distance of 125 m.

(i) Show that the resistance force on the car when the brakes are applied is 5120 N. **[4]**

(ii) Find the time the car takes to come to rest. **[2]**

For the rest of this question, assume that when Robin applies the brakes there is a constant resistance force of 5120 N on the car.

The car returns to its speed of $40\,\text{m}\,\text{s}^{-1}$ and the road remains straight and horizontal.

Robin sees a red light 155 m ahead, takes a short time to react and then applies the brakes.

The car comes to rest before it reaches the red light.

(iii) Show that Robin's reaction time is less than 0.75 s. **[2]**

The 'stopping distance' is the total distance travelled while a driver reacts and then applies the brakes to bring the car to rest. For the rest of this question, assume that Robin is still driving the car described above and has a reaction time of 0.675 s. (This is the figure used in calculating the stopping distances given in the Highway Code.)

(iv) Calculate the stopping distance when Robin is driving at $20\,\text{m}\,\text{s}^{-1}$ on a horizontal road. **[3]**

The car then travels down a hill which has a slope of 5° to the horizontal.

(v) Find the stopping distance when Robin is driving at $20\,\text{m}\,\text{s}^{-1}$ down this hill. **[6]**

(vi) By what percentage is the stopping distance increased by the fact that the car is going down the hill? Give your answer to the nearest 1%. **[1]**

7 Fig. 7 shows the trajectory of an object which is projected from a point O on horizontal ground. Its initial velocity is $40\,\mathrm{m\,s^{-1}}$ at an angle of α to the horizontal.

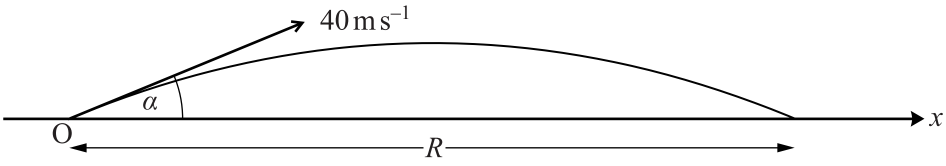

Fig. 7

(i) Show that, according to the standard projectile model in which air resistance is neglected, the flight time, T s, and the range, R m, are given by

$$T = \frac{80\sin\alpha}{g} \text{ and } R = \frac{3200\sin\alpha\cos\alpha}{g}.$$ **[6]**

A company is designing a new type of ball and wants to model its flight.

(ii) Initially the company uses the standard projectile model.

Use this model to show that when $\alpha = 30°$ and the initial speed is $40\,\mathrm{m\,s^{-1}}$, T is approximately 4.08 and R is approximately 141.4.

Find the values of T and R when $\alpha = 45°$. **[3]**

The company tests the ball using a machine that projects it from ground level across horizontal ground. The speed of projection is set at $40\,\mathrm{m\,s^{-1}}$.

When the angle of projection is set at 30°, the range is found to be 125 m.

(iii) Comment briefly on the accuracy of the standard projectile model in this situation. **[1]**

The company refines the model by assuming that the ball has a constant deceleration of $2\,\mathrm{m\,s^{-2}}$ in the horizontal direction.

In this new model, the resistance to the vertical motion is still neglected and so the flight time is still 4.08 s when the angle of projection is 30°.

(iv) Using the new model, with $\alpha = 30°$, show that the horizontal displacement from the point of projection, x m at time t s, is given by

$$x = 40t\cos 30° - t^2.$$

Find the range and hence show that this new model is reasonably accurate in this case. **[4]**

The company then sets the angle of projection to 45° while retaining a projection speed of $40\,\mathrm{m\,s^{-1}}$. With this setting the range of the ball is found to be 135 m.

(v) Investigate whether the new model is also accurate for this angle of projection. **[3]**

(vi) Make one suggestion as to how the model could be further refined. **[1]**

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Wednesday 25 January 2012 – Afternoon

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4761 Mechanics 1

PRINTED ANSWER BOOK

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Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

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DC (NH/JG) 50252/2

Section A (36 marks)

1	
2 (i)	

2 (ii)	
2 (iii)	

3 (i)	
3 (ii)	

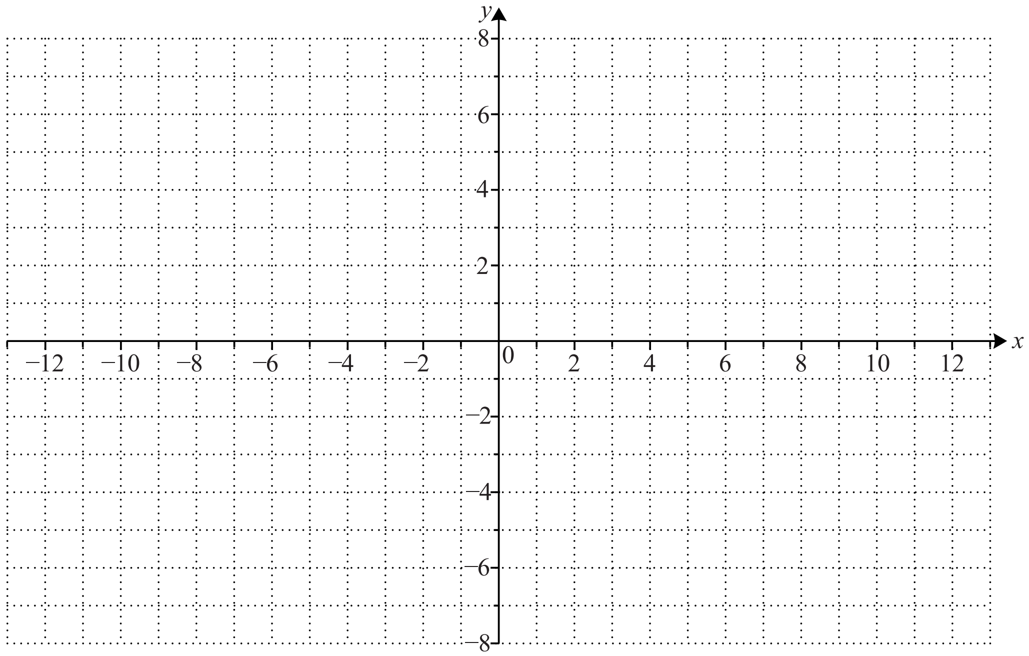
3 (ii)	(continued)
3 (iii)	

4 (i)(*A*)	
4 (i)(*B*)	
4 (ii)	

4 (iii)	

5 (i)	
5 (ii)	

5 (iii)



Section B (36 marks)

6 (i)	
6 (ii)	

6 (iii)	
6 (iv)	

6 (v)	
6 (vi)	

7 (i)	
7 (ii)	

7 (iii)	
7 (iv)	

7 (v)	
7 (vi)	

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RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4761:** Mechanics 1

Mark Scheme for January 2012

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. 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.

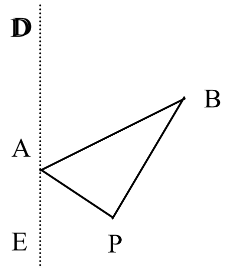
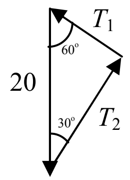
'Fresh starts' will not affect an earlier decision about a misread.

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.

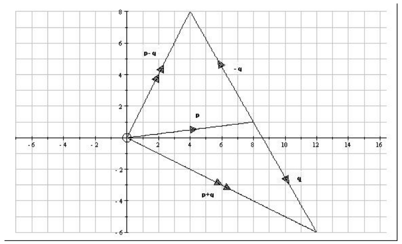
Question			Answer	Marks	Guidance	
1			Let the tension in the string be T N and the acceleration be a m s^{-2}	M1	One correct equation which must involving a and a weight	
			3 kg block: $T - 3g = 3a$	M1	A second correct equation; this one must involve a, T and a weight	
			5kg block: $5g - T = 5a$			
			$2g = 8a$	M1	Elimination of both T and a from their equations or substitution of their a in their 3-term equation	
			$a = g/4 = 2.45$ (m s^{-2})	A1	Cao dependent on at least one of the first two M marks	
			$T = 36.75$ (N)	A1	Cao dependent on at least one of the first two M marks	
				[5]		

2	(i)		 $\angle\text{BAD} = 60°$ and $\angle\text{PAE} = 60° \Rightarrow \angle\text{PAB} = 60°$ (Angles on straight line) $\angle\text{PAB} = 60°$ and $\angle\text{ABP} = 30° \Rightarrow \angle\text{APB} = 90°$ (Angles in triangle)	B1 **[1]**	Any valid argument Allow an "argument" containing only numbers and no words	
2	(ii)			B1 B1 B1	**Diagram** A triangle with angles of approximately 90°, 60° and 30°. No mark for an isosceles or equilateral triangle. No extra forces. Do not award this mark to candidates who draw a force diagram, ie showing 3 concurrent forces. **Arrows** Triangle: the sides are marked with arrows following a cycle round the triangle Force diagram: the directions of the three forces are indicated by arrows. No extra forces. **Labels** Triangle: all sides are labelled consistently and unambiguously with the angles, ie 20 opposite 90°, T_{AP} opposite 30° and T_{BP} opposite 60°. Force diagram: all forces labelled Condone 20g or W	

			T_1 = Tension in AP. T_2 = Tension in BP	**[3]**		
	(iii)		$T_2 = 20\cos 30°$	M1	An attempt to apply trigonometry to a triangle of forces to find the tension in either string	
			Tension in string BP is 17.3 N	A1	No mark if derived from "weight = 20*g*" (giving 169.7)	
			Tension in string AP is 10 N	A1	FT for "weight = 20*g*" (giving 98)	
				[3]		
2.	(iii)		**Alternative**		Award up to all 3 marks for using horizontal and vertical equilibrium	
			Horizontal equilibrium: $T_2 \cos 60° = T_1 \cos 30°$	(M1)	An attempt at both horizontal and vertical equilibrium equations	
			Vertical equilibrium: $T_2 \sin 60° + T_1 \sin 30° = 20$			
			Tension in BP is 17.3 N	(A1)	No mark if derived from "weight = 20*g*" (giving 169.7)	
			Tension in AP is 10 N	(A1)	FT from "weight = 20*g*" (giving 98)	
				([3])		
2.	(iii)		**Alternative**		Award up to all 3 marks for using equilibrium in directions PA and PB	
			$T_1 = 20\cos 60°,\ \ T_2 = 20\cos 30°$	(M1)	An attempt to resolve the weight in the directions PA and PB. This method may be implied by subsequent work	
			Tension in BP is 17.3 N	(A1)	No mark if derived from "weight = 20*g*" (giving 169.7)	
			Tension in AP is 10 N	(A1)	FT from "weight = 20*g*" (giving 98)	
				([3])		

3	(i)		$v=\int(4-t)\,dt$ $v=4t-\frac{1}{2}t^2+c \quad (t=0, v=0 \Rightarrow c=0)$ $v=4t-\frac{1}{2}t^2$ for $0 \le t \le 4$ When $t=4$, $v=8$ and for $t>4$, $a=0$ so $v=8$ for $t>4$	M1 A1 B1 **[3]**	Attempt to integrate Condone no mention of arbitrary constant $a=0$ must be seen or implied	
	(ii)		$s=\int(4t-\frac{1}{2}t^2)\,dt$ $s=2t^2-\frac{1}{6}t^3$ When $t=4$, Nina has travelled $2\times4^2-\frac{1}{6}\times4^3=21\frac{1}{3}$ m When $t=5\frac{1}{3}$, Nina has travelled $21\frac{1}{3}+8\times1\frac{1}{3}=32$ m	M1 A1 A1 F1 **[4]**	 Again condone no mention of arbitrary constant Allow follow through from their $21\frac{1}{3}$ Exact answer required; if rounded to 32, award 0	
	(iii)		When $t=5\frac{1}{3}$, Marie has run $6\times5\frac{1}{3}=32$ m. Nina has also run 32 m so caught up Marie	 B1 **[1]**	Allow an equivalent argument that when Marie has run 32 m, $t=5\frac{1}{3}$, as for Nina This mark is dependent on an answer 32 in part (ii) but allow this where it is a rounded answer and in this particular case the rounding can be in part (iii)	

4	(i)	(*A*) (*B*)	Height 5 m g has been taken to be 10 m s^{-2}	B1 B1 **[2]**	No units required; apply ISW if incorrect units given Allow +10 or –10. No units required; apply ISW if incorrect units given	
4	(ii)		Displacement is $\begin{pmatrix}150\\80\end{pmatrix}-\begin{pmatrix}90\\80\end{pmatrix}$ $=\begin{pmatrix}60\\0\end{pmatrix}$	M1 A1 **[2]**	Displacement must be given as a vector. Allow a description of a vector in words. Attempts at substitution for t and subtraction of vectors must be seen Cao If the candidate then goes on to give a non-vector answer of "60 m", apply ISW.	
4	(iii)		$x=30t$ $y=5+40t-5t^2$ $y=5+40\times\left(\frac{x}{30}\right)-5\times\left(\frac{x}{30}\right)^2$ $y=5+\frac{4}{3}x-\frac{x^2}{180}$	B1 B1 M1 A1 **[4]**	Attempt to eliminate t No errors	

5	(i)		$\lvert\mathbf{p}\rvert = \sqrt{8^2 + 1^2}$ $\lvert\mathbf{p}\rvert = \sqrt{65}$ $\lvert\mathbf{q}\rvert = \sqrt{4^2 + (-7)^2} = \sqrt{65}$ They are equal	M1 A1 A1 **[3]**	For applying Pythagoras theorem Condone no explicit statement that they are equal	
5	(ii)		$\mathbf{p} + \mathbf{q} = 12\mathbf{i} - 6\mathbf{j}$ $\mathbf{p} + \mathbf{q} = 6(2\mathbf{i} - \mathbf{j})$ so $\mathbf{p} + \mathbf{q}$ is parallel to $2\mathbf{i} - \mathbf{j}$	M1 E1 **[2]**	Accept argument based on gradients being equal. “Parallel” may be implied	
5	(iii)		 The angle is 90°	B1 B1 B1 **[3]**	One mark for each of $\mathbf{p} + \mathbf{q}$ and $\mathbf{p} - \mathbf{q}$ drawn correctly SC1 if arrows missing or incorrect from otherwise correct vectors Cao	

6	(i)		$v^2 - u^2 = 2as$ $0^2 - 40^2 = 2 \times a \times 125$ $\Rightarrow a = -6.4$ $F = ma$ $F = 800 \times (-)6.4 = (-)5120$	 M1 A1 M1 E1 **[4]**	 Substitution required. For *u v* interchange award up to M1 A0 Condone no – sign Allow +5120 or –5120	
6	(ii)		$v = u + at$ $0 = 40 - 6.4 \times t$ $t = 6.25$ It takes 6.25 seconds to stop	 M1 A1 **[2]**	 FT for *a*	
			Alternative $s = \frac{1}{2}(u+v)t$ $125 = \frac{1}{2}(40+0) \times t$ $t = 6.25$ it takes 6.25 seconds to stop	 (M1) (A1) **[2]**		
			Alternative $s = ut + \frac{1}{2}at^2$ $125 = 40t + \frac{1}{2} \times (-6.4)t^2$ $3.2t^2 - 40t + 125 = 0$ $t = 6.25$	 (M1) (A1) **([2])**		

6	(iii)		Reaction distance $< 155 - 125 = 30$ m Time taken to travel 30 m at 40 m s^{-1} is 0.75 s	M1 E1 **[2]**	30 must be seen and used	
6	(iv)		Distance travelled before braking $= 20 \times 0.675 = 13.5\,\text{m}$ Distance travelled while braking $= \dfrac{20^2}{2 \times 6.4} = 31.25$ Stopping distance $= 13.5 + 31.25 = 44.75\,\text{m}$	B1 B1 B1 **[3]**	 Cao	

6	(v)		The distance travelled during the reaction time is not affected by the slope. It is $20 \times 0.675 = 13.5\text{ m}$		13.5 is rewarded later	
			Component of the car's weight down the slope	M1	Allow cos for sin for M1 Allow omission of *g* for this mark only	
			$= mg\sin\alpha = 800 \times 9.8 \times \sin 5^{\circ}\ (= 683.3\text{ N})$	A1	Cao	
			Force opposing motion when the brakes are applied $= 5120 - 683.3 = 4436.9$	M1	The resistance (5120) and their weight component (683.3) must have opposite signs.	
			Acceleration $= (-)\dfrac{4436.7}{800} = (-)5.546\text{ ms}^{-2}$	A1		
			Distance travelled while braking			
			$= -\dfrac{u^2}{2a} = -\dfrac{400}{2 \times (-)5.546} = 36.06\text{ m}$	A1		
			Stopping distance $= 13.5 + 36.06 = 49.56\text{ m}$	F1	Allow FT for 36.06 from previous answer. Allow FT of 13.5 from part (iv)	
				[6]		
6	(vi)		Increase in stopping distance on account of slope			
			$= 49.56 - 44.75 = 4.81\text{ m}$			
			Percentage increase $= \dfrac{4.81}{44.75} \times 100 = 11\%$	B1	Cao This mark is dependent on a correct final answer to part (v)	
				[1]		

7	(i)		Vertical motion: initial speed $40\sin\alpha$ $h=(40\sin\alpha)t-\frac{1}{2}gt^2$ $h=0\Rightarrow t=0$ or $\frac{2\times 40\times\sin\alpha}{g}$ $\Rightarrow T=\frac{80\sin\alpha}{g}$	B1 M1 E1	 Correct expression for h must be seen. Condone omission of the case $t=0$ Perfect argument (but still condone omission of $t=0$)	
			Alternative Vertical motion: initial speed $40\sin\alpha$ $v=40\sin\alpha-gt$ When $v=0$, $t=\frac{T}{2}$ $\Rightarrow T=\frac{80\sin\alpha}{g}$	 (B1) (M1) (E1)	 Correct expression for v must be seen Perfect argument	
			Horizontal motion: initial speed $40\cos\alpha$ $R=40\cos\alpha\times T$ $\Rightarrow R=\frac{3200\sin\alpha\cos\alpha}{g}$	B1 M1 E1 **[6]**	 There must be evidence of intention to use T Perfect argument	
7	(ii)		$\alpha=30°$: $T=\frac{80\sin 30°}{9.8}\simeq 4.08$ $\Rightarrow R=\frac{3200\times\sin 30°\times\cos 30°}{9.8}=141.4$ $\alpha=45°$: $T=5.77$	 B1 B1	 Both answers required for the mark. Evidence of substitution required	

			$\alpha = 45°$: $R = 163.3$	B1 **[3]**	Accept 3 significant figures	
7	(iii)		The standard model is not accurate; 125 is much less than 141.4	B1 **[1]**	The comment must be based on the figures given in the question	
7	(iv)		Horizontal motion: $s = ut + \frac{1}{2}at^2$ $x = 40\cos 30° \times t - \frac{1}{2} \times 2 \times t^2$ $x = 40t\cos 30° - t^2$ Flight time = 4.08 s $R = 40 \times \cos 30° \times 4.08 - \frac{1}{2} \times 2 \times 4.08^2$ $R = 124.7$ This is close to the experimental result of 125 m	M1 A1 M1 E1 **[4]**	Use of correct formula A comparison with 125 m is required	

7	(v)		When $\alpha = 45°$, $T = 5.77$ $R = 40 \times \cos 45° \times 5.77 - \frac{1}{2} \times 2 \times 5.77^2$ $R = 129.9$ 129.9 m is not very close to 135 m so the model is not very accurate for this angle.	M1 A1 B1 **[3]**	Use of correct formula, with substitution for α and T. FT their T from (ii) but not 4.08. SC1 for substituting for T but using 30^{o} for α Comparison of their 129.9 with 135 If 4.08 used for T and answer 98.8 obtained for R allow FT for this mark Allow argument that to get to 135m takes 6.07 s which is greater than 5.77 s	
7	(vi)		Allow for resistance in the vertical direction as well	B1 **[1]**	Any sensible comment, but do not award a mark for "Allow for air resistance" without mention of the vertical direction.	

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4761 Mechanics 1

General Comments

This paper was well answered. There were few very low scores and most candidates were clearly well prepared for it. Many of them used the conventions for writing mathematics well, and so were able to communicate their intentions effectively. There were, however, some who experienced difficulty with the questions involving modelling.

There was no evidence of candidates being under time pressure.

Comments on Individual Questions

1 Motion round a smooth pulley

There was a wide spread of marks on this question. While many candidates scored full marks, there were also plenty who did not, including a few who did not know how to start. Nearly all of those who did not score full marks failed to write down two correct equations of motion, with sign errors particularly common. Some correctly used the overall equation, $5g – 3g = 8a$, to obtain $a = 2.45$ but were then unable to go on to find the tension in the string.

2 Equilibrium of an object under three forces

This was the least well answered question on the paper.

The question started with a simple geometrical request and almost all candidates were able to provide a satisfactory answer.

In the next part they were asked to draw a triangle of forces. This was not done well. Many candidates did not seem to know the meaning of the term ‘triangle of forces’ and drew an ordinary force diagram instead (which was given some credit). Those who attempted to draw a triangle of forces were often unsuccessful with incorrect arrows and labels particularly common. Another common mistake was to think that the tensions in both strings were equal.

In the third and final part, candidates were asked to calculate the tensions in the two strings. Those who had drawn a correct triangle of forces in part (ii) almost invariably went on to obtain correct answers. Most candidates, however, worked from horizontal and vertical equilibrium equations and many of them were successful although algebraic and arithmetical errors were not uncommon.

3 Motion with variable acceleration

This question was about two runners. One travelled at constant speed while the other had a two-stage motion, accelerating to maximum speed and thereafter travelling at constant speed. While this presented no difficulty to many candidates, there were others who were unable to deal with the two stages and consequently lost several marks.

In the last part, candidates were asked to show that one girl had caught up with the other at a given time. Some candidates did not seem to realise that a few words would be expected in their answers to such a question.

4 Describing motion

In part (i) of this question candidates were asked to “read” a vector equation and extract information from it. Nearly all did this well but a few did not see the point in part (i)(*B*) and gave an answer of 9.8 instead of 10 for *g*.

In part (ii) candidates were asked to use the given equation to find a displacement and most obtained full marks. The most common mistake was not to appreciate that displacement is a vector quantity.

In part (iii), candidates were asked to deduce the equation of a trajectory from the given equation, and this was very well answered.

5 Vectors

This question was well answered.

In part (i) candidates were required to show that two vectors were of the same magnitude and a large majority did so correctly.

In part (ii) they were asked to show that two vectors were parallel and most knew how to do this. However, a few made the mistake of trying to divide one vector by another.

In part (iii) candidates were asked to show two vectors on a grid and to find the angle between them. Most were able to do this but many lost a mark by not putting arrows on their vectors.

6 The stopping distance of a car

Almost all candidates got started on this question and many worked successfully through to the end and obtained full marks.

Parts (i) and (ii) required the use of *suvat* equations and $F = ma$ and a large majority of candidates obtained full marks.

In part (iii), candidates had to take a driver’s reaction time into account and many did not see how to do this. This was important for the rest of the question and a pleasing number were able to recover and score well in part (iv) and in part (v), where the car was being driven down a slope and so the stopping distance was greater. Most candidates were able to deal with motion on the slope.

The question ended with a calculation of the percentage increase in the stopping distance of the car because it is on a given slope; information which is useful for drivers.

7 Modelling the motion of a projectile

Most candidates scored quite well on this question but many dropped a few marks as they went through its various parts. It was pleasing to see that many candidates clearly understood the process of setting up a model, testing it and then refining it.

In part (i) candidates were asked to derive the standard results for the flight time and range of a projectile. This was well answered but it was also common to see marks lost because of unconvincing arguments about the time of flight. A number of candidates lost marks by missing out essential steps in the derivations; the results were given so a high standard was expected.

In part (ii), candidates used the formulae to obtain a number of values that they would need in the rest of the question. Nearly all candidates got this part right; the most common cause of losing marks was not reading the question carefully and so missing out some of the answers.

Part (iii) was the first of four places where candidates were required to make some comment; some did not appreciate that this was expected to be based on the information that had just been given in the question and made general statements instead.

In part (iv) the standard projectile model was refined by allowing a constant horizontal retardation. Candidates were required to derive a given equation for x but many omitted to do so. They then had to use the equation for a given angle of projection and comment on the result; many lost a mark by not commenting.

In part (v) candidates were required to use the model with a different angle of projection and comment on its accuracy and this led into the final part where they were asked to suggest how the model could be further improved. While a few candidates gave up before the end, most obtained some marks for these parts.