

**GCE**

**Mathematics**

Advanced GCE

Unit **4730**: Mechanics 3

**Mark Scheme for June 2012**

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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.

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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 (OCR) 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 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 be the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the work must 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 methods must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) 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. Marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate to state the intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an accuracy mark is 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 would be expected for an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct answer is not ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply if 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 says otherwise; and similarly where there are several B marks allocated. (The notation 'dep \*' is used to indicate that a part is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate is 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, if 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 work. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) mark is given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a question, 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 be given for 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is in a different 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. It should be 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 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 all parts of a question.

#### **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 accuracy error, except for errors due to premature approximation. A candidate should be penalised only once in the examination.

There is no penalty for using a wrong value for  $g$ . E marks will be lost except when results agree to the accuracy required.

## g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, 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 (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 the same, the question should be marked according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally lost. 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, they 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). If an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting working, 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) $[40d = 30 \times 2]$ Distance is 1.5 m	M1 A1 [2]	For taking moments about $B$ for $BC$
	(ii) $30 = 0.75 R$ Horizontal component on $AB$ at $B$ is 40 N to the left For resolving forces on $BC$ vertically, or taking moments about $C$ Vertical component on $AB$ at $B$ is 10 N down	B1 B1  M1 A1  [4]	$Y + 30 = 40$ , or $40 \times \frac{1}{2} = Y \times 2$ Accept directions on diagram, if not contradicted in text SR A1 if both magnitudes correct but directions wrong/not stated
	(iii) $(+/-)10 \times 2 + 60 \times 0.8d = (+/-)40 \times 1.5$ Distance is 0.833 m	M1 A1 FT A1 [3]	For taking moments about $A$ for $AB$ FT magnitudes of components at $B$ ; need to use ' $x = d \cos \theta$ '  May see moments about $A$ for $ABC$ ( $60 \times 0.8d + 40 \times 3.5 = 30 \times 2$ ) moments about $B$ for $AB$ – need to get equation with only ' $d$ '
2	(i) Since plane is smooth impulse is perpendicular to plane (so $\theta = 15^\circ$ )	B1 [1]	
	(ii) Use of $v^2 = (u^2) + 2 \times g \times 2.5$ $v = 7 \text{ ms}^{-1}$ after impact: Speed parallel to plane is $7 \sin 15^\circ$ $u = 7 \sin 15^\circ / \cos 60^\circ$ $u = 3.62$ $I = 0.45(7 \cos 15^\circ + u \sin 60^\circ)$ $I = 4.45$  Or For using a triangle with sides 3.15 ( $0.45 \times 7$ ), $I$ and $0.45 \times u$ (or 7, $I/0.45$ and $u$ ) and correct angles $135^\circ$ , $15^\circ$ and $30^\circ$ Use of sin rule or cos rule (correct) $u = 3.62$ $I = 4.45$	M1 A1  B1 M1 A1 M1 A1 [7] M1  A1 M1 A1 A1	1.81(173...) Allow sin/cos errors  Allow sin/cos errors or $I = 0.45(7 \cos 15^\circ + 7 \sin 15^\circ \tan 60^\circ)$ $4.45477\dots$ May see $e = 0.464$  Need 2 correct sides and 1 correct angle All correct OR $I \cos 15^\circ = 3.15 + 0.45 u \cos 45^\circ$ M1 $I \sin 15^\circ = m u \cos 45^\circ$ B1 Solve sim equations M1, dep attempt at two Answers A1A1

Question	Answer	Marks	Guidance
3	(i) $v \, dv/dx = g - 0.0025v^2$ $\int \frac{v \, dv}{g - 0.0025v^2} = \int dx$ $200 \ln(g - 0.0025v^2) = x + A$ $A = 200 \ln g$ $[g - 0.0025v^2 = ge^{0.005x}]$ $v^2 = 400g(1 - e^{-0.005x})$ $0 < e^{-0.005x} \leq 1 \rightarrow v^2 \text{ cannot reach } 400g$ <p style="text-align: center;">ie cannot reach 3920</p>	M1 A1 M1 A1 M1* *M1 A1 B1 <b>[8]</b>	For using N's 2 <sup>nd</sup> law with $a = v \, dv/dx$ ; 3 terms For correctly separating variable and attempting to integrate Attempt to find $A$ from $B \ln(C - Dv^2)$ For transposing equation to remove $\ln$ dependent on getting other 7 marks. Need '0 <' oe
	(ii) $v^2 = 400g(1 - e^{-0.5})$ <p>Speed of <math>P</math> is <math>39.3 \text{ ms}^{-1}</math></p>	M1 A1 <b>[2]</b>	For substituting for $x$ and evaluating $v$ must have $v^2 = A + B e^{-kx}$ in this form
4	(i) $\frac{1}{2} m v^2 + mg(0.6)(1 - \cos \theta) = \frac{1}{2} m 4^2$ $v^2 = 4.24 + 11.76 \cos \theta$ $R - 0.45g \cos \theta = 0.45v^2/0.6$ $R = 3.18 + 13.23 \cos \theta$	M1 A1 A1 M1 A1 <b>[6]</b>	For using the pce condone sin/cos and sign errors; need KE difference in PE AG For using Newton's 2 <sup>nd</sup> law, condone sin/cos and sign errors;
	(ii) $\cos \theta = 3.18/13.23$ $[v^2 = 4.24 - 11.76 \times 3.18/13.23]$ <p>Speed is <math>1.19 \text{ ms}^{-1}</math></p>	M1 A1 FT M1 A1 <b>[4]</b>	For using $R = 0$ $-0.24036...$ or $-106/441$ or $\theta = 103.9^\circ$ ft from $R = A + B e^{-kx}$ For substituting for $\cos \theta$ CAO without wrong working

Question	Answer	Marks	Guidance
5	(i) $[0.8mgx/0.78 = mg(5/13)]$ $x = 0.375$ $PE = mg(0.78 + 0.375) \times 5/13$ $EE = 0.8mg \times 0.375^2 \div (2 \times 0.78)$ $[\frac{1}{2}mv^2 = m(4.353... - 0.7067...)]$ Maximum speed is $2.70 \text{ ms}^{-1}$  OR at extension $x$ $PE = mg(x + 0.78) \times \frac{5}{13}$ $EE = \frac{0.8mgx^2}{2 \times 0.78}$ $mg(x + 0.78) \times \frac{5}{13} - \frac{1}{2}mv^2 = \frac{0.8mgx^2}{2 \times 0.78}$ $v^2 = 10.05x^2 - 7.53x + 5.88$  $v^2 = 10.05(x^2 - 0.749x + 0.585)$  for attempting to complete square $v^2 = 10.05(x - 0.375)^2 + 0.726$  Max speed is $2.70 \text{ ms}^{-1}$	M1 A1 B1 FT B1 FT M1 A1 <b>[6]</b>  B1 B1  M1          M1 A1 A1	For resolving forces and using $T = \lambda x / L$ at equilibrium Accept 1.155 for $e + l$ FT value of $x$ FT value of $x$ For using $\frac{1}{2}mv^2 = PE \text{ loss} - EE \text{ gain}$          For using $\frac{1}{2}mv^2 = PE \text{ loss} - EE \text{ gain}$  $v^2 = \frac{40 \times 9.8}{39}x^2 - \frac{98}{13}x + \frac{9.8 \times 3.9 \times 2}{13}$ $v^2 = \frac{392}{39}(x^2 - \frac{3}{4}x + \frac{3 \times 3.9 \times 2}{40})$  $v^2 = \frac{392}{39}(x - \frac{3}{8})^2 + 0.725625$  Note, after getting equation for $v^2$ , can instead Differentiate $v^2$ wrt $x$ M1 Establish max at $x = 0.375$ A1 Max speed $2.70 \text{ ms}^{-1}$ A1

Question	Answer	Marks	Guidance
	(ii) $mg(0.78 + x) \times 5/13 = 0.8mgx^2 \div (2 \times 0.78)$  $[x^2 - 0.75x - 0.585 = 0 \text{ if } x \text{ is extension}]$ $x = 1.2268$ so Distance is 2.01 m  OR put $v = 0$ in $v^2$ equation from above Solve to get $x = 1.23 (+0.78) = 2.01$ m	M1* A1  *M1 A1 <b>[4]</b>  M1A1ft M1A1	For using PE loss = EE gain or $mg(x) \times 5/13 = 0.8mg(x - 0.78)^2 \div (2 \times 0.78)$ if $mg(x+0.78+0.375) \times 5/13 = 0.8mg(x + 0.375)^2 \div (2 \times 0.78)$ For arranging in quadratic form and attempting to solve $[x^2 - 2.31x + 0.6084 = 0 \text{ if } PO = x]$ $[20x^2 = 14.5125, \text{ if } PO = x]$ $[x = 2.0068]$ $[x = 0.8518\dots]$

Question		Answer	Marks	Guidance
6	(i)	$\frac{1}{2} \times 2(5^2 - v^2) = 7.56$ ( $v^2 = 17.44$ ) Speed is $4.18 \text{ ms}^{-1}$	M1 A1 A1 <b>[3]</b>	For using $\frac{1}{2} m(u^2 - v^2) = 7.56$ and solving for $v$ ; $v$ missing $\frac{1}{2}$ , missing $m$ . Do not award if this is not candidate's final answer.
	(ii)	$v_{Ay} = u_{Ay} = 5 \sin \alpha = 4$ $[v_{Ax}^2 + 4^2 = 17.44 \rightarrow v_{Ax}^2 = 1.44]$ $v_{Ax} = \pm 1.2$ and $v_{Ax}$ must be less than $0.8$ $\rightarrow$ Component has magnitude $1.2 \text{ ms}^{-1}$ and direction to the left	B1 M1 A1 <b>[3]</b>	For using $v_{Ax}^2 + v_{Ay}^2 = 17.44$
	(iii)	$2 \times 3 - m \times 2 = 2 \times (1.2) + m \times 0.8$ $m = 3$	M1 A1 FT A1 <b>[3]</b>	For using the pcm parallel to loc must use $5 \cos \alpha$ , $2$ , $0.8$ and equivalent, allow sign errors, condone one mass missing FT incorrect $v_{Ax}$ CAO
	(iv)	$[e(3 + 2) = (1.2 + 0.8)]$ $e = 0.4$	M1 A1 <b>[2]</b>	For using NEL with their '1.2' and $5 \cos \alpha$ , $2$ and $0.8$ ; allow sign way up

Question	Answer	Marks	Guidance
7	(i) $E_{(AP=2.9)} = 120 \times 0.9^2/4 + 180 \times 0.1^2/6$ $= (24.3 + 0.3)$ and $E_{(AP=2.1)} = 120 \times 0.1^2/4 + 180 \times 0.9^2/6$ $= (0.3 + 24.3) \rightarrow$ same for each position Conservation of energy $\rightarrow v = 0$ when AP = 2.1, string taut here so taut throughout motion – oe,	M1  A1  B1 [3]	For using EPE = $\lambda x^2/2L$ for both strings for one  24.6 seen twice Need to point out that $v = 0$ when AP = 2.1 or KE = 0  Dep on M1A1
	(ii) $T_A = 120(0.5 + x)/2$ , $T_B = 180(0.5 - x)/3$ $[(30 - 60x) - (30 + 60x) = (+/-)0.8a]$ $a = 450x$	B1 M1 A1 [3]	soi For using Newton's 2 <sup>nd</sup> law; allow omission of 0.8 With no wrong working
	(iii) SHM because $a = k$ (where $k > 0$ ) $[T = 2\pi / \sqrt{150}]$ Time interval is 0.257 s	M1 M1 A1 FT [3]	SHM because $a = -\omega^2 x$ or in words For using $T = 2\pi/n$ ; must follow from (ii) FT $\pi \div$ candidate's $n$ 0.256509...
	(iv) $[x = 0.4 \cos(\sqrt{150} \times 0.6) = 0.194]$ $[\text{distance} = 4a + (a - 0.194)]$  Distance travelled is 1.81 m	M1 M1 A1 [3]	For using $x = a \cos(0.6n)$ , where $n$ follows from (ii) and $a$ is n For using $T < 0.6 < 1.25 T \rightarrow$ distance = $4a + (a - x)$ ; may be distance < 2.0 CAO, no wrong working
	(v)  Speed is $4.29 \text{ ms}^{-1}$ .	M1  A1 [2]	For using $\dot{x} = -an \sin(0.6n)$ , where $n$ follows from (ii) Or using $v^2 = n^2(a^2 - x^2)$ , where $n$ follows from (ii) and $x$ follows or using $\dot{x} = an \cos(0.6n)$ if $x = a \sin(0.6n)$ used in (iv), where Condone -4.29

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