GCE

Mathematics

Advanced Subsidiary GCE

Unit **4728:** Mechanics 1

Mark Scheme for June 2013

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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.

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

Annotations

Annotation	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
cso	Correct solution only
cv()	Candidates value for()
CorS	Cos or Sin

Subject-specific Marking Instructions

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
If the answer does not have an exact decimal value, accept answers correctly rounded to 2 s.f. If more figures are offered they must be correct.

If the final answer has an exact decimal value, the answer may be correctly rounded to 3 s.f.

In general intermediate answers may be given to any degree of accuracy, as there is no obligation on the candidate to evaluate an expression.

A wrong answer used later does not prohibit the award of method marks. Any subsequent final answer which is "correct" is treated as fortuitously correct, and should not gain A1. Premature approximation of an answer which is used later can however lead to the award of a final A1, if that answer meets the 2 s.f. or 3 s.f. criteria set out in the previous paragraphs.

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

g. Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h. For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

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

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

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

i. If a graphical calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers (provided, of course, that there is nothing in the wording of the question specifying that analytical methods are required). Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j. If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	Guidance
1	(i)			M1	Momentum for Q/R, no g, at least 3 correct terms
			$0.3u + 0.6 \times 0.8 = (0.3 + 0.6) \times 1$	A1	NB 0.48 in "before" from 0.8×0.6; not $1.5 \times 0.1 + 1.1 \times 0.3$ (A0)
			$u = 1.4$ m s^{-1}	A1	
				[3]	
1	(ii)		$0.1 \times 1.5 + 0.3 \times 1.1 = \pm 0.1v + 0.3 \times 1.4$	M1	P,Q +ve "before", allow P –ve "after". Accept cv (1.4)
			$v = 0.6$	A1	Velocity of P, will be –ve if $-0.1v$ in momentum equation, accept $v = \pm 0.6$
			Momentum change $= \pm 0.09$ kg m s^{-1}	A1	Tolerate loss of – sign if "small – large" has +ve answer
			OR	**[3]**	
			Momentum change $Q = \pm 0.3(1.4 - 1.1) = \pm 0.09$	M1A1	Change for P is the change for Q
			Momentum change $P = \pm 0.09$	A1	
			OR		
			$0.1 \times 1.5 + 0.3 \times 1.1 + 0.6 \times 0.8 = (\pm)0.1v + 0.9(\times 1)$	M1A1	Overall equation
			Momentum change $P = \pm 0.09$	A1	From $\pm$ $(0.9 \times 1 - 0.3 \times 1.1 - 0.6 \times 0.8)$
2	(i)		$U = 0.5g$ *OR* $U - 0.5g = 0$	M1	Consider descent *OR* ascent. $v = u + at$ with consistent signs for non-zero terms. $U + 0.5g = 0$ is M0 hence A0.
			$U = 4.9$ m s^{-1}	A1	Allow use of 4.9 without penalty in (ii) and (iii) even if 0/2 here.
				[2]	
2	(ii)		$U^2 = \pm 2gs$	M1	$v^2 = u^2 + 2as$
			$4.9^2 = \pm 2 \times 9.8 \times s$	A1	
			$s = 1.225$ m	A1	+ve, 49/40, 1.22 or 1.23 BoD loss of – sign in final answer
				[3]	
			OR		
			$s = \pm(ut \pm gt^2/2)$ *OR* $s = \pm gt^2/2$	M1	Rise to/fall from greatest height. $S = \pm(vt \pm g\frac{t^2}{2})$ is similar.
			$s = \pm(4.9 \times 0.5 - g \times 0.5^2/2)$ *OR* $s = \pm g \times 0.5^2/2$	A1	
			$s = 1.225$ m	A1	+ve, 1.22 or 1.23 BoD loss of – sign in final answer
			OR		
			$s = \pm Ut/2$	M1	$s = (u + v)t/2$
			$s = \pm 4.9 \times 0.5/2$	A1	
			$s = 1.225$ m	A1	+ve, 1.22 or 1.23 BoD loss of – sign in final answer

Question			Answer	Marks	Guidance
2	(iii)		$v^2 = 2g(s \pm 0.539)$ $v^2 = 2 \times 9.8 \times (0.539 + 1.225)$ $v = 5.88$ ms^{-1} *OR* $v^2 = u^2 \pm 2g \times 0.539$ $v^2 = 4.9^2 + 2g \times 0.539$ $v = 5.88$ ms^{-1}	M1 A1ft A1 **[3]** M1 A1ft A1	Overall descent, zero initial speed ft cv (1.225), tolerate sign change from (ii) Exact, isw rounding of 5.88 to 5.9 if 5.88 seen Motion from projection level down, non-zero initial speed ft cv (4.9), tolerate sign change from (i) Exact, isw rounding of 5.88 to 5.9 if 5.88 seen
3	(i)	(a)	$\tan\theta = 8/12$ $\theta = 33.7°$ *OR* correct trig using ans **(i)(b)** $\sin\theta = 8/$cv(14.4) or $\cos\theta = 12/$cv(14.4) $\theta = 33.7°$	M1 A1 **[2]** M1 A1	Must be correct angle. Must be correct angle A1 needs 2/2 in (i)(b). cos $\theta = 12/14.4$ gives $\theta = 33.6$ A1
3	(i)	(b)	$R^2 = 8^2 + 12^2$ $R = 14.4$ N	M1 A1 **[2]**	Pythagoras, 3 squared terms, R as hypotenuse Accept $4\sqrt{13}$ not $\sqrt{208}$
3	(ii)	(a)	$12\text{CorS}\theta = \pm 8$ $12\sin\theta = 8$ $\theta = 41.8°$ *OR* correct trig using **(ii)(b)** 12CorS $\theta =$ cv(8.94), cv(8.94)$\tan\theta = 8$, or $8\tan\theta =$ cv(8.94) $12\cos\theta = 8.94$ or $8.94\tan\theta = 8$ $\theta = 41.8°$	M1 A1 A1 **[3]** M1 A1 A1	Either angle. If other angle is targeted, this A1 requires "90 –". *OR* $12\cos\theta = 8.94$, $8.94\tan\theta = 8$. cao Either angle If other angle is targeted, this A1 requires "90 –" Both A1 marks require 2/2 in (ii)(b)
3	(ii)	(b)	$R = 12\cos41.8$ $R = 8.94$ N	M1 A1 **[2]**	Using candidate's angle from 3iia. *OR* $R^2 = 12^2 - 8^2$, $R^2 + 8^2 = 12^2$ Accept 8.9 or 8.95, $4\sqrt{5}$, not 9 or 9.0 not $\sqrt{80}$. For A1, the trig solution requires 3/3 in (ii)(a)

Question			Answer	Marks	Guidance
4	(i)		$v = 18 + 2.4 \times 5$ $v = 30$	M1 A1 **[2]**	$v = u + at$
4	(ii)		Distance while accelerating $= (18 + 30) \times 5/2$ Distance at constant speed $= 30(t - 5)$ $30(t - 5) + (18 + 30) \times 5/2 = 300$ $t = 11$ *OR* Distance while accelerating $= (18 + 30) \times 5/2$ (=120) Distance at constant speed $= 300 - \text{cv}(120)$ Time at constant speed $= \dfrac{(300 - \text{cv}(120))}{30}$ Time at constant speed $= 6$ $t = 11$ *OR* Distance $= 30t$ Distance $= (30 - 18) \times 5/2$ $30t - (30 - 18) \times 5/2 = 300$ $t = 11$ *OR* Distance while accelerating $= (18 + 30) \times 5/2$ Distance at constant speed $= 30(t - 5)$ Distance at constant speed $= 300 - 120 = 30(t - 5)$ $t = 11$	B1 B1 M1 A1 A1 **[5]** B1 M1 B1 A1 A1 B1 B1 M1A1 A1 B1 B1 M1A1 A1	Or $30 \times 5 - (30 - 18) \times 5/2$ etc $= 120$, or $45 + 75$. Numerical. Tolerate $30t$. Algebraic. Adds their areas to get 300 $30T = 300 - 120$, $30t + 45 + 75 = 300$, etc Or $30 \times 5 - (30 - 18) \times 5/2$ etc $= 120$, or $45 + 75$. Numerical. Subtracts their area from 300 Equivalent to "distance at constant speed algebraic" Rectangle, comprising 300 + area of "missing triangle" "Missing triangle", to be removed Subtracts their areas to get 300 120 May be implied. Tolerate $30t$. Algebraic. *OR* $180 = 30t$ M1, $t = 6$ A1

Question			Answer	Marks	Guidance
4	**(iii)**		$S = 30^2/(2 \times (\pm 6))$ $S = 75$ Distance = 375 m *OR* $T = 30/6$ and $S = 30T/2$ $S = 75$ Distance = 375m	M1 A1 A1ft **[3]** M1 A1 A1ft	$0^2 = 30^2 \pm 2 \times 6S$, with candidate's v(i) 300 + cv(75) Accept $T = 5$ if no working or from 30/–6, with candidate's v(i) 300 + cv(75)
5	**(i)**		$d = 3u + 4 \times 3^2/2$ (= $3u + 18$) $2d = 5u + 4 \times 5^2/2$ (= $5u + 50$) $6u + 36 = 5u + 50$ $u = 14$ ms^{-1} $2d = 5 \times 14 + 4 \times 5^2/2$ *OR* $d = 3 \times 14 + 18$ *OR* $d = 2 \times 14 + 32$ Length = 120 m	B1 B1 M1 A1 M1 A1 **[6]**	 *OR* $d = (5 - 3)(u + 3 \times 4) + 4 \times 2^2/2$ for lower half of slope ($d = 2u + 32$) Attempts to solve 2 SE in u and d, at least one with 3 terms. Tolerate u, d switch to x, y for solving reasons Substitutes in 3 term eqn, starts *suvat* again, or solves SEs again. If u is negative, allow substitution of +ve equivalent.
5	**(ii)**		$4(m) = (m)g\sin\theta$ $\theta = 24.1°$	M1 A1 **[2]**	Mass may be omitted on both sides. Allow $4(m) = (m)g\cos\theta$
5	**(iii)**		$6 = mg\cos 24.1$ $m = 0.671$ kg	M1 A1 **[2]**	Or $6 = mg\sin 24.1$, uses numerical answer referring to (ii) www
6	**(i)**		$V = d(0.06t^3 - 0.45t^2 - 0.24t)/\mathrm{d}t$ $V = 0.18t^2 - 0.9t - 0.24$ $A = \mathrm{d}(0.18t^2 - 0.9t - 0.24)/\mathrm{d}t$ $A = 0.36t - 0.9$ $V(0) = -0.24$ m s^{-1} $A(0) = -0.9$ m s^{-2}	M1 A1 M1 A1 A1 A1 ft **[6]**	Differentiates displacement Accept with $+c$, unsimplified coefficients Differentiates velocity Accept with $+c$, unsimplified coefficients cao, if coeffs in $V(t)$ wrong A0 ft cv(–0.9), the constant in expression for A. Tolerate wrong coeff t

Question			Answer	Marks	Guidance
6	(ii)		Solves $A = 0$ for t $0.36t - 0.9 = 0$ $t = 2.5$ $x(2.5) = -2.475$ Speed = $\lvert v(2.5) \rvert = 1.365$ m s^{-1}	M1 A1 A1 A1 A1 **[5]**	Not if A(t) includes $+c$ in this section Final answer must be negative. Accept –2.47 and –2.48. Final answer must be positive. Accept 1.36 or 1.37.
6	(iii)		Uses $v = 0$ $0.18t^2 - 0.9t - 0.24 = 0$ $t = 5.25$ s	M1 A1ft A1 **[3]**	 Forms and offers solution of 3 term QE using cv(V(i)) Must select +ve answer explicitly. Accept 5.3, not 5.2
7	(i)		$0.5g - T = \pm 0.5 \times 1.4$ $0.5g - T = 0.5 \times 1.4$ $T = 4.2$ N	M1 A1 A1 **[3]**	N2L for Q, difference of 2 force terms
7	(ii)		$4.2 - F - 0.6g\sin 30 = 0.6 \times 1.4$ *OR* $4.2 - \mu R - 0.6g\sin 30 = 0.6 \times 1.4$ Friction (= $4.2 - 0.6g\sin 30 - 0.6 \times 1.4$) = 0.42 Reaction = $0.6g\cos 30$ $0.42 = 0.6g\cos 30\mu$ *OR* $\mu = 0.42/ 0.6g\cos 30$ $\mu = 0.0825$	M1 A1 B1 M1 A1 **[5]**	N2L for P, 3 forces including a component of weight of P and cv(4.2) May be implied May be implied $F = \mu R$, R a component of weight of P and F has been found using a component of the weight of P. Tolerate F –ve and |–veF|. Accept 0.082, not 0.083.
7	(iii)		$R = (0.6g + 7)\cos 30$ $R = 11.2$ Fr = $7\sin 30 - 0.42$ Fr = 3.08 $\mu = 3.08/11.2$ $\mu = 0.276$ $\mu \geq 0.276$	M1 A1 M1* A1 D*M1 A1 B1 ft **[7]**	Includes weight cmpts of P and B, allow $7g$ 11.154… May be implied Wt cmpt B (allow $7g$) – Fr(ii) must be difference. May be implied. Both quantities +ve, F and R both from 2 term equations Value of μ, accept 0.28, disregard inequality sign ft cv (μ found in (iii)) direction of greater than or equal to sign; isw any work relating to an upper limit for μ

APPENDIX 1

Method marks which include a wrong value calculated by the candidate in earlier work can automatically gain M1 for the correct method.

A1 ft marks identify the occasions when a wrong value or expression is given an accuracy mark, a consequence of a candidate obtaining an erroneous earlier value.

A candidate may answer part (i) wrongly, then calculate the correct answers to part (i) at the start of (ii). These correct answers should not be regarded as later attempts to do (i), but do mean that the candidate can get part (ii) fully correct and gain all the marks available.

A candidate may when working out part (i) of a question actually discover some quantity which the scheme expects to be calculated in part (ii). If reference is made to this quantity in (ii), allow in (ii) all the marks available for what was seen in (i).

Notes:
Q1i
Inclusion of P is automatically M0. Inclusion of 0.1 (unless a MR) is automatically M0 even in the case
$0.1 \times 1.5 + 0.3u + 0.6 \times 0.8 = 0.1 \times 1.5 + (0.3\ \ 0.6) \times 1$
$u = 1.4$
Exceptions: use of 0.6 or v(ii) instead of 1.5 in the example above **is** valid
part (ii) can be done first, then $0.1 \times 0.6 + 0.3u = 0.1 \times 1.5 + 0.3 \times 1.1$, $u = 1.4$

Q2
If using $g = 9.81$ the answers are: (i) $u = 4.905$, so accept 4.9(0) or 4.91. (ii) $s = 1.226..$, so accept 1.23 but not 1.2. (iii) $v = 5.8851..$, so accept 5.89 but not 5.9.

Q3
(iia)(iib) numbers must be +ve for A marks.
(iib) $R + 12\cos 41.8 = 0$ is M0
(iib) Squaring, adding and square rooting $12\cos\theta$ and $(8 - 12\sin\theta)$ with candidate's value of θ from (iia) is a valid method.

Q4ii
Splitting area horizointally

Distance = $18t$	B1	Lower portion of area
Distance = $(t + [t - 5]) \times (30 - 18)/2$	B1	Upper portion of area
$18t + (t + [t - 5]) \times (30 - 18)/2 = 300$	M1A1	$30t - 30 = 300$
$t = 11$	A1	

Q5(i)
Candidates who use s or x instead of d can be given marks BoD
M1 for getting to a single equation with one unknown having used two different equations.
Candidates who find $2d = 120$ from their SE and then give a final answer $d = 60$ get A0.
Candidates who find $2d = 120$ from their SE and then give no further work get A1.

5(ii)
Value for mass assumed or wrong, allow M1A0 fortuitous.

5(iii)
Candidates who use cos in (ii) and sin in (iii) will fortuitously get the correct mass. However (iii) is given M1A0.

Q6(ii)
The value of t for the minimum velocity may be found by completing the square, M1.
$0.18(t^2 – 5t – 4/3)$ gives $(t – 2.5)^2$ A1[– 91/12] hence $t = 2.5$ A1. Candidates can either return to the formula for $v(t)$ or calculate $|0.18x – 91/12|$.
As $v(t)$ is a quadratic function, finding two values of t giving the same velocity identifies the mean of these t values as the time for the minimum velocity.

7(iii)
Some scripts offer a variety of approaches, and it seems that many candidates believe that a "range" must have upper and lower bounds. Some additional solutions are inspired by P having left the surface. Give credit for the single attempt which addresses the correct scenario, whether it is presented first or second.
The B1 ft mark is assigned or withheld for the correct inequality sign attached to the mu value which has been marked.
If in doubt about which of two alternatives to mark, please contact your team leader.

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