

**Mathematics**

Advanced Subsidiary GCE

Unit **4728**: Mechanics 1

**Mark Scheme for June 2012**

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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

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
cv( )	Candidate's value
N2L	Newton's second law
Wt	Weight

## 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 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. *if the correct answer is not an exact one*. If a correct answer is exact, the exact value should be given, but award full marks to a correct answer properly rounded to 3 s.f. If a correct answer is shown, and subsequently incorrectly rounded, award the mark for the correct answer and annotate the script “isw”.

Intermediate values (which candidates are not actually required to evaluate) can be given to any degree of accuracy and still gain A1 or B1 marks.

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)	$F^2 = 17^2 - 8^2$ $F = 15$ $\cos\alpha = 8/17$ $\alpha = 61.9^\circ$	M1 A1 M1 A1 <b>[4]</b>	$F^2 = 17^2 +/- 8^2$ Exact accept 15.0 Correct method for angle between 8 N and 17 N forces Accept $62^\circ$ from correct work
1	(ii)	$E = 17$ Angle = $118(.1)^\circ$ OR $242^\circ$ ( $241.9^\circ$ )	B1 B1 FT <b>[2]</b>	Exact $180 - cv(\alpha(i))$ OR $180 + cv(a(i))$ Must be 3sf or better
2	(i)	$v = 7 - 0.4 \times 9.8$ $v = 3.08 \text{ ms}^{-1}$ $s = 7 \times 0.4 - 9.8 \times 0.4^2/2$ $s = 2.016 \text{ m}$ OR $3.08^2 = 7^2 - 2 \times 9.8s$ $s = 2.016 \text{ m}$ OR $v^2 = 7^2 - 2 \times 9.8 \times 2.016$ $v = 3.08 \text{ ms}^{-1}$	M1 A1 M1 A1 <b>[4]</b> M1 A1  M1 A1	$v = 7 +/- 0.4g$ Exact, or correct to 3sf from $g=9.81(3.076)$ or 10 (3) $s = 7 \times 0.4 +/- g0.4^2/2$ Exact but accept 2.02. $g=9.81$ (2.0152) or $g=10$ (2)  $(cv(v))^2 = 7^2 +/- 2gs$ Exact but accept 2.02. $g=9.81$ (2.0152) or $g=10$ (2)  $v^2 = 7^2 +/- 2g(cv(s))$ Exact or correct to 3sf. Accept $v=3.07$ from $s=2.02$ . From $g=9.81(3.076$ or $3.06$ from $s=2.02)$ or 10 (3)
2	(ii)	$H = \pm 7^2/(2 \times 9.8)$ ( $= \pm 2.5$ ) $S = \pm (7 \times 0.9 - \frac{1}{2} \times 9.8 \times 0.9^2)$ ( $= \pm 2.331$ ) $D = 2.5 + (2.5 - 2.331)$ $D = 2.669 \text{ m}$ OR (Using $t_U = 7/9.8=0.7143$ , $t_D = 0.9-0.7143=0.1857 \text{ s}$ ) $H = \pm (7 \times 0.7143 - 9.8 \times 0.7143^2/2)$ ( $= \pm 2.5$ ) $s_D = \pm 9.8 \times 0.1857^2/2$ ( $= \pm 0.169$ ) $D = 2.5 + 0.169$ $D = 2.669 \text{ m}$	B1 B1 M1 A1 <b>[4]</b> B1 B1 M1 A1	Greatest Height, $g=9.81$ (2.497 accept 2.5) $g=10$ (2.45) Height when $t = 0.9$ , $g=9.81$ (2.32695) $g=10$ (2.25) $2 \times$ greatest height – $S(0.9)$ Exact but accept 2.67, $g=9.81$ (2.66705) $g=10$ (2.65) “OR” method uses distance from greatest height. OR $\pm 9.8 \times 0.7143^2/2$ . Gains B1 for $H$ as above Equivalent to B1 for $S$ as above Greatest height + Descent distance $\ll H$ Exact but accept 2.67, $g=9.81$ (2.66705) $g=10$ (2.65)

Question		Answer	Marks	Guidance
3	(i)	$(10-8)/5 = T_{\text{dec}}$ OR $8 = 10 - 5T_{\text{dec}}$ $t (= 2 - 0.4) = 1.6$	M1 A1 [2]	Attempt to find $T_{\text{dec}} = \pm 0.4 = \pm 2/5$ Exact. Accept 1 3/5, not 8/5, www
3	(ii)	$S_B = \frac{1}{2} \times 8 \times 2$ $S_A = 10 \times 1.6 + \frac{1}{2} \times (10+8) \times 0.4$ OR $S_A = 10 \times 2 - \frac{1}{2} \times (2-1.6) \times (10-8)$ $S_A = 19.6$ $AB = 19.6 - 8 + 1$ $AB = 12.6 \text{ m}$	B1 M1 A1 M1 A1 [5]	$S_B = 8$ Using area under graph is distance (at least two parts) Complete method for $S_A$ run in the first 2s, using $cv(t)$ Accept as 16+3.6 or 20-0.40, from $t=1.6$ (however obtained) $AB = +/- (S_A - S_B +/- 1)$ Exact Or $AB = -12.6 \text{ m}$
4	(i)	$Fr = 14\cos 30$ $R = 28 - 14\sin 30$ $(14\cos 30) = \mu (28 - 14\sin 30)$ $\mu = 0.577$	B1 B1 M1 A1 [4]	12.1(24.. 21 12.1(24..)/21. Allow  component of 14 / cv(R)  for M1 0.577(35..)
4	(ii)	Mass = 28/g $Fr = 0.577 \times 28$  $(28/9.8)a = \pm 0.577 \times 28$  $a = \pm 5.66$ from exact $\mu$ , $a = \pm 5.65$ from $\mu = 0.577$ $0 = u^2 - 2 \times 5.66 \times 3.2$ $u = 6.02 \text{ m s}^{-1}$	B1 B1  M1  A1 M1 A1 [6]	2.857.. Award here if seen in (i) <u>and</u> used in (ii) 16.156 or 0.57735.. x 28 = 16.1658..  Award also for $cv(m)$ , $m = 28$ . Must be only one force (friction), allow $Fr(i)$ .  $g=10 (\pm 5.77)$ Valid signs with $cv(5.66)$ Accept any answer rounding to 6.0 (inc 6.0, not 6) or 6.1 from $g=10$



Question		Answer	Marks	Guidance
5	(i)	$T - 0.4g = 0.4 \times 2.45$ $T = 4.9 \text{ N}$	M1 A1 A1 [3]	N2L on $P$ , two vertical forces, accept with $0.4 \times 2.45g$ Correct terms and signs Exact, $g=9.81$ (4.904, accept 4.9) $g=10$ (4.98, not 5.0)
5	(ii)	$mg - T = \pm 2.45m$ $m = 2/3 \text{ kg}$  $v = 2.45 \times 0.3 (= 0.735)$ Momentum = $(2/3) \times (2.45 \times 0.3)$ Momentum loss = $0.49 \text{ kgms}^{-1}$	M1 A1 FT  B1 M1 A1 [5]	Correct terms (possible incorrect signs), and use of $cv(T(i))$ FT $cv(T(i))/7.35$ , $g=9.81$ (FT $cv(T(i))/7.351 = 0.667$ ) $g=10$ (FT $cv(T(i))/7.55 = 0.6596 = 0.66$ ) This may be seen in (i). The M1A1 pair of marks may be awarded only in part (ii) when the candidate uses the value of $m$ which was found in (i). Must be positive Accept $\pm$ . $cv(m) \times cv(v)$ Exact, but accept any value which rounds to $\pm 0.490$ . $g=9.81$ (0.49) $g=10$ (0.4848=0.485, not 0.48)
5	(iii)	$S = 2.45 \times 0.3^2 / 2$ $S = \pm 0.11(025)$ OR $S = (0 + 0.735) \times 0.3 / 2$ $S = \pm 0.11(025)$ $0 = (2.45 \times 0.3)^2 \pm 2 \times 9.8s$ $s = \pm 0.027(56..)$ OR (using $t_A = 0.735/9.8 = 0.075$ ) $s = 0.735 \times 0.075 - 9.8 \times 0.075^2 / 2$ $s = \pm 0.027(56..)$ Distance = $0.248 \text{ m}$	M1 A1  M1 A1  A1 FT [5]	Distance while $Q$ descends. Watch for $s = vt - at^2/2$ . If $v=0$ , M0A0  M1 Using landing speed from (ii) A1 M1 Distance $P$ ascends while $Q$ at rest, must use $g$ A1 May be implied, $g=9.81$ (0.02753) $g=10$ (0.0270) Calculating ascend time after string goes slack M1 Using candidate's values of speed and $t_A$ to find $\pm s$ A1 May be implied $2 \times  cv(S)  +  cv(s) $ . Accept 0.25. $g=9.81$ (0.248) $g=10$ (0.247511..)

Question		Answer	Marks	Guidance
6	(i)	$mg = 6.4\cos 40$ $m = 0.5(00)$	M1 A1 [2]	One cmpt of 6.4 N force (allow 6.4 x sin/cos 40 or 50), mg not resolved Accept 0.5, g=9.81 (0.49976..=0.5) g=10 (0.49026.. = 0.49)
6	(ii)	$H = 6.4 + 6.4\sin 40$ OR $2 \times 6.4 \cos 25 = 0.5g \cos 65 + H \cos 25$ $H = 10.5$	M1 A1 [2]	Resolves horizontally, all necessary terms (allow e.g. $6.4 \pm 6.4\cos 40$ ) Resolves parallel to bisector of strings, inc cmpt weight Accept 11
6	(iii)	$R = 32\cos 30 - 6.4\sin 30$ $R = 24.5$ $Fr = 32\sin 30 + 6.4\cos 30$ $Fr = 21.5$ $\mu = (32\sin 30 + 6.4\cos 30)/(32\cos 30 - 6.4\sin 30)$ $\mu = 0.879$	M1 A1 M1 A1 M1 A1 [6]	Difference of Wt cmpt and Tension ( <u>not</u> $H$ ) cmpt May be implied Sum of Wt cmpt and Tension ( <u>not</u> $H$ ) cmpt May be implied <b>Either</b> Fr <b>or</b> R obtained from 2 term numerical expressions, in $ \text{Fr}  = \mu/R $
6	(iv)	$F_{\max} = 0.879 \times 32\cos 30 (= 24.4 \text{ N})$ Wt cmpt down slope = $32\sin 30 (= 16 \text{ N})$ Remains in eqbm OR $\pm ma = 32\sin 30 - 0.879 \times 32\cos 30$ Finds acceleration Remains in eqbm OR angle of friction = $\tan^{-1}0.879 = 41^\circ$ Slope is $30^\circ$ Remains in eqbm	B1* D*M1 A1 [3] B1* D*M1 A1  B1* D*M1 A1	May be described simply as $F$ or friction Finding Wt component down slope and comparing with friction Needs Wt cmpt = $16 < F_{\max}$  For friction calculation Sets up and solves N2L for $a$ Needs $a$ clearly in direction of friction (impossible)  Must be explicit Values of angle of friction and slope stated in 6(iv)

Question		Answer	Marks	Guidance
7	(i)	$\text{Before mom} = 0.2 \times 4 + 0.3 \times 2.5$ $0.2 \times 4 + 0.3 \times 2.5 = (0.2 + 0.3)v$ $v = 3.1 \text{ ms}^{-1}$	B1 M1 A1 <b>[3]</b>	Accept with $g$ Accept with $g$ Exact. Award if $g$ used and cancelled.
7	(ii) (a)	$V_0 = 3.1$	B1 FT <b>[1]</b>	FT cv(v(i))
7	(ii) (b)	$s = \int 3.1 - 3t^2 dt$ $s = 3.1t - 3t^3/3 (+c)$ $\text{CR} = [3.1t - t^3]_0^{0.3}$ $\text{CR} = 0.903 \text{ m}$	M1* A1 FT D*M1 A1 <b>[4]</b>	Uses integration of velocity(t) FT cv(v(i)) or cv( $V_0$ (ia)) Uses their $s(0.3)$ . Award if $+c$ never shown or assumed = 0 Ans <u>not</u> given, so explicit substitution not needed. Allow 0.90, not 0.9
7	(ii) (c)	$a = d(V_0 - 3t^2)/dt$ $a = -6 \times 0.3$ $a = -1.8 \text{ ms}^{-2}$	M1* D*M1 A1 <b>[3]</b>	Uses differentiation of $v$ Substitutes $t = 0.3$ (no other value acceptable) Exact. Must be negative (accept deceleration is -1.8). Award if $V_0$ wrong but not if $V_0$ omitted.
	(iii)	$\text{Mom } C = (0.2 + 0.3)(3.1 - 3 \times 0.3^2)$ Conservation of momentum used, no $g$ $(0.2 + 0.3)(3.1 - 3 \times 0.3^2) = 1.5v - 0.5v$ $v = 1.415 \text{ ms}^{-1}$	B1 M1 A1FT A1 <b>[4]</b>	1.415 Before momentum must be numerical, after momentum needs two terms in $v$ (accept $2v$ or $v$ ) FT cv(before momentum) Exact. Accept 1.41 or 1.42.

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