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Mark Scheme (Results)

January 2014

Pearson Edexcel International Advanced Level

Mechanics 2 (WME02/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark
  ⌙

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

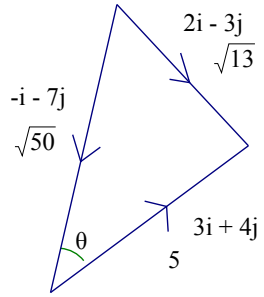
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

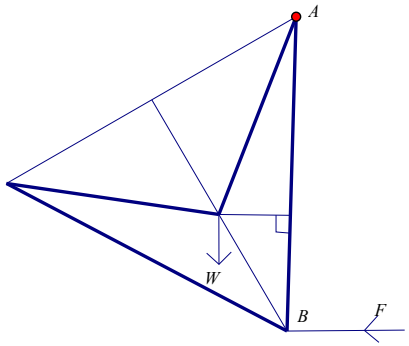
General Notes From Chief Examiner

- Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is accuracy error not method error.
- Omission of mass from a resolution is method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.
- N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),.....then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft.

Question Number	Scheme	Marks	
1a	$2((2\mathbf{i} - 3\mathbf{j}) - (3\mathbf{i} + 4\mathbf{j})) = \mathbf{I}$ $= -2\mathbf{i} - 14\mathbf{j}$ $\lvert\mathbf{I}\rvert = \sqrt{2^2 + 14^2} = \sqrt{200} = 10\sqrt{2}$ (Nm)	M1 A1 A1 M1 A1 [5]	Use of impulse = change in momentum Must be subtracting Correctly substituted Use of Pythagoras for their impulse in the form $a\mathbf{i} + b\mathbf{j}$ $\sqrt{200}$, $10\sqrt{2}$, 14.1 or better
1b	 $\cos\theta = \dfrac{50 + 25 - 13}{2 \times 5 \times \sqrt{50}}$ $(\theta = 28.7°)$, required angle = 151°	M1 A1 A1 [3]	Use of cosine rule in a triangle correct for their **I.** (all momentum or all velocity/speed) Correct unsimplified expression for $\cos\theta$ Or better
Alt 1b	$\cos\theta = \frac{-3-28}{5\times\sqrt{50}}$ $\theta = 151°$	M1 A1 A1 [3]	Correct use of scalar product (for their **I**) Correct unsimplified expression for $\cos\theta$. NB scalar product of **I** and **u** is OK Or better
Alt 1b	$\tan^{-1}\frac{4}{3} + \tan^{-1}\left(\text{their}\ \frac{2}{14}\right) + 90$ or equivalent $\theta = 151°$	M1 A1 A1 [3] **[8]**	Correct strategy Correct unsimplified Or better

Question Number	Scheme	Marks	
2a	$v = 3t^2 - 16t + 20 \Rightarrow a = 6t - 16$	M1	Differentiation of v (having multiplied out). Need evidence of correct method but condone a slip.
		A1	Correct differentiation of their 3 term quadratic
	$t = 3, a = 18 - 16 = 2$ (ms^{-2})	A1 [3]	cso
2b	$s = \int 3t^2 - 16t + 20\text{d}t = t^3 - 8t^2 + 20t(+C)$	M1	Integration of v
		A2	cao Condone missing C. -1 each error
	$t = 0, s = 0$ $t = 2, s = 8 - 32 + 40 = 16$ $t = 3, s = 27 - 72 + 60 = 15$	M1	Strategy for total distance - needs to include use of $t = 2$
		A1	Correct unsimplified
	Distance = $16 + 1 = 17$ (m)	A1 [6]	cao
2c	$s = 0 \Rightarrow t^3 - 8t^2 + 20t = 0$ $t \neq 0 \Rightarrow t^2 - 8t + 20 = 0$	M1	Set $s = 0$ and solve for t
	$(t-4)^2 + 4 \geq 4 \forall t$, (or >0) so no solutions, so s is never zero again	A1 [2]	Or equivalent argument for $s \neq 0$
Alt 2c	$t = \frac{10}{3}$, $s = 14.8$	M1	Consider s when P stops going towards O
	$t > \frac{10}{3}$, $v > 0$ so s never decreases again - no return	A1 [2] **[11]**	

Question Number	Scheme	Marks	
3a	Horizontal: max speed $\Rightarrow$ Driving force = R Use of $P = Fv$ $\quad P = 30R$ On the slope: $F = mg\sin\theta + R\left(= \frac{550g}{14} + R\right)$ $P = 25\left(\frac{550g}{14} + R\right) = 25(385 + R)$ $30R = 25R + 385\times 25 = 25R + 9625$ or $P = 25\left(385 + \frac{P}{30}\right)$ R = 1900 (1930) N $\quad P$ = 58 000 (57 800) W	B1 B1 M1 A1 DM1 DM1 A2 [8]	Resolve to find driving force parallel to the slope. Condone sign and sin/cos confusion. Correct unsimplified equation Use of P = Fv Use simultaneous equations to form an equation in P or R A1 for each one correct to 2 or 3 s.f. Lose first A1 for one or both overspecified.
3b	At 20 m s^{-1}, $\frac{50{,}000}{20} - R = 550a$ $\frac{50000}{20} - 1925 = 550a$ Acceleration = 1.0 (1.05) m s^{-2}	M1 A1 DM1 A1 [4] **[12]**	Use of $F = ma$ and $P = Fv$ Correct equation (with or without substitution for R) Substitute for their R and solve for a. Max 3 s.f. (Not $\frac{23}{22}$ unless over-accuracy already penalised)

Question Number	Scheme	Marks	
4a		B1	Correct area ratios
		B1	Correct distances
		M1	Moments about AC or an axis parallel to AC. Needs to include all relevant terms.
		A1	Correct unsimplified equation
		M1	Simplify to 3 term quadratic
		M1	Solve for h
		A1	Obtain given answer correctly
		M1	Substitute $h=\sqrt{3}$ in their equation
			Simplify
		A1	Confirm given result correctly
		[7]	
4b		M1	Taking moments about A.
		A1	$4F = W \times d$ with d indicated correctly on diagram
		A1	Equation with d correct ($F \times 4 = W \times \sqrt{7}\sin 19.1$)
		A1	Accept $F = 0.22W$ or better
		[4]	
		[11]	

ABC	ACD	ABCE
$2\times 2\sqrt{3}(=4\sqrt{3})$	$2h$	$4\sqrt{3}-2h$
$\frac{2\sqrt{3}}{3}$	$\frac{h}{3}$	h

Area

c of m from base

$$4\sqrt{3}\times\frac{2\sqrt{3}}{3}-2h\times\frac{h}{3}=h\left(4\sqrt{3}-2h\right)$$

$$8-\frac{2}{3}h^2=4\sqrt{3}h-2h^2$$

$$h^2-3\sqrt{3}h+6=0$$

$$h=\frac{3\sqrt{3}\pm\sqrt{27-24}}{2}=\frac{2\sqrt{3}}{2}=\sqrt{3}\,(\text{m})$$

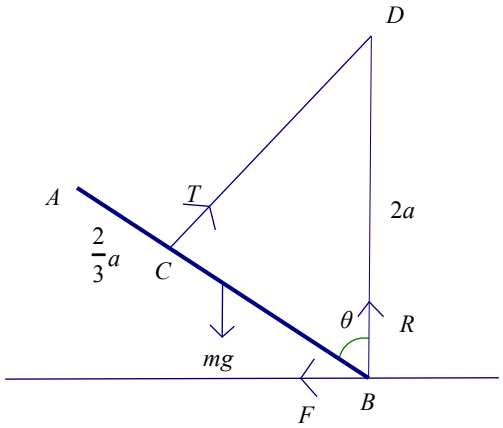
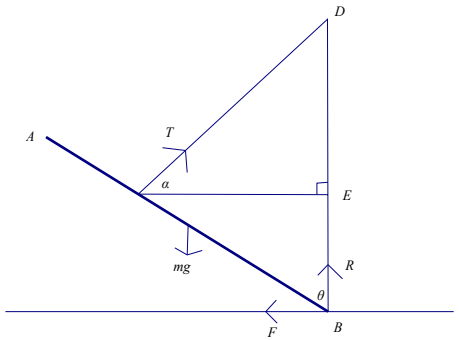
$$\left(\sqrt{3}\right)^2-3\sqrt{3}\sqrt{3}+6$$

$$=3-9+6=0$$

$$F\times 4=W\times\left(2\sqrt{3}-\sqrt{3}\right)\times\sin 30$$

$$=W\times\frac{\sqrt{3}}{2}$$

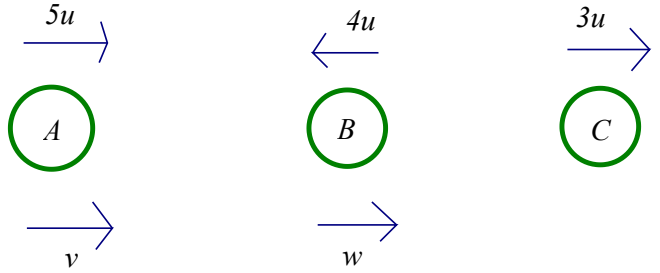
$$F=\frac{\sqrt{3}W}{8}$$

Question Number	Scheme	Marks	
5a	 $mg \times a\sin\theta = F \times 2a$ $F = \frac{mg\sin\theta}{2}$	M1 A1 A1 [3]	Moments about D. Condone sin/cos confusion. The Q tells them to use D but accept complete alternative routes to the given answer. Correct unsimplified equation ***Given Answer***
5b	$mg \times \frac{a}{3}\sin\theta + F \times \frac{4a}{3}\cos\theta = R \times \frac{4a}{3}\sin\theta$ $mg(1+2\cos\theta) = 4R$, $R = \frac{mg(1+2\cos\theta)}{4}$	M1 A2 DM1 A1 [5]	Moments about C. Need all three terms. Condone sin/cos confusion and sign errors. -1each error Substitute for F and find R
5b alt		M1 A1 A1 M1 A1 [5]	Resolve vertically or horizontally $T\cos\alpha = F$ $T\sin\alpha + R = mg$ $R = mg - \frac{mg\sin\theta\sin\alpha}{2\cos\alpha}$ Link α and θ: $\tan\alpha = \frac{DE}{CE} = \frac{2a - \frac{4}{3}a\cos\theta}{\frac{4}{3}a\sin\theta}$ $R = mg - mg\sin\theta\frac{2a-(4/3)a\cos\theta}{2\times(4/3)a\sin\theta}\left(=\frac{mg}{4}(1+2\cos\theta)\right)$

Question Number	Scheme	Marks	
5c	Use of $F = \mu R$	M1	
	Use of $\sin\theta = \frac{4}{5}$ and $\cos\theta = \frac{3}{5}$	DM1	Substitute trig values. Dependent on the preceding M mark
	$\mu = \frac{\frac{mg\sin\theta}{2}}{\frac{mg(1+2\cos\theta)}{4}} = \frac{2\sin\theta}{1+2\cos\theta} = \frac{8}{11}$	A1 [3] **[11]**	0.73 or better

Question Number	Scheme	Marks	
6a	Velocity after t seconds = $3\mathbf{i} + (v - gt)\mathbf{j}$	B1	Horizontal component
		B1	Vertical component Both B marks could be implied in the KE equation
	KE $9 + v^2 = 2\left(9 + (v - gt)^2\right)$	M1	KE equation condone 2 on the wrong side
	$9 + v^2 = 18 + 2v^2 - 12v + 18$	A2	Correct unsimplified equation. -1each error
	$v^2 - 12v + 27 = 0$	A1	Correct equation in v
	$(v-3)(v-9) = 0, \quad v = 9$	DM1 A1 [8]	Solve for v only
6a alt	$s_y = v \times \frac{15}{49} - \frac{g}{2}\left(\frac{15}{49}\right)^2$	B2	Vertical height when $t = \frac{15}{49}$ Allow with t -1 each error
	$\frac{1}{2} \times \frac{1}{2}\left(9 + v^2\right) = g\left(\frac{15v}{49} - 4.9\left(\frac{15}{49}\right)^2\right)$	M1 A2	Use of GPE gained = KE lost Allow with t -1 each error. t must be substituted
	$v^2 - 12v + 27 = 0$	A1	Correct equation in v
	$(v-3)(v-9) = 0, \quad v = 9$	DM1 A1 [8]	Solve for v only
6b	At B, vertical component = -6 (= - (v-3)) $-6 = 9 - gt$	B1 M1	Allow for their v for their v
	$t = \frac{15}{g} = \left(\frac{75}{49}\right) = 1.53 \quad (1.5)$	A1 [3]	Correct only
6b alt	Time to top $= \frac{9}{g}$	B1	Or time to ground ....
	Time to same height $= \frac{9}{g} + \left(\frac{9}{g} - \frac{15}{49}\right)$	M1	... and work back
	$t = 1.53$	A1 [3]	

Question Number	Scheme	Marks	
6b alt	Height at A is $\frac{225}{98}$	B1	
	$\frac{225}{98} = 9t - \frac{1}{2}gt^2$	M1	Use *suvat* for vertical distance
	$t = 1.53$	A1	
		[3]	
		[11]	

Question Number	Scheme	Marks	
7a			
	CLM: $5mu-4mu=mv+mw\ \ (u=v+w)$	M1 A1	Needs all the terms. Condone sign errors
	NEL: $w-v=9ue$	M1 A1	Impact law - condone sign errors but must be used the right way round.
	$2w=9eu+u,\quad w=\frac{u}{2}(9e+1)$	DM1 A1	Solve for v or w. Dependent on both of the preceding M marks
	$2v=u-9eu,\quad v=\left\|\frac{u}{2}(1-9e)\right\|$	A1	The Q asks for speed, so need the modulus.
		(7)	
7b	B cannot catch C: $w\le 3u\Rightarrow 9eu+u\le 6u,\quad e\le\frac{5}{9}$	M1	A correct inequality (condone strict inequality $w<3u$)
		A1	A correct critical value $\frac{5}{9}$ or $\frac{1}{9}$
	Direction of A reversed: $v<0\Rightarrow 1-9e<0,\quad e>\frac{1}{9}$	M1	Second inequality correct
	$\frac{1}{9}<e\le\frac{5}{9}$	A1	cao
		(4) **[11]**	

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