Mark Scheme (Results)

Summer 2019

Pearson Edexcel GCE In Mechanics 4
Paper 6680/01

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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.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- 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 Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

- Omission or extra g in a resolution is an accuracy error not method error.

- Omission of mass from a resolution is a 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. However, premature approximation should be penalised every time it occurs.

  Marks must be entered in the same order as they appear on the mark scheme.

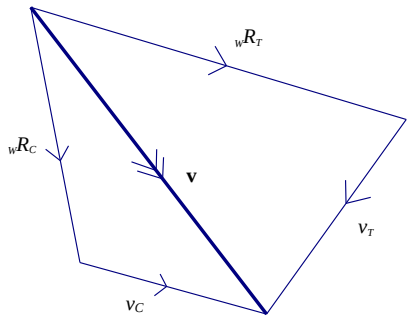
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),.....then that working can only score marks for that part of the question.

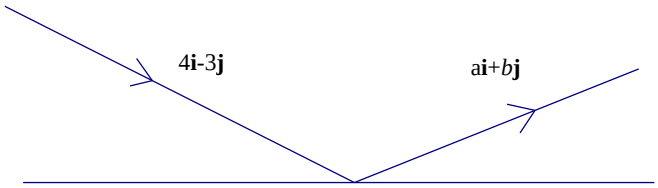
- Accept column vectors in all cases.

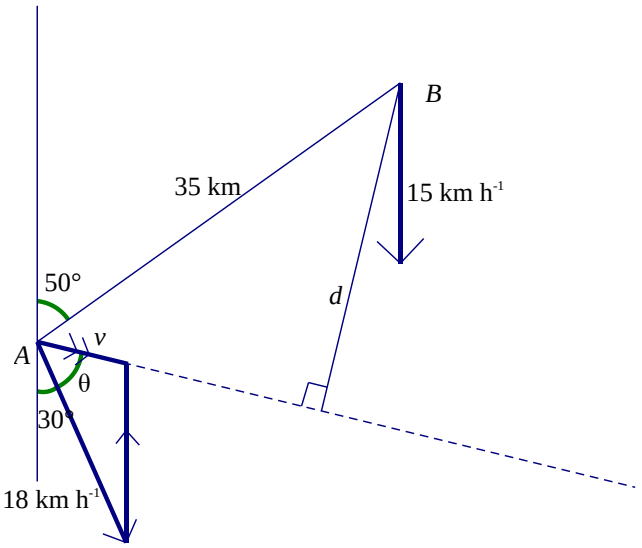
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

- Mechanics Abbreviations

M(A)	Taking moments about A
N2L	Newton's Second Law (Equation of Motion)
NEL	Newton's Experimental Law (Newton's Law of Impact)
HL	Hooke's Law
SHM	Simple harmonic motion
PCLM	Principle of conservation of linear momentum
RHS, LHS	Right hand side, left hand side.

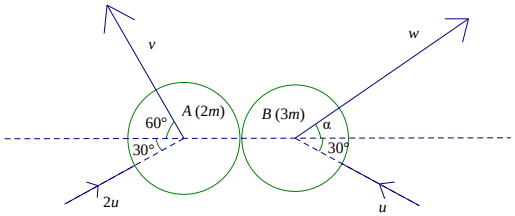
Question Number	Scheme	Marks
1		
	From vector triangles: $\mathbf{v}=\lambda(\mathbf{i}-\mathbf{j})+(-6\mathbf{i}-8\mathbf{j})=(\lambda-6)\mathbf{i}+(-\lambda-8)\mathbf{j}$	M1A1
	$=\mu(-\mathbf{i}-2\mathbf{j})+(6\mathbf{i}-5\mathbf{j})=(6-\mu)\mathbf{i}+(-5-2\mu)\mathbf{j}$	A1
	Compare components: $\lambda-6=6-\mu \quad (\lambda+\mu=12)$ $-\lambda-8=-5-2\mu \quad (\lambda-2\mu=-3)$	M1
	Solve for λ or μ : $3\mu=15,\ \mu=5\ (\text{or } \lambda=7)$	M1
	$\mathbf{v}=\mathbf{i}-15\mathbf{j}$	A1
		[6]
		Total 6

Question Number	Scheme	Marks
2		
	Parallel to the wall: $4 = a$	B1
	Perpendicular to the wall: $b = 3e$	B1
	KE before & after: $\frac{4}{5} \times \frac{1}{2} m\left(4^2 + 3^2\right) = \frac{1}{2} m\left(a^2 + b^2\right)$	M1A1
	Substitute and solve for e	M1
	$e = \frac{2}{3}$ (0.67 or better)	A1
		[6]
		Total 6

Question Number	Scheme	Marks
3a		
	Using cosine rule: $v^2 = 15^2 + 18^2 - 2\times15\times18\times\cos30° \left(= 81.3...\right)$	M1A1
	Relative speed $= 9.02$ (km h^{-1})	A1
	Using sine rule: $\dfrac{\sin\theta}{15} = \dfrac{\sin 30}{\text{their } v}$ $\left(\theta = 56.25...°\right)$	M1A1
	Bearing : $\left(150 - 56.25... = 93.74...\right)$ 094°	A1
3a alt	*A* rel *B*: $v = \left(9\mathbf{i} - 9\sqrt{3}\mathbf{j}\right) - \left(-15\mathbf{j}\right) - = 9\mathbf{i} + \left(15 - 9\sqrt{3}\right)\mathbf{j}$	M1
	Relative speed $= \sqrt{81 + \left(9\sqrt{3} - 15\right)^2}$	A1
	$= 9.02$ (km h^{-1})	A1
	$\tan\theta = \dfrac{9\sqrt{3} - 15}{9}$, $\theta = 3.74°$	M1A1
	Bearing 094°	A1
		[6]
3b	Minimum distance : $35\times\sin\left(\text{their bearing} - 50\right)$	M1
	$= 24.2$ (km) (24.3)	A1
		[2]
3c	Distance at relative velocity: $35\times\cos\left(\text{their bearing} - 50\right)\left(= 25.3\right)$	M1
	Time taken: $\dfrac{\text{their distance}}{\text{their relative speed}}\left(= 2.80 \text{ hrs}\right)$	DM1
	Time: 14.48 (2.48 pm)	A1
	(Accept 14.47 or 2.47)	**[3]**
		Total 11

Question Number	Scheme	Marks
4a	Extension in string $=\left(6a-2a\cos\theta\right)-3a=a\left(3-2\cos\theta\right)$	B1
	EPE $=\dfrac{kmga^2\left(3-2\cos\theta\right)^2}{6a}$	B1
	GPE of rod $=5mga\cos\theta$ (with zero level at A)	B1
	$\Rightarrow V=5mga\cos\theta+\dfrac{kmga}{6}\left(9-12\cos\theta+4\cos^2\theta\right)+\text{constant}$	M1
	$=mga\cos\theta\left(5-2k\right)+\dfrac{2}{3}kmga\cos^2\theta+\text{constant}$	A1
		[5]
4b	Differentiate: $\dfrac{\mathrm{d}V}{\mathrm{d}\theta}=mga\left(-\sin\theta\left(5-2k\right)\right)-\dfrac{4}{3}kmga\cos\theta\sin\theta$	M1A1
	In equilibrium: $\dfrac{dV}{d\theta}=0\Rightarrow -mga\sin\theta\left(5-2k+\dfrac{4}{3}k\cos\theta\right)=0$	M1
	$\cos\theta=\dfrac{3\left(2k-5\right)}{4k}$	
	$0<\theta<\dfrac{\pi}{2}\Rightarrow 1>\cos\theta>0$ (need not state $k>0$)	M1
	$\cos\theta>0\Rightarrow k>\dfrac{5}{2}$ or $\cos\theta<1\Rightarrow 2k-5<\dfrac{4}{3}k\Rightarrow k<\dfrac{15}{2}$	A1
	$\dfrac{5}{2}<k<\dfrac{15}{2}$	A1
		[6]
4c	Smooth wire $\Rightarrow$ no friction $\Rightarrow$ reaction vertical weight of ring vertical $\Rightarrow$ tension in string vertical Or: Smooth wire $\Rightarrow$ no friction $\Rightarrow$ no horizontal component of tension $\Rightarrow$ tension acts vertically $\Rightarrow$ string vertical	B1
		[1]
		Total 12

Question Number	Scheme	Marks
5a	Use of $T = \dfrac{\lambda x}{l}$: $T_A = \dfrac{2mgx}{a}$ or $T_B = \dfrac{3mg(3a-x)}{a}$	B1
	In equilibrium: $T_A = T_B \Rightarrow 2mgx = 3mg(3a-x)$	M1
	$x = \dfrac{9a}{5}$, $k = \dfrac{9}{5}$ ***Given Answer***	A1
		[3]
5b	Equation of motion: $T_B - T_A + R = m\ddot{x}$	M1
	$\dfrac{3mg}{a}\left(\dfrac{6a}{5} - x\right) - \dfrac{2mg}{a}\left(\dfrac{9a}{5} + x\right) + 6m\omega v = m\ddot{x}$	A2
	$m\ddot{x} + 6m\omega\dot{x} + \dfrac{5mgx}{a} = 0$	
	$\Rightarrow \dfrac{\mathrm{d}^2x}{\mathrm{d}t^2} + 6\omega\dfrac{\mathrm{d}x}{\mathrm{d}t} + 5\omega^2 x = 0$ ***Given Answer***	A1
		[4]
5c	$t = 0,\ x = \dfrac{2}{5}a \ \Rightarrow\ \dfrac{2}{5}a = A + B$	M1A1
	Differentiate: $\dot{x} = -A\omega\mathrm{e}^{-\omega t} - 5B\omega\mathrm{e}^{-5\omega t}$	M1
	$t = 0,\ \dot{x} = 0 \ \Rightarrow\ 0 = -A\omega - 5\omega B \ \ (A + 5B = 0)$	A1
	Solve for A, B : $A = \dfrac{a}{2},\ B = -\dfrac{a}{10} \ \Rightarrow \dot{x} = \dfrac{a\omega}{2}\left(\mathrm{e}^{-5\omega t} - \mathrm{e}^{-\omega t}\right)$	M1
	$\Rightarrow v = \left\lvert\dfrac{a\omega}{2}\left(\mathrm{e}^{-5\omega t} - \mathrm{e}^{-\omega t}\right)\right\rvert = \dfrac{a\omega}{2}\left(\mathrm{e}^{-\omega t} - \mathrm{e}^{-5\omega t}\right)$	A1
		[6]
		Total 13

Question Number	Scheme	Marks
6a		
	For $A \updownarrow$: $2u\sin 30° = v\sin 60°$	M1
	$v = \frac{2}{\sqrt{3}}u \left(= \frac{2\sqrt{3}}{3}u \right)$	A1
		[2]
6b	CLM : $2m\times 2u\cos 30° - 3m\times u\cos 30° = 3m\times w\cos\alpha - 2m\times v\cos 60°$	M1A1
	$\left(u\cos 30° + v = 3w\cos\alpha\right)$	
	$w\cos\alpha = \frac{1}{3}\left(\frac{\sqrt{3}}{2}u + \frac{2\sqrt{3}}{3}u\right) = \frac{7\sqrt{3}}{18}u$	A1
	For $B \updownarrow$: $u\sin 30° = w\sin\alpha = \frac{u}{2}$	M1A1
	$\Rightarrow \tan\alpha = \frac{9}{7\sqrt{3}}$	M1
	$\Rightarrow$ deflected through $\theta = 150° - \alpha = 113.4°$ $\left(113°\right)$ (1.98 radians)	M1A1
		[8]
6c	Impact law: $w\cos\alpha + v\cos 60° = e\left(3u\cos 30°\right)$	M1A1
	$\left(\frac{7\sqrt{3}}{18}u + \frac{2\sqrt{3}}{3}u\times\frac{1}{2} = e\times\frac{3\sqrt{3}}{2}u\right)$	
	$e = \frac{13}{27}\left(=0.48\right)$	A1
		[3]
		Total 13

Question Number	Scheme	Marks
7a	Use of $P = Fv$	B1
	Equation of motion : $F - 25v = 800\dfrac{\mathrm{d}v}{\mathrm{d}t}$	M1
	$\dfrac{22500}{v} - 25v = 800\dfrac{\mathrm{d}v}{\mathrm{d}t} \Rightarrow \dfrac{900}{v} - v = \dfrac{900 - v^2}{v} = 32\dfrac{\mathrm{d}v}{\mathrm{d}t}$ ***Given Answer***	A1
		[3]
7b	Separate variables and attempt integration: $\int \dfrac{32v}{900 - v^2}\mathrm{d}v = \int 1\mathrm{d}t$	M1
	$\Rightarrow -16\ln\left(900 - v^2\right) = t\left(+C\right)$	M1A1
	Use limits 10 and V: $T = -16\ln\left(900 - V^2\right) + 16\ln\left(800\right)$	M1
	$T = 16\ln\left(\dfrac{800}{900 - V^2}\right)$	A1
		[5]
7c	Equation of motion in v and x: $32v\dfrac{\mathrm{d}v}{\mathrm{d}x} = \dfrac{900 - v^2}{v}$	B1
	Separate variables and rearrange to integrate: $\int \dfrac{32v^2}{900 - v^2}\mathrm{d}v = \int 1\mathrm{d}x = 32\int -1 + \dfrac{900}{900 - v^2}dv$	M1
	$\Rightarrow x = 32\left(-v + 15\ln\left(\dfrac{30 + v}{30 - v}\right)\right)(+C)$	M1A1
	Use limits 10 and 20: $\Rightarrow x = 32\left(-20 + 15\ln\left(\dfrac{50}{10}\right)\right) - 32\left(-10 + 15\ln\left(\dfrac{40}{20}\right)\right)$	M1
	$32\left(-10 + 15\ln\left(\dfrac{50}{10} \times \dfrac{20}{40}\right)\right) = 480\ln\dfrac{5}{2} - 320$ ***Given Answer***	A1
		[6]
		Total 14

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