Mark Scheme

Mock Paper (Set 2)

December 2019

Pearson Edexcel GCE Mathematics
Paper 9MA0/32 Mechanics

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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 50.

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.

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

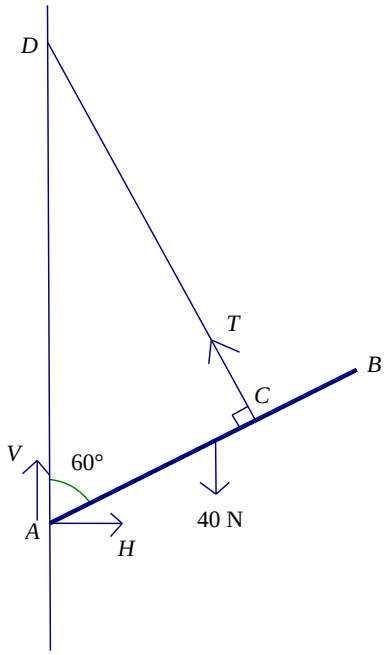
  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

RHS, LHS Right hand side, left hand side.

Question	Scheme	Marks	AOs
1 (a)	Differentiate **v** to obtain **a**	M1	3.4
	$\mathbf{a} = (6t - 12)\mathbf{i} + (18t - 3)\mathbf{j}$	A1	1.1b
		(2)	
(b)	Integrate **v** to obtain **r**	M1	3.4
	$\mathbf{r} = \left(t^3 - 6t^2\left(+C_1\right)\right)\mathbf{i} + \left(3t^3 - \frac{3t^2}{2}\left(+C_2\right)\right)\mathbf{j}$	A1	1.1b
		(2)	
(c)	Solve $\mathbf{a} = \lambda\mathbf{j}$ to obtain t	M1	3.1a
	$6t - 12 = 0 \Rightarrow t = 2$	A1	1.1b
	Substitute their t	M1	1.1b
	$\mathbf{r} = -16\mathbf{i} + 18\mathbf{j}$	A1	2.2a
		(4)	
			(8 marks)

Notes:	
(a)	
M1	Powers going down by 1
A1	Correct only
(b)	
M1	Powers going up by 1. Condone missing constants of integration
A1	Correct only
(c)	
M1	Set coefficient of **i** equal to zero and solve for t
A1	Correct only
M1	Substitute their t in an expression of the form $\mathbf{r} = \left(at^3 - bt^2 + c\right)\mathbf{i} + \left(dt^3 - et^2 + f\right)\mathbf{j}$ where $abde \neq 0$
A1	Correct only

Question	Scheme	Marks	AOs
2 (a)			
	Take moments about A:	M1	3.3
	$T \times 2 = 40 \times 1.5 \cos 30°$	A1	1.1b
	$T = 15\sqrt{3}\,(\text{N}) \quad 26.0\,(\text{N})$	A1	1.1b
		(3)	
(b)	Resolve horizontally	M1	3.4
	$H = T\cos 60° \left(= \dfrac{15\sqrt{3}}{2} = 12.99.... \right)$	A1	1.1b
	Resolve vertically	M1	3.4
	$V + T\cos 30° = 40 \quad (V = 17.5)$	A1	1.1b
	Combine components : $\sqrt{17.5^2 + 225 \times \dfrac{3}{4}}$	M1	3.1b
	$= \sqrt{475} = 5\sqrt{19} = 22(\text{N})$	A1	2.2a
		(6)	
(b) alt	Resolve parallel to the beam	M1	3.4
	$X = 40\cos 60° \quad (= 20)$	A1	1.1b
	Resolve perpendicular to the beam	M1	3.4
	$Y + T = 40\cos 30° \quad \left(Y = 20\sqrt{3} - 15\sqrt{3} = 5\sqrt{3} \right)$	A1	1.1b
	Combine components : $\sqrt{20^2 + 25 \times 3}$	M1	3.1b

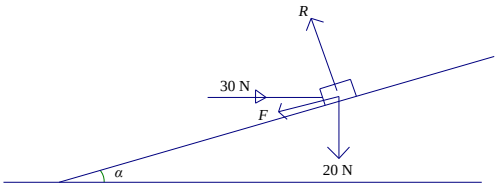
	$= \sqrt{475} = 5\sqrt{19} = 22(\text{N})$	A1	2.2a
		(6)	
(c)	The tension will not be constant	B1	3.5a
	The tension will increase as you go up the rope since it is supporting more rope	B1	2.4
		(2)	
			(11 marks)

Notes:	
(a)	
M1	Or alternative complete method to form an equation in *T*
A1	Correct unsimplified equation in *T*
A1	26 or better
(b)	
M1	First equation. Required terms and no extras. Condone sign errors and sin/cos confusion.
A1	Correct unsimplified equation
M1	Second equation. Required terms and no extras. Condone sign errors and sin/cos confusion.
A1	Correct unsimplified equation
M1	Correct strategy to find the resultant force
A1	22 or better (21.79….)
	N.B. There are many approaches to this. Alternative equations include e.g. moments about *C* and moments about *D*
(c)	
B1	Correct answer
B1	Correct reasoning

Question	Scheme	Marks	AOs
3 (a)	Distance travelled	M1	3.1b
	$=\frac{(15+17)}{2}\times16\times60+\frac{(10+12)}{2}\times16\times60$	A1	1.1b
	$=16\times16\times60+11\times16\times60=15360+10560$ $=25920\,\text{m}=25.92\,\text{km}$	A1	1.1b
		(3)	
(b)	Both trains have travelled the same distance	M1	3.1b
	$\Rightarrow 25920=\frac{\left(M+\left(M-2\right)\right)}{2}\times24\times60$	A1ft A1ft	1.1b 1.1b
	Solve for T	M1	1.1b
	$M-1=18\Rightarrow T=33-19=14$	A1	2.2a
		(5)	
(c)	e.g. the platforms at A, B and C have no length the trains have no length A, B and C modelled as points the trains are modelled as particles.	B1	3.5b
		(1)	
			(9 marks)

Notes:

(a)	
M1	Complete method to find the distance AC. Condone confusion between minutes and seconds.
A1	Unsimplified expression with at most one error (the omission of $\times60$ in each term is one error)
A1	26000 m or 26 km or better
(b)	
M1	Equate the distance travelled by Y to their answer from (a)
A1ft **A1ft**	Unsimplified equation in one unknown with at most one error. Follow their (a) Correct unsimplified equation in one unknown. Follow their (a)
M1	Solve for T
A1	Correct answer only
(c)	
B1	Any relevant assumption

Question	Scheme	Marks	AOs
4 (a)			
	Resolve perpendicular to the plane: $R = 20\cos\alpha + 30\sin\alpha$	M1	3.4
	$R = 20\times\frac{12}{13} + 30\times\frac{5}{13} = 30$ (N)	A1	1.1b
		(2)	
(b)	Forces parallel to the plane:	M1	3.1b
	$30\cos\alpha \geqslant F_{\max} + 20\sin\alpha$	A1ft	1.1b
	Use of $F_{\max} = \mu R$	M1	1.2
	$30\mu \leqslant 30\times\frac{12}{13} - 20\times\frac{5}{13}, \qquad \mu \leqslant \frac{2}{3}$	A1	2.2a
		(4)	
(c)	Resolve perpendicular to the plane and use $F_{\max} = \mu R$	M1	3.1b
	$F_{\max} = \frac{1}{3}\times 20\cos\alpha \quad \left(=\frac{80}{13}\right)$	A1	1.1b
	Equation of motion:	M1	3.3
	$20\sin\alpha - F_{\max} = \frac{20}{g}a \quad \left(\frac{100}{13} - \frac{80}{13} = \frac{20}{g}a\right)$	A1ft	1.1b
	$a = \frac{g}{13}$, 0.75 or $0.754\,(\text{m s}^{-2})$	A1	2.2a
		(5)	
			(11 marks)

Notes:	
(a)	
M1	All terms required. Condone sign errors and sin/cos confusion
A1	Correct answer only
(b)	
M1	All terms required. Condone sign errors and sin/cos confusion. Condone equality
A1ft	Correct unsimplified inequality follow their R

M1	Use $F_{\max} = \mu R$ to find the range of values for μ
A1	$\mu \leqslant 0.67$ or better
(c)	
M1	Resolve perpendicular to the plane and use $F = \frac{1}{3}R$. No additional terms in resolution. Condone sin/cos confusion.
A1	Correct unsimplified equation for $F_{\max}$
M1	Equation of motion down the slope. Condone missing g
A1ft	Correct unsimplified equation. Follow their $F_{\max}$
A1	Exact or 0.75 or 0.754

Question	Scheme	Marks	AOs
5 (a)	Vertical speed:	M1	3.4
	$-u\sin\theta = u\sin\theta - gt \qquad \left(t = \dfrac{2u\sin\theta}{g}\right)$	A1	1.1b
	Horizontal distance $= u\cos\theta t$	B1	3.4
	$= u\cos\theta \times \dfrac{2u\sin\theta}{g}$	M1	2.1
	$= \dfrac{u^2}{g} \times 2\sin\theta\cos\theta = \dfrac{u^2\sin 2\theta}{g}$ *	A1*	2.2a
		(5)	
(b)	$\dfrac{25^2\sin 2\theta}{g} \geqslant 40 \quad \Rightarrow \quad \sin 2\theta \geqslant \dfrac{40g}{625} \quad (= 0.627.....)$	M1	3.4
	$\Rightarrow (38.8° \leqslant) 2\theta \leqslant 141.2° \qquad \theta_{MAX} = 70.6°(71°)$	A1	1.1b
		(2)	
(c)	Vertical height : $3 = u\sin\theta t - \dfrac{1}{2}gt^2$	M1	3.1b
	$3 = \dfrac{25}{2}t - \dfrac{1}{2}gt^2$	A1	1.1b
	$4.9t^2 - 12.5t + 3 = 0$	M1	3.1a
	$\Rightarrow T = 2.28282.. - 0.26819.. = 2.01 \quad (2.0)$	A1	1.1b
		(4)	
			(11 marks)

Notes:

(a)	
M1	Complete method using *suvat* to find t Condone sign errors and sin/cos confusion
A1	Correct unsimplified equation in t
B1	Correct expression in u, θ and t for the horizontal distance travelled. Seen or implied.
M1	Obtain expression for distance in terms of u and θ
A1*	Correct justification of given answer from correct working.
(b)	
M1	Use given formula or complete *suvat* method to find inequality in θ
A1	71° or 70.6°

(c)	
M1	Use *suvat* to form an equation in t. Condone sign errors and sin/cos confusion
A1	Correct unsimplified equation
M1	Solve to find T
A1	2.0 or 2.01 only