Pearson

Mark Scheme (Results)

January 2018

Pearson Edexcel
International Advanced Subsidiary Level
In Mechanics M2 (WME02)
Paper 01

edexcel

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January 2018
Publications Code WME02_01_1801_MS

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.

PEARSON EDEXCEL IAL 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
   - o.e. – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper or ag- answer given
   - $\lfloor$ or d… 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.
- 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

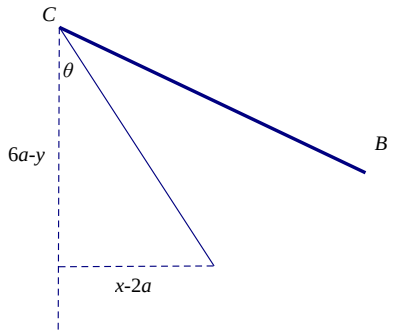
  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

Jan 2018
Mechanics WME02
Mark Scheme

Q	Scheme	Marks	Notes
1.	Impulse- momentum equation	M1	Must be subtracting velocities (or equivalent). Dimensionally correct.
	$4\mathbf{i}+5\mathbf{j}=\frac{1}{2}(\mathbf{v}-(2\mathbf{i}-3\mathbf{j}))$	A1	Correct unsimplified equation.
	$\mathbf{v}=10\mathbf{i}+7\mathbf{j}$	A1	Seen or implied
	KE Gain	M1	Dimensionally correct. Condone ± Must be difference of two KE terms.
	$=\frac{1}{2}0.5(10^2+7^2-(2^2+(-3)^2))$	A1ft	Correct unsimplified expression Follow their **v** . Condone ±
	$=34$ J	A1	CSO
		(6)	
2(a)	Use of $a=\frac{\mathrm{d}v}{\mathrm{d}t}$	M1	Usual rules for differentiation. Condone slip in multiplying brackets
	$v=3t-2t^2-1,\ a=\frac{\mathrm{d}v}{\mathrm{d}t}=3-4t$	A1	
	$t=\frac{1}{2},\ a=1\ (\mathrm{m\,s^{-2}})$	A1	CSO
		(3)	
2(b)	$v=0\Rightarrow t=0.5$	B1	Seen or implied
	$s=\int 3t-2t^2-1\ \mathrm{d}t$	M1	Usual rules for integration
	$=\frac{3t^2}{2}-\frac{2t^3}{3}-t(+C)(=F(t))$	A1ft	Follow their v
	Correct strategy for distance	M1	For their "0.5" in (0,1) Must take account of change in direction
	$-[F(t)]_0^{0.5}+[F(t)]_{0.5}^1=F(1)-2F(0.5)+F(0)$	A1	Or equivalent, accept ± . For their $F(t)$
	$\left(=\frac{5}{24}+\frac{1}{24}\right)=0.25$ m	A1	CSO
			NB Candidates who show no working and use their calculator to integrate must be starting with the correct function and show no errors in order to be able to score any marks. Full marks are available for a correct answer with no error seen.
		(6)	
		[9]	

Q	Scheme	Marks	Notes
3(a)	$36a^2(6)$ | $6a^2(1)$ | $30a^2(5)$ $3a$ | $\frac{14a}{3}$ | $\bar{x}$ $3a$ | $5a$ | $\bar{y}$	B1	Mass ratios for a valid combination of shapes
		B1	Distance from *OD* or equivalent for a valid combination of shapes
		B1	Distance from *OA* or equivalent for a valid combination of shapes
	$6\times 3a - 1\times\frac{14a}{3} = 5\bar{x}$ or $6\times 3a - 1\times 5a = 5\bar{y}$	M1	Moments equation for a horizontal or vertical axis or a vector equation combining both. For a valid dissection.
	$\Rightarrow \quad \bar{x} = \frac{8a}{3}$	A1	One correct distance
	$\bar{y} = \frac{13a}{5}$	A1	Both distances correct
		(6)	
3(a) alt	$12a^2$ | $6a^2$ | $12a^2$ | $30a^2$ a | $\frac{10a}{3}$ | $4a$ | $\bar{x}$ $3a$ | $4a$ | $\frac{3a}{2}$ | $\bar{y}$		
3(b)			
	$\theta = \tan^{-1}\left(\frac{\bar{x}-2a}{6a-\bar{y}}\right)$	M1	Trig ratio of a relevant angle
	$\alpha = \tan^{-1}\left(\frac{4}{3}\right) - \tan^{-1}\left(\frac{\bar{x}-2a}{6a-\bar{y}}\right)$	DM1	expression for the required angle for their $\bar{x}, \bar{y}$
	$\left(\text{or } \tan^{-1}\left(\frac{6a-\bar{y}}{\bar{x}-2a}\right) - \tan^{-1}\left(\frac{3}{4}\right)\right)$ $\left(\text{or } 90 - \theta - \tan^{-1}\frac{3}{4}\right)$	A1ft	Correct unsimplified substituted expression
	$\alpha = 42^\circ$	A1	The Q asks for the answer to the nearest degree.
		(4)	
			See over page

Q	Scheme	Marks	Notes
3(b) alt	Correct method for lengths of all three sides of triangle CBG	M1	$\left(\sqrt{\frac{2701}{225}}a,\ \sqrt{\frac{2536}{225}}a,\ 5a\right)$
	Correct use of cosine rule	M1	
	$\cos\alpha = \dfrac{25+\frac{2701}{225}-\frac{2536}{225}}{2\times5\times\sqrt{\frac{2701}{225}}}$	A1ft	Correct unsimplified for their values of the correct distances
	$\alpha = 42^{o}$	A1	The Q asks for the answer to the nearest degree.
		(4)	
		[10]	

Q	Scheme	Marks	Notes
4(a)			NB three variants possible: both to right, both to the left or as diagram
	Conservation of momentum	M1	Dimensionally correct. All terms required. Condone sign errors
	$2mu-3mu=-2mv_P+mv_Q \quad \left(-u=-2v_P+v_Q\right)$	A1	Correct unsimplified equation
	Impact law	M1	Must be used the right way round. Condone sign errors.
	$4eu=v_P+v_Q$	A1	Correct unsimplified equation. Signs consistent with CLM equation
	Solve simultaneous equations for v_P or v_Q	DM1	Dependent on the 2 preceding M marks
	$v_P=\frac{u(1+4e)}{3}$	A1	One correct (must be positive) or equivalent
	$v_Q=\frac{u(8e-1)}{3}$	A1	Both correct (must be positive) or equivalent
		(7)	
4(b)	$\frac{u(1+4e)}{3}>0$	M1	Working from a correct inequality for their v_P
	Always true because $e\geq 0 \quad \left(\text{or } e>\frac{1}{8}\right)$	A1	Correct justification from correct work
		(2)	
4(c)	$e=\frac{3}{4} \Rightarrow v_Q=\frac{5u}{3}$	B1	Seen or implied
	Speed of Q after collision $=fv_Q$	M1	Impact law for collision with the wall
	To collide with P: $fv_2>v_1=\frac{4u}{3}$	M1	Correct inequality for second collision
	$1\geq f>\frac{4}{5}$	A1	Both limits required
		(4)	
		[13]	

Q	Scheme	Marks	Notes
5(a)	Moments about A	M1	or a complete method to form an equation in R and W
	$W \times 8b\cos\theta = R \times 12b$	A1	Correct unsimplified equation
	$R = \frac{2W}{3}\cos\theta = \frac{2W}{3} \times \frac{12}{13}$	DM1	Substitute correctly for trig and solve for R Dependent on preceding M1
	$R = \frac{8W}{13}$	A1	Allow $R = 0.615W$
		(4)	
5(b)	Resolve horizontally	M1	Form one equation in X and/or Y
	$(\rightarrow)\ X = R\sin\theta \left(= \frac{40W}{169} \right)$	A1	Correct unsimplified equation
	Resolve vertically	M1	Form a second equation in X and/or Y
	$(\uparrow)\ Y = W - R\cos\theta \left(= \frac{73W}{169} \right)$	A1	Correct unsimplified equation
	Parallel to rod: $W\sin\theta = X\cos\theta + Y\sin\theta$		
	Perpendicular: $R + Y\cos\theta = W\cos\theta + X\sin\theta$		
	$\tan\alpha = \frac{X}{Y}$	DM1	Use their X and Y to find $\tan\alpha$ Dependent on M marks for the two equations
	$\tan\alpha = \frac{40}{73}$ **Given answer**	A1	Obtain given answer from correct work
		(6)	
		[10]	

Q	Scheme	Marks	Notes
6(a)	$F = \frac{1000P}{10}$	M1	Use of $P = Fv$
	Equation of motion	M1	All terms required. Dimensionally correct. Accept separate equations for the car and the trailer.
	$F - 300g\sin\alpha - 800g\sin\alpha - 200 - 600 = 1100\times 0.5$	A1	Unsimplified equation(s) with at most one error
		A1	Correct unsimplified equation in F (or P)
	$P = 21.2$	A1	Accept 21. Max. 3 sf
		(5)	
6(b)	Work-energy equation for the trailer	M1	The Q requires work-energy. Equation for the trailer, with all terms dimensionally correct. Condone sign errors
	$200d = \frac{1}{2}.300.12^2 - 300dg\sin\alpha$	A1	Unsimplified equation with at most one error
		A1	Correct unsimplified equation
	Solve for d	DM1	Dependent on the previous M1
	$d = 52.7\ (\text{m})$ or $53\ (\text{m})$	A1	Max 3 sf
		(5)	
		[10]	

Q	Scheme	Marks	Notes
7(a)	Horizontal distance in terms of U, t and α	M1	
	$x = Ut\cos\alpha$	A1	Correct unsimplified equation
	Vertical distance in terms of U, t and α	M1	Condone sign error
	$y = Ut\sin\alpha - \frac{1}{2}gt^2$	A1	Correct unsimplified equation
	$y = U\sin\alpha\frac{x}{U\cos\alpha} - \frac{1}{2}g(\frac{x}{U\cos\alpha})^2$	DM1	Substitute for t Dependent on the first 2 M marks
	$y = x\tan\alpha - \frac{gx^2\sec^2\alpha}{2U^2}$	DM1	Simplify the trig. and use Pythagoras Dependent on the first 2 M marks
	$y = x\tan\alpha - \frac{gx^2(1+\tan^2\alpha)}{2U^2}$ given answer	A1	Obtain **given answer** from correct working
		(7)	
(b)	$(\rightarrow)\ v_H = U$	B1	Horizontal component in U, g, T
	$(\downarrow)\ v_V = gT$	B1	Vertical component in U, g, T. Accept $\pm$
	Use of Pythagoras	M1	
	$v = \sqrt{U^2 + g^2T^2}$	A1	Or equivalent. Allow t for T
		(4)	
(b) alt	$-h = d\tan 0 - \frac{gd^2}{2U^2}\left(1+\tan^2 0\right)$	B1	$\left(h = \frac{gd^2}{2U^2}\right)$
	$d = UT\ \left(\Rightarrow h = \frac{gT^2}{2}\right)$	B1	
	$\frac{1}{2}mv^2 - \frac{1}{2}mU^2 = mgh$	M1	Energy equation
	$v^2 = U^2 + 2gh = U^2 + g^2T^2$, $v = \sqrt{U^2 + g^2T^2}$	A1	
		(4)	
(c)	$d = UT$	B1	Horizontal distance
	$-h = d\tan\alpha - \frac{gd^2(1+\tan^2\alpha)}{2U^2}$	M1	Substitute for x and y in given equation. Condone sign error
	$h = \frac{1}{2}gT^2$	B1	Vertical distance
	$-\frac{1}{2}gT^2 = d\tan\alpha - \frac{g(UT)^2(1+\tan^2\alpha)}{2U^2}$	M1	Substitute to eliminate U from the equation
	$0 = d\tan\alpha - \frac{gT^2}{2}\tan^2\alpha$	A1	Correct equation in T and d
	$d = \frac{1}{2}gT^2\tan\alpha$ **given answer**	A1	Obtain given answer from correct working
		(6)	
		[17]	

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