Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Mechanics 2R
(6678/01R)

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the world's leading learning company. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information, please visit our website at www.edexcel.com.

Our website subject pages hold useful resources, support material and live feeds from our subject advisors giving you access to a portal of information. If you have any subject specific questions about this specification that require the help of a subject specialist, you may find our Ask The Expert email service helpful.

www.edexcel.com/contactus

Pearson: helping people progress, everywhere

Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

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.

PEARSON 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:

<u>'M' marks</u>
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

<u>'A' marks</u>
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

<u>'B' marks</u>
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General 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 $\sqrt{}$ 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. 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.

6. 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)
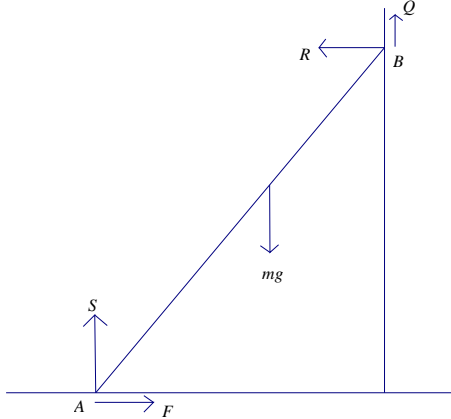
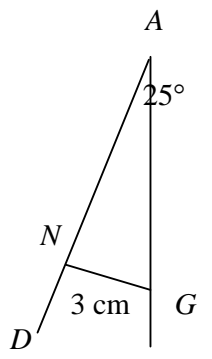 HL   Hooke's Law

  SHM   Simple harmonic motion

  PCLM   Principle of conservation of linear momentum

  RHS, LHS   Right hand side, left hand side.

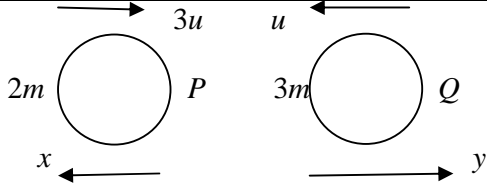| Question Number	Scheme	Marks	Notes
1. (a)	Tractive force $= \dfrac{25000}{20} = 1250$ N	B1	Seen or implied
	$1250 = R + 600g\sin\theta$	M1	Equation in R. Condone sign errors and sin/cos confusion
	$R = 1250 - 600g \times \dfrac{1}{16}\,(=882.5)$	A1ft	Correct unsimplified expression for R. Allow with their 1250
	$= 883$ or 880 N	A1　(4)	2 or 3 s.f. 882.5 is A0
(b)	$T\,F = \dfrac{30000}{20} = 1500$ N		
	$1500 - 600g \times \dfrac{1}{16} - R = 600a$	M1	Equation of motion. Must have all the terms. Condone sign errors and sin/cos confusion
		A2	-1 each error
	$a = \dfrac{1500 - 600 \times 9.8 \div 16 - 882.5}{600}\,(= 0.4166\ldots.)$		
	$= 0.42$ or 0.417 m s^{-1}	A1　(4)	2 or 3 s.f.　$\dfrac{5}{12}$ is A0
		[8]	
	882.5 and $\dfrac{5}{12}$ is A0 at the end of (a) and A1 at the end of (b) – penalise once only.		
	Use of 9.81 is an accuracy error – penalise at the end of the first part affected.		

Question Number	Scheme	Marks	Notes
2. (a)	$0.4\mathbf{u} + (-5\mathbf{i} + 3\mathbf{j}) = 0.4(12\mathbf{i} + 15\mathbf{j})$	M1 A1	Impulse-momentum equation. Requires all 3 terms. Must be dimensionally correct. Condone sign error(s). Correct unsimplified equation
	$\mathbf{u} = \dfrac{9.8\mathbf{i} + 3\mathbf{j}}{0.4} = 24.5\mathbf{i} + 7.5\mathbf{j}$		
	$\text{Speed} = \sqrt{24.5^2 + 7.5^2} = 25.6 \text{ m s}^{-1}$	M1 A1 (4)	Use of Pythagoras' theorem to find magnitude of their $\mathbf{u}$ 25.6 or better
(b)	$\tan^{-1}\left(\dfrac{15}{12}\right), \quad \tan^{-1}\left(\dfrac{7.5}{24.5}\right)$	M1 A1	Use trig. to find useful angles. Follow their $\mathbf{u}$ Correct unsimplified. (51.3° & 17.0°, 38.7° & 73°)
	$= 34.319...° \text{ or } 0.59899....\text{rad}$	A1 (3)	Combine correctly to find the required angle. 34°, 0.60 rads or better
		[7]	
Alt(b)	$\cos\theta = \dfrac{\begin{pmatrix} 24.5 \\ 7.5 \end{pmatrix} \boxdot \begin{pmatrix} 12 \\ 15 \end{pmatrix}}{\sqrt{24.5^2 + 7.5^2}\sqrt{12^2 + 15^2}}$	M1 A1	Use scalar product. Follow their $\mathbf{u}$ Correctly substituted.
	$\theta = 34.319...° \text{ or } 0.59899....\text{rad}$	A1	

Question Number	Scheme	Marks	Notes
3.			NB As the rod is not uniform, the use of moments equations is not helpful in part (a).
(a)	$R = F$	B1	Resolve horizontally
	$S + Q = mg$	B1	Resolve vertically (requires Q acting upwards)
	$Q = \dfrac{2}{3}R, \quad F = \dfrac{1}{4}S$	B1	Use both coefficients of friction
	$Q = \dfrac{2}{3}R = \dfrac{2}{3}\times\dfrac{1}{4}S, \qquad S + \dfrac{1}{6}S = mg, \ S = \dfrac{6}{7}mg$	M1	Solve to find S in terms of m & g. (Can be scored if Q is acting downwards)
		A1 (5)	
(b)	$\mathrm{M}(A) \ \ mg \times x\cos 60 = Q \times 2l\cos 60 + R \times 2l\sin 60$	M1	Moments equation – must include all terms. Condone sign errors and sin/cos confusion
	$\mathrm{M}(B) \ \ mg(2l - x)\cos 60 + F \times 2l\sin 60 = S \times 2l\cos 60$		
	M (c of m) $Sx\cos 60 = Fx\sin 60 + R(2l - x)\sin 60 + Q(2l - x)\cos 60$	A2	Correct unsimplified equation (for their S.) -1 each error
	$mgx\cos 60 = \dfrac{1}{6}\times\dfrac{6}{7}mg \times 2l\cos 60 + \dfrac{1}{4}\times\dfrac{6}{7}mg \times 2l\sin 60$	DM1	Form an equation in x. Depends on the preceding M
	$\dfrac{1}{2}x = \dfrac{1}{7}\times 2l\times\dfrac{1}{2} + \dfrac{3}{14}\times l\sqrt{3}$		
	$AG = x = 1.028.....l \ \ x = 1.03l$	A1 (5)	$1.03l$ or better $\dfrac{l\left(2 + 3\sqrt{3}\right)}{7}$

Question Number	Scheme	Marks	Notes
4. (a)	 $\quad\quad\quad\quad\quad\quad ABC \quad\quad\quad PQRS \quad\quad\quad Result$ Mass ratio $\quad\quad\quad 48 \quad\quad\quad\quad 16 \quad\quad\quad\quad 32$ Dist of c of m $\quad \dfrac{8}{3} \quad\quad\quad\quad 2 \quad\quad\quad\quad \overline{x}$ from AB $\quad\quad\quad 48 \times \dfrac{8}{3} - 16 \times 2 = 32\overline{x}$ $\quad\quad\quad \overline{x} = (8-2) \div 2 = 3 \ (\text{cm})$	 M1 A2 A1 (4)	 Take moments about AB. Must be subtracting the square from the triangle for mass & moments.. Correct unsimplified equation. -1 each error Could have a common factor of g.
(b)	 $\quad\quad\quad\quad\quad A$ $\quad\quad\quad\quad\quad$ 25° $\quad\quad N$ $\quad\quad\quad$ 3 cm $\quad$ G $\quad D$ $\tan 25 = \dfrac{\text{their } 3}{AN}$ or $\dfrac{AN}{\text{their } 3} = \tan 65$ Dist of G from $DC = \dfrac{3}{\tan 25} - 6$ $(-)\overline{y} = 2\left(\dfrac{\text{their } 3}{\tan 25} - 6 \right)$ $\quad\quad\quad$ Distance $= 0.867....$ cm		 $\quad\quad\quad\quad\quad\quad ABC \quad\quad\quad PQRS \quad\quad\quad Result$ Mass ratio $\quad\quad 48 \quad\quad\quad\quad 16 \quad\quad\quad\quad 32$ Dist of c of m $\quad 0 \quad\quad\quad\quad \overline{y} \quad\quad \dfrac{3}{\tan 25} - 6$ from DC
		M1 A1 M1 M1 A1ft A1 (6)	Use trig to find the distance AN. Condone tan the wrong way up Correct for their 3 Moments equation in $\overline{y}$ Correct unsimplified expression for $\overline{y}$ 0.87 or better – must be positive.
		[10]	

Question Number	Scheme	Marks	Notes
5. (a)	PE lost $= mgh = 2 \times 9.8 \times 5 \sin 30 = 49$ J	M1 A1 (2)	Condone sin/cos confusion Accept $5g$
(b)	$49 = \dfrac{1}{2} \times 2 \times 4^2 + F_r \times 5$ $F_r = 6.6$ N $N = 2g \cos 30$ $\mu = \dfrac{F_r}{N} = \dfrac{6.6}{2g \cos 30} = 0.389$ or 0.39	M1 A2 A1 B1 M1 A1 (7)	Must be using work-energy. Must be using 5 for distance. Allow with their 49. Condone sign error(s) -1 each error. Allow with their 49 Accept $\dfrac{5g-16}{5}$ 16.97 Use of $F = \mu N$ with their F & N 2 s.f. or 3 s.f. only
(c)	$49 = \dfrac{1}{2} \times 2 \times v^2 - \dfrac{1}{2} \times 2 \times 3^2 + F_r \times 5$ $49 + 9 - 33 = v^2$ $v = 5$ m s^{-1}	M1 A1 DM1 A1 (4)	Work Energy equation. All terms required, must be dimensionally correct but condone sign error(s) Correct equation for their F– any equivalent form. Substitute and solve for v. Dependent on preceding M1
Alt(c)	$2g \sin 30 - F = 2a$ $(a = 1.6)$ $v^2 = 9 + 2 \times a \times 5 (= 25)$ $v = 5$ m s^{-1} Watch out – there are a lot of incorrect ways of reaching a final answer of 5	M1 A1 DM1 A1 (4)	Using N2L with their F. Condone sign error Correct equation (with their F) Use of $v^2 = u^2 + 2as$ with their a. Dependent on preceding M1

Question Number	Scheme	Marks		Notes
6. (a)	$0 = \left(25\sin\alpha\right)^2 - 2gs$	M1		A complete method using *suvat* to find *s*
	$s = 400 \div 19.6 \quad (20.4)$	A1		Correct expression in *s* only
	Height above ground $= 10 + 400 \div 19.6 = 30$ or 30.4 m	A1	(3)	30 or 30.4 only
(b)	$10 = -25 \times \dfrac{4}{5}t + \dfrac{1}{2} \times gt^2$	M1		A complete method using *suvat* to find the total time from *A* to *B*. Condone sign slips.
		A1		Correctly substituted equation in *t*
	$4.9t^2 - 20t - 10 = 0 \qquad t = \dfrac{20 \pm \sqrt{400 + 4 \times 4.9 \times 10}}{2 \times 4.9}$	DM1		Dependent on the preceding M1. Solve for *t*
	$t = 4.531...$ s	A1		
	Horiz distance $= 25\cos\alpha t\left(= 15t \text{ m}\right)$	M1		
	$= 68$ m	A1	(6)	68 or 68.0 only
(c)	At *C* horiz speed $= 15 \text{ m s}^{-1}$			
	Vert speed $= \dfrac{15}{\tan\alpha}$	M1		Use similar triangles, or equivalent, to find vertical speed at C
	$= 11.25$	A1		
	$11.25 = -20 + gt$	DM1		Use *suvat* to find time from *A* to *C*. Dependent on the preceding M1
	$t = \dfrac{20 + 11.25}{9.8} = 3.2$ or 3.19	A1	(4)	3.2 or 3.19 only
		[13]		

Question Number	Scheme	Marks	Notes
7.			
(a)	$6mu - 3mu = 3my - 2mx$	M1	CLM Needs all the terms. Condone sign errors
	$3y - 2x = 3u$	A1	Correct equation
	$4ue = x + y$	M1	Impact law. Must be used the right way round.
		A1	Correct equation. Signs with x, y must be consistent with the CLM equation.
	$y = \dfrac{u}{5}(8e + 3)$ **	DM1	Dependent on the two preceding M marks
		A1 (6)	Obtain the **given result** correctly
	This is a given result – the candidate needs to show sufficient working to support the answer.		
(b)	$x = 4ue - y$	M1	Use one of their equations from (a) and $\pm$ the given y to find x.
	$x = \dfrac{1}{5}u(20e - 8e - 3) = \dfrac{3}{5}u(4e - 1)$	A1	Any equivalent form. Accept $\pm$
	$x > 0 \Rightarrow e > \dfrac{1}{4}$	M1	Use x > 0 to solve find values of e. The inequality must match their x.
	$\therefore \dfrac{1}{4} < e \leqslant 1$	A1 (4)	Need both limits.

Question Number	Scheme	Marks	Notes
(c)	$e = \dfrac{1}{2} \quad x = \dfrac{3u}{5} \quad y = \dfrac{u}{5}(4+3) = \dfrac{7u}{5}$	B1	Allow $x = -\dfrac{3u}{5}$
	$T = \dfrac{1}{2} \times 2m \times 9u^2 + \dfrac{1}{2} \times 3mu^2 \quad \left(= \dfrac{21mu^2}{2} \right)$	M1	KE before or KE after, in terms of u
	$kT = \dfrac{1}{2} \times 2m \times \dfrac{9u^2}{25} + \dfrac{1}{2} \times 3m \times \dfrac{49u^2}{25} \quad \left(= \dfrac{165mu^2}{50} \right)$	M1	Second KE in terms of u and use to find k.
	$k = \dfrac{\dfrac{1}{2} \times 2 \times \dfrac{9}{25} + \dfrac{1}{2} \times 3 \times \dfrac{49}{25}}{\dfrac{1}{2} \times 2 \times 9 + \dfrac{1}{2} \times 3} \quad \left(\text{or } \dfrac{165}{50} \div \dfrac{21}{2} \right) = \dfrac{11}{35}$	A1 (4)	Or equivalent. 0.314 or better
		[14]	