edexcel

Mark Scheme (Results)

June 2011

GCE Mechanics M4 (6680) Paper 1

Edexcel is one of the leading examining and awarding bodies in the UK and throughout the world. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers.

Through a network of UK and overseas offices, Edexcel's centres receive the support they need to help them deliver their education and training programmes to learners.

For further information, please call our GCE line on 0844 576 0025 or visit our website at www.edexcel.com.

If you have any subject specific questions about the content of this Mark Scheme that require the help of a subject specialist, you may find our **Ask The Expert** email service helpful.

Ask The Expert can be accessed online at the following link:
http://www.edexcel.com/Aboutus/contact-us/

June 2011
Publications Code UA028446

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.

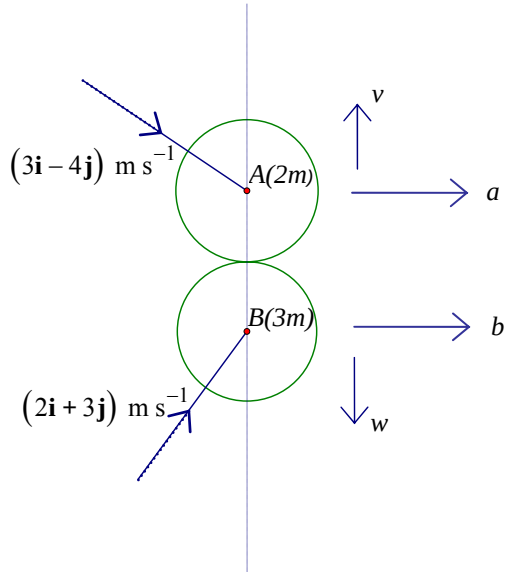
3. Abbreviations

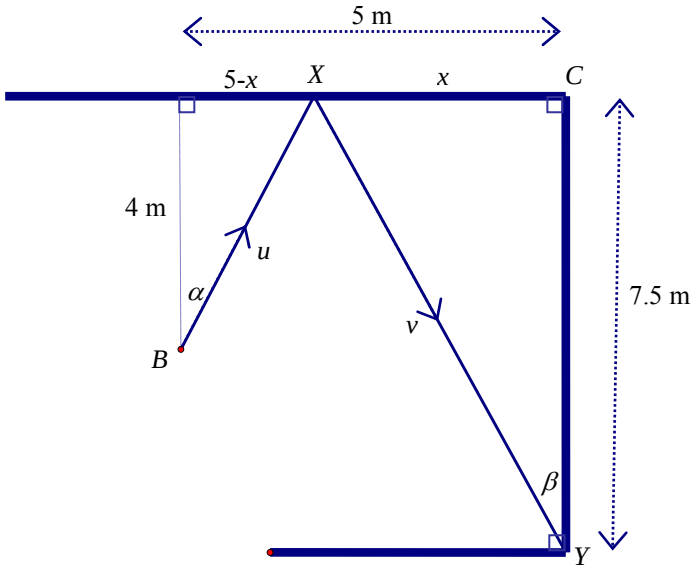
   These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

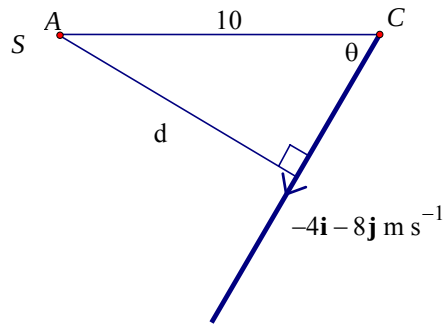
   - bod – benefit of doubt
   - ft – follow through
   - the symbol ^ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round 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

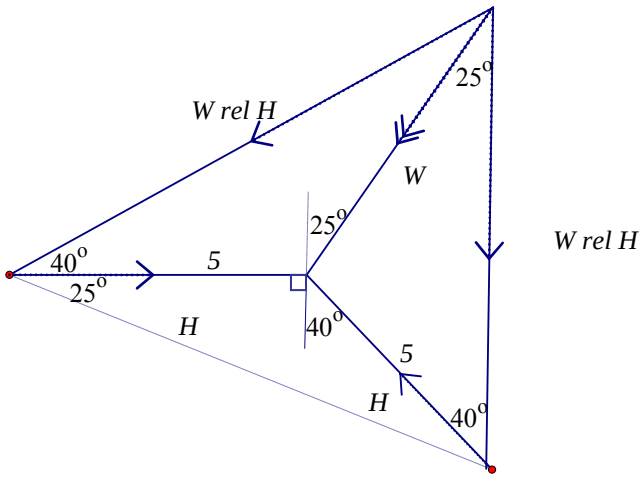
edexcel
advancing learning, changing lives

June 2011
6680 Mechanics M4
Mark Scheme

Question Number	Scheme	Marks
1.		
	$\leftrightarrow a=3$ & $b=2$	B1
	b Conservation of linear momentum : $-4\times2+3\times3=2v-3w\,(=1)$	M1A1
	Restitution : $v+w=\text{e}\times7\ (=3)$	M1A1
	Solve the simultaneous equations giving $v=2$ and $w=1$	DM1 A1
	KE lost $=\frac{1}{2}\times2m\times((16+9)-(4-9))+\frac{1}{2}\times3m\times((9+4)-(1-4))$	M1A1
	$=24m\ (\text{J})$	A1
		10

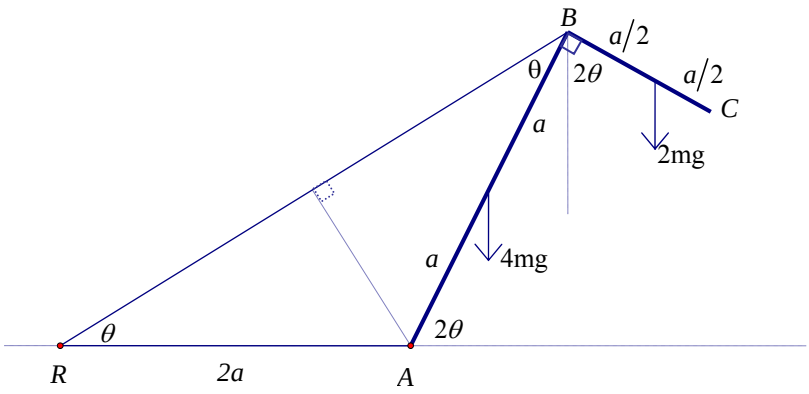
Question Number	Scheme	Marks
2.		
	At X: $\leftrightarrow\ u\sin\alpha = v\sin\beta$	M1A1
	$\updownarrow\ \ v\cos\beta = eu\cos\alpha$	M1A1
	$4v\cos\beta = 3u\cos\alpha$	
	Eliminate u & v by dividing: $\dfrac{\tan\alpha}{3} = \dfrac{\tan\beta}{4}$	M1
	Substitute for the trig ratios: $\dfrac{5-x}{3\times 4} = \dfrac{x}{4\times 7.5}$	DM1A1
	Solve for x: $37.5 - 7.5x = 3x$	DM1
	$x = 3.57\ (\text{m})$ or better, $\dfrac{25}{7}$	A1
		9
3. **(a)**	Velocity of C relative to S $= (8\mathbf{i} + u\mathbf{j}) - (12\mathbf{i} + 16\mathbf{j})$	M1
	$= (-4\mathbf{i} + (u-16)\mathbf{j})\ (\text{m s}^{-1})$	A1
		(2)
(b) (i)	C intercepts S $\Rightarrow$ relative velocity is parallel to **i**.	
	$\Rightarrow u - 16 = 0,\ u = 16$	M1A1
		(2)
(ii)	10 km at 4 km h^{-1} takes 2.5 hours, so 2.30pm	M1A1
		(2)

Question Number	Scheme	Marks
(c)	$u = 8$, relative velocity $= -4\mathbf{i} - 8\mathbf{j}$.	B1
		
	Correct distance identified	B1
	Using velocity: $\tan\theta = \frac{8}{4} = 2 \Rightarrow \sin\theta = \frac{2}{\sqrt{5}}$	
	Using distance: $\sin\theta = \frac{d}{10} = \frac{2}{\sqrt{5}}$,	M1A1
	$\mathrm{d} = \frac{20}{\sqrt{5}} = 4\sqrt{5} = 8.9\ (\mathrm{km})$	A1 (5)
		11

Question Number	Scheme	Marks
4. **(a)**	 2 vector triangles with a common side …..correct and drawn on a single diagram Wind is from bearing 025°, (N 25° E)	 M1 A1 A1 (3)
(b)	$\frac{5}{\sin 25^\circ} = \frac{W}{\sin 40^\circ}$ (ft on their 25°) $W = \frac{5 \times \sin 40^\circ}{\sin 25^\circ} = 7.6 \left(\text{km h}^{-1}\right)$	M1A1ft M1A1 (4)

Question Number	Scheme	Marks
5. **(a)**	Need an equation linking speed and displacement, so $mv\frac{dv}{dx} = -(a+bv^2)$ Separating the variables: $\int \frac{6v}{a+bv^2}dv = \int -1dx$ Integrating : $\frac{3}{b}\ln(a+bv^2) = -x + (C)$ $X = \frac{3}{b}\left[\ln(a+bU^2) - \ln(a)\right] = \frac{3}{b}\ln\left[1+\frac{bU^2}{a}\right]$ ** as required	M1A1 M1 A1 M1A1 (6)
(b)	Equation connecting v and t: $6\frac{dv}{dt} = -(12+3v^2)$ Separate the variables: $\int \frac{-6}{12+3v^2}dv = \int 1dt$ $\int_U^0 \frac{-2}{4+v^2}\mathrm{d}v = \int_0^U \frac{2}{4+v^2}\mathrm{d}v = T$ $T = \frac{2}{2}\tan^{-1}\frac{U}{2} = \tan^{-1}\frac{U}{2}(\mathrm{s})$	M1 M1, A1 M1 A1 (5) **11**

Question Number	Scheme	Marks
6. **(a)**	Using F = ma: $4\frac{d^2x}{dt^2} = -9x - 12v$ $= -9x - 12\frac{dx}{dt}$ Hence $4\frac{d^2x}{dt^2} + 12\frac{dx}{dt} + 9x = 0$ **	M1A1 M1 A1 (4)
(b)	Auxiliary eqn : $4m^2 + 12m + 9 = 0$, $(2m+3)^2 = 0, m = -3/2,\ \lambda = 3/2$ $t = 0, x = 4 \Rightarrow B = 4$ $t = 0,\ \dot{x} = e^{-\lambda t}\left(-\lambda(At + B) + A\right) = 0 \Rightarrow -6 + A = 0,\ A = 6$	B1 B1 B1 B1 (4)
(c)	$\dot{x} = e^{-\frac{3}{2}t}(-\frac{3}{2}(6t+4)+6) = -9te^{-\frac{3}{2}t}$ $\ddot{x} = e^{-\frac{3}{2}t}(-9-(-9t)\times\frac{3}{2})$, so acceleration = 0 when $t = 2/3$ at which time, $v = -6e^{-1}$, so max speed $= 6/e \approx 2.21$ m s^{-1} (3sf)	M1A1 M1 A1, A1 (5) **13**

Question Number	Scheme	Marks
7. **(a)**		
	$\text{BR} = 2\times 2a\cos\theta = 4a\cos\theta$	B1
	$\text{EPE} = 3mg\dfrac{(4a\cos\theta)^2}{2\times 2a}$	M1
	$= 12mga\cos^2\theta = 6mga + 6mga\cos 2\theta$	A1
	GPE: taking AR as the level of zero GPE, GPE = GPE of AB + GPE of BC $= 4mg\times a\sin 2\theta + 2mg\left(2a\sin 2\theta - a/2\cos 2\theta\right)$ $= 8mga\sin 2\theta - mga\cos 2\theta$	M1+M1 A1
	$\Rightarrow$ Total $V = 8mga\sin 2\theta + 5mga\cos 2\theta + \text{constant}$, as required. **	A1
		(7)
(b)	$\dfrac{dV}{d\theta} = 16mga\cos 2\theta - 10mga\sin 2\theta$	M1 A1
	$\dfrac{dV}{d\theta} = 0 \Rightarrow 10\sin 2\theta = 16\cos 2\theta$	M1
	$\Rightarrow \tan 2\theta = \dfrac{8}{5} \Rightarrow \theta = 0.51$ radians (29.0°)	A1
		(4)
	Or: $8mga\sin 2\theta + 5mga\cos 2\theta = \sqrt{89}mga\cos(2\theta - \alpha)$, $\tan\alpha = \dfrac{8}{5}$	M1A1
	t. pts when $2\theta - \alpha = n\pi \Rightarrow \theta = 0.51$ rads.	M1A1
(c)	$\dfrac{d^2V}{d\theta^2} = -32mga\sin 2\theta - 20mga\cos 2\theta$	M1
	$\theta = 0.51 \Rightarrow \dfrac{\mathrm{d}^2V}{\mathrm{d}\theta^2} < 0$, equilibrium is unstable. cso	M1A1
		(3) **14**
	Or: $2\theta - \alpha = 0 \Rightarrow \cos(2\theta - \alpha) = 1$ Max value $\Rightarrow$ equilibrium is unstable	

Further copies of this publication are available from
Edexcel Publications, Adamsway, Mansfield, Notts, NG18 4FN

Telephone 01623 467467
Fax 01623 450481
Email publication.orders@edexcel.com
Order Code UA028446 June 2011

For more information on Edexcel qualifications, please visit
www.edexcel.com/quals

Pearson Education Limited. Registered company number 872828
with its registered office at Edinburgh Gate, Harlow, Essex CM20 2JE