EDEXCEL FOUNDATION

Stewart House 32 Russell Square London WC1B 5DN

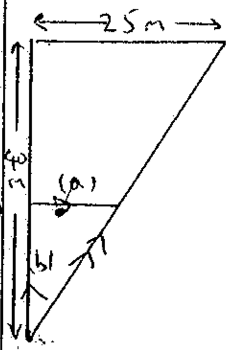
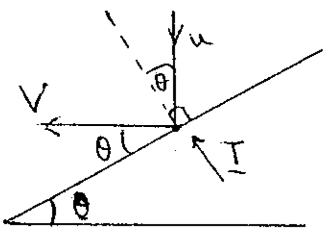
January 2002

Advanced Subsidiary /Advanced Level

General Certificate of Education

Subject **MECHANICS 6680**

Paper No. **M4**

Question number	Scheme	Marks	
1. (a)	 Complete method for speed of current	M1	
	e.g $= \frac{25\text{m}}{30\text{s}}$ or find V(1.57), θ(32°) and use $V\sin\theta$ or equiv.		
	$= \frac{5}{6}$ ms^{-1} or 0.83(3) ms^{-1}	A1	(2)
(b)	Complete method for speed of swimmer	M1	
	e.g. $= \frac{40\text{m}}{30\text{s}}$ or $\sqrt{\{V^2 - (a)^2\}}$ or $V_c \sin\theta_c$		
	$= \frac{4}{3}$ ms^{-1} or 1.3(3) ms^{-1}	A1	(2)
2.	Equation of motion: $-mg - mkv = ma$; $\frac{dv}{dt} = -(g + kv)$	M1;A1	
	Separating variables: $\int dt = -\int \frac{dv}{g+kv}$	M1	
	Integrating $t = (-)\frac{1}{k}[\ln(g+kv)]$ (+c)	A1	
	Using limits to give $T = \frac{1}{k}[\ln(g+kv)]_0^u$ or using limits [t=0,v=u]to find c:	M1A1√	
	Completing to give $T = \frac{1}{k}\ln(\frac{g+ku}{g})$	M1A1	(8)
	[Mark finding greatest height as Mr]		
3. (a)	 Parallel to plane: $u\sin\theta = V\cos\theta$	M1A1	
	Perpendicular to plane: $eu\cos\theta = V\sin\theta$	M1A1	
	Eliminating u and V: $e\cot\theta = \tan\theta$	M1	
	Given result: $e = \tan^2\theta$ *	A1	(6)
(b)	Impulse = change in momentum $= m(V\sin\theta + u\cos\theta)$	M1A1	
	Expression in m, u and θ: $= m(eu\cos\theta + u\cos\theta) = mu\cos\theta(1 + \tan^2\theta)$	M1	
	or $= mu\left(\frac{\sin^2\theta}{\cos\theta} + \cos\theta\right)$		
	Completion $= mu\sec\theta$ *	A1	(4)

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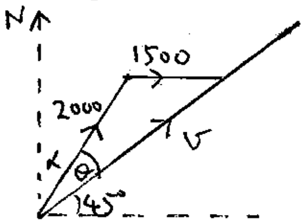
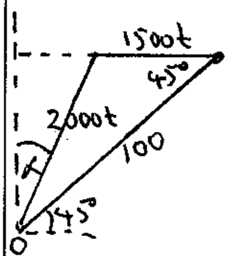
4. (a)	*Using velocity diagram* $\dfrac{\sin\theta}{1500} = \dfrac{\sin 45°}{2000}$	M1A1
		
	$\theta = 32°$ (32.03)	M1A1
	Bearing $= 90° - (45° + \theta) = 013°$	M1A1 (6)
(b)	Method for v: e.g. (i) $v^2 = 1500^2 + 2000^2 - 2.1500.2000.\cos(90 + 13_c)°$	M1A1√
	or (ii) $v\cos 45° = 2000\cos 13_c°$	
	or (iii) $\dfrac{\sin 45°}{2000} = \dfrac{\sin 103°}{v}$	
	$v = 2756$ km h^{-1}	A1
	Time $= \dfrac{100}{v}$ h $= 131$ *s*	M1A1 (5)
	[Time $= \dfrac{100\cos 45°}{2000\cos 13_c°}$ gains M1M1A1 immediately, correct answer gains A2]	
	Using displacement method (several variations)	
	(i) In the case below α is bearing; but other relevant angle may be used	
		
	One equation in t and α: e.g. $2000\,t\sin\alpha = 50\sqrt{2} - 1500\,t$	M1A1
	Second equation in t and α: e.g. $2000\,t\cos\alpha = 50\sqrt{2}$	M1A1
	Equation in one variable: e.g. $4\cos\alpha - 4\sin\alpha = 3$	M1A1
	Reducing to simple equation e.g. $4\sqrt{2}\cos(\alpha + 45°) = 3$	M1A1√
	Bearing = (0)13°	A1
	Sustituting for α to find t; $t = 131$ *s*	M1A1
	(ii) Using cosine rule: $(2000t)^2 = (1500t)^2 + 100^2 - 2.100.1500t\cos 45°$	M2A1A1
	Quadratic form: $175t^2 + 15\sqrt{2}\,t - 1 = 0$	M1A1 √
	Solving : $t = 131s$	M1A1
	Equation in t and α	M1A1
	Bearing = (0)13°	A1

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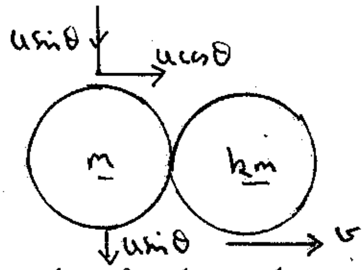
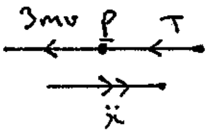
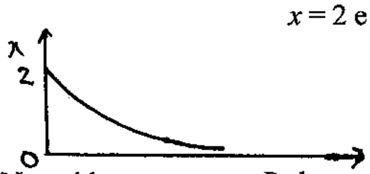
Question number	Scheme	Marks	
5. **(a)**	 CLM: $mu\cos\theta = kmv$	M1 A1	
	NIL: $eu\cos\theta = v$	M1 A1	
	Eliminating θ,	M1	
	$e = \frac{1}{k}$ *	A1	(6)
(b)	$\frac{1}{2}m v_a^2 + \frac{1}{2}(2m)(\frac{1}{2}u\cos\theta)^2 = \frac{3}{4}.\frac{1}{2}mu^2$ (or equivalent)	M1 A1	
	$\frac{1}{2}m(u\sin\theta)^2 + \frac{1}{2}(2m)(\frac{1}{2}u\cos\theta)^2 = \frac{3}{4}.\frac{1}{2}mu^2$ [M1 for $v_a = u\sin\theta$]	M1 A1√	
	$[4\sin^2\theta + 2\cos^2\theta = 3]$		
	$4\sin^2\theta + 2(1-\sin^2\theta) = 3$	M1	
	$\sin^2\theta = \frac{1}{2}$		
	$\theta = 45°$	A1	(6)
	[$\frac{1}{2}m(u\cos\theta)^2 - \frac{1}{2}(2m)(\frac{1}{2}u\cos\theta)^2 = \frac{1}{4}\frac{1}{2}mu^2$ accepted for first 4 marks unless it is clear that candidate is working along line of centres only; e.g. $\frac{1}{2}m(u\cos\theta)^2 - \frac{1}{2}(2m)(\frac{1}{2}u\cos\theta)^2 = \frac{1}{4}\frac{1}{2}m(u\cos\theta)^2$, then max M1]		
6. **(a)**	 $T = \frac{2mL}{L}x$	B1	
	Equation of motion: $-3m\dot{x} - T = m\ddot{x}$	M1 A1	
	$\Rightarrow \ddot{x} + 3\dot{x} + 2x = 0$ *	A1 (cso)	(4)
(b)	A.E. $m^2 + 3m + 2 = 0 \quad \Rightarrow \quad m = -1$ or -2	M1 A1	
	G.S. $x = Ae^{-t} + Be^{-2t}$	A1√	
	$t = 0, x = 2: \quad \Rightarrow \quad A + B = 2$	B1	
	Differentiating $\dot{x} = -Ae^{-t} - 2Be^{-2t}$	M1	
	$t = 0, \dot{x} = -4: \quad \Rightarrow \quad A + 2B = 4$ (any equivalent form)	A1	
	Correctly solving simultaneous equations ($A = 0$, $B = 2$)	M1	
	$x = 2e^{-2t}$	A1	(8)
(c)	 Shape	B1√	
	(0,2), $x = 0$ asymptote Totally correct	B1	(2)
(d)	No, with reason, e.g. P always moving	B1	(1)

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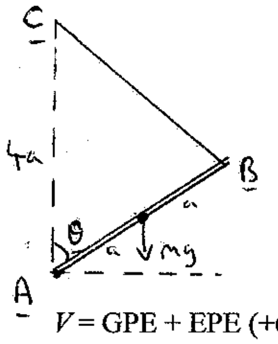
7. (a)			
	GPE: (from a fixed point) e.g. $mga\cos\theta$ (+C)	M1	
	EPE: $\frac{1}{2}mg\frac{(\text{ext})^2}{4a}$	B1	
	$BC^2 = (4a)^2 + (2a)^2 - 2.4a.2a.\cos\theta = 20a^2 - 16a^2\cos\theta$	M1 A1	
	$\Rightarrow$ EPE $= \frac{1}{2}mga[5 - 4\cos\theta - 2\{\sqrt{(5-4\cos\theta)}\} + 1]$	M1 A1	
	V = GPE + EPE (+C) applied	M1	
	$= mga\{-\cos\theta - \sqrt{(5-4\cos\theta)} + 3\} + C$ ($\sqrt{}$ dep. on all Ms)	A1$\sqrt{}$	
	$= mga\{-\cos\theta - \sqrt{(5-4\cos\theta)}\}$ + constant * (no errors seen)	A1	(9)
(b)	$\frac{dV}{d\theta} = mga\left\{\sin\theta - \frac{4\sin\theta}{2\sqrt{5-4\cos\theta}}\right\}$	M1A1	
	$\frac{dV}{d\theta} = 0$; $[\sin\theta\{\sqrt{(5-4\cos\theta)} - 2\} = 0]$	M1	
	$\Rightarrow \sin\theta = 0$ or $\sqrt{(5-4\cos\theta)} = 2$		
	$\Rightarrow \theta = 0$ or π (0° or 180°)	A1	
	$\Rightarrow$ or $\theta = \cos^{-1}(\frac{1}{4}) = 1.32$ (75.5°)	M1A1	(6)