

**Mark Scheme 4730  
January 2007**

1		M1	For using the principle of conservation of energy
	$\frac{1}{2} 0.6 \times 5^2 - \frac{1}{2} 0.6 v^2 = 0.6g(2 \times 0.4)$ [ $v^2 = 9.32$ ]	A1	
	[ $T + 0.6g = 0.6a$ ]	M1	For using Newton's second law
	[ $a = 9.32/0.4$ ]	M1	For using $a = v^2/r$
	T + 0.6g = 0.6x9.32/0.4 Tension is 8.1N	A1ft A1	ft incorrect energy equation
			6

2	$28\cos 30^\circ - 10\cos 30^\circ$ [ $=  \Delta v_H  = (I/m)\cos \theta$ ]	B1	
	$10\sin 30^\circ + 28\sin 30^\circ$ [ $=  \Delta v_V  = (I/m)\sin \theta$ ]	B1	
	[ $X = -I\cos \theta = -0.8885$ , $Y = I\sin \theta = 1.083$ ]	M1	For using $mv$ change for component or resultant
		M1	For using $I^2 = X^2 + Y^2$
	I = 1.40	A1	
	[ $\tan \theta = 1.083/0.8885$ or $19/15.588..$ ]	M1	For using $\theta = \tan^{-1}(Y/-X)$ or $\tan^{-1}( \Delta v_V  /  \Delta v_H )$
$\theta = 50.6$	A1		7

<b>ALTERNATIVELY</b>			
2		M1	For using cosine rule in correct triangle
	$(I/m)^2 = 28^2 + 10^2 - 2 \times 28 \times 10 \cos 60^\circ$ [ $=604$ ]	A1	
	[ $I = 0.057 \sqrt{604}$ ]	M1	For using $I = mv$ change
	I = 1.40	A1	
		M1	For using sine rule in correct triangle
	$(I/m)/\sin 60^\circ = 10/\sin(\theta - 30^\circ)$ or $28/\sin(150^\circ - \theta)$	A1	
$\theta = 50.6$	A1		7

3	(i)	$160a = 2aY$	M1		For taking moments for AB about B
		Component at B is 80N	A1		
		Component at C is 240N	B1ft	3	ft 160 + Y
	(ii)		M1		For taking moments for BC about B or C (and using X = F) or for whole about A
		$160a \cos 60^\circ + 2aF \sin 60^\circ = 240 \times 2a \cos 60^\circ$	A1ft		
		or			
		$80 \times 2a \cos 60^\circ + 160a \cos 60^\circ = 2aX \sin 60^\circ$			
		or			
		$240(2 + 2 \cos 60^\circ)a = 160a + 160(2 + \cos 60^\circ)a + 2aF \sin 60^\circ$			
		Frictional force is 92.4N	A1		
	Direction is to the left	B1	4		
(iii)	[92.4/240]	M1		For using $F = \mu R$	
	Coefficient is 0.385	A1ft	2		
4	(i)		M1		For using $T = mg$ and $T = \lambda e/L$
		$3.5e/0.7 = 0.2g$	A1		
		[e = 0.392]			
		Position is 1.092m below O.	A1	3	AG
	(ii)		M1		For using Newton's second law
		$0.2g - 3.5(0.392 + x)/0.7 = 0.2a$	A1ft		ft incorrect e
		a = -25x	A1ft		ft incorrect e
		[ $25A^2 = 1.6^2$ or	M1		For using $A^2 n^2 = v_{\max}^2$ or
		$\frac{1}{2}(0.2)1.6^2 + 3.5x(0.392^2)/(2 \times 0.7) + 0.2gA$			Energy at lowest point =
		$= 3.5x(0.392 + A^2)/(2 \times 0.7)$			energy at equilibrium point (4 terms needed including 2 EE terms)
	Amplitude is 0.32m	A1ft	5		
(iii)	[x = 0.32sin $2^\circ$ ]	M1		For using $x = A \sin nt$ or $A \cos(\pi/2 - nt)$	
	x = 0.291	A1			
	[v = 0.32x5cos $2^\circ$ or $v^2 = 25(0.32^2 - 0.291^2)$	M1		For using $v = A \cos nt$ or $v^2 = n^2(A^2 - x^2)$ or	
	or			Energy at equilibrium point =	
	$0.256 + 0.38416 + 0.2g(0.291)$			energy at x = 0.291	
	$= \frac{1}{2} 0.2v^2 + 2.5(0.683)^2$				
	$v^2 = 0.443$	A1		May be implied	
	v = -0.666 (or 0.666 upwards)	A1	5		

5	(i)	$[mg - mkv^2 = ma]$	M1		For using Newton's second law
		$(v \, dv/dx)/(g - kv^2) = 1$	A1	2	AG
	(ii)	$[-\frac{1}{2} [\ln(g - kv^2)]/k = x + C]$	M1		For separating variables and attempting to integrate
		$[-(\ln g) / 2k = C]$	M1		For using $v(0) = 0$ to find C
		$x = [-\frac{1}{2} [\ln\{(g - kv^2)/g\}]/k]$	A1		Any equivalent expression for x
		$[\ln\{(g - kv^2)/g\} = \ln(e^{-2kx})]$	M1		For expressing in the form $\ln f(v^2) = \ln g(x)$ or equivalent
		$v^2 = (1 - e^{-2kx})g/k$	A1		
			M1		For using $e^{-Ax} \rightarrow 0$ for +ve A
		Limiting value is $\sqrt{g/k}$	A1ft	7	AG
	(iii)	$[1 - e^{-600k} = 0.81]$	M1		For using $v^2(300) = 0.9^2 g/k$
	$[-600k = \ln(0.19)]$	M1		For using logarithms to solve for k	
	$k = 0.00277$	A1	3		
6	(i)	$[u \sin 30^\circ = 3]$	M1		For momentum equation for B, normal to line of centres
		$u = 6$	A1	2	
	(ii)	$[4\sin 88.1^\circ = v \sin 45^\circ]$	M1		For momentum equation for A, normal to line of centres
		$v = 5.65$	A1		
			M1		For momentum equation along line of centres
		$0.4(4\cos 88.1^\circ) - mu \cos 30^\circ = -0.4v \cos 45^\circ$	A1		
		$m = 0.318$	A1	5	
	(iii)		M1		For using NEL
		$0.75(4\cos \theta + u \cos 30^\circ) = v \cos 45^\circ$	A1		
		$4\sin \theta = v \sin 45^\circ$	B1		
	$[3\cos \theta + 4.5\cos 30^\circ = 4\sin \theta]$	M1		For eliminating v	
	$8\sin \theta - 6\cos \theta = 9\cos 30^\circ$	A1	5	AG	
7	(i)(a)	Extension = $1.2\alpha - 0.6$	B1		
		$[T = mg \sin \alpha]$	M1		For resolving forces tangentially
		$0.5 \times 9.8 \sin \alpha = 6.86(1.2\alpha - 0.6)/0.6$	A1ft		
		$\sin \alpha = 2.8\alpha - 1.4$	A1	4	AG
	(i)(b)	$[0.8, 0.756.., 0.745.., 0.742.., 0.741.., 0.741.., ]$	M1		For attempting to find $\alpha_2$ and $\alpha_3$
		$\alpha = 0.74$	A1	2	
	(ii)	$\Delta h = 1.2(\cos 0.5 - \cos 0.8)$	B1		
		$[0.217..]$			
		$[0.5 \times 9.8 \times 0.217.. = 1.06355..]$	M1		For using $\Delta(\text{PE}) = mg \Delta h$
		$[6.86(1.2 \times 0.8 - 0.6)/(2 \times 0.6) = 0.74088]$	M1		For using $EE = \lambda x^2/2L$
		M1		For using the principle of conservation of energy	
	$\frac{1}{2} 0.5v^2 = 1.06355.. - 0.74088$	A1		Any correct equation for $v^2$	
	Speed is $1.14 \text{ms}^{-1}$	A1			
	Speed is decreasing	B1ft	7		