Mark Scheme 4730
January 2007

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

2	$28\cos30^o - 10\cos30^o$ [$= \lvert\Delta v_H\rvert = (I/m)\cos\theta$]	B1		
	$10\sin30^o + 28\sin30^o$ [$= \lvert\Delta v_V\rvert = (I/m)\sin\theta$]	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 $\tan^{-1}(\lvert\Delta v_V\rvert / \lvert\Delta v_H\rvert)$
	$\theta = 50.6$	A1	7	

	ALTERNATIVELY			
2		M1		For using cosine rule in correct triangle
	$(I/m)^2 = 28^2 + 10^2 - 2\text{x}28\text{x}10\cos60^o$ [=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
	$(I/m)/\sin60^o = 10/\sin(\theta - 30^o)$ or $28/\sin(150^o - \theta)$	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
	$160a\cos60^o + 2aF\sin60^o = 240 \times 2a\cos60^o$ or $80 \times 2a\cos60^o + 160a\cos60^o = 2aX\sin60^o$ or $240(2 + 2\cos60^o)a = 160a + 160(2 + \cos60^o)a + 2aF\sin60^o$	A1ft		
	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 $T = \lambda e/L$
	$3.5e/0/7 = 0.2g$ [e = 0.392]	A1		
	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 $\frac{1}{2}(0.2)1.6^2 + 3.5 \times 0.392^2/(2 \times 0.7) + 0.2gA = 3.5 \times (0.392 + A)^2/(2 \times 0.7)$	M1		For using $A^2n^2 = v_{max}^2$ or Energy at lowest point = energy at equilibrium point (4 terms needed including 2 EE terms)
	Amplitude is 0.32m	A1ft	5	
	(iii) $[x = 0.32\sin2^c]$	M1		For using x = Asin nt or $A\cos(\pi/2 - nt)$
	x = 0.291	A1		
	$[v = 0.32 \times 5\cos2^c$ or $v^2 = 25(0.32^2 - 0.291^2)$ or $0.256 + 0.38416 + 0.2g(0.291) = \frac{1}{2}0.2v^2 + 2.5(0.683)^2$	M1		For using v = Ancos nt or $v^2 = n^2(A^2 - x^2)$ or Energy at equilibrium point = energy at x = 0.291
	$v^2 = 0.443$	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)	$[-\frac{1}{2}[\ln(g - kv^2)]/k = x \quad (+C)]$	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)	$[u \sin 30^o = 3]$	M1		For momentum equation for B, normal to line of centres
		u = 6	A1	2	
	(ii)	$[4\sin 88.1^o = v \sin 45^o]$	M1		For momentum equation for A, normal to line of centres
		v = 5.65	A1		
			M1		For momentum equation along line of centres
		$0.4(4\cos 88.1^o) - mu\cos 30^o = -0.4v\cos 45^o$	A1		
		m = 0.318	A1	5	
	(iii)		M1		For using NEL
		$0.75(4\cos\theta + u\cos 30^o) = v\cos 45^o$	A1		
		$4\sin\theta = v\sin 45^o$	B1		
		$[3\cos\theta + 4.5\cos 30^o = 4\sin\theta]$	M1		For eliminating v
		$8\sin\theta - 6\cos\theta = 9\cos 30^o$	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 α_2 and α_3
		$\alpha = 0.74$	A1	2	
	(ii)	$\Delta h = 1.2(\cos 0.5 - \cos 0.8)$ [0.217…]	B1		
		[0.5x9.8x0.217.. = 1.06355..]	M1		For using $\Delta(PE) = mg\Delta h$
		$[6.86(1.2 \times 0.8 - 0.6)^2/(2 \times 0.6) = 0.74088]$	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 $1.14 ms^{-1}$	A1		
		Speed is decreasing	B1ft	7	