Mark Scheme 4730
June 2006

1	(i)		M1		For using I = Δ(mv) in the direction of the original motion (or equivalent from use of relevant vector diagram).
		$20\cos\theta = 0.4 \times 25$	A1		
		Direction at angle 120^o to original motion	A1	3	Accept $\theta = 60^o$ with θ correctly identified.
	(ii)		M1		For using I = Δ(mv) perp. to direction of the original motion (or equivalent from use of relevant vector diagram).
		$20\sin60^o = 0.4v$	A1ft		
		Speed is 43.3 ms^{-1}	A1	3	
2			M1		For applying Newton's 2^{nd} Law.
			M1		For using a = v(dv/dx).
		$2v(dv/dx) = -(2v + 3v^2)$	A1		
			M1		For separating variables and attempting to integrate.
		$2/3\ln(2 + 3v) = -x$ (+C)	A1ft		ft absence of minus sign,
		[$2/3\ln14 = C$]	M1		For using v(0) = 4.
		[$2/3\ln2 = -x + 2/3\ln14$]	M1		For attempting to solve v(x) = 0 for x.
		Comes to rest after travelling 1.30m	A1	8	AG

3	**(i)**		M1		For taking moments about C for the whole structure.
		1.4R = 0.35x360 + 1.05x200	A1		
		Magnitude is 240N	A1		AG
			M1		For taking moments about A for the rod AB.
		0.7x240 = 0.35x200 + 1.05T	A1		
		Tension is 93.3N	A1	6	
	OR (i)		M1		For taking moments about A for AB and AC.
		$0.7R_B = 70 + 1.05T$ and $0.7R_C = 126 + 1.05T$	A1		
			M1		For eliminating T or for adding the equations, and then using $R_B + R_C = 560$.
		$0.7(560 – R_B) – 0.7R_B = 126 – 70$ or $0.7 \times 560 = 70 + 126 + 2.1T$	A1		For a correct equation in R_B only or T only
		Magnitude is 240N	A1		AG
		Tension is 93.3N	A1	6	
	(ii)	Horizontal component is 93.3 N to the left	B1ft		
		Y = 240 - 200	M1		For resolving forces vertically.
		Vertical component is 40 N downwards	A1	3	

4	**(i)**		M1		For using Newton's 2nd Law perp. to string with a = L$\ddot{\theta}$.
		L(m)$\ddot{\theta}$ = -(m)gsinθ or (m)$\ddot{s}$ = -(m)gsin(s/L)	A1		
		$\ddot{\theta} \approx$ -kθ or $\ddot{s}$ = -ks [and motion is therefore approx. simple harmonic]	B1		
			M1		For using T = 2π/n and k = w^2 or T = $2\pi\sqrt{L/g}$ for simple pendulum.
		Period is 3.14s.	A1	5	AG
	(ii)		M1		For using $\dot{\theta}^2 = n^2(\theta_0{}^2 - \theta^2)$ or the principle of conservation of energy
		$\dot{\theta}^2$ =4(0.1^2 – 0.06^2) or ½ m(2.45$\dot{\theta}$)^2 = 2.45mg(cos0.06 – cos0.1)	A1		
		Angular speed is 0.16 rad s^{-1}.	A1	3	(0.1599… from energy method)
	OR	(in the case for which (iii) is attempted before (ii))			
	(ii)	[$\dot{\theta}$= -0.2sin2t]	M1		For using $\dot{\theta}$= d(Acos nt)/dt
		$\dot{\theta}$= -0.2sin(2x0.464)	A1ft		
		Angular speed is 0.16 rad s^{-1}.	A1	3	
	(iii)		M1		For using θ= Acos nt or Asin(π/2 – nt) or for using θ= Asin nt and T =$t_{0.1} - t_{0.06}$
		0.06 = 0.1cos2t or 0.1sin(π/2 – 2t) or 2T = π/2 – sin^{-1}0.6	A1ft		ft angular displacement of 0.04 instead of 0.06
		Time taken is 0.464s	A1	3	

5			M1		Σmv conserved in **i** direction.
		2x12cos60^o – 3x8 = 2a + 3b	A1		
			M1		For using NEL
		For LHS of equation below	A1		
		0.5(12cos60^o + 8) = b - a	A1		Complete equation with signs of a and b consistent with previous equation.
			M1		For eliminating a or b.
		Speed of B is 0.4ms^{-1} in **i** direction	A1		
		a = -6.6	A1		
		Component of A's velocity in **j** direction is 12sin60^o	B1		May be shown on diagram or implied in subsequent work.
		Speed of A is 12.3ms^{-1}	B1ft		
			M1		For using θ = tan^{-1}(**j**comp/$\pm$ **i** comp)
		Direction is at 122.4^o to the **i** direction	A1ft	12	Accept θ = 57.6^o with θ correctly identified.
6	**(i)**	T = 1470x/30	B1		
		[49x = 70x9.8]	M1		For using T = mg
		x = 14	A1		
		Distance fallen is 44m	A1ft	4	
	(ii)	PE loss = 70g(30 + 14)	B1ft		
		EE gain = 1470x14^2/(2x30)	B1ft		
		[½ 70v^2 = 30184 – 4802]	M1		For a linear equation with terms representing KE, PE and EE changes.
		Speed is 26.9ms^{-1}	A1	4	AG
	OR (ii)	[0.5 v^2 = 14g – 68.6 + 30g]	M1		For using Newton's 2nd law (vdv/dx = g – 0.7x), integrating (0.5 v^2 = gx – 0.35x^2 + k), using v(0)^2 = 60g➔ k = 30g, and substituting x = 14.
		For 14g + 30g	B1ft		
		For $\mp$68.6	B1ft		Accept in unsimplified form.
		Speed is 26.9ms^{-1}	A1	4	AG
	(iii)	PE loss = 70g(30 + x)	B1ft		
		EE gain = 1470x^2/(2x30)	B1ft		
		[x^2 – 28x – 840 = 0]	M1		For using PE loss = KE gain to obtain a 3 term quadratic equation.
		Extension is 46.2m	A1	4	
	OR (iii)		M1		For identifying SHM with n^2 = 1470/(70x30)
			M1		For using v_{max} = An
		$A = 26.9/\sqrt{0.7}$	A1		
		Extension is 46.2m	A1	4	

7	**(i)**	$\frac{1}{2}\,0.3v^2 + \frac{1}{2}\,0.4v^2$	B1		
		$\pm 0.3g(0.6\sin\theta)$	B1		
		$\pm 0.4g(0.6\theta)$	B1		
		$[0.35v^2 = 2.352\theta - 1.764\sin\theta]$	M1		For using the principle of conservation of energy.
		$v^2 = 6.72\theta - 5.04\sin\theta$	A1	5	AG
	(ii)		M1		For applying Newton's 2nd Law radially to P and using $a = v^2/r$
		$0.3(v^2/0.6) = 0.3g\sin\theta - R$	A1		
		$[\frac{1}{2}(6.72\theta - 5.04\sin\theta) =$ $0.3g\sin\theta - R]$	M1		For substituting for v^2.
		Magnitude is $(5.46\sin\theta - 3.36\theta)$N	A1		AG
		$[5.46\cos\theta - 3.36 = 0]$	M1		For using $dR/d\theta = 0$
		Value of θ is 0.908	A1	6	
	(iii)	$[T - 0.3g\cos\theta = 0.3a]$	M1		For applying Newton's 2nd Law tangentially to P
		$[0.4g - T = 0.4a]$	M1		For applying Newton's 2nd Law to Q [If $0.4g - 0.3g\cos\theta = 0.3a$ is seen, assume this derives from $T - 0.3g\cos\theta = 0.3a$ ……. M1 and $T = 0.4g$ ……. M0]
		Component is $5.6 - 4.2\cos\theta$	A1	3	
	OR (iii)	$0.4g - 0.3g\cos\theta = (0.3 + 0.4)a$	B2		
		Component is $5.6 - 4.2\cos\theta$	B1	3	
	OR (iii)	$[2v(dv/d\theta) = 6.72 - 5.04\cos\theta]$	M1		For differentiating v^2 (from (i)) w.r.t. θ
		$2(0.6a) = 6.72 - 5.04\cos\theta$	M1		For using $v(dv/d\theta) = ar$
		Component is $5.6 - 4.2\cos\theta$	A1	3	