Question	Answer	Marks	Notes
1(i)	$(4 = 5r)$ $r = 0.8$ m	**B1**	Uses $v = r\omega$
	Total:	**1**	
1(ii)	$T = 0.2 \times 5^2 \times 0.8$	**M1**	Uses Newton's Second Law horizontally
	$T = 4$ N	**A1 FT**	FT with their radius from part (i)
	$4 = \lambda(0.8 - 0.6) / 0.6$	**M1**	Uses $T = \lambda x / L$
	$\lambda = 12$	**A1**	
	Total:	**4**	
2(i)	$6\cos60 = 4\cos60 + mg$	**M1**	Resolve vertically
	$m = 0.1$ kg	**A1**	
	Total:	**2**	
2(ii)	radius $= 0.7\sin60$	**B1**	
	$6\sin60 + 4\sin60 = 0.1\,v^2 / (0.7\sin60)$	**M1**	Uses Newton's Second Law horizontally with 3 terms
	$v = 7.25$ m s^{-1}	**A1**	
	Total:	**3**	
3(i)	Height of C of M of each vertical face above the base = 0.1 m	**B1**	
	$5 \times 3y = 4 \times 3 \times 0.1$	**M1**	Takes moments about the base. y is the height of the C of M above the base
	$y = 0.08$ m	**A1**	
	Total:	**3**	

Question	Answer	Marks	Notes
3(ii)	Moment of lid about the base = $3 \times (0.2 + 0.1\sin\theta)$	**B1**	θ is the angle the lid makes with the horizontal
	$(6 \times 3 + 2) \times 0.12 = 5 \times 3 \times 0.08 + 2 \times 0.2 + 3 \times (0.2 + 0.1\sin\theta)$	**M1**	Take moments about the base
		A1	
	$\theta = 41.8°$	**A1**	
	Total:	**4**	
4(i)	$0.4a = 0.4g - 0.2v^2$	**M1**	Uses Newton's Second Law vertically
	$v\mathrm{d}v / \mathrm{d}x = 10 - 0.5v^2$	**A1**	AG
	Total:	**2**	
4(ii)	$\int v\ \mathrm{d}v / (10 - 0.5v^2) = \int \mathrm{d}x$	**M1**	Separates the variables and attempts to integrate
	$-\ln(10 - 0.5v^2) = x\ (+ \mathrm{c})$	**A1**	
	$x = 0$, $v = 0$ hence $\mathrm{c} = -\ln 10$	**M1**	Attempts to find c using $x = 0$, $v = 0$
	$v = \sqrt{(20 - 20\mathrm{e}^{-x})}$	**A1**	$10 - 0.5v^2 = \mathrm{e}^{-x+\ln 10} = 10\,\mathrm{e}^{-x}$
	Total:	**4**	
4(iii)	Increase$= \sqrt{(20 - 20\mathrm{e}^{-8})} - \sqrt{(20 - 20\mathrm{e}^{-4})}$	**M1**	**M1** if x values are substituted into their value for part (ii)
	Increase $= 0.0404\ \mathrm{m\,s^{-1}}$	**A1**	Allow 0.04
	Total:	**2**	

Question	Answer	Marks	Notes
5(i)	$0.3g = 6e / 0.8$	**M1**	Uses $T = \lambda x / L$
	$e = 0.4$ m	**A1**	
	EE $= 6 \times 0.4^2/(2 \times 0.8)$	**B1 FT**	FT for their e
	$0.3v^2/2 - 0.3 \times 2^2/2 = 0.3\,g(0.8 + 0.4) - 6 \times 0.4^2/(2 \times 0.8)$	**M1**	Sets up a 4 term energy equation involving EE, KE and PE
	$v = 4.9(0)$ m s^{-1} or $2\sqrt{6}$	**A1**	
	Total:	**5**	
5(ii)	$0.3 \times 2^2/2 + 0.3gL = 6(\mathrm{L} - 0.8)^2/(2 \times 0.8)$	**M1**	Sets up a 3 term energy equation involving EE, KE and PE
		A1	
	$L = 2.18$ m	**A1**	Ignore answers less than 0.8
	Total:	**3**	
6(i)	$3 \times 0.6 = 8\cos 60\,\bar{x}$	**M1**	Takes moments about A
	$\bar{x} = 0.45$ m	**A1**	
	Total:	**2**	
6(ii)	$P\cos 60 \times 0.6 = 8 \times 0.45\cos 60$	**M1**	Takes moments about A
	$P = 6$ N	**A1**	
	Total:	**2**	

Question	Answer	Marks	Notes
6(iii)	$\mu = 3\cos30 / (8 - 3\sin30)$	**M1**	Uses $F = \mu R$ used
	$\mu = 6\cos30 / (8 + 6\sin30)$	**M1**	
	$\mu = 0.4$ or 0.472	**A1**	
	$\mu =$ 0.472 accept 0.47	**A1**	
	Total:	**4**	
7(i)	$\tan\theta = 2$	**B1**	Note $\theta = 63.4349..^\circ$
	Total:	**1**	

Question	Answer	Marks	Notes
7(ii)	*EITHER:* $a = 2a - 25a^2 / V^2$ $(25a = V^2)$	**(B1**	Substitutes $x = y = a$ into the trajectory equation
	$a = V\cos 63.4349.. \times 4$	**B1**	Horizontal motion
	$V^2 = 25 \times 4 \times V\cos 63.4349..$	**M1**	Attempts to eliminate a
	$V = 44.7(213..)$ or $20\sqrt{5}$	**A1**	
	$a = 80$	**A1)**	
	OR: $a = V\sin 63.4349.. \times 4 - g4^2/2$	**(B1**	Uses $s = ut + at^2/2$ vertically
	$a = V\cos 63.4349.. \times 4$	**B1**	Horizontal motion
	$V\sin 63.4349.. \times 4 - g4^2/2 = V\cos 63.4349.. \times 4$	**M1**	Attempts to solve the 2 equations
	$V = 44.7(213..)$or $20\sqrt{5}$	**A1**	
	$a = 80$	**A1)**	
	Total:	**5**	
7(iii)	$v_v = 44.7213..\sin 63.4349.. - 4g\ (= 0)$	**M1**	v_v = vertical component of the velocity
	$\alpha = \tan^{-1} +/- 0 / (44.7213..\cos 63.4349..)$	**M1**	$\tan\alpha = v_v / v_h$ where v_h = horizontal velocity
	$\alpha = 0°$	**A1**	
	Total:	**3**	