Question	Answer	Marks	Guidance
1	$0 = 15\sin 60 - gt$ $(t = 3\sqrt{3}/4 = 1.30)$	**M1**	Uses $v = u + at$ vertically
	$x = 15\cos 60 \times 1.3$ (= 9.7428..)	**A1**	
	$y = (15\sin 60)^2/(2g)$ (= 8.4375..)	**B1**	Uses $v^2 = u^2 + 2as$ vertically
	$D = \sqrt{(9.74^2 + 8.44^2)}$	**M1**	Applies Pythagoras's theorem
	$D = 12.9$ m	**A1**	
	Total:	**5**	

Question	Answer	Marks	Guidance
2(i)	$M = 2\pi \times 0.2 \times 0.9 + \pi \times 0.2^2$	**B1**	M = total mass of the container
	$(2\pi \times 0.2 \times 0.9 + \pi \times 0.2^2)\bar{x}$ $= 2\pi \times 0.2 \times 0.9 \times 0.9/2$	**M1**	Takes moments about the base
	$\bar{x} = 0.405$ m AG	**A1**	
	Total:	**3**	
2(ii)	$\tan\theta = 0.2/0.405$	**M1**	θ is the angle of slope of the plane
	$\mu = \tan\theta$	**B1**	
	$\mu = 0.494$	**A1**	
	Total:	**3**	

Question	Answer	Marks	Guidance
3(i)	$30 = (20\sin 60)t + \frac{1}{2}gt^2$	**M1**	Uses $s = ut + \frac{1}{2}at^2$ vertically
	$5t^2 + 10\sqrt{3}\,t - 30 = 0$	**M1**	Sets up a quadratic equation and attempts to solve it
	$t = 1.27$	**A1**	
	Total:	**3**	

Question	Answer	Marks	Guidance
3(ii)	$v^2 = (20\sin 60)^2 + 2g$ x 30 (hence v = 30)	**B1**	Uses $v^2 = u^2 + 2as$ vertically
	$V = \sqrt{30^2} + (20\cos 60)^2$ or $\tan\theta = 30/(20\cos 60)$	**M1**	
	$V = 31.6$ ms^{-1}	**A1**	
	$\theta = 71.6°$ with the horizontal	**A1**	Or 18.4° with the downward vertical
	Total:	**4**	

Question	Answer	Marks	Guidance
4(i)	A = 0.6 x 0.75 + 0.3 x 0.75/2 (= 0.5625)	**B1**	A = total area of the lamina
	$0.5625\,\bar{x}$ = 0.75 x 0.6 x 0.3 + $\frac{1}{2}$ 0.3 x 0.75 x (0.6 + 0.3/3)	**M1**	Takes moments about AB
	$\bar{x}$ = 0.38 m (from AB) AG	**A1**	
	$0.5625\,\bar{y}$ = 0.75 x 0.6 x 0.375 + $\frac{1}{2}$ 0.3 x 0.75 x 0.25	**M1**	Takes moments about BC
	$\bar{y}$ = 0.35 m (from BC)	**A1**	
	Total:	**5**	
4(ii)	$\tan\theta = 0.35/0.38$	**M1**	$\tan\theta = \bar{y}/\bar{x}$ where θ is the required angle
	$\theta = 42.6°$	**A1**	
	Total:	**2**	

Question	Answer	Marks	Guidance
5(i)	$T\cos 60 = 1.5 + 0.4g$	**M1**	Resolve vertically for P
	T = 11 N	**A1**	
	$T\sin 60 = 0.4\,\omega^2$ x0.5sin60	**M1**	Uses Newton's Second Law horizontally for P
	ω = $\sqrt{55}$ = 7.42	**A1**	
	Total:	**4**	

Question	Answer	Marks	Guidance
5(ii)	$m = 0.15$ (from $mg = 1.5$)	**B1**	Resolves vertically for Q
	$T^* = 0.15 \times 7.42^2 \times 0.5\sin 60$	**M1**	Uses Newton's Second Law horizontally for Q
	$T^* = 3.57$ N	**A1**	
	Total:	**3**	

Question	Answer	Marks	Guidance
6(i)	Friction = 0.4 x 0.4g	**B1**	Uses $F = \mu R$
	$0.4v\mathrm{d}v/\mathrm{d}x = -0.4 \times 0.4g - 0.8/x$	**M1**	Uses Newton's Second Law and $a = v\mathrm{d}v/\mathrm{d}x$
	$v\mathrm{d}v/\mathrm{d}x = -4 - 2/x$	**A1**	
	Total:	**3**	
6(ii)	$\int v\mathrm{d}v = \int\left(-4 - \frac{2}{x}\right)\mathrm{d}x$	**M1**	Separates the variables and attempts to integrate
	$v^2/2 = -4x - 2\ln x$ (+ c)	**A1**	
	$v = U$ when $x = 1$ hence $c = U^2/2 + 4$	**M1**	Attempts to find c
	$0 = -4 \times 2 - 2\ln 2 + U^2/2 + 4$ [$U^2 = 10.7(725)$] $0 = -4 \times 2.1 - 2\ln 2.1 + U^2/2 + 4$ [$U^2 = 11.7(677)$]	**M1**	Put $v = 0$ and $x = 2$ Put $v = 0$ and $x = 2.1$
	$3.28 < U < 3.43$	**A1**	
	Total:	**5**	

Question	Answer	Marks	Guidance
7(i)	$0.4g = 24e/0.6$	**M1**	Uses $T = \lambda x/L$
	$e = 0.1$ m	**A1**	
	Total:	**2**	
7(ii)	Initial EE = $24 \times 0.1^2/(2 \times 0.6)$ (= 0.2 J)	**B1**	Uses EE = $\lambda x^2/2L$
	$0.4 \times 5^2/2 + 0.4gd = 24(0.1 + d)^2/(2 \times 0.6) - 24 \times 0.1^2/(2 \times 0.6)$	**M1 A1**	Set up a 4 term energy equation involving EE, PE and KE
	$d = 0.5$ m	**A1**	
	Total:	**4**	

Question	Answer	Marks	Guidance
7(iii)	$e = 0.2$	**B1**	
	$0.8v^2/2=24 \times 0.6^2/(2 \times 0.6) - 24 \times 0.2^2/(2 \times 0.6) - 0.8g \times 0.4$	**M1 A1**	Set up a 4 term energy equation in EE, PE and KE
	$v = 2\sqrt{2} = 2.83$ ms^{-1}	**A1**	
	Total:	**4**	