Centres Of Mass Exam Questions MS (From OCR 4729)

Q1, (Jun 2005, Q1)

(i)	use of h/4	B1			
	com vert above lowest pt of contact	B1		can be implied	
	r = 5 x tan24°	M1			
	r = 2.2	A1	4	2.226	
(ii)	No & valid reason (eg 24°☝26.6°)	B1√	1	√Yes if their r ☜ 2.5	5

Q2, (Jan 2006, Q4)

(i)	horiz comps in opp direct	B1		at E & F	
	Right at E + Left at F	B1	2		
(ii)	1.6x9.8x30 = 20X or	M1		or 10X + 1.6gx30 = 30X M(A)	
	0.5x30g + 0.7x30g + 0.2x60g = 20X	A1		or 10X + (. . . = 470.4) = 30X M mark ok without g but 3 parts	
	X = 23.5 N	A1	3		
(iii)	$1.6\bar{y}$ =	M1		must be moments with vert dists	
	20x0.2 + 20x0.2 +40x0.5	A1		or $1.6\bar{y}$=20x0.2x2+40x0.7(22.5)	
	$\bar{y}$ = 17.5 cm	A1	3		8

Q3, (Jun 2006, Q3)

(i)	d = 2.25	B1		3/8x6 *OG* (be generous)	
	h = 1.125 or 1.12 or 1.13 or 9/8	B1	2	horizontal distance	
(ii)	$T_1 + T_2 = 12$ resolving vertically	M1		if not then next M1 ok	
	T_1 x 6cos30° = 12xh (their h)	M1		or mom(*A*)T_2x6cos30°= 12(6cos30° – h)	
	mom(*O*) (their h ok for A1)	A1			
	T_1 = 2.60 N or 3√3/2	A1		or T_2 = 9.40	
	T_2 = 9.40 N √ (12 – T_1)	A1√	5	or T_1=2.60 or √(12–T_2)	7
	above √ depends on at least one of the M marks (T_s > 0)				

Q4, (Jan 2007, Q6)

(i)	com of Δ 4 cm right of *C*	B1			
	1.5 x 10 + 7 x 20 = $\bar{x}$ x 30	M1			
		A1			
	$\bar{x}$ = 5.17	A1		5 1/6 31/6	
	com of Δ 6 cm above *E*	B1		or 3 cm below *C*	
	4.5 x 10 + 6 x 20 = $\bar{y}$ x 30	M1			
		A1			
	$\bar{y}$ = 5.5	A1	8		
(ii)	tanθ = 5.17/3.5	M1		right way up and (9–$\bar{y}$)	
	55.9° or 124°	A1√	2	√ their $\bar{x}$ /(9 – $\bar{y}$)	
(iii)	d = 15sin45° (10.61)	B1		dist to line of action of T	
	Td = 30 x 5.17	M1		allow Tx15 i.e. T vertical	
	T = 14.6	A1	3		13

Q5, (Jun 2007, Q8)

(i)	com of hemisphere 0.3 from O	B1	**or** 0.5 from base
	com of cylinder $h/2$ from O	B1	
	0.6x45 = 40x0.5 + (0.8+h/2) x 5 **or**	M1	**or** 40x0.3 – 5xh/2 = 45 x 0.2
	45(h+0.2) = 5h/2 +40(h+0.3)	A1	**or** 5(0.2 + h/2) = 40x0.1
	27 = 20 + (0.8+h/2) x 5	M1	solving
	h = 1.2	A1 **6**	**AG**
(ii)	1.2 T	B1	
	0.8 F	B1	
	0.8F = 1.2T	M1	
	F = 3T/2	A1 **4**	aef
(iii)	F + Tcos30°	B1	**or** 45 x 0.8 sin30°
	45sin30° must be involved in res.	B1	T x (1.2 + 0.8cos30°)
	resolving parallel to the slope	M1	mom. about point of contact
	F + Tcos30° = 45sin30° aef	A1	45.0.8sin30°=T(1.2+0.8cos30°)
	T = 9.51	A1	
	F = 14.3	A1 **6**	**16**
or	T + Fcos30° = Rsin30°	B1	res. horizontally
(iii)	Rcos30° + Fsin30° = 45	B1	res. vertically
	tan30°=(T+Fcos30°)/(45-Fsin30°)	M1	eliminating R

Q6, (Jan 2009, Q3)

(i)	140 x X = 40 x 70	M1	
	X = 20 N	A1	
	at F 20 N to the right	B1	inspect diagram
	at G 20 N to the left	B1 **4**	**SR** B1 for correct directions only
(ii)	đ = (2x40sinΠ/2)÷3Π/2	M1	must be radians
		A1	
	đ = 17.0	A1	16.98 160/3Π (8/15Π m)
	70 $\bar{y}$ = 100x60 + 217 x 10	M1	
		A1 ft	ft 200 + their đ or 2 + their đ (m)
	$\bar{y}$ = 117	A1 **6**	116.7 **10**

Q7, (Jan 2010, Q3)

(i)	ū = 0.2 (from vertex) or 0.8 or 0.1	B1	com of conical shell
	0.5đ = 0.2×ū + 0.3×0.65	M1	
		A1	
	đ = 0.47	A1 [4]	AG
(ii)	s = 0.5	B1	slant height, may be implied
	Tsin80°× 0.5 = 0.47 × 0.5 × 9.8	M1	
		A1	
	T = 4.68 N	A1 [4]	8

Q8, (Jun 2014, Q3)

(i)		CoM of triangle = $^1/_3$ x cv(12) from *BD*	B1	OR $^2/_3$ x cv(12) from C. CoM of triangle
		$(80 + 60)x_G$	M1	Table of values idea
		$= 4(80) + 12(60)$	A1	
			A1	
		$x_G = 7.43$ cm	A1	7.42857… or $^{52}/_7$ cm
			[5]	
(ii)		$\tan\theta = (8 - x_G)/5$	M1	Using tan to find a relevant angle
		$\tan\theta = 0.5714…/5$	A1ft	ft their x_G to target angle with the vertical
		$\theta = 6.52°$	A1	6.5198… Allow 6.5(0) from $x_G = 7.43$
			[3]	

Q9, (Jun 2015, Q4)

(i)		$2(8)\sin(\pi/2)/(3\pi/2)$	B1	CoM of semi-circle (3.395305….); ($32/3\pi$)
			M1	Table of values idea to get an equation/expression, using any fixed axis
		$(80 + 32\pi)\, x_G$	A1	
		$=80(2) + 32\pi(4 + \text{cv(CoM)})$	A1ft	Relative to the axis they are using; ft their CoM
		$x_G = 5(.00)$ cm	A1	(5.004444492 cm)
			[5]	
(ii)			M1	Moments about E or A; allow wrong distance for either force
		$4(20) = W(x_G$ from (i) – 4)	A1ft	ft on cv(x_G); *mg* OK here; if $x_G < 4$ need (4 - x_G from (i))
		$4(20) = W(x_G$ from (i))	A1ft	ft on cv(x_G); *mg* OK here
		(Greatest) $W = 80$ N	A1	79.64601393 from exact x_G; allow anything between 79.6 and 80
		(Least) $W = 16$ N	A1	15.98579026 from exact x_G
			[5]	SC for masses found only, 4/5 for both 8.13 to 8.16 and 1.63

Q10, (Jun 2016, Q3)

(i)		CoM of one semicircular lamina is $\frac{4a}{\pi}$, $\frac{4a}{3\pi}$	B1	oe, may be unsimplified, allow $^{4r}/_{3\pi}$
			M1	Table of values idea
		$-\left(\frac{1}{2}\pi a^2\right)\left(\frac{4a}{3\pi}\right)+\left(\frac{1}{2}\pi(3a)^2\right)\left(\frac{12a}{3\pi}\right)$	A1	
		$=\left(\frac{1}{2}\pi(3a)^2-\frac{1}{2}\pi a^2\right)x_G$	A1	
		$x_G=\frac{13a}{3\pi}$	A1	AG Correctly shown
			[5]	
(ii)			M1	Moments equation in terms of *a* and *T*, with correct number of terms, dimensionally correct, resolving on *T* side of equation; if conflicting evidence about point taking moments mark to benefit of candidate.
		$3g\left(\frac{13a}{3\pi}\right)=(T\cos 40)(6a)$	A1	
		$T = 8.82$ N	A1	$T = 8.822960...$
			[3]	
(iii)		$X = T\cos 40$	B1	ft candidates value of T if substituted ($X = 6.758779...$)
		$Y = 3g + T\sin 40$	B1	ft candidates value of T if substituted ($Y = 35.071289...$)
		$\tan\theta=\frac{35.0712...}{6.7587...}$	M1	Any relevant angle
		$\theta = 79.1$ above horizontal (to the left)	A1	$\theta = 79.0919...$ (10.9 to the upward vertical); above or upwards may be implied by a correct diagram.
OR			**[4]**	
		$x^2 = (3g)^2 + T^2 - 2\times 3g\times T\times\cos 130$	M1A1ft	
		Use of sine rule to find either of the missing angles	M1	
		$\theta = 79.1$ above horizontal (to the left)	A1	$\theta = 79.0919...$ (10.9 to the upward vertical); above or upwards may be implied by a correct diagram.