Forces and Equilibrium 1 MS

Q1.

4		M1		For resolving forces in the x-direction or in the y-direction
	$X = 160 + 250\cos\alpha$	A1		
	$Y = 370 - 250\sin\alpha$	A1		
		M1		For using $R^2 = X^2 + Y^2$
	Magnitude is 500 N	A1ft		ft 264 N for consistent sin/cos mix
		M1		For using $\tan\theta = Y/X$
	Required angle is 36.9° (or 0.644 rads)	A1ft		ft 29.5° for consistent sin/cos mix
			[7]	

Q2.

3		M1		For using triangle of forces or for resolving in dir^n XP_1 or for using Lami's theorem or for resolving forces at X vertically and horizontally (equations must contain not more than one unknown angle)
	For correct Δ or resolve XP_1 and $\cos\alpha = 5.5/7.3$; or $5.5/\sin(90^\circ + \alpha) = 7.3/\sin 90^\circ$ (Lami); or $5.5\cos\alpha + W\sin\alpha = 7.3$ and $5.5\sin\alpha = W\cos\alpha$.	A1		
	Angle $AP_1X = 41.1^\circ$ or 0.718^c	A1		
	For correct triangle and $W^2 = 7.3^2 - 5.5^2$; or $W/\sin(180^\circ - 41.1^\circ) = 7.3/\sin 90^\circ$; or $W\sin 41.1^\circ = 7.3 - 5.5\cos 41.1^\circ$ or $W\cos 41.1^\circ = 5.5\sin 41.1^\circ$	A1ft		ft incorrect α
	$W = 4.8$	A1	[5]	

Q3.

3		M1		For resolving forces in **i** and **j** directions (3 terms in at least one of the equations)
	$6\cos\alpha^\circ + 5\cos(90^\circ - \alpha^\circ) = F$ and $6\sin\alpha^\circ - 5\sin(90^\circ - \alpha^\circ) = F$	A1		
	$[6\cos\alpha^\circ + 5\sin\alpha^\circ = 6\sin\alpha^\circ - 5\cos\alpha^\circ$ $\rightarrow 11\cos\alpha^\circ = \sin\alpha^\circ]$	DM1		For attempting to solve for α°. Dependent on 1st M1
	$\alpha = 84.8$	A1		
	$[F = 6\cos 84.8^\circ + 5\sin 84.8^\circ$; $F = 6\sin 84.8^\circ - 5\cos 84.8^\circ]$	DM1		For substituting to find F; dependent on the 1st M1
	$F = 5.52$	A1	**[6]**	

Forces and Equilibrium 1 MS

First alternative scheme		
$[2F^2 = 25 + 36]$	M1	For using '(resultant of forces of magnitude F)^2 = (resultant of forces of magnitudes 5 and 6)^2'
$F = 5.52$	A1	
	M1	For using 'resultant of forces of magnitudes 5 and 6 makes angle 45° with x-axis'
	M1	For using relevant trigonometry
$\tan(\alpha^\circ - 45^\circ) = 5/6$ or $\tan(135^\circ - \alpha^\circ) = 6/5$ or $\cos(\alpha^\circ - 45^\circ)$ or $\sin(135^\circ - \alpha^\circ) = 6/\sqrt{61}$ or $\sin(\alpha^\circ - 45^\circ)$ or $\cos(135^\circ - \alpha^\circ) = 5/\sqrt{61}$	A1	
$\alpha = 84.8$	A1	
Second alternative scheme		
$[6\cos\alpha^\circ + 5\cos(90^\circ - \alpha^\circ) = 6\sin\alpha^\circ - 5\sin(90^\circ - \alpha^\circ)]$	M1	For using Rx = Ry
$[11\cos\alpha^\circ - \sin\alpha^\circ = 0]$	M1	For attempting to solve for α°
$\alpha = 84.8$	A1	
For $F = 6\cos\alpha^\circ + 5\cos(90^\circ - \alpha^\circ)$ or $F = 6\sin\alpha^\circ - 5\sin(90^\circ - \alpha^\circ)$	B1	
	M1	For substituting for α
$F = 5.52$	A1	

Q4.

3	**(i)** $[2T\cos30^\circ = 3\sqrt{3}$	M1		For expressing resultant in terms of T and equating with value
	or $T/\sin30^\circ = 3\sqrt{3}/\sin120^\circ$			or for using sine rule
	or $T^2 = T^2 + (3\sqrt{3})^2 - 2T(3\sqrt{3})\cos30^\circ$			or for using cosine rule
	or $\sqrt{\{(T\cos30^\circ)^2 + (T + T\cos60^\circ)^2\}} = 3\sqrt{3}$]			or for finding Rx and Ry and equating resultant to $3\sqrt{3}$
	Tension is 3 N	A1	**[2]**	AG
	(ii) $[T = F + mg\sin30]$	M1		For resolving forces on Q parallel to AC
	$R = mg\cos30$	B1		
		M1		For using $F = \mu R$
	$3 = 0.75(10\cos30^\circ)m + 10m\sin30^\circ$	A1		
	Mass is 0.261 kg	A1	**[5]**	

Forces and Equilibrium 1 MS

Q5.

4	**(i)**		M1		For resolving forces parallel to the plane (either case) – 3 terms needed
		$2X + F = 11g\sin30^\circ$ and $9X - F = 11g\sin30^\circ$	A1		
		$X = 10$	A1	**[3]**	
	(ii)	$F = 35$	B1		May be implied.
		$R = 11g\cos30^\circ$	B1		
			DM1		For using $\mu = F/R$
		Coefficient is 0.367	A1ft	**[4]**	

Q6.

6	**(i)**		M1		For resolving forces on R vertically
		$2T\cos\alpha = 0.6g$	A1		Where α = ½ angle ARB
		Tension is 5N	A1	**[3]**	
	(ii)	$[F = T\sin\alpha]$	M1		For resolving forces on B horizontally
		Frictional component is 4N	A1		
		$[N = 0.4g + T\cos\alpha]$	M1		For resolving forces on B vertically
		Normal component is 7 N	A1	**[4]**	
	(iii)		M1		For using $\mu = F/N$
		Coefficient is 4/7 or 0.571	A1ft	**[2]**	ft conditional on both M1 marks scored in **(ii)**; ft F and/or N

	Alternative for Q6(i)/(ii)				
	(i)	For finding the relevant angles and using Lami's theorem	M1		
		$6/\sin106.26° = T/\sin126.87°$	A1		
		Tension is 5N	A1	**[3]**	
	(ii)	$F/\sin126.87° = 5/\sin90°$	B1		
		Frictional component is 4N	B1		
		$(R - 4)/\sin143.13° = 5/\sin90°$	B1		
		Normal component is 7 N	B1	**[4]**	

Forces and Equilibrium 1 MS

Q7.

2	(i)	$X = 14 - 13\cos\theta$ and $Y = 13\sin\theta$ or triangle with sides 13, 14, 15 and θ opposite 15	B1		
		$[14^2 + 13^2 - 2 \times 13 \times 14\cos\theta = 15^2]$	M1		For using $X^2 + Y^2 = R^2$ or cosine rule
		$\theta = 67.4$	A1	[3]	
	(ii)		M1		For evaluating X or $15\cos[\tan^{-1}(Y/X)]$
		Component is 9 N	A1ft	[2]	

Q8.

7	(i)		M1		For resolving forces vertically and horizontally at B
		$T_C \times (2/2.5) - T_A \times (1.5/2.5) = 0$	A1		
		$T_C \times (1.5/2.5) + T_A \times (2/2.5) = 8$	A1		
		$[0.6\ T_C + 0.8\ (4T_C/3) = 8 \rightarrow (5/3)\ T_C = 8$ or $0.6(0.75T_A) + 0.8T_A = 8 \rightarrow 1.25T_A = 8\ ]$	M1		For eliminating T_A or T_C and attempting to find T_C or T_A
		Tension in AB is 6.4 N; tension in BC is 4.8 N	A1	[5]	
	(ii)		M1		For resolving forces vertically
		$F + 0.2\ g = T_A \times (1.5/2.5)$	A1		
		$N = T_A \times (2/2.5)$	B1		
		$[\mu = (3.84 - 2)/5.12]$	M1		For using $\mu = F/N$ with F vertical and N horizontal
		Coefficient is 0.359	A1	[5]	Accept 0.36

Forces and Equilibrium 1 MS

Q9.

2	**(i)**	M1		For resolving forces horizontally or vertically
	$T\cos\theta + T\sin\theta = 11.2$ (or $-T\cos\theta + T\sin\theta = 0.16g$)	A1		
	$-T\cos\theta + T\sin\theta = 0.16g$ (or $T\cos\theta + T\sin\theta = 11.2$)	A1	[3]	
	(ii) [$T\cos\theta = 4.8$ and $T\sin\theta = 6.4$ and $T^2 = 4.8^2 + 6.4^2$ or $\tan\theta = 6.4/4.8$] [$4T^2(\cos^2\theta + \sin^2\theta) = (11.2 - 1.6)^2 + (11.2 + 1.6)^2$ or $2T\sin\theta \div 2T\cos\theta = (11.2 + 1.6) \div (11.2 - 1.6)$ or $(T\cos\theta + T\sin\theta) \div (-T\cos\theta + T\sin\theta) = 11.2 \div 1.6$]	M1		For finding $T\cos\theta$ and $T\sin\theta$ and hence finding T or θ, OR for finding the value of $4T^2(\cos^2\theta + \sin^2\theta)$ or of $2T\sin\theta \div 2T\cos\theta$ or of $(T\cos\theta + T\sin\theta) \div (-T\cos\theta + T\sin\theta)$
	$T = 8$ (or $\theta = 53.1$)	A1		
	$\theta = 53.1$ or $T = 8$	A1	[3]	