Forces and Equilibrium 2 MS

Q1.

6	(i)		M1		For resolving forces parallel to the plane
		$F = 5.9 - 6.1 \sin\alpha$	A1		
		$R = 6.1\cos\alpha$	B1		
		$[5.9 - 6.1 \sin\alpha \le \mu(6.1\cos\alpha)]$	M1		For using $F \le \mu R$
		$\mu > \frac{4}{5}$	A1	[5]	AG
	(ii)	$[6.1 \times (11/61) + 5.9 - \mu 6.1 \times (60/61) > 0]$	M1		For using $F = \mu R$ and 'net downward force > 0'
		$\mu < \frac{7}{6}$	A1	[2]	AG
	(iii)	$[6.1 \times (11/61) + 5.9 - \mu\, 6.1 \times (60/61) = 0.61 \times 1.7]$	M1		For using Newton's 2^{nd} law and $F = \mu R$
		$\mu = 0.994$	A1	[2]	

Q2.

4	$[T_1\sin APN = T_2\sin BPN]$	M1		For resolving forces horizontally
	$(12 \div 13)T_1 = (15 \div 25)T_2$ or $T_1\sin 67.4° = T_2\sin 36.9°$	A1		AEF
	$[T_1\cos APN + T_2\cos BPN = 21]$	M1		For resolving forces vertically
	$(5 \div 13)T_1 + (20 \div 25)T_2 = 21$ or $T_1\cos 67.4° + T_2\cos 36.9° = 21$	A1		AEF
		M1		For solving for T_1 and T_2
	Tension in S_1 is 13 N, tension in S_2 is 20 N	A1	6	

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	Alternative solution using Lami's Theorem			
4	[T_1/sin(180 – *BPN*) = 21/sin(*APN* + *BPN*)]	M1		For using Lami's Theorem to form an equation in T_1
	T_1/sin (180 – $\cos^{-1}$(20/25))= 21/sin($\cos^{-1}$(20/25) + $\cos^{-1}$(20/52)) or T_1/sin(180 – 36.9) = 21/sin(36.9 + 67.4)	A1		AEF
	[T_2/sin(180 – *APN*) = 21/sin(*APN* + *BPN*)]	M1		For using Lami's Theorem to form an equation in T_2
	T_2/sin(180 – $\cos^{-1}$(20/52)) = 21/sin($\cos^{-1}$(20/25) + $\cos^{-1}$(20/52)) or T_2/sin(180-67.4)=21/sin(36.9 + 67.4)	A1		AEF
		M1		For solving for T_1 and T_2
	Tension in S_1 is 13 N, tension in S_2 is 20 N	A1	6	

	Alternative solution using Sine Rule			
4	[T_1/sin*BPN* = 21/sin(180 –(*APN* + *BPN*))]	M1		For using the Sine Rule on a triangle of forces to form an equation in T_1
	T_1/(15/25) = 21/sin($\cos^{-1}$(20/25) + $\cos^{-1}$(20/52)) or T_1/sin36.9° = 21/sin(180 –(36.9 + 67.4))	A1		AEF
	[T_2/sin*APN* = 21/sin(180 –(*APN* + *BPN*))]	M1		For using the Sine Rule to form an equation in T_2
	T_2/(12/13) = 21/sin($\cos^{-1}$(20/25) + $\cos^{-1}$(20/52)) or T_2/sin67.4° = 21/sin(180 –(36.9 + 67.4))	A1		AEF
		M1		For solving for T_1 and T_2
	Tension in S_1 is 13 N, tension in S_2 is 20 N	A1	6	

Q3.

2 (i)	$2.4 = 0.25g\cos\alpha$	B1		
	$\alpha = 16.3$	B1	[2]	
(ii)	[$\mu = 0.28 \div 0.96$]	M1		For using $\mu = F/R$ or $\mu = \tan\alpha$
	Least possible value of μ is 7/24 or 0.292	A1	[2]	

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Q4.

1 (i)	[N + component of X = Weight of B]	M1		For resolving forces acting on the block vertically (3 terms required)
	Normal component is $(70 - X\cos 15^\circ)$ N	A1	[2]	
(ii)	$F = X\sin 15^\circ$	B1		
	$[X\sin 15^\circ = 0.4(70 - X\cos 15^\circ)]$	M1		For using $F = \mu R$
	Value of X is 43.4	A1	[3]	

Q5.

2		M1		For a triangle of forces with sides 18, R and W for A or for B – or – for resolving forces acting on A or on B parallel to line of greatest slope
	For A: right angle between 18 and R **and** 30° opposite 18 **or** $W_A \sin 30^\circ = 18$ **or** For B: right angle between 18 and W **and** 30° opposite 18 **or** $W_B \sin 30^\circ = 18\cos 30^\circ$	A1		
	For B: right angle between 18 and W **and** 30° opposite 18 **or** $W_B \sin 30^\circ = 18\cos 30^\circ$ **or** For A: right angle between 18 and R **and** 30° opposite 18 **or** $W_A \sin 30^\circ = 18$	B1		
	Weight of A is 36 N and weight of B is 31.2 N	A1	4	

Q6.

4	$R = 15g\cos 20^\circ$	**B1**		140.95
	$F = \mu R = 0.2 \times 15g\cos 20^\circ$	**B1**		28.19
		M1		For resolving parallel to the plane (F acting up plane)
	$X + 0.2 \times 15g\cos 20^\circ = 15g\sin 20^\circ$	**A1**		
	Least value of X is 23.1	**A1**		AG
	$[X = 15g\sin 20^\circ + 0.2 \times 15g\cos 20^\circ]$	**M1**		For resolving parallel to the plane (F acting down plane)
	Greatest value of X is 79.5	**A1**	7	

Forces and Equilibrium 2 MS

Q7.

3	(i)	$[X = 60\cos25 + 50\cos15]$	M1		For resolving both forces in the direction of river
		$= 103$ N	A1	[2]	Value of X is 102.7 N
	(ii)	$Y = 60\sin25 - 50\sin15$ [= 12.4]	B1		Component perpendicular to the direction of the river
		$[R^2 = X^2 + Y^2]$ or $[\alpha = \arctan(Y/X)]$	M1		For using Pythagoras or for using arctan to find the resultant force or its direction
		Magnitude is 103 N (or $\alpha = 6.9^\circ$ with direction specified unambiguously)	A1		Magnitude is 103.4 N
		$\alpha = 6.9^\circ$ with direction specified unambiguously (or Magnitude = 103 N)	B1	[4]	

Q8.

5	$F = \mu mg\cos30$	B1		
	$[10 + F - mg\sin30 = 0]$	M1		Resolving up, first case
	$[75 - F - mg\sin30 = 0]$	M1		Resolving up, second case
	$[85 = 2mg\sin30]$ or $[10 + \mu mg\cos30 - mg\sin30 = 0$ $75 - \mu mg\cos30 - mg\sin30 = 0]$	M1		Either attempt to solve for m or Solve a pair of two 3 term simultaneous equations for either m or μ
	$m = 8.5$ kg or $\mu = 0.442$	A1		
	$\mu = 0.442$ or $m = 8.5$ kg	B1	[6]	

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Q9.

3	$R = 0.6g\cos 21$ [= 5.60]	B1	
	$F = 0.3R = 1.8\cos 21$ [= 1.68]	M1	Using $F = \mu R$
	$P + F = 6\sin 21[= 2.15]$	M1	Slipping down
	$P = 2.15 - 1.68 = 0.470$ AG	A1	Least possible value
	$P - F = 6\sin 21$	M1	Slipping up
	$P = 2.15 + 1.68 = 3.83$	A1	Greatest possible value
	Total:	6	

Q10.

3	*EITHER*:	(M1	Resolve horizontally and/or vertically at the 25 N weight
	$A\cos 30 + B\cos 40 = 25$	A1	
	$A\sin 30 = B\sin 40$	A1	
		M1	Solve for A and/or B
	$A = 17.1$	A1	
	$B = 13.3$	A1)	
	OR:	(M1	Attempt Lami's theorem
	$\frac{25}{\sin 70} = \frac{A}{\sin 140} = \frac{B}{\sin 150}$	A1	One correct equation
		A1	A second correct equation
		M1	Solve for A and/or B
	$A = 17.1$	A1	
	$B = 13.3$	A1)	
	Total:	6	

Q11.

7(i)	$R = mg\cos 30$	B1	Resolves normally
	$F = 2m\cos 30$ [$= m\sqrt{3}$]	M1	Uses $F = \mu R$
	$T = 4g$ [= 40]	B1	Particle B
	$T = mg\sin 30 + F$	M1	Resolves parallel to plane for particle A
	$40 = 5m + m\sqrt{3}$	A1	Equation in m
	$m = \frac{40}{5+\sqrt{3}} = 5.94$	A1	**AG** All correct and no errors seen
	Total:	6	

Forces and Equilibrium 2 MS

7(ii)	*EITHER:* $[R = 3g\cos 30]$ $F = 0.2 \times 3g\cos 30$ $(3\sqrt{3} = 5.196)$	**(B1**	
	$4g - T = 4a$ or $T - 3g\sin 30 - F = 3a$ or $4g - 3g\sin 30 - F = 7a$	**M1**	Applies Newton's Second Law to one of the particles or forms system equation in a $(m_B g - m_A g\sin 30 - F = (m_A + m_B)a)$
	$T - 3g\sin 30 - 3\sqrt{3} = 3a$ or $40 - T = 4a$ or $4g - 3g\sin 30 - 3\sqrt{3} = 7a \rightarrow a = \ldots$	**M1**	Applies Newton's Second Law to form second equation in T and a and solves for a or solves system equation for a
	$a = \dfrac{25 - 3\sqrt{3}}{7}$ $= 2.83.$	**A1**	
	$v^2 = 2 \times 2.83 \times 0.5$ $v = 1.68\ldots$	**B1 FT**	v as T becomes zero FT on a
	$-3g\sin 30 - 0.2(3g\cos 30) = 3a$ $-15 - 3\sqrt{3} = 3a$ $\rightarrow a = \ldots(-5-\sqrt{3} = -6.73)$	**M1**	Applies Newton's Second Law and solves for a
	$0 = 1.68^2 - 2 \times 6.73s$ $s = \ldots(0.210)$	**M1**	Uses $v^2 = u^2 + 2as$ and solves for s
	Total distance = 0.710 m	**A1)**	
	OR: $[R = 3g\cos 30]$ $F = 0.2 \times 3g\cos 30$ $(3\sqrt{3} = 5.196)$	**(B1**	