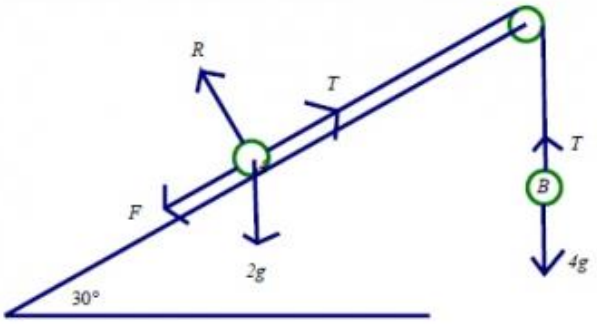
Yr2 Connected Particles With Friction (Sheet 2) Mark Scheme

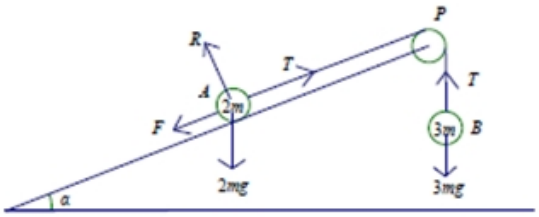
Q1.

Question Number	Scheme	Marks
(a)	B: $2mg - T = 2m \times 4g/9$	M1 A1
	$\Rightarrow T = \underline{10mg/9}$	A1 (3)
(b)	A: $T - \mu mg = m \times 4g/9$	M1 B1 A1
	Sub for T and solve: $\mu = 2/3$ *	DM1 A1 (5)
(c)	When B hits: $v^2 = 2 \times 4g/9 \times h$	M1 A1
	Deceleration of A after B hits: $ma = \mu mg \Rightarrow a = 2g/3$	M1 A1 f.t.
	Speed of A at P: $V^2 = 8gh/9 - 2 \times 2g/3 \times h/3$	DM1
	$\Rightarrow V = \frac{2}{3}\sqrt{(gh)}$	A1 (6)
(d)	Same tension on A and B	B1 (1)
		15

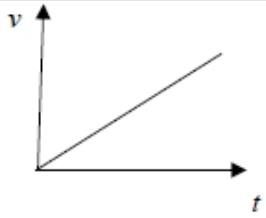
Q2.

Question Number	Scheme	Marks
		
	Equation of motion of B: $4g - T = 4a$	M1A1
	Equation of motion of A: $T - F - 2g\sin 30 = 2a$	M1A2
	OR: $4g - F - 2g\sin 30 = 6a$	
	Resolve perpendicular to the plane at A: $R = 2g\cos 30$	B1
	Use of $F = \mu R$: $F = \frac{1}{\sqrt{3}} \times 2g\cos 30 (= g)$	M1
	$T - g - g = T - 2g = 2a$	
	$2T - 4g = 4g - T$, $3T = 8g$, $T = \frac{8g}{3} (\approx 26)$ 26.1(N)	**DM1**A1
		(9) **[9]**
	Notes for Question	
	First M1 for resolving vertically (up or down) for B, with correct no. of terms. First A1 for a correct equation. Second M1 for resolving parallel to the plane (up or down) for A, with correct no. of terms. A2 for a correct equation (-1 each error) **OR**: M2 A3 for the whole system equation - any method error loses all the marks. B1 for perpendicular resolution Third M1 for sub for R in $F = \mu R$ Fourth DM1, dependent on first and second M marks, for eliminating a. Fourth A1 for 8g/3, 26.1 or 26 (N). (392/15 oe is A0)	

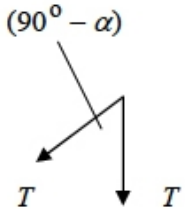
Q3.

Part	Working or answer an examiner might expect to see	Mark	Notes
(a)			
	$R = 2mg\cos\alpha = \frac{24mg}{13}$	B1	This mark is given for using the model to state the normal reaction between A and the plane
	$F_{max} = \frac{2}{3}R = \frac{16mg}{13}$	B1	This mark is given for the use of $F = \mu R$
	Equation of motion for A is $T - F_{max} - 2mg\sin\alpha = 2ma$	M1	This mark is given for a method form an equation of motion for A
		A1	This mark is given for a correct equation of motion for A
	Equation of motion for B is $3mg - T = 3ma$	M1	This mark is given for a method to form an equation of motion for B
		A1	This mark is given for a correct equation of motion for B
	$3mg - \frac{16mg}{13} - \frac{10mg}{13} = 5ma$	M1	This mark is given for a method using the equations of motion for A and B to solve for T
	$T = 3mg - \frac{3mg}{5} = \frac{12mg}{5}$	A1	This mark is given for a full method and correct working to show the answer given
(b)	$F_{max} = \frac{16mg}{13} > \frac{10mg}{13}$ $\frac{10mg}{13}$ is the component of the weight parallel to the slope	M1	This mark is given for a comparison of F_{max} with the component of weight
	Thus A will not move	A1	This mark is given for a fully justified and correct conclusion
(c)	Have the model consider air resistance	B1	This mark is given for one correct refinement stated
	Have the model use an extensible string	B1	This mark is given for one correct refinement stated

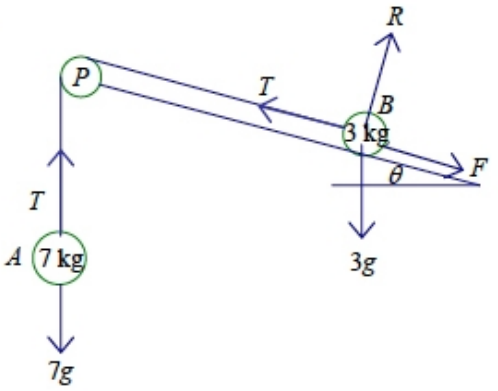
Q4.

Question	Scheme	Marks	AOs
	Mark parts (a) and (b) together		
(a)	Equation of motion for A	M1	3.3
	$3mg\sin\alpha - F - T = 3ma$	A1	1.1b
		(2)	
(b)	Resolve perpendicular to the plane	M1	3.4
	$R = 3mg\cos\alpha$	A1	1.1b
	$F = \frac{1}{6}R$	B1	1.2
	Equation of motion for B **OR** for whole system	M1	3.3
	$T - mg = ma$ **OR** $3mg\sin\alpha - F - mg = 3ma + ma$	A1	1.1b
	Complete method to solve for a	DM1	3.1b
	$a = \frac{1}{10}g$ *	A1*	2.2a
		(7)	
(c)		B1	1.1b
	e.g. acceleration (of B) is constant; dependent on first B1	DB1	2.4
		(2)	
(d)	e.g. the tensions in the two equations of motion would be different. Tension on A would be different to tension on B	B1	3.5a
		(1)	
			(12 marks)

Q5.

Question Number	Scheme	Marks
(a)	$T - 5g\sin\alpha = 5a$ $15g - T = 15a$ solving for a $a = 0.6g$ solving for T $T = 6g$	M1 A1 M1 A1 M1 A1 M1 A1 (8)
(b)	For Q : $5g - N = 5a$ $N = 2g$	M1 A1 A1 f.t. (3)
(c)	 $F = 2T\cos(\frac{90^\circ - \alpha}{2})$ $= 12g\cos 26.56..^\circ$ $= 105$ N	M1 A2 A1 f.t. A1 (5) [16]

Q6.

Question Number	Scheme	Marks
(a)	 $\tan\theta = \frac{5}{12}$ $\sin\theta = \frac{5}{13}$ $\cos\theta = \frac{12}{13}$	
	For A: $7g - T = 7a$	M1 A1
	For B: parallel to plane $T - F - 3g\sin\theta = 3a$	M1 A1
	perpendicular to plane $R = 3g\cos\theta$	M1 A1
	$F = \mu R = 3g\cos\theta = 2g\cos\theta$	M1
	Eliminating T, $7g - F - 3g\sin\theta = 10a$	DM1
	Equation in g and a: $7g - 2g\times\frac{12}{13} - 3g\frac{5}{13} = 7g - \frac{39}{13}g = 4g = 10a$	DM1
	$a = \frac{2g}{5}$ *oe* or 3.9 or 3.92	A1
		(10)
(b)	After 1 m,	
	$v^2 = u^2 + 2as$, $v^2 = 0 + 2\times\frac{2g}{5}\times 1$	M1
	$v = 2.8$	A1
		(2)
(c)	$-(F + 3g\ \sin\theta) = 3a$	M1
	$\frac{2}{3}\times 3g\times\frac{12}{13} + 3g\times\frac{5}{13} = 3g = -3a,\ a = -g$	A1
	$v = u + at,\ 0 = 2.8 - 9.8t,$	DM1
	$t = \frac{2}{7}$ oe, 0.29. 0.286	A1
		(4) **[16]**

Q7.

Question Number	Scheme	Marks
(a)	Inextensible string	B1 (1)
(b)	$4mg - T = 4ma$ $T - 2mg\sin\alpha - F = 2ma$	M1A1 M1A1 (4)
(c)	$F = 0.25R$ $R = 2mg\cos\alpha$ $\cos\alpha = 0.8$ or $\sin\alpha = 0.6$ Eliminating R, F and T $a = 0.4g = 3.92$	B1 B1 B1 M1 A1 (5)
(d)	$v^2 = 2 \times 0.4gh$ $-2mg\sin\alpha - F = 2ma'$ $a' = -0.8g$ $0^2 = 0.8gh - 2 \times 0.8g \times s$ $s = 0.5h$ $XY = 0.5h + h = 1.5h$	M1 M1 A1 M1 A1 A1 (6) **16**

Q8.

Question Number	Scheme	Marks
(a)	$R = 4g\cos\alpha$ $T - 0.5g = 0.5a$ $4g\sin\alpha - T - F = 4a$ (OR: $4g\sin\alpha - F - 0.5g = 4.5a$) $F = \frac{1}{2}R$; $\sin\alpha = \frac{4}{5}$ or $\cos\alpha = \frac{3}{5}$ Eliminating a or finding a Solving for T (must have had an a) $T = \frac{2g}{3}$N or 6.5N or 6.53N	M1 A1 M1 A1 M1 A1 B1; B1 M1 M1 A1 (11)
(b)	Magnitude $= 2T\cos\left(\frac{90-\alpha}{2}\right)$ $= 2 \times \frac{2g}{3} \times \frac{3}{\sqrt{10}}$ (0.94868..) $= 12N$ or $12.4N$ $\left(\frac{4g}{\sqrt{10}}\right)$	M1 A1 **A1 ft on T** A1 (4) **15**