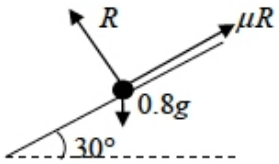
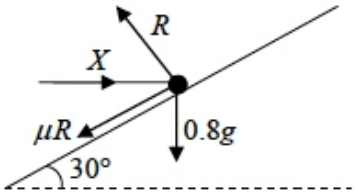
Statics and Dynamics in 2d With Friction (Sheet 2) Mark Scheme

Q1.

Question Number	Scheme	Marks
	(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 2.7 = \frac{1}{2}a \times 9$	M1 A1
	$a = 0.6\,(\text{m s}^{-2})$	A1 (3)
	(b)  $\nwarrow\ R = 0.8g\cos 30°\ (\approx 6.79)$	B1
	Use of $F = \mu R$	B1
	$\swarrow\ 0.8g\sin 30° - \mu R = 0.8 \times a$	M1 A1
	$(0.8g\sin 30° - \mu 0.8g\cos 30° = 0.8 \times 0.6)$	
	$\mu \approx 0.51$ accept 0.507	A1 (5)
	(c) 	
	$\uparrow\ R\cos 30° = \mu R\cos 60° + 0.8g$	M1 A2 (1,0)
	$(R \approx 12.8)$	
	$\rightarrow\ X = R\sin 30° + \mu R\sin 60°$	M1 A1
	Solving for X, $X \approx 12$ accept 12.0	DM1 A1 (7)
		[15]
	Alternative to (c)	
	$\nwarrow\ R = X\sin 30° + 0.8 \times 9.8\sin 60°$	M1 A2 (1,0)
	$\swarrow\ \mu R + 0.8g\cos 60° = X\cos 30°$	M1 A1
	$X = \frac{\mu 0.8g\sin 60° + 0.8g\cos 60°}{\cos 30° - \mu\sin 30°}$	
	Solving for X, $X \approx 12$ accept 12.0	DM1 A1 (7)

Q2.

Question Number	Scheme	Marks
(a)	$R = mg\cos 40$	B1
	Use of $F = \mu R$	B1
	$mg\sin 40 - F = \pm ma$	M1A1
	$acc = 2.55$ (m s^{-2}) or 2.5 (m s^{-2})	A1 (5)
(b)	$v^2 = u^2 + 2as = 2\times a\times 3$ Speed at B is 3.9 (m s^{-1}) or 3.91(m s^{-1})	M1A1 (2)
		[7]

Notes for Question

(Deduct only 1 mark in **whole question** for not giving an answer to either 2 sf or 3 sf, following use of g = 9.8)

Question (a)

First B1 for $R = mg\cos 40°$

Second B1 for $F = \mu R$ seen or implied(can be on diagram)

M1 for resolving parallel to plane, correct no. of terms, mg resolved (F does not need to be substituted)

First A1 for a correct equation

Second A1 for 2.5 (ms^{-2}) or 2.55 (ms^{-2}) Must be **positive.**

S.C. If m is given a specific numerical value, can score max B1B1M1A0A0

Question (b)

M1 is for a complete method for finding speed (usually $v^2=u^2+2as$)

A1 for 3.9 (ms^{-1}) or 3.91(ms^{-1})

Q3.

Question Number	Scheme	Marks
	$12.6^2 = 2a.50 \quad (\Rightarrow a = 1.5876)$	M1 A1
	$800g\sin 15 - F = 800a$	M1 A1
	$R = 800g\cos 15$	M1 A1
	$F = \mu R$	B1
	$800g\sin 15 - \mu 800g\cos 15 = 800 \text{ x } 1.5876$	M1
	$\mu = 0.1, 0.10, 0.100$	A1
		9

Q4.

Question Number	Scheme	Marks
	$0.5g\sin\theta - F = 0.5a$	M1 A1 A1
	$F = \frac{1}{3}R$ seen	B1
	$R = 0.5g\cos\theta$	M1 A1
	Use of $\sin\theta = \frac{4}{5}$ or $\cos\theta = \frac{3}{5}$ or decimal equiv or decimal angle e.g 53.1° or 53°	B1
	$a = \frac{3g}{5}$ or 5.88 m s^{-2} or 5.9 m s^{-2}	DM1 A1 [9]

Q5.

Question Number	Scheme	Marks
(a)	$F = \frac{1}{3}R$	B1
	$(\uparrow)\ R\cos\alpha - F\sin\alpha = 0.4g$	M1 A1
	$R = \frac{2}{3}g = 6.53$ or 6.5	M1 A1 (5)
(b)	$(\rightarrow)P - F\cos\alpha - R\sin\alpha = 0$	M1 A2
	$P = \frac{26}{45}g = 5.66$ or 5.7	M1 A1 (5) [10]

Q6.

Question Number	Scheme	Marks
(a)	R (// plane): $49\cos\theta = 6g\sin 30$	M1 A1
	$\Rightarrow \cos\theta = 3/5$ *	A1 (3)
(b)	R (perp to plane): $R = 6g\cos 30 + 49\sin\theta$	M1 A1
	$R \approx$ 90.1 or 90 N	DM1 A1 (4)
(c)	R (// to plane): $49\cos 30 - 6g\sin 30 = 6a$	M1 A2,1,0
	$\Rightarrow a \approx 2.17$ or 2.2 m s^{-2}	A1 (4)
		11

Q7.

Question	Scheme	Marks	AOs
(a)	$R = mg\cos\alpha$	B1	3.1b
	Resolve parallel to the plane	M1	3.1b
	$-F - mg\sin\alpha = -0.8mg$	A1	1.1b
	$F = \mu R$	M1	1.2
	Produce an equation in μ only and solve for μ	M1	2.2a
	$\mu = \frac{1}{4}$	A1	1.1b
		(6)	
(b)	Compare $\mu mg\cos\alpha$ with $mg\sin\alpha$	M1	3.1b
	Deduce an appropriate conclusion	A1 ft	2.2a
		(2)	
			(8 marks)

Notes:

(a)

B1: for $R = mg\cos\alpha$

1st M1: for resolving parallel to the plane

1st A1: for a correct equation

2nd M1: for use of $F = \mu R$

3rd M1: for eliminating F and R to give a value for μ

2nd A1: for $\mu = \frac{1}{4}$

(b)

M1: comparing size of limiting friction with weight component down the plane

A1ft: for an appropriate conclusion from their values

Q8.

Question	Scheme	Marks	AOs
(a)(i)	Resolve vertically	M1	3.1b
	F acting UP the plane: **OR** F acting DOWN the plane: $(\uparrow) F\sin\alpha + 68.6\cos\alpha = 5g$ $\quad -F\sin\alpha + 68.6\cos\alpha = 5g$ Other possible equations from which X would need to be eliminated to give an equation in F **only** to earn the M mark are shown below. The equation in F **only** must then be correct to earn the A mark. Possible equations: $(\nwarrow) 68.6 = X\sin\alpha + 5g\cos\alpha$ (leads to $X = 49$ with $g = 9.8$) F acting UP the plane: **OR** F acting DOWN the plane: $(\nearrow) F + X\cos\alpha = 5g\sin\alpha$ $\quad -F + X\cos\alpha = 5g\sin\alpha$ $(\rightarrow) F\cos\alpha + X = 68.6\sin\alpha$ $\quad -F\cos\alpha + X = 68.6\sin\alpha$	A1	1.1b
	9.8 (N) (49/5 is A0) **N.B.** If sin and cos are interchanged in all equations, this leads to an answer of 9.8 in the wrong direction and can only score (a) (i)M1A0A0 (ii) A0	A1	1.1b
		(3)	
(a)(ii)	Down the plane (Allow down or downwards or an arrow ↙, but must appear as the answer to (a) (ii) not just on the diagram.)	A1	2.2a
		(1)	
(b)	**N.B.** If they use $R = 68.6$ in this part, the maximum they can score is M1A1M0A0M0A0 If they use $F = 9.8$ or their F from (a) in this part, the maximum they can score is M1A1M0A0M0A0		
	Equation of motion down the plane	M1	2.1
	$5g\sin\alpha - F = 5a$ Allow $(-a)$ instead of a	A1	1.1b
	Resolve perpendicular to the plane	M1	3.1b
	$R = 5g\cos\alpha$	A1	1.1b
	$F = 0.5R$ seen	M1	3.4
	$a = 1.96$ or 2.0 or 2 (m s^{-2}) or $\frac{1}{5}g$	A1	1.1b
		(6)	
			(10 marks)