Applications of Forces - Answers

May 2013 Mathematics Advanced Paper 1: Mechanics 1

1.

Question Number	Scheme	Marks
3.	$T\cos\alpha - F = 2g\cos 60^o$	M1 A1
	$T\sin\alpha + R = 2g\cos 30^o$	M1 A1
	$F = \frac{1}{3}R$	B1
	eliminating F and R	**DM**1
	$T = g(1+\frac{1}{\sqrt{3}})$, 1.6g (or better), 15.5, 15 (N)	**DM**1 A1
		(8)
		[8]
Notes for Question 3		
Q3	First M1 for resolving parallel to the plane with correct no. of terms and both T and $2g$ terms resolved. First A1 for a correct equation. (use of α instead of 30° or 60° or vice versa is an A error not M error; similarly if they use sin(3/5) or cos(4/5) when resolving, this can score M1A0) Second M1 for resolving perpendicular to the plane with correct no. of terms and both T and $2g$ terms resolved. Second A1 for a correct equation (use of α instead of 30° or 60° or vice versa is an A error not M error; similarly if they use sin(3/5) or cos(4/5) when resolving, this can score M1A0) B1 for $F = 1/3\ R$ seen or implied. Third M1, dependent on first two M marks and appropriate angles used when resolving in *both* equations, for eliminating *F and R.* Fourth M1 dependent on third M1, for solving for T Third A1 for 15(N) or 15.5 (N). N.B. The first two M marks can be for two resolutions in any directions. Use of tan α = 4/3 leads to an answer of 17.83…and can score max 7/8.	

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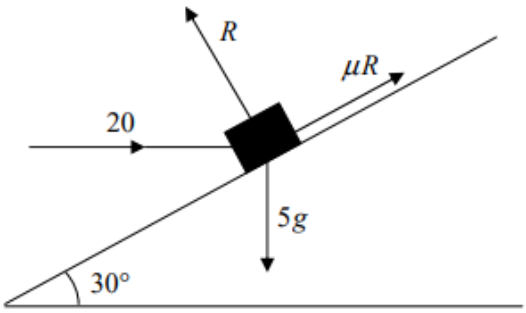
2.

Question Number	Scheme	Marks
3.		
	(a) ⊥ plane $R = 20\cos 60° + 5g\cos 30°$ $= 52.4\ (\text{N})$ or 52	M1 A2(1,0) A1 **(4)**
	(b) $F_r = \mu R$ P plane $F + 20\cos 30° = 5g\cos 60°$ Leading to $\mu = 0.137$ or 0.14	B1 M1 A2(1, 0) A1 **(5)** **[9]**

Question 3(a)

First M1 for resolving perpendicular to plane with usual criteria
First A2 for a correct equation (A1A0 one error, A0A0 for two or more errors)
Second A1 for either 52 or 52.4
N.B. In part (a), the M1 is for a complete method, so they must have sufficient equations to be able to solve for R. The A2 marks are then for *all* the equations.

Question 3(b)

B1 for use of $F=\mu R$ (could just be on diagram)
First M1 (allow if F is used rather than μR) for resolving parallel to the plane with usual criteria
First A2 for a correct equation (A1A0 one error, A0A0 for two or more errors)
Second A1 for either 0.14 or 0.137
N.B. If they resolve vertically AND horizontally, there are max 6 marks available (M1A2, M1A2) for the TWO equations, but if they only have one equation, there are no marks available for that equation.
The marks for the horizontal resolution should be entered first on ePen.

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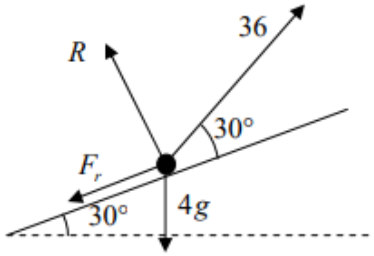
3.

Question Number	Scheme	Marks
8 (a)		
	$R + 36\sin 30° = 4g\cos 30°$	M1 A1
	$R \approx 15.9,\ 16$	M1 A1
		(4)
(b)	Use of $F_r = \mu R$	B1
	$36\cos 30° = F + 4g\sin 30°$	M1 A1
	$\mu = \dfrac{36\cos 30° - 4g\sin 30°}{R} \approx 0.726$	M1 A1
	0.73	
		(5)
(c)	After force is removed	
	$R = 4g\cos 30°$	B1
	$-\mu 4g\cos 30° - 4g\sin 30° = 4a$	M1 A1
	$a = (-)11.06\ldots$	
	$v^2 = u^2 + 2as \Rightarrow 0^2 = 16^2 - 2\times 11.06\ldots \times s$	M1
	$s = \dfrac{16^2}{2\times 11.06\ldots} \approx 11.6 \quad (\text{m})$	A1
	12	
		(5)
		14

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4.

Question Number	Scheme	Marks
3.	↗ $4\cos\alpha + F = W\sin\alpha$ ↖ $R = 4\sin\alpha + W\cos\alpha$ $F = 0.5R$ $\cos\alpha = 0.8$ or $\sin\alpha = 0.6$ $R = 20N$ ** GIVEN ANSWER $W = 22N$	M1 A1 M1 A1 B1 B1 M1 A1 A1 (9)
OR	→ $R\sin\alpha = 4 + F\cos\alpha$ ↑ $R\cos\alpha + F\sin\alpha = W$ $F = 0.5R$ $\cos\alpha = 0.8$ or $\sin\alpha = 0.6$ $R = 20N$ ** GIVEN ANSWER $W = 22N$	M1 A1 M1 A1 B1 B1 M1 A1 A1 (9) **9**

5.

6. **(a)**	$R = 0.3g\cos\alpha$ $= 0.24g = 2.35$ (3sf)=2.4 (2sf)	M1 A1 (2)
(b)	$mg - T = 1.4m$ $T - 0.3g\sin\alpha - F = 0.3 \times 1.4$ $F = 0.5R$ Eliminating R and T $m = 0.4$	M1 A1 M1 A2 M1 **DM**1 A1 (8)
(c)	$v = 1.4 \times 0.5$ $-0.3g\sin\alpha - F = 0.3a$ $a = -9.8$ $0 = 0.7 - 9.8t$ $t = 0.071$ s or 0.0714 s (1/14 A0)	B1 M1 A1 A1 M1 A1 (6) **16**

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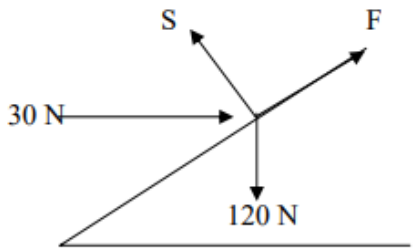
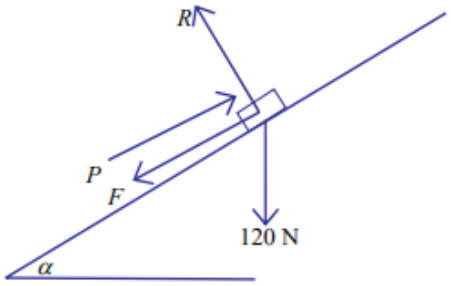
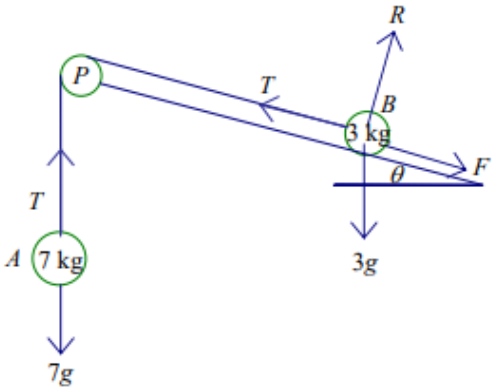
6.

Question Number	Scheme	Marks
6. **(a)**	 Resolving perpendicular to the plane: $S = 120\cos\alpha + 30\sin\alpha$ $= 114$ *	 M1 A1 A1 A1 (4)
(b)	 Resolving perpendicular to the plane: $R = 120\cos\alpha$ $= 96$ $F_{max} = \frac{1}{2}R$ Resolving parallel to the plane: In equilibrium: $P_{max} = F_{max} + 120\sin\alpha$ $= 48 + 72 = 120$	 M1 A1 A1 M1 M1 A(2,1,0) A1 (8)
(c)	$30 + F = 120\sin\alpha$ **OR** $30 - F = 120\sin\alpha$ So $F = 42$N acting up the plane.	M1 A1 A1 (3) **[15]**

7.

Question Number	Scheme	Marks
7. **(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]**

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8.

Q3	$(\rightarrow)\ 100\cos 30 = F$ $F = 0.5\,R$ *seen* $(\downarrow)\ mg + 100\cos 60 = R$ $m = 13$ kg or 12.6 kg	M1 A1 A1 **(B1)** M1 A1 DM1 A1 **[7]**

9.

Q7	(a)	$F = \frac{1}{3}R$ $(\uparrow)\ R\cos\alpha - F\sin\alpha = 0.4g$ $R = \frac{2}{3}g = 6.53$ or 6.5	B1 M1 A1 M1 A1 (5)
	(b)	$(\rightarrow) P - F\cos\alpha - R\sin\alpha = 0$ $P = \frac{26}{45}g = 5.66$ or 5.7	M1 A2 M1 A1 (5) **[10]**

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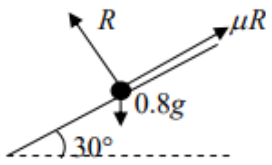
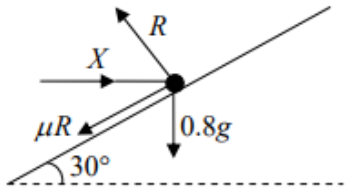
10.

Question Number	Scheme	Marks
Q5.	(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 2.7 = \frac{1}{2}a\times 9$ $a = 0.6\,(\text{m s}^{-2})$	M1 A1 A1 (3)
	(b)  ↖ $R = 0.8g\cos 30°\ (\approx 6.79)$ Use of $F = \mu R$ ↙ $0.8g\sin 30° - \mu R = 0.8\times a$ $(0.8g\sin 30° - \mu 0.8g\cos 30° = 0.8\times 0.6)$ $\mu \approx 0.51$ accept 0.507	B1 B1 M1 A1 A1 (5)

	(c)  ↑ $R\cos 30° = \mu R\cos 60° + 0.8g$ $(R \approx 12.8)$ → $X = R\sin 30° + \mu R\sin 60°$ Solving for X, $X \approx 12$ accept 12.0	M1 A2 (1,0) M1 A1 DM1 A1 (7) **[15]**
	Alternative to (c) ↖ $R = X\sin 30° + 0.8\times 9.8\sin 60°$ ↙ $\mu R + 0.8g\cos 60° = X\cos 30°$ $X = \dfrac{\mu 0.8g\sin 60° + 0.8g\cos 60°}{\cos 30° - \mu\sin 30°}$ Solving for X, $X \approx 12$ accept 12.0	 M1 A2 (1,0) M1 A1 DM1 A1 (7)

11.

Question Number	Scheme	Marks
Q6.	(a) N2L A: $5mg - T = 5m\times\frac{1}{4}g$	M1 A1
	$T = \frac{15}{4}mg$ * cso	A1 (3)
	(b) N2L B: $T - kmg = km\times\frac{1}{4}g$	M1 A1
	$k = 3$	A1 (3)

	(c) The tensions in the two parts of the string are the same	B1	(1)
	(d) Distance of A above ground $s_1 = \frac{1}{2} \times \frac{1}{4} g \times 1.2^2 = 0.18g \left(\approx 1.764\right)$	M1 A1	
	Speed on reaching ground $v = \frac{1}{4} g \times 1.2 = 0.3g \left(\approx 2.94\right)$	M1 A1	
	For B under gravity $\left(0.3g\right)^2 = 2gs_2 \Rightarrow s_2 = \frac{\left(0.3\right)^2}{2} g \left(\approx 0.441\right)$	M1 A1	
	$S = 2s_1 + s_2 = 3.969 \approx 4.0$ (m)	A1	(7)
			[14]