

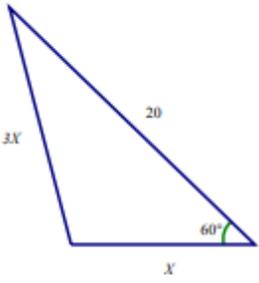
Forces and Friction - Answers

May 2014 Mathematics Advanced Paper 1: Mechanics 1

1.

Question Number	Scheme	Marks
2(a)	$R = mg \cos 40$	B1
	Use of $F = \mu R$	B1
	$mg \sin 40 - F = \pm ma$	M1A1
	$acc = 2.55 \text{ (m s}^{-2}\text{)} \text{ or } 2.5 \text{ (m s}^{-2}\text{)}$	A1 (5)
(b)	$v^2 = u^2 + 2as = 2 \times a \times 3$ Speed at <i>B</i> is $3.9 \text{ (m s}^{-1}\text{)} \text{ or } 3.91 \text{ (m s}^{-1}\text{)}$	M1A1 (2)
		[7]
Notes for Question 2		
(Deduct only 1 mark in whole question for not giving an answer to either 2 sf or 3 sf, following use of $g = 9.8$)		
<p>Question 2(a) First B1 for $R = mg \cos 40^\circ$ 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 $2.5 \text{ (ms}^{-2}\text{)} \text{ or } 2.55 \text{ (ms}^{-2}\text{)}$ Must be positive. S.C. If m is given a specific numerical value, can score max B1B1M1A0A0</p> <p>Question 2(b) M1 is for a complete method for finding speed (usually $v^2 = u^2 + 2as$) A1 for $3.9 \text{ (ms}^{-1}\text{)} \text{ or } 3.91 \text{ (ms}^{-1}\text{)}$</p>		

2.

Question Number	Scheme	Marks
6a	 <p data-bbox="462 619 901 682">Resolve and use Pythagoras $(X - 20\cos 60) ^ 2 + (20\cos 30) ^ 2 = (3X) ^ 2$</p> <p data-bbox="462 745 901 861">$8X^2 + 20X - 400 = 0$ $X = \frac{-5 \pm \sqrt{25 + 800}}{4} = 5.93$ (3 SF)</p>	<p data-bbox="1380 640 1469 682">M1 A1</p> <p data-bbox="1380 745 1510 861">A1 M1A1 (5)</p>
6a alt	<p data-bbox="462 871 982 945">Cosine rule $(3X)^2 = 20^2 + X^2 - 2 \cdot 20X \cos 60$ $8X^2 + 20X - 400 = 0$</p> <p data-bbox="657 976 1063 1050">$X = \frac{-5 \pm \sqrt{25 + 800}}{4} = 5.93$ (3SF)</p>	<p data-bbox="1380 871 1469 945">M1A1 A1</p> <p data-bbox="1380 976 1510 1050">M1A1 (5)</p>
b	<p data-bbox="462 1071 933 1123">$P - Q ^2 = 20^2 + X^2 - 2X \times 20 \times \cos 120$</p> <p data-bbox="462 1134 771 1176">$P - Q = 23.5$ (N) (3SF)</p>	<p data-bbox="1380 1071 1469 1123">M1A1</p> <p data-bbox="1380 1123 1510 1176">DM1 A1 (4)</p>
6b alt	<p data-bbox="462 1197 933 1249">$P - Q ^2 = (X + 20\cos 60) ^ 2 + (20\cos 30) ^ 2$</p> <p data-bbox="462 1249 771 1291">$P - Q = 23.5$ (N) (3SF)</p>	<p data-bbox="1380 1197 1469 1249">M1A1</p> <p data-bbox="1380 1249 1510 1302">DM1 A1 (4)</p>
		[9]

Notes for Question 6

In this question a misquoted Cosine Rule is M0.

The question asks for both answers to 3 SF but only penalise under or over accuracy once in this question.

Question 6(a)

First M1 for a complete method to give an **equation in X only** i.e. producing two components *and* usually squaring and adding and equating to $(3X)^2$ (condone sign errors and consistent incorrect trig. in the components for this M mark **BUT the x -component must be a difference**)

First A1 for a correct unsimplified equation in X only

e.g. allow $(\pm(X - 20\cos 60^\circ))^2 + (\pm(20\cos 30^\circ))^2 = (3X)^2$

Second A1 for any correct fully numerical 3 term quadratic = 0

Second M1(**independent**) for solving a 3 term quadratic

Third A1 for 5.93

Alternative using cosine rule:

First M1 for use of cosine rule with $\cos 60^\circ$ (**M0 if they use 120°**)

First A1 for a correct equation unsimplified e.g. allow $\cos 60^\circ$ and $(3X)^2$

Second A1 for any correct fully numerical 3 term quadratic = 0

Second M1(**independent**) for solving a 3 term quadratic

Third A1 for 5.93

Alternative using 2 applications of the sine rule:

First M1 for using $3X / \sin 60 = X / \sin a$ **AND**

Either: $X / \sin a = 20 / \sin (120^\circ - a)$

Or: $3X / \sin 60^\circ = 20 / \sin (120^\circ - a)$

(These could be in terms of b where $b = (120^\circ - a)$)

First A1 for two correct equations

Second A1 for $a = 16.778..^\circ$ (or $b = 103.221..^\circ$)

Second M1 for solving:

$$X / \sin a = 20 / \sin (120^\circ - a) \text{ or } 3X / \sin 60^\circ = 20 / \sin (120^\circ - a)$$

with their a or b to find X

Third A1 for 5.93

Question 6(b)

First M1 for use of cosine rule unsimplified with $\cos 120^\circ$ (**M0 if they use 60°**)

First A1 for a correct expression for $|P - Q|$ in terms of X (does not need to be substituted)

Second M1, **dependent on first M1**, for *substituting for their X and solving for $|P - Q|$*

Second A1 for 23.5

Alternative using components:

First M1 for a complete method i.e. producing two components *and* squaring and adding (no square root needed) (condone sign errors and consistent incorrect trig. in the components for this M mark **BUT the x -component must be a sum**)

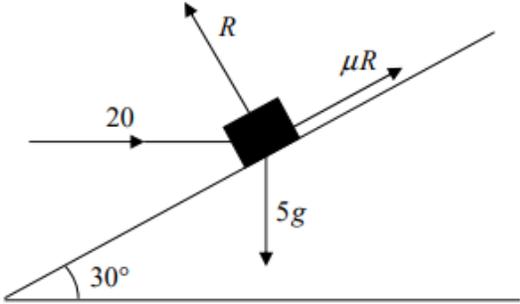
First A1 for a correct expression for $|P - Q|$

(e.g. allow $(\pm(X + 20\cos 60^\circ))^2 + (\pm(20\cos 30^\circ))^2$)

Second M1, **dependent on first M1**, for *substituting for their X and solving for $|P - Q|$*

Second A1 for 23.5

3.

Question Number	Scheme	Marks
3.	<div style="text-align: center;">  </div> <p>(a) \perp plane $R = 20 \cos 60^\circ + 5g \cos 30^\circ$ $= 52.4 \text{ (N)}$ or 52</p> <p>(b) P plane $F_r = \mu R$ $F + 20 \cos 30^\circ = 5g \cos 60^\circ$ Leading to $\mu = 0.137$ or 0.14</p>	<p>M1 A2(1,0) A1 (4)</p> <p>B1 M1 A2(1, 0) A1 (5) [9]</p>

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

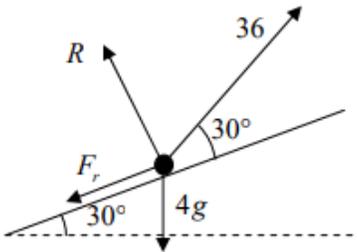
First A2 for a correct equation (A1A0 one error, A0A0 for two or more errors)

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.

4.

Question Number	Scheme	Marks
<p>8 (a)</p>	 $R + 36 \sin 30^\circ = 4g \cos 30^\circ$ $R \approx 15.9, 16$	<p>M1 A1 M1 A1 (4)</p>
<p>(b)</p>	<p>Use of $F_r = \mu R$</p> $36 \cos 30^\circ = F + 4g \sin 30^\circ$ $\mu = \frac{36 \cos 30^\circ - 4g \sin 30^\circ}{R} \approx 0.726$ <p style="text-align: right;">0.73</p>	<p>B1 M1 A1 M1 A1 (5)</p>
<p>(c)</p>	<p>After force is removed</p> $R = 4g \cos 30^\circ$ $-\mu 4g \cos 30^\circ - 4g \sin 30^\circ = 4a$ $a = (-)11.06 \dots$ $v^2 = u^2 + 2as \Rightarrow 0^2 = 16^2 - 2 \times 11.06 \dots \times s$ $s = \frac{16^2}{2 \times 11.06 \dots} \approx 11.6 \text{ (m)}$ <p style="text-align: right;">12</p>	<p>B1 M1 A1 M1 A1 (5) 14</p>

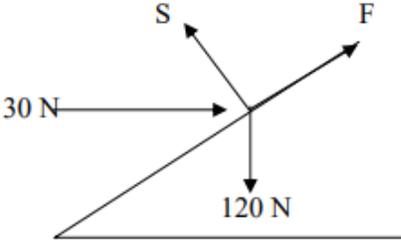
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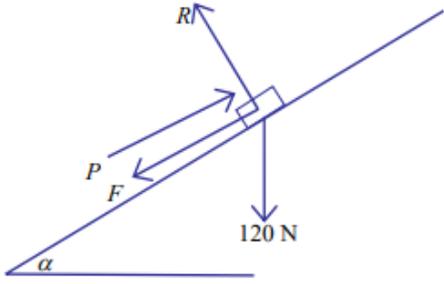
5.

Question Number	Scheme	Marks
<p>3.</p> <p><u>OR</u></p>	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>↗ $4 \cos \alpha + F = W \sin \alpha$ ↖ $R = 4 \sin \alpha + W \cos \alpha$ $F = 0.5R$ $\cos \alpha = 0.8$ or $\sin \alpha = 0.6$ $R = 20\text{N}$ ** GIVEN ANSWER $W = 22\text{N}$</p> </div> <div style="width: 45%;"> <p>→ $R \sin \alpha = 4 + F \cos \alpha$ ↑ $R \cos \alpha + F \sin \alpha = W$ $F = 0.5R$ $\cos \alpha = 0.8$ or $\sin \alpha = 0.6$ $R = 20\text{N}$ ** GIVEN ANSWER $W = 22\text{N}$</p> </div> </div>	<p>M1 A1 M1 A1 B1 B1 M1 A1 A1 (9)</p> <p>M1 A1 M1 A1 B1 B1 M1 A1 A1 (9)</p> <p>9</p>

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6.

Question Number	Scheme	Marks
<p>6.</p> <p>(a)</p>	<div style="text-align: center;">  </div> <p>Resolving perpendicular to the plane: $S = 120 \cos \alpha + 30 \sin \alpha$ $= 114$ *</p>	<p>M1 A1 A1 A1 (4)</p>

<p>(b)</p>	 <p>Resolving perpendicular to the plane: $R = 120 \cos \alpha$ $= 96$ $F_{\max} = \frac{1}{2} R$</p> <p>Resolving parallel to the plane: In equilibrium: $P_{\max} = F_{\max} + 120 \sin \alpha$ $= 48 + 72 = 120$</p>	<p>M1 A1 A1 M1 M1 A(2,1,0) A1 (8)</p>
<p>(c)</p>	<p>$30 + F = 120 \sin \alpha$ OR $30 - F = 120 \sin \alpha$</p> <p>So $F = 42\text{N}$ acting up the plane.</p>	<p>M1 A1 A1 (3) [15]</p>

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7.

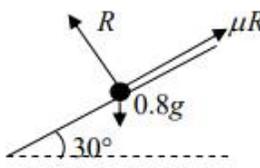
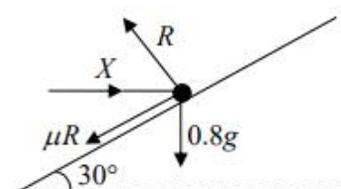
<p>Q3</p>	<p>(\rightarrow) $100 \cos 30 = F$ $F = 0.5 R$ seen</p> <p>(\downarrow) $mg + 100 \cos 60 = R$ $m = 13 \text{ kg}$ or 12.6 kg</p>	<p>M1 A1 A1 (B1) M1 A1 DM1 A1 [7]</p>
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8.

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

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9.

Question Number	Scheme	Marks	
Q5.	(a)	$s = ut + \frac{1}{2}at^2 \Rightarrow 2.7 = \frac{1}{2}a \times 9$ $a = 0.6 \text{ (m s}^{-2}\text{)}$	M1 A1 A1 (3)
	(b)	 $R = 0.8g \cos 30^\circ (\approx 6.79)$ Use of $F = \mu R$ $0.8g \sin 30^\circ - \mu R = 0.8 \times a$ $(0.8g \sin 30^\circ - \mu 0.8g \cos 30^\circ = 0.8 \times 0.6)$ $\mu \approx 0.51 \quad \text{accept } 0.507$	B1 B1 M1 A1 A1 (5)
	(c)	 $\uparrow R \cos 30^\circ = \mu R \cos 60^\circ + 0.8g$ $(R \approx 12.8)$ $\rightarrow X = R \sin 30^\circ + \mu R \sin 60^\circ$ Solving for X, $X \approx 12 \quad \text{accept } 12.0$	M1 A2 (1,0) M1 A1 DM1 A1 (7) [15]

Alternative to (c)

$$\swarrow R = X \sin 30^\circ + 0.8 \times 9.8 \sin 60^\circ$$

$$\swarrow \mu R + 0.8g \cos 60^\circ = X \cos 30^\circ$$

$$X = \frac{\mu 0.8g \sin 60^\circ + 0.8g \cos 60^\circ}{\cos 30^\circ - \mu \sin 30^\circ}$$

Solving for X , $X \approx 12$ accept 12.0

M1 A2 (1,0)
M1 A1

DM1 A1 (7)