



eClassroom

A-LEVEL MATHEMATICS • MECHANICS 1

Statics of a Particle

Worked Solutions

Pearson Edexcel International A Level (WME01) & A Level (9MA0) • Calculator and statistical tables allowed: take $g = 9.8 \text{ m s}^{-2}$ and give answers to 2 or 3 s.f.

Full worked solutions for the free Statics of a Particle worksheet, A-Level and International A-Level Maths



Tap a section to jump straight to it

Full worked solutions for every question on the Mechanics 1 Statics of a Particle worksheet, in the same order and with the same question numbers.

How to mark your work. Tick each step you got right, not just the final answer. At A-level most marks are for method, so a wrong final answer can still earn most of the marks. If you lost marks, find the *first* line where your working is different from ours. That is the thing to fix.

In Section E: **M** = method mark, **dm** = method mark that depends on the previous M mark, **A** = accuracy mark (needs the M mark before it), **B** = independent mark.

Question sheet

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A**Your turn answers**

Compare each line of your working with the solution.

CORE

A1 The strings are perpendicular: $50 \sin 50^\circ$, $50 \sin 40^\circ$: **38.3 N (at 50°), 32.1 N (at 40°)**

A2 $\mathbf{F} = -(5\mathbf{i} - 11\mathbf{j})$: **$-5\mathbf{i} + 11\mathbf{j}$, 12.1 N**

A3 $2g \tan 25^\circ$, $\frac{2g}{\cos 25^\circ}$: **$H = 9.14 \text{ N}$, $R = 21.6 \text{ N}$**

STRETCH

A4 $20 = \mu(7g)$: **$\mu = 0.292$**

A5 $\tan 32^\circ$: **0.625**

A6 $4g(\sin 40^\circ - 0.4 \cos 40^\circ)$: **13.2 N**

A7 Resultant $5\mathbf{i} - 12\mathbf{j}$, 13 N; the balancing force is $-5\mathbf{i} + 12\mathbf{j}$: **13 N on a bearing of 337°**

B**Fluency solutions**

One mark for each correct part. The notes in italics explain why each sequence was chosen.

CORE

B1 (a) $8g \sin 35^\circ$: **45.0 N** (b) $8g \sin 55^\circ$: **64.2 N** (c) $\frac{100}{\sin 55^\circ}$: **122 N** (d) **12.5 kg**

The steeper string carries more; it reaches 100 N first.

B2 (a) **$p = 2$** (b) **$q = 2$** (c) $|-4\mathbf{i} + 2\mathbf{j}|$: **4.47 N** (d) $|2\mathbf{i} + 3\mathbf{j}|$: **3.61 N**

Removing a force leaves a resultant equal and opposite to it.



B3 (a) $6g \sin 20^\circ$: **20.1 N** (b) $6g \cos 20^\circ$: **55.3 N** (c) $6g \tan 20^\circ$: **21.4 N** (d) $\frac{6g}{\cos 20^\circ}$: **62.6 N**

A horizontal force pushes into the plane, so R is larger.

B4 (a) $98 - 30 \sin 25^\circ$: **85.3 N** (b) $30 \cos 25^\circ$: **27.2 N** (c) $\frac{27.19}{85.32}$: **0.319** (d) **20 N**

With 20 N horizontally, friction only needs to match the pull.

CORE

B5 (a) $3g \sin 20^\circ$: **10.1 N** (b) $0.5(3g \cos 20^\circ)$: **13.8 N** (c) **$10.1 < 13.8$**

Friction is only as large as it needs to be.

B6 (a) **17.0 N** (b) **4.24 N** (c) $9.8 - 4.24$: **5.56 N** (d) $9.8 + 4.24$: **14.0 N**

Friction acts up the slope at the least P , and down it at the greatest.

STRETCH

B7 (a) $\cos^{-1} \frac{3}{5}$: **53.1°** (b) $30 \sin 53.13^\circ$: **24 N** (c) $30 \sin 36.87^\circ$: **18 N** (d) $3 \sin 53.13^\circ$: **2.4 m**

A 3-4-5 triangle has a right angle at P , so the strings are perpendicular.

B8 (a) $\frac{5g(\sin 25^\circ - 0.2 \cos 25^\circ)}{\cos 25^\circ + 0.2 \sin 25^\circ}$: **11.9 N** (b) $\frac{5g(\sin 25^\circ + 0.2 \cos 25^\circ)}{\cos 25^\circ - 0.2 \sin 25^\circ}$: **36.0 N**

(c) $5g \cos 25^\circ + 36.0 \sin 25^\circ$: **59.6 N** (d) $5g \sin 25^\circ - 20 \cos 25^\circ$: **2.58 N up the plane**

H also pushes into the plane, so R changes with H

B9 (a) $\sqrt{100 + 36}$: **11.7 N** (b) $180^\circ + \tan^{-1} \frac{6}{10}$: **211°** (c) **6 N due east** (d) $\frac{6}{0.5}$: **12 ms^{-2}**

The balancing force is opposite to the resultant of the other two.

B10 (a) $4g \sin 30^\circ$: **19.6 N** (b) $Mg = 19.6$: **2** (c) $4g \cos 30^\circ$: **33.9 N** (d) $2(19.6) \cos 30^\circ$: **33.9 N**

The two parts of the string meet at 60° at the pulley.



C

Reasoning solutions

Your wording can be different. Check that your reason makes the same point.

CORE

- C1 The string's vertical component supports part of the weight: $R = mg - T \sin \theta$
- C2 In equilibrium $a = 0$: **the resultant force is zero**.
- C3 $F = \mu R$ only when limiting; otherwise $F < \mu R$, and F is found by resolving.
- C4 At the greatest P the particle is about to move up, so **friction acts down the plane**.

STRETCH

- C5 At rest, the friction needed is at most the friction available: $P \cos \alpha \leq \mu R$
- C6 The weight is $2g$, not 2: $2g \sin 30^\circ = \mathbf{9.8 \text{ N}}$
- C7 The vertical side is opposite the angle: $10 \sin 30^\circ = \mathbf{5 \text{ N}}$
- C8 (a) Resolve along each string: the other string has no component there, so $T_1 = W \sin \theta$, $T_2 = W \cos \theta$
 (b) For $\theta > 45^\circ$, $\sin \theta > \cos \theta$: **the string at θ (the steeper one)**

D

Problem solving solutions

There is often more than one correct method. Any complete, correct method scores full marks.

CORE

- D1 Smooth ring: same tension both parts. Horizontal: $T \cos \theta = 3$, so $T = 3 \cdot \frac{13}{12}$: $\mathbf{3.25 \text{ N}}$
 Vertical: $T + T \sin \theta = mg$, so $3.25 \left(1 + \frac{5}{13}\right) = 4.5$: $\mathbf{0.459 \text{ kg}}$



D2 (a) $\mathbf{F}_3 = (9 - 2c)\mathbf{i} + (c - 13)\mathbf{j}$

(b) $(6\mathbf{i} - 3\mathbf{j}) + (-9\mathbf{i} + 13\mathbf{j}) = -3\mathbf{i} + 10\mathbf{j}$: $10.4 \text{ N}, 106.7^\circ$

D3 (a) $T = 2g(\sin 25^\circ - 0.3 \cos 25^\circ)$: 2.95 N

(b) $\tan 25^\circ = 0.466 > 0.3$: friction cannot hold it alone

D4 $R = W + \frac{3}{5}P$; at rest $\frac{4}{5}P \leq \frac{1}{3}(W + \frac{3}{5}P)$, so $\frac{12}{5}P \leq W + \frac{3}{5}P$: $P \leq \frac{5}{9}W$

STRETCH

D5 (a) About to slip down: $H \cos \alpha + 0.2R = 3g \sin \alpha$, $R = 3g \cos \alpha + H \sin \alpha$

$H(\frac{12}{13} + 0.2 \cdot \frac{5}{13}) = 3g(\frac{5}{13} - 0.2 \cdot \frac{12}{13})$: $H = 5.88$

(b) $3g \cdot \frac{12}{13} + 5.88 \cdot \frac{5}{13}$: 29.4 N

D6 $R = 0.6T$. About to slip down: $0.8T + 0.5(0.6T) = 0.5g$, $T = 4.45$; about to slip up: $0.8T - 0.3T = 0.5g$, $T = 9.8$

$4.45 \leq T \leq 9.8$

D7 (a) $mg = 0.35(5g)$: $m = 1.75$

(b) $1g < 0.35(5g)$, so not limiting: 9.8 N

D8 (a) $W(\sin 30^\circ - 0.4 \cos 30^\circ) \leq P \leq W(\sin 30^\circ + 0.4 \cos 30^\circ)$: $0.154W \leq P \leq 0.846W$

(b) $P = W \sin 30^\circ$: $\frac{1}{2}W$

E

Exam practice solutions

Mark-scheme notes are shown on the right of each line.



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CORE

Exam questions for everyone

- E1** (a) Horizontal: $T_1 \cos 20^\circ = T_2 \cos 50^\circ$ M1 A1
 Vertical: $T_1 \sin 20^\circ + T_2 \sin 50^\circ = 4g$ M1 A1
 $T_1 = 26.8 \text{ N}, T_2 = 39.2 \text{ N}$ A1
 (b) Tensions are proportional to the weight: $T_1 = 0.684W, T_2 = W$ M1
 $0.684W \leq 30$ gives $W \leq 43.9; W \leq 50$ M1
 4.48 kg A1

- E2** (a) $\tan 15^\circ = 0.268 < 0.4$ M1
 $\text{friction can hold it at rest}$ A1
 (b) $R = 20g \cos 15^\circ - T \sin 20^\circ$ M1 A1
 $T \cos 20^\circ = 20g \sin 15^\circ + 0.4R$ M1 A1
 $T = 117 \text{ N}$ A1
 (c) $20g \cos 15^\circ - 117.5 \sin 20^\circ$ M1
 149 N A1

STRETCH

- E3** (a) $-(\mathbf{F}_1 + \mathbf{F}_2) = -(2\mathbf{i} + 9\mathbf{j})$ M1
 $-2\mathbf{i} - 9\mathbf{j}$ A1
 (b) $\sqrt{85}: 9.22 \text{ N}; \tan^{-1} \frac{2}{9}: 12.5^\circ$ B1 B1
 (c) $\mathbf{F}_1 + \mathbf{F}_3 = 2\mathbf{i} - 6\mathbf{j}, \mathbf{a} = \mathbf{i} - 3\mathbf{j}$ M1
 3.16 ms^{-2} A1
 (d) $\frac{10}{3.162}$ M1
 3.16 s A1
 (e) $\frac{1}{2}(3.162)(16)$ M1
 25.3 m A1

