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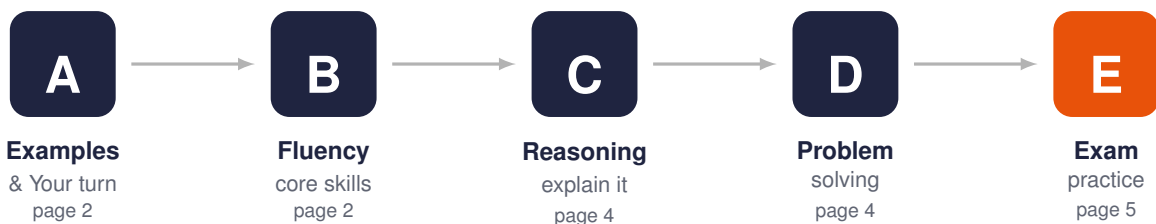
A-LEVEL MATHEMATICS • MECHANICS 1

Dynamics 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 Dynamics 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 Dynamics 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

Exam questions by topic

Mechanics 1 exam questions

More worksheets



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A**Your turn answers**

Compare each line of your working with the solution.

CORE

A1 $50 - 18 = 8a$: $a = 4 \text{ ms}^{-2}$

A2 Downwards: $5g - T = 5(1.5)$: $T = 41.5 \text{ N}$

A3 $\mathbf{a} = \frac{1}{4}(12\mathbf{i} + 5\mathbf{j}) = 3\mathbf{i} + 1.25\mathbf{j}$: 3.25 ms^{-2}

STRETCH

A4 $1700 = 1500a$: $a = 1.13 \text{ ms}^{-2}$; $T = 50 + 400(1.133)$: $T = 503 \text{ N}$

A5 $4g = 8a$: $a = 4.9 \text{ ms}^{-2}$; $T = 2(9.8 + 4.9)$: $T = 29.4 \text{ N}$

A6 $2g = 8a$: $a = 2.45 \text{ ms}^{-2}$; $T = 6(2.45)$: $T = 14.7 \text{ N}$

A7 Downwards: $mg - R = ma$; $R = 80(9.8 - 0.8)$: 720 N

B**Fluency solutions**One mark for each correct part. The notes in *italics* explain why each sequence was chosen.**CORE**

B1 (a) $\frac{15}{2.5}$: 6 ms^{-2} (b) 18 ms^{-1} (c) $5 + 2.5(10)$: 30 N (d) $20 - 2.5(4)$: 10 N

The same equation, solved for a different unknown each time.

B2 (a) 490 N (b) $50(10.4)$: 520 N (c) $50(9.2)$: 460 N (d) $\frac{600 - 490}{50}$: 2.2 ms^{-2} up

The tension is more than the weight only when the acceleration is upwards.

B3 (a) $(6\mathbf{i} + 4\mathbf{j}) \text{ N}$ (b) $p = 2, q = 7$ (c) $\sqrt{13}: 3.61 \text{ ms}^{-2}$ (d) 33.7°

ma gives the resultant; subtract the known force.

B4 (a) $\frac{2800 - 480}{1600}: 1.45 \text{ ms}^{-2}$ (b) $180 + 600(1.45): 1050 \text{ N}$ (c) 480 N (d) 180 N

At constant speed the towbar only balances the caravan's resistance.

CORE

B5 (a) $\frac{g}{9}: 1.09 \text{ ms}^{-2}$ (b) $4(9.8 + 1.089): 43.6 \text{ N}$ (c) $2T: 87.1 \text{ N}$

Both parts of the string pull down on the pulley.

B6 (a) $460(10.3): 4740 \text{ N}$ (b) $60(10.3): 618 \text{ N}$ (c) 588 N (d) $60(9.3): 558 \text{ N}$

Rising but slowing means the acceleration is downwards.

STRETCH

B7 (a) $\frac{3g - 4.9}{8}: 3.06 \text{ ms}^{-2}$ (b) $3(9.8 - 3.0625): 20.2 \text{ N}$ (c) $\sqrt{2(3.0625)(0.8)}: 2.21 \text{ ms}^{-1}$

(d) A decelerates at $\frac{4.9}{5} = 0.98: \frac{2.21^2}{1.96}: 2.5 \text{ m}$

Once B lands the string goes slack and only the resistance acts on A

B8 (a) $\frac{g}{5}: 1.96 \text{ ms}^{-2}$ (b) $1.96(2): 3.92 \text{ ms}^{-1}$ (c) $\frac{3.92^2}{2g}: 0.784 \text{ m}$ (d) 9.8 ms^{-2}

After the break each particle moves freely under gravity.

B9 (a) $\frac{18}{6}: 3 \text{ ms}^{-2}$ (b) $4(3): 12 \text{ N}$ (c) $\frac{18 \cos 30^\circ}{6}: 2.60 \text{ ms}^{-2}$ (d) $4(2.598): 10.4 \text{ N}$

Only the horizontal component of the pull accelerates the particles.

B10 (a) $\frac{30 - 5}{5}: 5 \text{ ms}^{-2}$ (b) $3 + 3(5): 18 \text{ N}$ (c) 18 N backwards (d) $3 + 3(7): 24 \text{ N}$

Newton's third law: equal and opposite.



C

Reasoning solutions

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

CORE

C1 g belongs in the weight only, not in ma : $50 - 4g = 4a$: $a = 2.7 \text{ ms}^{-2}$

C2 An equation for one particle uses that particle's mass only: $3g - T = 3a$

C3 The tension pulls it back, so $a < g$: $g = 5a$: $a = 1.96 \text{ ms}^{-2}$

C4 A magnitude is a number: $\sqrt{36 + 64} = 10 \text{ ms}^{-2}$

STRETCH

C5 Both parts of the string pull down on the pulley: $2 \times 36 = 72 \text{ N}$

C6 A negative tension means the towbar pushes: **it is a thrust of 650 N** on the trailer, slowing it down.

C7 After the break the string exerts no force; the particle **decelerates at $g = 9.8 \text{ ms}^{-2}$** until it stops, then falls.

C8 (a) $m_2g - T = m_2a$ and $T - m_1g = m_1a$; add: $a = \frac{(m_2 - m_1)g}{m_1 + m_2}$

(b) $T = m_1(g + a) = m_1g \cdot \frac{(m_1 + m_2) + (m_2 - m_1)}{m_1 + m_2} = \frac{2m_1m_2g}{m_1 + m_2}$

D

Problem solving solutions

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

CORE

D1 Whole system, up positive: $60 - 8g = 8a$, so $a = -2.3$: **2.3 ms^{-2} downwards**

Q: $T - 5g = 5(-2.3)$: **$T = 37.5 \text{ N}$**



D2 (a) Perpendicular to motion: $120 \sin 30^\circ = 90 \sin \alpha$, $\sin \alpha = \frac{2}{3}$: $\alpha = 41.8$

(b) $120 \cos 30^\circ + 90 \cos 41.8^\circ - 50 = 80a$: $a = 1.51 \text{ ms}^{-2}$

D3 $a = \frac{20-8}{30} = 0.4$; $D - 1500 = 3000(0.4)$: 2700 N

D4 $2g = 10a$: $a = 1.96 \text{ ms}^{-2}$; $T = 4(9.8 + 1.96)$: 47.0 N ; $2T$: 94.1 N

STRETCH

D5 (a) $2g = 5a$: $a = 3.92 \text{ ms}^{-2}$, $T = 11.8 \text{ N}$

(b) $\sqrt{2(3.92)(0.6)}$: 2.17 ms^{-1}

(c) The string is slack; the table is smooth, so constant speed: $\frac{1.2}{2.169}$: 0.553 s

D6 (a) $2400 - 400 = 1600a$: 1.25 ms^{-2}

(b) Trailer: $T - 100 = 400(1.25)$: 600 N

D7 (a) $6100 - 575g = 575a$: 0.809 ms^{-2}

(b) Man only: $R - 75g = 75(0.809)$: 796 N

D8 (a) $g = 5a$: 1.96 ms^{-2} (b) $1.96(1.2)$: 2.35 ms^{-1}

(c) $\frac{2.352^2}{2g}$: 0.282 m (d) $0 = 2.352t - 4.9t^2$: 0.48 s

E

Exam practice solutions

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



CORE

Exam questions for everyone

- E1** (a) $T - 1.5g = 1.5a$ M1 A1
- (b) $Q: 2.5g - T = 2.5a$; add: $g = 4a$ M1 A1
- $a = 2.45 \text{ ms}^{-2}, T = 18.4 \text{ N}$ A1
- (c) $2T: 36.8 \text{ N}$ B1
- (d) $v^2 = 2(2.45)(1.25) = 6.125$ M1 A1
 then free fall for 0.75 m: $v^2 = 6.125 + 2(9.8)(0.75)$ M1
 4.56 ms^{-1} A1

- E2** (a) $2g - T = 2a$ and $T - 7.84 = 4a$ M1 A1
- $19.6 - 7.84 = 6a: a = 1.96 \text{ ms}^{-2}$ A1
- (b) $2(9.8 - 1.96): 15.7 \text{ N}$ B1
- (c) $v^2 = 2(1.96)(1)$ M1
 1.98 ms^{-1} A1
- (d) A decelerates at $\frac{7.84}{4} = 1.96$; distance $\frac{3.92}{3.92} = 1 \text{ m}$ M1 A1
 $1 + 1 = 2 < 2.5: A \text{ stops before the pulley}$ A1
- (e) $\frac{1.98}{1.96} + \frac{1.98}{1.96}$ M1
 2.02 s A1

STRETCH

- E3** (a) $4200 - 800 = 3400a$ M1
 $a = 1 \text{ ms}^{-2}$ A1
- (b) $B: T_2 - 150 = 600; A: T_1 - 250 - T_2 = 800$ M1
 $T_2 = 750 \text{ N}, T_1 = 1800 \text{ N}$ A1 A1
- (c) $-(F + 800) = 3400(-1.5)$ M1
 $F = 4300 \text{ N}$ A1
- (d) B needs $600(1.5) = 900 \text{ N}$ backwards; resistance gives 150 M1
 $a \text{ thrust of } 750 \text{ N}$ A1
- (e) $0 = 144 - 2(1.5)s$ M1
 48 m A1
- (f) e.g. $\text{the couplings are light and stay horizontal; the resistances are constant}$ B1 B1

