Elite Mathematics
Edexcel International A Level

IAL MECHANICS 1 · WME01

WME01/01 January 2026 Worked Solutions

January 2026 paper rebuilt with the worked solution after each question.

7	2019–2026	Single-paper solutions
paper questions	18 exam sessions	checked by Dr Eslam



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PAST PAPER

WME01/01 January 2026

January 2026

7	75	1 h 30
questions	marks	exam time

Each question is followed by its worked solution and final answer.

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Question 1

6 marks | Momentum, Impulse & Collisions

1. A particle P of mass $3m$ and a particle Q of mass $5m$ are on a smooth horizontal surface. The particles move towards each other in opposite directions along the same straight line and collide.

Immediately before the collision, the speed of P is $3u$ and the speed of Q is $4u$

The magnitude of the impulse exerted on P by Q in the collision is $\frac{33}{2}mu$

Find

(i) the speed of P immediately after the collision,

(ii) the speed of Q immediately after the collision.

(6)

WORKED SOLUTION

Question 1 · WME01/01 January 2026

1 Choose a sign convention

Take the initial direction of P as positive. Then before impact, $v_P = 3u$ and $v_Q = -4u$. The impulse on P acts opposite to P\'s initial motion, so its signed impulse is $-\frac{33}{2}mu$.

2 Use impulse on P

For P, impulse equals change in momentum: $-\frac{33}{2}mu = 3m(v_P - 3u)$. Dividing by $3m$ gives $v_P - 3u = -\frac{11u}{2}$, so $v_P = -\frac{5u}{2}$.

3 Interpret the speed of P

The negative sign means P has reversed direction. Its speed is therefore $\left|-\frac{5u}{2}\right| = \frac{5u}{2}$.

4 Use the equal and opposite impulse on Q

Q receives impulse $+\frac{33}{2}mu$ in the positive direction. Hence $\frac{33}{2}mu = 5m(v_Q - (-4u)) = 5m(v_Q + 4u)$.

5 Interpret the speed of Q

Dividing by $5m$ gives $v_Q + 4u = \frac{33u}{10}$, so $v_Q = -\frac{7u}{10}$. Q is still moving in its original direction, and its speed is $\frac{7u}{10}$.

FINAL ANSWER

(i) speed of $\mathrm{P} = \dfrac{5u}{2}$. $\quad (ii)$ speed of $\mathrm{Q} = \dfrac{7u}{10}$.

Question 2

10 marks | Kinematics Graphs

2.

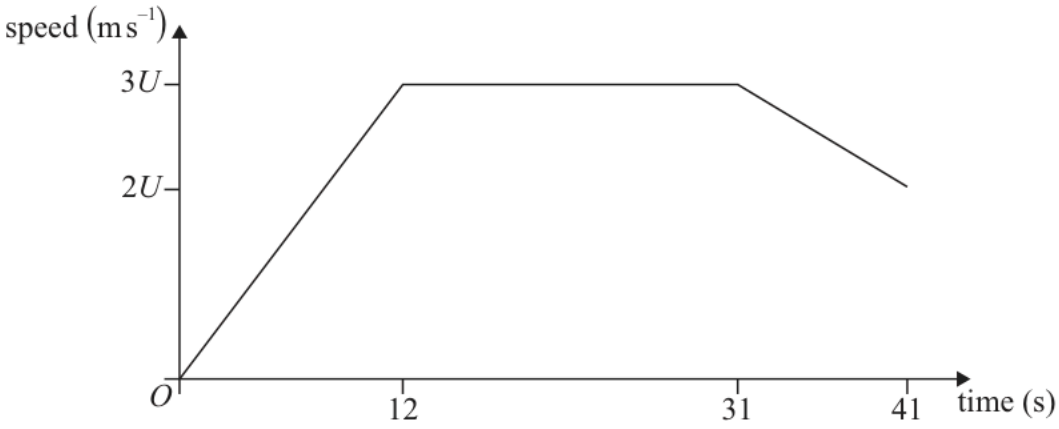


Figure 1

A particle P starts from rest at time $t = 0$ and moves in a straight line

- from $t = 0$ to $t = 12\,\text{s}$, P accelerates uniformly until it reaches a speed of $3U\,\text{m s}^{-1}$
- from $t = 12\,\text{s}$ to $t = 31\,\text{s}$, P moves with constant speed $3U\,\text{m s}^{-1}$
- from $t = 31\,\text{s}$ to $t = 41\,\text{s}$, P decelerates uniformly until it has speed $2U\,\text{m s}^{-1}$

as shown on the speed-time graph in Figure 1.

The distance travelled by P between $t = 0$ and $t = 41\,\text{s}$ is 600 m.

(a) Show that $U = 6$

(3)

(b) Find the distance travelled by P whilst moving from rest to a speed of $6\,\text{m s}^{-1}$

(2)

(c) Find the acceleration of P between $t = 0$ and $t = 12\,\text{s}$.

(1)

(d) Find the deceleration of P between $t = 31\,\text{s}$ and $t = 41\,\text{s}$.

(2)

(e) Sketch an acceleration-time graph to represent the motion of P from $t = 0$ to $t = 41\,\text{s}$.

(2)

1 Use area under the speed-time graph

Distance is the area under a speed-time graph. The three areas are a triangle from 0 to 12, a rectangle from 12 to 31, and a trapezium from 31 to 41.

2 Show that U is 6

$\frac{1}{2}(12)(3U) + 19(3U) + \frac{1}{2}(3U + 2U)(10) = 600$. This gives $18U + 57U + 25U = 600$, so $100U = 600$ and $U = 6$.

3 Find the distance to speed 6

Since $U = 6$, the final speed $6\ \text{m s}^{-1}$ occurs during the first section. The acceleration there is $\frac{18 - 0}{12} = 1.5\ \text{m s}^{-2}$, so the time to reach 6 is 4 s. The distance is $\frac{1}{2}(4)(6) = 12\ \text{m}$.

4 Find the acceleration and deceleration

From 0 to 12, $a = \frac{18}{12} = 1.5\ \text{m s}^{-2}$. From 31 to 41, the speed falls from 18 to 12, so the deceleration is $\frac{18 - 12}{10} = 0.6\ \text{m s}^{-2}$.

5 Describe the acceleration-time graph

The acceleration-time graph has three horizontal sections: 1.5 from $0 \leq t \leq 12$, 0 from $12 < t \leq 31$, and -0.6 from $31 < t \leq 41$.

FINAL ANSWER

$(a)\ U = 6.$ $(b)\ 12\ \text{m}.$ $(c)\ 1.5\ \text{m s}^{-2}.$ $(d)\ 0.6\ \text{m s}^{-2}.$ $(e)\ a(t) = 1.5, 0, -0.6$ on the three intervals.

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Question 3

8 marks | Forces

3. A particle moves on a smooth horizontal plane under the action of three horizontal forces, $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$, where

$$\mathbf{F}_1 = (2p\mathbf{i} - 3p\mathbf{j})\text{N}$$

$$\mathbf{F}_2 = (q\mathbf{i} + \mathbf{j})\text{N}$$

$$\mathbf{F}_3 = (3\mathbf{i} - q\mathbf{j})\text{N}$$

where p and q are constants.

The resultant force acts in the direction of the vector $(4\mathbf{i} - 5\mathbf{j})$

(a) Show that

$$2p - q = 19$$

(4)

The mass of the particle is 0.5 kg.

Given that $p = 7$

(b) find the acceleration of the particle.

(4)

WORKED SOLUTION

Question 3 · WME01/01 January 2026

1 Add the three forces

The resultant force is $(2p\mathbf{i} - 3p\mathbf{j}) + (q\mathbf{i} + \mathbf{j}) + (3\mathbf{i} - q\mathbf{j}) = (2p + q + 3)\mathbf{i} + (-3p + 1 - q)\mathbf{j}$.

2 Use the direction vector

The resultant acts in the direction $4\mathbf{i} - 5\mathbf{j}$, so the ratio of the components is the same:
$\dfrac{-3p + 1 - q}{2p + q + 3} = \dfrac{-5}{4}$.

3 Show the required relation

Cross-multiplying gives $4(-3p + 1 - q) = -5(2p + q + 3)$. Therefore $-12p + 4 - 4q = -10p - 5q - 15$, so $2p - q = 19$.

4 Find q when p is 7

With $p = 7$, the relation gives $14 - q = 19$, hence $q = -5$.

5 **Apply Newtons second law**

Substitute $p = 7$ and $q = -5$ into the resultant: $\mathbf{F} = 12\mathbf{i} - 15\mathbf{j}$. Since the mass is 0.5 kg, $\mathbf{F} = m\mathbf{a}$ gives $12\mathbf{i} - 15\mathbf{j} = 0.5\mathbf{a}$.

6 **Find the acceleration**

Dividing by 0.5 gives $\mathbf{a} = 24\mathbf{i} - 30\mathbf{j}\ \mathrm{m\,s^{-2}}$.

✓ **FINAL ANSWER**

$(a)\ 2p - q = 19.\quad (b)\ \mathbf{a} = 24\mathbf{i} - 30\mathbf{j}\ \mathrm{m\,s^{-2}}$.

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Question 4

9 marks | Moments

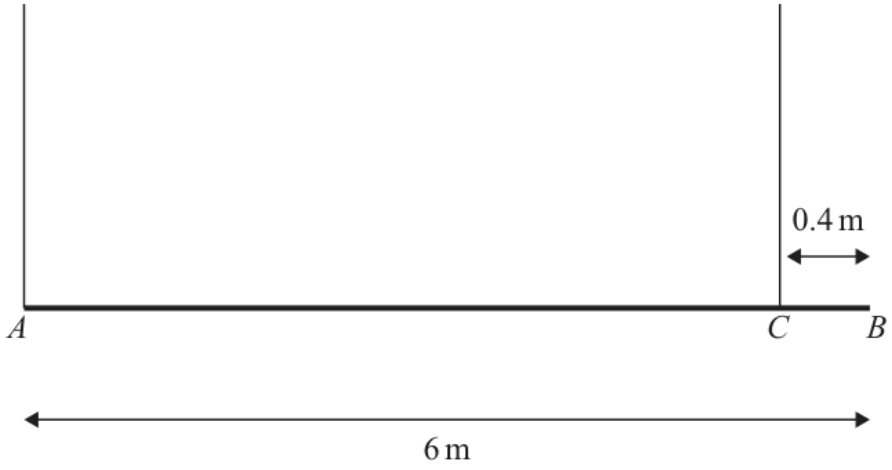


Figure 2

Figure 2 shows a uniform rod AB of length 6 m suspended by two light vertical ropes.

The first rope is attached to the rod at A.
The second rope is attached to the rod at the point C, where $CB = 0.4$ m.

The rod has mass 30 kg.

A particle of mass 20 kg is now attached to the rod at B.

The rod is in equilibrium in a horizontal position.

(a) Find

(i) the tension in the rope attached to the rod at C,
(ii) the tension in the rope attached to the rod at A.

(6)

The particle of mass 20 kg at B is removed and replaced by a particle of mass M kg.

The rod remains in equilibrium in a horizontal position.

(b) Find the exact maximum value of M.

(3)

WORKED SOLUTION

Question 4 · WME01/01 January 2026

1 Set the distances

The rod is 6 m long and C is 0.4 m from B, so $AC = 5.6$ m. The rod is uniform, so its weight $30g$ acts at the midpoint, 3 m from A. The 20 kg particle at B has weight $20g$.

2 **Take moments about A**

Moments about A remove the tension at A. Clockwise moments from the rod and particle equal the anticlockwise moment from the rope at C: $T_C(5.6) = 30g(3) + 20g(6)$.

3 **Find the tension at C**

$T_C(5.6) = 210g$, so $T_C = 37.5g = 367.5\ \text{N}$. To suitable accuracy, $T_C = 368\ \text{N}$, or $370\ \text{N}$ to 2 significant figures.

4 **Use vertical equilibrium**

Vertically, $T_A + T_C = 30g + 20g = 50g$. Therefore $T_A = 50g - 37.5g = 12.5g = 122.5\ \text{N}$, so $T_A = 123\ \text{N}$, or $120\ \text{N}$ to 2 significant figures.

5 **Use the limiting case for maximum M**

For the greatest possible mass at B, the rope at A is just slack, so $T_A = 0$. Take moments about C: the clockwise moment of Mg at B balances the anticlockwise moment of the rod weight.

6 **Solve for M**

The distance from C to B is 0.4 m and the rod weight acts $5.6 - 3 = 2.6$ m to the left of C. Hence $Mg(0.4) = 30g(2.6)$, so $M = \dfrac{78}{0.4} = 195$.

✓ **FINAL ANSWER**

$(a)(i)\ T_C = 368\ \text{N or } 370\ \text{N}.$ $(a)(ii)\ T_A = 123\ \text{N or } 120\ \text{N}.$ $(b)\ M = 195.$

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Question 5

12 marks | Resolving Forces, Inclined Planes

5. The points O, A, B and C are on a rough horizontal surface where $OABC$ is a straight line.

A particle is projected horizontally from O and slides across the surface, passing through A, B and C in that order.

The particle passes through

- A with speed $U\,\text{m s}^{-1}$
- B with speed $\frac{U}{2}\,\text{m s}^{-1}$

The coefficient of friction between the particle and the surface is $\frac{1}{7}$

It takes 0.75 s for the particle to move from A to B.

(a) Show that $U = 2.1$ to 2 significant figures.

(6)

The particle passes through C with speed $\frac{U}{3}\,\text{m s}^{-1}$

(b) Find the time taken to move from B to C.

(3)

(c) Find the distance AC.

(3)

WORKED SOLUTION

Question 5 · WME01/01 January 2026

1 **Find the acceleration from friction**

On a horizontal surface, $R = mg$ and the friction is $F = \mu R = \frac{1}{7}mg$. The friction is the only horizontal force, so the acceleration is opposite the motion with magnitude $\frac{F}{m} = \frac{g}{7} = 1.4\,\text{m s}^{-2}$.

2 **Use A to B to find U**

From A to B, $u = U$, $v = \frac{U}{2}$, $a = -\frac{g}{7}$ and $t = 0.75$. Using $v = u + at$: $\frac{U}{2} = U - \frac{g}{7}(0.75)$.

3 **Show the value of U**

With $g = 9.8$, $\frac{g}{7}(0.75) = 1.05$, so $\frac{U}{2} = U - 1.05$. Hence $U = 2.10\,\text{m s}^{-1}$, which is $2.1\,\text{m s}^{-1}$ to 2 significant figures.

4 Find the time from B to C

From B to C, the speed falls from $\frac{U}{2}$ to $\frac{U}{3}$ with the same acceleration -1.4. Thus $\frac{U}{3} = \frac{U}{2} - 1.4t$. With $U = 2.1$, this gives $0.7 = 1.05 - 1.4t$, so $t = 0.25\ \text{s}$.

5 Find the distance AC

Use average speed on each section. $AB = \frac{U + U/2}{2}(0.75) = 1.18125\ \text{m}$ and $BC = \frac{U/2 + U/3}{2}(0.25) = 0.21875\ \text{m}$. Therefore $AC = 1.18125 + 0.21875 = 1.4\ \text{m}$.

FINAL ANSWER

$(a)\ U = 2.1\ \text{m s}^{-1}$ to 2 s.f.. $(b)\ 0.25\ \text{s}$. $(c)\ AC = 1.4\ \text{m}$.

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Question 6

16 marks | Working with Vectors

6. [*In this question* **i** *and* **j** *are horizontal unit vectors directed due east and due north respectively and position vectors are given relative to a fixed origin O.*]

At 9 am, a ship S leaves a harbour and moves with constant velocity $(10\mathbf{i} + 15\mathbf{j})\,\text{km h}^{-1}$

(a) Find the exact speed of S

(2)

The harbour is at the origin O.

At 9 am, a boat B leaves the point with position vector $(50\mathbf{i} + 10\mathbf{j})$ km and moves with constant velocity $(-8\mathbf{i} + 10\mathbf{j})\,\text{km h}^{-1}$

(b) Find the direction in which B is moving, giving your answer as a bearing to the nearest degree.

(3)

(c) Show that at time t hours after 9 am,

$$\overrightarrow{SB} = [(50 - 18t)\mathbf{i} + (10 - 5t)\mathbf{j}]\,\text{km}$$

(4)

(d) Show that B and S do not collide.

(3)

When B is north-east of S, the distance between S and B is d km.

(e) Find the value of d.

(4)

WORKED SOLUTION

Question 6 · WME01/01 January 2026

1 **Find the speed of S**

The velocity of S is $10\mathbf{i} + 15\mathbf{j}$. Its speed is the magnitude: $\sqrt{10^2 + 15^2} = \sqrt{325} = 5\sqrt{13}\ \text{km h}^{-1}$.

2 **Find the bearing of B**

B has velocity $-8\mathbf{i} + 10\mathbf{j}$, so it moves west and north. The angle west of north satisfies $\tan\theta = \dfrac{8}{10}$, giving $\theta = 38.66°$. The bearing is $360° - 38.66° = 321°$ to the nearest degree.

3 **Write both position vectors**

At time t hours after 9 am, $\mathbf{r}_S = (10t)\mathbf{i} + (15t)\mathbf{j}$. Also $\mathbf{r}_B = (50\mathbf{i} + 10\mathbf{j}) + t(-8\mathbf{i} + 10\mathbf{j}) = (50 - 8t)\mathbf{i} + (10 + 10t)\mathbf{j}$.

4 **Find the relative position vector**

$\overrightarrow{SB} = \mathbf{r}_B - \mathbf{r}_S = [(50 - 8t) - 10t]\mathbf{i} + [(10 + 10t) - 15t]\mathbf{j} = (50 - 18t)\mathbf{i} + (10 - 5t)\mathbf{j}$.

5 **Show they do not collide**

For a collision, both components of $\overrightarrow{SB}$ must be zero at the same time. From $50 - 18t = 0$, $t = \dfrac{25}{9}$. From $10 - 5t = 0$, $t = 2$. These are different, so B and S do not collide.

6 **Find the north-east or south-west instant**

When the separation is along a $45°$ diagonal, the two components have equal magnitude. Using the given condition, set $50 - 18t = 10 - 5t$, so $40 = 13t$ and $t = \dfrac{40}{13}$.

7 **Find the distance d**

At $t = \dfrac{40}{13}$, both components are $-\dfrac{70}{13}$. Therefore $d = \sqrt{\left(\dfrac{70}{13}\right)^2 + \left(\dfrac{70}{13}\right)^2} = \dfrac{70\sqrt{2}}{13} = 7.6\ \text{km}$ to 2 significant figures.

FINAL ANSWER

$(a)\ 5\sqrt{13}\ \text{km h}^{-1}$. $(b)\ 321°$. $(c)\ \overrightarrow{SB} = (50 - 18t)\mathbf{i} + (10 - 5t)\mathbf{j}$. (d) no collision. $(e)\ d = \dfrac{70\sqrt{2}}{13}\ \text{km} \approx 7.6\ \text{km}$.

Question 7

14 marks | Resolving Forces, Inclined Planes

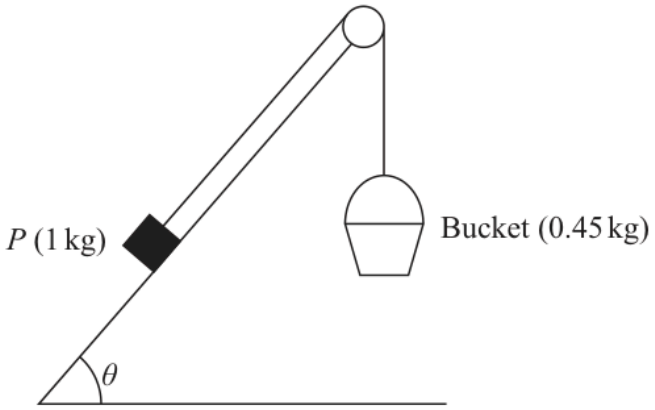


Figure 3

A rough plane is inclined at an angle θ to the horizontal, where $\tan\theta = \frac{4}{3}$

One end of a light inextensible string is attached to a package P.
The string passes over a smooth pulley that is fixed at the top of the plane.
The string from P to the pulley lies along a line of greatest slope of the plane.
The other end of the string is attached to a bucket.
The package P has mass 1 kg and is **held** at rest on the plane.
The bucket has mass 0.45 kg and hangs vertically below the pulley with the string taut, as shown in Figure 3.

The coefficient of friction between P and the plane is μ

When a small block of mass 0.2 kg is placed in the bucket, the system is released and remains at rest in **limiting equilibrium**, with P on the point of slipping down the plane.

(a) Show that $\mu = \frac{1}{4}$

(7)

Additional identical blocks of mass 0.2 kg are added one at a time into the bucket until P starts to move **up** the plane.
At the instant when P starts to move up the plane, there are a **total** of n blocks in the bucket.

(b) Find

(i) the value of n

(ii) the magnitude of the initial acceleration of P

(7)

1 **Find the trigonometric ratios**

Since $\tan\theta = \frac{4}{3}$, use a 3-4-5 triangle: $\sin\theta = \frac{4}{5}$ and $\cos\theta = \frac{3}{5}$.

2 **Use limiting equilibrium in part (a)**

With one 0.2 kg block in the bucket, the bucket side has mass $0.45 + 0.2 = 0.65$ kg. Since the package is on the point of slipping down the plane, friction on P acts up the plane.

3 **Find the friction force**

The tension equals the bucket weight, so $T = 0.65g$. Along the plane for P in equilibrium, $T + F = g\sin\theta$. Hence $0.65g + F = \frac{4}{5}g$, so $F = \frac{3g}{20}$.

4 **Find the normal reaction and mu**

Perpendicular to the plane, $R = g\cos\theta = \frac{3}{5}g$. Since $F = \mu R$, $\mu = \frac{F}{R} = \frac{3g/20}{3g/5} = \frac{1}{4}$.

5 **Set the condition for upward motion**

When P is about to move up the plane, friction acts down the plane. With n blocks in the bucket, the bucket-side mass is $0.45 + 0.2n$. The bucket weight must exceed the downslope resistance: $(0.45 + 0.2n)g > g\sin\theta + \mu R$.

6 **Find n**

Using $g\sin\theta = \frac{4}{5}g$ and $\mu R = \frac{1}{4}\cdot\frac{3}{5}g = \frac{3g}{20}$, the condition is $0.45 + 0.2n > \frac{4}{5} + \frac{3}{20} = 0.95$. Hence $0.2n > 0.50$, so $n > 2.5$ and the least integer is $n = 3$.

7 **Apply Newtons second law after motion begins**

For $n = 3$, the bucket-side mass is $0.45 + 0.6 = 1.05$ kg and the total moving mass is $1 + 1.05 = 2.05$ kg. The driving force is $1.05g - \frac{4}{5}g - \frac{3g}{20} = 0.10g$.

8 **Find the acceleration**

Using $F = ma$, $0.10g = 2.05a$, so $a = \frac{0.10g}{2.05} = \frac{2g}{41} = 0.478\ \mathrm{m\,s^{-2}}$ to 3 significant figures.

✓ **FINAL ANSWER**

$(a)\ \mu = \frac{1}{4}.\quad (b)(i)\ n = 3.\quad (b)(ii)\ a = \frac{2g}{41} = 0.478\ \mathrm{m\,s^{-2}}$ approximately.