STUDY FORMULA BOOKLET

Edexcel IAL Maths Unit M1 (WME01): mechanics 1

The booklet prints no M1 formulae, so everything is Learn it except the cosine rule for a resultant. Learn first the five constant acceleration formulae, F = ma, F = μ R, impulse and momentum, and moments.

GIVEN printed in the formula booklet LEARN IT not in the booklet: learn it

Built by CuratedPrep from 19 past question papers for Unit M1 in our question bank, October 2019 to January 2026. Given means it is in the Mathematical Formulae and Statistical Tables booklet (Issue 2, 2021) handed out in every unit exam. Learn it means a past question needed it and the exam did not print it.

Constants and units

The booklet prints nothing for M1 itself, so the units and the value of g come from the paper or from you.

Acceleration due to gravity

Not on the sheet: printed on the front of the paper. Use 9.8, not 9.81, and give answers to 2 or 3 significant figures: the schemes penalise g = 9.81 and over-accurate answers once. Used in: Jan 2026 Q5(a), showing U = 2.1 to 2 significant figures; Jun 2022 Q5, reactions in terms of M.

$$g = 9.8 \text{ m s}^{-2}$$

GIVEN

Unit conversions

Change to kilograms, metres and seconds before you use F = ma or the constant acceleration formulae. Used in: Jun 2025 Q4(b), a barge of 15 tonnes; Oct 2023 Q3(c), a distance of 12 cm.

$$1 \text{ tonne} = 1000 \text{ kg}, \quad 1 \text{ km h}^{-1} = \frac{1000}{3600} \text{ m s}^{-1}, \quad 1 \text{ cm} = 0.01 \text{ m}$$

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Vectors in mechanics

Magnitude of a vector

The speed from a velocity vector, the size of a force or acceleration, or the distance from a position vector. Leave it as an exact surd when the question asks. Used in: Jan 2026 Q6(a), exact speed of a ship; Jan 2026 Q6(e), distance between ship and boat; Oct 2021 Q4(b), distance of P from O.

$$|p\mathbf{i} + q\mathbf{j}| = \sqrt{p^2 + q^2}$$

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Direction of a vector

Draw a right-angled triangle from the i and j components, find the angle, then turn it into a bearing (measured clockwise from north) or an angle from i or j. Used in: Jan 2026 (A) Q4(a), bearing of a velocity; Jan 2023 Q3(b), angle with the direction of i; Oct 2021 Q4(a), angle with j.

$$\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$$

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Vector from a magnitude and a bearing

i is east and j is north. The i component is v sin(bearing) and the j component is v cos(bearing); a bearing of 150 degrees gives 20i - 34.6j for a speed of 40. Used in: Oct 2019 Q8(a), velocity of a speedboat on a bearing of 150 degrees; Jun 2024 Q7, speedboats given by speed and bearing.

$$\mathbf{v} = v\sin\beta\,\mathbf{i} + v\cos\beta\,\mathbf{j} \quad (\beta \text{ a bearing})$$

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Position under constant velocity r_0 is the position at t = 0. Measure t from the time the question gives for r_0. Used in: Jan 2026 (A) Q4(b), position of P at time t; Jan 2022 Q8(a), position of ship A.	$\mathbf{r} = \mathbf{r}_0 + \mathbf{v}t$	LEARN IT
Velocity from two positions Displacement divided by the time taken, with the time in hours when the units are km and km h^{-1}. Used in: Oct 2023 Q6(a), ship between 12:00 and 12:30; Oct 2021 Q8(a), ship from 7 am to 7.36 am.	$\mathbf{v} = \dfrac{\mathbf{r}_2 - \mathbf{r}_1}{t}$	LEARN IT
Position of one object relative to another Subtract the position vector of the start point from that of the end point. Used in: Jan 2026 Q6(c), SB for a ship and a boat; Jun 2022 Q8(b), PQ for two boats; Oct 2019 Q8(c), distance between two speedboats.	$\overrightarrow{AB} = \mathbf{b} - \mathbf{a}$	LEARN IT
Resultant and Newton's second law in vector form Add the forces first, collecting the i and j parts, then divide by the mass. Do not include weight for forces on a horizontal plane. Used in: Jan 2026 Q3(b), acceleration from three forces; Oct 2025 Q3(a), acceleration from two forces; Jan 2025 Q1(a), magnitude of acceleration.	$\mathbf{F}_1 + \mathbf{F}_2 + \cdots = m\mathbf{a}$	LEARN IT
Equilibrium of forces A particle at rest or at constant velocity has zero resultant force: set the i part and the j part to zero separately. Used in: Jun 2023 Q2(a), F3 in terms of c; Jun 2021 Q3(a), the unknown force F3 on a particle at rest.	$\mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3 = \mathbf{0}$	LEARN IT
Cosine rule Printed in the booklet. Use it on a triangle of two forces or velocities when the angle between them is known: $a^2 = b^2 + c^2 - 2bc \cos A$ for the third side. Used in: Jun 2024 Q2, magnitude of F = P + Q; Jan 2021 Q5(i), magnitude of R = F + G; Oct 2019 Q7(i), magnitude of P = 2F + G.	$a^2 = b^2 + c^2 - 2bc\cos A$	GIVEN
Sine rule Use it after the cosine rule to find the angle that gives the direction of a resultant, or on a triangle of forces. Used in: Jan 2021 Q5(ii), direction of R as a bearing; Oct 2019 Q7(ii), bearing of P; Jan 2023 Q6, angle of a rope.	$\dfrac{a}{\sin A} = \dfrac{b}{\sin B} = \dfrac{c}{\sin C}$	LEARN IT

Kinematics in a straight line

The specification lists the five constant acceleration formulae among those you must know, and the booklet does not print them. Every row here is Learn it.

Velocity after time t Rearrange to a = (v - u)/t. It works on i and j vectors when acceleration is constant. Used in: Jun 2025 Q7(b), acceleration of boat B from two velocities; Jan 2023 Q3(a), speed of P at t = 2; Oct 2023 Q2(a), speed at B from an acceleration-time graph.	$v = u + at$	LEARN IT

Displacement from u, a and t

Use it when you have the time but not the final speed. Put u = 0 for a body released from rest. Used in: Jan 2026 (A) Q3(a), height of a ball thrown up and landing 5 s later; Jun 2023 Q3(a), time for a book to fall 1.5 m; Jan 2022 Q4(a), time for a ball to reach the ground.

$$s = ut + \tfrac{1}{2}at^2$$

LEARN IT

Displacement from v, a and t

Here v is the final speed, which suits a body that decelerates to rest or a motion worked backwards. Used in: Jan 2026 (A) Q6(c), time for a car to stop in 40.5 m; Jun 2022 Q2(a), acceleration of a motorbike over PQ = 220 m.

$$s = vt - \tfrac{1}{2}at^2$$

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Speed and displacement

Use it when time is not asked for, and at the top of a flight where v = 0. Used in: Oct 2025 Q4(a), greatest height of a particle; Jan 2026 (A) Q3(b), speed at the ground; Jan 2025 Q3(b), acceleration of P between speeds 5 and 2.5 m s^{-1}.

$$v^2 = u^2 + 2as$$

LEARN IT

Distance from a speed-time graph

Split the area into triangles, rectangles and trapeziums; this gives the same result as s = (u + v)t/2 for a section of uniform acceleration. The schemes accept the area method or suvat. Used in: Jan 2026 Q2(a), total distance of 600 m; Jun 2022 Q7(b), time for a race.

$$s = \text{area under graph}, \quad A = \tfrac{1}{2}(a+b)h \text{ for a trapezium}$$

LEARN IT

Acceleration from a speed-time graph

Constant speed is a horizontal line, so the acceleration there is zero. Used in: Jan 2026 Q2(c), acceleration between t = 0 and 12 s; Oct 2025 Q6(a), acceleration from a velocity-time graph.

$$a = \text{gradient} = \frac{\Delta v}{\Delta t}$$

LEARN IT

Motion under gravity

Put a = -9.8 if upwards is positive. The ball is modelled as a particle moving freely, so air resistance is ignored. Used in: Oct 2025 Q4(a), particle projected up from a point 10 m above the ground; Jan 2026 (A) Q3, ball thrown vertically up; Oct 2019 Q2(b), height after a bounce.

$$a = g \text{ downwards}, \quad v = 0 \text{ at the greatest height}$$

LEARN IT

Dynamics: forces, friction and connected particles

Newton's second law

F is the resultant force in the direction of motion, so write one equation per particle and treat each as separate. Used in: Jan 2026 (A) Q6(a), thrust in a towbar on a trailer; Jun 2022 Q3(a), resistance on a block.

$$F = ma$$

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Weight

Weight acts vertically downwards, and the normal reaction from a floor or a lift floor is a separate force. Used in: Oct 2022 Q4(b), mass of Alan from the lift floor force; Jan 2026 Q4(a), rod of mass 30 kg; Jun 2023 Q3(b), book of mass 0.2 kg with resistance R.

$$W = mg$$

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Connected particles moving together

Use one equation for the whole system and one for each part: the mass in the ma term tells you which part the equation is for. The tension cancels in the system equation. Used in: Jan 2026 (A) Q6(b), mass of a car pulling a trailer; Oct 2019 Q3, driving force on a car and trailer on a slope; Jan 2026 Q7(a), whole system of package, string and bucket.

$$\text{driving force} - \text{resistances} = (m_1 + m_2)a$$

LEARN IT

Weight on a slope

Take a plane inclined at θ to the horizontal. Perpendicular to the plane R = mg cos(θ) when no other force has a perpendicular part; add or subtract it when a force has. Used in: Jan 2026 Q7(a), package on a slope with tan(θ) = 4/3; Oct 2025 Q7(b), block on a rough plane; Jun 2025 Q6(a), deceleration of a package up a slope.

$$\text{down the slope: } mg\sin\theta, \qquad R = mg\cos\theta$$

LEARN IT

Resolving a force at an angle

Horizontal and vertical parts of a force at angle θ to the horizontal, which change R as well as the motion. Swap sin and cos for an angle measured from the vertical or from a slope. Used in: Jan 2026 (A) Q2, strap at 20 degrees above the horizontal; Oct 2025 Q5(a), force at 30 degrees to the horizontal on a box; Jun 2022 Q4(a), force P at 30 degrees.

$$F\cos\theta \text{ and } F\sin\theta$$

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Friction

R is the normal reaction, found by resolving perpendicular to the surface. Friction acts against the motion, or against the way the body would slide. Used in: Jan 2026 Q5(a), coefficient of friction in an equation of motion; Jun 2022 Q4(a), comparing 12 N with the maximum 18 N; Jan 2022 Q5, limiting equilibrium both ways.

$$F \le \mu R, \qquad F = \mu R \text{ when sliding or about to slide}$$

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Force on a pulley

φ is the angle between the two straight parts of the string. Both parts vertical gives 2T; parts at right angles give T times root 2. Used in: Oct 2025 Q7(d), force on the pulley as kmg; Jan 2020 Q7(c), horizontal and vertical parts.

$$F = 2T\cos\frac{\varphi}{2}$$

LEARN IT

Work and energy as an alternative

This is M2 content, but the M1 schemes allow it as an alternative to an equation of motion and suvat. Used in: Oct 2023 Q3(c), resistance on a hammer and tent peg over 12 cm; Jun 2024 Q6(b), distance when the speed halves; Oct 2025 (A) Q4(b), resistance on blocks sinking into soft ground.

$$\text{KE} = \tfrac{1}{2}mv^2, \quad \text{PE} = mgh, \quad \text{work done} = Fd$$

LEARN IT

Momentum and impulse

The specification lists momentum = mv and impulse = mv - μ as formulae you must know. They are not printed in the booklet.

Impulse and momentum

Use the final minus the initial velocity, with a sign for direction. The impulse on one particle is equal and opposite to that on the other. Used in: Jan 2026 (A) Q1(a), speed of P after an impulse of 5mu; Jan 2025 Q3(a), impulse on P giving speed 5 m s^{-1}.

$$I = mv - mu, \qquad \text{momentum} = mv$$

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Conservation of momentum

Choose one direction as positive and give a particle moving the other way a negative velocity. Used in: Jan 2025 Q3(c), speed of P after hitting Q; Jan 2026 Q1(ii), speed of Q after the collision.

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

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Particles that join or a string that goes taut

Both parts move with the same speed v afterwards. Used in: Oct 2025 (A) Q4(b), blocks moving down together; Oct 2023 Q3(a), hammer and tent peg; Oct 2019 Q1(a), common speed when a string becomes taut.

$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

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Moments and equilibrium

Moment of a force

d is the perpendicular distance from the pivot to the line of the force. Take moments about the point where an unknown force acts so that it drops out. Used in: Jan 2026 Q4(a), tensions in two ropes on a rod; Oct 2025 (A) Q2(a), reactions on a plank.

$$M = F \times d$$

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Equilibrium of a rod

Include the weight of the rod at its centre of mass and the weight of every particle placed on it. Used in: Jan 2026 (A) Q7(a), position of the centre of mass when R_D = 2R_C; Jun 2022 Q5(a), reaction at C in terms of M; Oct 2019 Q5(b), position of a 15 kg particle.

$$\sum_{\text{moments}} F_{\uparrow} = \sum F_{\downarrow}, \qquad \text{clockwise moments} = \text{anticlockwise}$$

LEARN IT

Also learn these

Strings, pulleys and inextensible

The tension is the same throughout a light string, a smooth pulley does not change it, and an inextensible string gives both particles the same acceleration. Used in: Jun 2022 Q3(b), same acceleration; Oct 2021 Q7(d), smooth pulley; Jan 2022 Q7(d), tension throughout the string.

Tan to sin and cos

When the question gives tan of an angle, draw a right-angled triangle, find the third side, and read sin and cos from it. Used in: Jan 2026 Q7, plane with tan(θ) = 4/3; Jun 2025 Q6, plane with a given tan.

Direction given as a vector

A resultant parallel to (4i - 5j) has components in the ratio 4 to -5: form the equation from the ratio of the i and j parts. Used in: Jan 2026 Q3(a); Oct 2025 (A) Q3(a); Oct 2022 Q6(a).

Meeting and collision

Two objects meet when their position vectors are equal at the same time t, so set the i parts and the j parts equal and check that both give the same t. 'North-east of' means equal i and j parts of the displacement. Used in: Jan 2026 Q6(d); Oct 2023 Q6(c); Jan 2026 Q6(e).

Closest approach

Write the distance squared as a quadratic in t, then find its minimum by completing the square or by differentiating. Used in: Jan 2022 Q8(c), shortest distance between two ships.

Solving quadratics

Many M1 equations reduce to a three-term quadratic in T or t: solve it, then reject any root that does not fit the situation. Used in: Oct 2019 Q6(d), T = 10 not 50; Oct 2021 Q4(b), values of t for a distance of 2.5 m; Jun 2022 Q7(c), the acceleration time T of one child.

Limiting equilibrium

On the point of slipping, friction is at its maximum, $F = \mu R$, and acts opposite to the way the body would slide. Used in: Jan 2026 Q7(a), on the point of slipping down; Oct 2019 Q4, on the point of sliding down; Jan 2022 Q5, up and down.

Point of tilting

A rod on the point of tilting about one support has no reaction at the other support, so set that reaction to zero. Used in: Jan 2021 Q4; Jan 2023 Q4.

Centre of mass of a rod

A uniform rod has its weight at its midpoint; for a non-uniform rod the question gives the distance of the centre of mass from one end. Used in: Oct 2025 Q1; Oct 2019 Q5; Jun 2024 Q4.

Direction after a collision

A speed is positive, so after finding a velocity say which way the particle moves; a negative answer means its direction is reversed. Used in: Jan 2026 (A) Q1(b); Jun 2022 Q1(b); Oct 2021 Q2(b).

A force that changes

When a string goes slack or a particle hits the ground, write a new equation of motion with the new forces and a new acceleration; do not reuse the old one. Used in: Jan 2026 (A) Q8(c); Jun 2024 Q8(d).

Modelling words

Know what the assumptions mean: particle, light string, smooth pulley, uniform and non-uniform rod, freely under gravity, air resistance ignored. Used in: Oct 2019 Q6(e), improving a model of an athlete; Jun 2023 Q3, two models of a falling book; Jun 2022 Q3(b), inextensible cable.

Using the booklet in the exam

- The booklet prints no M1 formulae. Learn the five constant acceleration formulae, $F = ma$, $F = \mu R$, impulse and conservation of momentum before the exam, because nothing on your desk will help with them.
- The cosine rule is the one printed row that M1 questions needed: use it for the resultant of two forces or velocities at an angle. Learn the sine rule and the right-angled triangle ratios as well.
- Write one equation of motion for each particle or one for the whole system, and check that the mass in the ma term matches the part you are describing; the schemes mark it that way.
- For moments, take them about the point where an unknown force acts, and write 'on the point of tilting' as the reaction at the other support equal to zero.
- Use $g = 9.8$ and give answers to 2 or 3 significant figures. The schemes penalise $g = 9.81$ and over-accurate answers once.
- On 'show that' parts, write at least one line of working before the given answer: the scheme will not give the final mark for the equation and the answer alone.

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