

AP Physics C: Mechanics Formula and Strategy Guide

Calculus-based mechanics: kinematics via derivatives and integrals, Newton's laws, work and energy, momentum and center of mass, rotation, and oscillations and gravitation. Fluids are NOT part of this course — that is AP Physics 1/2 territory.

SECTIONS	6	WORKED EXAMPLES	2	FORMAT	Print friendly
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How to use this guide

A formula you cannot place is not knowledge yet. Work the recall drill below before the questions.

- Set up the physics model (diagram, chosen principle) before reaching for calculus — the math should serve the physics, not replace understanding it.
- Velocity is the derivative of position; acceleration is the derivative of velocity. Integrating reverses both.
- Check units and limiting cases at the end of every derivation.

1. Kinematics with calculus

NAME	FORMULA	WHEN TO USE
Velocity from position	$v(t) = dx/dt$	Position is given as a function of time.
Acceleration from velocity	$a(t) = dv/dt = d^2x/dt^2$	Velocity or position is given as a function of time.
Position from velocity	$x(t) = \text{INT } v(t) dt + x_0$	Velocity is known, position is not.
Velocity from acceleration	$v(t) = \text{INT } a(t) dt + v_0$	Acceleration is known, velocity is not.

WORKED EXAMPLE

Given $a(t) = 6t$, with $v(0) = 0$, find $v(t)$.

1. $v(t) = \text{INT } 6t dt = 3t^2 + C$
2. Apply $v(0) = 0$: $0 = 3(0)^2 + C$, so $C = 0$
3. $v(t) = 3t^2$

Check: Differentiating $3t^2$ gives back $6t$.

2. Newton's laws and translational dynamics

NAME	FORMULA	WHEN TO USE
Newton's second law	$F_{\text{net}} = ma = m dv/dt$	Relating net force to the rate of change of velocity.

NAME	FORMULA	WHEN TO USE
Variable force	$F(x)$ requires integration for work: $W = \int F(x) dx$	The force is not constant over the displacement.
Drag force models	often proportional to v or v^2	Setting up a differential equation for motion with resistance.

3. Work, energy, and power

NAME	FORMULA	WHEN TO USE
Work (variable force)	$W = \int F(x) dx$	A force changes with position, like a spring.
Potential energy from force	$F(x) = -dU/dx$	Finding force from a potential energy function.
Conservation of energy	total mechanical energy is constant without nonconservative forces	Relating energy at two points.
Power	$P = dW/dt = F \times v$	The instantaneous rate of energy transfer.

WORKED EXAMPLE

A spring has potential energy $U(x) = 2x^2$. Find the force as a function of x .

- $F(x) = -dU/dx$
- $F(x) = -d/dx[2x^2]$
- $F(x) = -4x$

Check: The negative sign shows the spring force opposes displacement, as expected.

4. Systems of particles and linear momentum

NAME	FORMULA	WHEN TO USE
Center of mass	$x_{cm} = \frac{\sum(m_i x_i)}{\sum(m_i)}$	Locating the balance point of a system of masses.
Impulse-momentum theorem	$J = \int F dt = \text{change in momentum}$	Relating a variable force over time to momentum change.
Conservation of momentum	total momentum before = total momentum after	Analyzing any collision, with no external net force.

5. Rotation

NAME	FORMULA	WHEN TO USE
Moment of inertia (by integration)	$I = \int r^2 dm$	Finding rotational inertia for a continuous mass distribution.
Torque	$\tau = I \alpha$ (rotational form of $F=ma$)	Relating net torque to angular acceleration.
Rotational kinetic energy	$KE_{rot} = \frac{1}{2} I \omega^2$	Energy of a rotating object.

NAME	FORMULA	WHEN TO USE
Angular momentum	$L = I \omega$, conserved with no net external torque	Analyzing rotational collisions or changes in shape.

6. Oscillations and gravitation

NAME	FORMULA	WHEN TO USE
SHM differential equation	$d^2x/dt^2 = -(k/m)x$	Confirming a system undergoes simple harmonic motion.
Period of a spring	$T = 2\pi\sqrt{m/k}$	Time for one oscillation of a mass on a spring.
Newton's law of gravitation	$F = Gm_1m_2/r^2$	Force between two masses separated by a distance.
Orbital velocity	$v = \sqrt{GM/r}$	Speed needed for a circular orbit at radius r .

Notes and tutor hand-off

Bring this page to your next session so the tutor can start from what actually blocked you.

Which unit needs another pass: kinematics, dynamics, energy, momentum, rotation, or gravitation?

One derivative or integral setup you want to redo from scratch:

Worksheet question numbers to review with a tutor:
