FULL REVIEW

Full Review: Motion in One Dimension

Review one-dimensional kinematics through derivatives, integrals, motion graphs, constant acceleration, and variable-acceleration models.

◷ TIME	◎ BEST FOR	✓ FINISH WITH
45–60 minutes	A complete unit review	A readiness check

After this full review, you'll be able to…
move fluently between x(t), v(t), and a(t), use definite integrals to reconstruct motion, and recognize constant-acceleration formulas as a special case.

HOW TO USE THIS GUIDE

Work through the stages in order. Write directly in the spaces provided, check your work in the Solutions section, and finish by choosing the next resource that matches your confidence.

Choose how you want to review: work through this guide, follow the online review, or watch the video review.

Start the Review Online →
Watch the Video Review →

YOU WILL NEED

Pencil or pen • Calculator if needed • Approximately 45–60 minutes

FR-02 • UNIT ALIGNMENT

Unit Alignment

This bundle is aligned to the approved Physics Sensei unit specification below. Use it to recover the unit structure, reinforce key decisions, and confirm readiness for the next study task.

ARCHITECTURE: Physics Sensei Independent Mechanics UNIT: MEC-U02 — Motion in One Dimension SCOPE: Unit Review PHYSICS LEVEL: Calculus-Based	BEST USED ✓ Before calculus-based kinematics homework ✓ Before a quiz or exam ✓ When derivative, integral, or variable-acceleration models need reinforcement

Review Prerequisites →

Physics Sensei is an independent educational resource. This review is independently authored and organized under the approved Physics Sensei mechanics architecture.

FR-03 • YOUR REVIEW PLAN

Your Review Plan

Complete these six stages in order. Each stage builds on the previous one and prepares you for the final readiness check.

6 stages • Approximately 45–60 minutes

PRINTING TIP

For student copies, print double-sided and keep the Solutions section after the student activities so learners attempt each activity before checking their work.

FR-04 • STAGE 1 OF 6

Warm-Up Check

Before you begin, take a moment to see what you already remember. Do not worry about getting everything right. This is only a starting point.

ACTIVITY 1

Recall Activity 1

Differentiate position once for velocity and twice for acceleration.

If $x(t) = 2t^3 - 5t^2 + 4$, write $v(t)$ and $a(t)$.

ACTIVITY 2

Recall Activity 2

Use a definite integral to accumulate signed displacement.

If $v(t)$ is known, what definite integral gives the displacement from t_1 to t_2?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Use the derivative condition, then check whether the sign changes.

For a differentiable x(t), what condition identifies a possible turning point?

Ready to strengthen your understanding?

You've refreshed what you already know. Next, reinforce the essential concepts that will help you solve problems with confidence.

Continue to Core Concepts — page 6 →

FR-05 • STAGE 2 OF 6

Core Concepts

Let's rebuild the key ideas one step at a time. Focus on understanding the relationships before worrying about solving problems.

KEY CONCEPT 1

Velocity and acceleration are derivatives

Instantaneous velocity is the first derivative of position. Acceleration is the derivative of velocity and the second derivative of position.

$$\Delta x = x_2 - x_1 \quad \bullet \quad v\_avg = \Delta x/\Delta t$$

EXAMPLE $v = dx/dt$; $a = dv/dt = d^2x/dt^2$. Example: $x = 2t^3 - 5t^2 + 4t$ gives $v = 6t^2 - 10t + 4$ and $a = 12t - 10$.

SENSEI NOTE A point where $v = 0$ is a candidate turning point. Inspect the sign of v on both sides to determine whether the direction actually reverses.

KEY CONCEPT 2

Integrals reconstruct displacement and velocity change

Integrating velocity gives displacement; integrating acceleration gives velocity change. Definite integrals naturally handle motion whose rate changes continuously.

$$v = v_0 + at \quad \bullet \quad \Delta x = v_0 t + \tfrac{1}{2}at^2$$

EXAMPLE $x(t_2) - x(t_1) = \int[t_1,t_2]\ v(t)dt$; $v(t_2) - v(t_1) = \int[t_1,t_2]\ a(t)dt$. If $a(t)=3t$ and $v(0)=2$, then $v(t)=2+1.5t^2$.

SENSEI NOTE The integral of signed velocity gives displacement. The integral of speed gives total distance.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Constant acceleration is the integrated special case

The familiar algebraic kinematics equations follow by integrating a constant acceleration. When acceleration varies, use the underlying derivative/integral relations instead of constant-a shortcuts.

slope(x–t) → v • slope(v–t) → a • area(v–t) → Δx

EXAMPLE $a = \text{constant} \Rightarrow v = v_0 + at$ and $x = x_0 + v_0t + ½at^2$. Example: if $a(t)=4-2t$ and $v(0)=1$, then $v(t)=1+4t-t^2$.

SENSEI NOTE Do not use constant-acceleration shortcut equations when a varies over the interval.

Ready to apply these ideas?

You've reinforced the essential concepts. Now put them into practice by working through guided examples and building your problem-solving confidence.

Continue to Guided Practice — page 8 →

FR-06 • STAGE 3 OF 6

Guided Practice

Now it's time to apply what you've reviewed. Work through each activity in order. The examples become gradually more challenging, and each prepares you for the final readiness check.

PRACTICE 1

Worked Example

Differentiate a position function and solve $v(t)=0$ to identify rest times.

A particle has $x(t)=t^3-6t^2+9t$ meters. Find $v(t)$, $a(t)$, and the times from 0 to 5 s when it is instantaneously at rest.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Integrate acceleration, use the initial condition, then integrate velocity.

A particle has $a(t)=6t-4$ m/s², $v(0)=3$ m/s, and $x(0)=2$ m. Find $v(t)$ and $x(t)$.

PRACTICE 3

Independent Problem

Use the definite integral of velocity and check whether v changes sign.

For $0 \le t \le 4$ s, $v(t)=5-t$ m/s. Find the displacement and total distance.

Ready to check your understanding?

You've practiced the essential skills with guidance. Now solve a few short problems on your own and confirm you're ready to move forward.

Continue to Confidence Check — page 10 →

FR-07 • STAGE 4 OF 6

Confidence Check

You've rebuilt the key ideas and practiced them with guidance. Now try these short questions on your own to check your understanding before moving on.

QUICK CHECK 1

Differentiate before substituting

Find the instantaneous velocity from x(t).

For $x(t)=4t^2-t^3$, find v at t = 2 s.

QUICK CHECK 2

Integrate acceleration

Use the initial velocity as the constant of integration.

If $a(t)=2t$ and $v(0)=-1$ m/s, find $v(3\ s)$.

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Choose the valid model

Recognize the assumption hidden in a shortcut equation.

Why is $v^2=v_0^2+2a\Delta x$ generally unsafe when acceleration varies with time?

HOW DID IT GO?

I answered ____ of 3 questions correctly.

Use the Solutions section to check your reasoning, then take one final look at the essential ideas.

You've checked your understanding.

Take one final look at the essential ideas before deciding what to do next.

Continue to Summary — page 12 →

FR-08 • STAGE 5 OF 6

Summary

Before moving on, take one final look at the most important ideas from this review.

KEY TAKEAWAY 1

Derivatives convert x → v → a

Local slopes are calculus statements: differentiate position for velocity and velocity for acceleration.

KEY TAKEAWAY 2

Integrals reconstruct motion

Signed areas under v(t) and a(t) accumulate displacement and velocity change.

KEY TAKEAWAY 3

Algebraic kinematics are a special case

Constant acceleration produces the familiar shortcut equations; variable acceleration requires the underlying calculus model.

MY ONE-SENTENCE SUMMARY

In my own words, the most important idea is:

Ready for your next step?

You've reviewed the essential ideas one last time. Now choose the resource that best matches how confident you feel.

Continue to Next Step — page 16 →

ANSWER KEY • CHECK AFTER ATTEMPTING

Solutions and Explanations

Use these solutions to check your reasoning—not only your final answer. Compare your setup, signs, units, and interpretation with the explanations below.

WARM-UP • ACTIVITY 1

Recall Activity 1

$v(t) = 6t^2 - 10t$; $a(t) = 12t - 10$.

WHY IT WORKS Instantaneous velocity is dx/dt and acceleration is d^2x/dt^2.

WARM-UP • ACTIVITY 2

Recall Activity 2

$\Delta x = \int[t_1,t_2]\ v(t)\ dt$.

WHY IT WORKS Integrating the instantaneous velocity over time accumulates the signed changes in position.

WARM-UP • ACTIVITY 3

Recall Activity 3

$v(t) = dx/dt = 0$, followed by a sign change in v for a true reversal.

WHY IT WORKS A zero derivative marks an instantaneous horizontal tangent, but the direction reverses only if velocity changes sign.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

$v = 3t^2-12t+9 = 3(t-1)(t-3)$; $a = 6t-12$; rest at $t = 1$ s and 3 s.

WHY IT WORKS Differentiate $x(t)$ to get $v(t)$, differentiate again for $a(t)$, then solve the quadratic $v(t)=0$.

PRACTICE 2

Guided Problem

$v(t)=3+3t^2-4t$; $x(t)=2+3t+t^3-2t^2$.

WHY IT WORKS Integrating $a(t)$ gives $v(t)=3t^2-4t+C$; $v(0)=3$ sets $C=3$. Integrating again and using $x(0)=2$ gives $x(t)$.

PRACTICE 3

Independent Problem

Displacement = 12 m; total distance = 12 m.

WHY IT WORKS $\int_0^4(5-t)dt = 12$ m. Because $v(t)>0$ throughout $0\le t\le 4$, speed equals velocity and distance equals displacement.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Differentiate before substituting

4 m/s.

WHY IT WORKS $v = dx/dt = 8t - 3t^2$. At $t=2$ s, $v=16-12=4$ m/s.

QUICK CHECK 2

Integrate acceleration

8 m/s.

WHY IT WORKS $v(3)=-1+\int_0^3 2t\,dt=-1+9=8$ m/s.

QUICK CHECK 3

Choose the valid model

It is derived for constant acceleration.

WHY IT WORKS The shortcut assumes a is constant throughout the derivation. Variable acceleration requires the appropriate differential or integral relation.

READINESS GUIDE

3 correct: You're ready to continue. • 2 correct: Review the missed idea, then continue. • 0–1 correct: Revisit Core Concepts or choose more practice.

FR-09 • STAGE 6 OF 6

Next Step: Continue Learning

Great work! You've completed this review. Choose the next resource that best matches how confident you feel.

? I'm Still Unsure	◎ I Need More Practice	✓ I'm Ready
Review the key ideas and examples again.	Continue with additional practice for this unit.	Continue to the next recommended resource.
Review again: return to Warm-Up Check on page 4.	**Go to Practice →**	**Continue →**

RECOMMENDED LINKS

Review again: return to Warm-Up Check on page 4.

Find additional practice →

Choose another type of physics help →

Continue reviewing with these companion resources.

Start the Review Online →
Watch the Video Review →

PHYSICS HELP THAT MAKES SENSE

A Physics Sensei review never ends at the last question. It always guides you toward the next useful step.

PhysicsSensei.com