FOCUSED REVIEW

Focused Review: Momentum and Collisions — Calculus-Based

15-minute calculus-based review of momentum and collisions, emphasizing vector momentum, impulse integrals, system momentum, and collision derivations.

◷	◎	✓
TIME	**BEST FOR**	**FINISH WITH**
15 minutes	Focused Review	Greater confidence

After this review, you'll be able to…

use p = mv and F = dp/dt, evaluate impulse integrals, analyze system momentum and center-of-mass motion, and solve collision constraints with momentum and energy conservation.

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 15 minutes

FR-02 • UNIT ALIGNMENT

Unit Alignment

This Physics Sensei Unit Review covers MEC-U07 — Momentum and Collisions using the Calculus-Based treatment. Use it to reinforce the unit, prepare for homework, or review before a quiz or exam.

UNIT ID: MEC-U07 **UNIT: Momentum and Collisions** **TREATMENT: Calculus-Based** **RESOURCE: Unit Review**	**BEST USED** ✓ After reading the chapter ✓ Before starting homework ✓ Before a quiz or exam

Explore Momentum and Collisions Online →

Physics Sensei Unit Reviews use independent organization, wording, examples, and explanations.

FR-03 • YOUR REVIEW PLAN

Your Review Plan

Complete these six focused stages in order. Each stage reinforces your understanding and prepares you for a final confidence check.

6 stages • Approximately 15 minutes

1 **Warm-Up Check — page 4** Refresh key ideas.	2 **Core Concepts — page 6** Reinforce the essentials.	3 **Guided Practice — page 7** Strengthen key skills.
4 **Confidence Check — page 8** Confirm your understanding.	5 **Summary — page 10** Remember the essentials.	6 **Next Step — page 14** Choose your next step.

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 minute to reactivate what you already know. This quick warm-up will help you focus on the most important ideas before moving on.

WARM-UP 1

Momentum Function

Differentiate or evaluate vector velocity before forming momentum.

A 2.0 kg particle has v(t) = <3t, 2> m/s. Write p(t).

WARM-UP 2

Impulse Integral

Recognize impulse as the time integral of net force.

If $F_x(t) = 6t$ N from t = 0 to 2.0 s, what is the x-impulse?

FR-04 • WARM-UP CHECK CONTINUED

WARM-UP 3

System Momentum

Relate total momentum to center-of-mass velocity.

For constant total mass M, what is the relation between total momentum P and center-of-mass velocity V_{cm}?

Ready to strengthen your understanding?

You've refreshed the most important ideas. Now reinforce the concepts you'll use most often.

Continue to Core Concepts — page 6 →

FR-05 • STAGE 2 OF 6

Core Concepts

Let's reinforce the most important concepts you'll need to solve problems with confidence. Focus on the ideas that appear most often in homework, quizzes, and exams.

KEY CONCEPT 1

Momentum Dynamics for a System

For a particle of constant mass, p = mv and F_{net} = dp/dt. For a system of particles, dP/dt = F_{ext} because internal force pairs cancel in the system sum. If the external impulse is negligible, P is constant.

$$p = mv;\ F_{net} = dp/dt;\ dP/dt = F_{ext}$$

EXAMPLE The center of mass moves as if all mass were concentrated there and acted on by the net external force: $M A_{cm} = F_{ext}$.

SENSEI NOTE Separate internal interaction forces from external forces before invoking conservation.

KEY CONCEPT 2

Impulse as an Integral

The impulse delivered from t1 to t2 is $J = \int F_{net}(t)\, dt = p(t2) - p(t1)$. Component-by-component integration handles time-varying forces. The signed area under each force component versus time gives the corresponding impulse component.

$$J = \int_0^t F_{net}(t)\, dt = p_f - p_i$$

EXAMPLE For $F_x = 6t$ N from 0 to 2 s, $J_x = 12$ N·s.

SENSEI NOTE Integrate the force component, not its magnitude, when direction matters.

Ready to apply these ideas?

You've reinforced the essential concepts. Now strengthen your problem-solving skills by working through a few guided examples.

Continue to Guided Practice — page 7 →

FR-06 • STAGE 3 OF 6

Guided Practice

Now apply the key concepts you've just reviewed. Work through these focused practice activities to reinforce your problem-solving skills before the final confidence check.

PRACTICE 1

Time-Dependent Force

Integrate the force to obtain impulse, then update momentum.

A 2.0 kg cart has $v_x(0) = 1.0$ m/s. It experiences $F_x(t) = 6t$ N from 0 to 2.0 s. Find $v_x(2.0\ s)$.

PRACTICE 2

Center-of-Mass Velocity

Use $P = M V_{cm}$.

A 1.0 kg cart moves at +6.0 m/s and a 2.0 kg cart moves at -1.0 m/s. Find V_{cm}.

Ready for a confidence check?

You've reinforced the essential skills through focused practice. Now confirm your understanding with two short questions.

Continue to Confidence Check — page 8 →

FR-07 • STAGE 4 OF 6

Confidence Check

You've reinforced the key concepts and practiced the essential skills. Now confirm you're ready to move forward by completing these short confidence checks.

CONFIDENCE CHECK 1

Derivative Form

Answer without notes and justify the reasoning.

If $p_x(t) = 2t^3 - t$ kg·m/s, what is F_x at $t = 1.0$ s?

CONFIDENCE CHECK 2

Impulse Integral

Answer without notes and justify the reasoning.

If $F_x(t) = 4 - 2t$ N from 0 to 3 s, what is J_x?

HOW DID IT GO?

I answered ____ of 2 questions correctly.

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

You've confirmed your understanding.

Take one final look at the essential ideas before choosing your next step.

Continue to Summary — page 10 →

FR-08 • STAGE 5 OF 6

Summary

Before moving on, take one final look at the essential ideas you'll want to remember.

KEY TAKEAWAY 1

External Force Controls System Momentum

$dP/dt = F_{ext}$; internal forces redistribute momentum without changing the system total.

KEY TAKEAWAY 2

Impulse Is a Force Integral

$J = \int F\,dt$ provides the exact momentum change for time-dependent forces.

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 14 →

ANSWER KEY • CHECK AFTER ATTEMPTING

Solutions and Explanations

Use these solutions to check your reasoning—not only your final answer. Use each answer and explanation to check both the setup and the physical interpretation.

WARM-UP • ACTIVITY 1

Momentum Function

$p(t) = \langle 6t, 4 \rangle$ kg·m/s.

WHY IT WORKS Multiply each velocity component by the constant mass.

WARM-UP • ACTIVITY 2

Impulse Integral

12 N·s.

WHY IT WORKS $J_x = \int_0^2 6t\,dt = 3t^2|_0^2 = 12$ N·s.

WARM-UP • ACTIVITY 3

System Momentum

$P = M V_{cm}$.

WHY IT WORKS The mass-weighted sum of particle velocities equals M times the center-of-mass velocity.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Time-Dependent Force

7.0 m/s.

WHY IT WORKS $J_x = \int_0^2 6t\,dt = 12$ N·s. $p_f = p_i + J = 2.0 + 12 = 14$ kg·m/s, so $v_f = 7.0$ m/s.

PRACTICE 2

Center-of-Mass Velocity

+1.33 m/s.

WHY IT WORKS $P = 1(6) + 2(-1) = 4$ kg·m/s and $M = 3$ kg, so $V_{cm} = 4/3$ m/s.

SOLUTIONS • CONFIDENCE CHECK

CONFIDENCE CHECK 1

Derivative Form

5 N.

WHY IT WORKS $F_x = dp_x/dt = 6t^2 - 1$; at $t = 1$, $F_x = 5$ N.

CONFIDENCE CHECK 2

Impulse Integral

3 N·s.

WHY IT WORKS $\int_0^3 (4 - 2t)\,dt = [4t - t^2]_0^3 = 12 - 9 = 3$ N·s.

READINESS GUIDE

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

FR-09 • STAGE 6 OF 6

Next Step: Continue Learning

Great work! You've completed this focused 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 focused review again to strengthen the essential concepts.	Build confidence with additional practice problems.	Continue to the next topic or learning 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