QUICK REVIEW

Quick Review: Center of Mass and Systems of Particles

Refresh the essential calculus-based center-of-mass model and its connection to system momentum and external force.

TIME	BEST FOR	FINISH WITH
5 minutes	A rapid refresh	Key ideas refreshed

After this quick review, you'll be able to…

choose between a discrete sum and a continuous integral, identify dm, and remember how rCM connects to P and net external force.

HOW TO USE THIS GUIDE

Work through the four stages in order. Write directly in the spaces provided, check your work in the Quick Answers 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 5 minutes

FR-02 • PHYSICS SENSEI UNIT REVIEW

Physics Sensei Unit Review

Use this Physics Sensei Unit Review to reinforce key concepts, prepare for homework, and review before a quiz or exam.

UNIT: MEC-U19 **TOPIC FAMILY: Mechanics** **TOPIC: Center of Mass and Systems of Particles** **COURSE LEVEL: Calculus-based introductory university physics**	**BEST USED** ✓ **To reinforce key concepts** ✓ Before starting homework ✓ Before a quiz or exam

Continue with Physics Sensei →

Physics Sensei is an independent educational resource organized around core college-physics ideas, problem-solving models, and study workflows.

FR-03 • YOUR REVIEW PLAN

Your Review Plan

Complete these four stages to quickly refresh the essential ideas and confirm you're ready to continue.

4 stages • Approximately 5 minutes

1 **Quick Recall — page 4** Refresh what you already know.	2 **Essential Idea — page 5** Review the most important concept.
3 **Confidence Check — page 6** Confirm you're ready to move on.	4 **Next Step — page 8** Continue your learning.

PRINTING TIP

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

FR-04 • STAGE 1 OF 4

Quick Recall

Let’s quickly refresh what you already know. This short recall activity will bring the most important ideas back to mind before you review them.

QUICK RECALL

Recall Activity

Complete the three statements from memory before revealing the answer.

1) For discrete particles use a ____; for a continuous distribution use an ____. 2) In rCM = (1/M)∫r dm, dm is a differential element of ____. 3) For constant M, dP/dt = ____.

Ready to refresh the essentials?

Great! Now review the most important idea you’ll want to remember.

Continue to Essential Idea — page 5 →

FR-05 • STAGE 2 OF 4

Essential Idea

Take one last look at the most important concept from this topic. If you remember this idea, the rest will come back much more easily.

ESSENTIAL IDEA

Choose Σ or ∫, Then Connect to System Dynamics

Use rCM = (1/M)Σmi ri for discrete particles and rCM = (1/M)∫r dm for continuous mass distributions. Build dm from the density model. For constant total mass, differentiating center-of-mass position leads to P = M VCM, and differentiating momentum gives dP/dt = net external force = M ACM.

$$\mathbf{r}_{CM} = \frac{1}{M}\int \mathbf{r}\, dm \qquad \mathbf{P} = M\mathbf{V}_{CM} \qquad \frac{d\mathbf{P}}{dt} = \sum \mathbf{F}_{ext}$$

EXAMPLE For a nonuniform rod, first write dm = λ(x)dx, then evaluate xCM = [∫x dm]/[∫dm] over the physical limits of the rod.

SENSEI NOTE The integral is only as good as the mass element and limits. Use symmetry before integrating whenever it simplifies the model.

Ready to check your memory?

You've refreshed the essential idea. Now see how much you remember before moving on.

Continue to Confidence Check — page 6 →

FR-06 • STAGE 3 OF 4

Confidence Check

You've refreshed the essential idea. Now answer this quick confidence check to confirm you're ready to move on.

CONFIDENCE CHECK

Five-Minute Readiness Check

Answer all three without notes.

State the center-of-mass expression for a continuous distribution and the system relation obtained after differentiating total momentum. What does net external force = 0 imply for VCM when M is constant?

Ready for your next step?

Great work! You've refreshed the essential idea. Now choose the resource that best matches what you'd like to do next.

Continue to Next Step — page 8 →

QUICK ANSWERS • CHECK AFTER ATTEMPTING

Quick Answers and Explanations

Use these concise answers to check your recall and confidence—not only your final response.

QUICK RECALL

Recall Activity

1) sum; integral; 2) mass; 3) net external force.

WHY IT WORKS The recall distinguishes the discrete sum from the continuous integral, identifies dm as differential mass, and connects momentum change directly to the net external force.

CONFIDENCE CHECK

CONFIDENCE CHECK

Five-Minute Readiness Check

For a continuous distribution, $r_{CM} = (1/M)\int r\, dm$. The system relation is dP/dt = net external force = $M a_{CM}$. If net external force = 0 and M is constant, V_{CM} remains constant.

WHY IT WORKS The continuous center-of-mass model uses $r_{CM} = (1/M)\int r\, dm$. Newton's second law for the complete system gives dP/dt = net external force; zero net external force keeps P and, for constant M, V_{CM} constant.

READINESS GUIDE

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

FR-07 • STAGE 4 OF 4

Next Step: Continue Learning

Great work! You've completed this quick 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 essential idea again.	Continue with additional practice for this topic.	Continue to the next recommended resource.
Review again: return to Essential Idea on page 5.	**Go to Practice →**	**Continue →**

RECOMMENDED LINKS

Review again: return to Essential Idea on page 5.

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.

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