

FULL REVIEW

Full Review — Relative Velocity in Two Dimensions — Calculus-Based

Review the essential ideas, relationships, and problem-solving tools for Relative Velocity in Two Dimensions.

 TIME 45–60 minutes	 BEST FOR A complete topic review	 FINISH WITH A readiness check
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After this full review, you'll be able to...

recall the essential ideas, apply them to representative problems, and determine what to study next.

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 • COURSE ALIGNMENT

Course Alignment

This Physics Sensei Topic Review is an independent learning resource. Use it to reinforce key concepts, prepare for homework, or review before a quiz or exam.

Related Unit Review: If you need to review the complete unit material, review [Motion in Two Dimensions here](#)



RESOURCE: Physics Sensei Topic Review TOPIC ID: MEC-U04-T02 TOPIC: Relative Velocity in Two Dimensions PARENT UNIT: MEC-U04 — Motion in Two Dimensions COURSE LEVEL: Calculus-Based	BEST USED ✓ After learning the topic ✓ Before starting homework ✓ Before a quiz or exam
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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

1 Warm-Up Check Activate prior knowledge.	2 Core Concepts Review the essential ideas.	3 Guided Practice Apply what you learned.
4 Confidence Check Confirm your understanding.	5 Summary Review the key ideas.	6 Next Step Continue your learning.

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**

Answer before revealing the response.

What does “A relative to B” mean in a velocity label?

ACTIVITY 2**Recall Activity 2**

Answer before revealing the response.

If A moves east at 6 m/s and B moves east at 2 m/s, how does A move as B watches?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Answer before revealing the response.

If A/B is $(3, -2)$ m/s, what is B/A ?

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 →](#)

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

Choose one reference frame

Label the moving object and observer and express both positions relative to the same ground frame G. Their difference is the relative position; its derivative is the relative velocity.

$$\vec{r}_{A/B}(t) = \vec{r}_{A/G}(t) - \vec{r}_{B/G}(t), \vec{v}_{A/B}(t) = \frac{d\vec{r}_{A/B}(t)}{dt}$$

EXAMPLE A train passenger and a platform observer can assign different velocities to the same walker because their reference positions change differently with time.

SENSEI NOTE Write object/observer labels before using numbers.

KEY CONCEPT 2

Subtract instantaneous components

Subtract the instantaneous velocity components measured in one common frame. Equivalently, differentiate each component of relative position with respect to time.

$$v_{x,A/B}(t) = \frac{dx_{A/B}(t)}{dt}, v_{y,A/B}(t) = \frac{dy_{A/B}(t)}{dt}$$

EXAMPLE With t in numerical seconds, positions A: (3t, 2t²) m and B: (t, t²) m give A/B velocity (2, 2t) m/s.

SENSEI NOTE Subtract signed components from the same frame.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Interpret instantaneous speed and direction

At a stated time, evaluate both signed relative components. The magnitude gives instantaneous relative speed; the signs locate the direction. Reversing A and B changes the vector sign but not the speed.

$$|\vec{v}_{A/B}| = \sqrt{v_{x,A/B}^2 + v_{y,A/B}^2}$$

EXAMPLE At $t = 2$ s, A/B velocity (2, 4) m/s gives speed about 4.47 m/s and a northeast direction.

SENSEI NOTE A speed alone cannot replace a direction-bearing velocity vector.

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 →

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**

Two moving objects: work with labeled frames.

Given ground positions A: $(5t, t^2)$ m and B: $(t, -t)$ m, with t measured numerically in seconds, find A/B velocity and evaluate it at $t = 1$ s.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Boat and current: work with labeled frames.

The boat/water velocity is $(0, 4)$ m/s and water/shore position is $(3t, 0)$ m, with t in seconds. Find boat/shore velocity.

PRACTICE 3

Independent Problem

Swap observers: work with labeled frames.

Given ground positions A: $(-2t, 5t)$ m and B: $(3t, t)$ m, with t measured numerically in seconds, find both relative velocities.

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 →](#)

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**Component difference**

Find the signed vector before interpreting it.

Find A/B if $A = (7, -1)$ m/s and $B = (2, 3)$ m/s relative to ground.

QUICK CHECK 2**Observer reversal**

Find the signed vector before interpreting it.

If $A/B = (-3, 4)$ m/s, give B/A and the common relative speed.

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Frame chain

Find the signed vector before interpreting it.

A swimmer moves north at 2 m/s relative to water moving east at 1 m/s relative to shore. Give swimmer/shore.

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 →

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

Name the observer

The second object in A/B is the observer; use a common reference frame.

KEY TAKEAWAY 2

Subtract signed components

Relative velocity is a vector difference in x and y.

KEY TAKEAWAY 3

Interpret the arrow

Report speed and direction; swapping A and B reverses the vector.

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 →

ANSWER KEY • CHECK AFTER ATTEMPTING

Solutions and Explanations

Use these solutions to check your reasoning—not only your final answer. Read the reasoning for each response and revisit any step that was unclear.

WARM-UP • ACTIVITY 1**Recall Activity 1**

B is the observer measuring A's changing position.

WHY IT WORKS The second object after “relative to” names the observer.

WARM-UP • ACTIVITY 2**Recall Activity 2**

A moves east at 4 m/s relative to B.

WHY IT WORKS Subtracting the observer's eastward 2 m/s leaves 4 m/s east.

WARM-UP • ACTIVITY 3**Recall Activity 3**

B/A is $(-3, 2)$ m/s.

WHY IT WORKS Swapping object and observer reverses the relative vector.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Worked Example**

A/B position is $(4t, t^2 + t)$ m; A/B velocity is $(4, 2t + 1)$ m/s. At 1 s: $(4, 3)$ m/s.

WHY IT WORKS Differentiate the relative position component by component in the same frame.

PRACTICE 2**Guided Problem**

Differentiating water/shore position gives $(3, 0)$ m/s. Boat/shore velocity is $(3, 4)$ m/s, speed 5 m/s.

WHY IT WORKS The time derivative supplies current velocity; then the velocity chain adds vectors.

PRACTICE 3**Independent Problem**

A/B velocity is $(-5, 4)$ m/s and B/A velocity is $(5, -4)$ m/s. Both speeds are about 6.40 m/s.

WHY IT WORKS The derivative of the reversed relative position has the opposite sign.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Component difference

$$A/B = (5, -4) \text{ m/s.}$$

WHY IT WORKS Subtract matching components: $7 - 2 = 5$ and $-1 - 3 = -4$.

QUICK CHECK 2

Observer reversal

$$B/A = (3, -4) \text{ m/s; speed } 5 \text{ m/s.}$$

WHY IT WORKS The vector reverses, while its magnitude remains unchanged.

QUICK CHECK 3

Frame chain

$$(1 \text{ east, } 2 \text{ north}) \text{ m/s; speed about } 2.24 \text{ m/s.}$$

WHY IT WORKS Add swimmer/water and water/shore as vectors, one component at a time.

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 Review the key ideas and examples again. Review Again →	 I Need More Practice Continue with additional practice for this topic. Go to Practice →	 I'm Ready Continue to the next recommended resource. Continue →
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RECOMMENDED LINKS

[Review this topic again →](#)[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