FULL REVIEW

Full Review: Projectile Motion — Algebra-Based

Review the essential ideas, relationships, and problem-solving tools for projectile motion.

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

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

analyze vector motion, solve representative projectile and relative-motion problems, and interpret circular acceleration.

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 bundle is designed to complement the chapter listed below. Use it to reinforce key concepts, prepare for homework, or review before a quiz or exam.

TEXTBOOK: Independent Physics Sensei Unit Review **CHAPTER: MEC-U15** **TOPIC: MEC-U15 — Projectile Motion** **COURSE LEVEL: Algebra-based introductory college physics**	**BEST USED** ✓ After reading the chapter ✓ Before starting homework ✓ Before a quiz or exam

Visit Physics Sensei →

Physics Sensei is an independent educational resource for college physics review and practice.

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 — page 4** Activate prior knowledge.	2 **Core Concepts — page 6** Review the essential ideas.	3 **Guided Practice — page 8** Apply what you learned.
4 **Confidence Check — page 10** Confirm your understanding.	5 **Summary — page 12** Review the key ideas.	6 **Next Step — page 16** 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

Resolve the launch velocity into horizontal and vertical components.

A ball is launched at 20.0 m/s at 30.0° above horizontal. Find v_0x and v_0y.

ACTIVITY 2

Recall Activity 2

Use the shared-time idea to update both velocity components.

A projectile is launched with v_0x = 12.0 m/s and v_0y = 18.0 m/s. Find v_x and v_y after 1.50 s. Use g = 9.80 m/s^2.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Recognize when the equal-height shortcuts are valid.

A projectile launches and lands at the same height. Which quantities can be found directly from the standard equal-height formulas?

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

Component Equations and Shared Time

Resolve the initial velocity before applying kinematics. In the ideal model, $a_x = 0$ and $a_y = -g$, so x motion uses constant velocity while y motion uses constant acceleration. Both axes must use the same elapsed time. Often the vertical equation determines time and the horizontal equation then gives range.

$$v_0x = v_0 \cos\theta;\ v_0y = v_0 \sin\theta;\ x = x_0 + v_0x\, t;\ y = y_0 + v_0y\, t - \tfrac{1}{2}gt^2;\ v_y = v_0y - gt.$$

EXAMPLE For a 24.0 m/s launch at 40.0° from 1.50 m above ground, v_0x = 18.4 m/s and v_0y = 15.4 m/s. Solving the vertical equation gives t = 3.24 s; the range is 59.6 m.

SENSEI NOTE Do not insert the full launch speed into a one-dimensional equation. Each axis uses its own component.

KEY CONCEPT 2

Range, Height, and Unequal-Height Launches

When launch and landing heights are equal, symmetry gives useful shortcuts. When they differ, return to the general vertical position equation and solve the resulting quadratic for the physically meaningful time. Maximum height follows from $v_y = 0$ or from the vertical kinematic relation that eliminates time.

$$\text{Equal heights: } T = 2v_0 \sin\theta/g;\ R = v_0^2 \sin(2\theta)/g;\ H = v_0^2 \sin^2\theta/(2g).\ \text{Unequal heights: solve } y\_f = y_0 + v_0y\, t - \tfrac{1}{2}gt^2.$$

EXAMPLE A projectile launched at 24.0 m/s and 40.0° from 1.50 m above ground stays airborne 3.24 s, travels 59.6 m horizontally, and reaches 13.6 m above the ground.

SENSEI NOTE The range formula $R = v_0^2 \sin(2\theta)/g$ is not valid when launch and landing heights differ.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Impact Velocity, Horizontal Launches, and Targeting

For a horizontal launch, $v_0y = 0$ and the drop determines flight time. For any projectile, compute impact velocity from its components at the impact time. Targeting problems work backward: impose the target coordinates and solve the component equations for the unknown time, speed, or angle.

Horizontal launch: $t = \sqrt{(2\Delta y/g)}$ when $v_0y = 0$; $v_y = -gt$; speed $= \sqrt{(v_x^2 + v_y^2)}$; direction $= \tan^{-1}(|v_y|/v_x)$.

EXAMPLE A ball launched horizontally at 18.0 m/s from a 45.0 m cliff falls for 3.03 s, travels 54.5 m, and impacts at 34.7 m/s, 58.8° below horizontal.

SENSEI NOTE Keep the sign of v_y until the final interpretation. A negative vertical component means downward when +y is upward.

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

Use the equal-height formulas and verify the result with components.

A ball is launched from level ground at 28.0 m/s and 35.0°. Find time of flight, range, and maximum height.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Solve the vertical quadratic first, then use the same time horizontally.

A ball is launched from 1.50 m above ground at 24.0 m/s and 40.0°. Find flight time, range, maximum height, and impact velocity.

PRACTICE 3

Independent Problem

Use the vertical drop to get time, then compute the impact vector.

A package leaves a horizontal conveyor at 18.0 m/s from a height of 45.0 m. Find the landing time, horizontal distance, and impact speed.

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

Choose the Correct Model

Identify whether a shortcut or the general equations are required.

A projectile is launched from a rooftop and lands on the street. Can $R = v_0^2 \sin(2\theta)/g$ be used directly?

QUICK CHECK 2

Apex Velocity

Evaluate the components at the top of the path.

A projectile is launched at 25.0 m/s at 50.0°. What are v_x, v_y, and acceleration at the apex?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Impact Vector

Do not report speed alone.

Why is an impact velocity not fully described by a single positive number?

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

Resolve First

Convert the launch speed and angle into v_0x and v_0y before using one-dimensional kinematics.

KEY TAKEAWAY 2

One Time Connects Both Axes

Horizontal and vertical equations are solved separately but must describe the same elapsed time.

KEY TAKEAWAY 3

Shortcuts Have Conditions

Equal-height formulas are efficient only when their assumptions match the physical situation.

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. Use each answer and explanation to identify the step that supports the result.

WARM-UP • ACTIVITY 1

Recall Activity 1

v_0x = 17.3 m/s; v_0y = 10.0 m/s.

WHY IT WORKS Use $v_0x = v_0 \cos\theta$ and $v_0y = v_0 \sin\theta$. With θ = 30.0°, the components are 20.0 cos 30° = 17.3 m/s and 20.0 sin 30° = 10.0 m/s.

WARM-UP • ACTIVITY 2

Recall Activity 2

v_x = 12.0 m/s; v_y = 3.30 m/s.

WHY IT WORKS $a_x = 0$, so v_x is unchanged. Vertically, $v_y = v_0y - gt$ = 18.0 – 9.80(1.50) = 3.30 m/s.

WARM-UP • ACTIVITY 3

Recall Activity 3

Time of flight, horizontal range, and maximum height above the launch point.

WHY IT WORKS Equal launch and landing heights make the vertical motion symmetric, enabling the standard formulas $T = 2v_0y/g$, $R = v_0^2 \sin(2\theta)/g$, and $H = v_0y^2/(2g)$.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

$T = 3.28$ s; $R = 75.2$ m; $H = 13.2$ m above the launch point.

WHY IT WORKS $v_0y = 28.0 \sin 35° = 16.1$ m/s. Then $T = 2v_0y/g = 3.28$ s, $R = v_0^2 \sin 70°/g = 75.2$ m, and $H = v_0y^2/(2g) = 13.2$ m.

PRACTICE 2

Guided Problem

$t = 3.24$ s; range = 59.6 m; maximum height = 13.6 m; impact velocity = $<18.4, -16.4>$ m/s, speed = 24.6 m/s at 41.7° below horizontal.

WHY IT WORKS Use $v_0x = 18.4$ m/s and $v_0y = 15.4$ m/s. Solve $0 = 1.50 + 15.4t - 4.90t^2$ for $t = 3.24$ s. Then $x = v_0x\, t$ and $v_y = v_0y - gt = -16.4$ m/s.

PRACTICE 3

Independent Problem

$t = 3.03$ s; horizontal distance = 54.5 m; impact speed = 34.7 m/s.

WHY IT WORKS With $v_0y = 0$, $45.0 = \frac{1}{2}gt^2$ gives $t = 3.03$ s. Then $x = 18.0t = 54.5$ m and $v_y = -gt = -29.7$ m/s, so speed $= \sqrt{(18.0^2 + 29.7^2)} = 34.7$ m/s.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Choose the Correct Model

No.

WHY IT WORKS That range formula assumes equal launch and landing heights. Use the vertical position equation to find the shared flight time, then compute horizontal displacement.

QUICK CHECK 2

Apex Velocity

v_x = 16.1 m/s; v_y = 0; acceleration = 9.80 m/s^2 downward.

WHY IT WORKS Horizontal velocity remains v_0 cos50° = 16.1 m/s. The vertical velocity reaches zero at the turning point, but gravity remains unchanged.

QUICK CHECK 3

Impact Vector

Because velocity is a vector; its horizontal and vertical components or its speed and direction are required.

WHY IT WORKS The sign and direction of v_y distinguish rising from falling motion even when the speed magnitude is the same.

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 topic.	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.

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