FOCUSED REVIEW

Focused Review: Friction, Inclines, and Connected Objects — Calculus-Based

Reinforce the essential ideas and problem-solving tools for Friction, Inclines, and Connected Objects.

◷ **TIME** 15–20 minutes	◎ **BEST FOR** Focused review	✓ **FINISH WITH** Greater confidence

After this focused review, you'll be able to…
recognize the key concepts, reinforce your problem-solving skills, and continue with greater confidence.

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 15–20 minutes

FR-02 • TOPIC ALIGNMENT

Topic Alignment

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

TEXTBOOK: Independent Physics Sensei Unit Review **CHAPTER: Mechanics • MEC-U17** **TOPIC: Friction, Inclines, and Connected Objects** **COURSE LEVEL: Calculus-Based**	**BEST USED** **✓ After reading the chapter** **✓ Before starting homework** **✓ Before a quiz or exam**

Review Prerequisites →

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 15–20 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

Key Ideas

Recall the static-friction rule.

In the stick regime, what mathematical role does static friction play?

WARM-UP 2

Common Mistakes

Recall the incline components.

State the tangent and normal projections of gravity on a straight incline.

FR-04 • WARM-UP CHECK CONTINUED

WARM-UP 3

Quick Application

Recall the connected-object rule.

If $x_1 + x_2 = L$, what is the acceleration constraint?

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

Friction and incline setup

The stick/slip model is piecewise. Projection onto tangent and normal directions separates the dynamical coordinate from the contact constraint.

$$|f_t| \le \mu_s N \text{ in stick; during slip } f_t = -\mu_k N \,\mathrm{sgn}(v_{rel,t});\ m(d^2s/dt^2) = \Sigma F \cdot \hat{t}.$$

EXAMPLE Impending gravity-driven slip occurs when $\tan\theta$ reaches μ_s in the simple one-block model.

SENSEI NOTE Determine the normal force and the stick/slip state before substituting a friction magnitude.

KEY CONCEPT 2

Connected objects: one FBD per object, one rope constraint

A holonomic rope-length constraint reduces the independent coordinates; differentiating it provides the velocity and acceleration relations used with projected Newton equations.

$$C(q)=0;\ d^2C/dt^2 = 0 \text{ supplies the acceleration constraint.}$$

EXAMPLE Using one generalized coordinate gives $(m_1 + m_2)(d^2x/dt^2) = m_2 g - \mu_k m_1 g$ for the same ideal geometry.

SENSEI NOTE Define one positive system direction before writing signs. A negative result means the actual acceleration is opposite that choice.

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

Guided Example

Test whether friction can hold on an incline.

Derive the gravity-only stick criterion for a simple incline.

PRACTICE 2

Independent Check

Solve a two-object connected system.

Write the same system with one generalized coordinate and identify the effective inertia.

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

Friction and incline readiness check

Answer without a calculator.

What condition marks impending gravity-driven slip on a simple incline?

CONFIDENCE CHECK 2

Connected-system readiness check

Identify the valid statement.

If $x_1 + x_2 = L$, what acceleration relation follows?

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

Classify contact and choose incline axes first

Static friction adjusts within $|f_s| \le \mu_s N$; kinetic friction models sliding. On inclines, use parallel/perpendicular axes, determine N, and then write the tangential equation.

KEY TAKEAWAY 2

For connected objects, separate the bodies before combining the equations

Draw one FBD per object, define a positive direction, apply the ideal-rope tension/constraint rules, and solve the simultaneous Newton equations.

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. Replace each placeholder with a concise answer and the essential explanation.

WARM-UP • ACTIVITY 1

Key Ideas

A constraint reaction determined by the equations while remaining inside the admissible bound.

WHY IT WORKS The maximum static friction is a limit, not the default value.

WARM-UP • ACTIVITY 2

Common Mistakes

g_t=g sinθ down slope; g_n=g cosθ into the surface.

WHY IT WORKS Incline axes expose the driving component and the normal constraint directly.

WARM-UP • ACTIVITY 3

Quick Application

$a_1 + a_2 = 0$ with consistently oriented coordinates.

WHY IT WORKS Separate dynamics plus one kinematic constraint is the core structure of connected-object problems.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Guided Example

$mg \sin\theta \le \mu_s mg \cos\theta$, hence $\tan\theta \le \mu_s$.

WHY IT WORKS Compare the friction required for equilibrium with the maximum allowed by the contact model.

PRACTICE 2

Independent Check

$(m_1 + m_2)(d^2x/dt^2) = m_2 g - \mu_k m_1 g$; effective inertia is m_1+m_2.

WHY IT WORKS The rope constraint makes one acceleration variable sufficient for the simple geometry, while separate FBDs recover tension.

SOLUTIONS • CONFIDENCE CHECK

CONFIDENCE CHECK 1

Friction and incline readiness check

$\tan\theta = \mu_s$.

WHY IT WORKS Static friction is bounded, while incline components come from vector projection.

CONFIDENCE CHECK 2

Connected-system readiness check

$a_1 + a_2 = 0$ for consistently oriented coordinates.

WHY IT WORKS The rope constrains motion; Newton's law still belongs to each object.

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