FULL REVIEW

Full Review: Friction, Inclines, and Connected Objects — Algebra-Based

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

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

> **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 • 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: Algebra-Based**	**BEST USED** ✓ After reading the chapter ✓ Before starting homework ✓ Before a quiz or exam

Review Prerequisites →

Physics Sensei is an independent educational resource designed to complement independently authored Physics Sensei materials. Physics Sensei content is independently authored and organized under the approved topic architecture.

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

Classify the friction model before calculating.

A 10 kg box remains at rest while pushed horizontally with 20 N. If μ_s=0.40, determine the static-friction force and compare it with its maximum possible value.

ACTIVITY 2

Recall Activity 2

Choose incline components and the normal force.

For a 6.0 kg block on a 30° incline with no other perpendicular forces, find the normal force.

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Identify the shared constraint in a connected system.

Write the acceleration relation for two masses connected by one taut inextensible rope over a fixed frictionless pulley.

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

Friction is a contact response, not a preset force

Use $|f_s| \le \mu_s N$ for static contact and $f_k = \mu_k N$ for the kinetic-friction magnitude. Determine N from the perpendicular force balance; do not assume N=mg when geometry or other forces change it.

$|f_s| \le \mu_s N$; at impending slip $|f_s| = \mu_s N$; $f_k = \mu_k N$.

EXAMPLE For m=8.0 kg and μ_s=0.50 on a horizontal floor, $f_{s,max}$ = 39.2 N. A 25 N push produces 25 N static friction, not 39.2 N.

SENSEI NOTE Ask first: is the contact sticking or sliding? Then compute the normal force. Only after those decisions should you choose a friction equation.

KEY CONCEPT 2

Inclines are Newton's laws in rotated axes

For a simple block on a fixed incline, weight components are mg sinθ parallel and mg cosθ perpendicular. If there is no perpendicular acceleration and no other perpendicular force, N = mg cosθ. Apply $\Sigma F_{\parallel} = ma$ with signs set by the assumed direction.

$N = mg\cos\theta$ (simple case); $\Sigma F_{\parallel} = ma$; impending slide: $mg\sin\theta = \mu_s mg\cos\theta$.

EXAMPLE A 5.0 kg block on a 30° incline has mg sin30°=24.5 N down slope and N=42.4 N when no other perpendicular forces act.

SENSEI NOTE Draw the weight vector straight down first. Components are mathematical projections of weight, not additional forces.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Connected objects require separate dynamics plus one constraint

For one massless rope over frictionless massless pulleys, the tension is uniform and the rope-length constraint gives the acceleration relation. Write ΣF=ma for each object, then solve the equations simultaneously.

Example table/hanging system: $T-f=m_1 a$; $m_2 g-T=m_2 a$.

EXAMPLE For $m_1=4.0$ kg on a horizontal table with $\mu_k=0.20$ and $m_2=2.0$ kg hanging, $a=[m_2 g-\mu_k m_1 g]/(m_1+m_2)=1.96$ m/s² and $T=15.7$ N.

SENSEI NOTE Do not write one giant force equation before isolating the objects. Separate free-body diagrams prevent missing friction, weight, or tension terms.

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

Test static friction first; if it cannot hold, switch to kinetic friction and solve the motion.

A 5.0 kg block is released on a 30° incline with μ_s=0.40 and μ_k=0.30. Determine whether it slips; if it does, find its acceleration.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Resolve forces on the incline and keep normal and tangential equations separate.

A 12 kg crate slides down a 20° incline with μ_k=0.25. Find its acceleration.

PRACTICE 3

Independent Problem

Draw both free-body diagrams, define one positive system direction, and solve with the rope constraint.

A 4.0 kg block on a horizontal table (μ_k=0.20) is connected over an ideal pulley to a 2.0 kg hanging mass. Find the acceleration and tension.

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

Static or kinetic friction check

Answer and justify briefly.

A 20 kg box on a horizontal floor has μ_s=0.30. What is the largest horizontal push that can be balanced without slipping?

QUICK CHECK 2

Incline setup check

Choose the correct component or relation.

For a simple block on a 40° incline with no perpendicular acceleration, what expression gives N?

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Connected-system check

Identify the valid statement.

For one ideal rope over a frictionless massless pulley, is the tension the same on both sides?

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

Friction must be classified before it is calculated

Use static friction as an adjustable force satisfying $|f_s| \leq \mu_s N$. Use $\mu_s N$ only at impending slip. For sliding, use the kinetic-friction model with direction opposite relative tangential motion.

KEY TAKEAWAY 2

Rotate the axes, not the physics

On a simple incline, resolve weight into $mg \sin\theta$ along the surface and $mg \cos\theta$ perpendicular to it. Determine N from the normal equation, then write the tangential Newton's-law equation.

KEY TAKEAWAY 3

Connected systems combine separate free-body diagrams with one constraint

Write one dynamics equation per object, choose a consistent positive direction, and apply the rope-length acceleration relation. Equal tension requires the ideal single-rope model; equal acceleration does not imply equal net force.

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

WARM-UP • ACTIVITY 1

Recall Activity 1

The actual static friction is 20 N opposite the push. N=98 N, so f_s,max = $\mu_s N$ = 39.2 N; 20 N is within the allowed range.

WHY IT WORKS Static friction supplies only the amount needed to prevent relative slipping, up to its limiting value. Do not set $f_s=\mu_s N$ unless the contact is at impending motion.

WARM-UP • ACTIVITY 2

Recall Activity 2

N=mg cos30°=(6.0)(9.8)(0.866)=50.9 N.

WHY IT WORKS For a simple fixed incline, resolving weight into parallel and perpendicular components reduces the force equations to the natural directions of motion and constraint.

WARM-UP • ACTIVITY 3

Recall Activity 3

The magnitudes of the two accelerations are equal for the simple one-rope geometry; signs depend on the chosen coordinates.

WHY IT WORKS The rope geometry creates the kinematic constraint. Equal acceleration magnitudes come from constant rope length, not from equal forces.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Worked Example

N=42.4 N. The required static friction is 24.5 N, but f_s,max = 17.0 N, so it slips. Then f_k=12.7 N and a=(24.5−12.7)/5.0=2.35 m/s² down the incline.

WHY IT WORKS Static friction is a feasibility test: compare the friction required for zero acceleration with the maximum available. Only after failure do you use kinetic friction.

PRACTICE 2

Guided Problem

N=mg cos20°=110.5 N; f_k=27.6 N; mg sin20°=40.2 N; a=(40.2−27.6)/12=1.05 m/s² down the incline.

WHY IT WORKS Incline problems become straightforward when weight is resolved once, N is obtained from the normal equation, and friction is then placed opposite sliding.

PRACTICE 3

Independent Problem

For the table block, T−7.84=4a. For the hanging mass, 19.6−T=2a. Thus a=1.96 m/s² and T=15.7 N.

WHY IT WORKS The two-body equations and the one-coordinate system equation are equivalent. The advantage of separate free-body diagrams is that they also reveal the internal tension.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Static or kinetic friction check

$f_s,max = \mu_s mg = 0.30(20)(9.8) = 58.8$ N.

WHY IT WORKS Static friction is a constraint reaction that adjusts to satisfy no-slip dynamics until the limiting value is reached.

QUICK CHECK 2

Incline setup check

$N = mg\cos 40°$.

WHY IT WORKS The parallel component drives sliding; the perpendicular component determines the normal force in the simple fixed-incline model.

QUICK CHECK 3

Connected-system check

Yes, within that ideal-rope model.

WHY IT WORKS The rope sets a kinematic relation; Newton's second law still applies separately to each mass.

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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