

FOCUSED REVIEW

Focused Review: Static Equilibrium and Stability

Review the most important ideas, reinforce the essential skills, and confirm you're ready to move on.

 TIME 15–20 minutes	 BEST FOR Focused review	 FINISH WITH Greater confidence
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After this focused review, you'll be able to...

reinforce the equilibrium conditions, apply torque and stability reasoning, and solve representative calculus-based problems with 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 • COURSE ALIGNMENT

Course Alignment

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

RESOURCE: Physics Sensei Unit Review
UNIT ID: MEC-U23
TOPIC: Static Equilibrium and Stability
COURSE LEVEL: Calculus-Based

BEST USED

- ✓ After learning the unit
- ✓ Before starting homework
- ✓ Before a quiz or exam

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 Refresh key ideas.	2 Core Concepts Reinforce the essentials.	3 Guided Practice Strengthen key skills.
4 Confidence Check Confirm your understanding.	5 Summary Remember the essentials.	6 Next Step 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

Vector Conditions

State the equilibrium equations for a rigid body.

State the equilibrium equations for a rigid body.

WARM-UP 2

Energy Criterion

What condition identifies an equilibrium configuration in $U(q)$?

What condition identifies an equilibrium configuration in $U(q)$?

FR-04 • WARM-UP CHECK CONTINUED

WARM-UP 3

Quick Application

If $d^2U/dq^2 > 0$ at an equilibrium point, classify it.

If $d^2U/dq^2 < 0$ at an equilibrium point, classify it.

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 →

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

Vector Force and Torque Balance

Rigid-body equilibrium requires both translational and rotational equations. In three dimensions, the vector equations supply up to six scalar conditions. Torque about an origin is the sum of $\mathbf{r} \times \mathbf{F}$ for all external forces.

$$\Sigma \mathbf{F} = 0 \quad \cdot \quad \Sigma \boldsymbol{\tau} = 0 \quad \cdot \quad dU/dq = 0$$

EXAMPLE A force whose line of action passes through the chosen origin contributes zero torque about that origin.

SENSEI NOTE Changing the origin changes individual torques, but for an equilibrium system the total torque remains zero.

KEY CONCEPT 2

Potential-Energy Stability

For a conservative one-coordinate system, equilibrium occurs at $dU/dq = 0$. A positive second derivative indicates a local minimum and stable equilibrium; a negative second derivative indicates a local maximum and unstable equilibrium.

$$\Sigma \mathbf{F} = 0 \quad \cdot \quad \Sigma \boldsymbol{\tau} = 0 \quad \cdot \quad dU/dq = 0$$

EXAMPLE Near a stable equilibrium q_0 , U can be approximated by a quadratic minimum.

SENSEI NOTE If the second derivative is zero, higher-order terms may be needed to classify the equilibrium.

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 →](#)

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**

Solve the problem and show the equilibrium reasoning.

A horizontal beam of length L and weight W is hinged at one end and supported by a cable with tension T at angle θ to the beam at the far end. Derive T .

PRACTICE 2**Independent Check**

Solve the problem and show the equilibrium reasoning.

A system has $U(q) = aq^2 + bq^4$ with $a > 0$ and $b > 0$. Classify $q = 0$.

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 →

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

Vector Torque

Evaluate the direction.

If r points in $+x$ and F points in $+y$, what is the direction of $\tau = r \times F$?

CONFIDENCE CHECK 2

Stability from Curvature

Classify the point.

At $q = q_0$, $dU/dq = 0$ and $d^2U/dq^2 < 0$. What type of equilibrium is present?

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 →

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**Equilibrium is vector balance**

Both ΣF and $\Sigma \tau$ must vanish for a rigid body in static equilibrium.

KEY TAKEAWAY 2**Stability can be read from energy**

A local minimum of potential energy corresponds to stable equilibrium in conservative systems.

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. Focus on the method and the physical meaning of each result.

WARM-UP • ACTIVITY 1

Vector Conditions

$\Sigma \mathbf{F} = 0$ and $\Sigma \boldsymbol{\tau} = 0$, with $\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$.

WHY IT WORKS The response uses the defining conditions for force, torque, and stability.

WARM-UP • ACTIVITY 2

Energy Criterion

$dU/dq = 0$ for the generalized coordinate q .

WHY IT WORKS The response uses the defining conditions for force, torque, and stability.

WARM-UP • ACTIVITY 3

Quick Application

Stable; the potential energy has a local minimum.

WHY IT WORKS Apply the relevant equilibrium or stability relationship directly.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Guided Example

Torque balance about the hinge gives $TL \sin \theta - W(L/2) = 0$, so $T = W/(2 \sin \theta)$.

WHY IT WORKS Use force balance, torque balance, or the stability criterion appropriate to the problem.

PRACTICE 2

Independent Check

$dU/dq = 2aq + 4bq^3$, so $q = 0$ is an equilibrium. $d^2U/dq^2 = 2a + 12bq^2$, which is positive at $q = 0$, so the equilibrium is stable.

WHY IT WORKS Use force balance, torque balance, or the stability criterion appropriate to the problem.

SOLUTIONS • CONFIDENCE CHECK

CONFIDENCE CHECK 1

Vector Torque

+z by the right-hand rule.

WHY IT WORKS The classification follows directly from the equilibrium and stability conditions.

CONFIDENCE CHECK 2

Stability from Curvature

Unstable equilibrium; U has a local maximum.

WHY IT WORKS The classification follows directly from the equilibrium and stability conditions.

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 Review the focused review again to strengthen the essential concepts. Review Again →	 I Need More Practice Build confidence with additional practice problems. Go to Practice →	 I'm Ready Continue to the next topic or learning 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](#)