FULL REVIEW

Full Review: Work, Energy, and Power

Review the essential ideas, relationships, and problem-solving tools for Work, Energy, and Power.

◷ 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.

ARCHITECTURE: Physics Sensei Independent Mechanics UNIT: MEC-U06 — Work, Energy, and Power TOPIC: Unit Review — Work, Energy, and Power PROFILE: Calculus-Based	BEST USED ✓ Before calculus-based energy homework ✓ Before a quiz or exam ✓ When variable forces or potential curves are involved

Review Prerequisites →

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

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

Variable-force work

Integrate the force-position function.

For $F_x = 3x^2$, find the work from $x = 0$ to $x = 2.0$ m.

ACTIVITY 2

Force from potential

Differentiate the potential-energy function.

If $U(x) = 2x^2$, what is $F_x(x)$?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Instantaneous power

Use the dot product.

A 10 N force is parallel to a 3.0 m/s velocity. What is the instantaneous power?

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

Variable-force work is a line integral

For one-dimensional motion, $W = \int F_x\, dx$. Graphically, work is the signed area under the force-position curve.

$$W = \int F_x\, dx \quad \bullet \quad W_{net} = \Delta K$$

EXAMPLE If $F_x = 6x + 2$ from 0 to 3.0 m, then $W = [3x^2 + 2x]_0^3 = 33$ J.

SENSEI NOTE A negative region below the x-axis contributes negative work.

KEY CONCEPT 2

The work-energy theorem follows from dynamics

Using $F_{net} = ma$ and $a = v\, dv/dx$ in one dimension gives $F_{net}\, dx = mv\, dv$. Integration produces $\int F_{net}\, dx = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \Delta K$.

$$F_x = -dU/dx \quad \bullet \quad P = F \cdot v$$

EXAMPLE This derivation shows why net work depends on kinetic-energy endpoints even when force varies with position.

SENSEI NOTE Calculus converts local force information into a finite energy change.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Potential-energy curves encode force and stability

For a conservative force, $F_x = -dU/dx$. Equilibrium occurs where $dU/dx = 0$; a local minimum of U is stable and a local maximum is unstable.

overturning moment = restoring moment

EXAMPLE $U = 5x^2 - 20x$ has equilibrium at $x = 2.0$ m, and $d^2U/dx^2 = 10 > 0$, so the equilibrium is stable.

SENSEI NOTE Potential-energy graphs let you infer force direction without solving the motion explicitly.

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

Integrate a polynomial force

Calculate work from F(x).

A force is $F_x = 2x^2 + 4$ N. Find the work from $x = 1.0$ m to $x = 3.0$ m.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Force from potential

Differentiate U(x).

A particle has $U(x) = 3x^4 - 8x^2$ J. Find $F_x(x)$ and the equilibrium positions.

PRACTICE 3

Power with changing direction

Use the dot product.

A 20 N force makes 60° with a particle's 5.0 m/s velocity. Find the instantaneous power.

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

Work from a force function

Integrate over the interval.

For $F_x = 6x$ N, find the work from $x = 0$ to $x = 2.0$ m.

QUICK CHECK 2

Stability from U(x)

Use derivatives.

For $U(x) = x^4 - 4x^2$, classify the equilibrium at $x = 0$.

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Instantaneous power

Use $P = F \cdot v$.

A 10 N force is parallel to a 3.0 m/s velocity. What is the instantaneous power?

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

Integrate force to obtain work

Variable-force work is the line integral $\int F \cdot dr$; in one dimension it is signed area under $F_x(x)$.

KEY TAKEAWAY 2

Differentiate potential to obtain force

$F_x = -dU/dx$ converts a potential-energy function into conservative force and reveals equilibrium.

KEY TAKEAWAY 3

Power is instantaneous energy-transfer rate

$P = dW/dt = F \cdot v$ connects force directly to the rate of doing work.

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

Variable-force work

8.0 J.

WHY IT WORKS $W = \int_0^2 3x^2\,dx = [x^3]_0^2 = 8.0$ J.

WARM-UP • ACTIVITY 2

Force from potential

$F_x = -4x$.

WHY IT WORKS For a conservative one-dimensional force, $F_x = -dU/dx$.

WARM-UP • ACTIVITY 3

Instantaneous power

30 W.

WHY IT WORKS $P = F \cdot v = Fv$ when force and velocity are parallel.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1

Integrate a polynomial force

25.3 J.

WHY IT WORKS $W = \int_1^3 (2x^2 + 4)dx = [(2/3)x^3 + 4x]_1^3 = 76/3$ J ≈ 25.3 J.

PRACTICE 2

Force from potential

$F_x = -12x^3 + 16x$; equilibria at $x = 0$ and $x = \pm\sqrt{(4/3)} \approx \pm 1.155$ m.

WHY IT WORKS $F_x = -dU/dx$. Set $F_x = 0$: $x(-12x^2 + 16) = 0$.

PRACTICE 3

Power with changing direction

50 W.

WHY IT WORKS $P = Fv \cos 60° = (20)(5.0)(0.5) = 50$ W.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Work from a force function

12 J.

WHY IT WORKS $W = \int_0^2 6x\,dx = [3x^2]_0^2 = 12$ J.

QUICK CHECK 2

Stability from U(x)

Unstable.

WHY IT WORKS $dU/dx = 4x^3 - 8x = 0$ at $x = 0$, and $d^2U/dx^2 = -8$ there, so U has a local maximum.

QUICK CHECK 3

Instantaneous power

30 W.

WHY IT WORKS $P = F \cdot v = (10)(3.0) = 30$ W.

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.

PhysicsSensei.com