

FULL REVIEW

Full Review — Newton's Laws of Motion — Calculus-Based

Review the essential ideas, relationships, and problem-solving tools for Newton's Laws of Motion.

 TIME 45–60 minutes	 BEST FOR A complete topic review	 FINISH WITH A readiness check
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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 • COURSE ALIGNMENT

Course Alignment

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

Related Unit Review: If you need to review the complete unit material, review Newton's Laws and Free-Body Diagrams here → <https://physicssensei.com/full-unit-review-newtons-laws-and-free-body-diagrams-calculus-based/>

RESOURCE: Physics Sensei Topic Review
TOPIC ID: MEC-U05-T01
TOPIC: Newton's Laws of Motion
PARENT UNIT: MEC-U05 — Newton's Laws and Free-Body Diagrams
COURSE LEVEL: Calculus-Based

BEST USED

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

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

Answer before revealing the response.

State Newton's second law in momentum form.

ACTIVITY 2**Recall Activity 2**

Answer before revealing the response.

If $\mathbf{v}(t)$ is constant, what are $\mathbf{a}$ and $\Sigma \mathbf{F}$ for constant mass?

FR-04 • WARM-UP CHECK CONTINUED

ACTIVITY 3

Recall Activity 3

Answer before revealing the response.

For an interaction A–B, write the vector relationship between the two third-law forces.

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 →

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

Newton's First Law and Inertia

Newton's first law is the constant-momentum case of Newtonian dynamics: zero net external force means momentum does not change with time. For constant mass, velocity is therefore constant.

$$\Sigma \mathbf{F} = 0 \rightarrow \mathbf{a} = 0$$

EXAMPLE Check the net force on one chosen object before deciding how its motion changes.

SENSEI NOTE Constant velocity means zero acceleration; it does not require the object to be at rest.

KEY CONCEPT 2

Newton's Second Law: Net Force and Motion

The general second-law statement relates net external force to the time rate of change of momentum. When mass is constant, differentiating $m \mathbf{v}$ gives $m \mathbf{a}$. This provides the bridge between force models and kinematic functions $\mathbf{v}(t)$ or $\mathbf{r}(t)$.

$$\Sigma \mathbf{F} = d \mathbf{p}/dt; \text{ for constant mass, } \Sigma \mathbf{F} = m d \mathbf{v}/dt = m \mathbf{a}$$

EXAMPLE Use object labels on interaction forces so third-law partners stay on different free-body diagrams.

SENSEI NOTE Do not pair weight and normal force as a third-law pair; both can act on the same object.

FR-05 • CORE CONCEPTS CONTINUED

KEY CONCEPT 3

Newton's Third Law: Interaction Pairs

Newton's third law is a vector statement about one interaction between two bodies. Equal and opposite interaction forces can still produce different accelerations because each force acts on a different mass.

$$\mathbf{F}_{A \rightarrow B} = -\mathbf{F}_{B \rightarrow A}$$

EXAMPLE Compare force direction with acceleration or momentum-change direction.

SENSEI NOTE Equal third-law forces can produce different accelerations when masses differ.

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 →

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**

Follow the model solution and identify the law used.

A 3.0 kg particle has $\mathbf{r}(t) = (2t^3 \hat{i} - t^2 \hat{j})$ m. Find $\mathbf{a}(t)$ and $\mathbf{F}(t)$.

FR-06 • GUIDED PRACTICE CONTINUED

PRACTICE 2

Guided Problem

Use the checkpoints, then complete the calculation or explanation.

A particle has $\mathbf{p}(t) = (5t^2 \hat{i} + 3t \hat{j}) \text{ kg}\cdot\text{m/s}$. Find the net force at $t = 2.0 \text{ s}$.

PRACTICE 3

Independent Problem

Solve independently and state the Newton's-law reasoning.

Two skaters of masses 75 kg and 50 kg push apart with a 150 N interaction force. Find both acceleration magnitudes and relate the result to Newton's third law.

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 →

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**Newton's Laws Check 1**

Solve and justify your conclusion.

If $\mathbf{v}(t) = (4t^2 \hat{i} - 3t \hat{j})$ m/s for a 2.0 kg particle, find $\mathbf{F}(t)$.

QUICK CHECK 2**Newton's Laws Check 2**

Solve and justify your conclusion.

If $\mathbf{F}(t) = (6t \hat{i})$ N and $\mathbf{p}(0)=0$, find $\mathbf{p}(t)$.

FR-07 • CONFIDENCE CHECK CONTINUED

QUICK CHECK 3

Newton's Laws Check 3

Solve and justify your conclusion.

A 100 kg object and a 25 kg object exert a third-law pair of 200 N. Compare acceleration magnitudes.

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 →

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

Zero net force means no change in velocity.

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KEY TAKEAWAY 2

Net external force determines acceleration or momentum change.

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KEY TAKEAWAY 3

Third-law forces are equal/opposite and act on different objects.

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

WARM-UP • ACTIVITY 1

Recall Activity 1

$$\Sigma \mathbf{F} = d \mathbf{p} / dt.$$

WHY IT WORKS The result follows by isolating one object and applying the net-force rule or the correct interaction pair.

WARM-UP • ACTIVITY 2

Recall Activity 2

$$\mathbf{a} = d \mathbf{v} / dt = 0 \text{ and therefore } \Sigma \mathbf{F} = 0.$$

WHY IT WORKS The result follows by isolating one object and applying the net-force rule or the correct interaction pair.

WARM-UP • ACTIVITY 3

Recall Activity 3

$$\mathbf{F}_{A \rightarrow B} = -\mathbf{F}_{B \rightarrow A}.$$

WHY IT WORKS The result follows by isolating one object and applying the net-force rule or the correct interaction pair.

SOLUTIONS • GUIDED PRACTICE

PRACTICE 1**Worked Example**

$$\mathbf{v} = (6t^2 \hat{i} - 2t \hat{j}) \text{ m/s}; \mathbf{a} = (12t \hat{i} - 2 \hat{j}) \text{ m/s}^2; \mathbf{F} = (36t \hat{i} - 6 \hat{j}) \text{ N}.$$

WHY IT WORKS The result follows by isolating one object and applying the net-force rule or the correct interaction pair.

PRACTICE 2**Guided Problem**

$$\mathbf{F} = d \mathbf{p}/dt = (10t \hat{i} + 3 \hat{j}) \text{ N}; \text{ at } 2.0 \text{ s, } \mathbf{F} = (20 \hat{i} + 3 \hat{j}) \text{ N}.$$

WHY IT WORKS The result follows by isolating one object and applying the net-force rule or the correct interaction pair.

PRACTICE 3**Independent Problem**

$$a_{75} = 150/75 = 2.0 \text{ m/s}^2; a_{50} = 150/50 = 3.0 \text{ m/s}^2. \text{ Equal forces do not imply equal accelerations.}$$

WHY IT WORKS The result follows by isolating one object and applying the net-force rule or the correct interaction pair.

SOLUTIONS • CONFIDENCE CHECK

QUICK CHECK 1

Newton's Laws Check 1

$\mathbf{a} = (8t \hat{i} - 3 \hat{j}) \text{ m/s}^2$, so $\mathbf{F} = (16t \hat{i} - 6 \hat{j}) \text{ N}$.

WHY IT WORKS The result follows by isolating one object and applying the net-force rule or the correct interaction pair.

QUICK CHECK 2

Newton's Laws Check 2

$\mathbf{p}(t) = \int_0^t 6\tau \, d\tau \hat{i} = 3t^2 \hat{i} \text{ kg}\cdot\text{m/s}$.

WHY IT WORKS The result follows by isolating one object and applying the net-force rule or the correct interaction pair.

QUICK CHECK 3

Newton's Laws Check 3

Accelerations are 2.0 m/s^2 for 100 kg and 8.0 m/s^2 for 25 kg ; the force magnitudes are equal.

WHY IT WORKS The result follows by isolating one object and applying the net-force rule or the correct interaction pair.

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 Review the key ideas and examples again. Review Again →	 I Need More Practice Continue with additional practice for this topic. Go to Practice →	 I'm Ready Continue to the next recommended 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