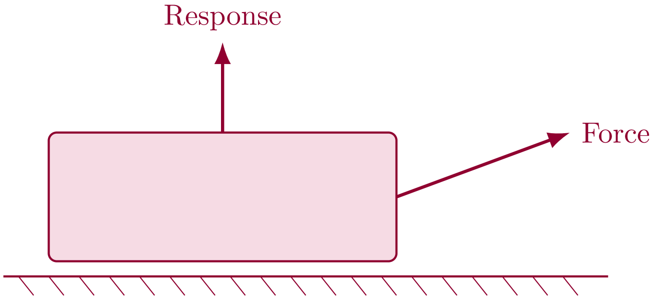
Summit PHYS 161: Physics I

Summit fully illustrated textbook edition



Original Summit-authored instructional text generated from the live course runtime, bibliography layer, and assessment structure.

March 22, 2026

@@TOKEN_0@@ Summit first edition draft @@TOKEN_1@@ college @@TOKEN_2@@ 4 @@TOKEN_3@@ 14 weeks @@TOKEN_4@@ 12.9 hours/week

Originality note

This textbook is a Summit-authored instructional text. It is informed by the course bibliography in @@TOKEN_0@@ and by open academic references used elsewhere in Summit, but it does not copy or restate any single commercial textbook.

How this textbook was built

This book was generated from the live Summit course runtime for Physics I: the syllabus, lesson sequence, reading chapters, guided practice, homework sets, quizzes, mastery exam, and workload standard. The design goal is to give a student a usable, course-complete book while preserving original Summit wording and sequencing.

An original Summit calculus-based physics course centered on motion, forces, work, energy, momentum, rotation, and oscillations. The course is built to support later statics, dynamics, fluids, structures, and aerospace systems work.

Mathematics chapters should move from concept to representation to fluent execution. Students should always know what the symbols mean before they try to manipulate them.

This volume is structured as a teaching book rather than a bare note pack. Every chapter contains explanation, worked examples, guided practice, chapter homework, and a rear answer key so the student can study independently and still get disciplined feedback.

Course use guide

- Read one chapter at a time in sequence; each chapter is aligned to a live lesson block in the course workspace.
- Rebuild the worked examples before attempting the graded homework or quiz material.
- Keep a scratch notebook beside the text and write down assumptions, diagrams, and the points where you usually get stuck.
- Use the course tutor, guided practice, and homework only after you can explain the chapter in your own words.

Contents

Course map

- 4 live lesson chapters
- 2 graded homework checkpoints
- 2 timed quizzes
- 1 cumulative mastery exam
- 5 declared course outcomes

Prerequisite and readiness position

Course prerequisites: calculus-i. Readiness clearances: calc-i-credit.

Summit Physics I is a calculus-based mechanics course. Students must arrive ready to use derivatives, vectors, and algebra fluently so the class can focus on modeling motion and forces rather than repairing math gaps.

Semester workload standard

Summit models this course as @@TOKEN_0@@ across a 14-week term plus final assessment window. The expected distribution is:

- Contact-equivalent instruction: 56 hours
- Reading: 18 hours
- Practice and problem solving: 48 hours
- Homework: 24 hours
- Lab, design, and reporting: 14 hours
- Exam preparation: 20 hours

Expected volume:

- 140-180 mechanics problems covering kinematics, force balance, energy, momentum, rotation, and oscillations.
- 10 graded assignments totaling 35-45 multistep physics problems with full supporting work.
- 4-5 experiment-style analyses, modeling memos, or applied writeups tied to physical interpretation.

Reference basis

Primary synthesis anchors from the bibliography for this course (50 listed references total):

1. Fundamentals of Physics
2. University Physics with Modern Physics
3. Physics for Scientists and Engineers
4. An Introduction to Mechanics
5. University Physics Volume 1
6. FlipItPhysics for University Physics: Classical Mechanics (Volume One)
7. University Physics: Mechanics. Chapter 1: Units and measurement
8. University Physics

Chapter 1

Chapter 1 Motion in one and two dimensions

Chapter purpose

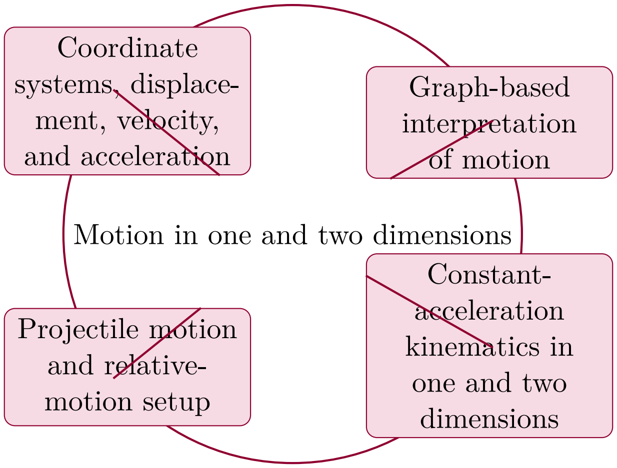
The course opens by making students precise about position, velocity, acceleration, and coordinate choices. Students learn to read motion graphs, build vector-based kinematics, and decide when constant-acceleration equations are legitimate rather than automatic.

This chapter sits at the opening of Physics I. It develops Coordinate systems, displacement, velocity, and acceleration, Graph-based interpretation of motion, Constant-acceleration kinematics in one and two dimensions, and Projectile motion and relative-motion setup so that the student can move from explanation to execution without losing the thread of the course.

The central habit in this chapter is to move across words, graphs, formulas, and worked algebra without losing meaning. A correct answer is not enough on its own; the student should be able to explain why the setup is valid and how the result fits the larger mathematical structure of the course.

Core ideas

- Coordinate systems, displacement, velocity, and acceleration
- Graph-based interpretation of motion
- Constant-acceleration kinematics in one and two dimensions
- Projectile motion and relative-motion setup



How to think through this chapter

Problem solving in this family starts with naming the structure of the task. Students should ask which theorem, definition, or representation controls the problem before choosing a computational path. Once the structure is clear, algebraic execution should be clean, annotated, and checked against the expected behavior of the function or model.

When working this chapter, keep the following question active: @@TOKEN_0@@ A good student answer should connect setup, assumptions, and conclusion instead of only chasing a final number or sentence.

Mechanics begins with motion description, not with force. Students need to become fluent in what position, velocity, and acceleration mean before they can explain why motion changes.

Equations do not replace a coordinate choice

A kinematics problem becomes manageable only after the student commits to a coordinate system and a sign convention. Upward can be positive or negative. Rightward can be positive or negative. What matters is consistency. Many beginner mistakes are not calculus mistakes or algebra mistakes. They are failures to choose a direction and then stay loyal to it.

This is one of the first engineering habits the course is building. Before solving, define the language of the model. After that, the equations start to say something useful.

Motion graphs are compressed stories

A position graph tells where the object is. Its slope tells how fast the position is changing. A velocity graph tells how speed and direction are evolving. Its slope gives acceleration, while its area can give displacement. These are not separate facts to memorize. They are relationships among quantities that describe the same motion at different levels.

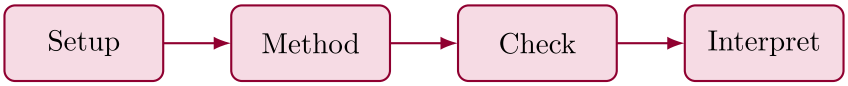
Students who learn to read the graphs as stories gain an advantage later. They can detect impossible answers quickly and they understand what the symbols mean physically.

Constant acceleration is a privilege, not a default

The familiar kinematics equations work because acceleration is constant. That assumption is powerful, but it is not automatic. Strong students ask whether the physical situation supports it before using those equations.

That small check matters because later engineering modeling depends on knowing when a shortcut is legitimate and when a more general method is required.

Worked example



@@TOKEN_0@@ A package drone rises vertically with initial velocity 6 m/s and constant acceleration 1.5 m/s^2 for 4 s. Find its displacement and final velocity.

1. Use the constant-acceleration model because the acceleration is specified as constant.
2. Final velocity is v = v0 + at = 6 + 1.5(4) = 12 m/s.
3. Displacement is s = v0 t + 0.5at^2 = 6(4) + 0.5(1.5)(16) = 36 m.
4. The sign choice stays positive because the motion is measured upward the entire time.

Read this example twice: once for the flow of ideas and once for the technical structure of the solution.

Worked-through guided example

@@TOKEN_0@@ A cyclist speeds up uniformly from 4 m/s to 10 m/s in 3 s. Find the acceleration.

1. Write the definition a = (v - v0) / t.
2. Substitute v = 10, v0 = 4, and t = 3.
3. Simplify and keep the units of m/s^2.

The acceleration is (10 - 4) / 3 = 2 m/s^2.

Instructor commentary

Students should annotate this chapter for structure, not just facts. Mark where the argument changes direction, where the method requires a hidden assumption, and where the conclusion becomes more general than the worked example. If the chapter feels easy while you are reading it but difficult when you close the page, you have not yet converted recognition into mastery.

The most effective study pattern is read, annotate, rebuild the worked example without looking, and then solve several short-to-long problems in one sitting so the idea becomes automatic.

Practice while you read

Practice Set: Kinematics and motion graphs

Build confidence in coordinate choice, graph interpretation, and constant-acceleration problem setup.

@@TOKEN_0@@ A cyclist speeds up uniformly from 4 m/s to 10 m/s in 3 s. Find the acceleration.

- Hint: This is a direct constant-acceleration problem, so use the velocity change over time.
- Step 1: Write the definition a = (v - v0) / t.
- Step 2: Substitute v = 10, v0 = 4, and t = 3.
- Step 3: Simplify and keep the units of m/s^2.
- Checkpoint: Acceleration = 2 m/s^2

@@TOKEN_0@@ A ball is thrown upward at 16 m/s from ground level. Neglect air resistance. How long does it take to reach the highest point?

- Hint: At the highest point, the vertical velocity is zero.
- Step 1: Use v = v0 - gt for upward motion.
- Step 2: Set v = 0 at the highest point.
- Step 3: Solve for t using g = 9.8 m/s^2.
- Checkpoint: Time to peak 1.63 s

Chapter homework

@@TOKEN_0@@ Kinematics setup, graph interpretation, projectile motion, and clean Newtons-law modeling.

1. A ball is launched horizontally from a 45 m rooftop at 12 m/s. Find the time to hit the ground and the horizontal range.

2. A car accelerates uniformly from 8 m/s to 26 m/s over 120 m. Find the acceleration and travel time.
3. A 6 kg crate on a horizontal floor is pulled by a 30 N force while kinetic friction is 9 N. Find the acceleration and the distance traveled in 5 s if it starts from rest.
4. Two blocks, 2 kg and 5 kg, are connected by a light rope on a frictionless surface and pulled by a 21 N force applied to the 5 kg block. Find the system acceleration and rope tension.

Answers for these homework problems appear in the back-of-book answer key.

Chapter summary and study notes

- Choose a coordinate system before writing any motion equation.
- Separate horizontal and vertical motion cleanly in a projectile model.
- Use graphs to explain motion rather than only quoting equations.

Study tips

- Choose axes before writing formulas.
- Use graph slope and area as interpretation tools, not only as afterthoughts.
- Check whether constant acceleration is actually justified.

Common traps

- Switching sign conventions midway through the solution.
- Treating speed and velocity as interchangeable words.
- Using constant-acceleration formulas when acceleration is not constant.

Family-level errors to watch for

- Starting algebra before identifying the governing definition or theorem.
- Dropping notation, units, or sign conventions in the middle of a calculation.
- Treating a symbolic answer as finished without interpreting what it means.

Chapter 2

Chapter 2 Force models and Newtonian dynamics

Chapter purpose

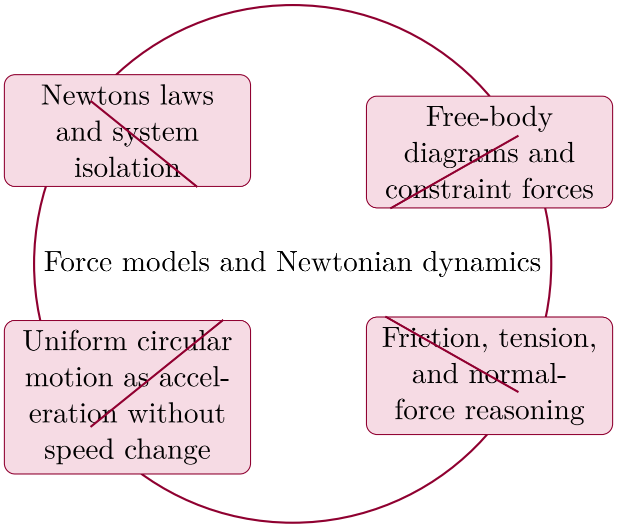
Students move from describing motion to explaining why it changes. The lesson builds disciplined free-body diagrams, develops Newtons laws, and uses them on connected particles, inclined systems, and circular-motion models. The emphasis is on isolation, not intuition alone.

This chapter sits in the middle of Physics I. It develops Newtons laws and system isolation, Free-body diagrams and constraint forces, Friction, tension, and normal-force reasoning, and Uniform circular motion as acceleration without speed change so that the student can move from explanation to execution without losing the thread of the course.

The central habit in this chapter is to move across words, graphs, formulas, and worked algebra without losing meaning. A correct answer is not enough on its own; the student should be able to explain why the setup is valid and how the result fits the larger mathematical structure of the course.

Core ideas

- Newtons laws and system isolation
- Free-body diagrams and constraint forces
- Friction, tension, and normal-force reasoning
- Uniform circular motion as acceleration without speed change



How to think through this chapter

Problem solving in this family starts with naming the structure of the task. Students should ask which theorem, definition, or representation controls the problem before choosing a computational path. Once the structure is clear, algebraic execution should be clean, annotated, and checked against the expected behavior of the function or model.

When working this chapter, keep the following question active: @@TOKEN_0@@ A good student answer should connect setup, assumptions, and conclusion instead of only chasing a final number or sentence.

Newtonian mechanics asks a different question than kinematics. Once students can describe what motion is doing, they now ask why it is doing it.

Free-body diagrams are the language of force

The free-body diagram is not classroom ceremony. It is the disciplined act of isolating one object from the rest of the world and listing the external forces that matter. Without that isolation step, many problems look harder than they are because forces from different bodies get mixed together.

Engineers trust a free-body diagram because it states clearly what belongs in the model and what does not. That clarity prevents most sign and direction mistakes before the algebra even starts.

Newtons second law is a balance of causes and response

The equation F = ma is compact, but it carries a lot of meaning. The left side records the net external cause. The right side records the response of the body. If the net force is zero, acceleration is zero. If the net force is not zero, the object changes velocity in the direction of the net force.

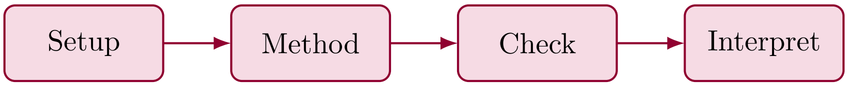
This is why students should avoid plugging values into Newtons second law too early. First identify the forces. Then choose axes. Then write the equations component by component.

Constraints make systems interesting

Ropes, pulleys, contact surfaces, and curved paths create constraints. These constraints do not add magic. They simply link the motion or forces of different parts of the system. Good modeling means writing those links explicitly instead of hoping intuition will carry the problem.

That discipline becomes especially valuable in later engineering mechanics and controls courses where coupled systems are normal rather than exceptional.

Worked example



@@TOKEN_0@@ A 5 kg block is pulled across a rough horizontal floor by a 22 N horizontal force. If kinetic friction is 7 N, find the acceleration.

1. Isolate the block and list the horizontal forces only.
2. The net horizontal force is 22 - 7 = 15 N.
3. Apply Newtons second law: a = Fnet / m = 15 / 5 = 3 m/s^2.
4. The acceleration points in the direction of the net force, so it is positive in the pull direction.

Read this example twice: once for the flow of ideas and once for the technical structure of the solution.

Worked-through guided example

@@TOKEN_0@@ A 3 kg block is pulled right by a 15 N horizontal force on a frictionless surface. Find the acceleration.

1. Write Fx = ma.
2. Set the net force equal to 15 N.
3. Solve a = 15 / 3.

Newtons second law gives a = 15 / 3 = 5 m/s^2.

Instructor commentary

Students should annotate this chapter for structure, not just facts. Mark where the argument changes direction, where the method requires a hidden assumption, and where the conclusion becomes more general than the worked example. If the chapter feels easy while you are reading it but difficult when you close the page, you have not yet converted recognition into mastery.

The most effective study pattern is read, annotate, rebuild the worked example without looking, and then solve several short-to-long problems in one sitting so the idea becomes automatic.

Practice while you read

Practice Set: Free-body diagrams and dynamics

Strengthen isolation, sign conventions, and Newtons-law equations.

@@TOKEN_0@@ A 3 kg block is pulled right by a 15 N horizontal force on a frictionless surface. Find the acceleration.

- Hint: On a frictionless horizontal surface, the pull is the net horizontal force.
- Step 1: Write Fx = ma.
- Step 2: Set the net force equal to 15 N.
- Step 3: Solve a = 15 / 3.
- Checkpoint: Acceleration = 5 m/s^2

@@TOKEN_0@@ A 4 kg block rests on a 30 degree incline with no friction. Find the acceleration down the plane.

- Hint: Use the component of weight parallel to the incline.
- Step 1: Write the downhill component as mg sin(theta).
- Step 2: Apply Newtons second law along the incline.
- Step 3: Cancel the mass and evaluate using sin 30ř = 0.5.
- Checkpoint: Acceleration = 4.9 m/s^2

Chapter homework

@@TOKEN_0@@ Kinematics setup, graph interpretation, projectile motion, and clean Newtons-law modeling.

1. A ball is launched horizontally from a 45 m rooftop at 12 m/s. Find the time to hit the ground and the horizontal range.

2. A car accelerates uniformly from 8 m/s to 26 m/s over 120 m. Find the acceleration and travel time.
3. A 6 kg crate on a horizontal floor is pulled by a 30 N force while kinetic friction is 9 N. Find the acceleration and the distance traveled in 5 s if it starts from rest.
4. Two blocks, 2 kg and 5 kg, are connected by a light rope on a frictionless surface and pulled by a 21 N force applied to the 5 kg block. Find the system acceleration and rope tension.

Answers for these homework problems appear in the back-of-book answer key.

Chapter summary and study notes

- Draw every relevant external force before writing component equations.
- Keep object-by-object equations separate in multi-body systems.
- Explain why circular motion still requires a net force.

Study tips

- Draw the object alone before drawing arrows.
- Write separate equations for separate bodies in a connected system.
- When stuck, ask which force is actually causing the acceleration you are solving for.

Common traps

- Including forces the object exerts on others instead of only forces acting on the object.
- Skipping the axis choice and then losing signs.
- Forgetting that uniform circular motion still requires inward acceleration.

Family-level errors to watch for

- Starting algebra before identifying the governing definition or theorem.
- Dropping notation, units, or sign conventions in the middle of a calculation.
- Treating a symbolic answer as finished without interpreting what it means.

Chapter 3

Chapter 3 Work, energy, impulse, and momentum

Chapter purpose

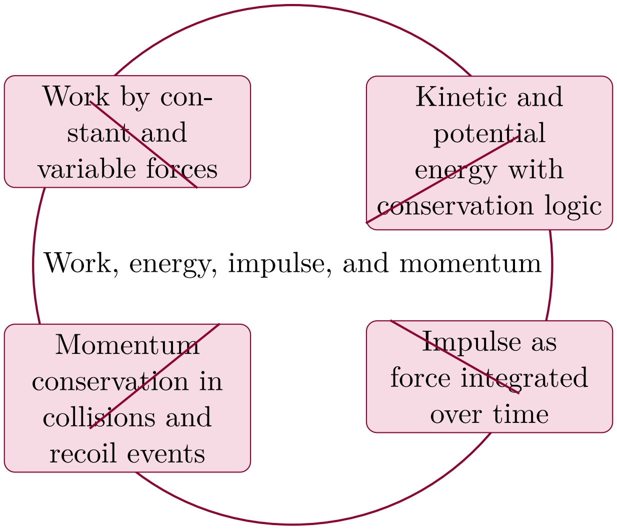
This lesson shows students when force-by-force acceleration is not the best route. Work-energy and impulse-momentum methods let them collapse long interactions into a small number of conserved or nearly conserved quantities. The hard part is identifying the correct system and interaction window.

This chapter sits in the middle of Physics I. It develops Work by constant and variable forces, Kinetic and potential energy with conservation logic, Impulse as force integrated over time, and Momentum conservation in collisions and recoil events so that the student can move from explanation to execution without losing the thread of the course.

The central habit in this chapter is to move across words, graphs, formulas, and worked algebra without losing meaning. A correct answer is not enough on its own; the student should be able to explain why the setup is valid and how the result fits the larger mathematical structure of the course.

Core ideas

- Work by constant and variable forces
- Kinetic and potential energy with conservation logic
- Impulse as force integrated over time
- Momentum conservation in collisions and recoil events



How to think through this chapter

Problem solving in this family starts with naming the structure of the task. Students should ask which theorem, definition, or representation controls the problem before choosing a computational path. Once the structure is clear, algebraic execution should be clean, annotated, and checked against the expected behavior of the function or model.

When working this chapter, keep the following question active: @@TOKEN_0@@ A good student answer should connect setup, assumptions, and conclusion instead of only chasing a final number or sentence.

Mechanics becomes much more powerful once students stop assuming every problem should be solved through $F = ma$. Energy and momentum compress long interactions into cleaner statements.

Energy methods reward system-level thinking

Work-energy methods are useful because they care about the total change in a system rather than every intermediate detail of the motion. If the only thing that matters is the speed after a long slide or the compression of a spring, energy often gets there faster than force equations.

That does not make force methods wrong. It means good engineers choose the language that fits the question.

Momentum is about short violent interactions

Collisions are often hard to analyze force by force because the contact force can be large and short-lived. Momentum bypasses that complexity by looking at the total impulse over the interaction. This is one of the most satisfying moves in physics: replace a messy time history with a clean before-and-after statement.

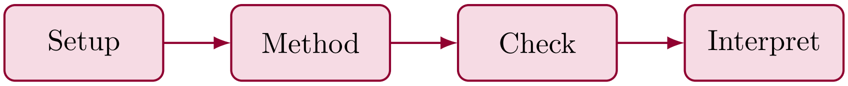
The tradeoff is that the student must choose the system boundary correctly. Conservation works only when external impulse is negligible over the interval.

Conservation is a claim that requires a reason

Students sometimes write "energy is conserved" or "momentum is conserved" as a reflex. Stronger work states why. Is the system isolated? Are nonconservative losses negligible? Is the collision interval short enough that external impulse can be ignored?

That small sentence of justification is how a worked solution starts to look like engineering rather than answer hunting.

Worked example



@@TOKEN_0@@ A 2 kg cart moving at 5 m/s collides and sticks to a 3 kg cart initially at rest. Find the common velocity just after impact.

1. Treat the two carts as one isolated horizontal system during the short collision.
2. Use momentum conservation: (2)(5) + (3)(0) = (2 + 3)v.
3. Solve for v = 10 / 5 = 2 m/s.
4. Because the carts stick, this is a perfectly inelastic collision and some kinetic energy is lost even though momentum is conserved.

Read this example twice: once for the flow of ideas and once for the technical structure of the solution.

Worked-through guided example

@@TOKEN_0@@ A 1 kg object drops 5 m from rest. Ignore air resistance. Find its speed just before impact.

1. Set initial potential energy equal to final kinetic energy.
2. Write mgh = 0.5mv^2.
3. Solve for v using h = 5 and g = 9.8.

From mgh = 0.5mv^2, v = (2gh) = (98) 9.9 m/s.

Instructor commentary

Students should annotate this chapter for structure, not just facts. Mark where the argument changes direction, where the method requires a hidden assumption, and where the conclusion becomes more general than the worked example. If the chapter feels easy while you are reading it but difficult when you close the page, you have not yet converted recognition into mastery.

The most effective study pattern is read, annotate, rebuild the worked example without looking, and then solve several short-to-long problems in one sitting so the idea becomes automatic.

Practice while you read

Practice Set: Energy and momentum choice

Decide when conservation logic is faster and cleaner than direct force modeling.

@@TOKEN_0@@ A 1 kg object drops 5 m from rest. Ignore air resistance. Find its speed just before impact.

- Hint: Use energy conservation instead of solving for time first.
- Step 1: Set initial potential energy equal to final kinetic energy.
- Step 2: Write mgh = 0.5mv^2.
- Step 3: Solve for v using h = 5 and g = 9.8.
- Checkpoint: Speed 9.9 m/s

@@TOKEN_0@@ A 2 kg cart moving at 3 m/s collides and sticks to a 1 kg cart at rest. Find the common speed after the collision.

- Hint: The short collision interval suggests momentum conservation.
- Step 1: Write initial momentum of the two-cart system.
- Step 2: Set it equal to final combined momentum.
- Step 3: Solve for the common speed.
- Checkpoint: Final speed = 2 m/s

Chapter homework

@@TOKEN_0@@ Energy accounting, impulse and momentum, rigid-body rotation, and oscillation setup.

1. A 0.8 kg puck slides at 6 m/s into a spring with k = 180 N/m on a frictionless track. Find the maximum compression.

2. A 1500 kg car moving at 18 m/s rear-ends a 1000 kg car moving at 9 m/s, and they lock together. Find the common velocity after impact.
3. A 12 N force is applied tangentially to the rim of a solid disk of radius 0.25 m and mass 4 kg. Find the angular acceleration.
4. A 2 kg block oscillates on a spring with k = 8 N/m. Find the period and frequency.

Answers for these homework problems appear in the back-of-book answer key.

Chapter summary and study notes

- Identify when an energy method is cleaner than a force-and-acceleration method.
- Track the system boundary correctly in a momentum problem.
- Explain why momentum can be conserved even when kinetic energy is not.

Study tips

- Choose the system before writing conservation equations.
- Use energy when the path details are irrelevant and momentum when the interaction window is short.
- State why conservation applies instead of assuming it silently.

Common traps

- Applying momentum conservation to only one object when the whole system should be used.
- Forgetting that kinetic energy is not conserved in perfectly inelastic collisions.
- Mixing initial and final system definitions.

Family-level errors to watch for

- Starting algebra before identifying the governing definition or theorem.
- Dropping notation, units, or sign conventions in the middle of a calculation.
- Treating a symbolic answer as finished without interpreting what it means.

Chapter 4

Chapter 4 Rotation, torque, and oscillations

Chapter purpose

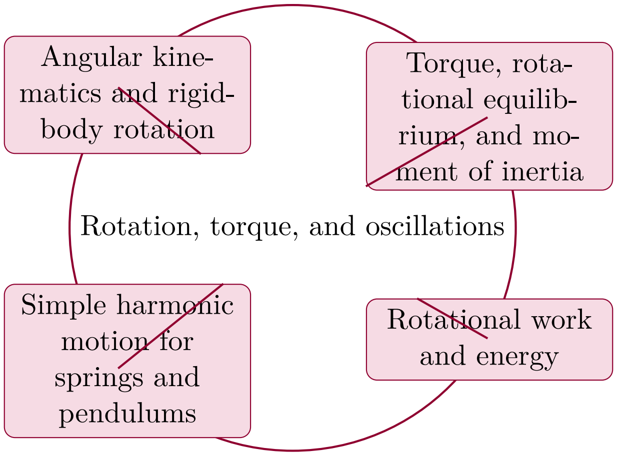
The closing lesson extends linear ideas into rotating systems and then into oscillations. Students connect torque to angular acceleration, rotational energy to translation analogies, and restoring-force models to periodic motion.

This chapter sits at the end of Physics I. It develops Angular kinematics and rigid-body rotation, Torque, rotational equilibrium, and moment of inertia, Rotational work and energy, and Simple harmonic motion for springs and pendulums so that the student can move from explanation to execution without losing the thread of the course.

The central habit in this chapter is to move across words, graphs, formulas, and worked algebra without losing meaning. A correct answer is not enough on its own; the student should be able to explain why the setup is valid and how the result fits the larger mathematical structure of the course.

Core ideas

- Angular kinematics and rigid-body rotation
- Torque, rotational equilibrium, and moment of inertia
- Rotational work and energy
- Simple harmonic motion for springs and pendulums



How to think through this chapter

Problem solving in this family starts with naming the structure of the task. Students should ask which theorem, definition, or representation controls the problem before choosing a computational path. Once the structure is clear, algebraic execution should be clean, annotated, and checked against the expected behavior of the function or model.

When working this chapter, keep the following question active: @@TOKEN_0@@ A good student answer should connect setup, assumptions, and conclusion instead of only chasing a final number or sentence.

Rotation and oscillation feel new at first, but they are best learned as familiar mechanics ideas wearing a different costume.

Rotation mirrors translation

Force becomes torque. Mass becomes moment of inertia. Linear acceleration becomes angular acceleration. Students who build this translation-rotation dictionary early usually find the chapter much less intimidating.

The analogy is not perfect, but it is close enough to be one of the best organizational tricks in the course.

Moment of inertia is a distribution story

Moment of inertia is not just "rotational mass." It measures how the mass is spread relative to the axis. Two objects with the same total mass can respond very differently to the same torque if their mass is distributed differently.

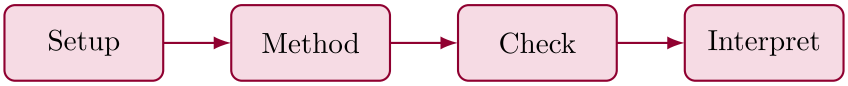
That insight is important because it prepares students for later design work where geometry matters as much as total mass.

Oscillation reveals structure beneath motion

Simple harmonic motion shows what happens when a restoring effect is proportional to displacement. Springs do this exactly in the ideal model. Small-angle pendulums do it approximately. The resulting motion has a predictable rhythm and a clean mathematical form.

Students should notice how much of engineering comes down to recognizing when a system wants to return to equilibrium and how quickly it can do so.

Worked example



@@TOKEN_0@@ A 1.5 kg mass is attached to a spring with k = 6 N/m. Find the oscillation period.

1. Use the simple-harmonic-motion period formula T = 2(m/k).
2. Substitute the values to get T = 2(1.5 / 6) = 20.25.
3. This simplifies to T = 2(0.5) = seconds.
4. The result shows that stiffer springs shorten the period while larger mass lengthens it.

Read this example twice: once for the flow of ideas and once for the technical structure of the solution.

Worked-through guided example

@@TOKEN_0@@ A torque of 8 Nům acts on a rigid body with moment of inertia 2 kgům^2. Find the angular acceleration.

1. Write = I.
2. Substitute the given torque and inertia.
3. Solve for .

= / I = 8 / 2 = 4 rad/s^2.

Instructor commentary

Students should annotate this chapter for structure, not just facts. Mark where the argument changes direction, where the method requires a hidden assumption, and where the conclusion becomes more general than the worked example. If the chapter feels easy while you are reading it but difficult when you close the page, you have not yet converted recognition into mastery.

The most effective study pattern is read, annotate, rebuild the worked example without looking, and then solve several short-to-long problems in one sitting so the idea becomes automatic.

Practice while you read

Practice Set: Rotation and oscillation models

Practice torque, angular response, and period calculations without losing the translation-rotation analogy.

@@TOKEN_0@@ A torque of 8 Nům acts on a rigid body with moment of inertia 2 kgům^2. Find the angular acceleration.

- Hint: Use the rotational version of Newtons second law.
- Step 1: Write = I.
- Step 2: Substitute the given torque and inertia.
- Step 3: Solve for .
- Checkpoint: Angular acceleration = 4 rad/s^2

@@TOKEN_0@@ A 1 kg mass is attached to a spring with k = 9 N/m. Find the oscillation period.

- Hint: Use the simple harmonic motion period formula.
- Step 1: Write T = 2(m/k).
- Step 2: Substitute m = 1 and k = 9.
- Step 3: Simplify the square root first.
- Checkpoint: Period = 2/3 s

Chapter homework

@@TOKEN_0@@ Energy accounting, impulse and momentum, rigid-body rotation, and oscillation setup.

1. A 0.8 kg puck slides at 6 m/s into a spring with k = 180 N/m on a frictionless track. Find the maximum compression.
2. A 1500 kg car moving at 18 m/s rear-ends a 1000 kg car moving at 9 m/s, and they lock together. Find the common velocity after impact.

3. A 12 N force is applied tangentially to the rim of a solid disk of radius 0.25 m and mass 4 kg. Find the angular acceleration.
4. A 2 kg block oscillates on a spring with k = 8 N/m. Find the period and frequency.

Answers for these homework problems appear in the back-of-book answer key.

Chapter summary and study notes

- Use rotational analogs of force, mass, and acceleration correctly.
- Choose the correct moment of inertia model for a simple rigid body.
- Recognize when an oscillation model is genuinely harmonic and when it is only approximately so.

Study tips

- Translate every new rotational equation back to its translational analog.
- Ask where the mass sits relative to the axis when thinking about inertia.
- For oscillations, identify the restoring mechanism before using the SHM formulas.

Common traps

- Using the wrong moment of inertia model for the body shape.
- Forgetting that torque depends on lever arm as well as force magnitude.
- Applying SHM formulas to motions that are not actually harmonic.

Family-level errors to watch for

- Starting algebra before identifying the governing definition or theorem.
- Dropping notation, units, or sign conventions in the middle of a calculation.
- Treating a symbolic answer as finished without interpreting what it means.

Chapter 5

Quiz review and official exam preparation

Homework structure

- Homework Set 1: Motion and force analysis: 4 graded problems attached to chapter 1.
- Homework Set 2: Energy, collisions, and rotation: 4 graded problems attached to chapter 2.

Quiz structure

- Quiz 1: Motion and Newtonian models: 3 questions, timed, and single-attempt in the live course. Quiz 1 should be taken only after you can solve the chapter homework without outside prompts.
- Quiz 2: Energy, momentum, and rotation: 3 questions, timed, and single-attempt in the live course. Quiz 2 should be taken only after you can solve the chapter homework without outside prompts.

Official mastery exam

- Physics I mastery exam: 5 major questions, Engineering standard, cumulative, and calculation heavy rigor, first official attempt locks the course grade.

Physics I mastery exam preparation checklist

- Rebuild kinematics, dynamics, energy, and momentum equations from meaning rather than memory alone.
- Redraw every free-body diagram from the homework sets without looking at prior notes.
- Practice deciding whether force, energy, or momentum is the fastest honest route before solving.

- Review rotational analogs carefully so torque and angular acceleration do not blur together.

How to use this book before assessment

- Read the relevant chapter and rebuild both worked examples without looking.
- Solve the guided practice in the chapter before attempting the graded homework.
- Check your chapter-homework answers only after you complete a full written attempt.
- Review the quiz answer key after each chapter block and classify your errors by concept, setup, algebra, or interpretation.
- Before the official exam, revisit the chapter purposes, homework corrections, and answer-key notes rather than rereading formulas only.

Chapter 6

Course vocabulary index

- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.
- @@TOKEN_0@@: treat this as a working term in the course. You should be able to define it, recognize where it appears, and use it correctly in a solution or explanation.

Chapter 7

Back-of-book answers and solution outlines

Guided practice answer key

Chapter 1: Motion in one and two dimensions

@@TOKEN_0@@

1. A cyclist speeds up uniformly from 4 m/s to 10 m/s in 3 s. Find the acceleration.

- Checkpoint answer: Acceleration = 2 m/s^2 - Solution note: The acceleration is (10 - 4) / 3 = 2 m/s^2.

1. A ball is thrown upward at 16 m/s from ground level. Neglect air resistance. How long does it take to reach the highest point?

- Checkpoint answer: Time to peak 1.63 s - Solution note: Set 0 = 16 - 9.8t, so t = 16 / 9.8 1.63 s.

Chapter 2: Force models and Newtonian dynamics

@@TOKEN_0@@

1. A 3 kg block is pulled right by a 15 N horizontal force on a frictionless surface. Find the acceleration.

- Checkpoint answer: Acceleration = 5 m/s^2 - Solution note: Newtons second law gives a = 15 / 3 = 5 m/s^2.

1. A 4 kg block rests on a 30 degree incline with no friction. Find the acceleration down the plane.

- Checkpoint answer: Acceleration = 4.9 m/s^2 - Solution note: Along the incline, a = g sin 30ř = 9.8(0.5) = 4.9 m/s^2.

Chapter 3: Work, energy, impulse, and momentum

@@TOKEN_0@@

1. A 1 kg object drops 5 m from rest. Ignore air resistance. Find its speed just before impact.

- Checkpoint answer: Speed 9.9 m/s - Solution note: From mgh = 0.5mv^2, v = (2gh) = (98) 9.9 m/s.

1. A 2 kg cart moving at 3 m/s collides and sticks to a 1 kg cart at rest. Find the common speed after the collision.

- Checkpoint answer: Final speed = 2 m/s - Solution note: Momentum conservation gives (2)(3) = (3)v, so v = 2 m/s.

Chapter 4: Rotation, torque, and oscillations

@@TOKEN_0@@

1. A torque of 8 Nům acts on a rigid body with moment of inertia 2 kgům^2. Find the angular acceleration.

- Checkpoint answer: Angular acceleration = 4 rad/s^2 - Solution note: = / I = 8 / 2 = 4 rad/s^2.

1. A 1 kg mass is attached to a spring with k = 9 N/m. Find the oscillation period.

- Checkpoint answer: Period = 2/3 s - Solution note: T = 2(1/9) = 2/3 s.

Homework answer key

Homework Set 1: Motion and force analysis

1. A ball is launched horizontally from a 45 m rooftop at 12 m/s. Find the time to hit the ground and the horizontal range.

- Answer / solution summary: Use y = 0.5gt^2 with y = 45 to get t 3.03 s. Then range = vx t = 12(3.03) 36.4 m.

1. A car accelerates uniformly from 8 m/s to 26 m/s over 120 m. Find the acceleration and travel time.

- Answer / solution summary: From v^2 = v0^2 + 2ax, 26^2 = 8^2 + 2a(120), so a = 2.55 m/s^2. Then t = (26 - 8)/2.55 7.06 s.

1. A 6 kg crate on a horizontal floor is pulled by a 30 N force while kinetic friction is 9 N. Find the acceleration and the distance traveled in 5 s if it starts from rest.

- Answer / solution summary: The net force is 21 N, so a = 21/6 = 3.5 m/s^2. Starting from rest, the displacement in 5 s is 0.5(3.5)(25) = 43.75 m.

1. Two blocks, 2 kg and 5 kg, are connected by a light rope on a frictionless surface and pulled by a 21 N force applied to the 5 kg block. Find the system acceleration and rope tension.

- Answer / solution summary: The system mass is 7 kg, so a = 21/7 = 3 m/s^2. On the 2 kg block, the only horizontal force is tension, so T = ma = 6 N.

Homework Set 2: Energy, collisions, and rotation

1. A 0.8 kg puck slides at 6 m/s into a spring with k = 180 N/m on a frictionless track. Find the maximum compression.

- Answer / solution summary: 0.5mv^2 = 0.5kx^2 gives 0.5(0.8)(36) = 90x^2, so x^2 = 0.16 and x = 0.40 m.

1. A 1500 kg car moving at 18 m/s rear-ends a 1000 kg car moving at 9 m/s, and they lock together. Find the common velocity after impact.

- Answer / solution summary: v = (1500ů18 + 1000ů9) / 2500 = 14.4 m/s.

1. A 12 N force is applied tangentially to the rim of a solid disk of radius 0.25 m and mass 4 kg. Find the angular acceleration.

- Answer / solution summary: Torque is = rF = 3 Nům. For a solid disk, I = 0.5mr^2 = 0.125 kgům^2, so = /I = 24 rad/s^2.

1. A 2 kg block oscillates on a spring with k = 8 N/m. Find the period and frequency.

- Answer / solution summary: T = 2(m/k) = 2(2/8) = s, so f = 1/ 0.318 Hz.

Quiz answer key

Quiz 1: Motion and Newtonian models

1. Which quantity is the slope of a velocity-versus-time graph?

- Answer key: Acceleration. The slope of velocity versus time is acceleration.

1. A particle starts from rest and accelerates at 4 m/s^2 for 3 s. What is its final speed?

- Answer key: Accepted answer(s): 12, 12.0. Use v = v0 + at = 0 + 4(3) = 12 m/s.

1. A correct free-body diagram for an object includes:

- Answer key: All external forces acting on the isolated object. A free-body diagram shows the isolated object and all external forces acting on it.

Quiz 2: Energy, momentum, and rotation

1. Which statement is always true in an isolated collision?

- Answer key: Momentum is conserved. Momentum is conserved in an isolated collision even when kinetic energy is not.

1. A 1 kg mass on a spring with k = 4 N/m undergoes simple harmonic motion. What is the period?

- Answer key: Accepted answer(s): 3.1416, 3.142, 3.14, pi. T = 2(m/k) = 2(1/4) = seconds.

1. Torque is most directly associated with which rotational change?

- Answer key: Angular acceleration. Net torque plays the same role in rotation that net force plays in translation: it produces angular acceleration.

Mastery exam solution outlines

Physics I mastery exam

1. Solve a multi-step kinematics problem and justify the model assumptions.

- What to show: Coordinate choice and correct motion equations; A final answer with consistent units - Solution outline: Review the full course methods and connect setup to interpretation.

1. Build and solve a Newtons-law model from a free-body diagram.

- What to show: External forces only; A correct net-force equation - Solution outline: Review the full course methods and connect setup to interpretation.

1. Use energy or momentum reasoning on a system where direct force equations are inefficient.

- What to show: A clear system boundary; A correct conservation statement - Solution outline: Review the full course methods and connect setup to interpretation.

1. Analyze a rotational or oscillatory system and connect the result to physical behavior.

- What to show: A correct rotational or SHM model; Interpretation of the result - Solution outline: Review the full course methods and connect setup to interpretation.

1. Synthesize multiple mechanics ideas in a cumulative engineering problem.

- What to show: Method choice; A complete and defensible solution path - Solution outline: Review the full course methods and connect setup to interpretation.

Reference note

For the full bibliography behind this textbook, use @@TOKEN_0@@. The answer key in this book is Summit-authored and aligned to the live course runtime.