

AP PHYSICS UNIT 7 - TORQUE AND ROTATIONAL MOTION

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Belleville Public Schools

Curriculum Guide

AP PHYSICS 11,12

TORQUE AND ROTATIONAL MOTION

Belleville Board of Education

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Unit Overview

Unit 7 completes the study of mechanical physics by introducing students to torque and rotational motion. Although these topics present more complex scenarios, the tools of analysis remain the same: The content and models explored in the first six units of AP Physics 1 set the foundation for Unit 7. During their study of torque and rotational motion, students will be confronted with different ways of thinking about and modeling forces. As in previous units, it's critical that students are given opportunities to create and use representations and models to make predictions and justify claims. It's equally important that students are comfortable deriving new expressions from fundamental principles to help them make predictions in unfamiliar, applied contexts. Unit 7 also focuses on the mathematical practice of estimating quantities that can describe natural phenomena. For example, students need to be able to estimate the torque on an object caused by various forces in comparison to other situations. Although this particular science practice doesn't appear often in AP Physics 1, it nonetheless is an important conceptual skill for students to be able to compare estimated values of physical quantities. Throughout this unit, students will have opportunities to compare and connect their understanding of linear and rotational motion, dynamics, energy, and momentum to make meaning of these concepts as a whole, rather than as distinct and separate units.

Enduring Understanding

An observer in a reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.

Displacement, velocity, and acceleration are all vector quantities.

Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values.

A choice of reference frame determines the direction and the magnitude of each of these quantities.

There are three fundamental interactions or forces in nature: the gravitational force, the electroweak force, and the strong force. The fundamental forces determine both the structure of objects and the motion of objects.

In inertial reference frames, forces are detected by their influence on the motion (specifically the velocity) of an object. So force, like velocity, is a vector quantity. A force vector has magnitude and direction. When multiple forces are exerted on an object, the vector sum of these forces, referred to as the net force, causes a change in the motion of the object. The acceleration of the object is proportional to the net force.

The kinematic equations only apply to constant acceleration situations. Circular motion and projectile motion are both included. Circular motion is further covered in Unit 3.

This also includes situations where there is both a radial and tangential acceleration for an object moving in a circular path.

For uniform circular motion of radius r , v is proportional to ω (for a given r), and proportional to r (for a given ω). Given a radius r and a period of rotation T , students derive and apply $v = (2\pi r)/T$.

Only the force component perpendicular to the line connecting the axis of rotation and the point of application of the force results in a torque about that axis.

The lever arm is the perpendicular distance from the axis of rotation or revolution to the line of application of the force.

The magnitude of the torque is the product of the magnitude of the lever arm and the magnitude of the force.

The net torque on a balanced system is zero.

The presence of a net torque along any axis will cause a rigid system to change its rotational motion or an object to change its rotational motion about that axis.

Rotational motion can be described in terms of angular displacement, angular velocity, and angular

acceleration about a fixed axis.

Rotational motion of a point can be related to linear motion of the point using the distance of the point from the axis of rotation.

The angular acceleration of an object or a rigid system can be calculated from the net torque and the rotational inertia of the object or rigid system.

A torque exerted on an object can change the angular momentum of an object.

Angular momentum is a vector quantity, with its direction determined by a right-hand rule.

The magnitude of angular momentum of a point object about an axis can be calculated by multiplying the perpendicular distance from the axis of rotation to the line of motion by the magnitude of linear momentum.

The magnitude of angular momentum of an extended object can also be found by multiplying the rotational inertia by the angular velocity. Students do not need to know the equation for an object's rotational inertia, as it will be provided at the exam. They should have a qualitative sense of what factors affect rotational inertia—for example, why a hoop has more rotational inertia than a puck of the same mass and radius.

The change in angular momentum of an object is given by the product of the average torque and the time the torque is exerted.

Torque, angular velocity, angular acceleration, and angular momentum are vectors and can be characterized as positive or negative depending on whether they give rise to or correspond to counterclockwise or clockwise rotation with respect to an axis.

The angular momentum of a system may change due to interactions with other objects or systems.

The angular momentum of a system with respect to an axis of rotation is the sum of the angular momenta, with respect to that axis, of the objects that make up the system.

The angular momentum of an object about a fixed axis can be found by multiplying the momentum of the particle by the perpendicular distance from the axis to the line of motion of the object.

Alternatively, the angular momentum of a system can be found from the product of the system's rotational inertia and its angular velocity. Students do not need to know the equation for an object's rotational inertia, as it will be provided at the exam. They should have a qualitative sense that rotational inertia is larger when the mass is farther from the axis of rotation.

The change in angular momentum is given by the product of the average torque and the time interval during which the torque is exerted.

If the net external torque exerted on the system is zero, the angular momentum of the system does not change.

The angular momentum of a system is determined by the locations and velocities of the objects that make up the system. The rotational inertia of an object or a system depends on the distribution of mass within the object or system. Changes in the radius of a system or in the distribution of mass within the system result in changes in the system's rotational inertia, and hence in its angular velocity and linear speed for a given angular momentum. Examples include elliptical orbits in an Earth-satellite system. Mathematical expressions for the moments of inertia will be provided where needed. Students will not be expected to know the parallel axis

theorem. Students do not need to know the equation for an object's rotational inertia, as it will be provided at the exam. They should have a qualitative sense that rotational inertia is larger when the mass is farther from the axis of rotation.

Essential Questions

How are the linear and rotational motion connected?

How does linear motion equations apply to rotational motion?

What are the various forms of rotational motion?

How do physicists describe and quantify rotational motion?

How does one describe motion of satellites and planets?

What is the difference between centripetal and centrifugal acceleration, centripetal and centrifugal force?

How are torque and angular acceleration related?

Why do animals that walk on two legs have larger feet than those that walk on four legs?

Why does a figure skater pull her arms and legs very tight to her body when going into a spin, and then extend her arms and legs outward away from her body after the spin is over?

If you were to walk across a tight rope, what are some ways you could increase your chances of not falling off?

What are the pros and cons of putting very large tires on your car?

How can we use rotational dynamics to predict rotational motion?

How does exerting a torque affect an object's motion?

How are angular acceleration, angular momentum and torque related?

What causes rotational motion?

How is rotational motion described mathematically?

What is the analog of mass in a rotational system?

Why would a tight-rope walker use a long pole?

How does the law of conservation of angular momentum apply to Kepler's 2nd Law?

Exit Skills

- Describe how angular acceleration depends on the torque.
- Identify the force that causes torque.
- Use the Law of torque to find angular acceleration

New Jersey Student Learning Standards (NJSL-S)

[NextGen Science Standards](#)

	Energy and Matter
SCI.HS-PS2-1	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
SCI.HS-PS2.A	Forces and Motion
SCI.HS-PS2-4	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
SCI.HS-PS2.B	Types of Interactions
SCI.HS-PS3.A	Definitions of Energy
SCI.HS-PS3.A	Definitions of Energy
SCI.HS-PS3.B	Conservation of Energy and Energy Transfer
SCI.HS-PS3.C	Relationship Between Energy and Forces
SCI.HS-LS2	Ecosystems: Interactions, Energy, and Dynamics
SCI.HS-LS2-3	Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
	Energy and Matter

SCI.HS-ESS1	Earth's Place in the Universe
SCI.HS-ESS1-4	Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
SCI.HS.ESS2.D	Weather and Climate
SCI.HS.ESS1.B	Earth and the Solar System
SCI.HS.ESS2.D	Weather and Climate
SCI.HS.ESS3.D	Global Climate Change
SCI.HS-ETS1	Engineering Design
SCI.HS-ETS1-4	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
CS.9-12.8.1.12.DA.2	Describe the trade-offs in how and where data is organized and stored.
CS.9-12.ETW	Effects of Technology on the Natural World

Interdisciplinary Connections

Please list all and any additional **Interdisciplinary Connections/Cross-Curricular** New Jersey Student Learning Standards that link to this unit, and which are not included in the NJSLS section above.

MA.A-SSE.A	Interpret the structure of expressions
MA.A-SSE.A.1	Interpret expressions that represent a quantity in terms of its context.
MA.A-SSE.A.1b	Interpret complicated expressions by viewing one or more of their parts as a single entity.
LA.RH.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, qualitatively, as well as in words) in order to address a question or solve a problem.
LA.RH.11-12.8	Evaluate an author's claims, reasoning, and evidence by corroborating or challenging them with other sources.
LA.RH.11-12.9	Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.
LA.RH.11-12.10	By the end of grade 12, read and comprehend history/social studies texts in the grades 11-CCR text complexity band independently and proficiently.
MA.A-APR.A	Perform arithmetic operations on polynomials
LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.2	Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

MA.G-SRT	Similarity, Right Triangles, and Trigonometry
LA.RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
LA.WHST.11-12.1.A	Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
LA.WHST.11-12.1.B	Develop claim(s) and counterclaims using sound reasoning and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.
LA.WHST.11-12.1.E	Provide a concluding paragraph or section that supports the argument presented.

Learning Objectives

The student will be able to..

Express the motion of an object using narrative, mathematical, and graphical representations.

Use representations of the relationship between force and torque.

Compare the torques on an object caused by various forces.

Estimate the torque on an object caused by various forces in comparison with other situations.

Design an experiment and analyze data testing a question about torques in a balanced rigid system.

Calculate torques on a two-dimensional system in static equilibrium by examining a representation or model (such as a diagram or physical construction).

Make predictions about the change in the angular velocity about an axis for an object when forces exerted on the object cause a torque about that axis.

Plan data-collection and analysis strategies designed to test the relationship between a torque exerted on an object and the change in angular velocity of that object about an axis.

Predict the behavior of rotational collision situations by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum.

In an unfamiliar context or using representations beyond equations, justify the selection of a mathematical routine to solve for the change in angular momentum of an object caused by torques exerted on the object.

Plan data-collection and analysis strategies designed to test the relationship between torques exerted on an object and the change in angular momentum of that object.

Describe a representation and use it to analyze a situation in which several forces exerted on a rotating system of rigidly connected objects change the angular velocity and angular momentum of the system.

Plan data-collection strategies designed to establish that torque, angular velocity, angular acceleration, and angular momentum can be predicted accurately when the variables are treated as being clockwise or counterclockwise with respect to a well-defined axis of rotation, and refine the research question based on the examination of data.

Describe a model of a rotational system and use that model to analyze a situation in which angular momentum changes due to interaction with other objects or systems.

Plan a data-collection and analysis strategy to determine the change in angular momentum of a system and relate it to interactions with other objects and systems.

Use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum. Plan a data-collection strategy designed to test the relationship between the change in angular momentum of a system and the product of the average torque applied to the system and the time interval during which the torque is exerted.

Make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque.

Make calculations of quantities related to the angular momentum of a system when the net external torque on the system is zero.

Describe or calculate the angular momentum and rotational inertia of a system in terms of the locations and velocities of objects that make up the system. Use qualitative reasoning with compound objects and perform calculations with a fixed set of extended objects and point masses.

Identify the force that causes torque.

Describe angular displacement.

Describe torque and the factors that determine it.

Calculate net torque.

Define center of mass.

Use Newton's law of universal gravitation to solve problems.

Solve orbital motion problems.

Relate weightlessness to objects in free fall.

Describe gravitational fields.

Relate Kepler's laws to the law of universal gravitation.

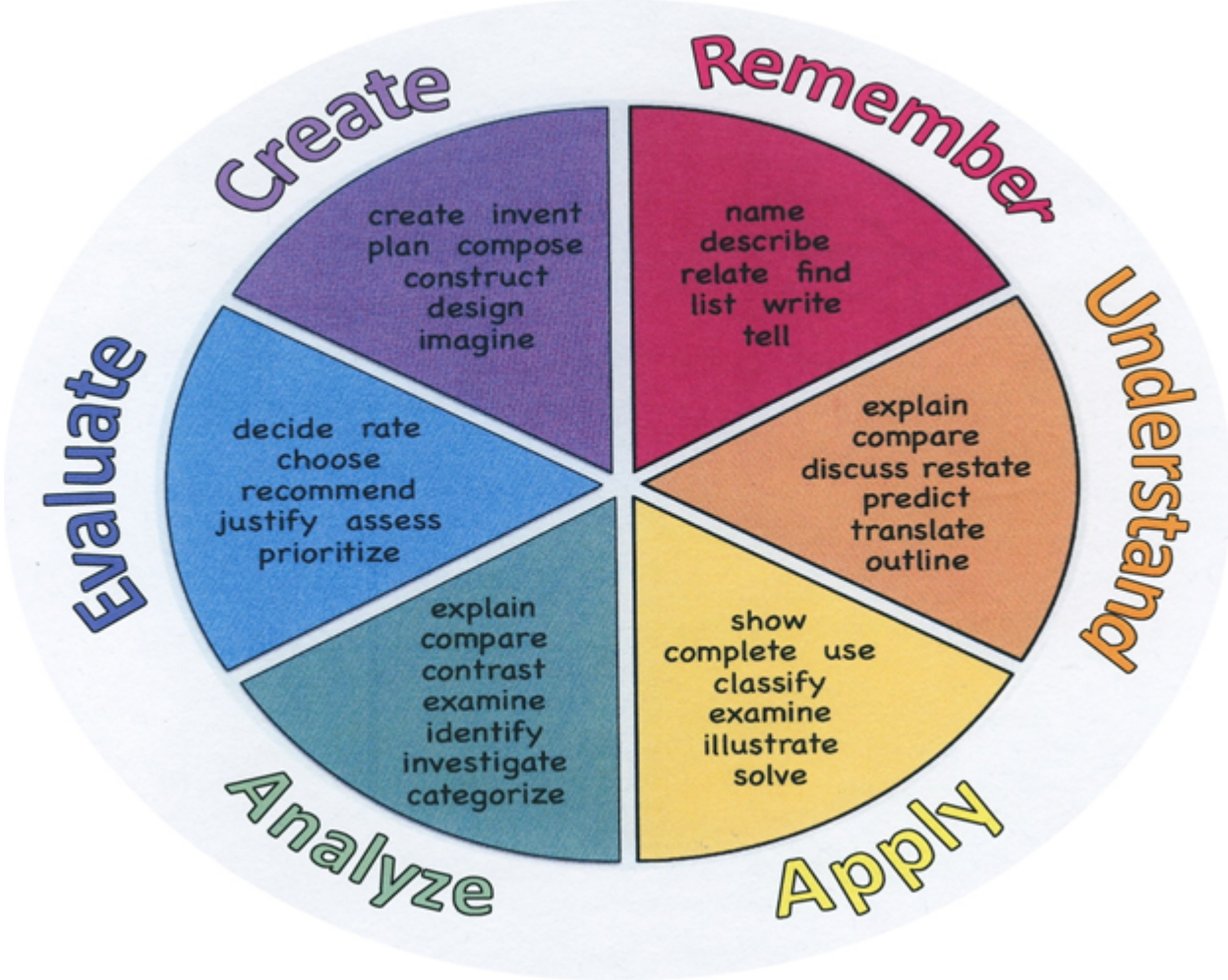
Calculate orbital speeds and periods.

Outline the process of climate change · analyze the global impact of climate change.

Action Verbs: Below are examples of action verbs associated with each level of the Revised Bloom's Taxonomy.

Remember	Understand	Apply	Analyze	Evaluate	Create
Choose	Classify	Choose	Categorize	Appraise	Combine
Describe	Defend	Dramatize	Classify	Judge	Compose
Define	Demonstrate	Explain	Compare	Criticize	Construct
Label	Distinguish	Generalize	Differentiate	Defend	Design
List	Explain	Judge	Distinguish	Compare	Develop
Locate	Express	Organize	Identify	Assess	Formulate
Match	Extend	Paint	Infer	Conclude	Hypothesize
Memorize	Give Examples	Prepare	Point out	Contrast	Invent
Name	Illustrate	Produce	Select	Critique	Make
Omit	Indicate	Select	Subdivide	Determine	Originate
Recite	Interrelate	Show	Survey	Grade	Organize
Select	Interpret	Sketch	Arrange	Justify	Plan
State	Infer	Solve	Breakdown	Measure	Produce
Count	Match	Use	Combine	Rank	Role Play
Draw	Paraphrase	Add	Detect	Rate	Drive
Outline	Represent	Calculate	Diagram	Support	Devise
Point	Restate	Change	Discriminate	Test	Generate
Quote	Rewrite	Classify	Illustrate		Integrate
Recall	Select	Complete	Outline		Prescribe
Recognize	Show	Compute	Point out		Propose
Repeat	Summarize	Discover	Separate		Reconstruct
Reproduce	Tell	Divide			Revise
	Translate	Examine			Rewrite
	Associate	Graph			Transform
	Compute	Interpolate			
	Convert	Manipulate			
	Discuss	Modify			
	Estimate	Operate			

	Extrapolate Generalize Predict	Subtract			
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Suggested Activities & Best Practices

Predict and Explain; Spin a bike wheel (preferably with the tire removed so that it will roll on its metal rims), and release it from rest on a floor or long table. Have students predict what will happen to the wheel’s linear velocity (will increase) and its angular velocity (will decrease) as the wheel “peels out.” Then explain why this happens using a force diagram.

Desktop Experiment Task; Have students release a yo-yo from rest, calculate its acceleration from distance and time measurements, and then determine the yo-yo’s rotational inertia (requires the yo-yo’s mass and the radius at which the string connects to the yo-yo). Next, have them roll the yo-yo down a ramp and use distance and time data to construct a conservation of energy equation that can be solved for the yo-yo’s rotational

inertia.

Concept-Oriented Demonstration; Obtain a ring and a disk of equal mass and radius, and load up a low-friction cart with weights to make it the same mass. “Race” the three objects from rest down identical inclines to show students the cart wins, then the disk, and then the ring. Have students explain why, with forces and then with energy.

Ranking; A wheel rolls down an incline from rest and across a flat surface. Case 1: Tracks are rough enough that there is no slipping. Case 2: Tracks have some friction, but there is slipping. Case 3: Tracks have negligible friction. Have students rank translational kinetic energies at the end, rotational kinetic energies at the end, and total mechanical energies of the wheel at the end as three separate tasks. ($KT3 > KT2 > KT1$), ($KR1 > KR2 > KR3$), and ($E1 = E3 > E2$).

Calculating net force and net torque

Determining if an object is at rest by checking net force and net torque.

Balancing different masses on a meter stick.

Analysing the shifts in the Earth's axis of rotation since the 1990s as a result of the massive melting of glaciers as a result of global heating

Assessment Evidence - Checking for Understanding (CFU)

Students must be able to determine if an object is at rest by checking net force and net torque. (Formative)

Students must be able to calculate total angle covered by adapting kinematics formulas into rotational motion. (Formative)

Common, Department Quarterly Benchmarks (Benchmark)

Oncourse Assessment Tools (Formative)

Unit Test/Quiz (Summative)

"Do Now/Exit Ticket" Activity (Formative)

- Admit Tickets
- Anticipation Guide
- Common Benchmarks
- Compare & Contrast
- Create a Multimedia Poster
- DBQ's
- Define
- Describe
- Evaluate
- Evaluation rubrics
- Exit Tickets
- Explaining
- Fist- to-Five or Thumb-Ometer
- Illustration
- Learning Center Activities
- Multimedia Reports
- Outline
- Question Stems
- Quickwrite
- Quizzes
- Red Light, Green Light
- Self- assessments
- Socratic Seminar
- Study Guide
- Surveys

- Teacher Observation Checklist
- Think, Pair, Share
- Think, Write, Pair, Share
- Top 10 List
- Unit review/Test prep
- Unit tests
- Web-Based Assessments
- Written Reports

Primary Resources & Materials

Textbook, Giancoli AP Edition

Internet

AP Physics Exam, Princeton Review

Masteringphysics.com

Please list all district-provided Primary Resources & Materials and/or those outside that are accessed with district resources.

Ancillary Resources

Teacher Prepared Materials

Lab Materials

Study Guide Materials

United Streaming Videos

The Physics Classroom: www.thephysicsclassroom.com

STEM Lab

AP Central Resources.

Please list all additional resources that will be used to strengthen this unit's lessons.

Technology Infusion

Students must be able to use virtual labs to calculate net torque

Students must be able to use virtual labs to calculate angular acceleration

Students must be able to use virtual labs to calculate total angle covered during the rotational motion.

Albert.io

AP Collegeboard

What **Technology Infusion** and/or strategies are integrated into this unit to enhance learning? Please list all hardware, software and strategies. Please find a technology pedagogy wheel for assistance while completing this section.

Alignment to 21st Century Skills & Technology

Mastery and infusion of **21st Century Skills & Technology** and their Alignment to the core content areas is essential to student learning. The core content areas include:

- English Language Arts;
- Mathematics;
- Science and Scientific Inquiry (Next Generation);
- Social Studies, including American History, World History, Geography, Government and Civics, and Economics;
- World languages;
- Technology;
- Visual and Performing Arts.

WRK.9.2.12.CAP.1	Analyze unemployment rates for workers with different levels of education and how the economic, social, and political conditions of a time period are affected by a recession.
WRK.9.2.12.CAP.2	Develop college and career readiness skills by participating in opportunities such as structured learning experiences, apprenticeships, and dual enrollment programs.
WRK.9.2.12.CAP.3	Investigate how continuing education contributes to one's career and personal growth.
WRK.9.2.12.CAP.4	Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
WRK.9.2.12.CAP.13	Analyze how the economic, social, and political conditions of a time period can affect the labor market.
TECH.9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
TECH.9.4.12.CI.2	Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12prof.CR2b, 2.2.12.LF.8).
TECH.9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).
TECH.9.4.12.CT.1	Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
TECH.9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
TECH.9.4.12.CT.3	Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
TECH.9.4.12.DC.1	Explain the beneficial and harmful effects that intellectual property laws can have on the creation and sharing of content (e.g., 6.1.12.CivicsPR.16.a).
TECH.9.4.12.TL.1	Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specified task (e.g., W.11-12.6.).
TECH.9.4.12.GCA.1	Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political, economic, cultural) may work

better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).

21st Century Skills/Interdisciplinary Themes

Upon completion of this section, please remove all remaining descriptions, notes, outlines, examples and/or illustrations that are not needed or used.

Please list only the **21st Century/Interdisciplinary Themes** that will be incorporated into this unit.

- Communication and Collaboration
- Creativity and Innovation
- Critical thinking and Problem Solving
- ICT (Information, Communications and Technology) Literacy
- Information Literacy
- Life and Career Skills
- Media Literacy

21st Century Skills

Upon completion of this section, please remove all remaining descriptions, notes, outlines, examples and/or illustrations that are not needed or used.

Please list only the **21st Century Skills** that will be incorporated into this unit.

- Civic Literacy
- Environmental Literacy
- Financial, Economic, Business and Entrepreneurial Literacy
- Global Awareness
- Health Literacy

Differentiation

Please remember: Effective educational **Differentiation** in a lesson lies within content, process, and/or product.

Please identify the ones that will be employed in this unit.

Differentiations:

- Small group instruction
- Small group assignments
- Extra time to complete assignments
- Pairing oral instruction with visuals
- Repeat directions
- Use manipulatives
- Center-based instruction
- Token economy
- Study guides
- Teacher reads assessments allowed
- Scheduled breaks
- Rephrase written directions
- Multisensory approaches
- Additional time
- Preview vocabulary
- Preview content & concepts
- Story guides
- Behavior management plan
- Highlight text
- Student(s) work with assigned partner
- Visual presentation
- Assistive technology
- Auditory presentations
- Large print edition
- Dictation to scribe
- Small group setting

Hi-Prep Differentiations:

- Alternative formative and summative assessments
- Choice boards
- Games and tournaments
- Group investigations
- Guided Reading
- Independent research and projects
- Interest groups
- Learning contracts
- Leveled rubrics
- Literature circles
- Multiple intelligence options
- Multiple texts
- Personal agendas
- Project-based learning
- Problem-based learning
- Stations/centers
- Think-Tac-Toes
- Tiered activities/assignments

- Tiered products
- Varying organizers for instructions

Lo-Prep Differentiations

- Choice of books or activities
- Cubing activities
- Exploration by interest
- Flexible grouping
- Goal setting with students
- Jigsaw
- Mini workshops to re-teach or extend skills
- Open-ended activities
- Think-Pair-Share
- Reading buddies
- Varied journal prompts
- Varied supplemental materials

Special Education Learning (IEP's & 504's)

Please identify the **Special Education Learning** adaptations that will be employed in the unit, using the ones identified below.

- Students must be able to convert rpm into rps. (Special Ed)

- printed copy of board work/notes provided
- additional time for skill mastery
- assistive technology
- behavior management plan
- Center-Based Instruction
- check work frequently for understanding
- computer or electronic device utilizes
- extended time on tests/ quizzes
- have student repeat directions to check for understanding
- highlighted text visual presentation
- modified assignment format
- modified test content
- modified test format
- modified test length

- multi-sensory presentation
- multiple test sessions
- preferential seating
- preview of content, concepts, and vocabulary
- Provide modifications as dictated in the student's IEP/504 plan
- reduced/shortened reading assignments
- Reduced/shortened written assignments
- secure attention before giving instruction/directions
- shortened assignments
- student working with an assigned partner
- teacher initiated weekly assignment sheet
- Use open book, study guides, test prototypes

English Language Learning (ELL)

Spanish speaking students will complete spanish version of a phet simulation lab report.

- teaching key aspects of a topic. Eliminate nonessential information
- using videos, illustrations, pictures, and drawings to explain or clarify
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning;
- allowing students to correct errors (looking for understanding)
- allowing the use of note cards or open-book during testing
- decreasing the amount of work presented or required
- having peers take notes or providing a copy of the teacher's notes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using computer word processing spell check and grammar check features
- using true/false, matching, or fill in the blank tests in lieu of essay tests

At Risk

Ranking the inertia of rotating objects.

- allowing students to correct errors (looking for understanding)
- teaching key aspects of a topic. Eliminate nonessential information
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning
- allowing students to select from given choices
- allowing the use of note cards or open-book during testing
- collaborating (general education teacher and specialist) to modify vocabulary, omit or modify items to reflect objectives for the student, eliminate sections of the test, and determine how the grade will be determined prior to giving the test.
- decreasing the amount of work presented or required
- having peers take notes or providing a copy of the teacher's notes
- marking students' correct and acceptable work, not the mistakes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using authentic assessments with real-life problem-solving
- using true/false, matching, or fill in the blank tests in lieu of essay tests
- using videos, illustrations, pictures, and drawings to explain or clarify

Talented and Gifted Learning (T&G)

Please identify the **Talented and Gifted** adaptations that will be employed in the unit, using the ones identified below.

- Students must be able to derive rotational kinematics formulas by replacing distance by angle, linear acceleration by angular acceleration.

- Above grade level placement option for qualified students
- Advanced problem-solving
- Allow students to work at a faster pace
- Cluster grouping
- Complete activities aligned with above grade level text using Benchmark results

- Create a blog or social media page about their unit
- Create a plan to solve an issue presented in the class or in a text
- Debate issues with research to support arguments
- Flexible skill grouping within a class or across grade level for rigor
- Higher order, critical & creative thinking skills, and discovery
- Multi-disciplinary unit and/or project
- Teacher-selected instructional strategies that are focused to provide challenge, engagement, and growth opportunities
- Utilize exploratory connections to higher-grade concepts
- Utilize project-based learning for greater depth of knowledge

Sample Lesson

Unit Name: TORQUE AND ROTATIONAL MOTION

NJSLS: SCI.HS-PS2.B, SCI.HS-PS3.A, SCI.HS-PS3.B, SCI.HS-PS3.C, SCI.HS-PS2, SCI.HS-PS2-1, SCI.HS-PS2-2, SCI.HS.PS2.A, LA.RH.11-12.7, LA.RH.11-12.9, LA.RST.11-12.1, LA.RST.11-12.2, MA.A-APR.A, MA.A-CED.A.1, MA.A-CED.A.2

Interdisciplinary Connection: Vocabulary and algebra contents

Statement of Objective: The students will demonstrate the ability to decide how torque can be produced by preparing experiments with 90% accuracy.

Anticipatory Set/Do Now: convert 200 microm into km

Learning Activity:

Lecture –properties of rotational motion

Small group activity: decide how torque can be produced by preparing experiments.

Final review: units for waves

Student Assessment/CFU's: Eentry and exit ticket

Materials: Chromebook

Safety equipments.

Power Point.

21st Century Themes and Skills: Critical thinking and Problem Solving

Differentiation: Different level of questions

Students must be able to convert rpm to rps . (Gifted and Talented)

Students must be able to predict which rotational motion has a bigger rpm. (Special Ed)

Integration of Technology:PowerPoint