AP PHYSICS UNIT 3 - CIRCULAR MOTION AND GRAVITATION

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Title Section

Department of Curriculum and Instruction

Belleville Public Schools

Curriculum Guide

AP PHYSICS 11,12

CIRCULAR MOTION AND GRAVITATION

Belleville Board of Education

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Unit Overview

In Unit 3, students will continue to enhance their understanding of the physical world using models and representations to create a more complete and complex model of motion, particularly as it relates to gravitational mass and inertial mass. Again, translation and connections are essential—students must be able to use content and science practices from the previous two units and apply them in different ways. While it's essential that students are able to calculate numerical answers to questions, it is more important that they can combine mathematical representations to make new representations that more accurately describe natural phenomena. For example, students should be comfortable combining equations for uniform circular motion with gravitational equations to describe the circular path of a satellite circling a planet. It is also vital that students are given opportunities to think about and discuss the impact that changes or modifications have on physical scenarios. For example, students should be able to use mathematical and graphical representations to determine how doubling the distance of a satellite from a planet will change the period of orbit and then justify their answer with evidence and reasoning. Specific preconceptions will be addressed in this unit, such as the idea of a centrifugal force. Students will also have opportunities to wrestle with the idea of field models, which will be expanded upon in Unit 8.

Enduring Understanding

A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector.

Vector fields are represented by field vectors indicating direction and magnitude.
When more than one source object with mass or electric charge is present, the field value can be determined by vector addition.
Conversely, a known vector field can be used to make inferences about the number, relative size, and locations of sources.
Gravitational forces are exerted at all scales and dominate at the largest distances and mass scales.
Gravitational force describes the interaction of one object with mass with another object with mass.
The gravitational force is always attractive.
In a narrow range of heights above Earth's surface, the local gravitational field, g, is approximately constant.
A gravitational field g at the location of an object with mass m causes a gravitational force of magnitude mg to be exerted on the object in the direction of the field.
On Earth, this gravitational force is called weight.
The gravitational field at a point in space is measured by dividing the gravitational force exerted by the field on a test object at that point by the mass of the test object and has the same direction as the force.
If the gravitational force is the only force exerted on the object, the observed freefall acceleration of the object (in meters per second squared) is numerically equal to the magnitude of the gravitational field (in Newtons/kilogram) at that location.
The gravitational field caused by a spherically symmetric object with mass is radial and, outside the object, varies as the inverse square of the radial distance from the center of that object.
Only spherically symmetric objects will be considered as sources of the gravitational field.
Gravitational mass is the property of an object or a system that determines the strength of the gravitational interaction with other objects, systems, or gravitational fields.
The gravitational mass of an object determines the amount of force exerted on the object by a gravitational field.
Near Earth's surface, all objects fall (in a vacuum) with the same acceleration, regardless of their inertial mass.
Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.
The acceleration is equal to the rate of change of velocity with time, and velocity is equal to the rate of change of position with time.
The acceleration of the center of mass of a system is directly proportional to the net force exerted on it by all objects interacting with the system and inversely proportional to the mass of the system.
Force and acceleration are both vectors, with acceleration in the same direction as the net force.
The acceleration of the center of mass of a system is equal to the rate of change of the center of mass velocity with time, and the center of mass velocity is equal to the rate of change of position of the center of mass with time.
The variables x, v, and a all refer to the center-of-mass quantities.
If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.
Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.
An object can be drawn as if it were extracted from its environment and the interactions with the environment were identified.
A force exerted on an object can be represented as an arrow whose length represents the magnitude of the force and whose direction shows the direction of the force.
A coordinate system with one axis parallel to the direction of the acceleration simplifies the translation from the free-body diagram to the algebraic representation.
Free-body or force diagrams may be depicted in one of two ways—one in which the forces exerted on an object are represented as arrows pointing outward from a dot, and the other in which the forces are specifically drawn at the point on the object at which each force is exerted.
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.
For rotational motion, there are analogous quantities such as angular position, angular velocity, and angular acceleration.
For uniform circular motion of radius r, v is proportional to omega, ω (for a given r), and proportional to r (for a given omega, ω). Given a radius r and a period of rotation T, students derive and apply $v = (2\pi r)/T$.
Forces are described by vectors. a. Forces are detected by their influence on the motion of an object. b. Forces have magnitude and direction.
A force exerted on an object is always due to the interaction of that object with another object.
An object cannot exert a force on itself.
Even though an object is at rest, there may be forces exerted on that object by other objects.
The acceleration of an object, but not necessarily its velocity, is always in the direction of the net force exerted on the object by other objects.
If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction.

- Circular motion produces acceleration because of the constant change of direction.
- An unbalanced force must be present to cause any change in an object's state of motion or rest.
- Inertia is the property of matter that resists change in motion.
- Gravitational force between two masses strengthens as the masses become more massive and rapidly weakens as the distance between them increases.

Essential Questions

How are the linear and circular motion connected?
How does linear motion equations apply to circular motion?
What are the various forms of circular motion?
How do physicists describe and quantify circular motion?
How does one describe motion of satellites and planets?

What is the difference between centripetal and centrifugal acceleration, centripetal and centrifugal force ?
How do planets stay in orbit?
How do you think planets formed in the early universe?
Why are we “stuck” to the earth, even though the sun is much more massive?
Give examples of things that revolve and things that rotate. What are the differences?
Why does the moon not come crashing into the Earth?
How could you create artificial gravity in a spaceship?
How does circular motion differ from linear motion?
How does the Law of Universal Gravitation govern the interaction of objects in the universe?

Exit Skills

• Explain why an object moving in a circle at a constant speed is accelerated.
• Describe how centripetal acceleration depends up on the object’s speed and the radius of the circle.
• Identify the force that causes centripetal acceleration.
• Use the Law of Universal Gravitation to solve problems.

New Jersey Student Learning Standards (NJSLS-S)

NextGen Science Standards

SCI.HS-PS2	Motion and Stability: Forces and Interactions
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-PS2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
SCI.HS.PS2.A	Forces and Motion
SCI.HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
SCI.HS.PS2.A	Forces and Motion
SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
SCI.HS.PS3.A	Definitions of Energy
	Energy and Matter
SCI.HS-LS2	Ecosystems: Interactions, Energy, and Dynamics
	Systems and System Models
SCI.HS-LS2-7	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
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.ESS1.B	Earth and the Solar System
SCI.HS-ESS3	Earth and Human Activity
SCI.HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate change have influenced human activity.
SCI.HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.
SCI.HS-ESS3-5	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
SCI.HS.ESS3.D	Global Climate Change
SCI.HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change).
SCI.HS.ESS2.D	Weather and Climate
SCI.HS.ESS3.D	Global Climate Change
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.

	Systems and System Models
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

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

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	Seeing Structure in Expressions
MA.A-SSE.A	Interpret the structure of expressions
LA.RH.11-12.1	Accurately cite strong and thorough textual evidence, (e.g., via discussion, written response, etc.), to support analysis of primary and secondary sources, connecting insights gained from specific details to develop an understanding of the text as a whole.
MA.A-SSE.A.1	Interpret expressions that represent a quantity in terms of its context.
LA.RH.11-12.2	Determine the theme, central ideas, information and/or perspective(s) presented in a primary or secondary source; provide an accurate summary of how key events, ideas and/or author's perspective(s) develop over the course of the text.
MA.A-SSE.A.1a	Interpret parts of an expression, such as terms, factors, and coefficients.
LA.RH.11-12.3	Evaluate various perspectives for actions or events; determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain.
MA.A-SSE.B	Write expressions in equivalent forms to solve problems
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.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
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.WHST.11-12.1.E	Provide a concluding paragraph or section that supports the argument presented.
LA.WHST.11-12.6	Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.

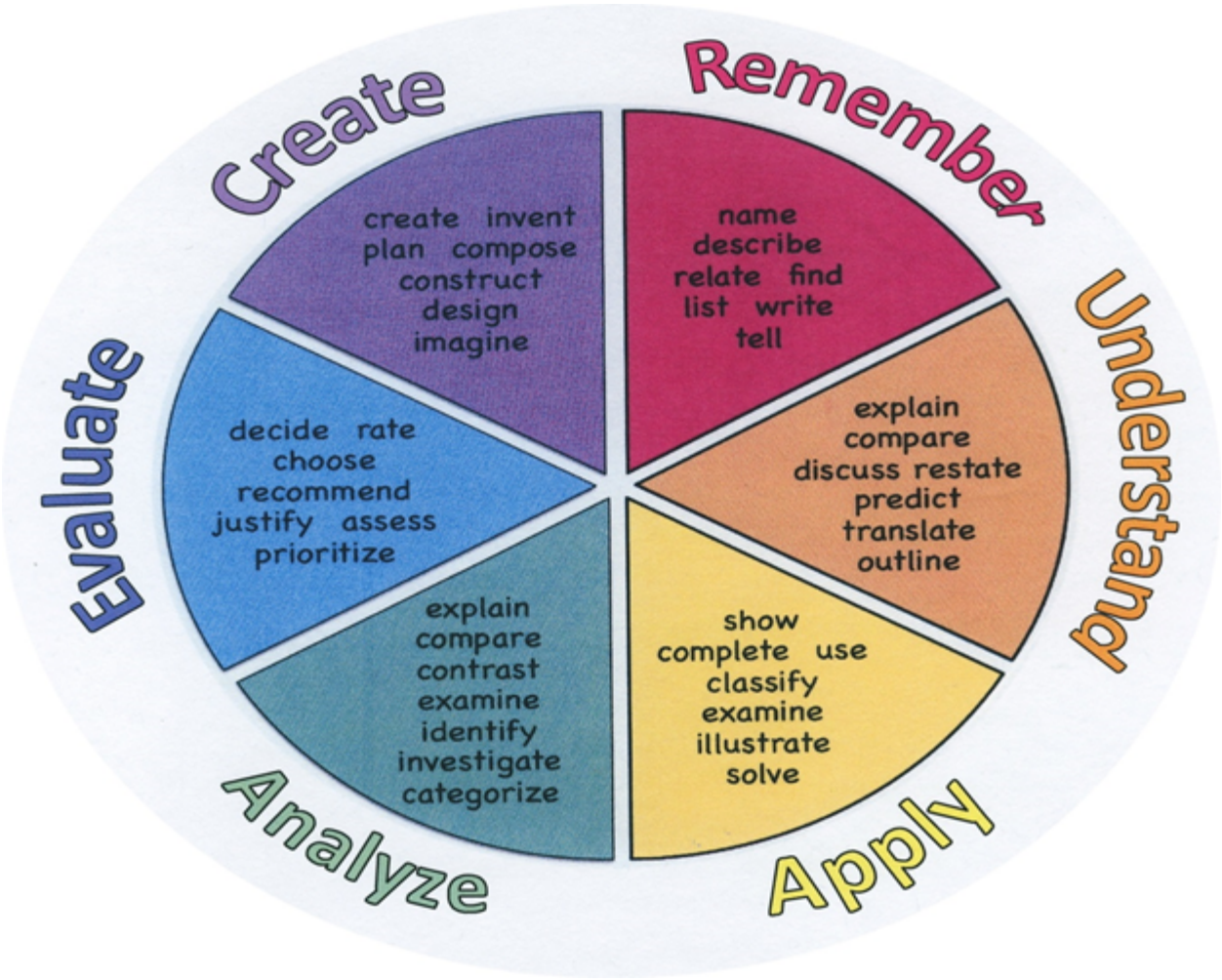
Learning Objectives

The student will be able to..

Articulate situations when the gravitational force is the dominant force.
Use Newton's law of gravitation to calculate the gravitational force that two objects exert on each other and use that force in contexts other than orbital motion.
Use Newton's law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion.
Apply $F = mg$ to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems.
Calculate the gravitational field due to an object with mass m, where the field is a vector directed toward the center of the object of mass m.
Approximate a numerical value of the gravitational field (g) near the surface of an object from its radius and mass relative to those of Earth or other reference objects.
Design a plan for collecting data to measure gravitational mass and to measure inertial mass and to distinguish between the two experiments.
Evaluate, using given data, whether all the forces on a system or whether all the parts of a system have been identified.
Design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements, and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces.
Re-express a free-body diagram representation into a mathematical representation, and solve the mathematical representation for the acceleration of the object.
Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.
Express the motion of an object using narrative, mathematical, and graphical representations.
Design an experimental investigation of the motion of an object.
Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations.
Represent forces in diagrams or mathematically, using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.
Analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces.
Describe a force as an interaction between two objects and identify both objects for any force.
Construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of actionreaction pairs of forces.
Use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact.
Analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces.
Explain why an object moving in a circle at a constant speed is accelerated.
Describe how centripetal acceleration depends up on the object's speed and the radius of the circle.
Identify the force that causes centripetal acceleration.
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.
Describe the greenhouse effect and global warming.

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	Subtract			
	Generalize				
	Predict				



Suggested Activities & Best Practices

Desktop Experiment Task; Have students use the “My Solar System” PhET applet to create circular orbits of varying radii around the central star and record radius, period, and planet mass for various trials. Next, have them calculate the speed using $v = 2\pi r/T$ and force using $F = mv2/r$. Using the data, students show that gravitational force is directly proportional to mass and inversely proportional to radius.

Construct an Argument; Ask students to consider two identical objects moving in circles (or parts of circles) of different radii. Ask them to think of a situation where the object with the smaller radius has a greater net force and another situation where the object with the larger radius has a greater net force.

Changing Representations; Describe something a driver could be doing in a car (e.g., “turning the steering wheel to the right while pressing the brake”). Have students walk out the motion while holding out one arm representing the velocity vector and the other arm representing the acceleration vector.

Create a Plan; Find a data table on stopping distance. Have students determine the coefficient of static friction of the car’s tires from this data and then create a new table of different car speeds and minimum turning radii to not skid.

Predict and Explain; Attach a pendulum of known weight (say, 2 N) to a force sensor and cause the bob to swing in a 180-degree arc. Ask students, “At the bottom, the bob is neither speeding up nor slowing down, so what force is registered at the bottom?” Expect students to (incorrectly) answer, “2 N.”

Balancing gravitational and centripetal forces.

Measuring centripetal force.

Measuring coefficient of kinetic friction using circular motion.

Measuring the efficiency of wind turbines and their contribution to climate change

Holocaust: humanity biggest tragedy. How Jewish Scientists made a difference in our society.

Assessment Evidence - Checking for Understanding (CFU)

Student must be able to graph fundamental quantities forces on cartesian coordinate plane. (Formative)

Students must be able to read map and calculate tension in the rope using a rotating object. (Formative)

Students must be able to calculate the net force after drawing a free body diagram. (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 the photogates to measure the centrifugal acceleration of a rotating object.

Students must be able to balance gravitational force by centripetal force by constructing their own apparatus.

Students must be able to use virtual labs to solve circular motion problems.

Albert.io

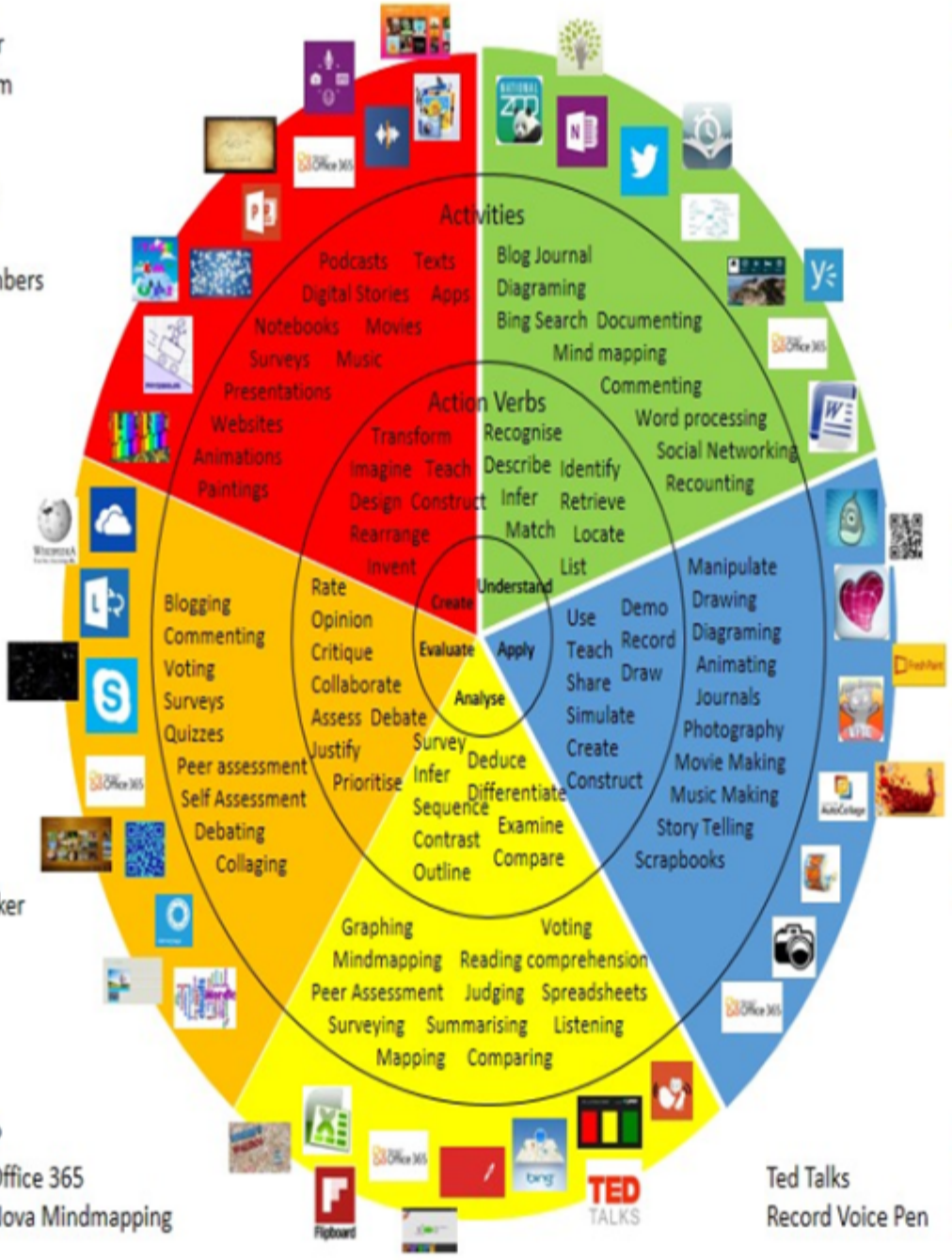
AP Collegeboard

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.

Win 8.1 Apps/Tools Pedagogy Wheel

Podcasts
Photostory 3
Kid Story Builder
Music Maker Jam
Paint A Story
Office 365
MS PowerPoint
Stack 'Em Up
NqSquared Numbers
Physamajig
Xylophone 8

Wikipedia
Skydrive
Lync
SkyMap
Skype
Office 365
Puzzle Touch
Easy QR
Memorylage
Life Moments
Word Cloud Maker



Where's Waldo?
MS Excel Office 365
Flipboard Nova Mindmapping

Ted Talks
Record Voice Pen

Originally taken from http://www.coetail.com/vzimmer/files/2013/02/iPadagogy-Wheel.001.jpg
And adapted for Windows 8.1 devices by Charlotte Beckhurst @CharBeckhurst

Alignment to 21st Century Skills & Technology

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

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).
TECH.9.4.12.IML.1	Compare search browsers and recognize features that allow for filtering of information.

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)

Visualizing the angle of rotation of a rotating object.

- 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)

Count number of rotations of a rotating object, measure time and calculate period of the circular motion.

- Students are provided with glossary in their native language.

- Spanish speaking students may utilize Spanish Edition of a Textbook

- teaching key aspects of a topic. Eliminate nonessential information
- using videos, illustrations, pictures, and drawings to explain or clarif
- 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 workpresented 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

Measure time for a complete rotation.

- 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 workpresented 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)

- Students must be able to solve problems with systems of equations.

- 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: CIRCULAR MOTION AND GRAVITATION

NJSLS: 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 compare linear and circular motion in terms of linear and radial variables with 90% accuracy.

Anticipatory Set/Do Now: fro Hz to microHz

Learning Activity:

Lecture –Linear and circular motion; x and y components of circular motion

Small groups activity: Acceleration of a rotating object

Final review: Properties of circular motion

Student Assessment/CFU's:

The Dynamics Review test will be given in the AP Classroom.

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 calculate angular velocity. (Gifted and Talented)

Students must be able to measure period . (Special Ed)

Integration of Technology:Power Point