COURSE TITLE

Advanced Placement Physics C

LENGTH

Full Year

DEPARTMENT

STEM Department

SCHOOL

Rutherford High School

DATE

September 10, 2018

Initial BOE Approval Date (Born on): 6/5/2017

Advanced Placement Physics C

I. Introduction/Overview/Philosophy

Recognizing that a student's attitudes or feelings about physics are just as important in the long run as his or her acquisition of specific physical concepts, it is our goal to instill in the student an in-depth understanding of the principles and laws that govern everyday physics. To this end, the extensive use of laboratory experimentation and demonstrations as well as rigorous problem solving course work will be an integral part of the everyday physics classroom. All of the following should culminate in a sufficient knowledge of physics to excel in post-high school academics or in the appropriate Advanced Placement exam.

AP Physics C: Mechanics provides a systematic development of the main principles of physics, emphasizing problem solving and helping students develop a deep understanding of physics concepts. Students taking this course should be enrolled in a Calculus course.

II. Objectives

Course Outline:

1. Kinematics (including vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration)
    i. Motion in one dimension
    ii. Motion in two dimensions, including projectile motion
2. Newton's laws of motion
    i. Static equilibrium (first law)
    ii. Dynamics of a single particle (second law)
    iii. Systems of two or more objects (third law)
3. Work, energy, power
    i. Work and work–energy theorem
    ii. Forces and potential energy
    iii. Conservation of energy
    iv. Power
4. Systems of particles, linear momentum
    i. Center of mass
    ii. Impulse and momentum
    iii. Conservation of linear momentum, collisions
5. Circular motion and rotation
    i. Uniform circular motion
    ii. Torque and rotational statics
    iii. Rotational kinematics and dynamics
    iv. Angular momentum and its conservation
6. Oscillations and gravitation
    i. Simple harmonic motion (dynamics and energy relationships)

ii. Mass on a spring
iii. Pendulum and other oscillations
iv. Newton's law of gravity
v. Orbits of planets and satellites
    1. Circular
    2. General

Student Outcomes:

After successfully completing this course, the student will:

- Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.
- Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.
- Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.
- Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/co-relational relationships, and anomalous data.
- Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.
- Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.
- Reflect on and revise understandings as new evidence emerges.
- Use data representations and new models to revise predictions and explanations.
- Consider alternative theories to interpret and evaluate evidence-based arguments.
- Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.
- Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.
- Demonstrate how to use scientific tools and instruments.

New Jersey Student Learning Standards

CAREER READY PRACTICES

CRP1 Act as a responsible and contributing citizen and employee.

Career-ready individuals understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams, families, community and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good.

CRP2 Apply appropriate academic and technical skills.

Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation

CRP4 Communicate clearly and effectively and with reason.

Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, and/or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others' time. They are excellent writers; they master conventions, word choice, and organization, and use effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.

CRP5. Consider the environmental, social and economic impacts of decisions.

Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact and/or mitigate negative impact on other people, organization, and the environment. They are aware of and utilize new technologies, understandings, procedures, materials, and regulations affecting the nature of their work as it relates to the impact on the social condition, the environment and the profitability of the organization.

CRP6. Demonstrate creativity and innovation.

Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.

CRP7. Employ valid and reliable research strategies.

Career-ready individuals are discerning in accepting and using new information to make decisions, change practices or inform strategies. They use reliable research process to search for new information. They evaluate the validity of sources when considering the use and adoption of external information or practices in their workplace situation.

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

Career-ready individuals readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem. They are aware of problems when they occur and take action quickly to address the problem; they thoughtfully investigate the root cause of the problem prior to introducing solutions. They carefully consider the options to solve the problem. Once a solution is agreed upon, they follow through to ensure the problem is solved, whether through their own actions or the actions of others.

CRP11. Use technology to enhance productivity.

Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks-personal and organizational-of technology applications, and they take actions to prevent or mitigate these risks.

TECHNOLOGY

Standard 8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
Strand A. Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems and operations.
8.1.12.A.4- Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.
Standard 8.2 Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.
Strand C. Design: The design process is a systematic approach to solving problems.
8.2.12.C.5- Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
Strand E: Research and Information Fluency: Students apply digital tools to gather, evaluate, and use information.
8.1.12.E.1- Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.

21ST CENTURY LIFE AND CAREERS

9.2 Career Awareness, Exploration, and Preparation
Strand C: Career Preparation
9.2.12.C.1 Review career goals and determine steps necessary for attainment.

COMPANION STANDARDS FOR SCIENCE AND TECHNICAL SUBJECTS

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.
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.
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.
WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.11-12.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

NEW JERSEY STUDENT LEARNING STANDARDS- SCIENCE

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
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.
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.
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.

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.
HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
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 motion of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media
HS-PS4-2. Evaluate questions about the advantages of using digital transmission and storage of information
HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

III. Proficiency Levels

AP Physics C is a full year course appropriate for grade 12 students that are also taking Honors Calculus or AP Calculus.

IV. Methods of Assessment

Student Assessment
The teacher will provide a variety of assessments during the course of the year. The assessment may include but is not limited to: chapter and unit tests and quizzes, application problems, homework, laboratory reports, and projects.

Curriculum/Teacher Assessment
The teacher will provide the subject area supervisor with suggestions for changes on an ongoing basis.

V. Grouping

The minimum prerequisites for AP Physics C are the proficient completion of Biology, Chemistry, and Physics. The minimum co-requisite is Honors Calculus or AP Calculus.

VI. Articulation/Scope & Sequence/Time Frame

Course length is one year.

VII. Resources

Texts/Supplemental Reading/References

Resources include but are not limited to:
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1. References
    a. Nolan, Peter, Fundamentals of College Physics. Wm. C. Brown Publishers, Dubuque, IA. 1995.
    b. Faughn, Jerry and Serway, Raymond. Holt Physics. Holt, Rinehart and Winston. Austin, 2000.
    c. Hewitt, Paul. Conceptual Physics. Prentice Hall, Upper Saddle River, NJ. 2002.
    d. Zitzewitz, Paul. Physics, Principles and Problems. Glencoe/McGraw Hill, Columbus, Ohio. 2002.
2. Various Internet sites appropriate to topics being studied.

VIII. Suggested Activities

Appropriate activities are listed on the curriculum map.

IX. Methodologies

AP Physics C is a laboratory science with class time spent on laboratory experiments and hands-on activities. Group instruction, cooperative learning and individual projects are also utilized.

X. Interdisciplinary Connections

Applications to math, biology, and language arts literacy will be made on a daily basis through a variety of projects and explorations.

XI. Differentiating Instruction for Students with Special Needs: Students with Disabilities, Students at Risk, English Language Learners, and Gifted & Talented Students

Differentiating instruction is a flexible process that includes the planning and design of instruction, how that instruction is delivered, and how student progress is measured. Teachers recognize that students can learn in multiple ways as they celebrate students' prior knowledge. By providing appropriately challenging learning, teachers can maximize success for all students.

Differentiating in this course includes but is not limited to:

Differentiation for Support (ELL, Special Education, Students at Risk)

- Peer mentoring on problems
- Differentiated teacher feedback on assignments
- Modeling out problems on whiteboard
- Visual aids as we project problems on whiteboard
- Study guides
- Tiered assignments

- Scaffolding of materials and assignments
- Re-teaching and review
- Guided note taking
- Exemplars of varied performance levels
- Multi-media approach to accommodating various learning styles

Differentiation for Enrichment

- Supplemental reading material for independent study
- Flexible grouping
- Tiered assignments
- Topic selection by interest
- Enhanced expectations for independent study
- Elevated questioning techniques using Webb's Depth of Knowledge matrix

XII. Professional Development

The teacher will continue to improve expertise through participation in a variety of professional development opportunities.

XII. Curriculum Map/Pacing Guide

Unit Topic	Time Allocated	Differentiating Instruction for Students with Disabilities, Students at Risk, English Language Learners, & Gifted & Talented Students	Standards	Assessments
Kinematics (Calculus-Based) • Linear Motion • Free Fall • 2-D motion (projectiles)	8 weeks	*For Support:* College Board Equation Sheet, graphing calculator *For Enhancement:* Real world applications, Phet Computer, Simulations, Student Choice, Student driven projects	HS-PS2-1 CRP1,4,7,8,10,11,12 8.1.12.A.4 8.2.12.E.1 RST.11-12.3,4 WHST11-12.2	*Formative Assessment:* Homework, classwork, hands-on demos, labs *Summative Assessment:* Quiz – Linear Motion Quiz – Free Fall Test – Free Fall/Linear Motion Quiz – 2-D motion Test – All kinematics
Newton's Law (Forces/Dynamics – Calculus based) • First Law • Second Law • Third Law • Friction • Tension • Inclined Planes	9 weeks	*For Support:* College Board Equation Sheet, graphing calculator, Khan Academy *For Enhancement:* Analytical thinking tasks, Real world applications, Phet Computer, Simulations	HS-PS2-1 HS-PS2-2 HS-PS2-5 CRP1,4,7,8,10,11,12 8.1.12.A.4 8.2.12.E.1 RST.11-12.3,4 WHST11-12.2	*Formative Assessment:* Homework, classwork, hands-on demos, labs *Summative Assessment:* Quiz – Newton's Laws (concept) Quiz – 2nd Law simple applications Quiz – 3rd law applicaitons Test – Newton's Laws Quiz – Friction/Tension Quiz Inclined Plane Test – All Forces Benchmark
Circular Motion • Centripetal Force • Gravitation • Satellite Motion • Orbits	5 weeks	*For Support:* College Board Equation Sheet, graphing calculator, Use of Prompts *For Enhancement:* Real world applications,	HS-PS2-1 HS-PS2-4 HS-PS2-5 HS-ESS1-4 CRP1,4,7,8,10,11,12 8.1.12.A.4	*Formative Assessment:* Homework, classwork, hands-on demos, labs *Summative Assessment:* Quiz – Centripetal force/circular motion Quiz – Applications to other forces

Unit Topic	Time Allocated	Differentiating Instruction for Students with Disabilities, Students at Risk, English Language Learners, & Gifted & Talented Students	Standards	Assessments
		Phet Computer, Simulations, Adjusted Student pacing	RST.11-12.4	Quiz – Gravitation Test – Satellite Motion Quiz – Orbits Test – Circular Motion
Momentum (Calculus Based) • Momentum/Impulse • Linear Collisions • 2-D Collisions	4 weeks	*For Support:* College Board Equation Sheet, graphing calculator, Testing Accommodations, *For Enhancement:* Interest based content, Real world applications, Phet Computer, Simulations,	HS-PS2-2 HS-PS2-3 CRP1,4,7,8,10,11,12 RST.11-12.4 WHST.11-12.2	*Formative Assessment:* Homework, questioning on momentum, classwork, hands-on demos, labs *Summative Assessment:* Quiz – Momentum, Impulse, 1-D collisions Quiz – 2-D collisions Test – Momentum
Energies • Kinetic Energy • Gravitational Potential Energy • Elastic Energy • Work and Work/Energy Theorem • Conservation Laws	4 weeks	*For Support:* College Board Equation Sheet, graphing calculator, Rephrasing of Questions, Pre-teaching of vocabulary *For Enhancement:* Khan Academy, Phet Computer, Simulations, Adjustment Student pacing	HS PS3-1 HS PS3-2 HS PS3-3 CRP1,4,7,8,10,11,12 8.1.12.A.4 RST.11-12.4 WHST.11-12.2	*Formative Assessment:* Do nows, homework, group work, classwork, hands-on demos, labs *Summative Assessment:* Quiz – Kinetic and Potential Energy Quiz – Elastic Energy and its conservation Quiz – Complex conservation laws Test – Energies and Conservation Laws Benchmark
Center of Mass and Angular Motion • Center of Mass • Angular kinematics • Angular dynamics (torque) • Angular momentum (conservation laws) • Angular energy (conservation laws)	6 weeks	*For Support:* College Board Equation Sheet, graphing calculator, Khan Academy, Use of prompts *For Enhancement:* Real world applications, Phet Computer, Independent Study, Adjustment Student pacing	HS-PS3-3 HS-PS2-1 HS-PS2-2 HS-PS3-1 HS-PS3-2 CRP1,4,7,8,10,11,12 8.1.12.E.1 RST.11-12.4	*Formative Assessment:* Homework, classwork, group work, hands-on demos, labs *Summative Assessment:* Quiz – Center of mass Quiz – Angular kinematics Quiz – Angular dynamics (torque) Test – Angular kinematics/dynamics Quiz – Angular energies and momenta

Unit Topic	Time Allocated	Differentiating Instruction for Students with Disabilities, Students at Risk, English Language Learners, & Gifted & Talented Students	Standards	Assessments
				Test – Angular Motion unit test Benchmark
Applied Physics (Real Scenarios) • Project 1: Popular Physics Research Project • Project 2: Hollywood Physics Research Project • Final Assessment – Macgyver Physics (compare to science consultant on production staff)	4 weeks	*For Support:* College Board Equation Sheet, graphing calculator, Scaffolding, Teacher Modeling *For Enhancement:* Extension Activities, Real world applications, Phet Computer, Simulations,	HS-PS1 HS-PS2 HS-PS3 HS-PS4 CRP1,4,7,8,10,11,12 8.1.12.A.4 8.2.12.C.5 8.2.12.E.1 RST.11-12.4,8 WHST.11-12.2,5,7	*Formative Assessment:* Homework, classwork, research and presentations *Summative Assessment:* Project 1 - research will count as a quiz grade, presentation will count as a test grade Project 2 - research will count as a quiz grade, presentation will count as a test grade Final Benchmark Assessment