SPRING GROVE AREA SCHOOL DISTRICT

PLANNED COURSE OVERVIEW

Course Title: Applied Physics – Aerospace Engineering	Length of Course: 1 semester (15 cycles)
Grade Level(s): 10-12	Periods Per Cycle: 6
Units of Credit: .5 credits	Length of Period: 43 minutes
Classification: Elective	Total Instructional Time: 64.5 hours

Course Description

This advance level course examines the characteristics of the flight of a rocket including drag, stability margin, and thrust. Newtonian mechanics are used to describe and explain the flight cycle of the rocket and aid in the design of the final project. The course also focuses on all of the steps of the engineering cycle including design, prototype, production, testing, and modification. The students in the course have the unique opportunity to participate in the NASA Student Launch Initiative (SLI) and the Team America Rocketry Challenge (TARC) competitions to apply their knowledge from the course. Ultimately, the course is designed to encourage students to ignite an interest in science, technology, engineering, and math and to pursue careers in aerospace or other Science, Technology, Engineering, and Math education (STEM) fields.

Prerequisite: Successful completion of Biology 1 or Biology 1 Honors with a minimum grade of 75% and successful completion of or concurrent enrollment in Physics 1 or AP Physics 1.

Instructional Strategies, Learning Practices, Activities, and Experiences

Critical Thinking	Bell Ringers	Teacher Demonstration
Formal Assessments	Class Discussion	Detailed Laboratory Experiments
Guided Practice	Flexible Groups	Inquiry Laboratory Experiments
Rocket construction	APL Strategies	Online Tutorials/Resources
Rocket Design	Posted Objectives and Agenda	Homework

Assessments

Completed Designs	Test Launches	Concept Quizzes
Completed Rockets		

Materials/Resources

RockSim	NASA SLI Statement of Work	Handbook of Model Rocketry (all support materials)
Open Rocket		

Adopted: 5/16/16
Revised:

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Newtonian Mechanics	
CONTENT/KEY CONCEPTS	**OBJECTIVES/STANDARDS**
A. Rocketry 1. Vocabulary 2. Parts of a Rocket 3. Rocket Design Software 4. Stability 5. Applicable Laws 6. Rocketry Associations 7. Rocketry Competitions 8. Rocket Construction	1. Label all of the parts of a rocket including their correct order for assembly. S11.A.3.1: Analyze the parts of a simple system, their roles, and their relationships to the system as a whole. 2. Use RockSim or Open Rocket to design a rocket that is stable and is able to reach a specific height and return to earth safely. S11.A.2.1.2 - Critique the elements of the design process (e.g. identify the problem, understand criteria, create solutions, select solution, test/evaluate, communicate results) applicable to a specific technological design. 3. Describe stability and know the factors that affect stability. S11.C.3.1.3 - Describe the motion of an object using variables (i.e., acceleration, velocity, displacement). 4. Understand all applicable federal and state laws for motors and rocketry flight. 5. Compare and contrast the National Association of Rocketry and Tripoli. 6. Describe all of the aspects of the TARC competition and use the new specifications to design a rocket that will meet all criteria. S11.A.1.3.1 - Use appropriate quantitative data to describe or interpret change in systems (e.g., biological indices, electrical circuit data, automobile diagnostic systems data). 7. Build a TARC rocket and test launch. S11.A.3.2.3 - Describe how relationships represented in models are used to explain scientific or technological concepts (e.g., dimensions of objects within the solar system, life spans, size of atomic particles, topographic maps). S11.A.3.1.4 - Apply the universal systems model of inputs, processes, outputs, and feedback to a working system (e.g., heating, motor, food production) and identify the resources necessary for operation of the system. 8. Describe all aspects of the NASA Student Launch Competition (SLI) and understand what is expected in the design reviews and flysheets. S11.A.2.1 - Apply knowledge of scientific investigation or technological design to develop or critique aspects of the experimental or design process.

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CONTENT/KEY CONCEPTS	**OBJECTIVES/STANDARDS**
B. Kinematics (including vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration) 1. Motion in one dimension 2. Motion in two dimensions, including projectile motion	1. State from memory the meaning of key terms and phrases used in kinematics. S11.C.3.1.3 - Describe the motion of an object using variables (i.e., acceleration, velocity, displacement). 2. List the SI unit and its abbreviation associated with displacement, velocity, acceleration, and time. 3. Describe the motion of an object relative to a particular frame of reference. S11.C.3.1.3 - Describe the motion of an object using variables (i.e., acceleration, velocity, displacement). 4. State from memory the meaning of the symbols used in kinematics: x, x_0, v, v_0, a, y,y_0, g, t 5. Write from memory the equations used to describe motion at constant acceleration. 6. Analyze the altitude versus time graph to determine the descent velocity while under the drogue parachute and under the main. S11.A.2.1.3 - Use data to make inferences and predictions, or to draw conclusions, demonstrating understanding of experimental limits. 7. Determine the descent time and calculate drift based on set wind velocities. S11.A.3.1.4 - Apply the universal systems model of inputs, processes, outputs, and feedback to a working system (e.g., heating, motor, food production) and identify the resources necessary for operation of the system.

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CONTENT/KEY CONCEPTS	**OBJECTIVES/STANDARDS**
C. Newton's laws of motion 1. Static equilibrium (first law) 2. Dynamics of a single particle (second law) 3. Systems of two or more objects (third law)	1. Differentiate between a vector quantity and a scalar quantity, and state which quantities used in kinematics are vector quantities and which are scalar quantities. 2. Multiply or divide a vector quantity by a scalar quantity. 3. Use the component method to determine the resultant vector in problems involving vector addition or subtraction of two or more vector quantities. 4. State Newton's three laws of motion and give examples that illustrate each law. S11.A.1.1.4 - Explain how specific scientific knowledge or technological design concepts solve practical problems (e.g., momentum, Newton's universal law of gravitation, tectonics, conservation of mass and energy, cell theory, theory of evolution, atomic theory, theory of relativity, Pasteur's germ theory, relativity, heliocentric theory, ideal gas laws). 5. Explain what is meant by the term, net force. 6. Use the methods of vector algebra to determine the net force acting on an object. 7. Define each of the following terms: mass, inertia, weight. 8. Distinguish between mass and weight. 9. Identify the SI units of force, mass, and acceleration. 10. Draw an accurate free-body diagram locating each of the forces acting on an object or a system of objects. 11. Use free-body diagrams and Newton's laws of motion to solve word problems. S11.A.1.1.4 - Explain how specific scientific knowledge or technological design concepts solve practical problems (e.g., momentum, Newton's universal law of gravitation, tectonics, conservation of mass and energy, cell theory, theory of evolution, atomic theory, theory of relativity, Pasteur's germ theory, relativity, heliocentric theory, ideal gas laws)

Newtonian Mechanics	
CONTENT/KEY CONCEPTS	**OBJECTIVES/STANDARDS**
C. Newton's laws of motion (continued)	12. Use the kinematics equations along with the vector component method to solve problems involving two-dimensional projectile motion. 13. Determine the thrust to weight ratio of the rocket with a given motor. 14. Determine the proper motor for a given altitude and vehicle. S11.A.1.3.1 - Use appropriate quantitative data to describe or interpret change in systems (e.g., biological indices, electrical circuit data, automobile diagnostic systems data). 15. Calculate acceleration, exit rail velocity, and minimum stable velocity.

Newtonian Mechanics	
CONTENT/KEY CONCEPTS	**OBJECTIVES/STANDARDS**
D. Work, energy, power 1. Work and work–energy theorem 2. Forces and potential energy 3. Conservation of energy 4. Power	1. Write the definition of work in terms of force and displacement, and calculate the work done by a constant force when the force and displacement vectors are at an angle. 2. Use graphical analysis to calculate work done by a force that varies in magnitude. 3. Define types of mechanical energy and give examples of types of energy that are not mechanical. S11.C.2.1.3 - Apply the knowledge of conservation of energy to explain common systems (e.g., refrigeration, rocket propulsion, heat pump). 4. State the work-energy principle and apply it to solve problems. S11.A.3.1.4 - Apply the universal systems model of inputs, processes, outputs, and feedback to a working system (e.g., heating, motor, food production) and identify the resources necessary for operation of the system. 5. State the law of conservation of energy and apply it to problems involving mechanical energy. S11.C.2.1.3 - Apply the knowledge of conservation of energy to explain common systems (e.g., refrigeration, rocket propulsion, heat pump). 6. Calculate the decent kinetic energy of each of the parts of a rocket. S11.A.1.1.4 - Explain how specific scientific knowledge or technological design concepts solve practical problems (e.g., momentum, Newton's universal law of gravitation, tectonics, conservation of mass and energy, cell theory, theory of evolution, atomic theory, theory of relativity, Pasteur's germ theory, relativity, heliocentric theory, ideal gas laws). 7. Use conservation of energy to predict the height of a rocket given the impulse of the motor. S11.C.2.1.3 - Apply the knowledge of conservation of energy to explain common systems (e.g., refrigeration, rocket propulsion, heat pump).

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E. Systems of particles, linear momentum 1. Center of mass 2. Impulse and momentum 3. Conservation of linear momentum, collisions	1. Define linear momentum and write the mathematical formula for linear momentum from memory. 2. Distinguish between the unit of force and the unit of momentum. 3. Write Newton's second law of motion in terms of momentum. 4. Define impulse and write the equation that connects impulse and momentum. 5. State the laws of conservation of momentum and write, in vector form, the law for a system involving two or more objects. 6. Apply the laws of conservation of momentum and energy to problems involving collisions between two objects S11.C.2.1.3 - Apply the knowledge of conservation of energy to explain common systems (e.g., refrigeration, rocket propulsion, heat pump). 7. Define center of mass and center of gravity, and distinguish between the two concepts. 8. Determine the stability margin of a rocket. S11.A.1.1.4 - Explain how specific scientific knowledge or technological design concepts solve practical problems (e.g., momentum, Newton's universal law of gravitation, tectonics, conservation of mass and energy, cell theory, theory of evolution, atomic theory, theory of relativity, Pasteur's germ theory, relativity, heliocentric theory, ideal gas laws). 9. Describe the body changes of a rocket that will affect the stability margin of a rocket. S11.A.1.1.3 - Evaluate the appropriateness of research questions (e.g., testable vs. not-testable). 10. Explain how the stability of a rocket affects weather cocking.

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CONTENT/KEY CONCEPTS	**OBJECTIVES/STANDARDS**
F. Oscillations and gravitation 1. Simple harmonic motion (dynamics and energy relationships) 2. Newton's law of gravity 3. Orbits of planets and satellites	1. Write the equation for Newton's universal law of gravitation, and explain the meaning of each symbol in the equation. 2. Determine the magnitude and direction of the gravitational force (F_G) at a distance *r* from an object of mass *m.* 3. Use Newton's second law of motion, the universal law of gravitation, and the concept of centripetal acceleration to solve problems involving the orbital motion of satellites. 4. Explain the "apparent weightlessness" of an astronaut in orbit. 5. Use Newton's second law of motion, the universal law of gravitation, and the concept of centripetal acceleration to derive Kepler's third law. 6. Explain how a planet's gravity can aid in the velocity of a spacecraft. 7. Research the current design and plans of spacecraft designed to reach deep space and Mars. S11.A.1.1.3 - Evaluate the appropriateness of research questions (e.g., testable vs. not-testable).

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G. Fluid Mechanics 1. Hydrostatic pressure 2. Fluid flow continuity 3. Bernoulli's equation	1. Define pressure and calculate the pressure that an object of known weight exerts on a surface of known area. 2. Calculate the pressure acting at a depth below the surface of a liquid. 3. State Pascal's Principle and apply this principle to basic hydraulic systems. 4. State Archimedes' Principle and use this principle to solve problems related to buoyancy. S11.A.2.1.3 - Use data to make inferences and predictions, or to draw conclusions, demonstrating understanding of experimental limits. 5. Use Bernoulli's equation and the concept of streamline flow to solve for the velocity of a fluid and/or the pressure exerted by a fluid at a particular point in a closed pipe. S11.A.2.1.2 - Critique the elements of the design process (e.g. identify the problem, understand criteria, create solutions, select solution, test/evaluate, communicate results) applicable to a specific technological design.

Newtonian Mechanics	
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H. Conductors, capacitors, dielectrics 1. Electrostatics with conductors 2. Capacitors	1. Write from memory the definitions of electric potential. S11.C.2.1.3 - Apply the knowledge of conservation of energy to explain common systems (e.g., refrigeration, rocket propulsion, heat pump). 2. Explain how a simple battery can produce an electric current. 3. Define current, ampere, voltage, resistance, resistivity, and temperature coefficient of resistance. S11.A.3.1.4 - Apply the universal systems model of inputs, processes, outputs, and feedback to a working system (e.g., heating, motor, food production) and identify the resources necessary for operation of the system.

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CONTENT/KEY CONCEPTS	**OBJECTIVES/STANDARDS**
I. Electric circuits 1. Current, resistance, power 2. Steady-state direct current circuits with batteries and resistors only 3. Capacitors in circuits a. Steady state b. Transients in RC circuits	1. Write the symbols used for electric current, resistance, resistivity, temperature coefficient of resistivity, and power and state the units associated with each quantity. 2. Distinguish between conventional current and electron flow and between direct current and alternating current. S11.C.2.1.3 - Apply the knowledge of conservation of energy to explain common systems (e.g., refrigeration, rocket propulsion, heat pump). 3. Given the length of the wire and its cross-sectional area, resistivity, and temperature coefficient of resistivity, determine the wire's resistance at room temperature and at some higher or lower temperatures. S11.A.3.1.4 - Apply the universal systems model of inputs, processes, outputs, and feedback to a working system (e.g., heating, motor, food production) and identify the resources necessary for operation of the system. 4. Use Ohm's law to solve simple dc circuit problems. S11.A.3.2.3 - Describe how relationships represented in models are used to explain scientific or technological concepts (e.g., dimensions of objects within the solar system, life spans, size of atomic particles, topographic maps).