Lesson Title	Blast Off!
Length of Lesson	110 minutes (2 class periods)
Created By	Emily Burtnett
Subject	Math SL
Grade Level	11^{th} – 12^{th}
State Standards	Physics I: 3c-g
DOK Level	2
DOK Application	Investigate physical dynamics. Explain physical dynamics in terms of Newton's Three Laws of Motion. Solve problems using Newton's Three Laws of Motion. Apply the principles of impulse and conservation of momentum to interpret Newton's Third Law of Motion. Explain the effects of the Law of Universal Gravitation and calculate the force between two masses. Explore the principles and applications for solving problems in two-dimensional motion.
National Standards	Develop and evaluate inferences and predictions that are based on data.
Graduate Research Element	The Navier-Stokes equations are the basic governing equations for a viscous, heat conducting fluid. It is a vector equation obtained by applying Newton's Law of Motion to a fluid element and is also called the momentum equation. Newton's Law of Motion is applied to motion of a rocket in this lesson plan.

Student Learning Goal:

Students will focus on their developed physics and aerospace engineering knowledge to understand how space flight is achieved from an engineering standpoint. Students will work in a group to build and launch a rocket. They will analyze the forces on the rocket, Newton's Laws, and other principles and challenges of space flight and rocket launch.

Materials Needed (supplies, hand-outs, resources):

paper, pencils, model rocket kit, online rocket simulator (www.grc.nasa.gov/WWW/k-12/rocket/)

Lesson Performance Task/Assessment:

Students will review the laws of Newton and focus on application to rocket launches. Students will be challenged to build a rocket to overcome challenges. Teams will consider payload, weather, and shape and weight of rocket. They will build and re-engineer rocket design. If necessary, they can use the online rocket simulator to observe various flight patterns of other rockets. The rocket will be launched, observations will be taken and the students will reflect on the experience.

Lesson Relevance to Performance Task and Students:
Students will develop an understanding of aerospace engineering, engineering design, space flight, and team work.

Anticipatory Set/Capture Interest:
Telling students they will be building rockets to launch is enough to capture their interest. Introduce the lessons with questions about Newton's Laws and quiz them on what they can recall. The instructor will transition into rocket principles and how rockets fly.

Guided Practice:
DAY 1
Instructor will discuss rocket principles briefly with the students.

The best analogy for a rocket is a balloon. A small opening at one end of the chamber allows gas to escape, and in doing so provides a thrust that propels the rocket in the opposite direction. With space rockets, the gas is produced by burning propellants that can be solid or liquid in form or a combination of two.

Newton's Laws of Motion
1. Objects at rest will stay at rest and objects in motion will stay in a straight line unless acted upon by an unbalanced force.
2. Force is equal to mass times acceleration.
3. For every action there is always an opposite and equal reaction.

Using the three laws, precise determinations of rocket performance can be made.

FIRST LAW: In rocket flight, forces become balanced and unbalanced all the time. A rocket sitting on the launch pad is balanced (in equilibrium). Gravity pulls the rocket down while the launch pad pushed the rocket up. Once the engines start up, there is a thrust force downward unbalancing the rocket and it travels upward. When the fuel runs out, the rocket slows down, stops at the highest point in its flight upward and falls back down. The rocket will also react to forces. As long as the forces are in balance while it is in constant motion, the rocket will travel in a straight line (assuming it is far from the pull of Earth's gravity). If it comes near a large body in space, the gravity of that body will unbalance the forces and curve the path of the spacecraft. This is why if a rocket is shot up fast enough the spacecraft will orbit Earth. In summation, if a rocket is at rest, it takes an unbalanced force to make it move (thrust). If an object is already moving, it takes an unbalanced force to stop it, change its direction from a straight line or alter its speed.

THIRD LAW:

Recall that thrust pushes the rocket upward, overcoming the weight and downward pull of gravity.

SECOND LAW:
Balance the equation, F=ma. The greater the mass of rocket fuel burned, the faster the gas produced can escape the engine, the greater the thrust of the rocket.

Summarize: An unbalanced force must be exerted for a rocket to lift off from a launch pad or for a craft in space to change speed or direct (first law). The amount of thrust (force) produced by a rocket engine will be determined by the mass of the rocket fuel that is burned and how fast the gas escapes the rocket (second law). The reaction, or motion, of the rocket is equal to and in the opposite direction of the action, or thrust, from the engine (third law).

Review the four fundamental forces on a rocket. Note, they are different for a rocket than an airplane. On an airplane, the lift force is used to overcome the weight. On a rocket, thrust is used in opposition to weight. Lift is used to stabilize and control the direction of flight. On an airplane, most aerodynamic forces are generated by the wings and the tail surfaces. For a rocket, the aerodynamic forces act through the center of pressure while the weight acts through the center of gravity. Rockets generally have greater drag.

Students should be given time to begin research and design their rockets.

DAY 2
Instructor should supervise: students will build their rockets and launch. The discussion should be completed in class. Discussion questions:

- How did the height you estimated your rocket would reach compare to the actual estimated height?
- What do you think might have caused any differences in the height you achieved?
- Did your rocket launch straight up? If not, why do you think it veered off course?
- Did you adjust your model rocket at all? How? Did this help or hinder results?
- How would the rocket have launched differently if it were launched in a weightless atmosphere?
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Independent Practice:
On day two, students will build and launch a rocket, under supervision of instructor. They will complete the worksheet and share experiences with the class.

Remediation and/or Enrichment:

The rocket can be already build to save time or for remediation. Individual IEPs will be supported.

For enhancement, students could use an altimeter to measure acceleration as part of the lesson and incorporate g-force discussions.

Check(s) for Understanding:
Students can accurately describe the motion and forces of a rocket versus an aircraft. The students can execute a successful launch and complete the worksheet correctly.

Closure:
Teams reflect on the experience, and present to the class.

Possible Alternate Subject Integrations:
Physics

Teacher Notes:
www.estesrockets.com to purchase rocket kits, preferably this one:
http://www.estesrockets.com/rockets/launch-sets/001465-helicattm
www.grc.nasa.gov/WWW/k-12/rocket to research and use online rocket simulator.

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