ESTES® ROCKET LAB™

GRADES 9-12
One Class Lesson Plan

Science

Up and Down and All Around with Newton

STEP 1 LEARN (15 minutes)

Objectives

- Students will gain knowledge of Newton's Three Laws of Motion.
- Students will demonstrate how all Three Laws of Motion work by constructing and launching an Estes model rocket.

Materials

1. Firestreak SST™ Rocket Lab Pack™ (24 pack) - 1 or more
2. Rocket Engine Lab Pack™ (24 pack) - 1 or more
3. Electron Beam® Launch Controller - 1 or more
4. Porta-Pad® II Launch Pad - 1 or more
5. Balloon – 2 or more

Time

One class session

Background

Sir Isaac Newton

What is known about rocketry today can be traced back to the time of Sir Isaac Newton (1642-1727). After "being struck on the head by a falling Apple", Newton described the motion of objects falling to the Earth in his book *Philosohpiae Naturalis Principia Mathematica* where he outlined three laws of motion. Although Newton was merely describing principles of nature, Newton's Laws apply to the physics of rocketry. His laws are simple statements regarding the physics governing motion and can be used to provide precise explanations of rocket flight.

NATIONAL STANDARD

Standard B
Physical Science

Standard 10
Understands forces and motion

Benchmark 8
Knows that laws of motion can be used to determine the effects of forces on the motion of objects (e.g., objects change their motion only when a net force is applied; whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object; the magnitude of the change in motion can be calculated using the relationship F=ma, which is independent of the nature of the force)

Newton's First Law of Motion
Objects at rest will stay at rest and objects in motion will stay in motion in a straight line unless acted upon by an unbalanced force.

During a model rocket flight, forces become balanced and unbalanced all the time. A rocket on the launch pad is in a state of rest. It is balanced all the time. It is balanced because the surface of the pad pushes the rocket up while the force of gravity tries to pull it down. An unbalanced force must be exerted for a rocket to lift off from a launch pad. A rocket blasting off the launch pad changes from a state of rest to a state of motion. It will keep moving in a straight line at the same speed unless it is acted upon by an unbalanced force (drag and gravity). There are four forces that act on all objects that travel through the air. These forces are lift, thrust, gravity and drag. Drag and gravity are the two unbalanced forces that act on a model rocket. Drag is the resistance or frictional force between the surface of a moving object and air. Drag increases with speed. Gravity is the force pulling an object back to the surface of the Earth. The amount of this force is proportional to the mass of the object. When the rocket lifts off the launch pad it is guided by the launch rod in a straight line upward. The unbalanced forces (drag and gravity) cause it to arch and fall to the ground. The Firestreak has a streamer that is activated so the rocket will be recovered safely to be launched again.

KEY WORDS

action
balanced force
combustion chamber
drag
frictional force
gravity
mass
Newton's Laws of Motion
oxidizer
physics
reaction
resistance
Sir Isaac Newton
unbalanced force

Newton's Second Law of Motion
Force is equal to mass times acceleration. (F=ma)

The amount of thrust (force produced by a rocket engine) will be determined by the mass of gases created and how fast the gas escapes the rocket. The greater the rate at which the rocket fuel is burned and the faster the velocity of the escaping gas, the greater the thrust of the rocket engine.

Newton's Third Law of Motion
For every action there is an equal and opposite reaction.

With rockets, the action is the expelling of gas out of the engine. The reaction is the movement of the rocket in the opposite direction. The rocket is pushed by the escaping gases produced by the chemical reaction of fuel and oxidizer combining in the combustion chamber.

Putting Newton's Laws of Motion Together

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 direction (First Law). The amount of thrust (force) produced by a rocket engine will be determined by the rate at which the mass of the rocket fuel burns and the speed of the gas escaping 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).

Activity

1. Make a Firestreak SST™ rocket. Place it on an Estes Porta-Pad® II Launch Pad in a prominent place in your classroom. Discuss who Sir Isaac Newton was and how his First Law of Motion explains how a rocket on a launch pad can change from a state of rest (Firestreak SST™ on the launch pad) to a state of motion in a straight line until affected by an unbalanced force (drag and gravity).
2. Demonstrate how the forces and energy of a balloon relate to those of a rocket engine. Ask students what will happen when you blow air into a balloon. What will happen if you let go of the balloon? Blow up a balloon and hold the nozzle tightly so the air does not escape (potential energy). The air in an inflated balloon is like the fuel in a rocket (stored energy). Let go of the nozzle to release the air. The air escapes from the balloon and it will fly about the room. When the air is released it is simulating the burning fuel of a rocket (kinetic energy). The balloon and the rocket are at rest until the release of energy forces them into motion in the opposite direction of the released energy – Newton's Third Law of Motion.

STEP 2 - BUILD (15 minutes)

Activity

1. To demonstrate how all of Newton's Laws of Motion work with rockets, students will make and launch a model rocket.
2. Build the Firestreak SST™ together with students, using step-by-step procedures. This is a snap together rocket that needs no gluing or cutting.

STEP 3 LAUNCH (30 minutes)

Activity

1. Assign and post launch jobs for students. Launch jobs are in the *Estes Educator Guide for Teachers & Youth Group Leaders.*
2. Prepare rockets for launching inside before going out to launch. Follow the Engine Preparation steps located in the Firestreak SST™ Instructions.
3. Launch rockets outside at a soccer field, football field, baseball field, green grass area or blacktop area.

Wrap Up - Touch Down & Recovery

1. Students will design a poster to demonstrate how all of Newton's Laws of Motion work with their Firestreak SST™ rocket. The poster will show how and where the rocket, from launch to touchdown, demonstrates all three Laws of Motion.
2. Students will discuss how Newton's Laws of Motion work with other objects.

Extensions

1. To observe different thrust values, altitudes and velocities, launch the rockets with different recommended engines. This will also help students understand F=ma.
2. A skateboard can also be used to show action-reaction. Start with a skateboard and a rider that are in a state of rest (not moving). Have the rider jump off the skateboard (the action). The skateboard will react to that action by traveling some distance in the opposite direction (reaction). Students may notice that the skateboard had much greater reaction than the action of the rider. This is not true. The skateboard traveled farther because it has less mass than the rider. Let each student have a chance to try the skateboard activity.

Evaluation/Assessment

- Students will successfully build and launch the Firestreak SST™ rocket.
- Students will design a poster to show how and where all of Newton's Laws of Motion apply when they launch their rocket.

References

- *Estes Educator™ - Guide for Teachers and Youth Group Leaders*
- Estes Educator™ - *Newton's Laws of Motion and Model Rocketry*
- Estes Educator™ - *Science and Model Rockets Curriculum*
- Estes Educator™ Website - www.esteseducator.com