National Aeronautics and Space Administration

NASA eClips™

Educator Guide

NASA LAUNCHPAD:

In Case of Emergency

Educational Product	
Educators & Students	Grades 9-12

NP-2009-12-231-LaRC

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eClips

In Case of Emergency

EDUCATOR GUIDE

National Standards:

National Science Education Standards (NSES)

Science as Inquiry

Understanding about scientific inquiry

Physical Science

Motions and forces

National Council of Teachers of Mathematics (NCTM)

Algebra

Use mathematical models to represent and understand quantitative relationships

Measurement

Apply appropriate techniques, tools, and formulas to determine measurements

Data Analysis and Probability

Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them

International Society for Technology in Education: National Educational Technology Standards (ISTE/NETS)

Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information.

Students process data and report results.

NASA LAUNCHPAD

Grade Level:
11-12

Subjects:
Algebra 2 and Trigonometry, Physics

Teacher Preparation Time:
45 minutes

Lesson Duration:
Two and a half 55-minute class meetings.
If you choose to complete the optional EXTEND design-based project, allow time for an additional two 55-minute class meetings.

Time Management:
Class time can be reduced to one and a half 55-minute time blocks if some of the work is completed at home.

Critical Thinking, Problem Solving, and Decision Making

Students collect and analyze data to identify solutions and/or make informed decisions.

Lesson Overview:

This lesson is developed using a 5E model of learning. Students are introduced to NASA technology and how basic laws of motion relate to spacecraft safety. Working in teams, students conduct an experiment and analyze data to explore projectile motion. Then, students are challenged to apply their knowledge to develop a working model of the Orion launch abort system.

To complete this lesson, students must have a basic understanding of vectors.

Icons flag four areas of interest or opportunities for teachers.

- **Technology** highlights opportunities to use technology to enhance the lesson.
- **Modification** denotes opportunities to differentiate the lesson.
- **Check for Understanding** suggests quick, formative assessment opportunities.
- **Connections** Icon identifies opportunities to relate the lesson to historical references and other topics of discussion.

Materials List:

For a class demonstration

- tennis ball, baseball, or softball

Per group of three

- foam dart gun
- stopwatch or a watch with a second hand
- meter stick
- digital video camera (optional)
- three copies of the Student Guide

Note: *foam dart guns can be purchased at a discount or dollar store. All students do not need to have the same type of gun.*

Essential Questions:

- How do safety considerations drive the advancement of technology in exploration?
- How can the motion of an object be predicted?

Instructional Objectives:

Students will:

- explore the horizontal and vertical components of projectile motion;
- calculate the launch angle and velocity of a foam dart using data collected in an investigation; and
- apply what they have learned to redesign the foam dart and create working models of the launch abort system.

5E Inquiry Lesson Development

ENGAGE (15 minutes)

1. Roll a ball (tennis ball, baseball, or softball) straight across a table and then throw it straight up into the air. Ask the students to describe each motion. Using the students' responses, establish that the ball follows a straight-line path, but that one path is in a vertical direction and the other is in a horizontal direction.

2. Toss the ball back and forth with one student. Ask the other students to describe this motion. Using their responses, establish that a tossed ball exhibits both vertical and horizontal motion. Explain to the students that this is called projectile motion and that the path of a projectile follows a curve shape called a parabola.

3. **(TECHNOLOGY)** Videotape the tossed ball and replay at a slower frame rate. If possible, show the playback on an interactive whiteboard and mark the position of the ball at intervals.

   (TECHNOLOGY) If available, use a motion detector attached to a data collection device to analyze the motion of the ball.

4. **(TECHNOLOGY)** Show the NASA eClips™ video segment, *Launchpad: The Launch Abort System and g-Forces* to students. This segment can be found on the NASA eClips™ page of the NASA web site:

   http://www.nasa.gov/audience/foreducators/nasaeclips/launchpad/exploration.html

   The video may be streamed or downloaded from the nasa.gov web site; a captioned version is also available at the nasa.gov site. When using the nasa.gov web site, click on the program playlist and scroll through the list beneath the video player to locate the appropriate segment.

(MODIFICATION) This video may be streamed from the NASA eClips YouTube™ channel:

http://www.youtube.com/watch?v=fytNgO00B5c&feature=PlayList&p=D7BEC5371B22BDD9&index=12

(CHECK FOR UNDERSTANDING) To assess student understanding of the relationship between time, velocity and acceleration prior to completing the activities in this lesson, ask students to calculate the velocity of the vehicle after 8 seconds using the 11 g value for acceleration given in the video.

Answer: Use the equation $v = v_0 + at$ *where v is the final velocity,* v_0 *is the initial velocity, a is the acceleration, and t is time. 11 g is the same as 107.8* m/s^2*. From the video, initial acceleration is 0 m/s so:*

$$v = 0 + 107.8(8)$$
$$v = 862.4 \text{ m/s}$$

5. Ask the students about the trajectory of the Orion crew module when it is ejected from the ARES I Launch Vehicle.
   (CHECK FOR UNDERSTANDING) Lead the discussion so students realize that when launched, the rocket and crew module follow a vertical trajectory. When the Launch Abort System is initiated, the trajectory of the crew module changes and follows projectile motion.

EXPLORE (40 minutes)

A projectile is any object that is thrown or otherwise projected into the air and is affected by Earth's gravity. A projectile may start at a given height and follows a curved path called a parabola. Regardless of its path, a projectile will always follow these rules:

- Projectiles always maintain a constant horizontal velocity (in the absence of air resistance).
- Horizontal and vertical motion are independent of each other.
- Changes in direction or speed for this motion are defined as acceleration.
- Objects dropped from a moving vehicle have the same velocity as the moving vehicle immediately after being released.

Objects shot horizontally from the same height, no matter what the speed, take the same amount of time to land. The greater the initial speed, the farther the objects travel, but all land at the same time. This is because the vertical motion of falling is not dependent on horizontal velocity. An object always falls with an acceleration of 9.8 m/s^2 (32 ft/s^2) at sea level (neglecting air resistance).

Therefore, the object always takes the same amount of time to hit the ground. The only variance is how far it lands from the initial firing point.

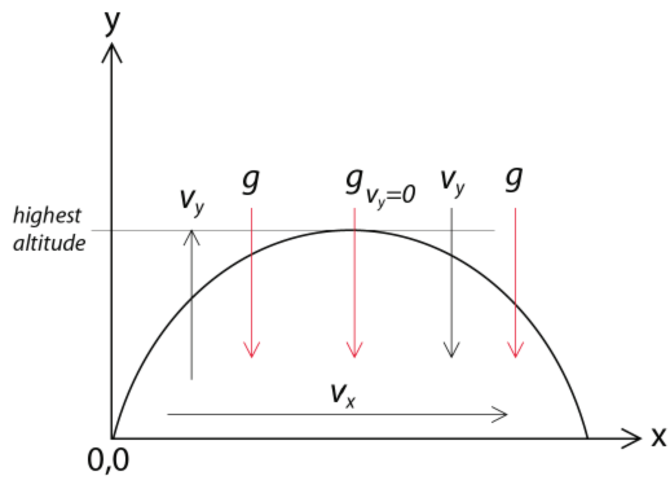

Figure 1. Parabolic motion of a projectile.

As shown in Figure 1, the path that a projectile follows has three components: horizontal velocity, v_x; vertical velocity, v_y, and acceleration due to gravity, *g*. As illustrated in the figure, acceleration due to gravity acts downward during the entire flight. The horizontal velocity always acts in the direction that that projectile was launched. However, the vertical velocity does not always act in the same direction. Its direction changes depending on where in the flight path the projectile is. When the projectile is first launched, vertical velocity is upward. At the highest point of flight, the vertical velocity is 0 m/s. As the projectile descends, the vertical velocity is downward. Because gravity and vertical acceleration are acting in opposite directions during the first half of the flight the projectile is said to be decelerating. During the second half of the flight the projectile is accelerating because velocity and acceleration are acting in the same direction.

In this EXPLORE activity, students record measurements to determine how fast a foam dart travels.

1. Gather the following materials for each group of three students:
   - foam dart gun
   - stopwatch or a watch with a second hand
   - meter stick
   - three copies of the Student Guide
   - digital video camera (optional)

2. Organize students into teams of three. Each person should launch the dart three times. During each launch, students will collect and record the following data in Table 1 of the Student Guide:
   a. The height of the foam dart BEFORE it is launched measured in meters. The dart should be launched at an upward angle (See Figure 2). Students will calculate the actual launch angle.
   b. The distance the dart travels in meters.
   c. The time of the dart's flight in second

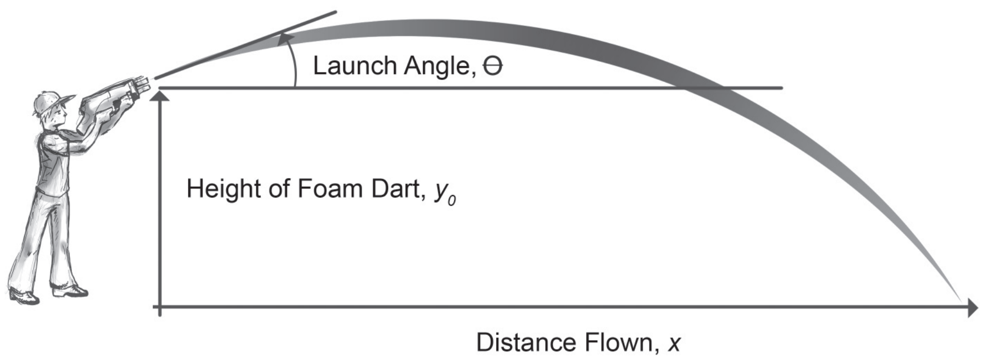

Figure 2: Launch set-up.

(MODIFICATION) To further illustrate to students that projectile motion has both a vertical and horizontal component, have the students launch the foam dart vertically and horizontally as well.

3. **(TECHNOLOGY)** If digital video cameras are available, students should record the dart's motion. The digital recording should complement, not substitute, for other data collection procedures.

EXPLAIN (30 minutes)

Students will analyze the data they collected during the EXPLORE activity.

The specific equations that govern projectile motion for this activity are found on the next page and will be used during the EXPLAIN sections of the lesson.

$y - y_0 = v_y t - \frac{1}{2} g t^2$

$x = v_x t$

$\theta = \arctan(v_y / v_x)$

$v_y = v \sin\theta$

$v_x = v \cos\theta$

y = final vertical height

y_0 = initial vertical height

v = velocity

v_y = vertical velocity

t = time of flight

g = 9.8 m/s^2 (acceleration due to gravity)

x = horizontal distance

v_x = horizontal velocity

θ = launch angle

1. Students will calculate the initial vertical and initial horizontal velocity of the dart from their data. From these calculations, they will determine the launch angle from which the dart was launched and the velocity of the dart.

2. Remind students that the final height for all trials is 0 meters since the foam dart ends up on the ground.

3. **(CHECK FOR UNDERSTANDING)** Ask students to identify sources of error in the experiment. Two major sources of error may be: inaccurate use of the stopwatch and increased air resistance (due to wind speed).

4. **(MODIFICATION/TECHNOLOGY)** If the students videotape the process, video capture software may be used to analyze the motion and to identify sources of error.

5. **(TECHNOLOGY)** Students can create a graphical representation of the trajectory of the foam dart using a graphing calculator or computer software.

EXTEND (optional - two 55-minute class meetings)

1. **(TECHNOLOGY)** Ask students to review the NASA eClips™ video segment, *Launchpad: The Launch Abort System and g-Forces* again. This segment can be found on the NASA eClips™ page of the NASA web site:

   http://www.nasa.gov/audience/foreducators/nasaeclips/launchpad/exploration.html

   or at

   http://www.youtube.com/watch?v=fytNgO00B5c&feature=PlayList&p=D7BEC5371B22BDD9&index=12

2. Discuss the details of the launch abort system. As shown in the video segment, in the event of an emergency, the launch abort system pulls the Orion crew module away from whatever danger there may be. After Orion is safely away, the crew module is reoriented. The crew module is then released from the abort system to begin its controlled descent.

3. Challenge your students to modify the foam dart used during the EXPLORE activity in whatever way they choose to try to control the dart's descent.

4. **(CONNECTIONS)** Review the design process with your students using the Middle School and High School Design Process Packet. This packet can be downloaded at
   http://www.nasa.gov/audience/foreducators/nasaeclips/toolbox/howto.html

EVALUATE (30 minutes)

1. Use questions, discussions, the design challenge rubric and the student guide to assess students' understanding.

2. Ask students to summarize their learning by answering these journal questions:
   a. Scientists use experimental design to guide discovery. Evaluate the experimental design of your EXPLORE experiment using these questions:

      1. What were the independent and dependent variables in this activity? (*Independent variables were launch speed and launch angle; dependent variables were time of flight and distance*)

      2. Why was it important to run several trials? (*Multiple trials show how small variations in speed and angle affect the flight of the dart*)

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3. Suggest ways to improve the data collection process. (*Answers will vary but may include increasing the number of trials, stabilizing the dart gun during the launch, etc.*)

b. You used different equations to solve for horizontal and vertical velocity. Identify the type of equation used in each case. (*Horizontal velocity is calculated using a linear equation; vertical velocity is calculated using a quadratic equation*)

c. How does the importance of safety drive the advancement of technology in exploration? (*Answers will vary but may include the need to protect crew members during launch, limiting g-forces, etc.*)

d. How can the motion of an object be predicted? (*Earth's gravity pulls on all objects with the same force. Therefore, an object always falls to Earth's surface with an acceleration of 9.8 m/s*^{2}*. Objects shot horizontally from the same height, no matter what the speed, take the same amount of time to land.*)

e. How did your redesigned foam dart simulate the motion of Orion's launch abort system? Describe similarities and differences. (*Answers will vary but may include descriptions of how added parachutes slow the dart's descent and change its parabolic motion.*)

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Essential Questions:

- How do safety considerations drive the advancement of technology in exploration?
- How can the motion of an object be predicted?

Background

America will send a new generation of explorers to the moon aboard NASA's **Orion** crew exploration vehicle (see Figure 1). **Orion** is part of the Constellation Program to send human explorers to destinations in the solar system. **Orion** will make its first flights to the International Space Station early in the next decade.

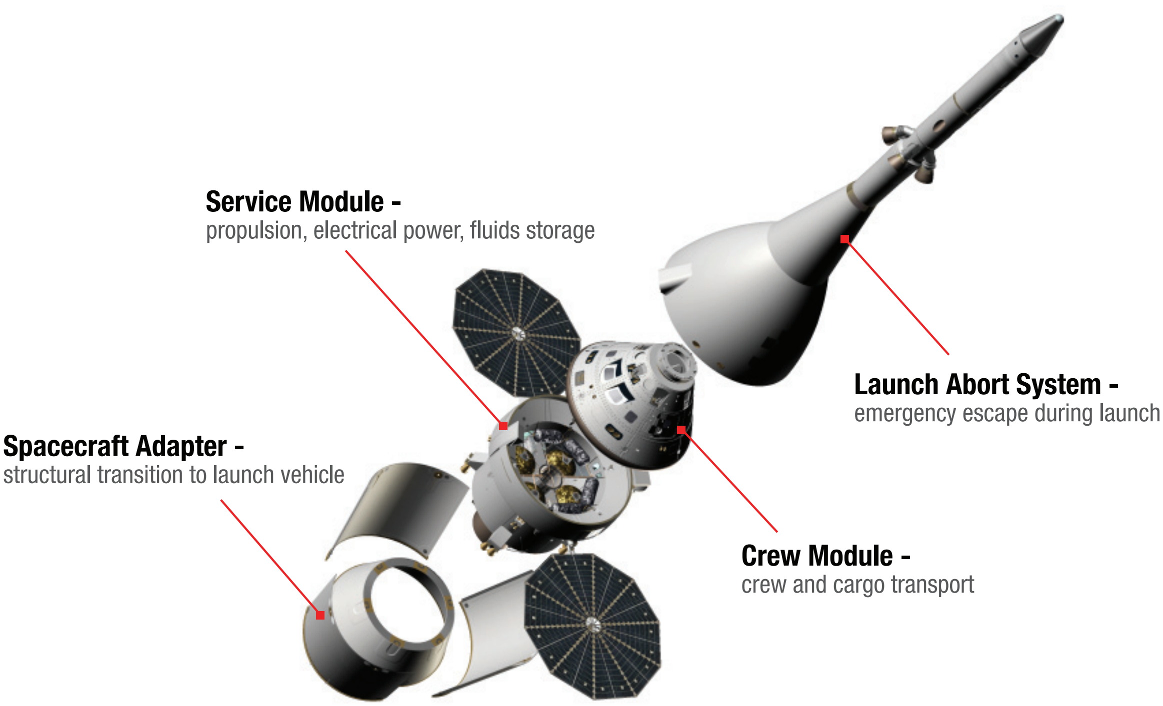

Figure 1: Components of the Orion spacecraft. Image Credit: NASA

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Astronauts traveling in the Orion crew exploration vehicle will lift off in a spacecraft that can escape safely if something goes wrong with the launch vehicle. The **launch abort system**, or **LAS**, is attached to the top of the Orion capsule. Its function is to safely pull the entire crew out of danger in the event of an emergency. The LAS is designed to work on the launch pad or during the climb to Earth orbit. The abort system will automatically separate the spacecraft from the rocket at a moment's notice and ensure that the capsule can land safely (see Figure 2).

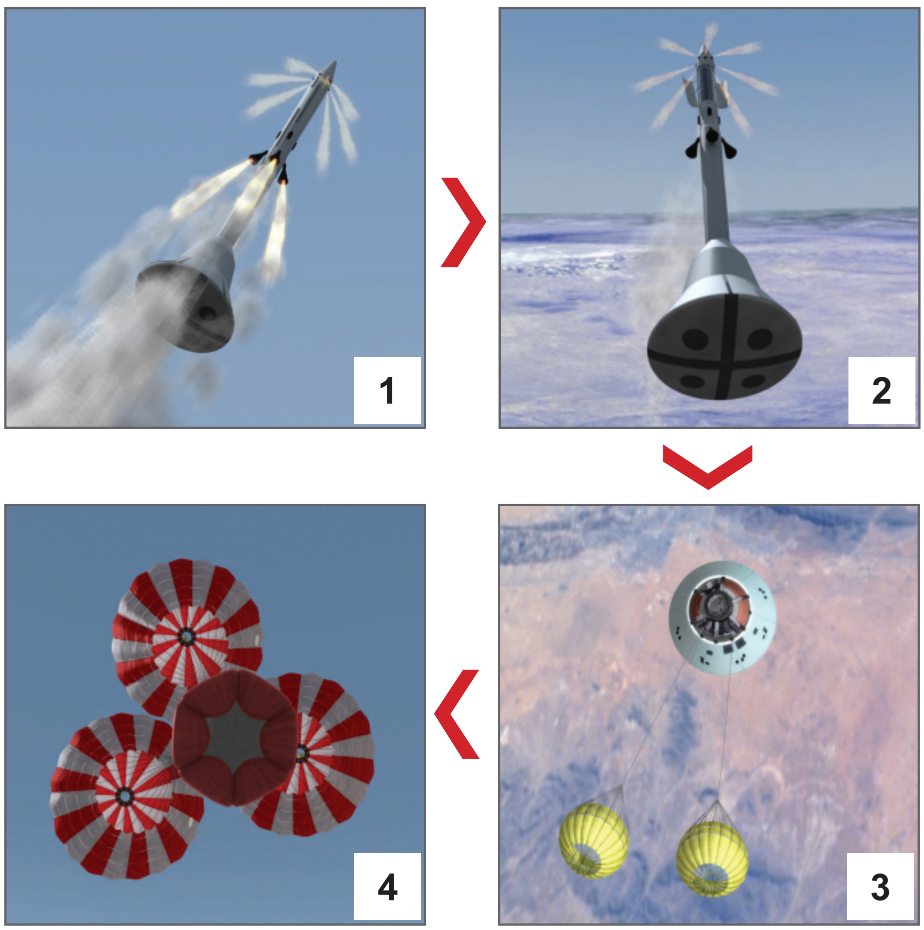

Figure 2: Orion's launch abort system is designed to pull the crew module to safety in an emergency.
Image Credit: NASA

STUDENT GUIDE

If a launch pad or in-flight emergency occurs, the **abort and attitude control motors** will ignite and move the Orion crew module free of the Ares I launch vehicle. To do this, the abort motor will generate about 1,800,000 Newtons (400,000 pounds) of thrust in a fraction of a second. This will cause the trajectory of the crew module to change from a vertical trajectory to a parabolic trajectory. This is the same type of trajectory that a projectile follows. The attitude control motors, motors responsible for correctly orienting the Orion crew module, will maintain stability during this process which will move the vehicle safely away from the booster. Next, the attitude control motor will reorient the capsule. The crew module is then released from the abort system and begins a **controlled descent**. During the controlled decent the same parachutes used for a normal landing will open above the crew module. The parachutes will help guide the capsule to Earth's surface. The launch abort system will not be recovered.

The launch abort system is a key element in NASA's continuing efforts to improve space flight safety for future exploration vehicles. Orion's launch abort system is modeled after the Apollo abort system. It has been improved to provide protection in a broader range of situations. The space shuttle does not have a launch abort system because the spacecraft is mounted side-by-side to **solid rocket boosters** and an external tank.

Resources:

NASA Web site:
http://www.nasa.gov/mission_pages/constellation/orion/index.html

NASAfacts: The Orion Launch Abort System
http://www.nasa.gov/pdf/317642main_FS-2008-11-156-LaRC-OrionLAS.pdf

For more information about the Constellation Program, visit:
http://www.nasa.gov/mission_pages/constellation/main/index.html

For more information on rockets, visit:
http://www.grc.nasa.gov/WWW/K-12/rocket/shortr.html

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Vocabulary

abort motor – The abort motor generates 1,800,000 Newtons (400,000 pounds) of thrust in a fraction of a second to rapidly move the crew to safety during a launch pad or in-flight emergency.

acceleration – Acceleration is the rate of change in velocity (when an object speeds up, slows down, or changes direction) over time. Acceleration can be described as positive or negative (e.g., speeding up is positive acceleration, slowing down is negative acceleration or deceleration).

attitude – Attitude describes the position of a spacecraft relative to the direction of motion.

attitude control motor – The attitude control motor helps to stabilize and reorient the Orion crew module before the crew module is released from the abort system to begin its controlled descent.

controlled descent – A controlled descent is a landing where the speed and direction of the fall is modified.

g **–** *g* describes the acceleration of an object dropped near the surface of Earth. The value of g near the surface of Earth is 9.8 m/s^2 (32 ft/s^2).

gravity – Gravity is a force between objects based on their masses and the distance between the objects.

launch abort system, or LAS – The launch abort system offers a safe, reliable method of moving the entire crew out of danger in the event of an emergency on the launch pad or during the climb to Earth orbit. See Figure 2 for an illustration of the LAS.

Orion – NASA's Orion crew exploration vehicle will replace the space shuttle after it is retired. Orion is the flagship of NASA's programs for space exploration beyond low Earth orbit and a key element of NASA's Constellation Program to explore the Moon, Mars and beyond. See Figure 1 for an illustration of the components of the Orion crew exploration vehicle.

projectile – A projectile is any object that is thrown or otherwise launched. It is affected by Earth's gravity. A projectile may start at a given height and move toward the ground in an arc. Regardless of its path, a projectile will follow these rules:

- Projectiles maintain a constant horizontal velocity (in the absence of air resistance).
- On Earth, projectiles experience a constant vertical acceleration of 9.8 m/s^2 (32 ft/s^2) downward (in the absence of air resistance).

solid rocket boosters – Solid rocket boosters use a propellant/fuel in solid form. Two solid rocket boosters enable the shuttle to reach Earth orbit.

trajectory – Trajectory is the path that an object takes moving through space.

velocity – Velocity is the speed and the direction of travel of an object. An example of speed is "the wind blowing at 40 kilometers per hour," while wind velocity is expressed as "40 kilometers per hour from the SE."

A. EXPLORE

An object's projectile motion can be measured, recorded and analyzed. Its horizontal motion (*x* direction) and vertical motion (*y* direction) can be analyzed independently.

During this experiment, you and your team will measure and gather data to describe a projectile's motion. You will also calculate this object's launch angle and velocity using the data you collect.

PROCEDURE

1. Gather these materials for your group:
   - foam dart gun
   - stopwatch or a watch with a second hand
   - meter stick
   - digital video camera (optional)

2. Each person should launch the dart three times. During each launch, complete the following steps. Record your measurements in Table 1.
   a. Measure the height of the foam dart in meters BEFORE LAUNCHING.
   b. When the timer calls start, launch the dart at an upward angle (see Figure 3).
   c. Measure the distance the dart travels in meters.
   d. Record the time of the dart's flight in seconds.

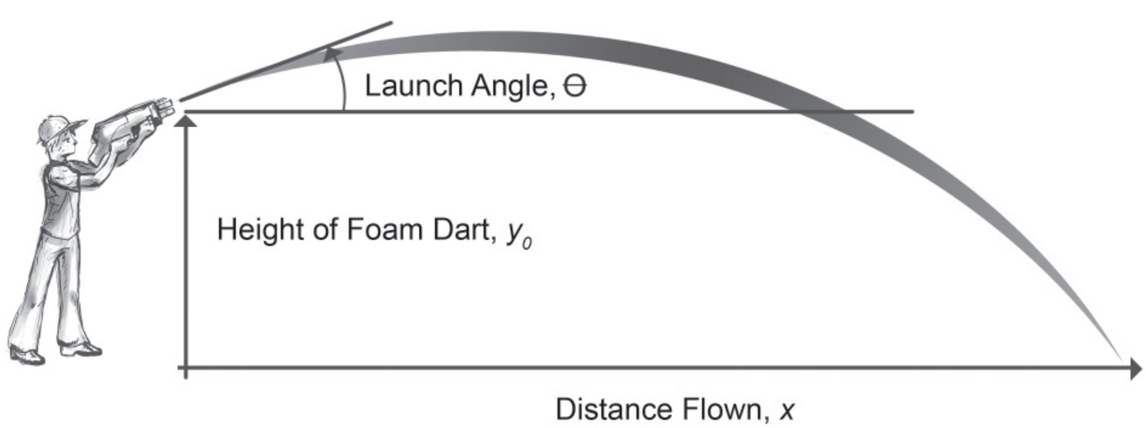

Figure 3: Launch set-up.

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Table 1. Foam Dart Launch Data

	Initial Height of Foam Dart, y_0 (m)	Distance Flown, x (m)	Time of Flight, t (s)
Trial 1			
Trial 2			
Trial 3			
Trial 4			
Trial 5			
Trial 6			
Trial 7			
Trial 8			
Trial 9			

B. EXPLAIN

Calculate the foam dart's projectile motion for each trial using the data from Table 1 and the equations below. Record your calculated answers in Table 2.

$$y - y_0 = v_y t - \frac{1}{2}gt^2$$

$$x = v_x t$$

$$\theta = \arctan(v_y / v_x)$$

$$v_y = v\sin\theta$$

$$v_x = v\cos\theta$$

y = final vertical height

y_0 = initial vertical height

v = velocity

v_y = vertical velocity

t = time of flight

g = 9.8 m/s^2 (acceleration due to gravity)

x = horizontal distance

v_x = horizontal velocity

θ = launch angle

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1. Calculate the initial velocity in the vertical direction. You know the time, vertical displacement, and acceleration.

2. Calculate the horizontal velocity. You know the distance and the time.

3. Use the initial vertical and horizontal velocities to calculate the launch angles of the dart.

4. Use the launch angles and initial velocities to calculate the velocity of the dart.

Table 2. Calculated Answers for the Foam Dart Launches

	Initial Vertical Velocity, v_y (m/s)	Launch Angle of Dart, θ (degrees)	Velocity of the Dart, v (m/s)	Initial Horizontal Velocity, v_x (m/s)	Launch Angle of Dart, θ (degrees)	Velocity of the Dart, v (m/s)
Trial 1						
Trial 2						
Trial 3						
Trial 4						
Trial 5						
Trial 6						
Trial 7						
Trial 8						
Trial 9						

5. Compare the velocities calculated using the initial vertical velocity with the velocities calculated using the initial horizontal velocity. Are these values the same for each trial? What might account for any variations?

6. If you videotaped the launches, use video analysis software to analyze the trials. How do the results from the video analysis compare to the results you calculated? Propose an explanation for any differences observed or explain why the results are the same.

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EXTEND

Review the NASA eClips™ video segment, *Launchpad: The Launch Abort System and g-Forces,* to compare the motion of Orion during a launch abort to the motion of the foam dart during the EXPLORE activity.

This segment can be found at NASA eClips You Tube™

http://www.youtube.com/watch?v=fytNgO00B5c&feature=PlayList&p=D7BEC5371B22BDD9&index=12

or on the NASA eClips™ page of the NASA web site

http://www.nasa.gov/audience/foreducators/nasaeclips/launchpad/exploration.html

As shown in the video segment, in the event of an emergency, the launch abort system moves Orion away from whatever danger there may be. After Orion is safely away, the capsule is reoriented. The crew module is then released from the abort system to begin its controlled descent.

Your challenge now is to modify the foam dart you used during the EXPLORE activity so that you may control the dart's descent. Any modifications should not interfere with the launching of the foam dart.

You will use the design process as outlined in the Middle School and High school Design Packet that your teacher will provide. This packet can also be downloaded at

http://www.nasa.gov/audience/foreducators/nasaeclips/toolbox/howto.html

Table 1. Foam Dart Launch Data

Answers will vary. Sample data is presented below.

	Initial Height of Foam Dart, y_0 (m)	Distance Flown, x (m)	Time of Flight, t (s)
Trial 1	1.29	8.58	1.90
Trial 2	1.37	8.36	1.67
Trial 3	1.94	7.24	1.39
Trial 4	2.00	7.01	2.03
Trial 5	1.43	8.48	1.62
Trial 6	1.48	4.54	2.05
Trial 7	1.85	9.76	1.65
Trial 8	1.37	8.51	1.51
Trial 9	1.33	8.30	1.65

B. EXPLAIN

Calculate the foam dart's projectile motion for each trial using the data from Table 1 and the equations below. Record your calculated answers in Table 2.

$y - y_0 = v_y t - \frac{1}{2}gt^2$

$x = v_x t$

$\theta = \arctan(v_y / v_x)$

$v_y = v\sin\theta$

$v_x = v\cos\theta$

y = final vertical height

y_0 = initial vertical height

v = velocity

v_y = vertical velocity

t = time of flight

g = 9.8 m/s^2 (acceleration due to gravity)

x = horizontal distance

v_x = horizontal velocity

θ = launch angle

1. Calculate the initial velocity in the vertical direction. You know the time, vertical displacement, and acceleration.

   $y - y_0 = v_y t - \frac{1}{2}gt^2$

   For Trial 1:

   $0 - 1.29 = v_y(1.90) - \frac{1}{2}(9.8)(1.90)^2$

   $v_y = 8.63\ m/s$

2. Calculate the horizontal velocity. You know the distance and the time.

   $x = v_x t$

   For Trial 1:

   $8.58 = v_x(1.90)$

   $v_x = 4.52\ m/s$

3. Use the initial vertical and horizontal velocities to calculate the launch angles of the dart.

   $\theta = \arctan(v_y / v_x)$

   For Trial 1:

   $\theta = \arctan(8.63/4.52)$

   $\theta = 62.4°$

4. Use the launch angles and initial velocities to calculate the velocity of the dart.

   $v\sin\theta = v_y$

   $v\cos\theta = v_x$

   ****solve for v in each equation****

   For Trial 1:

$8.63 = v\sin(62.4)$	$4.52 = v\cos(62.4)$
$v = 9.74\ m/s$	$v = 9.76\ m/s$

Table 2. Calculated Answers for the Foam Dart Launches

Answers will vary. Calculated data below based on sample data in Table 1.

	Initial Vertical Velocity, v_y (m/s)	Launch Angle of Dart , θ (degrees)	Velocity of the Dart, v (m/s)	Initial Horizontal Velocity, v_x (m/s)	Launch Angle of Dart, θ (degrees)	Velocity of the Dart, v (m/s)
Trial 1	8.63	62.4	9.74	4.52	62.4	9.76
Trial 2	7.36	55.8	8.89	5.01	55.8	8.91
Trial 3	5.42	46.1	7.52	5.21	46.1	7.51
Trial 4	8.96	69.0	9.60	3.45	69.0	9.63
Trial 5	7.06	53.5	8.78	5.23	53.5	8.79
Trial 6	9.32	76.7	9.58	2.21	76.7	9.61
Trial 7	6.96	49.7	9.13	5.91	49.7	9.14
Trial 8	6.49	49.0	8.60	5.64	49.0	8.60
Trial 9	7.34	55.6	8.89	5.03	55.6	8.90

5. Compare the velocities calculated using the initial vertical velocity with the velocities calculated using the initial horizontal velocity. Are these values the same for each trial? What might account for any variations?

   The answers should be the same. Differences may be due to experimental or mathematical error.

ANSWER KEY

6. If you videotaped the launches, use video analysis software to analyze the trials. How do the results from the video analysis compare to the results you calculated? Propose an explanation for any differences observed or explain why the results are the same.

   Answers may vary. Differences may be due to measurement error, mathematical error or increased air resistance due to wind.

EXTEND

Your challenge now is to modify the foam dart you used during the EXPLORE activity so that you may control the dart's descent.

You will use the design process as outlined in the Middle School and High School Design Packet that your teacher will provide. This packet can also be downloaded at

http://www.nasa.gov/audience/foreducators/nasaeclips/toolbox/howto.html.

Answers will vary. Use the Middle School and High School Design Packet to help guide the design process. Use the Design Challenge Evaluation Rubric on page 8 of the Design Packet to evaluate student designs.