Flight & Momentum

Topic	Forces, Kinetic Energy, Potential Energy, Momentum
Subject	Science, Physics
Grade Level	10-12
Time	70 minutes
Curriculum Alignment	Physics 20-A1.3s analyze data and apply mathematical and conceptual models to develop and assess possible solutions ● solve, quantitatively, projectile motion problems near Earth's surface, ignoring air resistance Physics 30-A1.2s students will conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information ● perform an experiment to demonstrate the conservation of linear momentum Physics 30-A1.2s students will conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information ● perform an experiment to demonstrate the conservation of linear momentum

Hook:	**Notes:**
Show Ex-Alta 1 3D Model Video	https://m.youtube.com/watch?v=Ew2N9OqL-F4

Introduction:	**Notes:**
What is AlbertaSat? ● AlbertaSat is a student group at the University of Alberta that builds CubeSats ● CubeSats are small (like a loaf of bread) satellites made up of standardized cubes. These cubes (known as units) are 10cm x 10cm 10cm	Ex-Alta 1 Deployment: https://www.youtube.com/watch?v=l2sMkNNGVCM

● Ex-Alta 1 (Experimental Albertan 1) is a 3U (3 unit/3 cube) CubeSat. It was the first satellite built by AlbertaSat. ● Ex-Alta 1 was built as part of an international project, QB50. This project was lead by the European Space Agency (ESA) to study space weather. ● Ex-Alta 1 was launched to the International Space Station (ISS) in April of 2017 and into orbit in May of 2017. ● Show Map of QB50 Satellites ● Ex-Alta 1 includes the following payloads: MNLP (Langmuir Probes), Dosimeter (studies radiation), Athena On-board Computer, Magnetometer	

Introduction:	**Notes:**
Background Information: ● Conservation of Momentum: Given two objects in an isolated system, the momentum lost by one object is equal to the momentum gained by the other object. ● Initial Velocity: After all of the fuel has been expelled, the impulse (the total change in momentum) of the rocket can be used to find the rocket's velocity.	● The momentum gained by the rocket must be equal to the mass of the fuel (water) expelled from the rocket multiplied by the exit velocity of the fuel leaving the rocket. ● Because the fuel leaves the rocket very quickly, we can assume that the velocity of the rocket after all of the fuel has been expelled is the initial velocity of the rocket.

Explanation of Activity	**Notes:**
1. Students must design a rocket to strike a target by deciding the air pressure, water volume and pitch angle. 2. Students should add a nose cone and fins to their rocket. Tell students to consider mass and aerodynamics in their design. 3. Once students have completed their design, they must determine the angle	1. The target could be two distances on the ground that the rocket must land between, whoever is closest to the middle of the range of distances would win. 2. The air pressure unit will depend on the gauge available - psi is recommended 3. Note: students responses should vary

(pitch) they would like to launch it at.

4. First, students will need to find the initial velocity. This can be done using a simulator (http://www.sciencebits.com/RocketCalculator)
    a. In order to fill out this simulator, students must:
        i. Use a scale to find the mass of their pop bottle while empty. This should be done after they have added the fins and the nose cone.
        ii. Use a scale to find the mass of the pop bottle it while it is filled with the amount of water they wish to use. This mass minus the mass of the pop bottle will give them the amount of water.
        iii. Students should decide the initial pressure as part of their design process
        iv. Students can assume the drag coefficient is ~0.6 or use the provided table to determine a more accurate answer
        v. Students can then measure the bottle radius and the nozzle radius.
        vi. The resulting graph will display the maximum velocity
    b. Because we assume the maximum velocity and the initial velocity is equivalent, students now know the initial velocity of the rocket.
5. Students should try a variety of combinations in the simulator to determine their preferred outcome.

between groups, their selected variables will affect their accuracy.

4. Note: the simulator assumes the rocket will be launched straight up (pitch of 90^{o}). Students will be launching their rockets at an angle, but the maximum velocity should be the same.
5. Simulation time step: this shows how many points the graph will make per x seconds.
6. Extension Activity: Determining the Initial Velocity .
    a. Student can use the second bonus section of the provided worksheet to determine a more accurate initial velocity
7. Potential Assessment:
    a. The worksheet (including bonus sections) could be handed in for assessment purposes.
    b. Students could also write a short report and/or complete a self-evaluation.

Once students have settled on their variables, students can determine the angle (pitch) using the provided formula. 6. Students should take some time to ensure they have filled out the worksheet entirely.	

Launching the Rockets:	**Notes:**

• Set up the target distance on the ground.
• Attach the rocket to the launch base. Have one person pump the rocket with the selected pressure (use a gauge to check).
• Release the latch to launch the rocket.
• Measure the distance it travelled
	• Safety Measures:
	  ○ Students should not use more than 50psi.
	  ○ The student pumping the pop bottle should wear safety glasses
	  ○ This must be done in an open outdoor space
	  ○ Students may get wet if they stand near the rocket. Students should not stand within the path of the rocket.
	  ○ Launch one rocket at a time.

Materials Required
• Smartphone, Laptop or Chromebook to access simulator online • Pop bottle (1L to 2L recommend) • Water • Bicycle tire pump with pressure gauge • Cardboard, foam, paper, or similar lightweight material for fins and nose cone • Launch base   ○ DIY Version: https://youtu.be/gyOzvqmUs4c • Note: open outdoor space is required • Tape measure • Rulers