



<b>Lesson Title</b>	Fly by Math
<b>Length of Lesson</b>	50 minutes
<b>Created By</b>	Emily Burtnett
<b>Subject</b>	SL Math, IB
<b>Grade Level</b>	11 <sup>th</sup> -12 <sup>th</sup>
<b>State Standards</b>	Physics 1d, Physics 3c-d
<b>DOK Level</b>	2
<b>DOK Application</b>	Apply fundamental mathematics used in physical concepts (P). Manipulate equations to solve problems. Investigate physical dynamics (E, P). Explain physical dynamics in terms of Newton's Three Laws of Motion. Solve problems using Newton's Three Laws of Motion.
<b>National Standards</b>	Build new mathematical knowledge through problem solving. Solve problems that arise in mathematics and in other contexts. Apply and adapt a variety of appropriate strategies to solve problems. Recognize and apply mathematics in contexts outside of mathematics.
<b>Graduate Research Element</b>	Understanding ratios, percents and other various calculations are the very essence to aerospace engineering in design and research.

**Student Learning Goal:**

Students will learn find the mathematical concepts embedded in the study of aerodynamics and present these to the rest of the class. This lesson has an emphasis on making mathematics relevant and practice and, hopefully, meaningful to students providing them with a peek into a topic whose concepts are not available in their school curriculum. Students will group the meaning of the underlying concepts in the topic of aerodynamics, integrate these concepts with their mathematical skills, do the basic computations, use facts, principals and concepts learned from pervious Aero 101 lessons to solve problems, and analyze and organize information.

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

Handouts

**Lesson Performance Task/Assessment:**

Students will learn revisit the four unbalanced forces for simplified aircraft motion. These concepts were previously presented in another lesson. The students will become familiar with Newton's second law of motion and a worksheet will be handed out allowing students to use mathematics to describe aircraft motion.

**Lesson Relevance to Performance Task and Students:**



The study of aerodynamics has provided the modern world with one of the most efficient means of transportation. Students will recognize that it is mainly through its applicability and technology that humans are able to explore and improve this field. The application of aerodynamics is embodied in various mathematical concepts. It is this relationship between aerodynamics and mathematics that students will explore in this lesson.

**Anticipatory Set/Capture Interest:**

A review of the four fundamental forces of flight will be given. Students will learn the basic components of an aircraft.

**Guided Practice:**

The instructor will show a slide reviewing the rules for simplified motion of an aircraft. The students will have seen this more in-depth in a previous lesson, but the instructor will explain that by simplified motion we meant that the four forces acting on the aircraft are balanced by other forces and that we are looking at only one force and one direction at a time. In reality, this simplified motion doesn't occur because all of the forces are interrelated to the aircraft's speed, altitude, orientation, etc. But looking at the forces ideally and individually does give us some insight and is much easier to understand.

An ideal situation, an airplane could maintain a constant speed and level flight in which the weight would be balanced by the lift, and the drag would be balanced by the thrust, i.e. an airliner. As fuel is burned, the weight decreases, but the change is relatively small compared to the total aircraft weight. In this situation, the constant cruise velocity is described by Newton's first law of motion.

“Every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it.”

Apply this to aerodynamics. Consider a ball released from a height. Before it is released, the object is in a state of rest (airspeed is zero). It has weight, but no drag. When the object is released, it accelerates (airspeed increases). However, drag is dependent on the airspeed, therefore the drag increases. When the drag is equal to its weight, the object no longer accelerates, but holds a constant velocity. This is termed terminal velocity.

When the forces become unbalanced, the aircraft will naturally move in the motion of the greater force. The acceleration the aircraft will experience can be computed with Newton's second law.

$$F=m*a$$

Where  $a$  is the acceleration and  $m$  is the mass of the aircraft.  $F$  is the net force acting on the aircraft. The net force is the difference between opposing forces. For example: lift minus weight or thrust minus drag. The resulting motion of the aircraft can be found.



Weight decreased, lift constant:

lift > weight → aircraft rises

Lift decreased, weight constant:

weight > lift → aircraft falls

Thrust increased, drag constant:

thrust > drag → aircraft accelerates

Drag increased, constant thrust:

drag > thrust → aircraft slows

Newton's second law defines a force to be equal to the change in momentum with a change in time. Momentum is defined to be mass of an object,  $m$ , times its velocity,  $v$ .

Assuming that we have an aircraft at a point "0" defined by its location  $x_0$  and  $t_0$ . The airplane has a mass  $m_0$  and travels at velocity  $v_0$ . The aircraft experiences an external force  $F$  and moves to a point "1." The new location is  $x_1$  and  $t_1$ . The mass and velocity of the airplane change during the flight changes to  $v_1$  and  $m_1$  and can be calculated assuming we know the force.

$$F = (m_1 * v_1 - m_0 * v_0) / (t_1 - t_0)$$

The change in velocity divided by change in time is the definition of the acceleration  $a$ . The second law reduces to the more familiar form,  $F = m * a$ .

### **Independent Practice:**

Students will apply newly acquired skills to a worksheet.

### **Remediation and/or Enrichment:**

This lesson is an attempt to develop a mathematical application that is suitable for students. This lesson will teach the basic math concepts with an emphasis of its usability in the aerospace engineering field. Students who struggle to see the purpose of math often lack the motivation. This lesson should provide students a peek into the real world application of basic math and should provide a source of motivation. Individual IEPs will be supported.

For enrichment, a field trip to an aircraft museum would give the students a first-hand look at how the concepts learned can be used.

### **Check(s) for Understanding:**

Students will be evaluated on the accuracy or feasibility of their answers. They will demonstrate the ability to complete calculations involving motions and forces.

### **Closure:**

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If time permits, the lesson will be wrapped up with a discussion led by the instructor on what students discovered during their work time with the worksheet. Students can ask questions and the instructor should give other examples of how these principles can be integrated into other real-world applications. It may also be beneficial to introduce students to the center of gravity concept in preparation for the upcoming lesson.

### **Possible Alternate Subject Integrations:**

Physics, algebra

### **Teacher Notes:**

<http://www.grc.nasa.gov/WWW/k-12/airplane/smotion.html>