Module Overview	
For grade level(s)	Middle School grades 6-8 High School grades 9/10 and 11/12
Suggested Time	MESA period: 3-5 weeks of daily 50 min. sessions MESA afterschool: 4 total sessions of 60-90 min periods MESA Saturday: 2 Saturdays for a total of 8 hours
Purpose	The purpose of this unit is to reinforce or introduce the engineering design process to MESA students, while introducing them to the principle of flight and aircraft design. Students will be prepared to build and fly a model aircraft that will sustain a long flight time in MESA Day competition.
Objectives	At the end of the unit students will; • Know the parts of the design cycle and relate them to aircraft design and construction • Critically analyze the design and construction in relation to the flight mission • Solve problems related to flight, lift and drag • Solve problems related to balance and torque • Solve problems related to angles • Understand the practical applications of the design process for students and engineers.
Standards Addressed Common Core and NGSS Common Core Mathematics	Ratios and Proportional Relationships 6. RP 1. Use ratio and rate reasoning to solve real-world and mathematical problems, e.g. by reasoning about tables of equivalent ratios, tape diagrams, or equations. 2. Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole given a part and the percentage. **Grade 6** Expressions and Equations 6. EE 1. Use variables to represent numbers and write expressions and when solving real-world or mathematical problems; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. **Geometry 6.G** Solve real-world and mathematical problems involving area, surface area, and volume.

Standards Addressed Common Core and NGSS Common Core Mathematics Cont.

Grade 7

Ratios and Proportional Relationship 7. RP
Analyze proportional relationships and use them to solve real-world and mathematical problems.

Expressions and Equations 7.EE

1. Understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities are related. For example, a + 0.05a = 1.05a means that "increase of 5%" is the same as "multiply by 1.05"

2. Use variables to represent quantities in a real-world or mathematical problem. And construct simple equations and inequalities solve problems by reasoning about the quantities

Geometry 7.G

1. Solve problems involving scale drawing of geometric figures, including computing actual lengths and areas from a scale drawing at a different scale.
2. Solve real-world and mathematical problems involving area. Volume, surface area of two and three-dimensional objects composed of triangles, quadrilateral, polygons, cubes, and right prism.

Grade 8

Expressions and Equations 8.EE

1. Know and apply the properties of integer exponents to generate equivalent numerical expressions. For example; 3 (2 -5) = 3 -3 = 1/33 = 1/27.

Statistics and probability 8. SP
Investigate patterns of association in bivariate data

1. Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering outlies, positive or negative associations, linear or non-linear associations.
2. Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear relationship, informally fit a straight line, and points to the straight line.

Higher Common Core Mathematics
Algebra 1- A1
Quantities N- Q
Reason quantitatively and use units to solve problems.

1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

Standards Addressed Common Core and NGSS Common Core Mathematics Cont.	**Seeing Structure in Expressions in A-SSE** Write expressions in equivalent forms to solve problems. 3-Choose and produce an equivalent form of an expression t reveal and explain properties of the quantity represented by the expression. **Statistics and Probability** Interpreting Categorical and Quantitative Data S-ID 1. Represent data with plots on the real number line (dot plots, histograms, and box plots.) **Make geometric constructions. G-CO** 2. Make geometric constructions using a variety of tools and methods (compass, and straight edge, sting, reflective device, paper folding, dynamic geometric software, etc.). **Geometric Measurement and Dimension G-GMD** 3. Identify the shapes of two-dimensional cross-sections of three dimensional objects, and identify three- dimensional objects by rotations of two-dimensional objects. **Modeling with Geometry G-MG** 1. Apply geometric methods to solve design problems (e.g. designing an object or structure to satisfy physical constraints or minimize cost, working with typographical grid systems based on ratios.) **Next Generation Science Standards** **Physical Science PS** **MS-PS2-2**- Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and on the mass of the object. [Clarification Statement: Emphasis is and on balanced (Newton's first law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's second law) frame of reference and specification of units. **HS-PS2-1-**Analyze data to support the claim that newton's second law of motion describes the mathematical relations among the net force on a macroscopic object, its mass, and its acceleration. Analyzing data using tools, technologies, and/ or models to make valid and reliable scientific claims or determine an optimal design solution. **Engineering Design** **MS-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit potential solutions.

Standards Addressed Common Core and NGSS Common Core Mathematics Cont.	**MS-ETS1-2** Evaluate competing design solutions using a systematic process to determine how well the meet the criteria and constrains of the problem. **MS-ETS-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. **HS-ETS1-2** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
Assessment	Students will be evaluated through the following methods; • Assessment work sheets • Oral presentations with rubrics • Lab reports with rubrics • Project testing and evaluation
Additional Resources	www.physicsclassroom.com www.grc.nasa.gov/WWW/k-12/airplane/short.html www.modelaircraft.org/education/edpacket.aspx

Background

The first evidence of man wanting to fly was a coin from about 3500 BC depicting a man flying on an eagle's back. About 1000 BC, the Chinese invented kites which carried men to scout troops.

The first step to modern aeronautical engineering was Leonardo da Vinci's designs about 1500. In 1799 Sir George Cayley invented the concept of fixed wing aircraft and followed that by building and flying a successful model glider. In 1903 the Wright brothers flew the first heavier than air, manned, engine powered airplane.

Since then aircraft development, design and manufacturing has progressed rapidly. Long distance travel is now dominated by commercial aircraft. There are still problems to be solved-fuel economy, safety, passenger comfort, crew fatigue, take-off and landing reliability, manufacturing costs and plane longevity.

For example, the addition of winglets on the wing tips significantly reduced drag and, therefore, saved much fuel.

Benefit To Society

Aircraft is now the major form of long distance travel. It is used for people, cargo, scientific experiments, hurricane watching, hospital, news watch, mail, firefighting, traffic watching, and the military. The next generation (there's always a new innovation that advances the aircraft status) is the use of pilotless aircraft.

With that change, came the need for safety assurances, new flying space regulations, privacy protection and less pollution. Today's commercial aircraft, i.e. Boeing and Airbus, are less reliant on pilots during long flights and are more fuel efficient.

The passengers generally are more comfortable and the fatality rate is low. There trips are quick, clean, relatively inexpensive, allowing more time at the flight terminus. A trip from LA to NY takes about 5-8 hours while a train requires 3+ days.

Engineering Design Process / Module Content

Engineers have to create solutions to a problem. The solution must fit into the given constraints the problem. In the MESA program, we learn to engineer solutions that can relate to real work problems. The use of the engineering design process contextualizes this problem solving approach for students.

This unit is organized around the steps in the engineering cycle. Define the problem, investigate, plan, create, evaluate and then start the process all over again until a valid competition ready project is created. The unit begins with an introductory activity that leads to students into the challenge to be addressed

Organization of the Module Content

Introduction

Build a foam plate glider (FPG-9) as an ice breaker.
www.modelaircraft.org/education/fpg-9aspx

Define the Problem

Read the specification closely to define the requirements including constraints to be met when your product, process, or system is designed. For example; wingspan limit? , propeller size? , material? And etc.

Investigate

Research glider/ propeller model aircraft on the web or other sources.

The NASA web site contains much of the aircraft science and math that is applicable to this program. (http://www.grc.nasa.gov/WWW/k-12/airplane/short.html) This site is a clickable index. Pick your subject and a click shows the Power Point and description. (NASA Aerodynamics Index is attached)

Review the reverent mathematics and science with students (the complexity and depth science background and is at the instructor's discretion).

- Newton's three laws of motion, torque, forces and torque, and equilibrium.
- Area, volume, acceleration, ratios, and geometry
- Identify how aircraft is constructed and what are the key parts and how does an aircraft fly? Thrust, lift, drag etc.

Introduce MESA students to the engineering design cycle.

There are many online resources to do this including, the "teach engineering" resource (www.teachengineering.org/k12engineering/designprocess) and the science buddies website (www.sciencebuddies.org/engineering-design-process/engineering-design-process-steps.shtml). And the NASA web site (www.nasa.gov/audience/foreducators/index.html)

Have the students create their own design notebooks. MESA students will use the journal to document the information gathering process they engaged in and any relevant information that will prepare them for designing and building their competition ready package. The logbook can also follow throughout the different stages of the project. Regular entries into notebook/journal are an essential part pf this unit/project. (http//www.sciencebuddies.org/blog/2010/01/labnotebooks.php).

Planning and Brainstorming

At this point the students should get experience building a small glider (~7 inch wingspan). A huge variety of plans can be found by "googling" "*plans for balsawood gliders".* The airplane building students can also search "*rubber powered flying model airplanes".* A few examples include;

http://www.amaflightschool.org/diy

http://www.4p8.com/eric.brasseur/glider2.html
http://www.theplanpage.com/months/2406/recordhlg.html

http://www.rubber-power.com/make-it.htm

After building and testing their small models, the team brainstorms the possible designs for the competition glider/airplane. They pick the best two or three ideas, and Design and build their Prototypes. Design means they draw the construction plans.

Prototype and Testing

After designing the prototype(s) must be built and tested. Good detailed records must be kept so the same mistakes are not continually repeated. Testing conditions need to be changed: wing locations, wing design, dihedral angles, aspect ratio, center of gravity, trim and etc.

Several tries at each condition are needed since one test is not adequate for data reliability. Not only is the design and construction important but the launch technique also needs to be developed and tested.

Analysis

After the prototype testing, the results are analyzed and the group selects the best potential design for their competition model. Using data tables from the notebook with all the information such as wing span, location of center of gravity, glider weight, angle of launch, and flying time and plotting the key information on graphs will enable clear visuals on how the glider/plane performed.

Then modify the design to correct the defects that prevent them from their reaching their goal. The engineering cycle is now repeated until the glider/plane achieves the flying time goal repeatedly and consistently.

The designs and construction must be regularly checked against the MESA specifications so the product doesn't drift into reject range. www.mesa.ucop.edu/mesa_day_rules.html.

Compete

If the final model meets the teams goals and the MESA specifications and does so repeatedly then it is ready for competition. If a drawing is required make sure it is complete in every detail.

Pacing Guide

Although Advisors can structure their lessons as they see fit, below is the suggested pacing guide for this module.

ACTIVITY	**APPROXIMATE TIME**
Introduction Foam Plate Glider (FPG-9)1-2 class periods. Discuss how to control the glider and answer the work sheet in the packet.	
Define the problem Read the MESA rules and discuss what are the constrictions. Summarize in the journal.	1 class period goals and the
Investigation Research gliders or rubber powered model airplanes on line. After the students identify potential plans have them build a small (~7 inch wingspan) glider to get a feel for working with balsa and flying. Follow-up with the physics and math of flying, designing, and building the aircraft. Investigation reflection in log. The students answer quizzes available in the NASA lessons.	5-8 45 min. class periods
Planning and Brainstorming Overview of the Engineering Cycle and math. brainstorm ideas (in logs) and select most probable routes to aircraft meeting specs. Draw preliminary design selections	3-4 class periods Students
Prototypes The first prototype(s) are built and tested. variables need to be evaluated such as aspect ratio, weight, launch conditions, and etc. Repeat tests to establish data reliability. Enter data directly into logs.	3-5 periods Several
Analysis Analyze the prototype results and select the design, build and fly it repeatedly and make the final trim adjustments until it is competition ready.	3-5 periods. Competition

Compete. ***GOOD LUCK!***