



*Glenn Research Center*

*7 JULY 06*

# *Interactive Educational Software and Websites*

**Tom Benson**

**Thomas.J.Benson@nasa.gov**



## *OUTLINE*

**Glenn  
Research  
Center**

---

- **Background**
- **Examples of Free Educational Software**
- **Examples from Beginner's Guides**
- **Current Efforts**
- **Future Plans**
- **Questions / Answers**



## ***MOST IMPORTANT SLIDE***

**Glenn  
Research  
Center**

---

**<http://education.grc.nasa.gov/>**

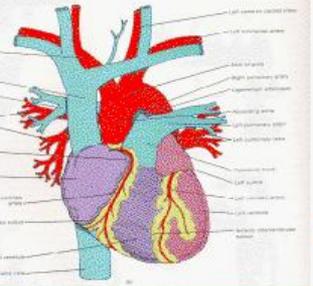
***Under: Related Multimedia***

**Beginner's Guide to Rocketry**  
**Beginner's Guide to Aeronautics**  
**Re-Living the Wright Way**

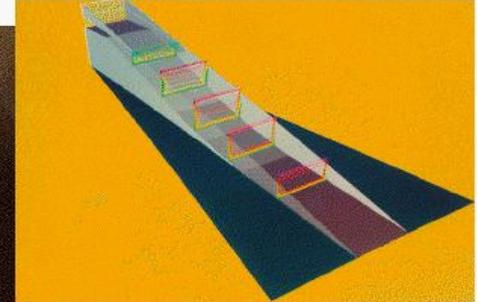
70



75



80



85

Internet Explorer: Parts of Airplane

File Edit View Go Communicator Help

Back Forward Reload Home Search Guide Print Security Stop

Bookmarks NetSite: <http://www.larc.nasa.gov/www/IFMD/airplane/airf>

Internet Lookup New&Cool

**Airplane Parts Definitions** Lewis Research Center

- Vertical Stabilizer: Control Yaw
- Horizontal Stabilizer: Control Pitch
- Wing: Generate Lift
- Jet Engine: Generate Thrust
- Cockpit: Command and Control
- Fuselage (Body): Hold Things Together (Carry Payload - Fuel)
- Slats: Change Lift
- Rudder: Change Yaw (Side-to-Side)
- Elevator: Change Pitch (Up-Down)
- Flaps: Change Lift and Drag
- Aileron: Change Roll (Rotate Body)
- Spoiler: Change Lift and Drag (Rotate Body)

An animated version of this slide is also available.

This slide shows the parts of an airplane and their functions. Airplanes come in many different shapes and sizes. The airplane on this slide is a turbine-powered airliner.

FoilSim

File Options Help

Airfoil View Panel

Plotter View Panel

Up Down

Left Right

Density: 1.22503 Pressure: 0.703 Temperature: 15

Speed of Sound: 340.3 m/s

Angle of Attack (Degrees): -20 -15 -10 -5 5 10 15 20

Lift (newtons): -500 0 500 1000 1500

Airfoil Input Panel

Airspeed: 230 km/hr

Altitude: 0 meters

Angle: 10.0 degrees

Thickness: 0.5

Camber: 0.5

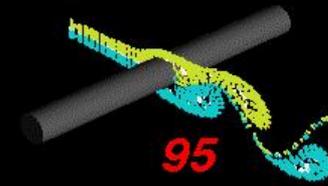
Area: 0.5 sq meters

Lift: 9.463 x100 newtons

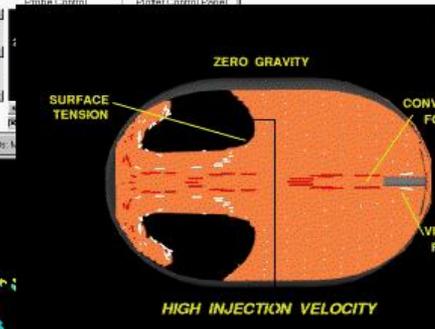
Play/Stop Reset Save Data Print Data Units



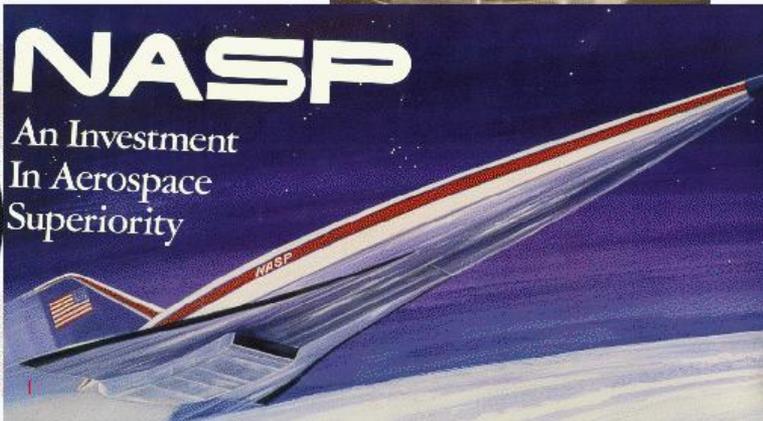
# Computational Fluid Dynamics



95



90





## ***OBJECTIVE***

Glenn  
Research  
Center

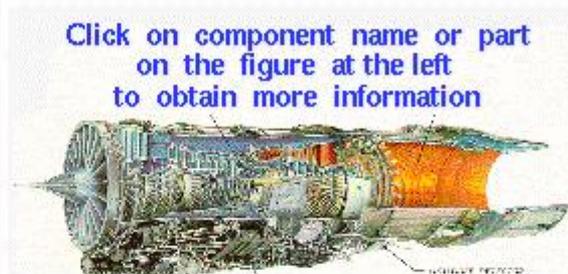
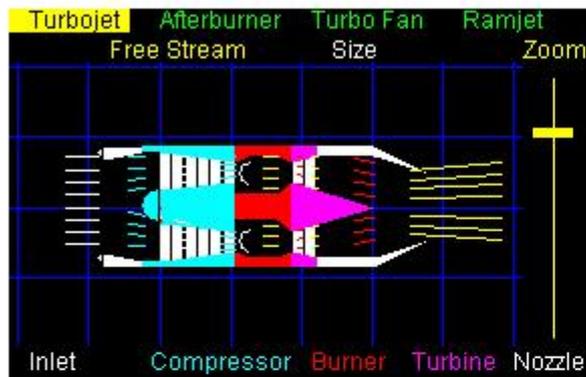
---

- **Use computer technology and student interest in airplanes and rockets to introduce and demonstrate science, technology, engineering and math.**
- **Develop educational materials for use by teachers.**
- **Use the Internet for world-wide distribution of NASA software and educational materials.**



# Example of Free Software EngineSim

This is the beta 1.5 version of the NASA Glenn **EngineSim** program, and you are invited to participate in the beta tests. If you would like to suggest improvements, please send an e-mail to [benson@grc.nasa.gov](mailto:benson@grc.nasa.gov).



Speed-mph	<input type="text" value="0.0"/>	<input type="range"/>
Mach	<input type="text" value="0.0"/>	
Altitude-ft	<input type="text" value="0.0"/>	<input type="range"/>
Throttle	<input type="text" value="100.0"/>	<input type="range"/>
Spec. Heat	<input type="text" value="1.4"/>	Gamma = f(T) <input type="text"/>

Output Display	<input type="text" value="Photos"/>
Design Mode	<input type="text" value="English Units"/>
Load My Design	<input type="button" value="Reset"/>

Engine Performance			
Thrust-lbs	<input type="text" value="6766"/>	Weight-lbs	<input type="text" value="640"/>
Fuel-lbm/hr	<input type="text" value="5688"/>	Air-lbm/sec	<input type="text" value="72"/>

With this software you can investigate how a [turbine \(or jet\)](#) engine produces [thrust](#) by changing the values of different engine parameters. You can also investigate the effects of engine performance on aircraft [range](#) by using another interactive version of [EngineSim](#). To return to the original software, click on the [link](#).

# Example of Free Software RocketModeler II

The screenshot displays the RocketModeler II software interface. On the left, a grid shows a rocket model with a red nose, a green body, and black fins. The grid includes a vertical 'Zoom' scale and horizontal markers for '1 foot' and '1 inch'. The rocket's center of gravity (Cg) is marked with a yellow dot and the center of pressure (Cp) with a black dot. The interface is divided into several sections:

- Top Navigation:** Buttons for 'Nose', 'Payload', 'Body' (highlighted), and 'Fins'.
- Units:** A dropdown menu set to 'English'.
- Model Selection:** Buttons for 'Ballistic', 'Stomp' (highlighted), '2-L Bottle', and 'Model'.
- Parameters:**
  - LO Weight: 0.271 oz
  - Drag Coeff: 0.7
  - Cg: 4.778 in
  - Cp: 3.95 in
- Mission Control:** Buttons for 'Design', 'Fuel', 'Pad', and 'Launch'.
- Material and Dimensions:**
  - GO: 0.0070 oz/in, 1/32 Cardboard
  - Length in: 8.0
  - Diam in: 1.0
  - Fairing: 0.0070 oz/in, 1/32 Cardboard
  - Length in: 0.0
  - Diam in: 1.0
  - Drag Coeff: 0.7
- Bottom Navigation:** Buttons for 'Find' and 'Track'.

# Example of Free Software Calculators

- Mach and Speed of Sound
- Standard Atmosphere
- Isentropic Flow
- Normal and Oblique Shocks
- Terminal Velocity

# Page from Beginner's Guide

Rocket Translations - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media Go

Address <http://www-dev.grc.nasa.gov/WWW/K-12/airplane/testing/translations.html>

## Rocket Translation

**Y - Displacement =  $d = Y_1 - Y_0$**   
**Average Y - Velocity =  $V = (Y_1 - Y_0) / (t_1 - t_0)$**   
**Instantaneous Velocity =  $V = dY / dt$**   
**Average Y - Acceleration =  $a = (V_1 - V_0) / (t_1 - t_0)$**   
**Instantaneous Acceleration =  $a = dV / dt$**

Final Position  $(X_1, Y_1, Z_1, t_1)$

Initial Position  $(X_0, Y_0, Z_0, t_0)$

Y

Z

X

V<sub>0</sub>

V<sub>1</sub>

We live in world that is defined by three spatial dimensions and one time dimension. Objects can move within this domain in two ways. An object can **translate**, or change **location**, from one point to another. And an object can **rotate**, or change its **attitude**. In general, the motion of an object involves both translation and rotation. The motion of a rocket is particularly complex because the rotations and translations are coupled together: a rotation affects the

Done

Start Eudora success Rocket Translations ... Local intranet 9:13 AM

# Samples of Content from the Beginner's Guides

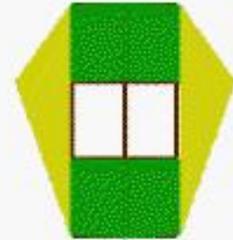
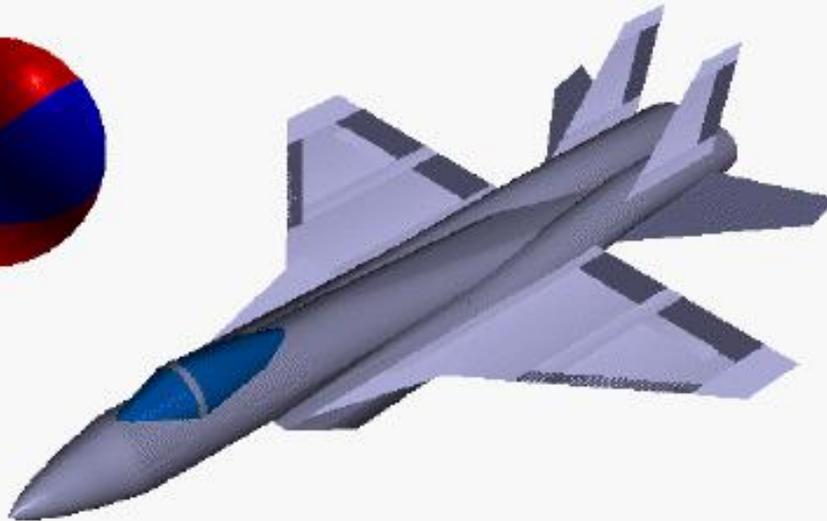
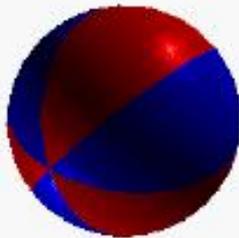
# General Science Information



## *Newton's First Law*

Glenn  
Research  
Center

"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."

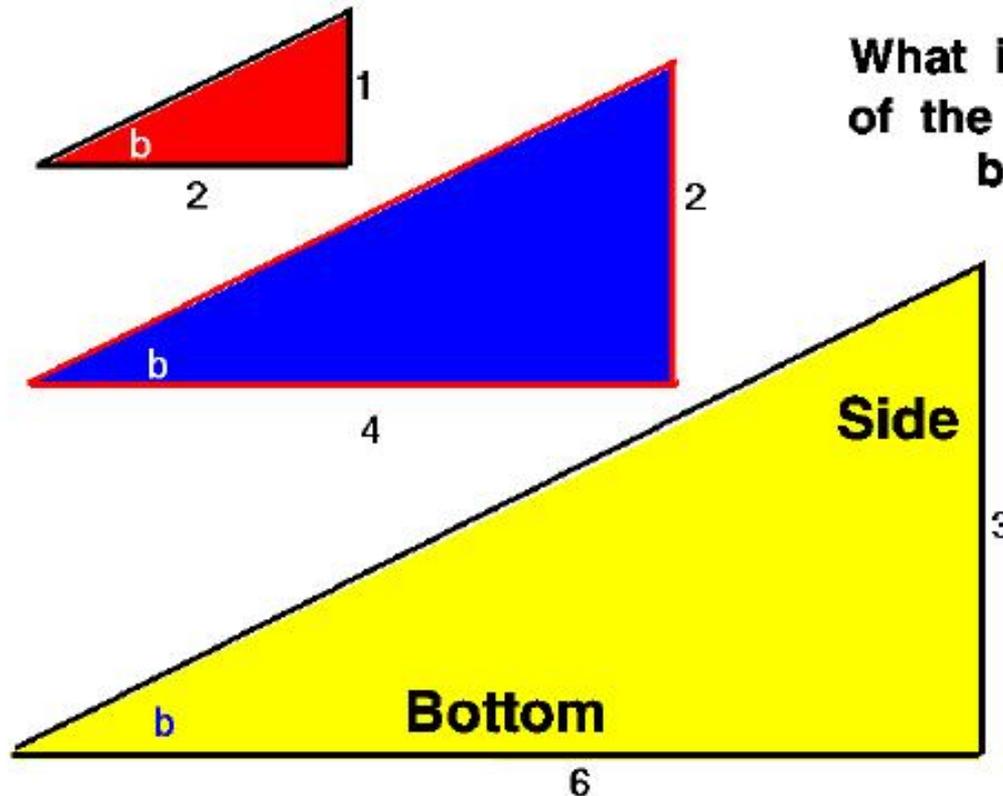


# Fundamental Mathematics



## *Ratios in Triangles*

Glenn  
Research  
Center



What is the ratio  
of the side to the  
bottom ?

# Animations

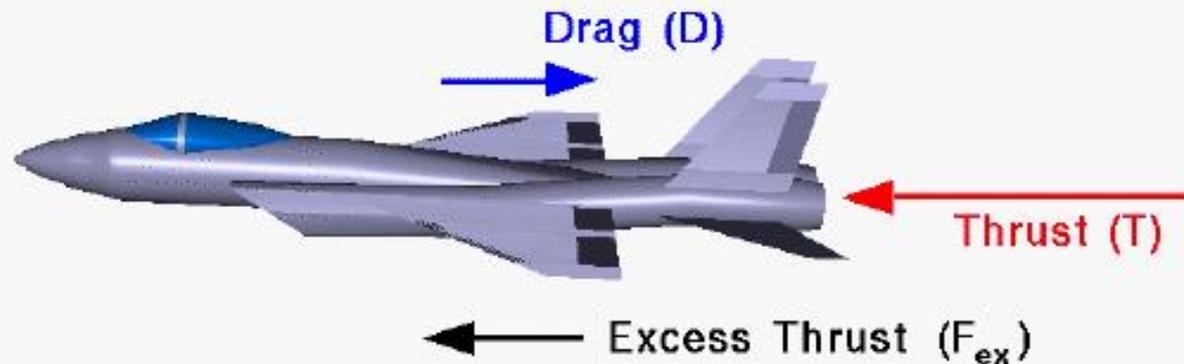


# Equations



## **Excess Thrust** (Thrust - Drag)

Glenn  
Research  
Center



**Excess Thrust = Thrust - Drag**

$$F_{ex} = T - D$$

*Newton's Second Law:*  $F_{ex} = m a$

$$a = F_{ex} / m$$

**a** = acceleration of aircraft

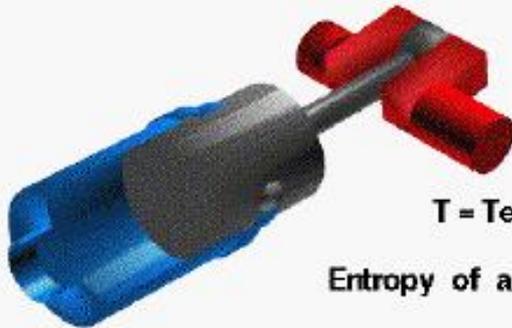
**m** = mass of aircraft

# Derivations



## ***Compression and Expansion*** *(no heat addition or losses)*

Glenn  
Research  
Center



$C_p$  = specific heat at constant pressure

$C_v$  = specific heat at constant volume     $R$  = Gas constant

$$C_p - C_v = R \quad \gamma = C_p / C_v$$

Algebra:  $R / C_p = 1 - 1 / \gamma$

$T$  = Temperature     $p$  = Pressure     $s$  = Entropy     $v$  = Volume

Entropy of a Gas:  $s_2 - s_1 = C_p \ln (T_2 / T_1) - R \ln (p_2 / p_1)$

Compression and expansion are reversible:  $s_2 - s_1 = 0$

Then:  $C_p \ln (T_2 / T_1) = R \ln (p_2 / p_1)$

Effect of Pressure on Temperature:  $(T_2 / T_1) = (p_2 / p_1)^{[1 - 1 / \gamma]}$

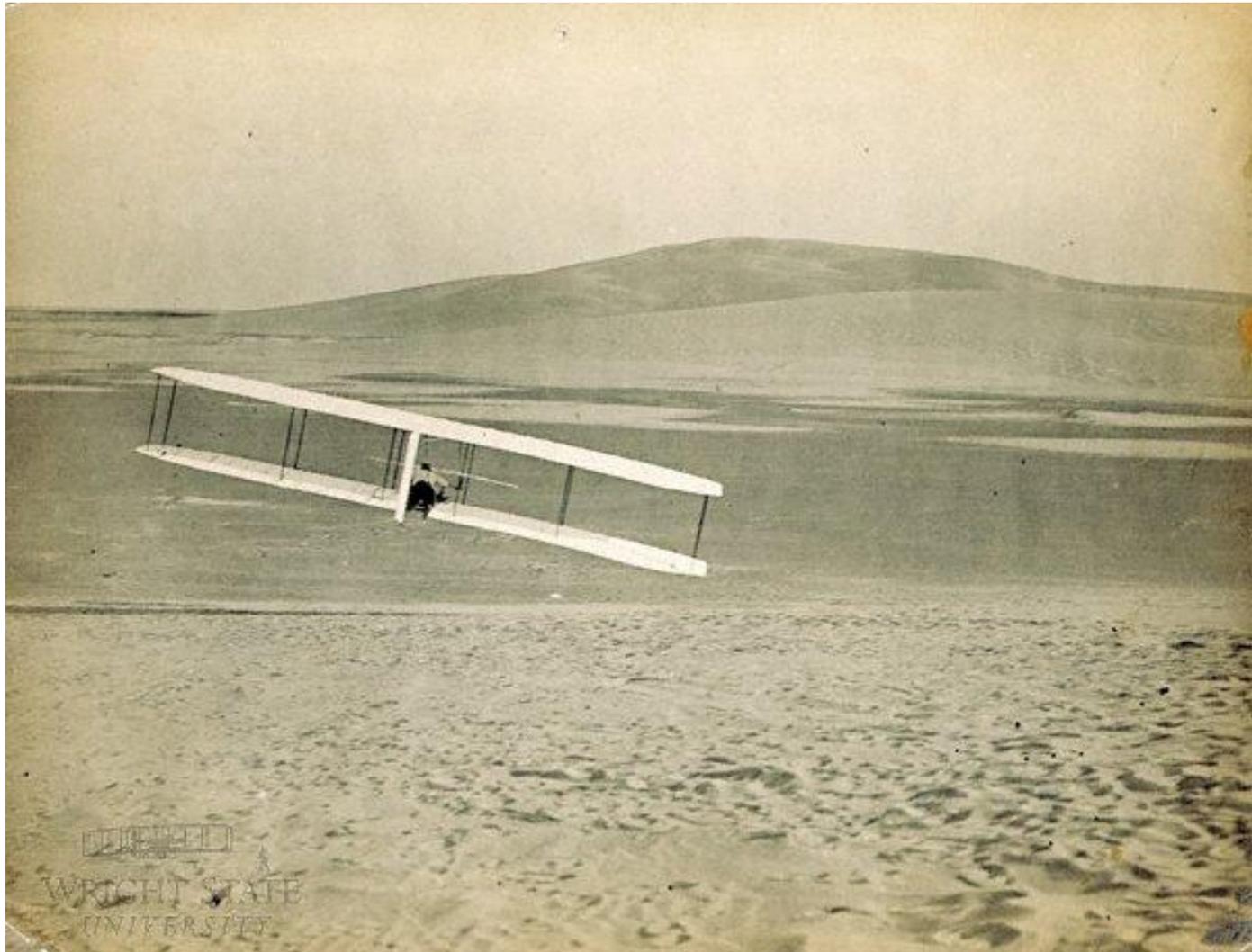
Equation of State:  $p v = R T$     Substitute:  $(p_2 v_2 / p_1 v_1) = (p_2 / p_1)^{[1 - 1 / \gamma]}$

Gather:  $v_2 / v_1 = (p_2 / p_1)^{[1 / \gamma]}$

Effect of Volume on Pressure:  $p_2 / p_1 = (v_2 / v_1)^\gamma$



# Photographs



# Applications of Math and Science



## Glide Angle

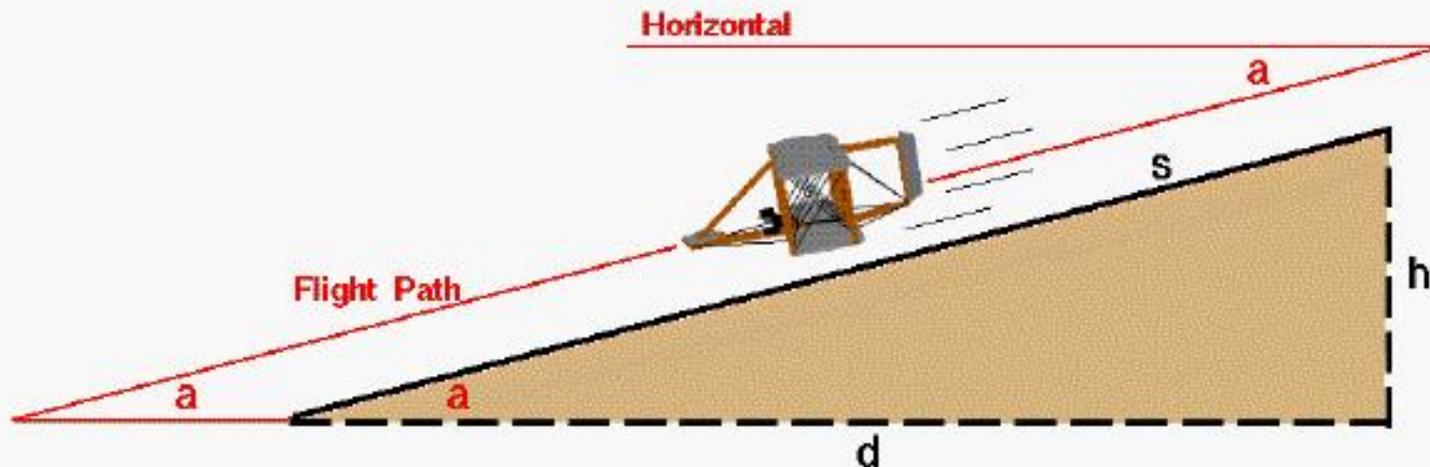
Glenn  
Research  
Center

$h$  = Vertical Height

$d$  = Horizontal Distance

$s$  = Surface Distance

**$a$  = Glide Angle**



From trigonometry:  $\tan(a) = \frac{h}{d}$        $\sin(a) = \frac{h}{s}$



## ***CURRENT EFFORTS***

**Glenn  
Research  
Center**

---

- **Beginner's Guide to Hypersonics**
  - Change of emphasis to undergraduates**
  - Include real gas effects in supersonic programs**
- **New TBCC simulator based on JPC 97 program**
- **Available Sept 2006**



## ***FUTURE PLANS***

**Glenn  
Research  
Center**

---

- **Extend current programs**
  - Change FoilSim solver – include drag, moment and ground effects**
  - Upgrade EngineSim to 3 spool, mixer nozzle, component design, and propellers**
  - Java version of GasLab**
  - More kite geometries**
- **New programs and websites**
  - Power and Energy**
  - Others ..**



## ***SUMMARY***

**Glenn  
Research  
Center**

---

- **Concepts related to aerospace can be used to demonstrate math and science**
- **Beginner's Guides are available on the Internet for teachers and students**
- **Interactive Software programs are available for student exploration and learning**
- **Comments / Questions**