



Bio-Inspired Airfoil Design

Dr. Kelly Cohen, Associate Professor of
Aerospace Engineering and Engineering
Mechanics

by Veronica Dean, Mt Healthy
Junior/Senior High School

Sherry Kembre, St. James the Greater

What if you could fly?
How would you do it?



There are four principles to flight,



Lift, Thrust



Drag, and Gravity.





Thrust is the force that propels an object or animal forward.



Lift occurs when air passes over and under a wing – because of the wing's shape.

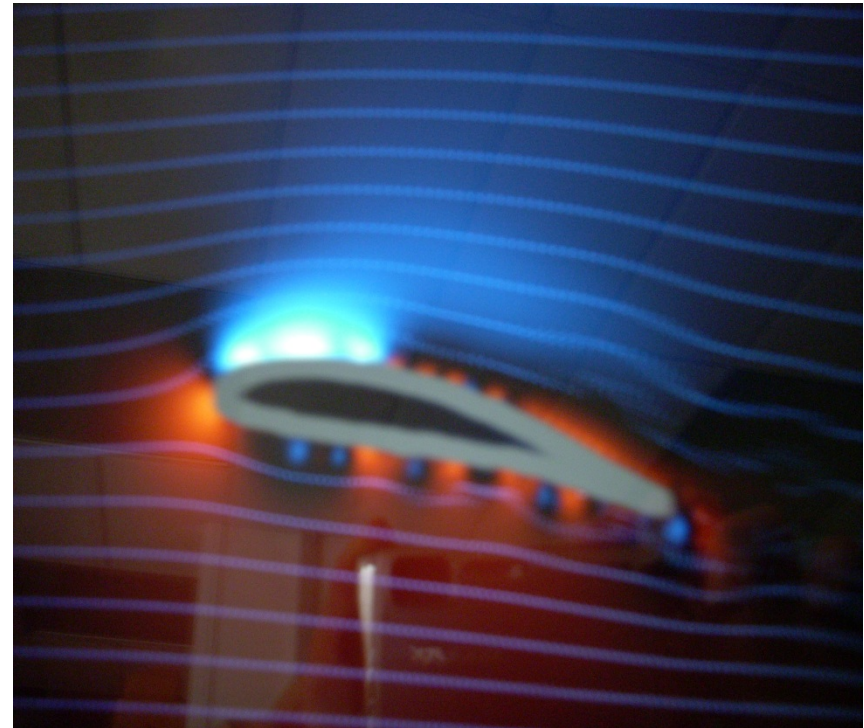
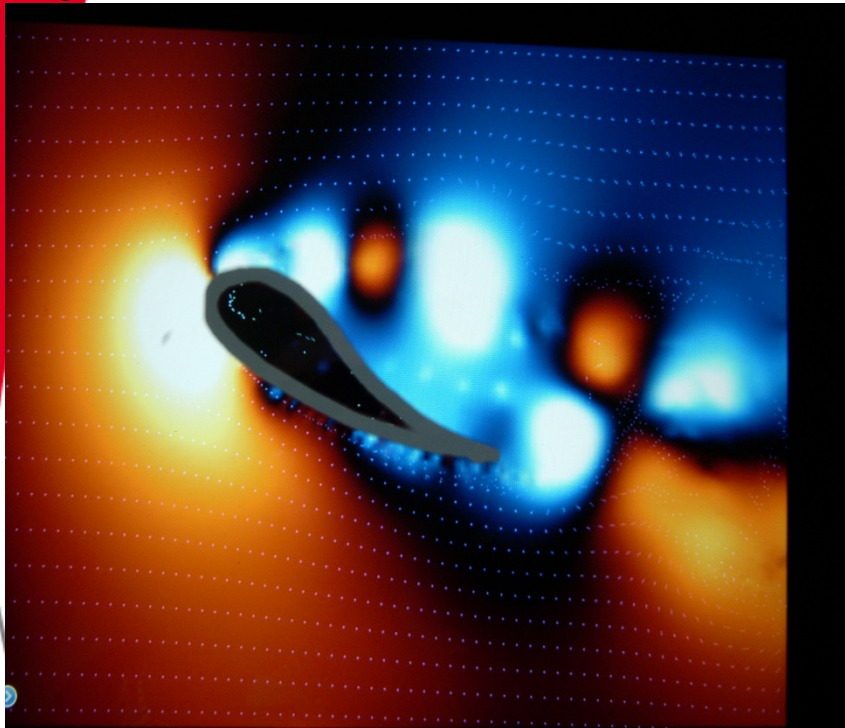


Weight is the force that causes an object or animal to fall downwards.



In flight, weight is countered by lift and thrust.

Drag is the resistance of the air to anything moving through it.



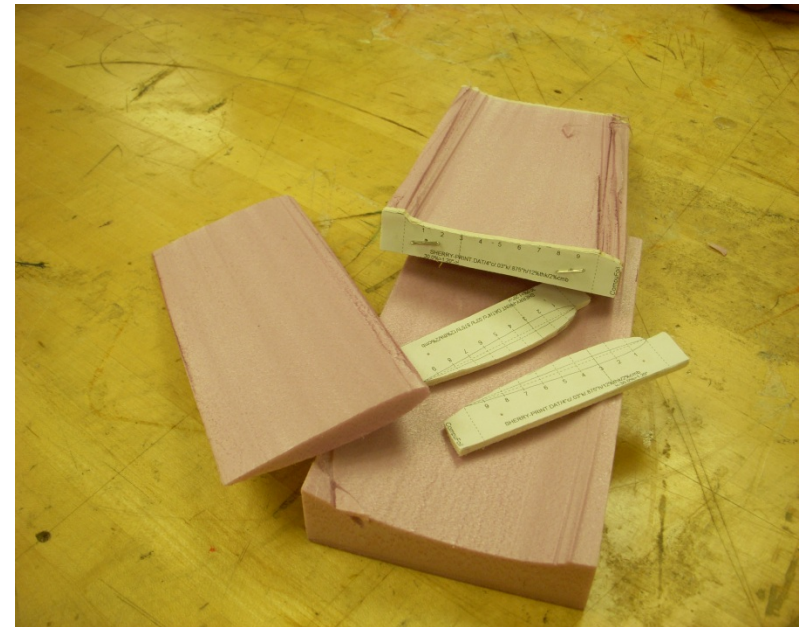
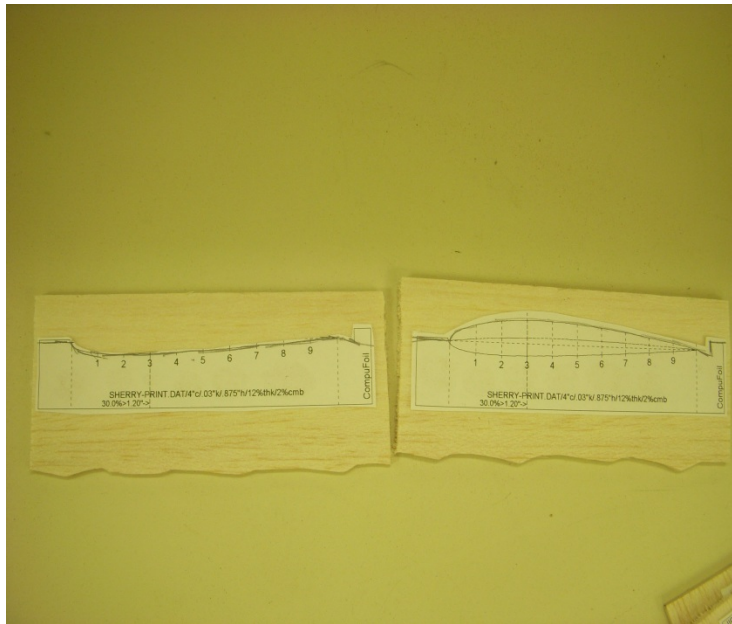
Our research ... Bio-Inspired Airfoil Design



- To study the principles of flight and bio-inspired optimization techniques with an emphasis on airfoil design for UAV (Unmanned Aerial Vehicles).



In other words, design, construct, and test a better airfoil on lessons learned from living organisms to help mankind!



Do not fear the Reynolds Number!

It's used to scale
planes, make a
reduced size model!

The model will have
a similar flight to the
original size aircraft!



A Genetic Algorithm maintains a population of candidate solutions for the problem at hand, and makes it evolve by iteratively applying a set of stochastic operators.



**In other words,
survival of the
fittest!**

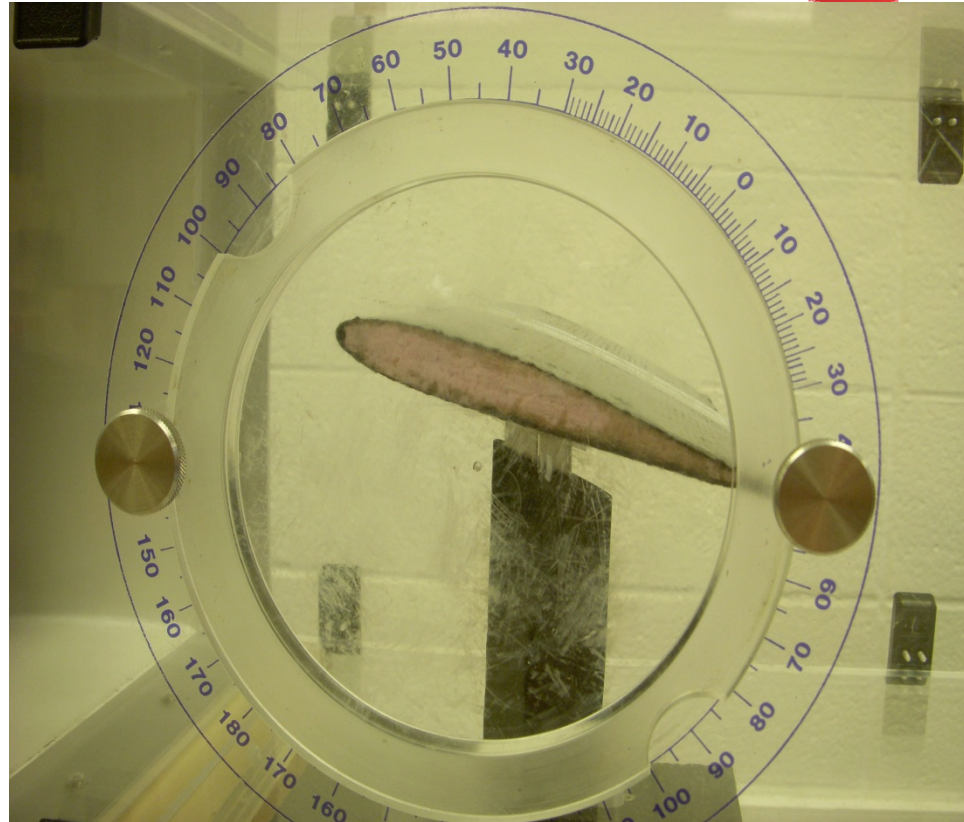
STOCHASTIC OPERATORS

Random
reproduction
base and
mutation.

- Genetic Algorithms are inspired by biological evolution process –
- Selection– original two of the best parts chosen mathematically.
- Recombination– mix two of the best mathematically.
- Mutation– mathematical variation to get the best.

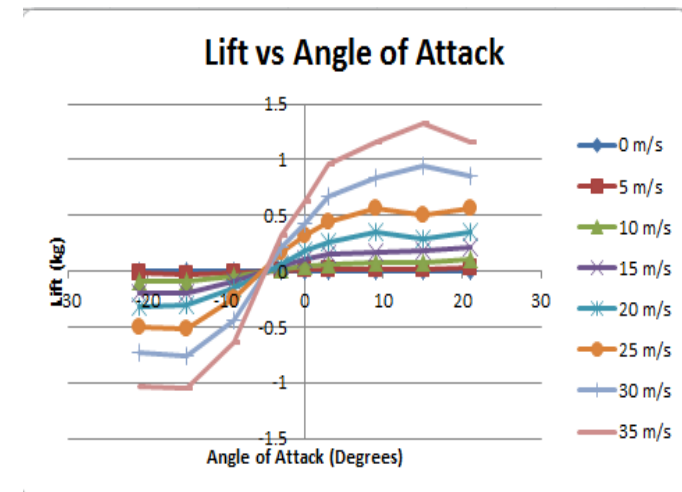
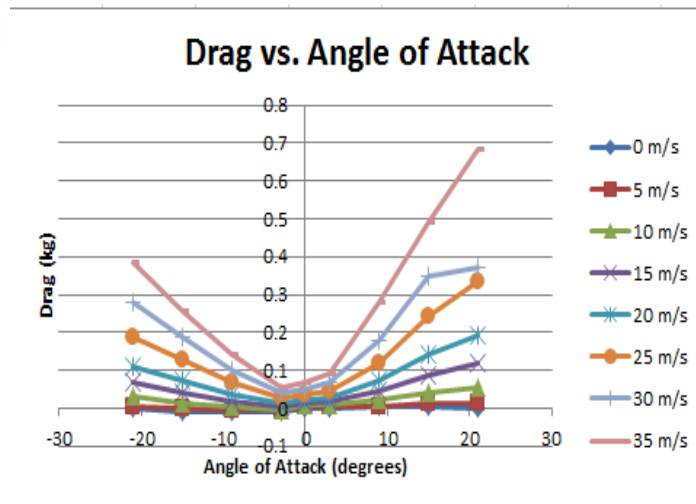


In the research Reynolds Number, Mach, Lift Coefficient were calculated; and inputted into the Xfoil software to create and test an airfoil.



Roni's Piper J3 Cub operates more efficiently at low angles of attack and the higher velocity, the drag increases resulting in stall.

With Sherry's Cessna, as velocity increases lift increases (slope increases) until stall may occur. Stall can occur with negative angles of attack also.





Classroom Implementation

**Mt. Healthy Junior Senior
High School, Mt. Healthy,
Ohio Dean, Science**

- 8th Grade
- 150 Students
- Public
- 65% receive free or reduced lunch
- 74% African American
- 20% White
- 5% Hispanic
- >1% Asian/Other

UNIVERSITY OF
Cincinnati

**St. James the Greater
School, Cincinnati, Ohio
Kembre, Science**

- 8th Grade
- 110 students
- Catholic Parochial
- 10% receive free or reduced lunch
- 96% White
- 2% African American
- 1 % Hispanic
- 1% Asian



Classroom Implementation

- Room is decorated like the interior of a passenger airplane.
- Students are greeted at the door, receive a boarding pass for heterogeneous grouping.
- Students take a pre-test.



Classroom Implementation

- Introduce the lesson by explaining Genetic Algorithm with the analogy of chicken breeding.
- Show pictures of flying animals and compare them to the design of an airfoil (wing).



Classroom Implementation

- Use the iPad 2 to demonstrate flow and pressure can influence efficiency of the airfoil.
- Students will use the NASA FOILSIM III simulator to design an airfoil for construction.
- Review with students by playing a game from the NASA website.



Classroom Implementation

- Students take post test.
- Extension – take students on a field trip to the National Museum of the US Air Force, Wright Patterson AFB, Dayton, Ohio.

Acknowledgements

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Engineering

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References

- Slide 2, aerial photo by Veronica Dean
- Slide 3 Bat, news.sciencemag.org
- Slide 4 Stork, flickrhivemind.net
- Eagle, true.wildlife.blogspot.com



Questions?

- Preguntas?
- Question?
- Frage?