Air Flow Unlimited

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Introduction

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- Design a display that will be used to demonstrate scientific principles to Viewers K-12
- Must be interactive

Sponsor requirements

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- It must have intuitive controls
- It must be rugged
- Fit into their current displays
- Have good explanations to have a large range of appeal
- Must have subject matter that is easy to grasp
- Low maintenance and operation requirements
- Should work off of the initial material constraints

Air Foil Design

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- Has a concept that is easy to demonstrate
- Allows us to demonstrate effects of air flow with a real life concept
- Allows for an interactive approach on controlling the content of the display
- Allows for an interesting flow visualization

Carts

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- A very basic understanding with a medium that makes sense to young minds
- Shows a different aspect when compared in contrast with the wing.
- Works well with the current limitations of the quality of the air flow that the box provides
- Can be used as an example for what drove the evolution of vehicle design

Pitot-Static Probe

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$\rho := 1.204\frac{kg}{m^3}$

$p_{d1} := 150Pa$ $p_{d2} := 130Pa$ $p_{d3} := 90Pa$

$v_1 := \left(2\cdot\frac{p_{d1}}{\rho}\right)^{\frac{1}{2}}$ $v_2 := \left(2\cdot\frac{p_{d2}}{\rho}\right)^{\frac{1}{2}}$ $v_3 := \left(2\cdot\frac{p_{d3}}{\rho}\right)^{\frac{1}{2}}$

$v_1 = 15.785\frac{m}{s}$ $v_2 = 14.695\frac{m}{s}$ $v_3 = 12.227\frac{m}{s}$

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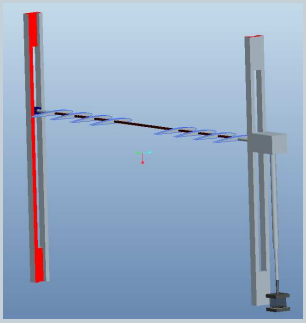

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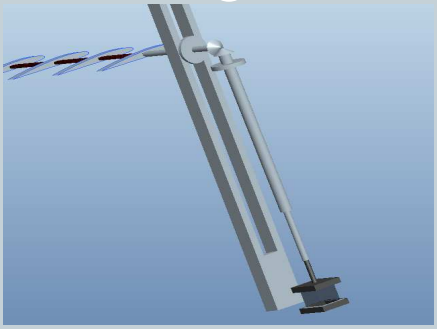

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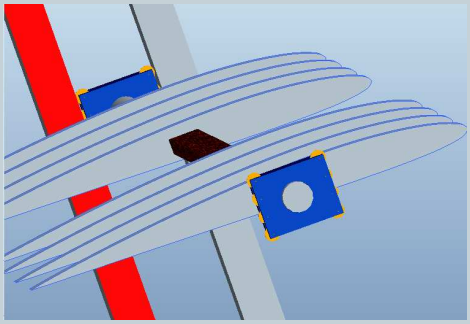

Materials

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- Wing
  - Cross Section
    - Balsa Wood
  - Covering and Boom
    - Polystyrene Sheet
  - Total Mass ~0.009lbs

Materials

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- Gears and Bearings
  - Polystyrene
  - Total Mass ~0.046lbs
- Overall Mass ~0.055lbs
- McMaster-Carr as Supplier

Calculated Lift

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- Calculated wind speed ~12m/sec
- Reynolds Number ~
- Lift Coefficient ~1.65
- Achievable Lift ~0.75lbs $C_L = 2\pi\theta$

Motor

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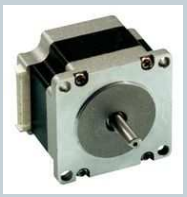
- Largest pressure difference 150Pa.
- Torque of 0.003 ft-lbs
- Trinamic stepper motor
- Motor stale torque 0.4 ft-lbs



Pasco Gocar

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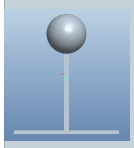

- 2 matching carts
- Geometric attachment(square, and circle)
- Attachments made of aluminum
- COMSOL of produced airflow

Material selection

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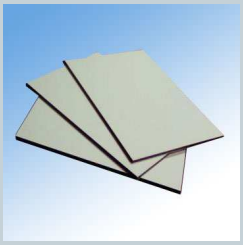

- The attachment materials will be made out of aluminum
- Cost effective
- Durable
- Easy to machine for simple geometries
- Low density metal(181 lb per cubic foot)

Calculations

Coefficent Circle

$C_{dc} := 0.47$

Coefficient Square

$C_{ds} := 1.05$

Cross Sectional Area Circle

$A_c := \pi \cdot r^2 = 3.142\,in^2$

Cross Sectional Area Square

$A_s := L_s \cdot W_s = 4\,in^2$

Drag for circle

$F_{dc} := \frac{1}{2} \cdot \rho \cdot V_0^2 \cdot C_{dc} \cdot A_c = 0.032\,lbf$

Drag for Square

$F_{ds} := \frac{1}{2} \cdot \rho \cdot V_0^2 \cdot C_{ds} \cdot A_s = 0.091\,lbf$

Torque generated by drag circle

$\tau_c := F_{dc} \cdot h = 0.161\,lbf \cdot in$

Torque generated by drag square

$\tau_s := F_{ds} \cdot h = 0.457\,lbf \cdot in$

Calculations

Density of aluminum

$\rho_{al} := 181.041 \frac{lb}{ft^3}$

$V_{square} := L_s^3 = 4.63 \times 10^{-3} \cdot ft^3$

Volume of Al in the Sphere

$V_1 := V_{baseplate} + V_{sphere} + V_{rod} = 3.701 \times 10^{-3} \cdot ft^3$

Volume of Al in the Square

$V_2 := V_{baseplate} + V_{square} + V_{rod} = 5.907 \times 10^{-3} \cdot ft^3$

Visualization for attachments

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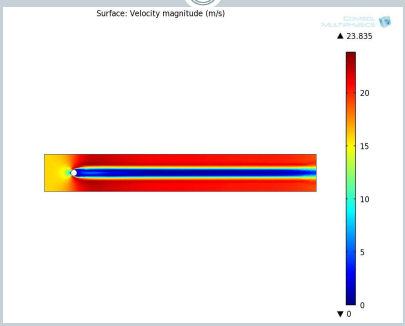

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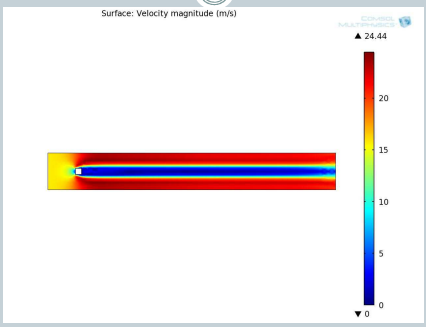
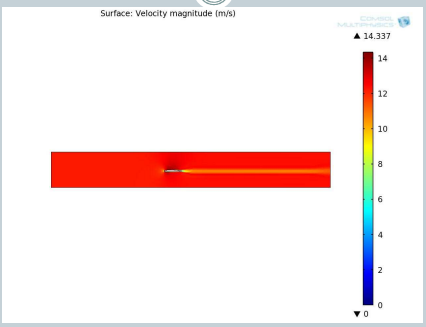


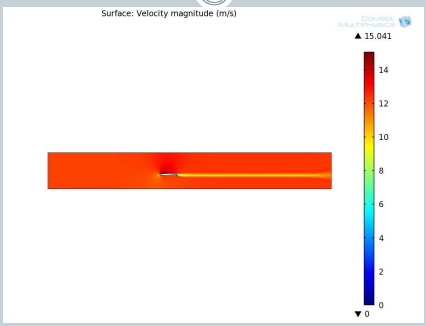
Airfoil @ angle 0°

20



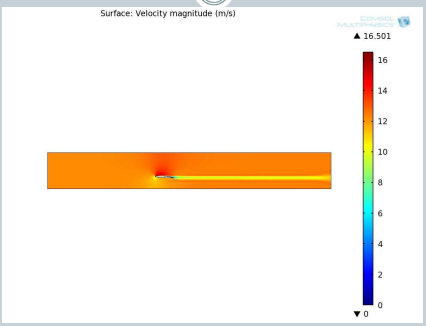
Airfoil @ angle 1.8°

21



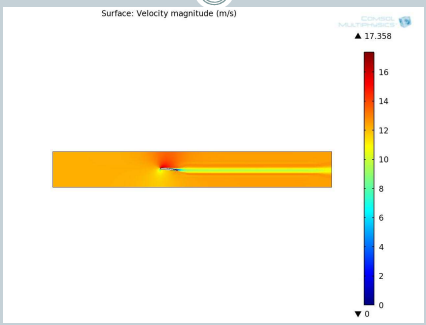
Airfoil @ angle 3.6°

22



Airfoil @ angle 5.4°

23



Airfoil @ angle 7.2°

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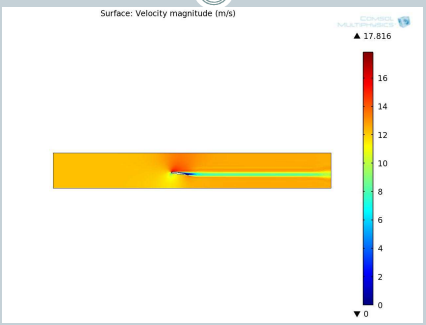
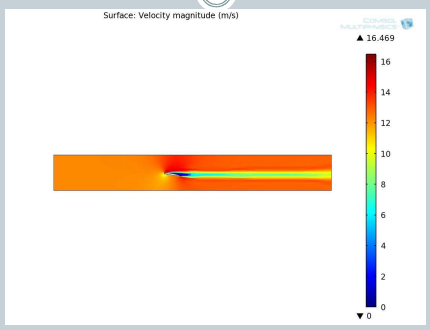


Airfoil @ angle 9.0°

25



Airfoil @ angle 10.8°

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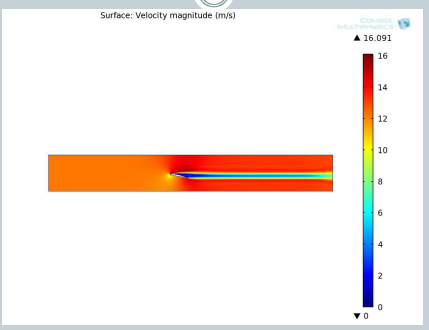

Airfoil @ angle 12.6°

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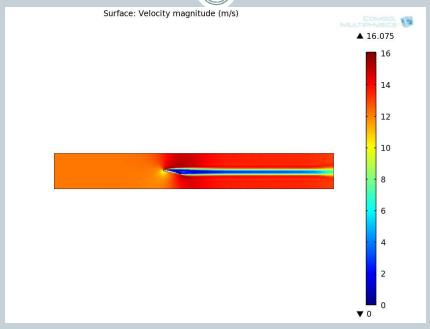

Airfoil @ angle 14.4°

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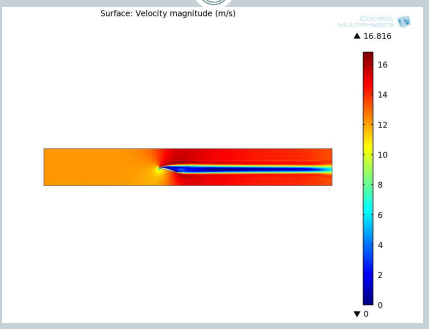
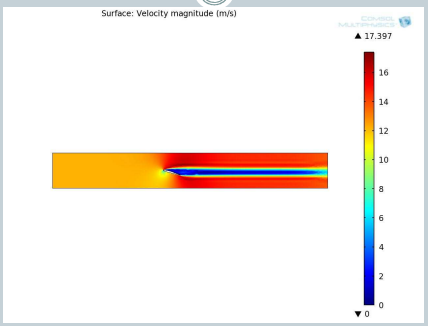


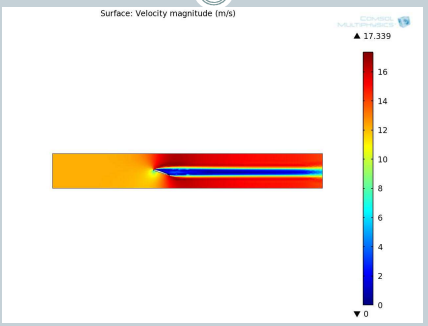
Airfoil @ angle 16.2°

29



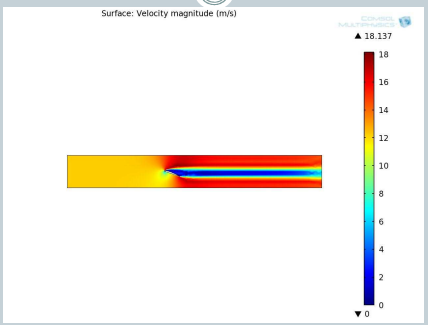
Airfoil @ angle 18.0°

30



Airfoil @ angle 19.8°

31



Actual wind tunnel

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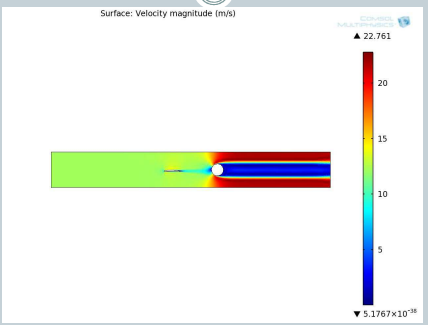
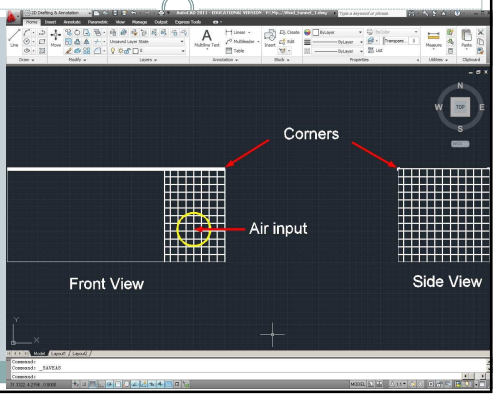


Mesh

- Intercrimp Mesh with 0.063” wire;
- US$5,00/ft²
- Estimated area need – 3.5 ft²

Corner

- Aluminum Structural Angle;
- 6 feet long;
- 2 bars;
- 2 X 2 X 3/16 [in]
- Price – US$57.36

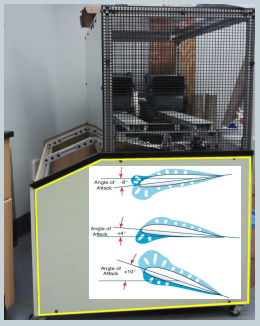


Monitors

- 2 Monitors;
- 7 inch colorful;
- US$89.99 each

Explanation

- Positioned at the side of the wind tunnel;
- Insight into the physics of the experiment;



Potentiometer

- Pot - Precision Electronics
- 10K Linear, 24mm, Slotted Shaft made by Precision Electronics
- 10% tolerance. RoHS Compliant
- Price – US$34.29/unit

Knob

- 13/16" Tall x 3/4" Dia
- Plastic
- US$3/unit

Bearings

- ProTek R/C
- 5x10x4mm rubber sealed "Speed" 1/8 clutch bearings;
- High quality steel/chrome;
- Price – US$10 (10 unit pack)

Bearings

- ProTek R/C
- 14x25.4x6mm
- High quality steel/chrome;
- Price – US$22.99/unit

Safety

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- The blowers do not generate much noise
- All aspects of the display are contained and separated from the viewers
- The only aspects in which a user can come in contact with any devices are the controls which will be rugged by soft edged knobs
- The supports for the box and the outer surfaces will not break or fracture due to appropriate loads
- General design of components in user interact are in line with the same design aspects as displays in current use

Schedule

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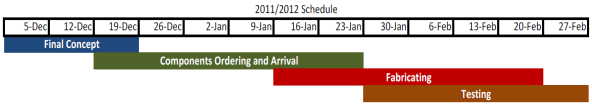

- Testing for viable airfoil regions of operation
- Testing for controls
- Testing for cart reactions

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- Motor: http://www.powerelectric.com/product-information/electric-motors/stepper-hybrid-motors.html
- Materials: www.mcmaster.com
- Mesh: http://www.twpinc.com/wire-mesh/TWPCAT_30/p_002X002A0630W36INTER
- Corner: http://www.metalsdepot.com/
- Monitor: http://www.amazon.com/Sylvania-SDVD9000B2-9-Inch-Portable-Player/dp/B004QGXWSQ/ref=sr_1_5?s=electronics&ie=UTF8&qid=1323198987&sr=1-5
- Potentiometer: http://www.bidlessnow.com/Pot-Precision-Electronics-p-1597627/
- Bearings: http://www.amainhobbies.com/product_info.php/cPath/1576_63/products_id/5725/n/ProTek-R-C-5x10x4mm-Rubber-Sealed-Speed-1-8-Clutch-Bearings-10 http://www.amainhobbies.com/product_info.php/cPath/1576_63/products_id/6251/n/TKO-Ceramic-14x254x6mm-Rear-Engine-Bearing-OS-V-Spec-Novarossi-RB-1