Semi-Span Flapping Wing Model

GROUP MEMBERS:
BRAYLER GONZALEZ
JULIA ROMANCHIK
BRYCE HORVATH
Outline

- Introduction
- Objectives
- Wing Design
- Mechanism
- Demonstration
- Test Methods
- Materials and Cost
- Conclusion
Introduction

- Flapping Wing Flight refers to flight driven by oscillating airfoils which imitate nature.
- Mathematical models of flapping flight still unavailable, with little research done to find exactly how and why flapping flight works.
- In our project, we will be modeling a single wing for testing in the wind tunnel.
Benefits

- To better apprehend flapping flight for future use in aircraft
  - The data collected in this experiment would allow for a better understanding of the air flow and forces acting on the wing, which could be used to improve the design to produce a more efficient flapping wing for use in aircraft.
  - Possibility:
    - Micro UAVs for use in spy missions
Project Objectives: Research

- Obtain information on flapping wing motion in bird flight, as well as bird anatomy and skeletal structure
- Research past and present flapping wing projects
- Determine a plausible and testable wing design using assumptions and simplifications obtained from research

Ornithopter Design by Leonardo da Vinci

Ornithopter by University of Toronto
Project Objectives: Design

- Design the simplified kinematic wing structure mechanism
- Perform calculations to determine the theoretical magnitude of forces which will act on the wing
- Determine possible materials which contain necessary properties to obtain vertical flapping motion and torsion
## Approach: Wing Design

### Semi-Span Wing Dimensions and Parameters: 10m/s & 5°

- NACA 0012 Model Reference
- Wingspan ~ 1.5 ft
- Wing Area ~ 0.807 ft²
- Wing Beat Frequency ~ 5 Hz
- Aspect Ratio: 5.577 Calculated
- Lift: 0.4166 lbs
- Drag: 0.0153 lbs
- L/D: 27.28

### Aeroelastically Twisting by Spar Torsion:

- **H1: Bending Resistant Spar** – Transmits Power
- **H2: Torsion Elastic Spar** – Determines Magnitude of Wing Twisting
Approach: Wing Design

Side View

Front View

Wind tunnel floor
Mechanism
Demonstration
Project Objectives: Test

- Measure forces using transducer
- Measure flow field using particle image velocimetry
- Use Reed Switch as tachometer
- Compile data using LabVIEW
## Materials and Cost

### Wing:
- Dacron: $15
- Carbon Fiber Rods: $30
- Glue: $10
- Kevlar thread: $0
- T-Connectors: $0

### Motion Drivers:
- 12V DC Motor: $50
- Turntable: $0

### Mechanism:
- Bearings
- Keyed Shaft
- Key
- Shaft Collars
- Screws
- Thrust Washers
  - Total: $95

### Testing Devices
- Digital Force Transducer: $0
- PIV System: $0
- ODU Low Speed Wind Tunnel: $0
- Reed Switch: $5

Total: $205
Conclusion

- Current
  - Tachometer

- Future
  - Integrate the Reed Switch and transducer using LabVIEW
  - Wind Tunnel Testing
Questions?
Particle Image Velocimetry

**Device Set-Up:**

**Description:**

- Fluid Visualization
- Measures instantaneous velocity
- Represented by 2-D Vector Fields
- Apparatus Consists of: Digital Powered Camera and High Laser
Testing Equipment: Force Transducer

<table>
<thead>
<tr>
<th>Fx, Fy</th>
<th>Fz</th>
<th>Tx, Ty</th>
<th>Tz</th>
</tr>
</thead>
<tbody>
<tr>
<td>±280 lbf</td>
<td>±930 lbf</td>
<td>±700 lbf-in</td>
<td>±730 lbf-in</td>
</tr>
<tr>
<td>1/160 lbf</td>
<td>1/80 lbf</td>
<td>1/80 lbf-in</td>
<td>1/80 lbf-in</td>
</tr>
</tbody>
</table>

Schematic of the Device:
Prototype Wing Construction

- Two main spars (one stiff and one flexible)
- Kevlar string with glue to attach ribs to stiff spar
- Mixture of glue and sewn pockets to attach skin to ribs