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Project 3: The Mechanics of Reduced-Gravity Aircraft

Poster Draft & Narrative

**ABSTRACT:**

Reduced gravity aircraft are used to train NASA astronauts and perform research in low-gravity situations similar to those encountered in space. The model abstracts this system to a point mass with four forces, gravitation, lift, thrust, and drag. We are determining how the thrust force changes the rider’s experienced g-force. Our goal is to maximize the amount of time in which the rider feels weightless.

**QUESTION:**

The mechanics of flight can be abstracted out to four forces: thrust, lift, gravitational, and drag. Reduced-gravity aircraft vary these forces to achieve a parabolic flight path. The aircraft initially thrusts to achieve a significant upward velocity. Next, the aircraft kills the thrust. At this point, the occupants of the aircraft and the plane itself are in free-fall. The occupants are essentially feeling 0G. After the plane has fallen for a certain period of time, the plane again thrusts.

We want to determine how manipulating the thrust force affects the amount of G’s experienced by the occupants of the plane. Ultimately, we want to maximize the amount of time the plane is in free-fall by varying thrust.

**SYSTEM:**

In this model, the reduced-gravity aircraft is abstracted to a point-mass. The four forces experienced by the point-mass are the gravitational force, the drag force, the lift force, and the thrust force. The free-body diagrams below show the direction of the forces in a single parabola of the flight path.

The state variables in this model are the position and the velocity of the plane in both the x and y directions.

**LIMITATIONS & ASSUMPTIONS:**

* Limitations
  + The model does not take into account the changes in the drag and lift force resulting from the manipulation of the wings of the aircraft.
  + The plane is modeled only in two dimensions
* Assumptions
  + The model is a point mass
  + Described plane using Boeing 727 data
  + The model’s drag coefficient does not change
  + The plane’s mass does not change with fuel consumption
  + The thrust force is constantly in a 45 degree direction
  + People will die before the plane breaks down
  + The plane cannot go into space because the atmosphere altitude is infinite
  + Gravitational force stays constant throughout flight

**OPERATIONAL REGIMES:**

* Not enough thrust to lift off
* Too much thrust that people can’t handle it (they either pass out or die)
* Little to no time in microgravity
* Too fast that the plane breaks down

**MODELING THE FLIGHT PATH:**

The model can be used to plot the position of the plane. Thus, this graph plots the flight path of the aircraft throughout ten parabolas. This model also plots the experienced G-force of the occupant inside the plane in the form of a heat-map. This plot demonstrates the trajectory of the aircraft and the experienced gravitational force.

**PUNCHLINE:**

This plot varies thrust and plots the G-force experienced by the occupant in the aircraft. From this graph, it is found that as the thrust force increases, the G-force felt increases exponentially. This plot will have multiple lines that show how thrust affects G-force at various points in the flight path, such as when the plane and occupant are in free-fall.

**VALIDATION:**

The model can be validated with data gathered from previous reduced-gravity flights. The peak of the parabolic flight path is at an altitude of 10000 m and the model also peaks at this altitude. The thrust is restarted at an altitude of 7300 m and the model restarts thrust close to that altitude. In addition, a parabola in total is approximately 65 seconds and our model is at 63 seconds.