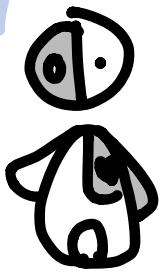
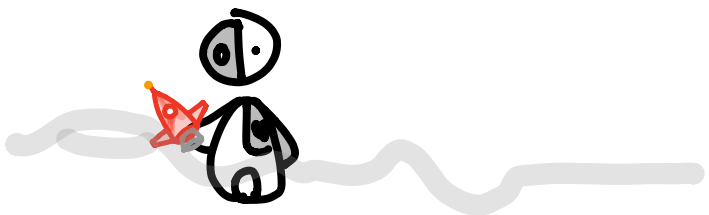
TENNIS RACKET THEOREM

by: Simaya Rosenbloom



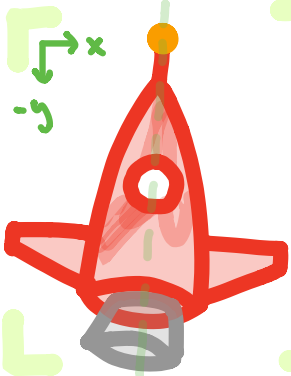
There once was a little alien boy,
And he went by the name of Lunar Loy.

He lived on the moon with his toy spaceship,
Aspiring to make his own for a trip.



Lunar Loy then began to see
how his rocket would come to be.

ROCKET ANALYZER:



TOP VIEW

ROTATE 90°

Material: Recycled "Moon Buggy" pieces.

Physical Symmetry (mass Symmetry):

- Symmetric about principle axis from top view.
  → note wings have mass.
- Also symmetric about principle axis from side view.
- IS symmetric by mass from nose to engine.

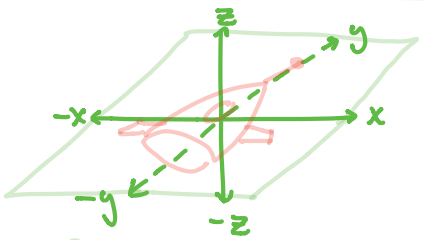
Other:

- Weirdly similar to a "tennis racket" found on earth...

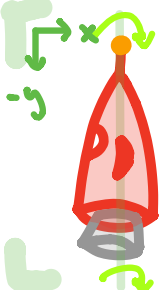
Test number one
was where he began.

Lunar Loy spun the rocket about the principle axis (y-axis)
And it went just like this:

ROCKET ANALYZER INITIALIZER:



$z = x \times y$
↑ cross



Rotation – XZ Plane:

- Steady rotation.
- Slight wobble
- Mass is closest to the axis of rotation (y axis)
- Small moment of inertia.

XZ-wobble

"When it spins this way,
the nose and the engine each in their spots, they tend to stay!"

Test number two
was similar to the first in how the rocket flew.

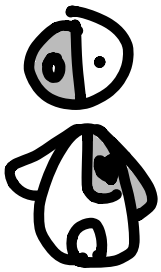
Once again the rocket rotated,
and Lunar Log notated.

"A slower spin this time!
Because of all the distance the outter masses
have to climb."

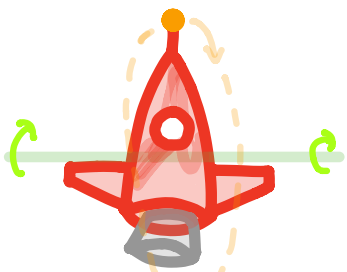
Test number three
was as surprising as can be!

Rotation – XY Plane:

- wings in the plane of rotation.
- like spinning scissors on a table on earth
- Stable rotation
- Slight wobble
- mass is further from axis of rotation
- large moment of inertia



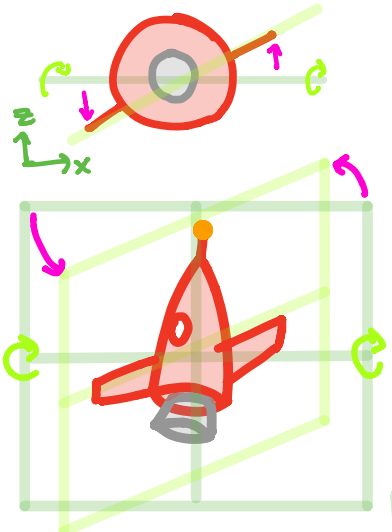
Rotation – YZ Plane:



- rotation about the x-axis AND z-axis
- unstable rotation
- medium moment of inertia.
- intermediate distribution of mass
  ⇒ intermediate axis = x-axis
- wings start in XY plane.

Any wobble or rotation off of the x axis
would lead to a π rad rotation in the xy plane
no matter how much he would practice!

Rotation-YZ Plane:

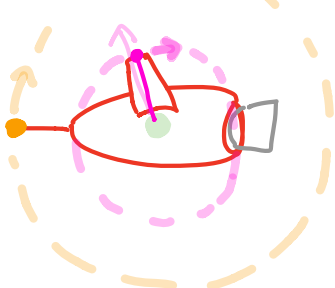


With some linear algebra,
Lunar Log could figure it out.
There was some moment vector
accumulating in an axis it wasn't turning about.

Suppose the rocket wings
were not perfectly lined up with XY plane.
But rather just tilted,
so the wings have a centripital force to obtain.

Rotation-YZ Plane:

- From Newtonian physics we know that there exists centripital force when a mass exists off of the axis of rotation.
- now, since the wings are not perfectly aligned with the rotating plane
  ⇒ there exists a distance between the axis of rotation and the rocket's axis of symmetry.
- now look at the rocket from the x axis:
  → there now exists a centripital force pushing the wing tip away from the axis of rotation (green dot) without any structure to pull it inwards.



- This extra centripital force exists on both sides of the rocket because of it's symmetry.

- Therefore, after multiple tilted rotations about the x axis, these extra torque vectors build up and flip the ship !!!