ASIAN TRY ZERO-G 2017/18

BEHAVIOUR OF BOOMERANG IN MICRO-GRAVITY BY SINGAPORE

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(1) Purpose of Experiment

We predict that the boomerang will precess around an axis almost perpendicular to it's velocity and it's angular momentum. The boomerang should also come back and continue acclerating till it slows down to a stop if it is rotating clockwise and acclerate away from its initial position if it is rotating anti-clockwise and also move upwards orthogonal to the plane it is moving on.

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(2) Materials & Methods

- A4 paper
  - 80gsm (pink)
  - 100gsm (white)
  - (Colour difference to make them distinguishable)
- Ruler

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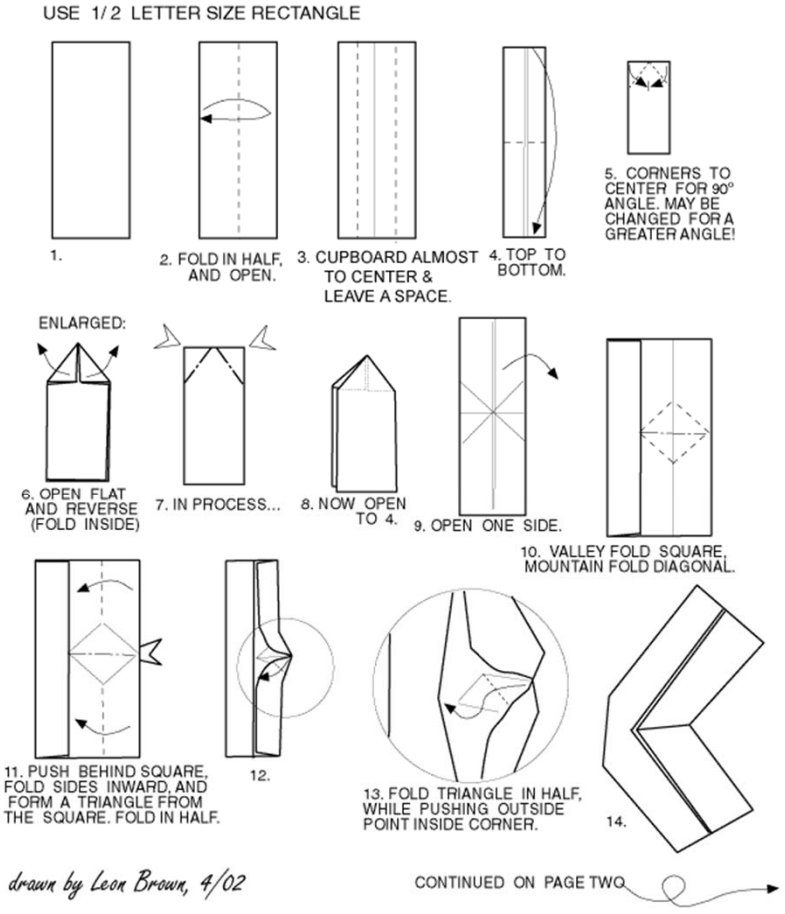
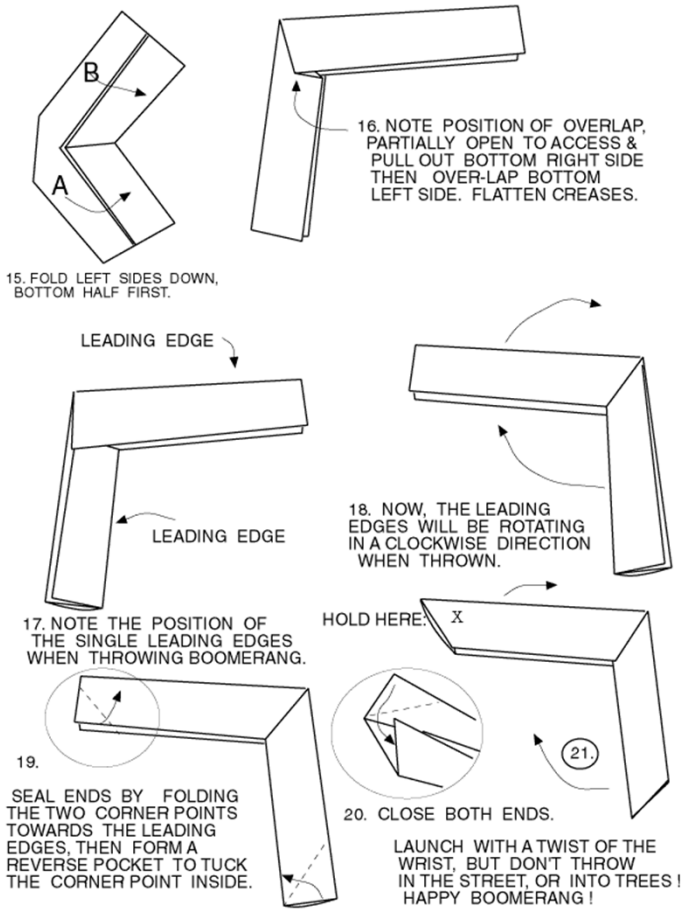
(2) Materials & Methods





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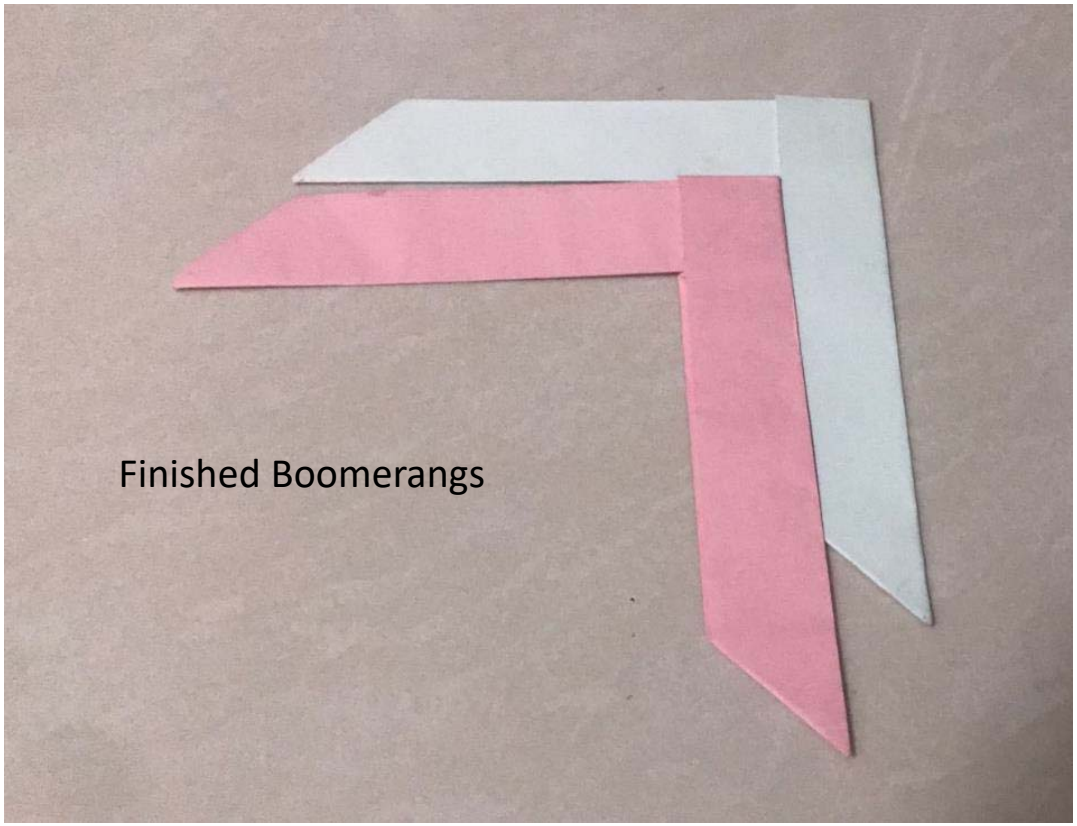
(2) Materials & Methods



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(3) Hypothesis

- On earth - Gravity, downwards acceleration, allows boomerang to return
- In space – Lack of gravitational acceleration, boomerang returns above thrower
- Pink boomerang returns faster than the white boomerang as it is lighter
- Lift force perpendicular to plane boomerang
- On earth, lift points towards thrower and upwards, opposing gravity
- In space, lift points towards thrower and upwards – comes back above thrower
- Lower mass – More acceleration – Moves back faster

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(4) Results

- Boomerang went on a large arc before hitting the upper walls of the space shuttle
- Boomerang does not return
- Pink boomerang has a smaller arc than white boomerang

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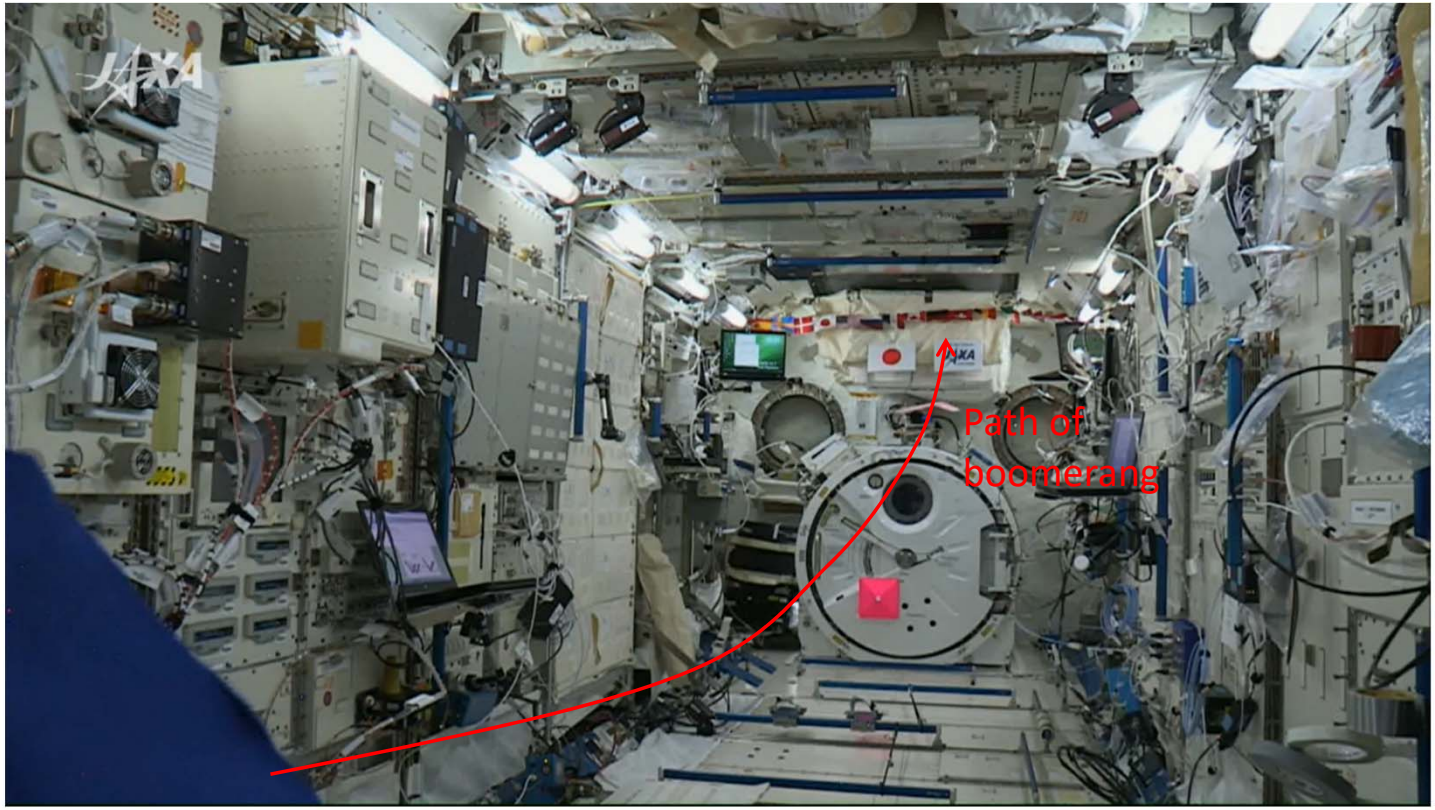
(4) Results



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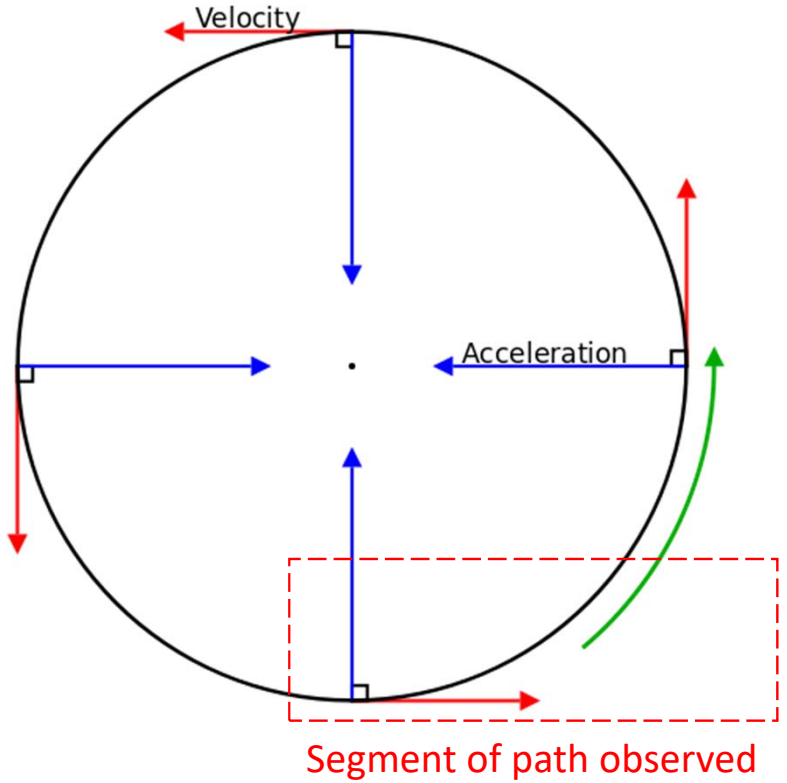
(5) Discussion

- Lift force perpendicular – Circular motion



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(5) Discussion

- Assuming both pink and white boomerangs have the same thrust, and $F = mv^2R^{-1}$
- We can see that $R = mv^2F^{-1}$
- This explains the pink boomerang's smaller arc, as it had less mass.

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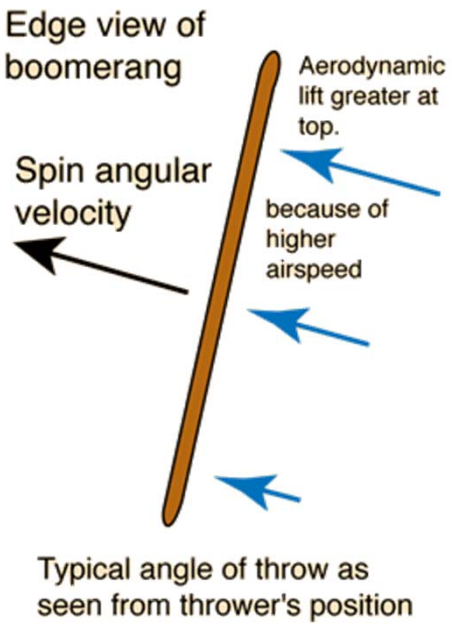
(5) Discussion

- As the boomerang rotates, a greater thrust is produced on one side.
- This could cause the boomerang to slowly “rotate”



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(5) Discussion

- Video camera and scale rule to properly trace trajectory
  - Testing theories
- Having mathematical description of boomerang
  - Lift force is hard to model

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(5) Discussion

- Boomerangs may not work in space, gravity is required
- Less mass – Returns faster
- As for different Angles of Attack (AoA):
  - A boomerang's lift is parallel with its rotational axis, changing its AoA would cause its lift vector to change too.

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(5) Discussion

- When AoA is zero, the boomerang would undergo what seems to be circular motion, with its lift as the centripetal force.

- When the boomerang's AoA is 90°, it would fly forwards directly, then return in a straight line. This is as the boomerang's lift vector is now retrograde to its initial velocity, kind of like throwing a ball straight up on Earth.

- For other AoA beyond 90° but less than 180°, the boomerang would be able to return, but require some effort to catch. However, beyond 180°, the vector of the boomrang's lift would now be pointing away from the thrower and it would not return

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(5) Discussion

- On the matter of different boomerangs,
  - Other types of boomerang will definitely be able to provide more lift compared to the paper boomerangs we are using, whilst their mass meaning the arc they would make at AoA=0° would likely be much smaller. As such they would likely be able to return to the thrower, with some effort on the thrower's part required to catch the boomerang.
  - However, if the mass of the boomerang also increases, the radius will decrease, thus for a small radius in order to be usable in a small confined area, a boomerang with a low mass and high lift is required

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Questions for Kanai-san

1) Do you have any insights on why the boomerang returned on Earth but not in microgravity?

2) If KIBO was larger, would it be possible for the boomerang to return?

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Thank You

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