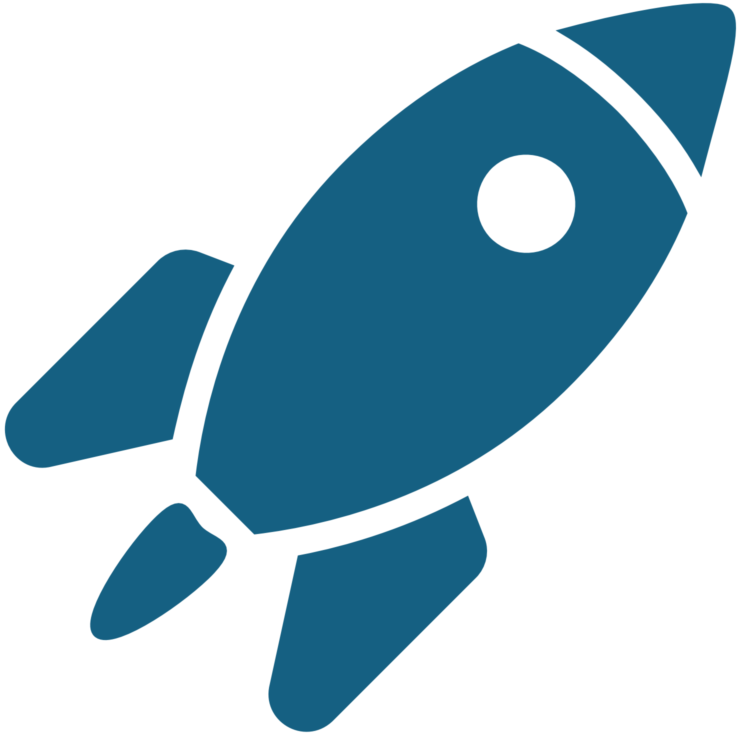


An experiment by Forrest Wang

The Effect of Model Rocket Tube Length on Stability

Research

The stability of a rocket is determined by the position of the center of pressure (CP) from the center of mass. (CG) (rocket aerodynamics) If the CP is aft of the CG, then the rocket is stable;, if otherwise, the rocket would be unstable. The CG is the point of balance of the mass on a rocket, while the CP is where the aerodynamic pressure acts in the rocket, or its it's balance point aerodynamically. (Nakka) One way to approximate the center of pressure is to draw an outline of the rocket and find the approximate center of the area of the out line. (rocket aerodynamics)

Materials that can be used for nose cones include: plastic, which is easier to paint and is usually hollow, balsa wood is more lightweight. (Materials for Model Rockets - Ukra) The three main materials for rocket fins are wood, plastic, and fiberglass. Balsa wood is the preferred type of wood, even though it tends to dent or split when handled roughly. Basswood can also be used if a stronger material is needed. Sheet plastic and fiberglass can also be used. (Materials for Model Rockets - Ukra) Commercial rocket engines have fuel that are usually made from either black powder or liquid nitrogen. (All about rocket engines) Rocket engines are marked with a three character code that goes as follows: Impulse (letter), Average thrust in newtons (number), and the time delay in seconds (number). Commercial rocket engines have levels from ¼A to H. (All about rocket engines)

How does the length of a tube affect the rocket's stability? When a rocket's length reaches a certain point, the center of pressure is no longer aft of the center of gravity (specific distance depends on length and material). As previously stated, a rocket's stability is dependent on the position of the CP to the CG. (Nakka) Since the length of the rocket causes the position of the CP to no longer be aft of the CG, when a rocket is either too long or too short, it will become unstable. (Why do tall and skinny rockets go unstable?)

Set-up

Question: What is the effect of model rocket tube length on model rocket stability?

Hypothesis: If the model rocket's tube length is increased, then the model rocket's stability will worsen.

IV: the length of the model rocket tube

DV: The angle of from the string of the model rocket

Levels: The levels would be different length of body tube (in inches): 2.5, 5, 10, 15

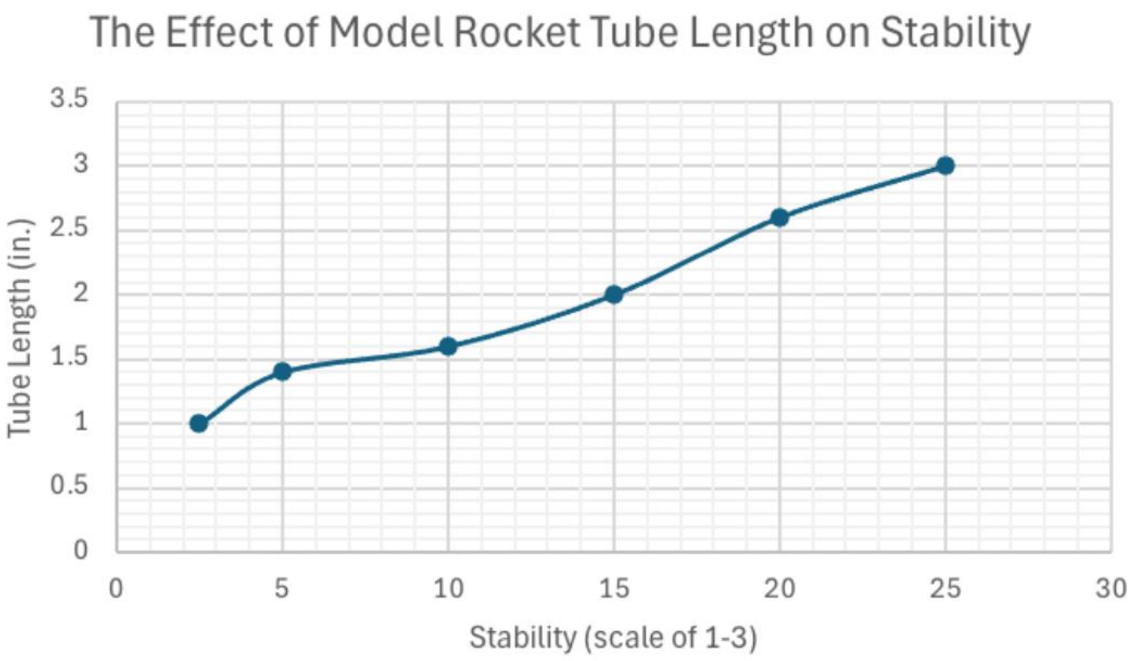
Materials

- Estes 18-inch BT-55 tubes (3)
- Estes NC-55 nose cones (4)
- Commercial B engines (4)
- Estes engine hooks (4)
- Estes B engine mounts (4)
- Cardboard cutter (1)
- Hot glue gun (1)
- Foam board (1)
- String (1)
- Masking tape (1)
- Pencil (1)

Procedure

1. Take the 3 BT-55 body tubes and cut into a 2.5 inch piece with the cardboard cutter.
2. Attach the NC-55 nose cone to the body tube by snugly fitting the nose cone inside the body tube. (see Attach an engine hook to the engine mount on the outside with hot glue and attach the engine mount to the end of the body tube without the nose cone with hot glue. Cut out 4 pieces of foam board in the shape of parallelograms with a base of 0.25 inches and a height of 0.5 inches with 2 angles of 100 degrees and 2 angles of 80 degrees.
3. Attach the 4 fins to the model rocket with the 0.5 inch ends touching the body tube of the rocket. The fins should all be at 120 degree intervals and be at the end of the rocket with the engine mount, with the end of the 0.5 inch side touching the edge of the tubes.
4. Fit the B-engine into the engine tube and adjust to make sure it would not fall out (glue or extra cardboard may be needed).
5. Repeat steps 1-6 three more times, each time with body tube lengths of 5, 10, and 15 inches, but make an extra 15-inch piece that could be attached to the other pieces via masking tape and hot glue.
6. Find the center of gravity of the rocket (this could be done by finding the single point where the rocket can balance on a thin object), and mark them with a pencil.
7. Tie a length of string around the center of gravity on the rocket, and use masking tape to make sure the string wouldn't move.
8. Hold one end of the string in your hand, and start to swing the rocket, similar to how a lasso is swung (make sure this is done in an open area), whilst having a different person follow the rocket with a camera.
9. Repeat steps 8-15 five more times, with three of the five more times using the prolonged body tube.

Data+Graph



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Tube Length (inches)	Stability (degree of 1-3)					
	Trial #1	Trial #2	Trial #3	Trial #4	Trial #5	Mean
2.5	1	1	1	1	1	1
5	1	2	1	1	2	1.4
10	2	1	2	2	1	1.6
15	2	2	2	2	2	2
20	3	2	3	3	2	2.6
25	3	3	3	3	3	3

Conclusion

The hypothesis is accepted. The seeds exposed to microwaves had average radicle lengths that were 7.2 mm and 4.8 mm shorter than the control group. When microwaved for more than 20 seconds the seeds did not germinate. The microwaves appear to cause stunted growth. To further validate these results, additional replicates should be run. Also, to determine if these results affect all seeds, the experiment should be run on a variety of seeds.

Error Analysis

There were several random errors noted in the procedure. The method of measurement often resulted in inaccurate measurements which may be hard to replicate. Another random error could be in the operation of the microwave. Fluctuations in electrical current could have caused fluctuations in the microwaves. Measurement of the water relied on human perception of the meniscus. If the meniscus was not read at exactly the same angle each time this would account for another error. A systemic error was in the design of the experiment. Five replicates of each level provided a minimum number of data points. To alleviate the chance of these errors impacting the results a large number (>100) of each level should be run.