Model Rocket Aerodynamics

Reasons Why Aerodynamics is Important

- Minimize drag
- Make it stable

How Do You Decrease Drag?

$$Drag = 0.5*\rho*V^2*Cd*A$$

ρ = air density

V = speed

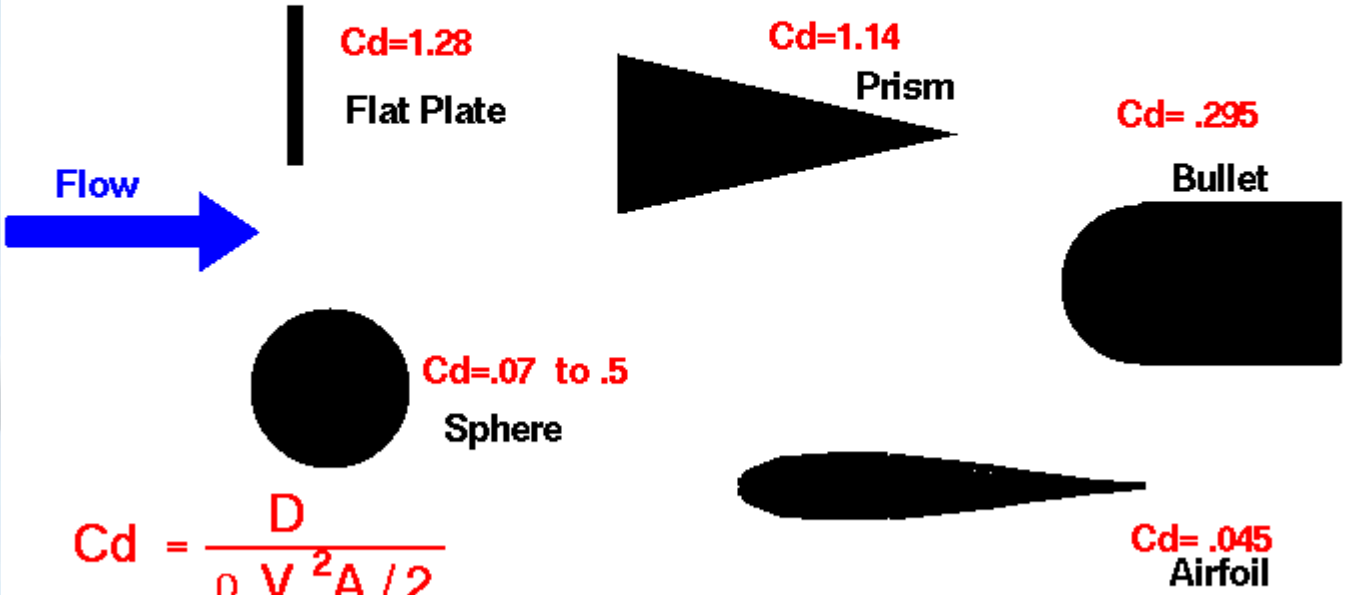
Cd = drag coefficient (shape)

A = reference area (size)

Shape Effects on Drag

Glenn Research Center

The shape of an object has a very great effect on the amount of drag.

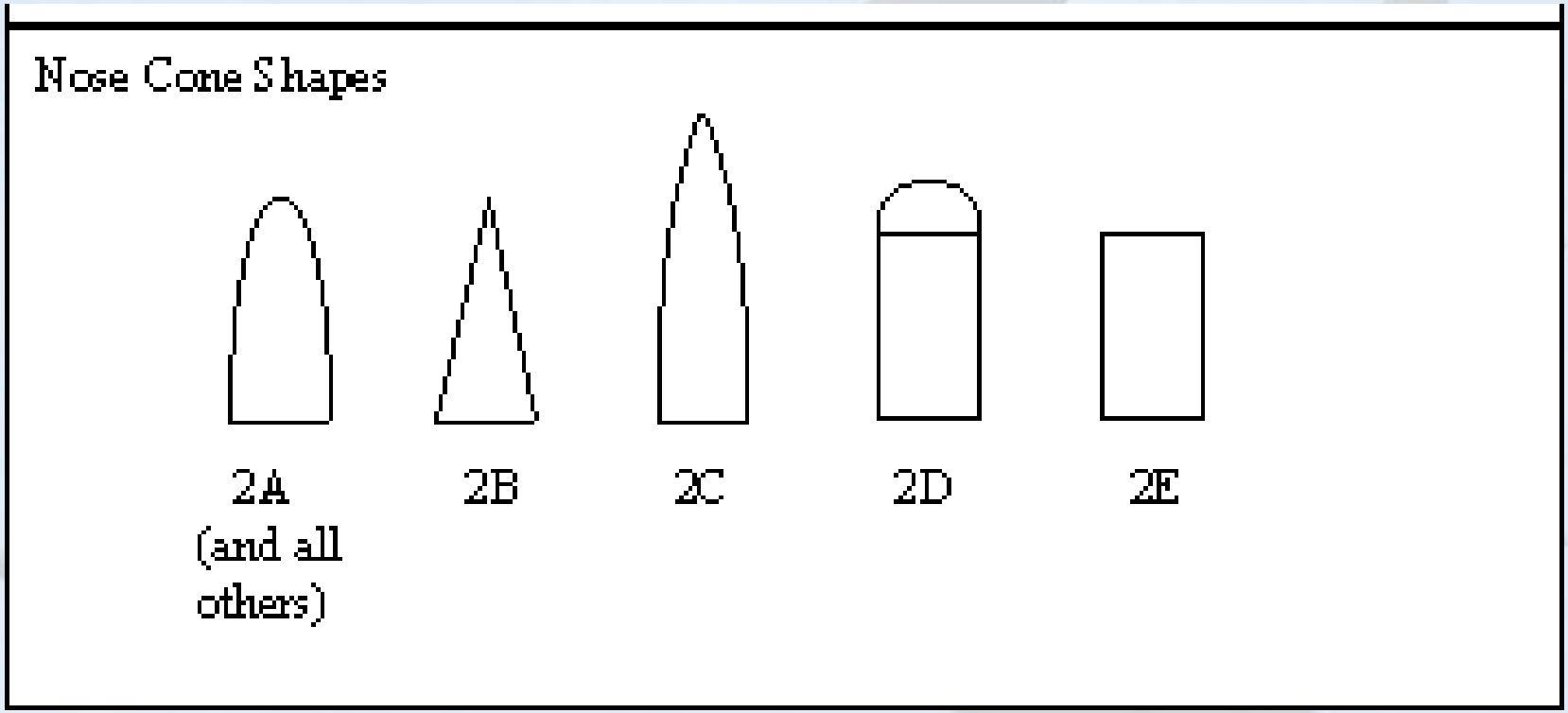


$$Cd = \frac{D}{\rho V^2 A / 2}$$

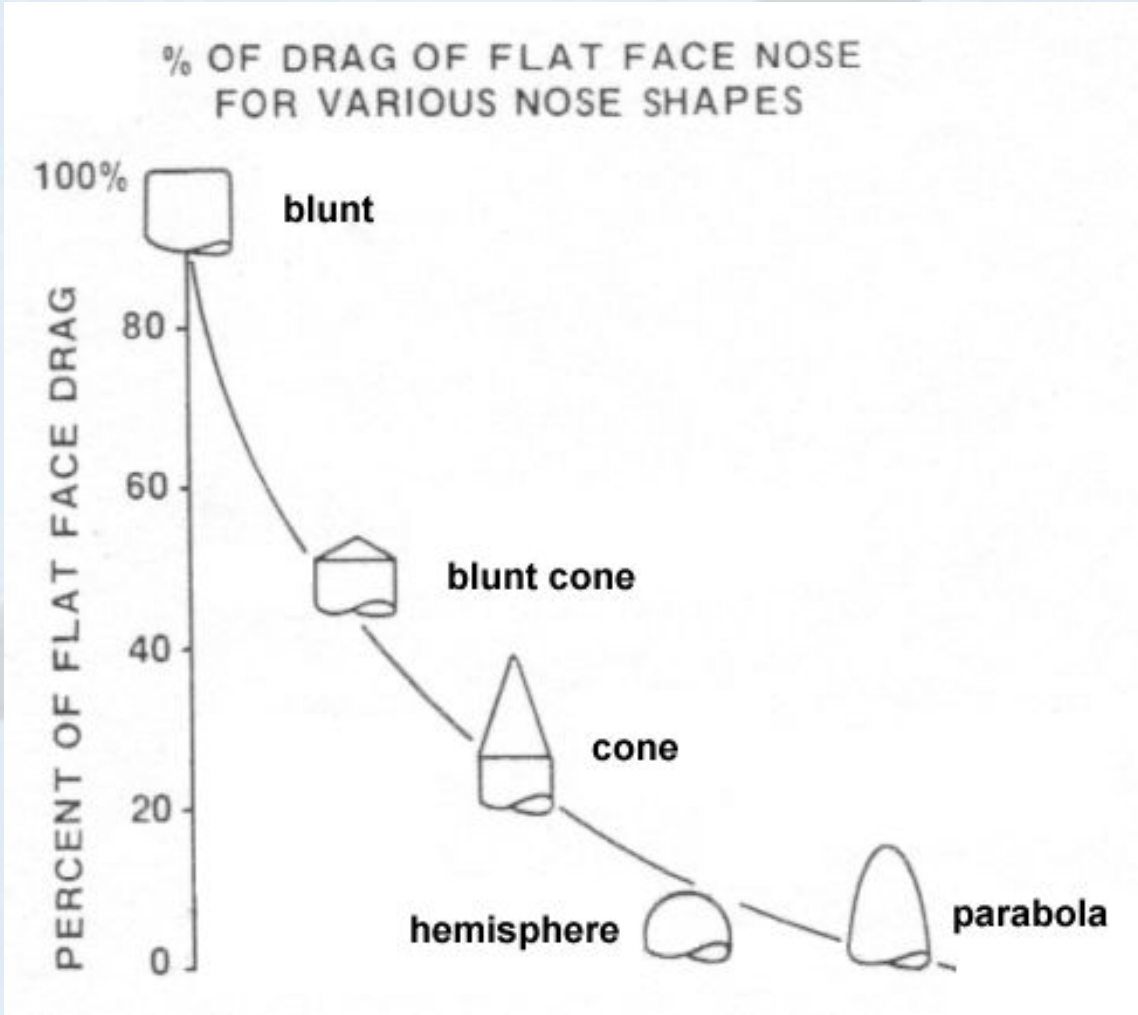
A = frontal area

All objects have the same frontal area.

Drag Coefficients of Various Shapes



Cd:	0.68	0.80	0.75	0.68	1.49


% OF DRAG OF FLAT FACE NOSE
FOR VARIOUS NOSE SHAPES
PERCENT OF FLAT FACE DRAG
100%
80
60
40
20
0
blunt
blunt cone
cone
hemisphere
parabola

Stability

- A vehicle will not fly unless aerodynamically stable, i.e. the nose must be pointed in the same direction during its upward flight.
- If unstable, the rocket will fly erratically and will probably crash into the ground. It is also very dangerous!

Center of Gravity

- The *center of gravity* (CG) is the balance point which a free-flying object rotates around. It is the pivot point for the three main forces acting on the rocket:
  - Thrust
  - Air on the Nose
  - Air on the Fins
- Location of center of mass.

Center of Pressure

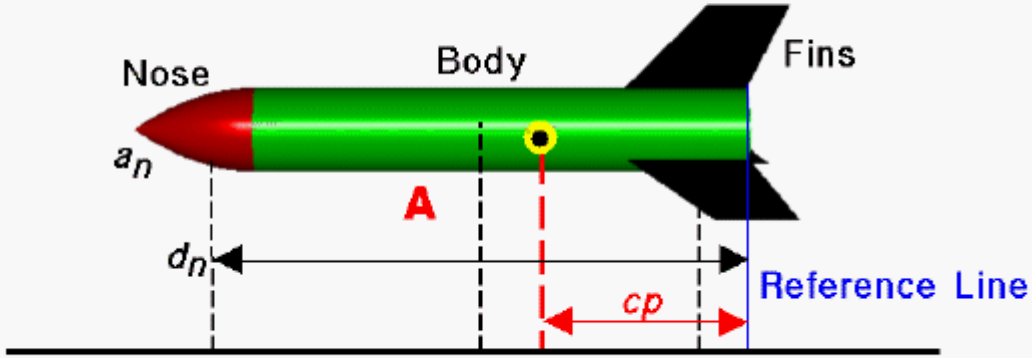
- The *center of pressure* (CP) is the point on which all of the aero forces act upon.
  - Aero force on body
  - Aero force on nose cone
  - Aero force on fins

Requirement of Stable Rocket

- Center of pressure must be behind the center of gravity.

Determining Center of Pressure – cp
(simplified)

Glenn Research Center



Each component has some area a_i located some distance d_i from reference line.

Distance *cp* times the area **A** equals the sum of the component distance times area.

$$cp\ A = d_n a_n + d_b a_b + d_f a_f$$

How To Move Cp Towards Back of Rocket?

- Use large fins
- Move fins as far back as possible
- Move payload as far forward as possible
- Avoid short, stocky body – long slender ones work better for stability
  - Rule of thumb: 10 to 1 length to diameter for body tube

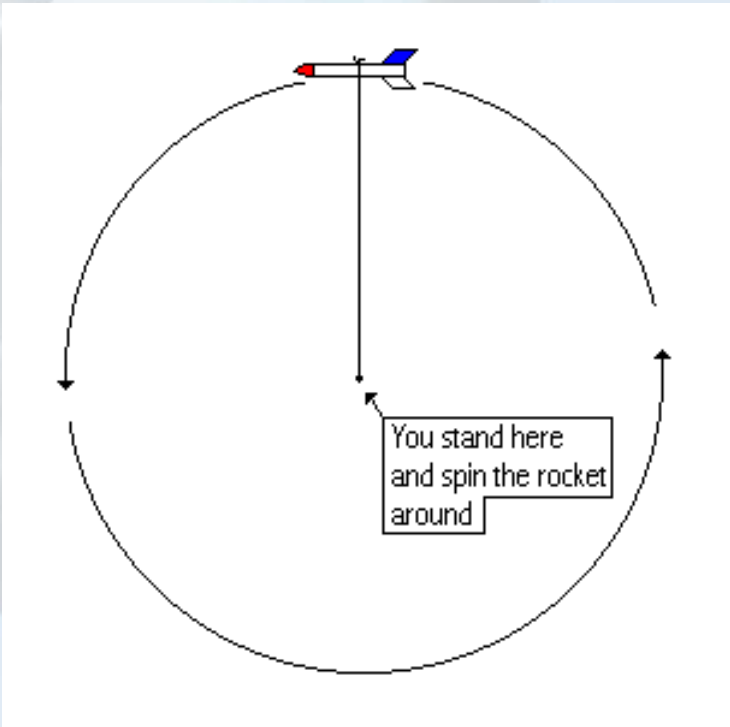
Swing Testing for Stability

To test the stability of a rocket, fly it without launching it.

1) Tape a loop of string around the rocket at the center of gravity (where the rocket balances horizontally).

2) Swing the rocket overhead in a circular path. (Be careful not to hit anything or anyone.)

If the rocket is stable, it will point forward into the wind created by its own motion.



Two Simple Ways to Make a Rocket Stable

1) Move the C.G. forward.

- Pack clay into hollow nose cones

- Add washers to solid nose cones.

2) Replace fins with larger ones, add tabs to the rear or tip edges of the fins,

or add additional fins to the model.

Teams

1	2	3	4
Christian Connors	Brian Munguia	Adam Dallaire	Erin Doran
David Ferrazzoli	Jason Iafigliola	Gaurav Idnany	Christian Keely
John Sobonya	Brandon McCall	Joshua Connors	Michael Munguia
Elias Nader	LaMonz Neuhoff	Kelsey Pickett	Lisa Pogue
Cory Rutherford	John Maroli	Steve Taras	James Weaver