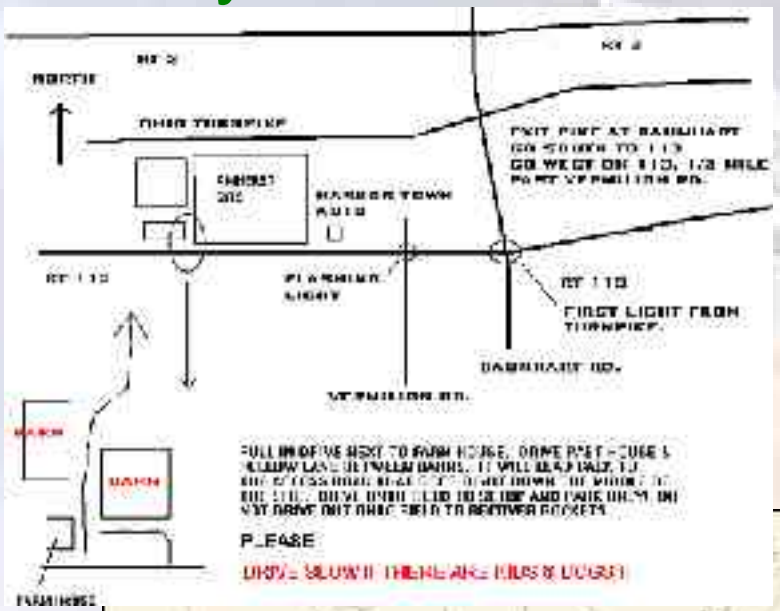
Plan for Saturday

The Field has not been open yet

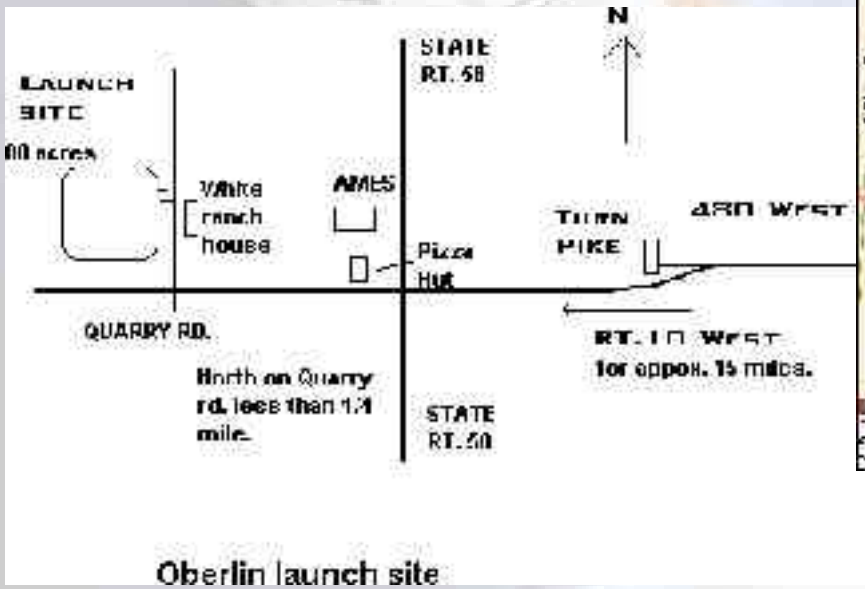
I expect to know the status Thursday

- Email test Wednesday
  - If you get an email from me wednesday, please reply to it.
  - If you do not get an email Wednesday (or thursday PLEASE SEND A EMAIL TO ME Thursday, david.b.snyder@nasa.gov
- Saturday Morning 9:15 AM DEB Lot, North of BrookPark Rd
  - Leave at 9:25AM
  - Bring Permission slip
- Or met us at the Amherst [or Oberlin] launch Site at 10AM
- Launch times 10AM-4PM
- Hope to be finished 12:30/!PM time frame
  - Return to DEB 1:30PM



Alternative Site

- Oberlin
  - Quarrt Rd, North of US20
-



N.A.R. Model Rocket Safety Code (1)

1. Materials. I will use only lightweight, non-metal parts for the nose, body, and fins of my rocket.
2. Motors. I will use only certified, commercially-made model rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer.
3. Ignition System. I will launch my rockets with an electrical launch system and electrical motor igniters. My launch system will have a safety interlock in series with the launch switch, and will use a launch switch that returns to the "off" position when released.
4. Misfires. If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.
5. Launch Safety. I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance.
6. Launcher. I will launch my rocket from a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up, and I will use a blast deflector to prevent the motor's exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is above eye level or will cap the end of the rod when it is not in use.

(Revision of February, 2001)

Model Rocket Safety Code (2)

7. Size. My model rocket will not weigh more than 1,500 grams (53 ounces) at liftoff and will not contain more than 125 grams (4.4 ounces) of propellant or 320 N-sec (71.9 pound-seconds) of total impulse. If my model rocket weighs more than one pound (453 grams) at liftoff or has more than four ounces (113 grams) of propellant, I will check and comply with Federal Aviation Administration regulations before flying.
8. Flight Safety. I will not launch my rocket at targets, into clouds, or near airplanes, and will not put any flammable or explosive payload in my rocket.

(Revision of February, 2001)

9. Launch Site. I will launch my rocket outdoors, in an open area at least as large as shown in the accompanying table, and in safe weather conditions with wind speeds no greater than 20 miles per hour. I will ensure that there is no dry grass close to the launch pad, and that the launch site does not present risk of grass fires.
10. Recovery System. I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.
11. Recovery Safety. I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places.

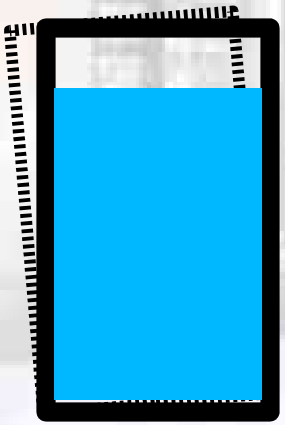
Range Safety

- **The Range Safety Officer's(RSO) word is as the word of God,**
  - nobody can override a Safety decision made by an RSO
- Only go on the field when it is safe. i.e. An announce-ment is made.
  - A large number of rockets may be flown from several areas
  - Several (5) rockets may be launched consecutively
- Stay behind the barriers
  - Unless you are given permission to prepare your rocket
- Do not chase your rocket until the 'all clear' is given
  - Watch where it lands, select a feature behind it to quide your search
  - Watch the egg carrier first and rocket body second.

Stability

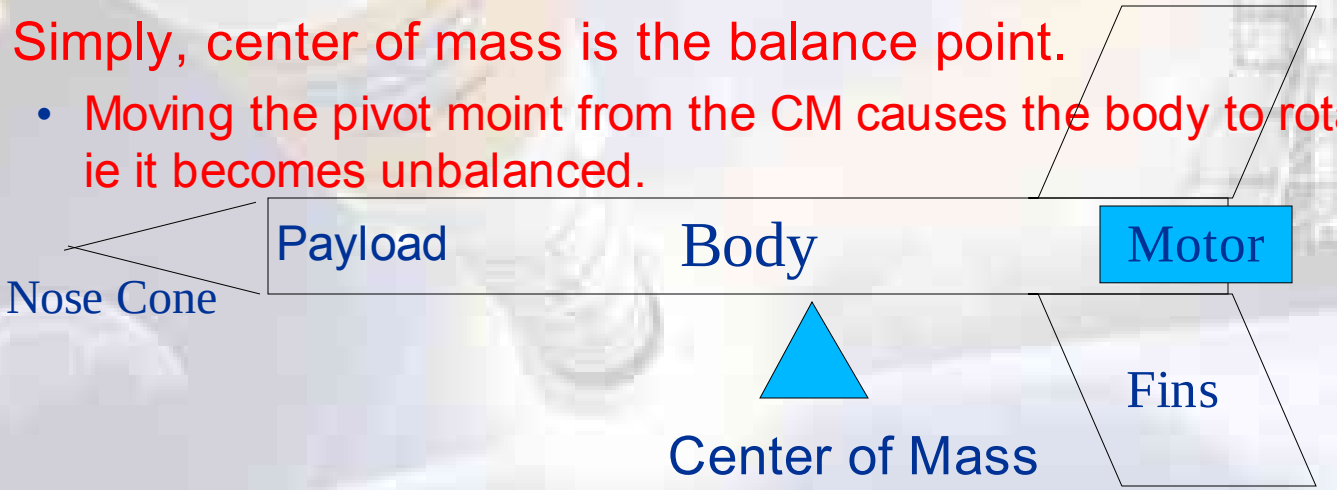
What is Stability

- Tendency to return to a position, when moved slightly.
- Glass returns to upright position when bumped
- We want a rocket that tends to move forward
  - Winds and asymmetries may bump the rocket off regular trajectory. Rocket may point away from direction of motion.
  - Rocket must return to pointing in the direction of motion.
    - Active: control surfaces might be changed to guide the rocket. This is how an airplane works.
    - Passive: The design makes the rocket tends to point the rocket in the direction of motion. Keeps thrust forward.



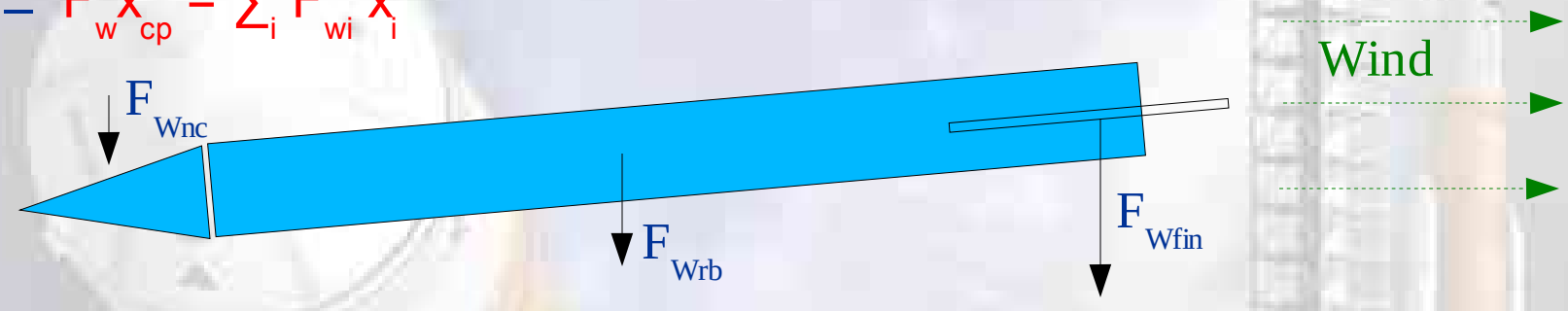
Center of Mass

- Two Concepts help design a stable Rocket
  - Center of Mass
  - Center of Pressure
- Center of Mass is the point that a body tends to pivot around.
  - Sum of (Masses x D
  - istance) = zero
  - x_{cm}, such that $\sum_i (x_i - x_{cm}) m_i = 0$
  - Simply, center of mass is the balance point.
    - Moving the pivot moint from the CM causes the body to rotate, ie it becomes unbalanced.



Center of Pressure

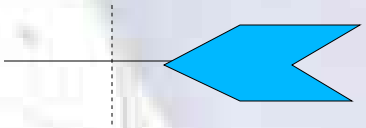
- Center of Pressure: Position that the wind force averages arround.
  - $F_w x_{cp} = \sum_i F_{wi} x_i$



- Approximately where the area balances.
  - If body is sideways, Wind force is proportional to Area.

Rocket Stability

- Weather Vane
  - If pivot point ahead of CP will point into wind.



- **Unstable** flight means the rocket may change direction suddenly, unpredictably - ***UNSAFE.***
- With a rocket the center of mass is the Pivot point
- **Requirement for safe flight: CM ahead of CP (by at least 1 to 1.5 body diameters)**
  - **Range Safety Officer may require proof of stability.**
- Launch rail guides the rocket until its speed builds up
- An slightly unstable rocket may become stable as rocket fuel is burned, shifting CM forward. *Unpredictable*.

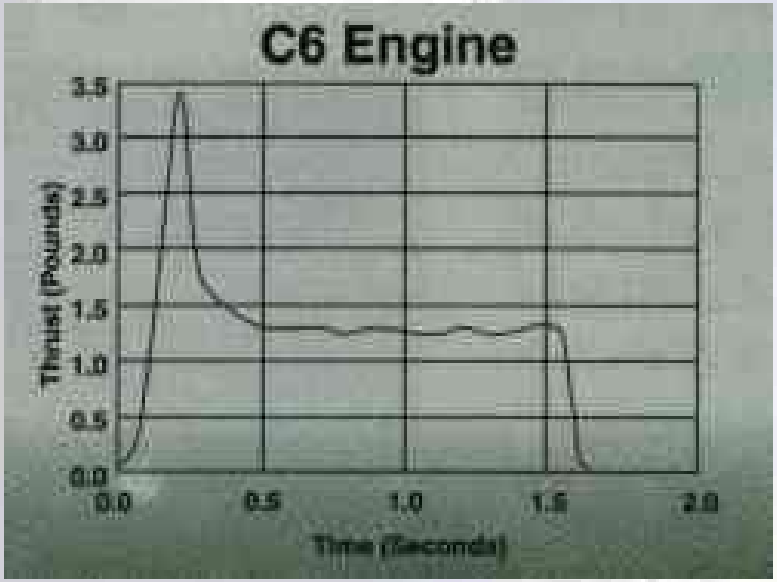
Model Rocket Trajectory

- Use Equation on Motion, F=ma
  - Use time intervals to calculate:
    - Adjusted Forces during Flight
    - Change in Velocity
    - Change in position
- Ma = F = -gravity + Thrust – Air Resistance
  - $F = -mg + F_T(t) - \frac{1}{2}CA\rho\, v^2$
  - $\Delta V = F*\Delta t / m$
  - $\Delta x = v*\Delta t\ [+1/2\ F/m\ *\Delta t^2]$
- Develop Table
  - Time, mass, mg, thrust, Air R, F, a, Δv, v, Δx, x
  - Need: Thrust Curve, $\frac{1}{2}CA\rho$, Mass

Estes C6 Thrust Curve

- Data from NAR

http://www.nar.org/SandT/pdf/Estes/C6.pdf

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; File produced October 3, 2000
; The total impulse, peak thrust, average thrust and burn time are
; the same as the averaged static test data on the NAR web site in
; the certification file. The curve drawn with these data points is as
; close to the certification curve as can be with such a limited
; number of points (32) allowed with wRASP up to v1.6.
C6 18 70 0-3-5-7 .0108 .0231 E
0.031 0.946
0.092 4.826
0.139 9.936
0.192 14.090
0.209 11.446
0.231 7.381
0.248 6.151
0.292 5.489
0.370 4.921
0.475 4.448
0.671 4.258
0.702 4.542
0.723 4.164
0.850 4.448
1.063 4.353
1.211 4.353
1.242 4.069
1.303 4.258
1.468 4.353
1.656 4.448
1.821 4.448
1.834 2.933
1.847 1.325
1.860 0.000
```

WorkSheet

Time	Thrust (N) C6 motor	Gravity N	v*v (m/s)^2	Air Resistar K*v*v (N)	Total force N	A (F/m)	Delta Veloc Dv = a*dt	Velocity(m V0+dv	Delta X dx=v*dt	Altitude x0+dx	Altitude (ft)
0.0	7.0	-1.20	0.0	0.00	5.8	47.58		0.0		0.0	0.0
0.2	7.0	-1.20	90.5	-0.05	5.75	47.15	9.5	9.5	1.90	1.9	6.2
0.4	4.4	-1.20	358.9	-0.21	3	24.58	9.4	18.9	3.79	5.7	18.7
0.6	4.4	-1.20									
0.8	4.4	-1.20									
1.0	4.3	-1.20									
1.2	4.3	-1.20									
1.4	4.4	-1.20									
1.6	3.0	-1.20									
1.8	0.0	-1.20									
2.0	0.0	-1.20									
2.5	0.0	-1.20									
3.0	0.0	-1.20									
3.5	0.0	-1.20									
4.0	0.0	-1.20									
4.5	0.0	-1.20									
5.0	0.0	-1.20									
5.5	0.0	-1.20									
6.0	0.0	-1.20									

Table

Egg Flight	Worksheet								
Mass	0.122	Egg	55.0	Rocket	57	Motor	10.0		
Area(m^2)	0.00182	Tube Diam	4.8	Cm					
Air Coef	0.5								
Air density	1.25	Temp (K)	280.0	Pressure	1.01E+05	R	8.3		
K = CA rho	0.00057								

Time	Thrust (N) C6 motor	Gravity N	v*v (m/s)^2	Air Resistar K*v*v (N)	Total force N	A (F/m)	Delta Velo Dv = a*dt	Velocity(m V0+dv	Delta X dx=v*dt	Altitude x0+dx	Altitude (ft)
0.0	7.0	-1.20	0.0	0.00	5.8	47.58		0.0		0.0	0.0
0.2	7.0	-1.20	90.5	-0.05	5.75	47.15	9.5	9.5	1.90	1.9	6.2
0.4	4.4	-1.20	358.9	-0.21	3	24.58	9.4	18.9	3.79	5.7	18.7
0.6	4.4	-1.20	569.4	-0.33	2.88	23.6	4.9	23.9	4.77	10.5	34.3
0.8	4.4	-1.20	816.9	-0.47	2.74	22.44	4.7	28.6	5.72	16.2	53.1
1.0	4.3	-1.20	1093.5	-0.63	2.48	20.32	4.5	33.1	6.61	22.8	74.8
1.2	4.3	-1.20	1378.8	-0.79	2.32	18.98	4.1	37.1	7.43	30.2	99.2
1.4	4.4	-1.20	1675.2	-0.96	2.25	18.41	3.8	40.9	8.19	38.4	126.0
1.6	3.0	-1.20	1990.2	-1.14	0.67	5.46	3.7	44.6	8.92	47.3	155.3
1.8	0.0	-1.20	2088.8	-1.19	-2.39	-19.59	1.1	45.7	9.14	56.5	185.3
2.0	0.0	-1.20	1746.0	-1.00	-2.19	-17.99	-3.9	41.8	8.36	64.8	212.7
2.5	0.0	-1.20	1075.3	-0.62	-1.81	-14.84	-9.0	32.8	16.40	81.2	266.5
3.0	0.0	-1.20	643.7	-0.37	-1.56	-12.82	-7.4	25.4	12.69	93.9	308.1
3.5	0.0	-1.20	359.6	-0.21	-1.4	-11.49	-6.4	19.0	9.48	103.4	339.2
4.0	0.0	-1.20	174.8	-0.10	-1.3	-10.62	-5.7	13.2	6.61	110.0	360.9
4.5	0.0	-1.20	62.6	-0.04	-1.23	-10.09	-5.3	7.9	3.95	114.0	373.9
5.0	0.0	-1.20	8.2	0.00	-1.2	-9.84	-5.0	2.9	1.43	115.4	378.6
5.5	0.0	-1.20	4.2	0.00	-1.19	-9.78	-4.9	-2.1	-1.03	114.4	375.2
6.0	0.0	-1.20	48.2	0.03	-1.17	-9.57	-4.9	-6.9	-3.47	110.9	363.8