Eggsploration – Opening Questions

Context: During a Rocket Launch

How is a Person Like an egg?

How are they different?

Ugly Bags of Mostly Water

- Biological Systems on Earth are mostly Water
  - Humans: 60% water
  - Eggs: 74% water
- Water is an 'incompressible' liquid
  - Pressure changes do not result in volume changes
  - If a volume of water is moved from one place, it has to go somewhere else.
  - A Gas (Air) is compressible – more air can be put in a volume by increasing the pressure.
- If I stand on my head
  - Would my feet shrink of expand?
  - Would my head shrink or expand?

Eggsploration - Strategies

- Methods to protect an egg/human
  - Exoskeleton
  - Cushion
  - Parachute

Eggsploration – Equation of Motion

Equation of Motion helps Understand Forces

- F=MA

$$v(t)=v_0+at$$

$$x(t)=x_0+v_0 t+1/2\,a t^2$$

$$a=g=9.8\,m/s$$

- **Drop time (*t*), v_0=0**

$$t=\sqrt{(2x/g)}$$

$$=\sqrt{(x(meters)/4.9)}\,seconds$$

$$V_{max}=a\,t=9.8\,t\,m/s$$

Drop Distance (ft)	Drop Distance (m	Time (s)	Velocity (m/s)	Velocit Mph
4	1.22	0.5	4.89	10.94
6	1.83	0.61	5.99	13.39
8	2.44	0.71	6.91	15.46
16	4.88	1	9.78	21.87

- Deceleration
  - Set v(t)=0 (object stopped),

$$a=-v_0/t$$

  - Δx = x(t)-x0 (cushion thickness)

$$\Delta x=v_0 t-1/2\,v_0 t=1/2\,v_0 t$$

$$t=2\Delta x/v_0$$

$$a=v_0 t=v_0^2/2\Delta x$$

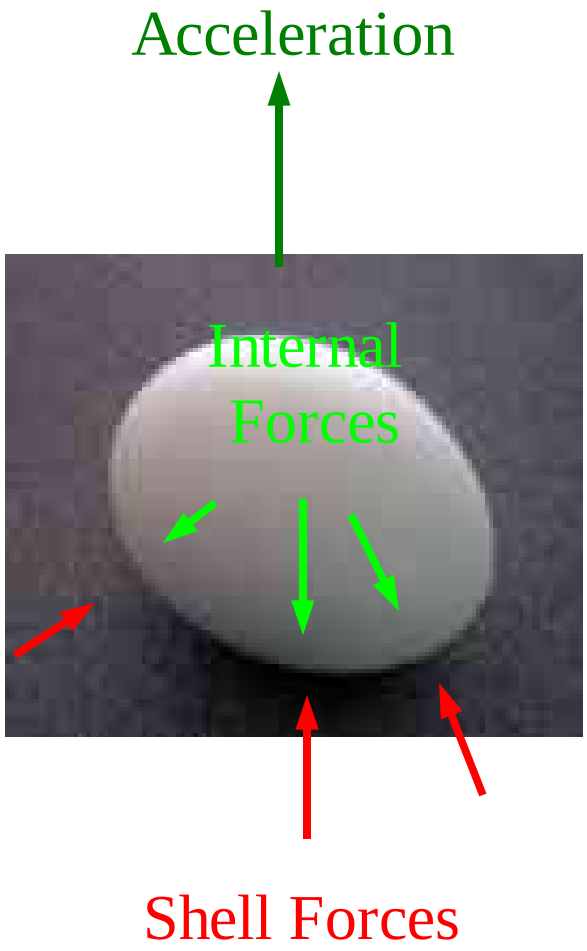
  - Acceleration in g's is a/g

$$a/g=2v_0^2/(2*9.8\Delta x)$$

	Initial Velocity	9.91 m/s	
Distance (in)	Distance (m)	Time	Acceleration (g)
1	0.03	0.202	5.01
0.25	0.01	0.050	20.04
0.13	0	0.025	40.08

Eggsploration - Eggoskeleton

- Exoskeleton: hard shell that contains fluids, redistributes forces. Keeps insides from moving.
  - Insects, Eggs, shoes
- Egg Protection
  - Add a harder stronger shell
    - Less Flexible
- People protection
  - Helmet
  - Military Pilots may use pressurized leg/foot wear to keep fluids out of feet and in the brain so they don't loose consciousness during High G maneuvers



Eggsploration - Cushions

Cushions help in two ways

- Distribute Force over larger area
  - Reduce Pressure
  - P = F/A, ¼ lb/ ¼ sq in > ¼ lb/ 1 sq in
- Reduce Force by reducing Acceleration.
  - Cushioned object can move a little relative to its container.
  - Reduces Force from Extreme to large

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- Can be effective when combined with Exoskeleton
  - Padding in a helmet.

Eggsploration - Parachute

- Parachute reduces Terminal velocity so that the object is traveling slower when he hits.
- Force due to gravity (Mg) is opposed by Air resistance force (C A v^2), at terminal velocity they are equal.
  - $Mg - CAv_t^2 = 0$
  - $v_t = \sqrt{(Mg/CA)}$

The parachute tests demonstrated a three-stage deployment sequence that included the use of an Orbiter drag chute, seen in this photo, to properly stage the unfurling of the main chute.