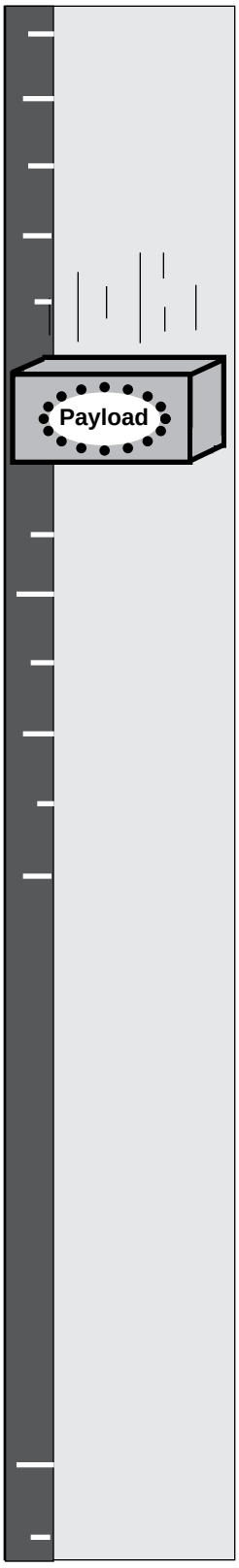
Mathematics Excursion

The "gee!" in Microgravity

Objective: To describe, understand, and use the mathematical relationship between the height of a drop tower or tube and the duration of the microgravity condition for experimental payloads experiencing free fall within the facility.

Materials:
- pencil, paper, calculator
- access to print or on-line general reference resources



Background: Microgravity can be achieved on earth using technologies dependent upon the act of free fall. Drop towers and drop tubes permit test payloads to drop a distance *d* from rest, at a gravitational acceleration *g* for a time *t.* The longer a payload falls after being released in a drop facility, the greater the distance it travels. Likewise, the taller the drop tower, the more time the payload has to fall -- so that more time is available for observing how the payload reacts in its temporary condition of microgravity.

The equation that describes this relationship is

$$\mathbf{d = gt^2/2}$$

where d = the distance the object falls

g = about 32 ft/s^2 for objects falling near earth

t = the time the object falls

From this equation, observe that doubling the drop time requires four times the distance.

Procedure: 1. For each of the following drop facilities compute t, the duration of free fall experienced by the falling payload.

Facility: NASA Lewis Research Center Drop Tower Height: 132m
Facility: NASA Marshall Space Flight Center Drop Tube Height: 100m
Facility: Converted mine shaft drop facility in Japan Height: 490m

Without changing the height of the above facilities, devise a way to double the time the payload spends in microgravity. (BIG HINT: Think about springboard divers, football game kickoffs, and sounding rockets on parabolic paths. All these examples represent free fall.)

2. Contact the local government offices for your hometown to determine the location and height of the tallest building in your city. What duration of free fall would NASA researchers obtain if you were to invite them to your community to conduct free fall experiments off this building? Given the heights of existing NASA microgravity facilities, do you think they would want to accept your invitation?

3. A team of Russian microgravity researchers wishes to obtain a drop duration of 6 seconds. Compute how tall the drop tower or tube must be. Is it reasonable to construct a tower of this magnitude?

4. Not to be outdone by their Russian counterparts, a team of Japanese microgravity researchers attempt to construct a drop tower which will allow payloads to experience 7 seconds of free fall. How tall would such a drop facility have to be? Is it reasonable to construct a tower of this height? What are the practical considerations for making a decision such as this?

5. The moon's gravitational acceleration is only 1/6 that of earth's. If the Russian research team were to construct their 6-second drop facility on the moon, how tall would it now need to be built? What about the Japanese team?

6. Using print or computer on-line resources, search for the name, location,and height of the five tallest buildings in the world. For each building, compute the time it would take a baseball dropped from rest off the top of the building to hit the ground.