Free Fall

A bit of history…

Aristotle (Greek philosopher/scientist) divided motion into two main classes:

1. *Natural Motio*n – results from "nature" of objects
   - Clay (from the earth) will fall to the ground
   - Smoke (being of air) rises
   - Feather (mostly Earth, a little air) falls to the ground but not as fast as clay

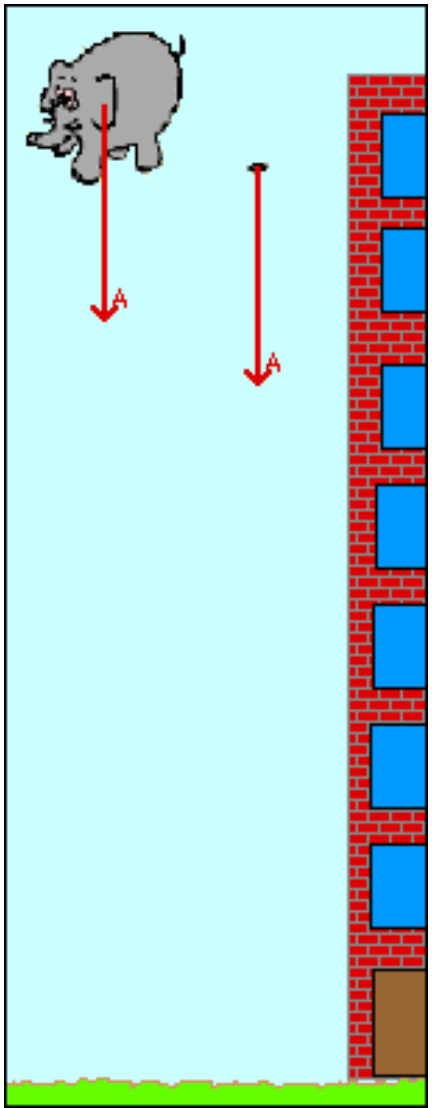
   *Objects fall at speeds proportional to their weights – the heavier the object, the faster it falls
2. *Violent Motion* – pushing cart, tug of war
   - Externally caused – outside forces cause object to move

<u>Summary:</u> All motions resulted from the nature of the moving object or from a sustained push or pull.

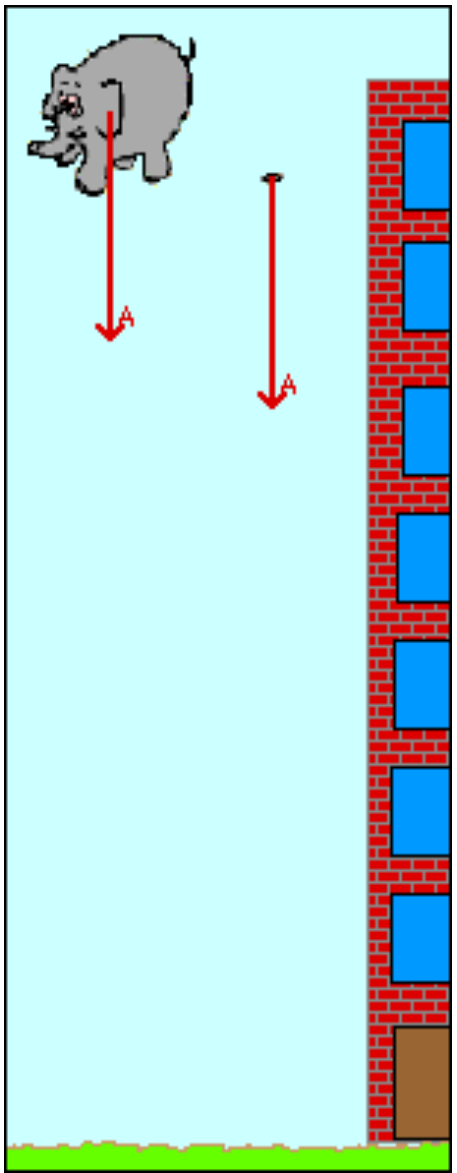
...a bit more history

- Galileo (Italy, 1600s) attempted to prove Aristotle's theories wrong.
- He drops objects of various weights from the top of the Leaning Tower of Pisa and compares the falls.
- He thinks that light objects and heavy objects will fall at the same rate.
- Galileo discovered that in the absence of air resistance all objects near the surface of earth accelerate at **$-9.8\ m/s^2$**.

The Elephant and the Feather, Free Fall



The Elephant and the Feather - Air Drag



Acceleration due to gravity, g

- If an object is in free fall, it ALWAYS accelerates at negative 'g'. ($g = 10\ m/s^2$)
- Gravity pulls objects towards earth (down), therefore we use acceleration due to gravity $a = -g$ when we are solving free fall problems

- **$\underline{a = -9.8\ m/s^2}$ for ANY object in free fall – ALWAYS!**

One Dimensional Motion: Recipe

1. Draw a cartoon with the coordinate axis at ground level.
2. Label the diagram with the given information.
3. Pick the proper equation and solve!

- $v_{top} = 0$ m/s
- If an object is dropped, $v_0 = 0$ m/s
- $t_{rise} = t_{fall}$ when objects return to same height
- **$a = -9.8$ m/s^2**

Formulas for Constant Acceleration

1. $v = at + v_0$
2. $s - s_0 = \bar{v}t = (\frac{v + v_0}{2})t$
3. $s = \frac{1}{2}at^2 + v_0 t + s_0$
4. $v^2 - {v_0}^2 = 2a(s - s_0)$

Notes:

1. If time is not involved in the problem, use equation 4.
2. If time is involved in the problem as a given value or as the unknown, use equation 1 or 3.
3. At the zenith, vertical velocity v_y=0.
4. For initial velocities:
    1. V_0=0 if we drop the ball
    2. V_0= (+) if we toss it upward
    3. V_0= (-) if we throw it downward

Conceptual Examples

Ex1: A ball is dropped off a cliff. What is its speed after 4 s? 9 s?

Ex2: A ball is tossed straight up at 30 m/s. How long does it take to reach max height? How long is it in the air?

Ex: A gumdrop is released from rest at the top of the Empire State Building, which is 381 m tall. Ignoring air resistance, calculate:

a) the total time the gumdrop is in the air

b) Its displacement at 3.00 s

c) Its final velocity

Example: Brad throws an orange straight up at 60 m/s.

a) Find the total time airborne

b) Find the time to the apex

c) Find the location at the zenith

d) Find the velocity with which it hits the ground

e) Find the time at which the speed is 20 m/s