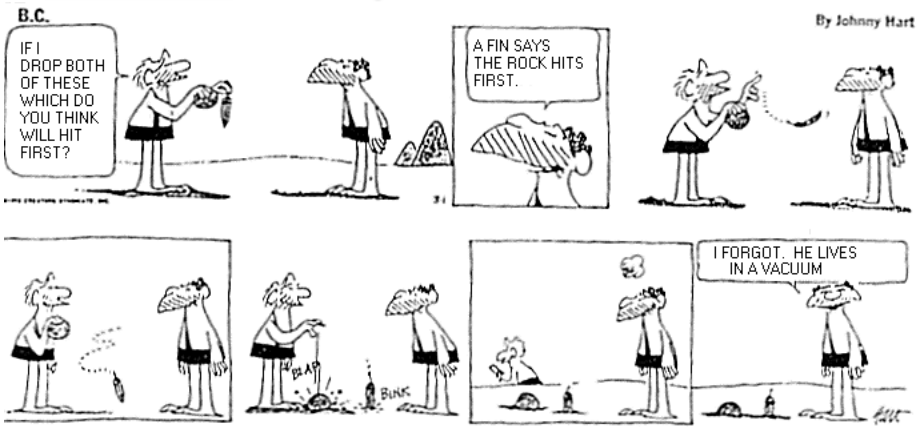
September 19, 2012 Physics 131 Prof. E. F. Redish

- **Theme Music: Free Fallin'**
  Tom Petty
- **Cartoon: Johnny Hart**



Conceptual ideas underlying Newton's Laws 1-3

1. Objects respond only to influences acting upon them at the instant that those influences act. (Object egotism) [Newton 0]
2. All outside effects on an object being equal, the object maintains its velocity (including direction). The velocity could be zero, which would mean the object is at rest. (Inertia) [Newton 1]
3. Every change in velocity an object experiences is caused by the object interacting with some other object – **forces**. (Interactions)

Conceptual ideas underlying Newton's Laws 4-6

4. If there are a lot of different objects that are interacting with the object we are considering, the overall result is the same as if we add up all the forces as vectors and produce a single effective force -- the **net force**. (Superposition)
5. When one object exerts a force on another, that force is shared over all parts of the structure of the object. (Mass)
6. The acceleration felt by an object at a given instant is the net force on the object at that instant divided by the object's mass. [Newton 2]
7. Whenever two objects interact, they exert forces on each other. (Reciprocity) [Newton 3]

The Properties of Gravity

- Experiment: See how it behaves when gravity is the only force acting on it. We expect it to speed up (accelerate). How does that acceleration depend on the object?

$$\vec{a}_A = \frac{\vec{W}_{E\to A}}{m_A}$$

The Gravitational Field Strength

- We find that, when we can ignore the effects of other objects (the air), that all objects accelerate the same in free fall (only *W* acting).

$$\vec{a}_A = \frac{\vec{W}_{E\to A}}{m_A} = \vec{g} \qquad \text{(independent of A!)}$$

- Experimentally, this is a constant independent of the object. Therefore:

$$\vec{W}_{E\to A} = m_A \vec{g}$$

- Define the constant g as the *gravitational field strength.* (Units of N/kg)

Foothold Ideas: Gravity

- Every object (near the surface of the earth) feels a downward pull proportional to its mass:

$$\vec{W}_{E\to m} = m\vec{g}$$

What object causes *W*?

where $\vec{g}$ is referred to as *the gravitational field.*

- This is a pForce even though nothing touching the object is responsible for it.
- The gravitational field has the same magnitude for all objects irrespective of their motion and at all points.
- The gravitational field always points down.
- It is measured to be $g \approx 9.8$ N/kg

Why N/kg instead of m/s^2?

Response to Gravity: Free Fall

- After an object has been released,
  - if it is dense enough so the forces from the air can be ignored
  - if nothing else is touching it

  the only force acting on it is gravity.

$$\vec{a} = \vec{F}^{net}/m = \vec{W}_{E\to m}/m = m\vec{g}/m = \vec{g}$$