October 1, 2012   Physics 131   Prof. E. F. Redish
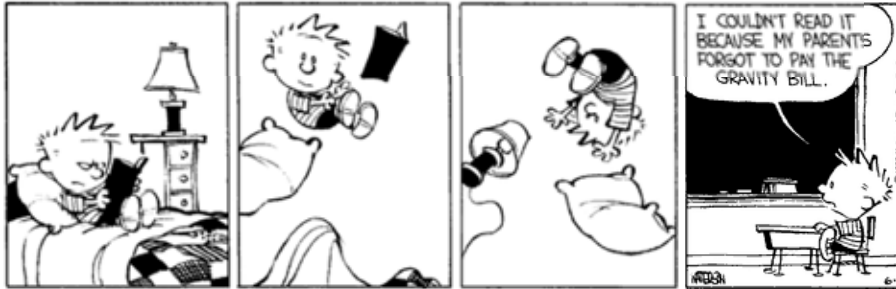
■ **Theme Music: Gravity**
       John Mayer

■ **Cartoon: Bil Watterson**
       Calvin & Hobbes

I COULDN'T READ IT BECAUSE MY PARENTS FORGOT TO PAY THE GRAVITY BILL.

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Foothold ideas:
Viscosity

■ Viscosity is a resistive force that an object feels when it moves through a fluid as a result of the fluid sticking to the object's surface. This layer of fluid tries to slide over the next layer of fluid and the friction between the speeds that layer up and so on.

■ The result is a force proportional to the velocity of the object.

$$\vec{F}^{viscous}_{fluid \to object} = -6\pi\mu R_{object}\vec{v}$$

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Foothold ideas:
Drag force

- The drag ("Newtonian drag") is a resistive force felt by an object moving through a fluid. It arises because the object is pushing fluid in front of it, bringing it up to the same speed it's going.

- The result is a force proportional to the density of the fluid, the area of the object, and the square of the object's velocity.

$$F_{fluid \to object}^{drag} = Cd_{fluid} A_{object} v^2$$

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Reynolds' Number

- Generally, for an object moving in a fluid both drag and viscosity are present. However, often, one is much more important.

- The ratio of the two forces (drag / viscosity) is called the Reynolds' Number (leaving out a few dimensionless constants)

$$\mathrm{Re} = \frac{dvR}{\mu}$$

- Small objects in water (v, R small) are generally dominated by viscosity; larger objects in air (v, R large) tend to be dominated by drag.

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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/s²?

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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.

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

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