

★Reading: chapter 6.

- Even though we're not learning about potential energy until next week, we get an appetizer of the idea in this week's chapter. How much work is required to lift a bag of groceries up some stairs? Consider carrying them up a ramp. Draw force diagram. Suppose that the height increase is  $h$ . Show that the work needed is

$$W = mgh$$

(we'll later identify this with potential energy). Note it depends only on the altitude increase, not on the slope of the ramp. Note that if  $h$  is negative, e.g. carrying groceries down to the basement, then  $W = mgh$  is negative.

- Example: An eraser, which weighs 1N (same as an apple) is lifted 2m. How much work is done? It is then released and dropped to the ground. How much kinetic energy does it have when it hits the ground? What is its velocity when it hits the ground?

- Example from book: Throcky on a swing, making angle  $\theta$  w.r.t. vertical. Horizontal push is  $F_x = T \sin \theta = w \tan \theta$ . The distance is  $d\vec{x} = R d\theta (\cos \theta \hat{i} + \sin \theta \hat{j})$ , so  $W = wR \int \sin \theta d\theta = wR(1 - \cos \theta_0) = mgh$ . The  $mgh$  answer is universal, we didn't really have to do the integral etc, could have written down the answer immediately.

- Springs! Hooke's law:  $F_x = -kx$ , where  $k$  is the spring constant, which depends on the spring (stretchy springs have small  $k$ , and stiff springs have large  $k$ ). We're taking  $x = 0$  to be the springs natural equilibrium position. Compute the work needed to compress or stretch a spring, from equilibrium to some point  $x$ :  $W = \int_0^x kx dx = \frac{1}{2}kx^2$ ,

$$W_{\text{on spring}} = \frac{1}{2}kx^2.$$

This energy is stored in the compressed spring. (Next week we'll call it the spring's potential energy.) The energy can come back out by letting the spring release.

- Example: consider a spring with  $k = 20N/m$ . It is compressed by 10cm and an apple, which weights 1N, is placed on top. There's a countdown, and the apple is launched, like a rocket, into the air. How high does the apple go, ignoring friction? What is the velocity of the apple when it lands, ignoring friction? Now suppose we don't ignore friction. What can you say about the velocity of the apple when it lands? Which half of the apple's journey takes longer, up or down? The power of energy conservation!