Chapter C7: Potential Energy

Physics I

College of the Atlantic

C7.1: The Electromagnetic Interaction

Don't worry about this section.

C7.2: The Gravitational Interaction

The main equation:

$$V(r) = -G\frac{m_1 m_2}{r} . \tag{1}$$

- This looks weird. Sketch the function and remember that all that matters is potential energy differences. Then it won't seem so bad.
- G is the universal gravitational constant: $G = 6.67 \times 10^{-11} \frac{\text{Jm}}{\text{kg}^2}$.

C7.3: Gravitation Near the Earth

The punchline of this section is Figure C7.3 on p. 123. This figure shows us that Eq. (1) is well approximated by $V(z) = mgz$ near the earth's surface.

C7.4: The Potential Energy of a Spring

- The main equation is:

$$V(r) = \frac{1}{2}k_s(r - r_0)^2 . \tag{2}$$

- This is often written in the simpler form:

$$V(r) = \frac{1}{2}k_s x^2 , \tag{3}$$

  where it is understood that the spring has zero potential energy when it is relaxed—i.e. neither compressed or stretched.

- This equation is an approximation. For most springs it is an extremely good approximation, as long as the string is not stretched or compressed too much.
- This equation is also used for any interaction whose potential energy function has a quadratic (parabola-like) minimum. This is the point of Fig. (C7.5).

C7.6: Significant Digits

Don't get carried away with digits.

Examples

1. A mango is thrown straight up at a speed of 20 m/s. How high does the mango go before it returns to earth?

2. The radius of the moon is 1740 km and its mass is 7.4×10^{22} kg. A 5 kg piece of cheese is dropped from a spaceship floating 50 km above the moon's surface. What is the cheese's speed right before it hits the moon?

3. A spring has a length of 8 cm when unstretched. It is then pushed in 3 cm (so that it is 5 cm long) and used to shoot a 12 g marble. What is the speed of the marble immediately after it is launched? The spring has a spring constant of 450 J/m^2.

Practice

1. A 50 kg diver jumps into the sea 40 meters below. The water into which she jumps is 20 meters deep. Determine her speed immediately before she hits the water. Do this problem two ways:
   (a) Use the surface of the water as your reference level.
   (b) Use the bottom of the sea as your reference level.

2. The space shuttle orbits at an altitude of 400 km above the earth's surface. Suppose the shuttle suddenly stops orbiting and falls to earth. What is the speed of the shuttle right before it hits the earth's surface? Ignore air friction. Do this problem two ways:
   (a) Use formula C7.3 for the gravitational potential energy
   (b) Use $V(z) = mgz$ for the gravitational potential energy

3. A spring with a spring constant of 300 $\mathrm{J/m^2}$ is compressed 3 cm. This is then used to shoot a 30 g marble straight up into the air.
   (a) What is the marble's speed immediately after the spring is released and before it begins its upward trajectory.
   (b) How high will the marble go?
   (c) What is the marble's speed when it is at half of its maximum height?

4. You would like to get a spring that is springey enough to launch your friend 2 meters into the air. What strength spring should you buy?