Lecture 18
(Conservation of Energy)

Physics 160-01 Fall 2012

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Conservation of Mechanical Energy

- The work-energy theorem can be written as:

$$W_{Other} = \Delta KE + \Delta U_{Gravity} + \Delta U_{Elastic}$$

- And if there are no "other" forces doing work, then:

$$0 = \Delta KE + \Delta U_{Gravity} + \Delta U_{Elastic}$$

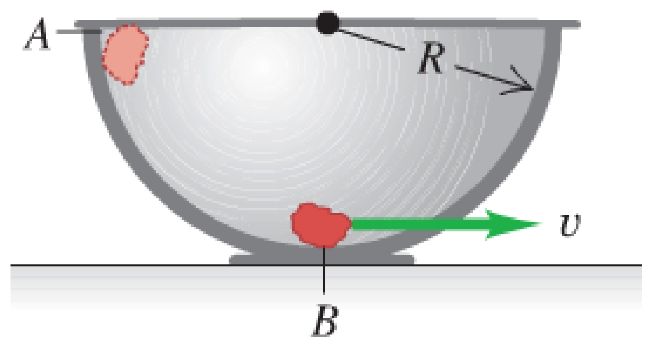
$$\Delta E = 0$$

$$E = KE + U_{Gravity} + U_{Elastic}$$

Problem 7.9

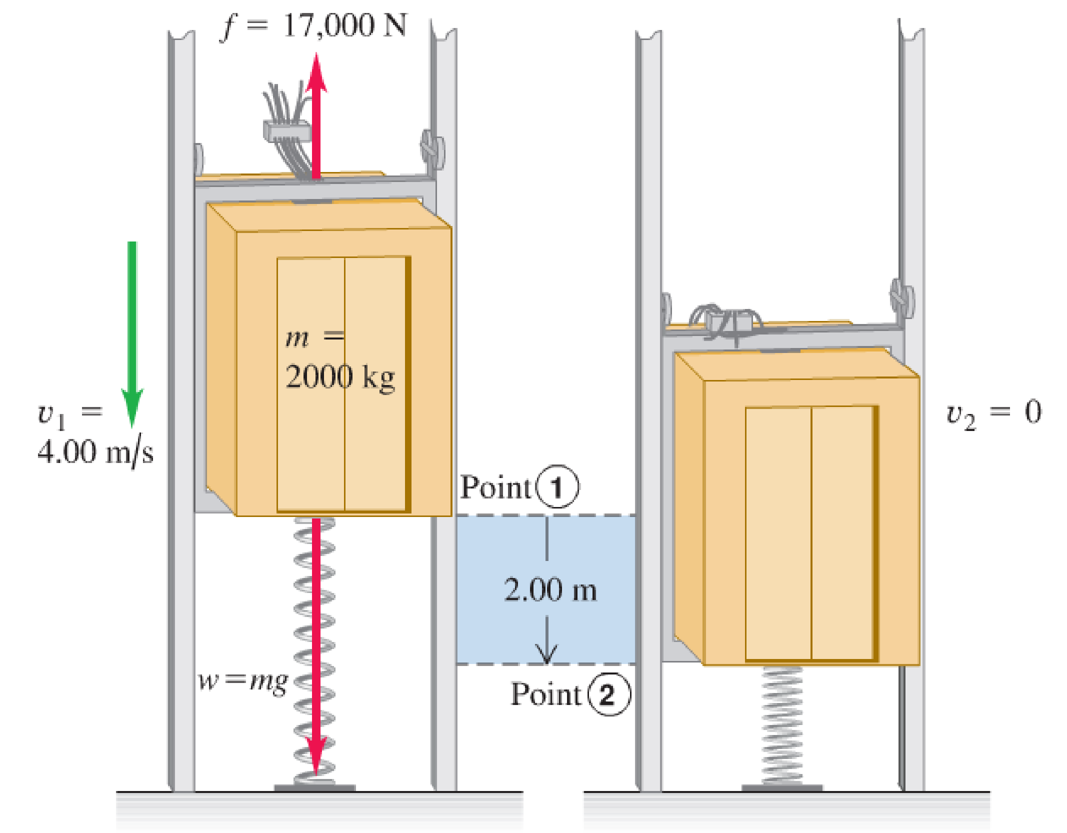
7.9. A small rock with mass 0.20 kg is released from rest at point A, which is at the top edge of a large, hemispherical bowl with radius $R = 0.50$ m (Fig. 7.25). Assume that the size of the rock is small compared to R, so that the rock can be treated as a particle, and assume that the rock slides rather than rolls. The work done by friction on the rock when it moves from point A to point B at the bottom of the bowl has magnitude 0.22 J. (a) Between points A and B, how much work is done on the rock by (i) the normal force and (ii) gravity? (b) What is the speed of the rock as it reaches point B? (c) Of the three forces acting on the rock as it slides down the bowl, which (if any) are constant and which are not? Explain. (d) Just as the rock reaches point B, what is the normal force on it due to the bottom of the bowl?

Figure 7.25 Exercise 7.9.



Problem 7.24

7.24. (a) For the elevator of Example 7.9 (Section 7.2), what is the speed of the elevator after it has moved downward 1.00 m from point 1 in Fig. 7.17? (b) When the elevator is 1.00 m below point 1 in Fig. 7.17, what is its acceleration?

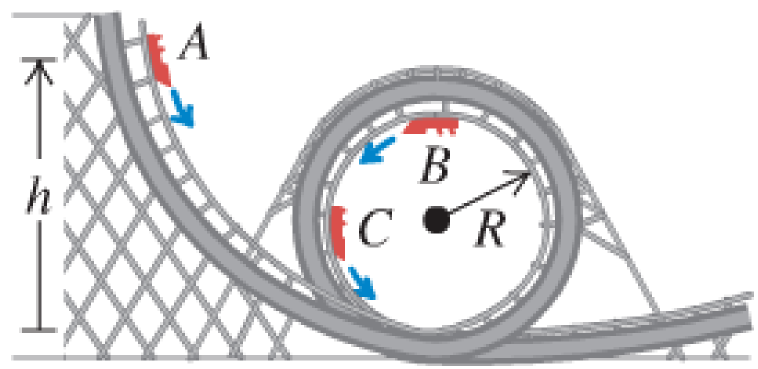


$k = 1.06 \times 10^4 N/m$

Problem 7.46

7.46. Riding a Loop-the-Loop. A car in an amusement park ride rolls without friction around the track shown in Fig. 7.32. It starts from rest at point A at a height h above the bottom of the loop. Treat the car as a particle. (a) What is the minimum value of h (in terms of R) such that the car moves around the loop without falling off at the top (point B)? (b) If $h = 3.50R$ and $R = 20.0$ m, compute the speed, radial acceleration, and tangential acceleration of the passengers when the car is at point C, which is at the end of a horizontal diameter. Show these acceleration components in a diagram, approximately to scale.

Figure 7.32 Problem 7.46.



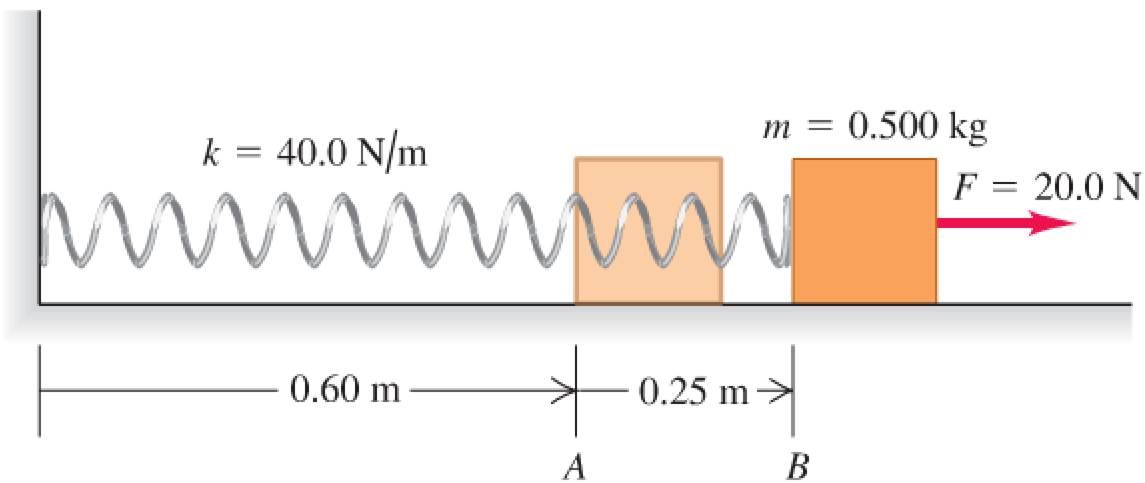
Problem 7.54

7.54 ••• You are designing a delivery ramp for crates containing exercise equipment. The 1470-N crates will move at 1.8 m/s at the top of a ramp that slopes downward at 22.0°. The ramp exerts a 550-N kinetic friction force on each crate, and the maximum static friction force also has this value. Each crate will compress a spring at the bottom of the ramp and will come to rest after traveling a total distance of 8.0 m along the ramp. Once stopped, a crate must not rebound back up the ramp. Calculate the force constant of the spring that will be needed in order to meet the design criteria.

Problem 7.75

7.75. A 0.500-kg block, attached to a spring with length 0.60 m and force constant 40.0 N/m, is at rest with the back of the block at point A on a frictionless, horizontal air table (Fig. 7.44). The mass of the spring is negligible. You move the block to the right along the surface by pulling with a constant 20.0-N horizontal force. (a) What is the block's speed when the back of the block reaches point B, which is 0.25 m to the right of point A? (b) When the back of the block reaches point B, you let go of the block. In the subsequent motion, how close does the block get to the wall where the left end of the spring is attached?

Figure 7.44 Problem 7.75.



Forces from Potential Energy

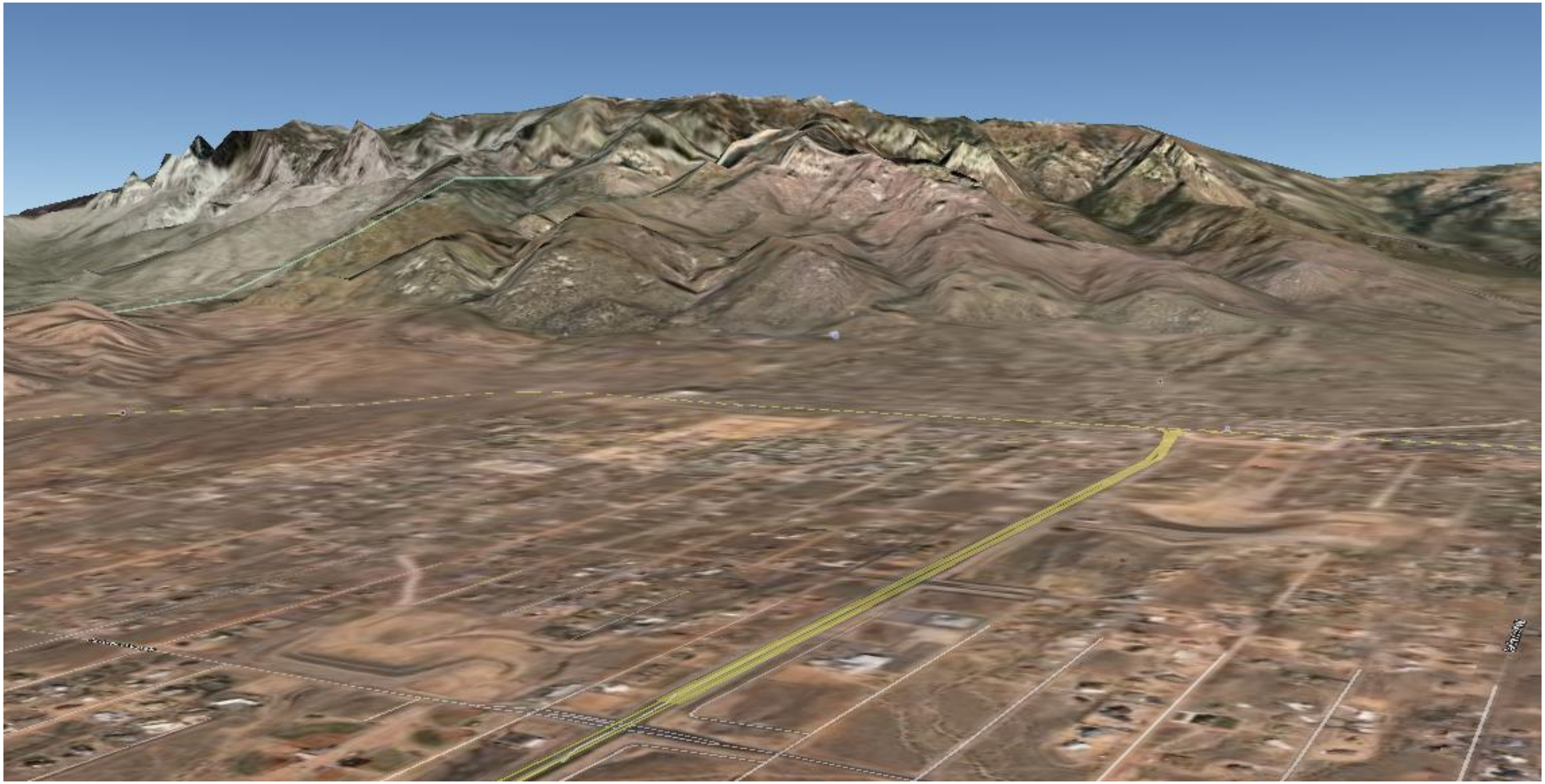
- Since the potential energy is derived from the work as:

$$\Delta U = -W = -\int_{initial}^{final} \vec{F}\cdot d\vec{s} = -\int_{x_{initial}}^{x_{final}} F_x dx - \int_{y_{initial}}^{y_{final}} F_y dy - \int_{z_{initial}}^{z_{final}} F_z dz$$

- Then, we can relate the Force to the derivatives of the potential energy function:

$$F_x = -\frac{\partial U(x,y,z)}{\partial x}; \quad F_y = -\frac{\partial U(x,y,z)}{\partial y}; \quad F_z = -\frac{\partial U(x,y,z)}{\partial z}$$

“Topological Map” circa 2009



Energy Graphs

- One can learn a lot about the behavior of an object, just by looking at a graph of its potential and total mechanical energies.