Problem Set 6
Due: see website for due date

Chapter 8: Potential Energy and Conservation of Energy
Exercises & Problems: 22, 27, 30, 34, 40, 54, 57, 64

Problem A
The three balls (of equal masses) are fired with equal speeds at the angles shown. Rank in order, from largest to smallest, their speeds \(v_a\), \(v_b\), and \(v_c\) as they cross the dashed horizontal line. All three are fired with sufficient speed to reach the line.) Explain why, using an energy bar diagram and short concise sentences.

Problem B
Experienced hikers prefer to step over a fallen log in their path rather than stepping on top and jumping down on other side. Explain.

Problem C
A baseball is thrown straight up with initial speed \(v_1\). If air resistance cannot be ignored, when the ball returns to its initial height its speed is less than \(v_1\). Explain why, using an energy bar diagram and short concise sentences.

Problem D
A woman bounces on a trampoline, going a little higher with each bounce. Explain how she increases the total mechanical energy using an energy bar diagram and short concise sentences.

Problem E
(i) Plot the gravitational potential energy function between an object and the earth. Use this graph to explain why objects thrown up always return to the surface of the earth. (ii) Repeat (i) for the spring potential energy. Use this graph to explain why objects moving away from the equilibrium point always return to the equilibrium point.

Problem 8.22
A 60 kg skier starts from rest at height \(h = 20\)m above the end of a ski-jump ramp and leaves the ramp at angle \(\theta = 28^\circ\). Neglect the effects of air resistance and assume the ramp is frictionless. (a) What is the maximum height \(h\) of his jump above the end of the ramp? (b) If he increased his weight by putting on a backpack, would \(h\) then be greater, less, or the same?

Problem 8.27
Tarzan, who weighs 688 N, swings from a cliff at the end of a vine 18 m long. From the top of the cliff to the bottom of the swing, he descends by 3.2 m. The vine will break if the force on it exceeds 950 N. (a) Does the vine break? (b) If no, what is the greatest force on it during the swing? If yes, at what angle with the vertical does it break?
Problem 8.30
A 2.0 kg breadbox on a frictionless incline of angle \( \theta = 40^\circ \) is connected, by a cord that runs over a pulley, to a light spring of spring constant \( k = 120 \text{N/m} \). The box is released from rest when the spring is unstretched. Assume that the pulley is massless and frictionless. (a) What is the speed of the box when it has moved 10 cm down the incline? (b) How far down the incline from its point of release does the box slide before momentarily stopping, and what are the (c) magnitude and (d) direction (up or down the incline) of the box’s acceleration at the instant the box momentarily stops?

Problem 8.34 (challenging)
A boy is initially seated on the top of a hemispherical ice mound of radius \( R = 13.8 \text{ m} \). He begins to slide down the ice, with a negligible initial speed. Approximate the ice as being frictionless. At what height does the boy lose contact with the ice?

Problem 8.40
The potential energy of a diatomic molecule (a two-atom system like H\(_2\) or O\(_2\)) is given by \( U(r) = A/r^{12} - B/r^6 \) where \( r \) is the separation of the two atoms of the molecule and \( A \) and \( B \) are positive constants. This potential energy is associated with the force that binds the two atoms together. (a) Find the equilibrium separation—that is, the distance between the atoms at which the force on each atom is zero. Is the force repulsive (the atoms are pushed apart) or attractive (they are pulled together) if their separation is (b) smaller and (c) larger than the equilibrium separation?

Problem 8.54
A child whose weight is 267 N slides down a 6.1 m playground slide that makes an angle of 20° with the horizontal. The coefficient of kinetic friction between slide and child is 0.10. (a) How much energy is transferred to thermal energy? (b) If she starts at the top with a speed of 0.457 m/s, what is her speed at the bottom?

Problem 8.57
A block slides along a track from one level to a higher level after passing through an intermediate valley. The track is frictionless until the block reaches the higher level. There a frictional force stops the block in a distance \( d \). The block’s initial speed \( v_0 \) is 6.0 m/s, the height difference \( h \) is 1.1 m, and \( \mu_k \) is 0.60. Find \( d \).

Problem 8.64
A block is released from rest at height \( d = 40 \text{ cm} \) and slides down a frictionless ramp and onto a first plateau, which has length \( d \) and where the coefficient of kinetic friction is 0.50. If the block is still moving, it then slides down a second frictionless ramp through height \( d/2 \) and onto a lower plateau, which has length \( d/2 \) and where the coefficient of kinetic friction is again 0.50. If the block is still moving, it then slides up a frictionless ramp until it (momentarily) stops. Where does the block stop? If its final stop is on a plateau, state which one and give the distance \( L \) from the left edge of that plateau. If the block reaches the ramp, give the height \( H \) above the lower plateau where it momentarily stops.