Problem Set 5
Due: see website for due date

Chapter 7: Kinetic Energy and Work
Exercises & Problems:  3, 15, 17, 21, 30, 54, 62

Problem A
A team of furniture movers wishes to load a truck using a ramp from the ground to the rear of the truck. One of the movers claims that less work would be done in loading the truck if the length of the ramp were increased, in order to decrease the angle of the ramp with respect to the horizontal. Is his claim valid? Explain.

Problem B
You are holding a briefcase by the handle, with your arm straight down by your side. Does the force by your hand do work on the briefcase when (i) you walk at a constant speed down a horizontal hallway and (ii) while you ride an escalator from the first to second floor of a building? In each case justify your answer.

Problem C
When a book slides along a tabletop, the force of friction does negative work on it. Can friction ever do positive work? Explain.

Problem D
For the cases shown, the object is released from rest at the top and feels no friction or air resistance. (i) Draw a work-energy bar diagram for all three cases. In which (if any) cases will the mass have (ii) the greatest speed at the bottom and (iii) the most work done on it by the time it reaches the bottom?

Problem E
As a car accelerates from rest to highway speed, a pedestrian watching the motion sees positive work done on the car because its kinetic energy increases. However, from the reference frame of someone driving in the same direction at highway speed, the car is initially moving (backward) and then becomes stationary, corresponding to negative work. Which observer is right?

Problem 7.3
On August 10, 1972, a large meteorite skipped across the atmosphere above the western United States and western Canada, much like a stone skipped across water. The accompanying fireball was so bright that it could be seen in the daytime sky and was brighter than the usual meteorite trail. The meteorite’s mass was about $4 \times 10^6$ kg; its speed was about 15 km/s. Had it entered the atmosphere vertically, it would have hit Earth’s surface with about the same speed. (a) Calculate the meteorite’s loss of kinetic energy (in joules) that would have been associated with the vertical impact. (b) Express the energy as a multiple of the explosive energy of 1 megaton of TNT, which is $4.2 \times 10^{15}$ J. (c) The energy associated with the atomic bomb explosion over Hiroshima
Problem 7.15
Three forces are applied to a trunk that moves leftward by 3.00 m over a frictionless floor. The force magnitudes are \( F_1 = 5.00 \text{ N} \), \( F_2 = 9.00 \text{ N} \), and \( F_3 = 3.00 \text{ N} \). During the displacement, (a) what is the net work done on the trunk by the three forces and (b) does the kinetic energy of the trunk increase or decrease?

Problem 7.17
A helicopter lifts a 72 kg astronaut 15 m vertically from the ocean by means of a cable. The acceleration of the astronaut is \( g/10 \). How much work is done on the astronaut by (a) the force from the helicopter and (b) the gravitational force on her? Just before she reaches the helicopter, what are her (c) kinetic energy and (d) speed?

Problem 7.21
A cord is used to vertically lower an initially stationary block of mass \( M \) at a constant downward acceleration of \( g/4 \). When the block has fallen a distance \( d \), find (a) the work done by the cord’s force on the block, (b) the work done by the gravitational force on the block, (c) the kinetic energy of the block, and (d) the speed of the block.

Problem 7.30
A block of mass \( m \) lies on a horizontal frictionless surface and is attached to one end of a horizontal spring (spring constant \( k \)) whose other end is fixed. The block is initially at rest at the position where the spring is unstretched \( (x = 0) \) when a constant horizontal force \( F \) in the positive direction of the \( x \) axis is applied to it. A plot of the resulting kinetic energy of the block versus its position \( x \) is shown. The scale of the figure’s vertical axis is set by \( K_S = 4.0 \text{J} \). (a) What is the magnitude of \( F \)? (b) What is the value of \( k \)?

Problem 7.54
The only force acting on a 2.0 kg body as the body moves along an \( x \) axis varies as shown in the figure. The scale of the figure’s vertical axis is set by \( F_S = 4.0 \text{ N} \). The velocity of the body at \( x = 0 \) is 4.0 m/s. (a) What is the kinetic energy of the body at \( x = 3.0 \text{m} \)? (b) At what value of \( x \) will the body have a kinetic energy of 8.0 J? (c) What is the maximum kinetic energy of the body between \( x = 0 \) and \( x = 5.0 \text{m} \)?

Problem 7.62
A 250.0 g block is dropped onto a relaxed vertical spring that has a spring constant of \( k = 2.500 \text{ N/cm} \). The block becomes attached to the spring and compresses the spring 12 cm before momentarily stopping. While the spring is being compressed, what work is done on the block by (a) the gravitational force on it and (b) the spring force? (c) What is the speed of the block just before it hits the spring? (Assume that friction is negligible.) (d) If the speed at impact is doubled, what is the maximum compression of the spring?