Formulae for reference

Kinematics (for constant a)

$$v^2 - u^2 = 2as$$

$$s = ut + \frac{1}{2}at^2$$

$$a = \frac{v - u}{t}$$

$$s = \frac{v + u}{2}t$$

Newton's Laws

1st (Inertia) An object at rest will stay at rest. An object in motion will stay in motion unless acted on by a net external force.

2nd For an object of constant mass m, the resulting acceleration a of an external force F is governed by

$$F = ma$$

3rd (Reaction force) For every action, there is an equal and opposite reaction.

Specifically, for any actor applying a force A to an object, there is a reaction force $B = -A$ from the object to the actor.

Varies Forces

weight $W = mg$

gravitational force $F_{gravity} = G\frac{Mm}{R^2}$

frictional force $F_{friction} = -\mu N$

Hooke's Law $F_{spring} = -kx$

Work and Energy

Work done (constant F)

$$W = Fs$$

Work done (F changes over x)

$$W = \int_{x_0}^{x} F\,dx$$

Any other formulas?

A tip for solving any physics problem, is to draw a diagram for yourself after reading the question. This helps you understand and visualize the situation.

Exercise 7

Chapter 7 Work and Energy

7. A record for stair climbing was achieved by a man who raced up the 1600 steps of the Empire State Building to a height of 320 m in 10 min 59 s. If his average mass was 75 kg, how much work did he do against gravity? At what average rate (in J/s) did he do this work?

*11. A man pushes a heavy box up an inclined ramp making an angle of 30° with the horizontal. The mass of the box is 60 kg, and the coefficient of kinetic friction between the box and the ramp is 0.45. How much work must the man do to push the box to a height of 2.5 m at constant speed? Assume that the man pushes on the box in a direction parallel to the surface of the ramp.

23. A particle moving along the x axis is subjected to a force F_x that depends on position as shown in the plot in Fig. 7.29. From this plot, find the work done by the force as the particle moves from $x = 0$ to $x = 8.0$m.

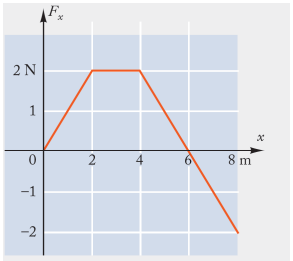

FIGURE 7.29 Position-dependent force.

39. An automobile of mass 1600 kg is traveling along a straight road at 80 km/h.

    (a) What is the kinetic energy of this automobile in the reference frame of the ground?

    (b) What is the kinetic energy in the reference frame of a motorcycle traveling in the same direction at 60 km/h?

    (c) What is the kinetic energy in the reference frame of a truck traveling in the opposite direction at 60 km/h?

43. Compare the kinetic energy of a golf ball (m = 45g) falling at a terminal velocity of 45 m/s with that of a person (75 kg) walking at 1.0 m/s.

45. A mass of 150 g is held by a horizontal spring of spring constant 20 N/m. It is *displaced from* its equilibrium position and released from rest. As it passes through equilibrium, its speed is 5.0 m/s. For the motion from the release position to the equilibrium position, what is the work done by the spring? What was the initial displacement?

49. The velocity of small bullets can be roughly measured with ballistic putty. When the bullet strikes a slab of putty, it penetrates a distance that is roughly proportional to the kinetic energy. Suppose that a bullet of velocity 160 m/s penetrates 0.80 cm into the putty and a second, identical bullet fired from a more powerful gun penetrates 1.2 cm. What is the velocity of the second bullet?

50. A particle moving along the x axis is subject to a force $F_x = -ax + bx^3$ where a and b are constants.

    (a) How much work does this force do as the particle moves from x_1 to x_2?

    (b) If this is the only force acting on the particle, what is the change of kinetic energy during this motion?

63. A block released from rest slides down to the bottom of a plane of incline 15° from a height of 1.5 m; the block attains a speed of 3.5 m/s at the bottom. By considering the work done by gravity and the frictional force, determine the coefficient of friction.

*69. A wrecking ball of mass 600 kg hangs from a crane by a cable of length 10 m. If this wrecking ball is released from an angle of 35°, what will be its kinetic energy when it swings through the lowest point of its arc?

*91. The luge track at Lillehammer, the site of the 1994 Olympics, starts at a height of 350 m and finishes at 240 m. Suppose that a luger of 95 kg, including the sled starts from rest and reaches the finish at 130 km/h. How much energy has been lost to friction against the ice and the air?

*29. The ends of a relaxed spring of length l and force constant k are attached to two points on two walls separated by a distance l.

(a) How much work must you do to push the midpoint of the spring up or down a distance y (see **Fig. 7.30**)?

(b) How much force must you exert to hold the spring in this configuration?

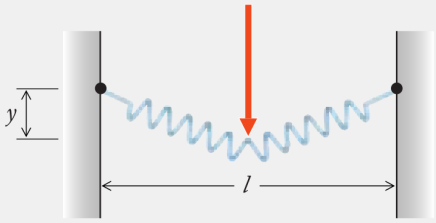

FIGURE 7.30 The midpoint of the spring has been pushed down a distance y. When the spring is relaxed, its length matches the distance l between the walls.

79. A particle initially sits on top of a large, smooth sphere of radius R (Fig. 7.36**). The particle begins to slide down the sphere, without friction. At what angular position θ will the particle lose contact with the surface of the sphere? Where will the particle land on the ground?

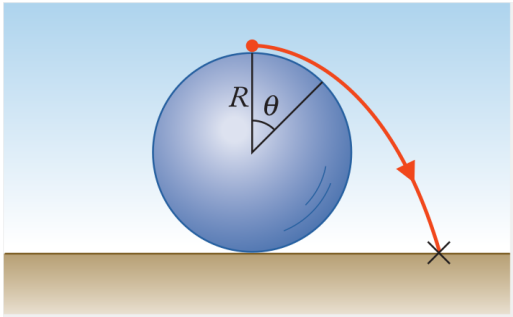

FIGURE 7.36 Particle sliding down a sphere.