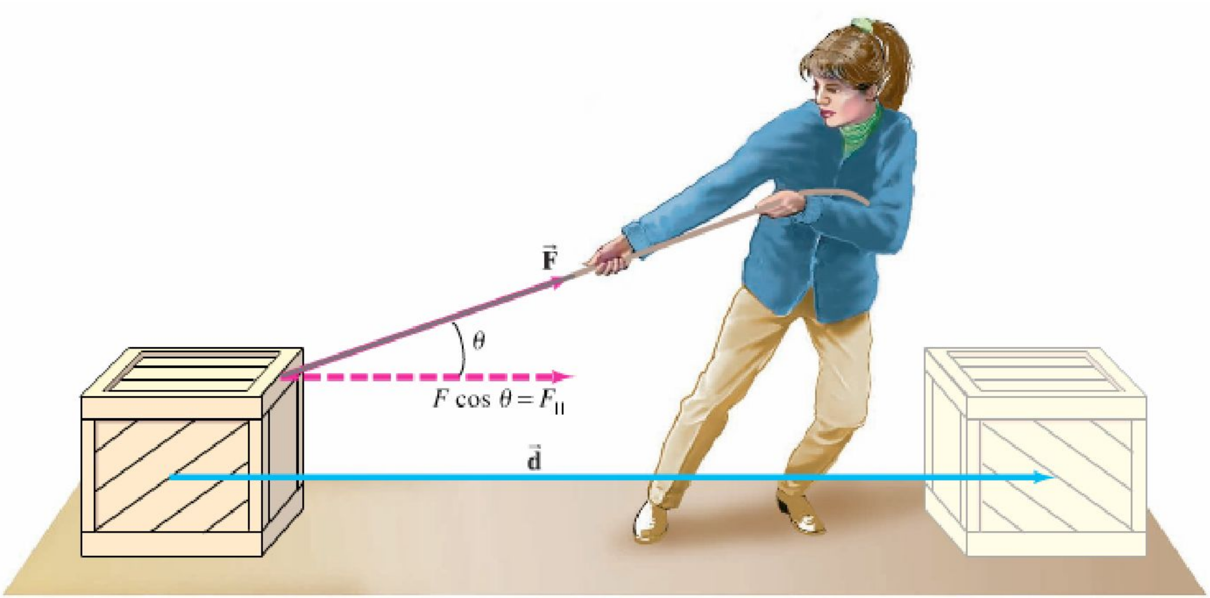
Work and Energy

Until now we have been studying the translational motion of an object in terms of Newton's three laws of motion. In this analysis, *force* has played a central role as the quantity determining the motion. In this Chapter and the next, we discuss an alternative analysis of the translational motion of objects in terms of the quantities *energy* and *momentum*. The significance of energy and momentum is that they are *conserved*. That is, in quite general circumstances they remain constant. That conserved quantities exist gives us not only a deeper insight into the nature of the world, but also gives us another way to approach solving practical problems.

The conservation laws of energy and momentum are especially valuable in dealing with systems of many objects, in which a detailed consideration of the forces involved would be difficult or impossible. These laws are applicable to a wide range of phenomena, including the atomic and subatomic worlds, where Newton's laws do not apply.

Work Done by a Constant Force



$$W = Fd\cos\theta,$$

F is the magnitude of the constant force

d is the magnitude of the displacement of the object,

θ is the angle between the directions of the force and the displacement

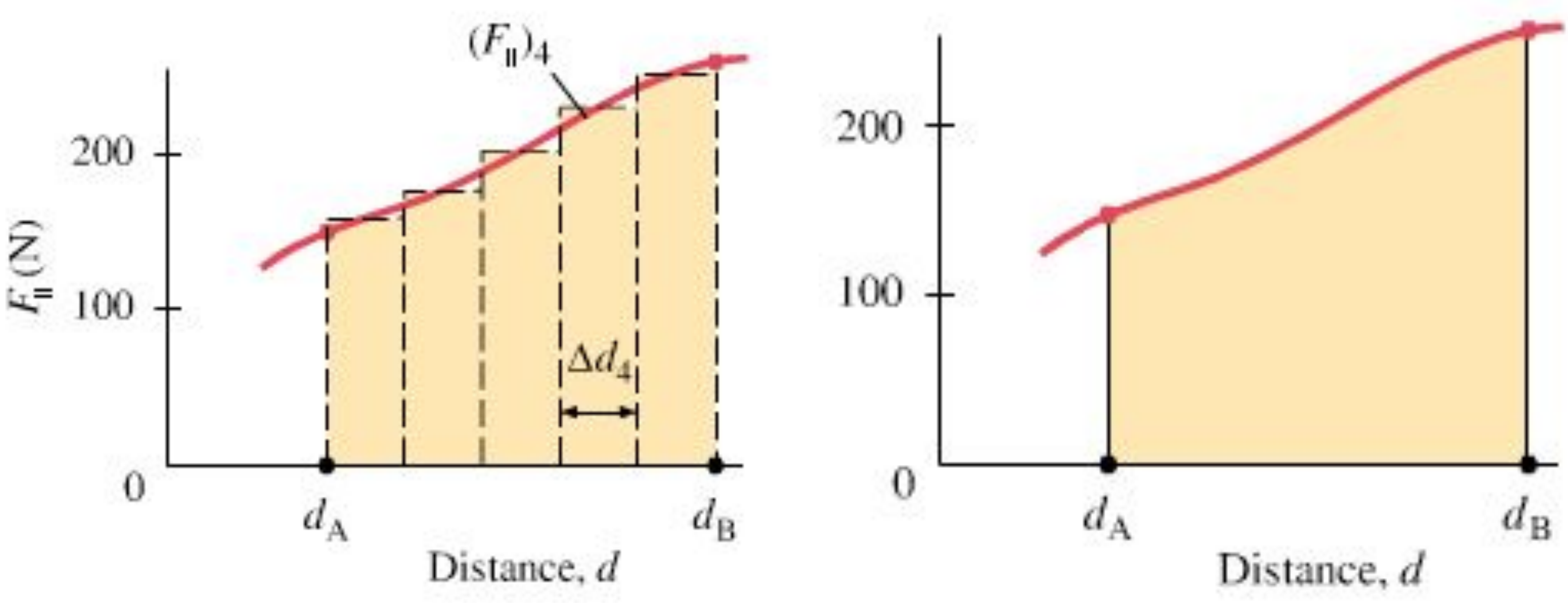
Let us first consider the case in which the motion and the force are in the same direction, so $\theta = 0$ and $\cos\theta = 1$; in this case, $W = Fd$. For example, if you push a loaded grocery cart a distance of 50 m by exerting a horizontal force of 30 N on the cart, you do $30\ \mathrm{N} \times 50\ \mathrm{m} = 1500\ \mathrm{N \cdot m}$ of work on the cart.

As this example shows, in SI units work is measured in newton-meters ($\mathrm{N \cdot m}$). A special name is given to this unit, the **joule** (J): $1\ \mathrm{J} = 1\ \mathrm{N \cdot m}$.

Work Done by a Varying Force

The general definition of mechanical work is given by the following line integral:

$$W_C = \int_C \mathbf{F} \cdot \mathrm{d}\mathbf{x}$$



kinetic energy (KE)

$$\text{KE} = \tfrac{1}{2}mv^2.$$

The net work done on an object is equal to the change in the object's kinetic energy.

$$W_{\text{net}} = \Delta\text{KE}.$$

WORK-ENERGY PRINCIPLE

The net work done on an object is equal to the change in the object's kinetic energy.

Potential Energy

We have just discussed how an object is said to have energy by virtue of its motion, which we call kinetic energy. But it is also possible to have **potential energy**, which is the energy associated with forces that depend on the position or configuration of an object (or objects) relative to the surroundings. Various types of potential energy (PE) can be defined, and each type is associated with a particular force.

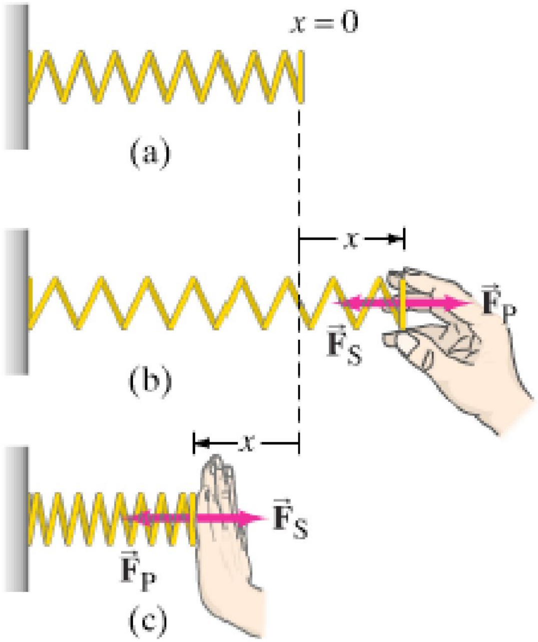
Gravitational PE

$$\mathrm{PE}_{\text{grav}} = mgy.$$

Height above some reference level

$$W_G = -(\mathrm{PE}_2 - \mathrm{PE}_1) = -\Delta\mathrm{PE}.$$

Spring equation or Hooke's law



$$F_P = kx,$$

spring stiffness constant

$$F_S = -kx$$

elastic potential energy

$$\text{elastic PE} = \tfrac{1}{2}kx^2.$$

CONSERVATION OF MECHANICAL ENERGY

$$KE_2 + PE_2 = KE_1 + PE_1$$

If only conservative forces are acting, the total mechanical energy of a system neither increases nor decreases in any process. It stays constant—it is conserved.

LAW OF CONSERVATION OF ENERGY

The total energy is neither increased nor decreased in any process. Energy can be transformed from one form to another, and transferred from one object to another, but the total amount remains constant.

Power is defined as the *rate at which work is done.*

$$\overline{P} = \text{average power} = \frac{\text{work}}{\text{time}} = \frac{\text{energy transformed}}{\text{time}}.$$

$$1\ \text{W} = 1\ \text{J/s}.$$

watt

1 horsepower (hp) = 746 W

Efficiency $e = \dfrac{P_{\text{out}}}{P_{\text{in}}}.$

57. (III) Early test flights for the space shuttle used a "glider" (mass of 980 kg including pilot) that was launched horizontally at 500 km/h from a height of 3500 m. The glider eventually landed at a speed of 200 km/h. (*a*) What would its landing speed have been in the absence of air resistance? (*b*) What was the average force of air resistance exerted on it if it came in at a constant glide of 10° to the Earth?

63. (II) A driver notices that her 1150-kg car slows down from 85 km/h to 65 km/h in about 6.0 s on the level when it is in neutral. Approximately what power (watts and hp) is needed to keep the car traveling at a constant 75 km/h?

Переклади будь ласка 63 задачу))

37. (II) A 65-kg trampoline artist jumps vertically upward from the top of a platform with a speed of 5.0 m/s. (*a*) How fast is he going as he lands on the trampoline, 3.0 m below (Fig. 6–38)? (*b*) If the trampoline behaves like a spring with spring stiffness constant 6.2×10^4 N/m, how far does he depress it?

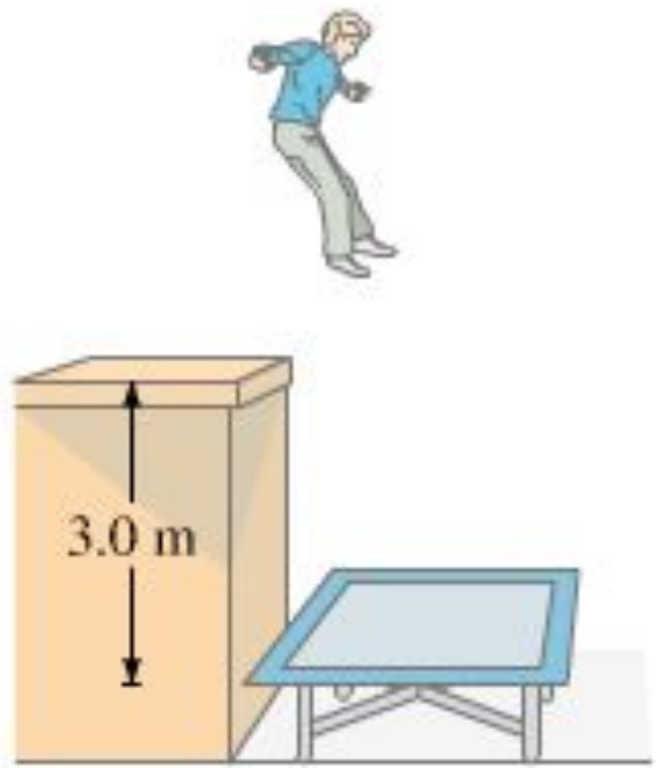


FIGURE 6–38 Problem 37.

62. (II) Electric energy units are often expressed in the form of "kilowatt-hours." (*a*) Show that one kilowatt-hour (kWh) is equal to 3.6×10^6 J. (*b*) If a typical family of four uses electric energy at an average rate of 520 W, how many kWh would their electric bill be for one month, and (*c*) how many joules would this be? (*d*) At a cost of \$0.12 per kWh, what would their monthly bill be in dollars? Does the monthly bill depend on the *rate* at which they use the electric energy?