conservative. We write the total (net) work W_{net} as a sum of the work done by conservative forces, W_C, and the work done by nonconservative forces, W_{NC}:

$$W_{net} = W_C + W_{NC}.$$

Then, from the work-energy principle, Eq. 6–4, we have

$$W_{net} = \Delta \text{KE}$$
$$W_C + W_{NC} = \Delta \text{KE}$$

where $\Delta \text{KE} = \text{KE}_2 - \text{KE}_1$. Then

$$W_{NC} = \Delta \text{KE} - W_C.$$

Work done by a conservative force can be written in terms of potential energy, as we saw in Eq. 6–7b for gravitational potential energy:

$$W_C = -\Delta \text{PE}.$$

We combine these last two equations:

$$W_{NC} = \Delta \text{KE} + \Delta \text{PE}. \tag{6–10}$$

WORK-ENERGY PRINCIPLE (general form)

Thus, *the work W_{NC} done by the nonconservative forces acting on an object is equal to the total change in kinetic and potential energies*.

It must be emphasized that *all* the forces acting on an object must be included in Eq. 6–10, either in the potential energy term on the right (if it is a conservative force), or in the work term on the left (but not in both!).

6–6 Mechanical Energy and Its Conservation

If only conservative forces are acting in a system, we arrive at a particularly simple and beautiful relation involving energy.

When no nonconservative forces are present, then $W_{NC} = 0$ in Eq. 6–10, the general form of the work-energy principle. Then we have

$$\Delta \text{KE} + \Delta \text{PE} = 0 \qquad \begin{bmatrix}\text{conservative}\\ \text{forces only}\end{bmatrix} \tag{6–11a}$$

or

$$(\text{KE}_2 - \text{KE}_1) + (\text{PE}_2 - \text{PE}_1) = 0. \qquad \begin{bmatrix}\text{conservative}\\ \text{forces only}\end{bmatrix} \tag{6–11b}$$

We now define a quantity E, called the **total mechanical energy** of our system, as the sum of the kinetic and potential energies at any moment:

$$E = \text{KE} + \text{PE}.$$

Total mechanical energy defined

Now we can rewrite Eq. 6–11b as

$$\text{KE}_2 + \text{PE}_2 = \text{KE}_1 + \text{PE}_1 \qquad \begin{bmatrix}\text{conservative}\\ \text{forces only}\end{bmatrix} \tag{6–12a}$$

CONSERVATION OF MECHANICAL ENERGY

or

$$E_2 = E_1 = \text{constant.} \qquad \begin{bmatrix}\text{conservative}\\ \text{forces only}\end{bmatrix} \tag{6–12b}$$

Equations 6–12 express a useful and profound principle regarding the total mechanical energy of a system—namely, that it is a **conserved quantity**. The total mechanical energy E remains constant as long as no nonconservative forces act: $(\text{KE} + \text{PE})$ at some initial time 1 is equal to the $(\text{KE} + \text{PE})$ at any later time 2.

To say it another way, consider Eq. 6–11a which tells us $\Delta \text{PE} = -\Delta \text{KE}$; that is, if the kinetic energy KE of a system increases, then the potential energy PE must decrease by an equivalent amount to compensate. Thus, the total, $\text{KE} + \text{PE}$, remains constant:

> **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.**

CONSERVATION OF MECHANICAL ENERGY

This is the **principle of conservation of mechanical energy** for conservative forces.