Then, the velocity of the block at $x = 5$ cm is

$= 0.1 \times 7.07 \times 0.866 \text{ m s}^{-1}$

$= 0.61 \text{ m s}^{-1}$

Hence the K.E. of the block,

$$= \frac{1}{2} m v^2$$

$= ½[1\text{kg} \times (0.6123 \text{ m s}^{-1})^2]$

$= 0.19$ J

The P.E. of the block,

$$= \frac{1}{2} k x^2$$

$= ½(50 \text{ N m}^{-1} \times 0.05 \text{ m} \times 0.05 \text{ m})$

$= 0.0625$ J

The total energy of the block at $x = 5$ cm,

= K.E. + P.E.

= 0.25 J

we also know that at maximum displacement, K.E. is zero and hence the total energy of the system is equal to the P.E. Therefore, the total energy of the system,

$= ½(50 \text{ N m}^{-1} \times 0.1 \text{ m} \times 0.1 \text{ m})$

$= 0.25$ J

which is same as the sum of the two energies at a displacement of 5 cm. This is in conformity with the principle of conservation of energy. ◀

14.8 SOME SYSTEMS EXECUTING SIMPLE HARMONIC MOTION

There are no physical examples of absolutely pure **simple harmonic motion**. In practice we come across systems that execute simple harmonic motion approximately under certain conditions. In the subsequent part of this section, we discuss the motion executed by some such systems.

14.8.1 Oscillations due to a Spring

The simplest observable example of simple harmonic motion is the small oscillations of a block of mass m fixed to a spring, which in turn is fixed to a rigid wall as shown in Fig. 14.17. The block is placed on a frictionless horizontal surface. If the block is pulled on one side and is released, it then executes a to and fro motion about the mean position. Let $x = 0$, indicate the position of the centre of the block when the spring is in equilibrium. The positions marked as $-A$ and $+A$ indicate the maximum displacements to the left and the right of the mean position. We have already learnt that springs have special properties, which were first discovered by the English physicist Robert Hooke. He had shown that such a system when deformed, is subject to a restoring force, the magnitude of which is proportional to the deformation or the displacement and acts in opposite direction. This is known as Hooke's law (Chapter 9). It holds good for displacements small in comparison to the length of the spring. At any time t, if the displacement of the block from its mean position is x, the restoring force F acting on the block is,

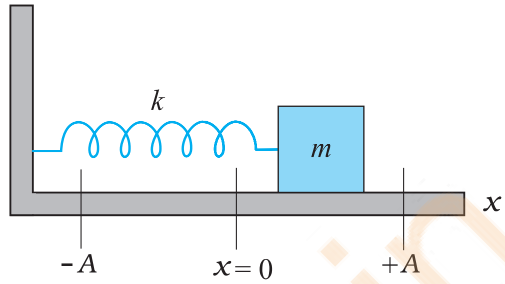

***Fig. 14.17** A linear simple harmonic oscillator consisting of a block of mass m attached to a spring. The block moves over a frictionless surface. The box, when pulled or pushed and released, executes simple harmonic motion.*

$$F(x) = -k\,x \tag{14.19}$$

The constant of proportionality, k, is called the spring constant, its value is governed by the elastic properties of the spring. A stiff spring has large k and a soft spring has small k. Equation (14.19) is same as the force law for SHM and therefore the system executes a simple harmonic motion. From Eq. (14.14) we have,

$$\omega = \sqrt{\frac{k}{m}} \tag{14.20}$$

and the period, T, of the oscillator is given by,

$$T = 2\pi\sqrt{\frac{m}{k}} \tag{14.21}$$

Stiff springs have high value of k (spring constant). A block of small mass m attached to a stiff spring will have, according to Eq. (14.20), large oscillation frequency, as expected physically.