swings is a good example of resonance. You might have realised that the skill in swinging to greater heights lies in the synchronisation of the rhythm of pushing against the ground with the natural frequency of the swing.

To illustrate this point further, let us consider a set of five simple pendulums of assorted lengths suspended from a common rope as shown in Fig. 14.22. The pendulums 1 and 4 have the same lengths and the others have different lengths. Now, let us set pendulum 1 into motion. The energy from this pendulum gets transferred to other pendulums through the connecting rope and they start oscillating. The driving force is provided through the connecting rope. The frequency of this force is the frequency with which pendulum 1 oscillates. If we observe the response of pendulums 2, 3 and 5, they first start oscillating with their natural frequencies of oscillations and different amplitudes, but this motion is gradually damped and not sustained. Their frequencies of oscillation gradually change, and ultimately, they oscillate with the frequency of pendulum 1, i.e., the frequency of the driving force but with different amplitudes. They oscillate with small amplitudes. The response of pendulum 4 is in contrast to this set of pendulums. It oscillates with the same frequency as that of pendulum 1 and its amplitude gradually picks up and becomes very large. A resonance-like response is seen. This happens because in this the condition for resonance is satisfied, i.e. the natural frequency of the system coincides with that of the driving force.

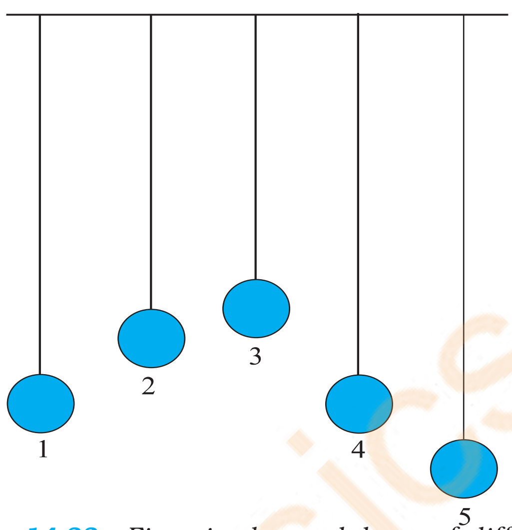

Fig. 14.22 *Five simple pendulums of different lengths suspended from a common support.*

We have so far considered oscillating systems which have just one natural frequency. In general, a system may have several natural frequencies. You will see examples of such systems (vibrating strings, air columns, etc.) in the next chapter. Any mechanical structure, like a building, a bridge, or an aircraft may have several possible natural frequencies. An external periodic force or disturbance will set the system in forced oscillation. If, accidentally, the forced frequency ω_d happens to be close to one of the natural frequencies of the system, the amplitude of oscillation will shoot up (resonance), resulting in possible damage. This is why, soldiers go out of step while crossing a bridge. For the same reason, an earthquake will not cause uniform damage to all buildings in an affected area, even if they are built with the same strength and material. The natural frequencies of a building depend on its height, other size parameters, and the nature of building material. The one with its natural frequency close to the frequency of seismic wave is likely to be damaged more.

SUMMARY

1. The motion that repeats itself is called *periodic motion.*
2. The *period T* is the time required for one complete oscillation, or cycle. It is related to the frequency ν by,

$$T = \frac{1}{\nu}$$