If the moment of inertia I does not change with time,

$$\frac{d}{dt}(I\omega) = I\frac{d\omega}{dt} = I\alpha$$

and we get from Eq. (7.45c),

$$\tau = I\alpha \qquad (7.43)$$

We have already derived this equation using the work - kinetic energy route.

7.13.1 Conservation of angular momentum

We are now in a position to revisit the principle of conservation of angular momentum in the context of rotation about a fixed axis. From Eq. (7.45c), if the external torque is zero,

$$L_z = I\omega = \text{constant} \qquad (7.46)$$

For symmetric bodies, from Eq. (7.44d), L_z may be replaced by L .(L and L_z are respectively the magnitudes of **L** and $\mathbf{L}_z$.)

This then is the required form, for fixed axis rotation, of Eq. (7.29a), which expresses the general law of conservation of angular momentum of a system of particles. Eq. (7.46) applies to many situations that we come across in daily life. You may do this experiment with your friend. Sit on a swivel chair (a chair with a seat, free to rotate about a pivot) with your arms folded and feet not resting on, i.e., away from, the ground. Ask your friend to rotate the chair rapidly. While the chair is rotating with considerable angular speed stretch your arms horizontally. What happens? Your angular speed is reduced. If you bring back your arms closer to your body, the angular speed increases again. This is a situation where the principle of conservation of angular momentum is applicable. If friction in the rotational mechanism is neglected, there is no external torque about the axis of rotation of the chair and hence $I\omega$ is constant. Stretching the arms increases I about the axis of rotation, resulting in decreasing the angular speed ω. Bringing the arms closer to the body has the opposite effect.

A circus acrobat and a diver take advantage of this principle. Also, skaters and classical, Indian or western, dancers performing a pirouette (a spinning about a tip–top) on the toes of one foot display 'mastery' over this principle. Can you explain?

7.14 ROLLING MOTION

One of the most common motions observed in daily life is the rolling motion. All wheels used in transportation have rolling motion. For specificness we shall begin with the case of a disc, but the result will apply to any rolling body rolling on a level surface. We shall assume that the disc rolls without slipping. This means that at any instant of time the bottom of the disc

Fig 7.36 (a) *A demonstration of conservation of angular momentum. A girl sits on a swivel chair and stretches her arms/ brings her arms closer to the body.*

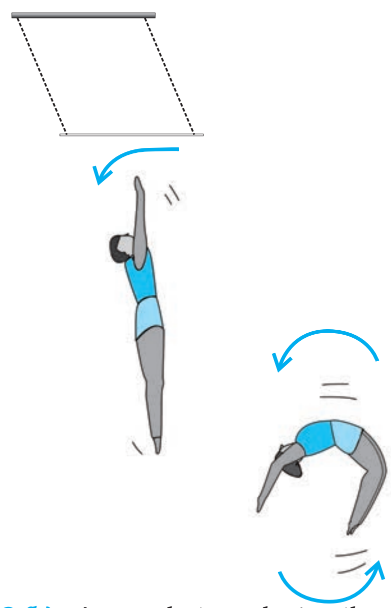

Fig 7.36 (b) *An acrobat employing the principle of conservation of angular momentum in her performance.*