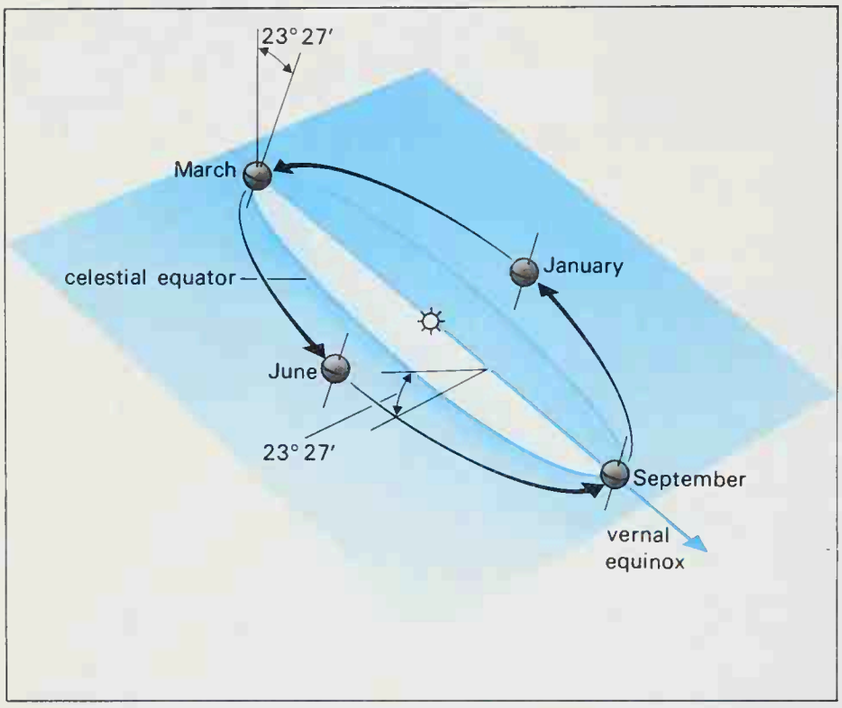
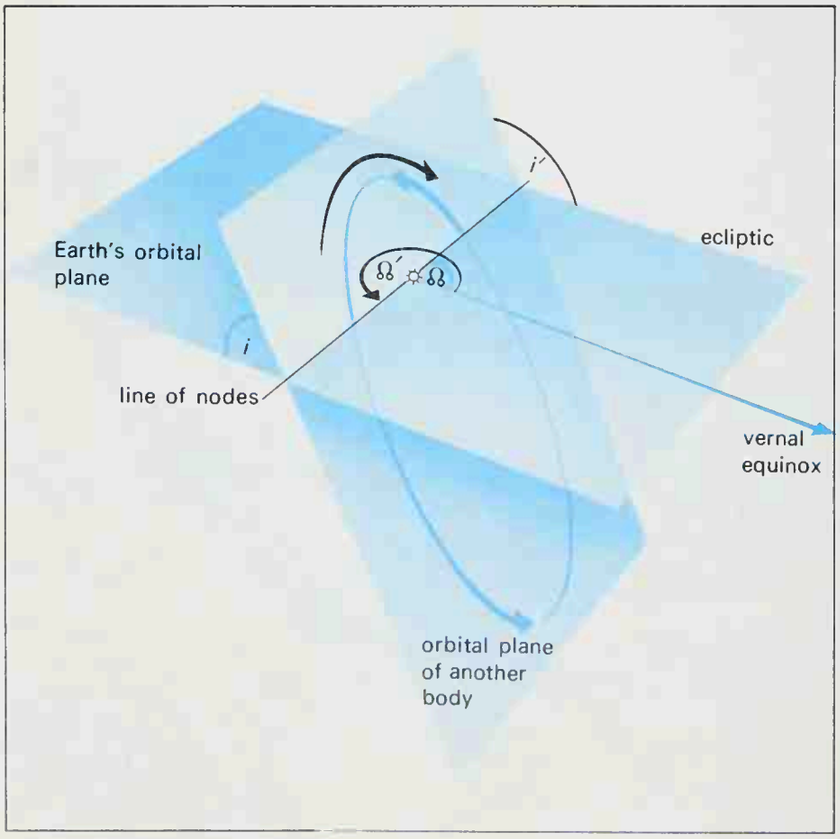
Motions of celestial bodies





All the objects comprising the Solar System are bound by the Sun's gravitational field and move round it in some kind of orbital path. However, because of the mass of the planets, especially of Jupiter, the centre of mass of the whole system lies just outside the surface of the Sun.

In order to describe these orbits and their position in space, several quantities or elements must be given, and Figs. 2·1 to 2·3 show how these are defined. The plane of the Earth's orbit is taken as the basis for the orbits of the other planets but for planetary satellites the basic reference is to the planet's equator, even though this is usually inclined to its orbit.

The points at which a planet's or satellite's orbit crosses these reference planes are known as **nodes**. The closest and most distant approaches of an orbiting body to the primary body around which it moves are denoted by the prefixes 'per-' and 'ap-'. Thus **perihelion** is the closest point and **aphelion** the most distant of a body orbiting the Sun, **perigee** and **apogee** similar points for a body orbiting the Earth. Recently, though, the more general terms **periapsis** and **apoapsis** have become common.

Looking down on the Earth's north pole, its axial rotation is anticlockwise, while its orbital motion and the motion of all the planets around the Sun is in the same direction. This is termed **direct** rotation and direct orbital motion, while the word **retrograde** is applied to movement in the opposite direction. Objects which orbit with retrograde motion have inclinations greater than 90° (Fig. 2·2).

The calculation of the position of any body in its orbit was not satisfactorily carried out until the early 1600s when Kepler developed his three laws of planetary motion (Figs. 2·4–2·6). Strictly speaking, these 'laws' are relationships derived from observation; the physical reasons for such planetary motion had to await Newton's theory of universal attraction, which took both distance and the masses of the bodies into account. Newtonian theory is sufficiently accurate to predict the motion of all the planets, except that of

Fig. 2·1, top: The Earth's orbit provides a reference plane in space, while a fixed direction is given by the vernal equinox where, as seen from the Earth, the Sun appears to cross the celestial equator from south to north.

Fig. 2·2, left: The orbital plane of any body intersects the ecliptic at a line of nodes. The angle, Ω, of the ascending node (south to north) is measured from the vernal equinox. Objects with retrograde motion have inclinations i′ greater than 90°.