3.3.1 Geometry of the Propeller

Propeller blade geometry can be roughly divided into two parts; the blade outline, which is governed by chord, skew and rake, and the sections, which are governed by pitch, camber and thickness. The coordinate systems and the propeller geometrical notation are shown in Fig. 3.11. A propeller-fixed Cartesian coordinate system O-xyz is first defined with origin fixed at the center of the propeller, the *x*- axis has been taken to coincide with the propeller axis and its direction is positive downstream. The *y* - axis is at any angular orientation relative to the key blade. The *z* - axis completes the right-handed system. A cylindrical coordinate system is defined as follows:

$$x = x$$

$$r = \sqrt{y^2 + z^2} \tag{3.18}$$

$$\theta = \tan^{-1}\frac{z}{y}$$

The radial distributions of skew, $\theta_m (r)$, and rake, $x_m (r)$, define the mid-chord line of the blade as illustrated in Fig. 3.12. The leading and trailing edges of the blade constructed by passing a helix of pitch angle, $\phi(r)$ through the mid-chord line can be expressed as:

$$x_{l,t}(r) = x_m(r) \mp \frac{c(r)}{2}\sin\phi(r)$$

$$\theta_{l,t}(r) = \theta_m(r) \mp \frac{c(r)}{2}\cos\phi(r) \tag{3.19}$$

$$y_{l,t}(r) = r\cos\theta_{l,t}(r)$$

$$z_{l,t}(r) = r\sin\theta_{l,t}(r)$$

where *c(r)* is the chord length at the radius *r*, and the subscript *l* and *t* denote the leading and trailing edges, respectively.

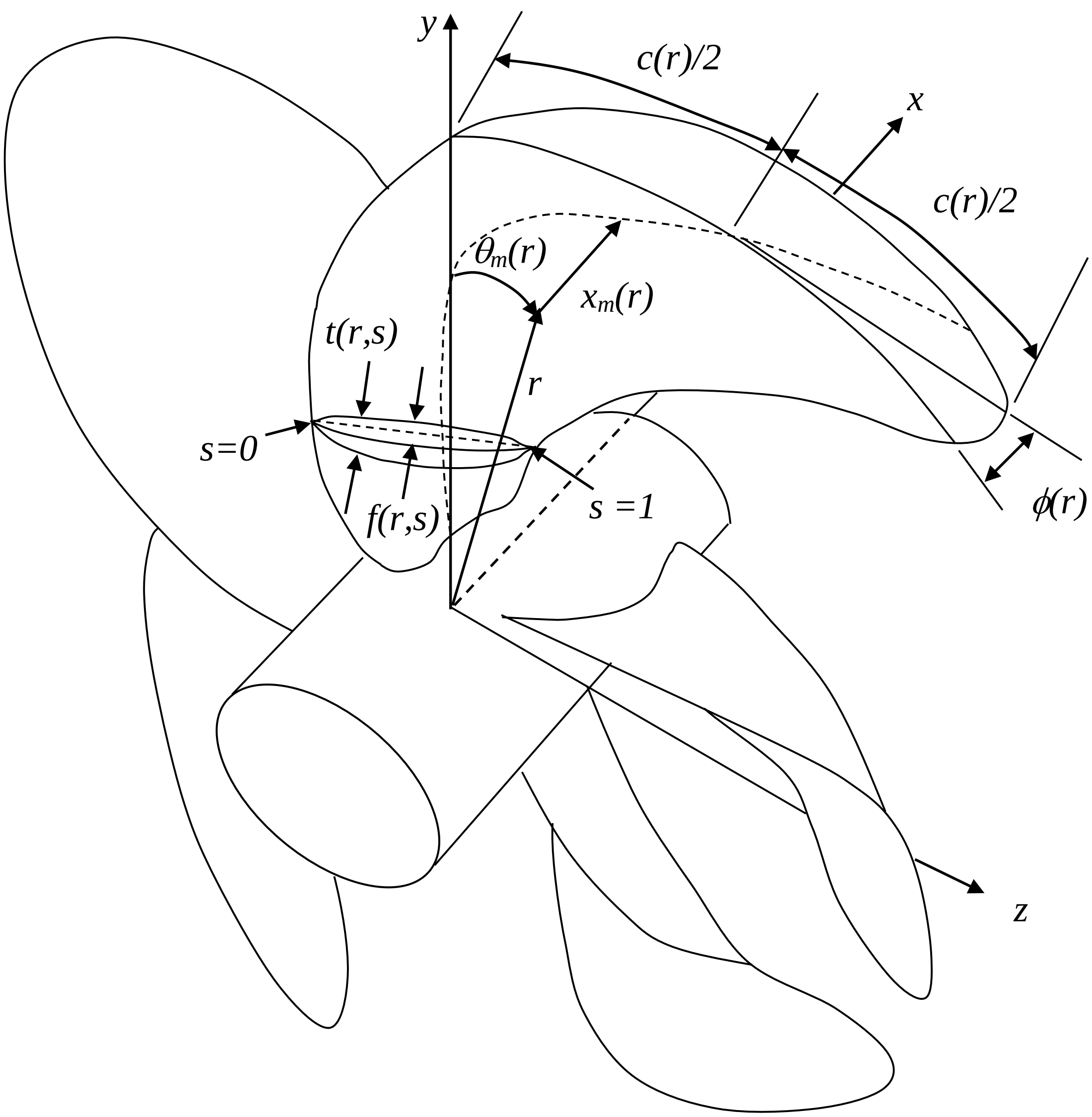

Fig. 3.11: Coordinate system and schematic diagram of propeller

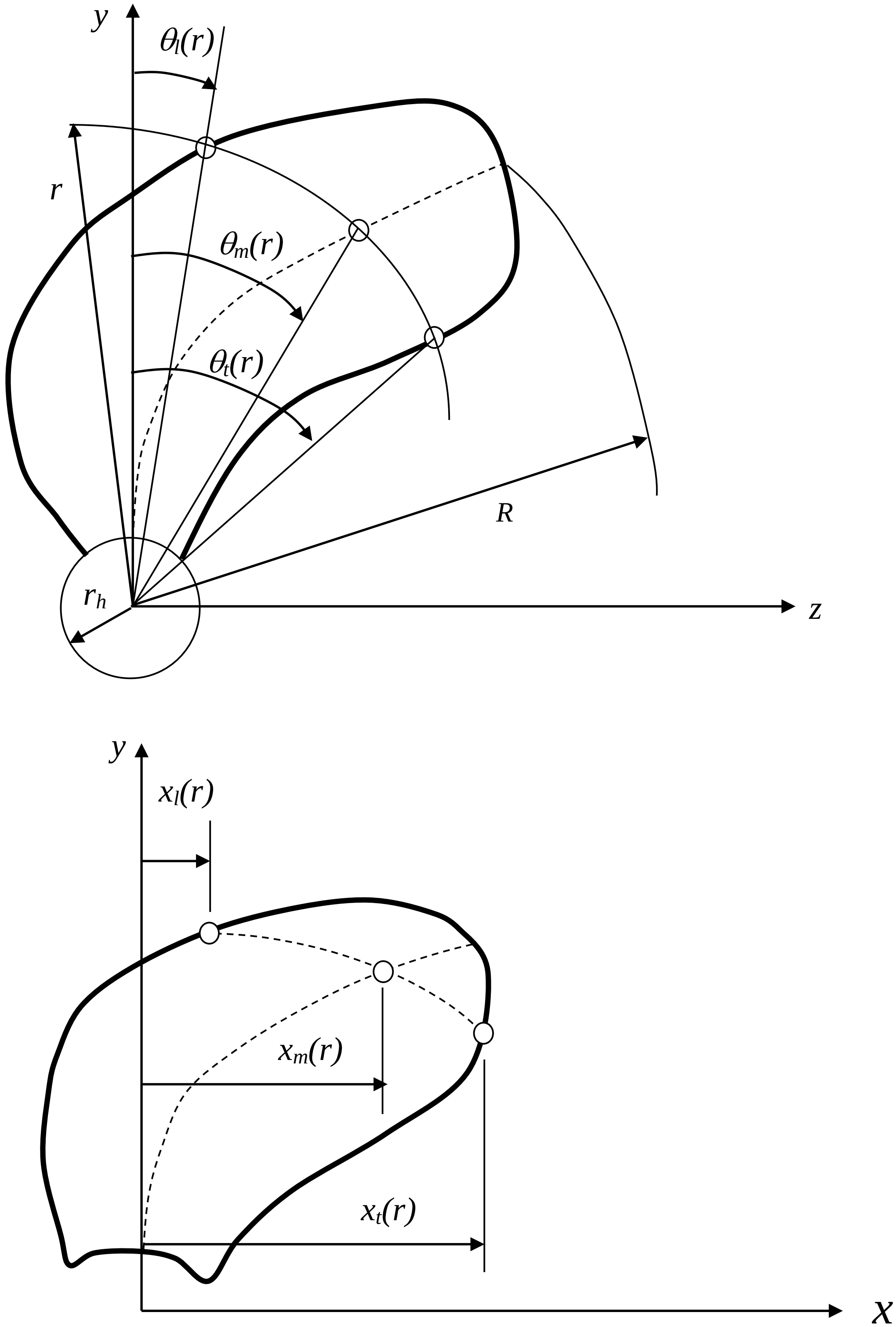

Fig. 3.12: Radial distribution of skew and rake

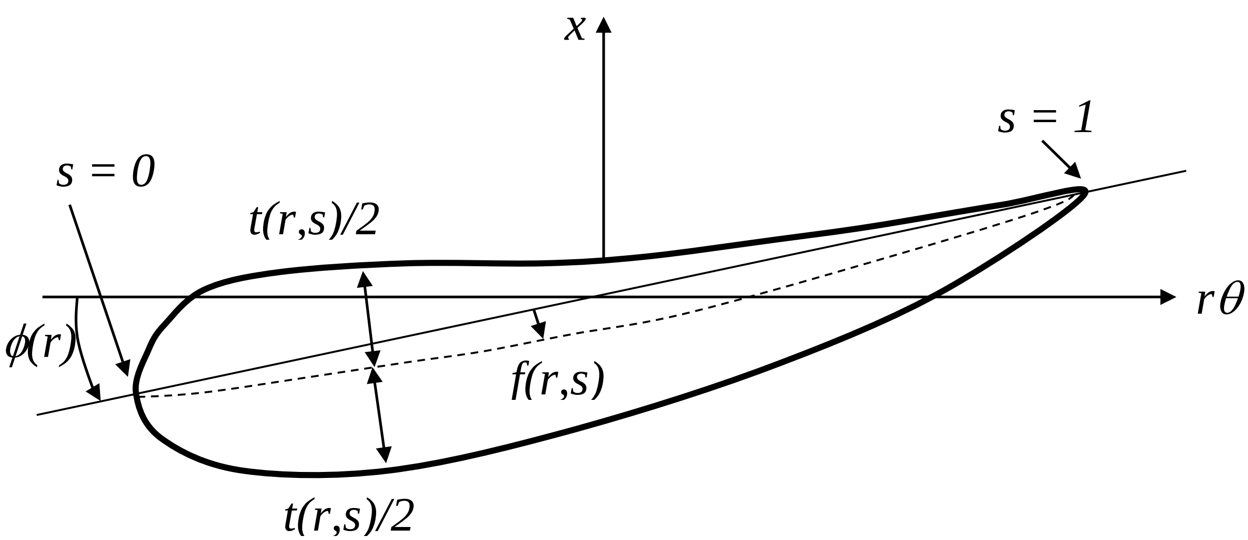

Fig. 3.13: Construction of blade section from mean camber line and thickness form.

The camber *f(r,s)* is measured on the cylindrical surface of radius *r* normal to the nose-tail helix, where *s* is a non-dimensional chordwise coordinate, which is 0 at the leading edge and 1 at the trailing edge. Finally, the thickness *t(r,s)* is added symmetrically to the camber line on the cylinder in the normal direction to the mean camber surface as shown in Fig. 3.13.

$$
\begin{aligned}
x_c(r,s) &= x_m(r) + c(r)\left(s - \frac{1}{2}\right)\sin\phi(r) - f(r,s)\cos\phi(r) \\
\theta_c &= \theta_m(r) + c(r)\left(s - \frac{1}{2}\right)\frac{\cos\phi(r)}{r} + f(r,s)\frac{\sin\phi}{r} \qquad (3.20) \\
y_c(r,s) &= r\cos\theta_c(r,s) \\
z_c(r,s) &= r\sin\theta_c(r,s)
\end{aligned}
$$

The maximum values of $f(r,s)$ and $t(r,s)$ at radius r are denoted as the maximum camber, $f_0(r)$, and the maximum thickness, $t_0(r)$, respetively.