Local variation of the velocity magnitude

Some simple but useful results follow immediately from the expression for local vorticity in terms of rectuangular co-ordinates with axes parallel to the location directions of **u**, of the principal normal to the streamline (directed towards the centre of curvature), and of the binomial to the streamline. If (s, n, b) represent co-ordinates in these three dimensions respectively, and (u, v, w) are the corresponding velocity components, we have

$$v = w = 0, \quad u = q, \quad \frac{\partial v}{\partial s} = \frac{q}{R}, \quad \frac{\partial w}{\partial s} = 0$$

locally, where R is the local radius of curvature of the streamline. The components of the vorticity locally are then

$$\omega_s = \frac{\partial w}{\partial n} - \frac{\partial v}{\partial b}, \quad \omega_n = \frac{\partial u}{\partial b}, \quad \omega_b = \frac{u}{R} - \frac{\partial u}{\partial n}.$$

Moreover, $$\left(\frac{\partial}{\partial s}, \frac{\partial}{\partial n}, \frac{\partial}{\partial b}\right) u = \left(\frac{\partial}{\partial s}, \frac{\partial}{\partial n}, \frac{\partial}{\partial b}\right) q$$

locally. Hence, in irrotational flow we have

$$\frac{\partial q}{\partial n} = \frac{q}{R}, \quad \frac{\partial q}{\partial b} = 0. \qquad (6.2.13)$$

The first of the relations (6.2.13) shows that, when the streamlines ...