Soccer Ball

Incremental Forces

$$LIFT \quad -\rho \, \Delta A \, \sin\sigma \, \cos\theta$$

$$DRAG \quad +\rho \, \Delta A \, \cos\sigma$$

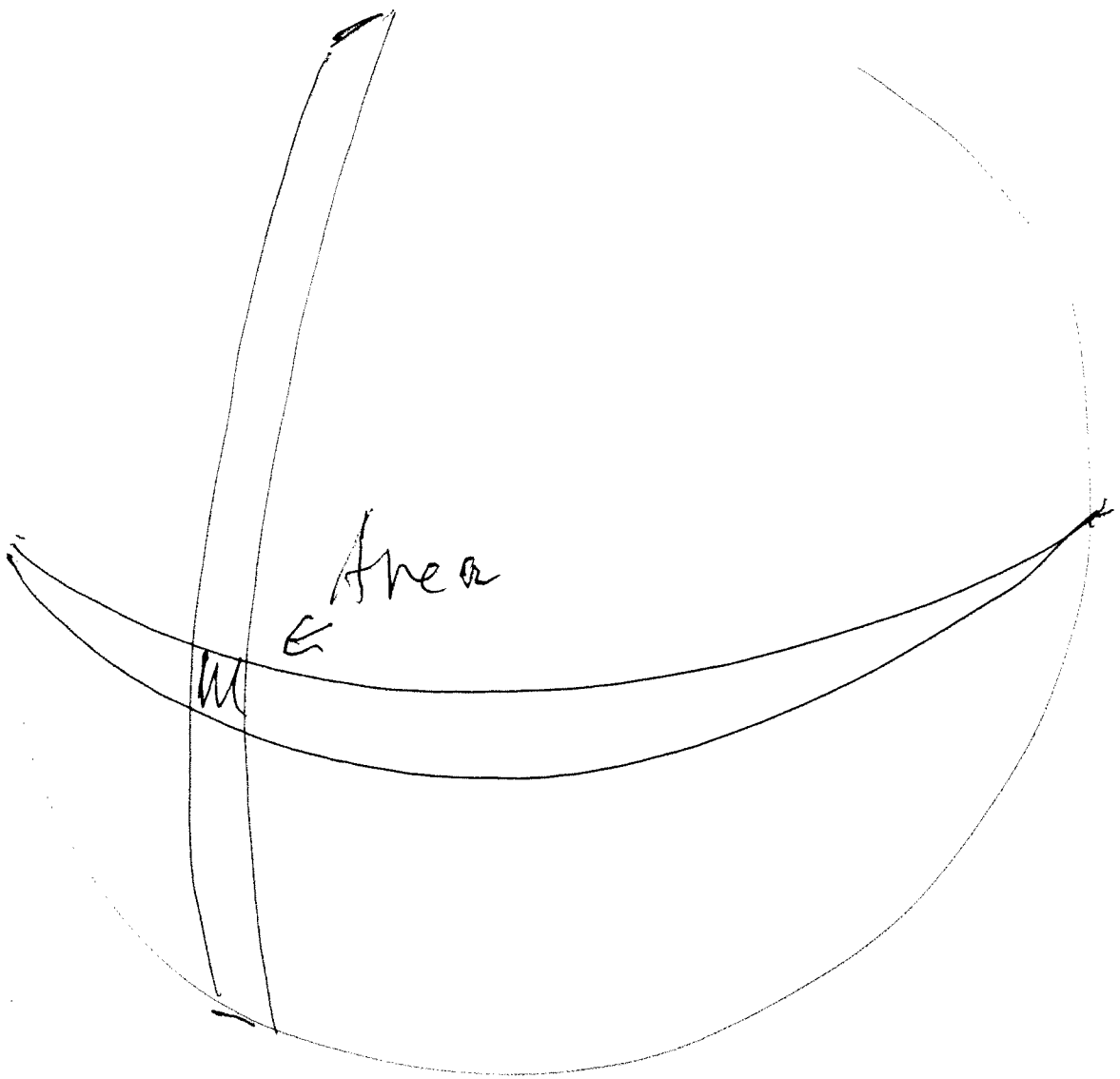
$$SIDE \quad +\rho \, \Delta A \, \sin\sigma \, \sin\theta$$

LIFT $\Sigma E - P \Delta A \sin\sigma \cos\theta$

DRAG $\Sigma E + P \Delta A \cos\sigma$

SIDE $\Sigma E + P \Delta A \sin\sigma \sin\theta$

Total Forces

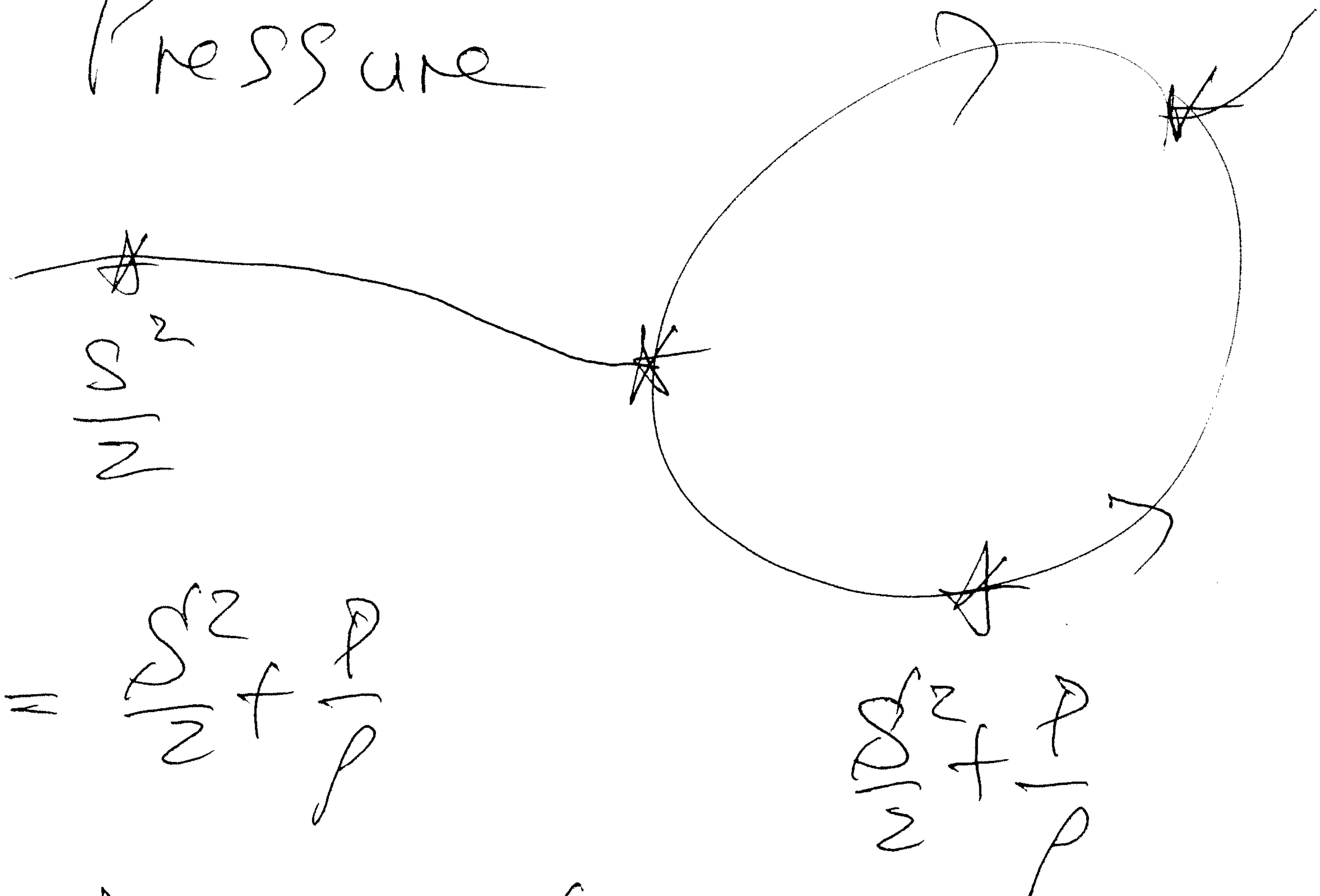

Area

Incremental Area

$$\Delta A = \rho \, \Delta\theta \, R \, \Delta\sigma$$

$$\rho = R \sin\sigma$$

Pressure



$$\frac{s^2}{2} = \frac{s'^2}{2} + \frac{p}{\rho}$$

$$p = \rho\left(\frac{s^2}{2} - \frac{s'^2}{2}\right)$$

Potential Components

$$\kappa_p = \frac{\partial \phi}{\partial c} = \frac{3}{2} S \sin \Gamma$$

$$U_p = + \kappa_p \sin \Gamma$$

$$V_p = - \kappa_p \cos \Gamma \sin \theta$$

$$W_p = + \kappa_p \cos \Gamma \cos \theta$$

Vortex Components

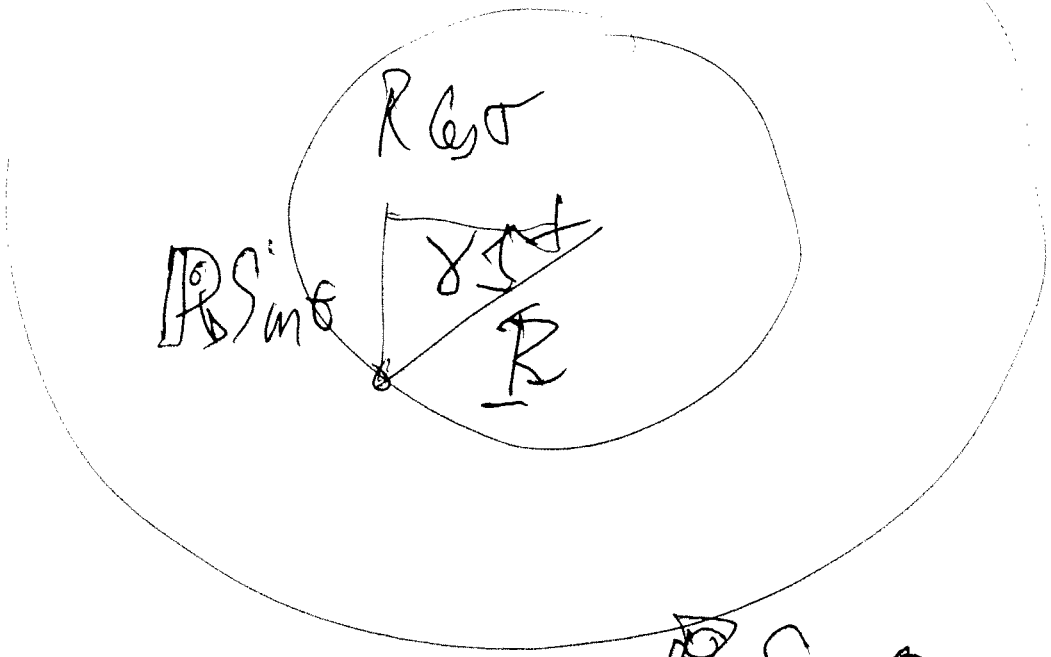
$$\rho_V' = R_x \omega$$

$$U_V = + \rho_V' \sin\gamma$$

$$V_V = - \rho_V' \cos\gamma$$

$$W_V = 0$$

$$\underline{R} = \sqrt{(R\cos\theta)^2 + (R\sin\theta)^2}$$



$$\gamma = \tan^{-1}\frac{R\sin\theta}{R\cos\theta}$$

$$U = U_p + U_v$$

$$V = V_p + V_v$$

$$W = W_p + W_v$$

$$S = \sqrt{U^2 + V^2 + W^2}$$