Dimensional analysis

Reading :

DGS sections 12.1 – 12.3, 12.5, 12.6. You should also have studied the web module on dimensional analysis (DGS section 8.12 – 8.15).

Easy problems :

Q.1. Find the appropriate dimensionless group for each case :

a. The dynamics of bubbles may depend on the velocity V, the density ρ of the surrounding fluid, the diameter d of the bubble and the surface tension σ of the interface (Weber number).

b. Ripples on water may depend on g, surface tension σ, viscosity μ and density ρ.

Q.2. A scale model of an aircraft wing is to be tested in a wind tunnel. The wing has a chord of 0.914 m, the model has a chord of 152 mm. If the results are to be used to investigate the performance of the wing at 145 km/hr, what speed should the wind tunnel tests be run at?

Advanced problems :

Q.3. Prove that the viscous resistance F of a sphere of diameter d moving at constant speed v through a fluid of density ρ and viscosity μ may be expressed as

$$F = k\frac{\mu^2}{\rho}\mathcal{F}\left(\frac{\rho v d}{\mu}\right)$$

Q.4. For a journal bearing of diameter d, length l, radial clearance c and eccentricity e, show that the load W that can be supported by the oil film of viscosity μ is given by

$$\frac{W}{\mu N d^2} = f\left(\frac{c}{d}, \frac{e}{d}, \frac{l}{d}\right)$$

Q.5. Establish an expression for the power input P to a propeller assuming P can be experessed in terms of the density ρ and viscosity μ of the air, the velocity V of the air stream, the rotational speed ω and diameter d of the propeller, and the speed of sound c.

Q.6. Oil of kinematic viscosity 4.65×10^{-5} m^2 s^{-1} is to be used in a prototype in which both viscous and gravity forces dominate. A model scale of 1 : 5 is to be used. What viscosity of model liquid is necessary to make both the Froude and Reynolds numbers the same in model and prototype?