

DEPARTMENT OF AEROSPACE ENGINEERING
IIT KHARAGPUR

Mid-semester Exams (Autumn 2009-10)
INTRODUCTION TO AERODYNAMICS (AE 21001)

II Year B.Tech & Dual Degree

Time: 2 Hrs.
Max. Marks: 40

Answer any FOUR full questions.

- Q.1) (a) Show that in the troposphere, $p = k \rho^{g/(g-LR)}$ where k is a constant, L = lapse rate and R is gas constant.
(b) If the pressure & temperature at sea level are 100500 N/m^2 and 20 C respectively while at some unknown altitude the pressure and density are 36590 N/m^2 and 0.5396 kg/m^3 respectively, calculate the lapse rate and estimate the unknown altitude. (Take $R=287 \text{ J/KgK}$) (4+6)
- Q.2) (a) State Buckingham's Pi Theorem.
(b) A thin flat disc of diameter D is rotated about a spindle through its center at a speed of ω rad/sec in a fluid of density ρ and kinematic viscosity ν , show that the power P needed to rotate the disc may be expressed as
$$P = \rho \omega^3 D^5 \cdot f(\nu/\omega D^2)$$
 (3+7)
- Q.3) (a) Derive the momentum equation in substantive derivative form.
(b) A vertical jet of oil (density = 900 kg/m^3) issues out of a 10 cm. diameter nozzle at a velocity of 15 m/sec. The jet is directed upwards and deflected by a horizontal fixed plate kept at a height of 3 m above the nozzle exit. Estimate the force of impact of the jet on the plate. (5+5)
- Q.4) (a) Explain the concept of stream function and velocity potential function. Distinguish between the two.
(b) What do you mean by 'vorticity'? Explain.
(c) For the given values of potential function ϕ , determine the stream function ψ :-
(i) $\phi = 3xy$ (ii) $\phi = 4(x^2 - y^2)$ (iii) $\phi = x+y+3$ (4+2+4)
- Q.5) Write short notes on :-
(a) Atmospheric Stability
(b) Doublet (5+5)