

3. Free Shear Flows

Free Shear Flows

Viscous flows which develop & spread in an infinite ambient fluid i.e. without walls or other boundaries

(1) mixing layer i.e. free shear layer between parallel streams of different U

(2) jets

(3) wakes

For large Re with dominant flow direction x , BL assumptions are valid (at least assuming far from origin of mixing, jet, or wake)

$$v \ll u$$

$$u_x \ll u_y \quad \& \quad u_{xx} \ll u_{yy}$$

$$p_y \sim 0$$

Additionally

$p_x \sim 0$ since no boundaries at far from origin

2D shear flow equations in Cartesian coordinates

$$u_x + v_y = 0$$

$$u u_x + v u_y = \nu u_{yy}$$

In all cases similarity solutions are possible, but not applicable in near field development region where BL & $p_x \sim 0$ assumptions not valid.

a. Mixing layers

b. Jets

i. 2D

1. Flat Plate
2. Non-lifting Body

ii. Axisymmetric (round) jet

c. Wakes

i. 2D

1. Flat Plate
2. Non-lifting Body

ii. Axisymmetric (round) wake

iii. Betz Method

1. Clark Y Reference Data