

Chapter 4 (3) Free Shear Flows

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

(1) mixing layers, 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 (away from origin of mixing layer, jet, or wake)

$$v \ll u$$

$$u_x \ll u_y \text{ and } u_{xx} \ll u_{yy}$$

$$p_y \approx 0$$

Additionally

$$p_x \approx 0 \quad \text{since no boundaries \& far from origin}$$

2D shear flow equations in Cartesian coordinates:

$$u_x + v_y = 0$$

$$uu_x + vu_y = vu_{yy}$$

Same Blasius but different BC. In all cases similarity solutions are possible. Note that not applicable in near field developing region where BL and $p_x \approx 0$ assumptions not valid.

3. Free Shear Flows

a. Mixing Layers

b. Jets

i. 2D

1. Derivation 1

2. Derivation 2

3. Derivation 3

ii. 2D Wall Jet

iii. Axisymmetric (Round) Jet

iv. Axisymmetric (Round) Jet with Swirl

c. Wakes

i. 2D

1. Far Wake Flat Plate

2. Plane Laminar Wake

a. Panton

b. White

ii. Axisymmetric (Round) Wake

iii. Simplified Betz Method

1. Clark Y Reference Data