

### 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. Note that not applicable in  
near field development region where BL  
&  $p_x \sim 0$  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. Non-Lifting Body
  - a. Panton
  - b. White

##### ii. Axisymmetric (Round) Wake

##### iii. Simplified Betz Method

1. Clark Y Reference Data