Particle image velocimetry (PIV) is a laser-based imaging technique that combines the accuracy of non-intrusive point measurements with the global flow imaging capability of flow visualization to obtain time-resolved, instantaneous velocity information over an extended region of the flow.

**Illumination**
- A laser beam is formed into a light-sheet using a combination of lenses
- The light-sheet is pulsed, “freezing” the location of particles in the planar measurement region
- The laser pulses are separated by a known time (\(\Delta t\))

**The Camera System**
- A camera captures an image of the particles in the light-sheet
- The magnification (M) is determined by the camera lens
- Two images are taken - one corresponding to each laser pulse
- Images are transferred to a computer for processing
- Spatial resolution increases with magnification
- Temporal resolution increases with image capture rate

**Processing Algorithms**
- Images are divided into many small “interrogation windows”
- Particle motion (\(\Delta x, \Delta y\)) between images is determined through cross-correlation
- Velocity is found by dividing the particle displacements by the time between pulses

**PIV Results**
- Instantaneous planar velocity vector fields
- Higher-order quantities such as vorticity, shear stress, Q-criterion, and turbulent energy
- A sequence of images can provide temporal flow characteristics (flow evolution)

**Measurement Region**
- Small tracer particles are added to the flow
- Light is scattered from the tracer particles in the light-sheet
- The measurement region, called Field of View (FoV), increases with pixel resolution:

\[
\text{FoV} = \frac{P_1 \cdot P_2}{M}
\]

\(P_1\) = Pixel resolution of the camera  
\(P_2\) = Size of Pixels  
\(M\) = Magnification of the Camera Lens

**Extensions of the Technique**
- StereoPIV - Two cameras at oblique angles can be used to obtain 3D velocity information in a plane
- Volumetric 3-Component Velocimetry (V3V) - Three cameras are used to determine 3D velocity fields in a volume
- A high speed camera and laser can be used to obtain time resolved velocity fields

**Overhead Formula**
- \(u = \frac{\Delta x}{M \Delta t}\)
- \(v = \frac{\Delta y}{M \Delta t}\)