

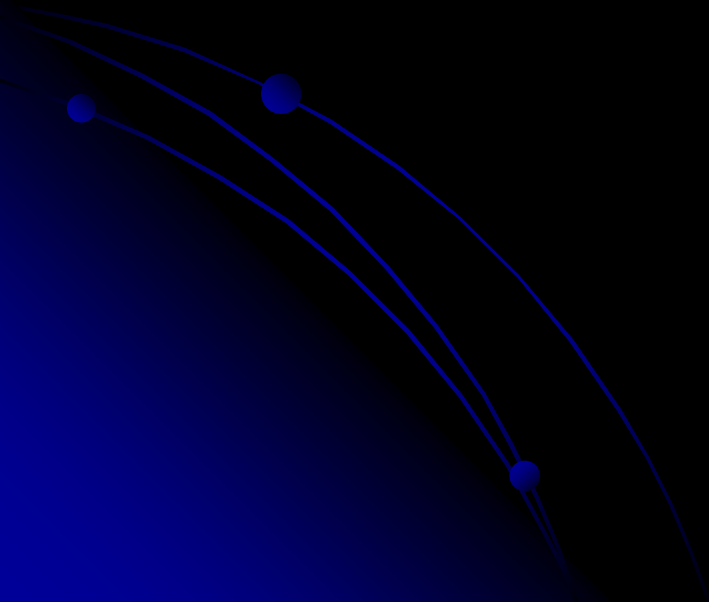
# 2D CFD-Simulation Example with Fluent

1. Turbulent flow in a manifold (Pag. 2)
2. Laminar flow in a manifold (Pag. 25)

Prepared by Dr. Over Díaz  
CES  
March 2007

# **Turbulent Flow in Manifold**

**(By considering only input velocities)**



# 1. Data

Fluid : water

Density = 998.2 kg/m<sup>3</sup>

Dynamic viscosity = 0.001003 kg/m.s

The flow is turbulent

Re  $\approx$  1x10<sup>6</sup>

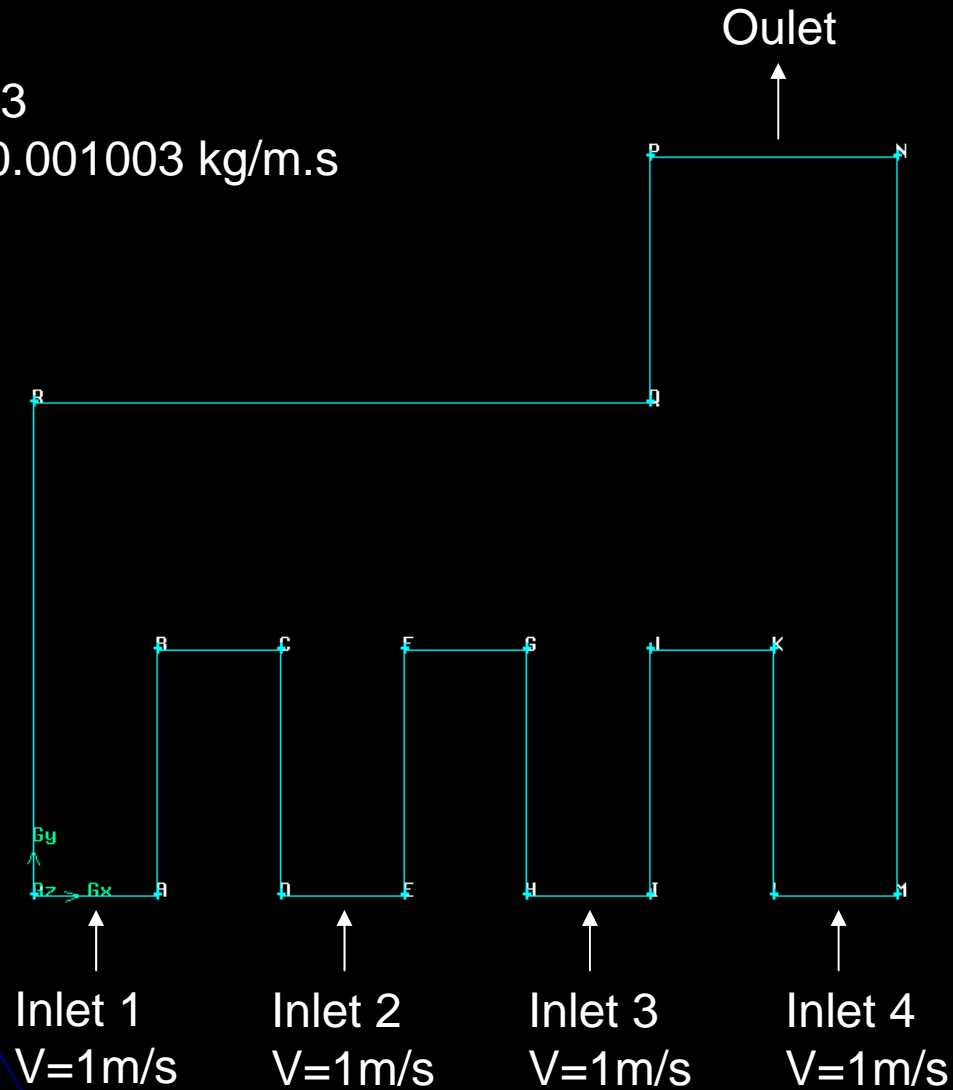
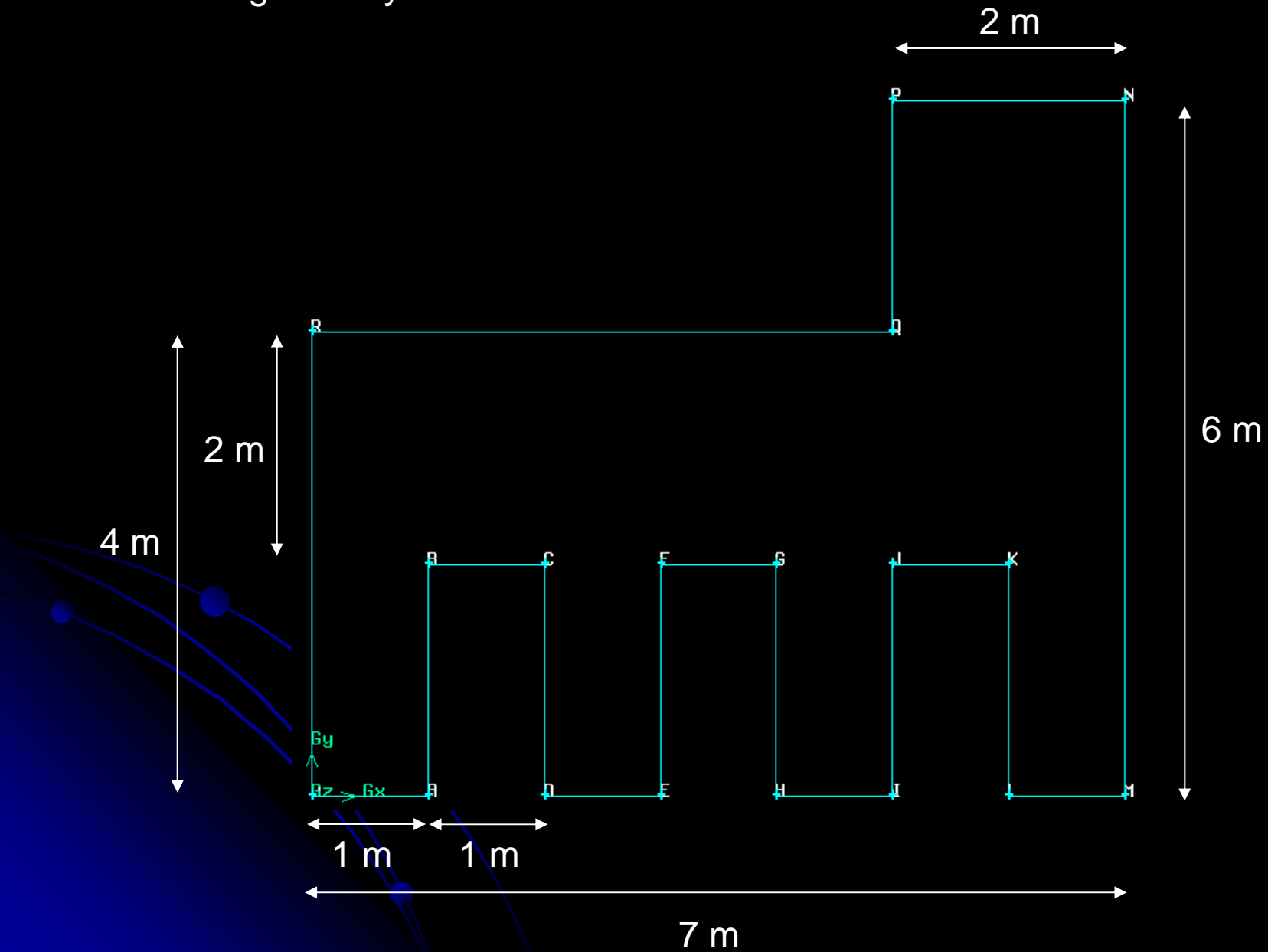
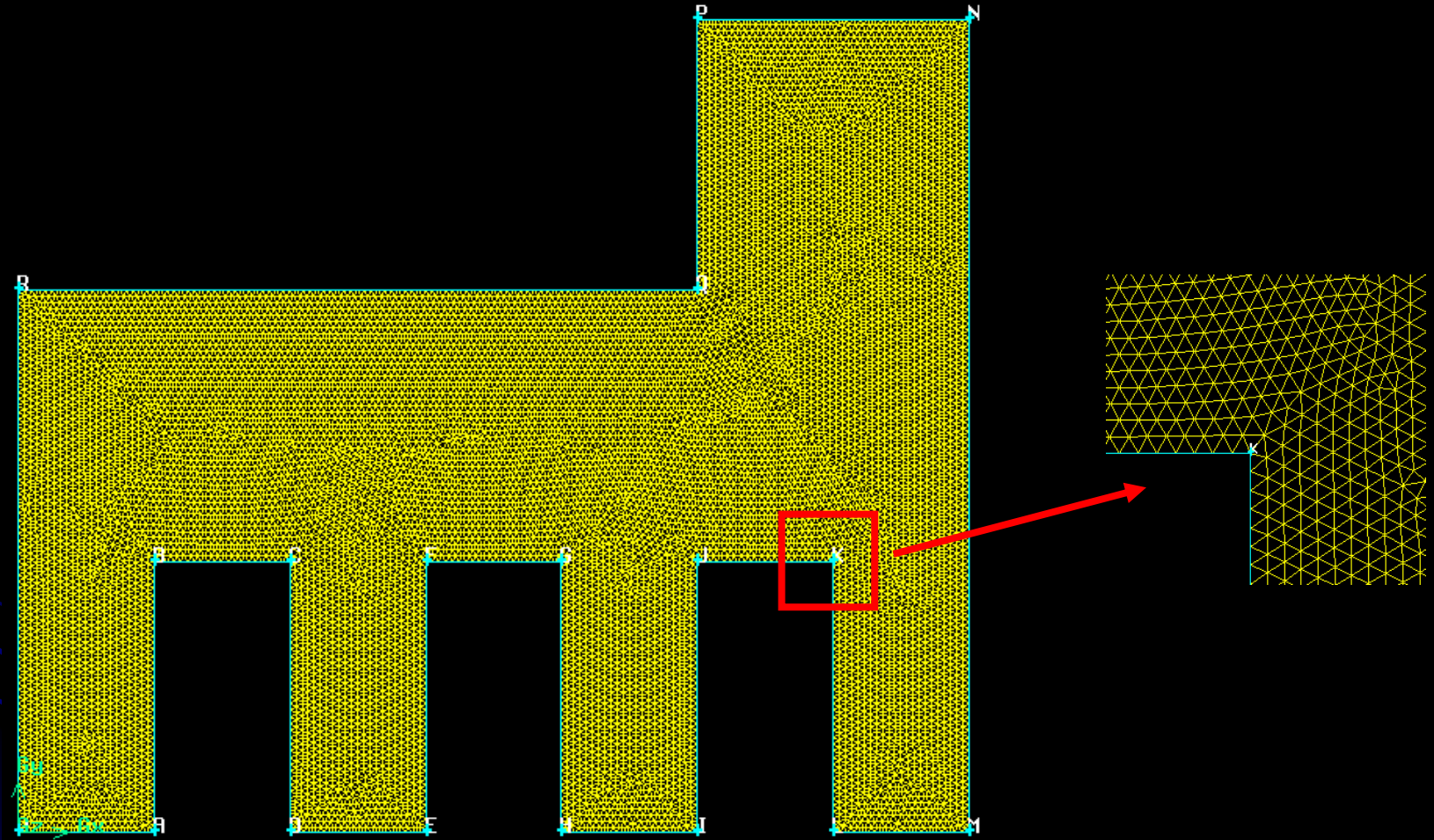


Fig. Manifold with 4 inlet pipes and 1 outlet pipe

# Manifold geometry



# Mesh generation with Gambit



**Fig. Triangular mesh created with Gambit**

# Define Solver and Viscous Model

**Solver**

**Solver**

Segregated  
 Coupled

**Formulation**

Implicit  
 Explicit

**Space**

2D  
 Axisymmetric  
 Axisymmetric Swirl  
 3D

**Time**

Steady  
 Unsteady

**Velocity Formulation**

Absolute  
 Relative

**Gradient Option**

Cell-Based  
 Node-Based

**Porous Formulation**

Superficial Velocity  
 Physical Velocity

OK Cancel Help

**Viscous Model**

**Model**

Inviscid  
 Laminar  
 Spalart-Allmaras (1 eqn)  
 k-epsilon (2 eqn)  
 k-omega (2 eqn)  
 Reynolds Stress (5 eqn)

**k-epsilon Model**

Standard  
 RNG  
 Realizable

**Near-Wall Treatment**

Standard Wall Functions  
 Non-Equilibrium Wall Functions  
 Enhanced Wall Treatment

**Model Constants**

Cmu  
0.09

C1-Epsilon  
1.44

C2-Epsilon  
1.92

TKE Prandtl Number  
1

**User-Defined Functions**

**Turbulent Viscosity**  
none

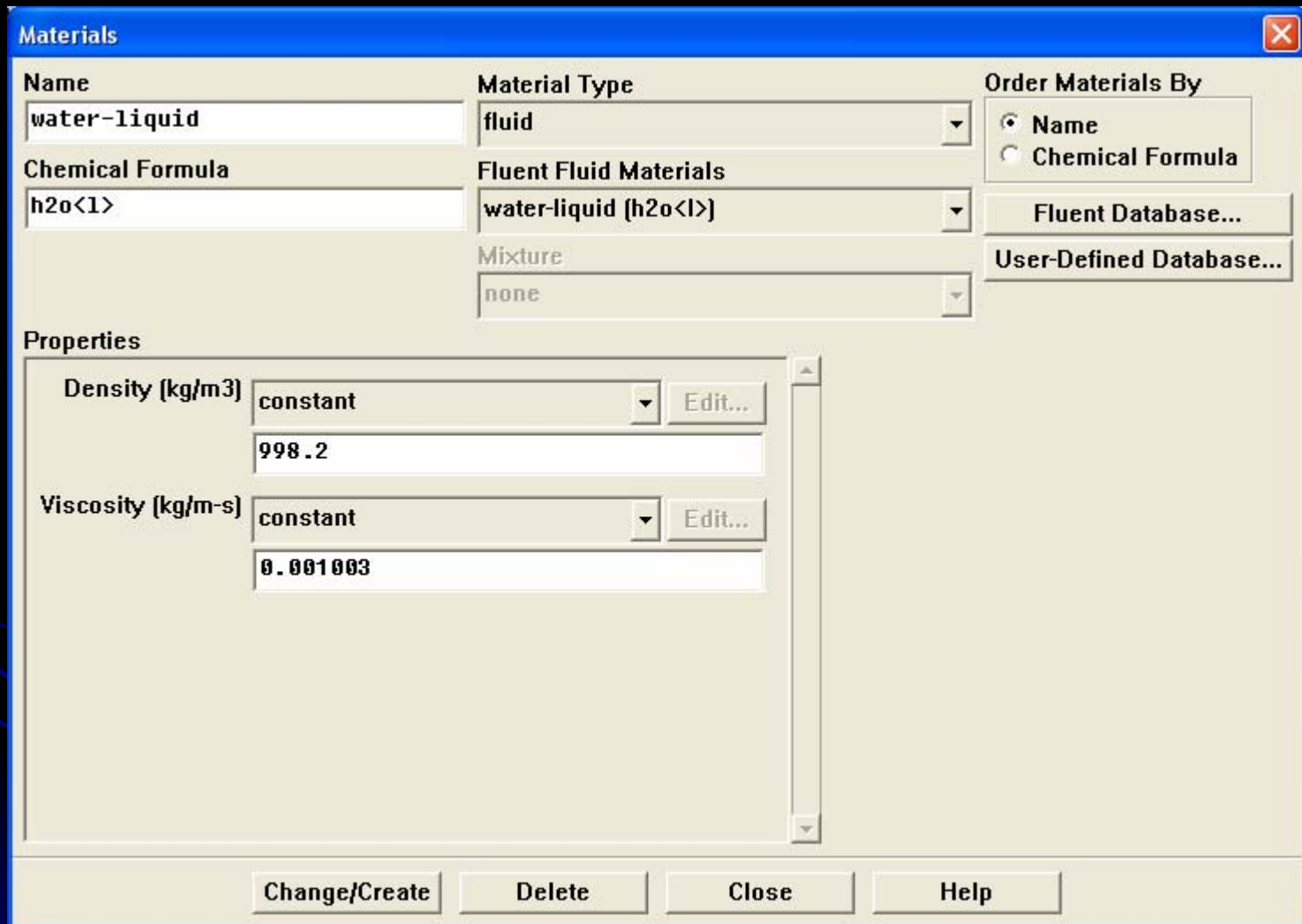
**Prandtl Numbers**

TKE Prandtl Number  
none

TDR Prandtl Number  
none

OK Cancel Help

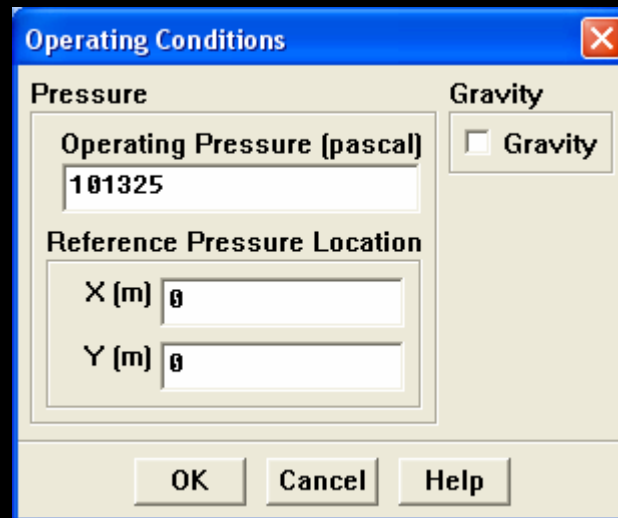
# Define Fluid



The image shows a screenshot of the 'Materials' dialog box in ANSYS Fluent. The dialog is titled 'Materials' and has a close button in the top right corner. It is divided into several sections: 'Name', 'Material Type', 'Chemical Formula', 'Fluent Fluid Materials', 'Mixture', 'Order Materials By', and 'Properties'. The 'Name' field contains 'water-liquid'. The 'Material Type' dropdown is set to 'fluid'. The 'Chemical Formula' field contains 'h2o<1>'. The 'Fluent Fluid Materials' dropdown is set to 'water-liquid (h2o<1>)'. The 'Mixture' dropdown is set to 'none'. The 'Order Materials By' section has two radio buttons: 'Name' (selected) and 'Chemical Formula'. There are two buttons: 'Fluent Database...' and 'User-Defined Database...'. The 'Properties' section is a scrollable area containing two property definitions: 'Density [kg/m3]' and 'Viscosity [kg/m-s]'. Each property has a dropdown menu set to 'constant' and an 'Edit...' button. The density value is '998.2' and the viscosity value is '0.001003'. At the bottom of the dialog are four buttons: 'Change/Create', 'Delete', 'Close', and 'Help'.

Field	Value
Name	water-liquid
Material Type	fluid
Chemical Formula	h2o<1>
Fluent Fluid Materials	water-liquid (h2o<1>)
Mixture	none
Order Materials By	<input checked="" type="radio"/> Name <input type="radio"/> Chemical Formula
Properties	Density [kg/m3]: constant, 998.2 Viscosity [kg/m-s]: constant, 0.001003

# Define Operating Conditions



The image shows a software dialog box titled "Operating Conditions". It is divided into two main sections: "Pressure" and "Gravity".

**Pressure Section:**

- Operating Pressure (pascal):** A text input field containing the value "101325".
- Reference Pressure Location:** A sub-section containing two input fields:
  - X (m):** A text input field containing the value "0".
  - Y (m):** A text input field containing the value "0".

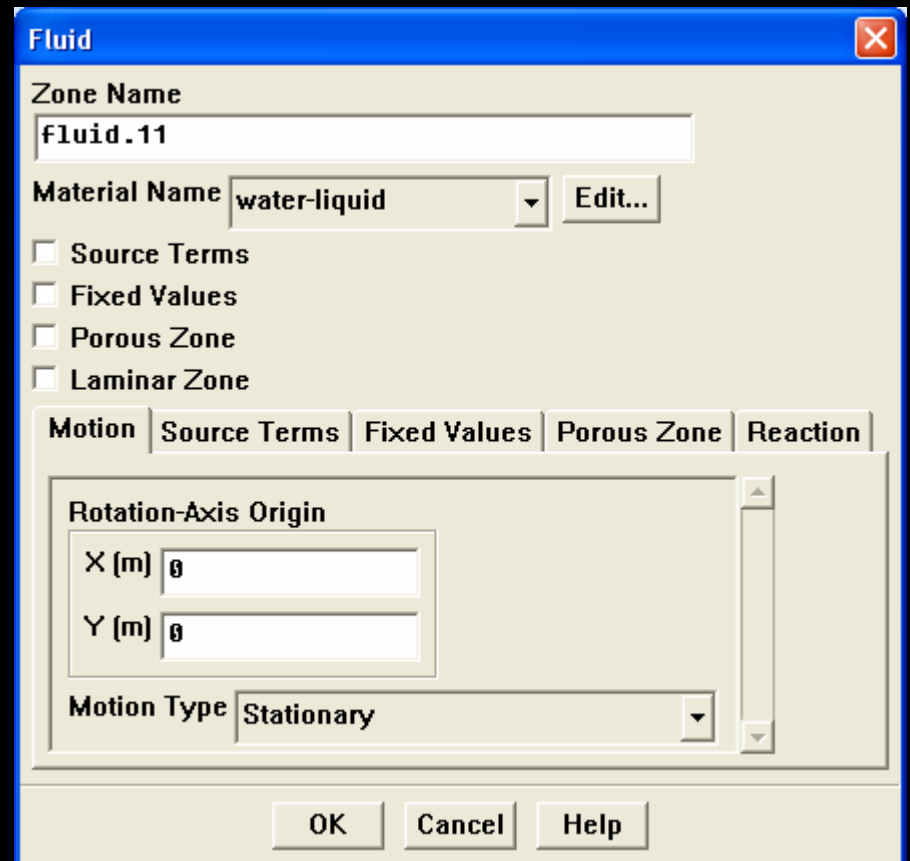
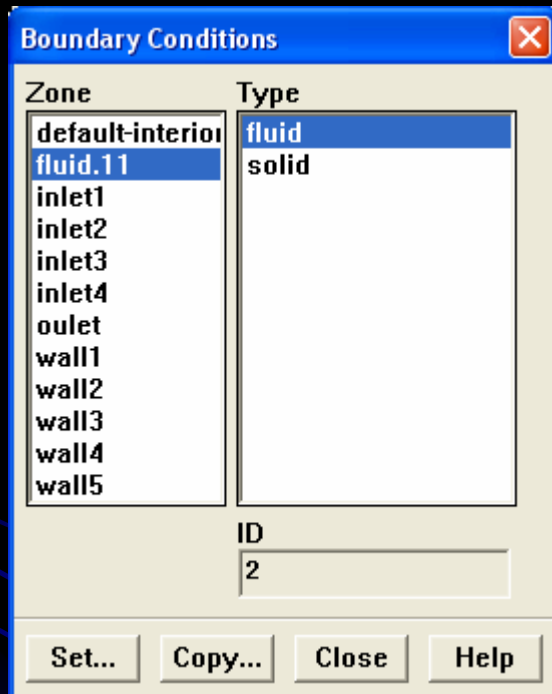
**Gravity Section:**

- Gravity:** A checkbox that is currently unchecked.

**Buttons:** At the bottom of the dialog box, there are three buttons: "OK", "Cancel", and "Help".



# Define Boundary Conditions



**Velocity Inlet** ✕

Zone Name

Velocity Specification Method

Reference Frame

Velocity Magnitude (m/s)

Turbulence Specification Method

Turbulence Intensity (%)

Hydraulic Diameter (m)

**Velocity Inlet** ✕

Zone Name

Velocity Specification Method

Reference Frame

Velocity Magnitude (m/s)

Turbulence Specification Method

Turbulence Intensity (%)

Hydraulic Diameter (m)

**Velocity Inlet** [X]

Zone Name  
inlet3

Velocity Specification Method: Magnitude, Normal to Boundary

Reference Frame: Absolute

Velocity Magnitude (m/s): 1 constant

Turbulence Specification Method: Intensity and Hydraulic Diameter

Turbulence Intensity (%): 10

Hydraulic Diameter (m): 1

OK Cancel Help

**Velocity Inlet** [X]

Zone Name  
inlet4

Velocity Specification Method: Magnitude, Normal to Boundary

Reference Frame: Absolute

Velocity Magnitude (m/s): 1 constant

Turbulence Specification Method: Intensity and Hydraulic Diameter

Turbulence Intensity (%): 10

Hydraulic Diameter (m): 1

OK Cancel Help

**Outflow** ✕

Zone Name  
oulet

Flow Rate Weighting 1

OK Cancel Help

**Wall** [X]

Zone Name  
wall1

Adjacent Cell Zone  
Fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion      Motion

Stationary Wall       Relative to Adjacent Cell Zone

Moving Wall

Shear Condition

No Slip

Specified Shear

Specularity Coefficient

Marangoni Stress

Wall Roughness

Roughness Height (m) 0.003      constant

Roughness Constant 0.5      constant

OK    Cancel    Help

**Wall** [X]

Zone Name  
wall2

Adjacent Cell Zone  
Fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion      Motion

Stationary Wall       Relative to Adjacent Cell Zone

Moving Wall

Shear Condition

No Slip

Specified Shear

Specularity Coefficient

Marangoni Stress

Wall Roughness

Roughness Height (m) 0.003      constant

Roughness Constant 0.5      constant

OK    Cancel    Help

**Wall** [Close]

Zone Name  
wall13

Adjacent Cell Zone  
fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion      Motion

Stationary Wall       Relative to Adjacent Cell Zone

Moving Wall

Shear Condition

No Slip

Specified Shear

Specularity Coefficient

Marangoni Stress

Wall Roughness

Roughness Height (m) 0.003      constant

Roughness Constant 0.5      constant

OK    Cancel    Help

**Wall** [Close]

Zone Name  
wall14

Adjacent Cell Zone  
fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion      Motion

Stationary Wall       Relative to Adjacent Cell Zone

Moving Wall

Shear Condition

No Slip

Specified Shear

Specularity Coefficient

Marangoni Stress

Wall Roughness

Roughness Height (m) 0.003      constant

Roughness Constant 0.5      constant

OK    Cancel    Help

Wall

Zone Name  
wall15

Adjacent Cell Zone  
fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion  
 Stationary Wall  
 Moving Wall

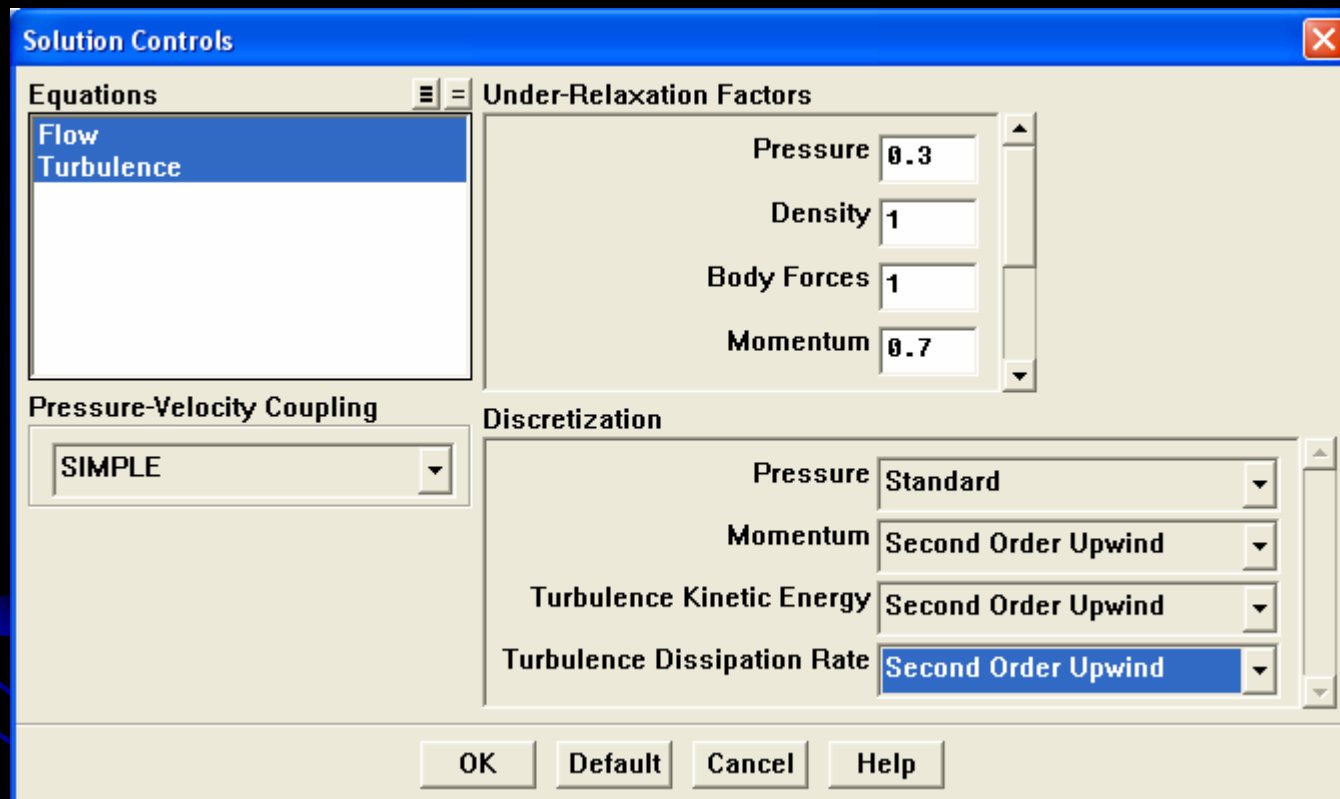
Motion  
 Relative to Adjacent Cell Zone

Shear Condition  
 No Slip  
 Specified Shear  
 Specularity Coefficient  
 Marangoni Stress

Wall Roughness  
Roughness Height (m) 0.003 constant  
Roughness Constant 0.5 constant

OK Cancel Help

# Solve control solutions





# Solve Solution Initialization and Residual Monitors

**Solution Initialization**

Compute From: **inlet1**

Reference Frame:  
 Relative to Cell Zone  
 Absolute

Initial Values

Gauge Pressure (pascal)	0
X Velocity (m/s)	0
Y Velocity (m/s)	1
Turbulence Kinetic Energy (m2/s2)	0.015

Init    Reset    Apply    Close    Help

**Residual Monitors**

Options:  
 Print  
 Plot

Storage:  
Iterations: **1000**

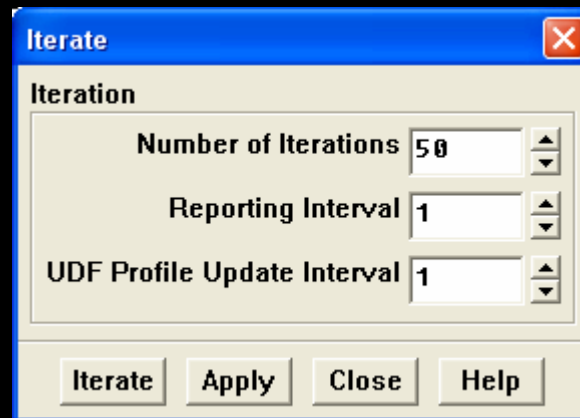
Normalization:  
 Normalize  Scale

Plotting:  
Window: **0**  
Iterations: **1000**  
Axes...    Curves...

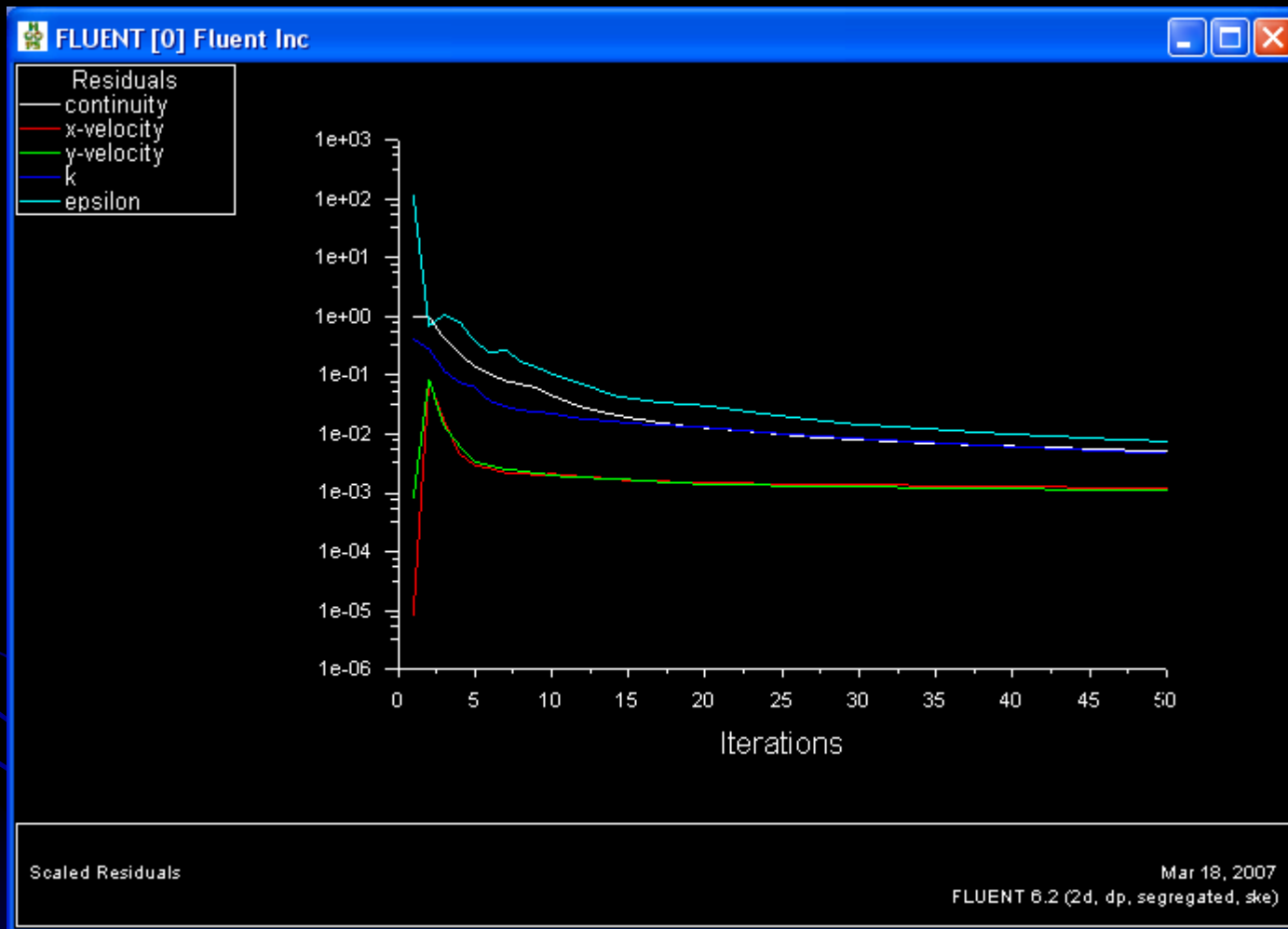
Residual	Check Monitor	Convergence	Convergence Criterion
continuity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001
x-velocity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001
y-velocity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001
k	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001
epsilon	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001

OK    Plot    Renorm    Cancel    Help

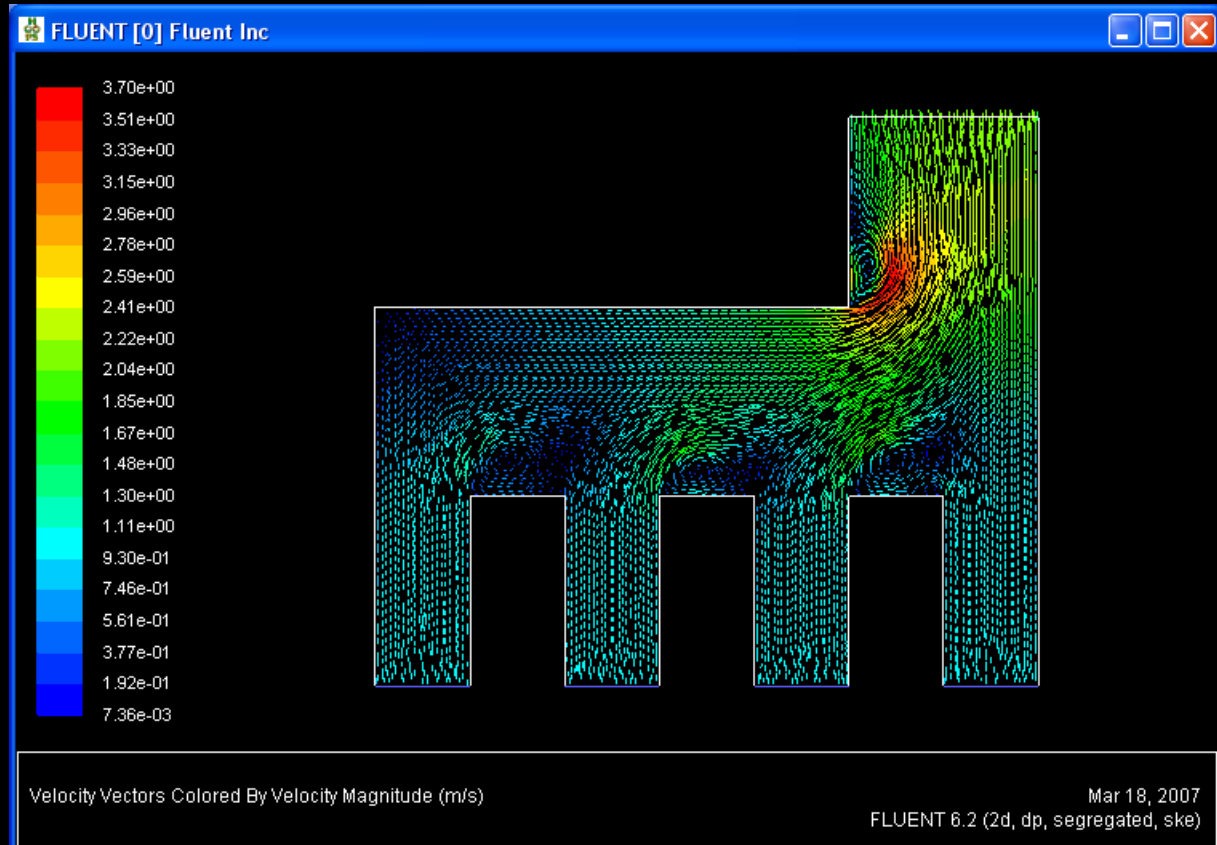
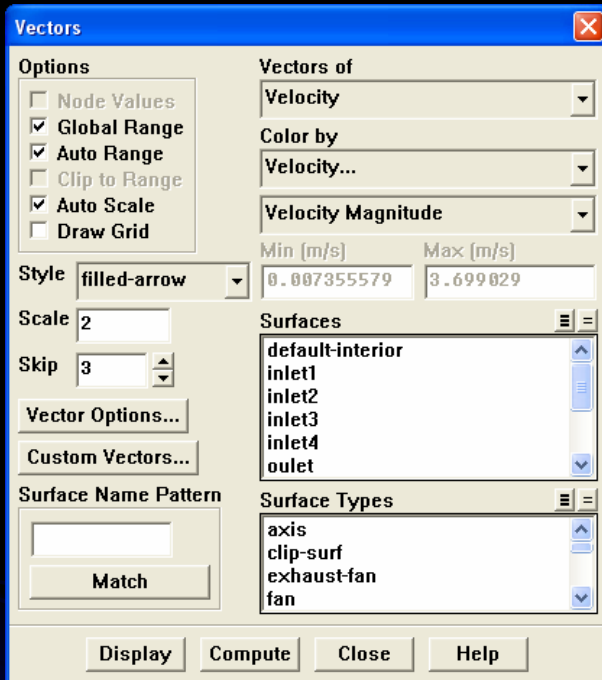
# Solve Iteration



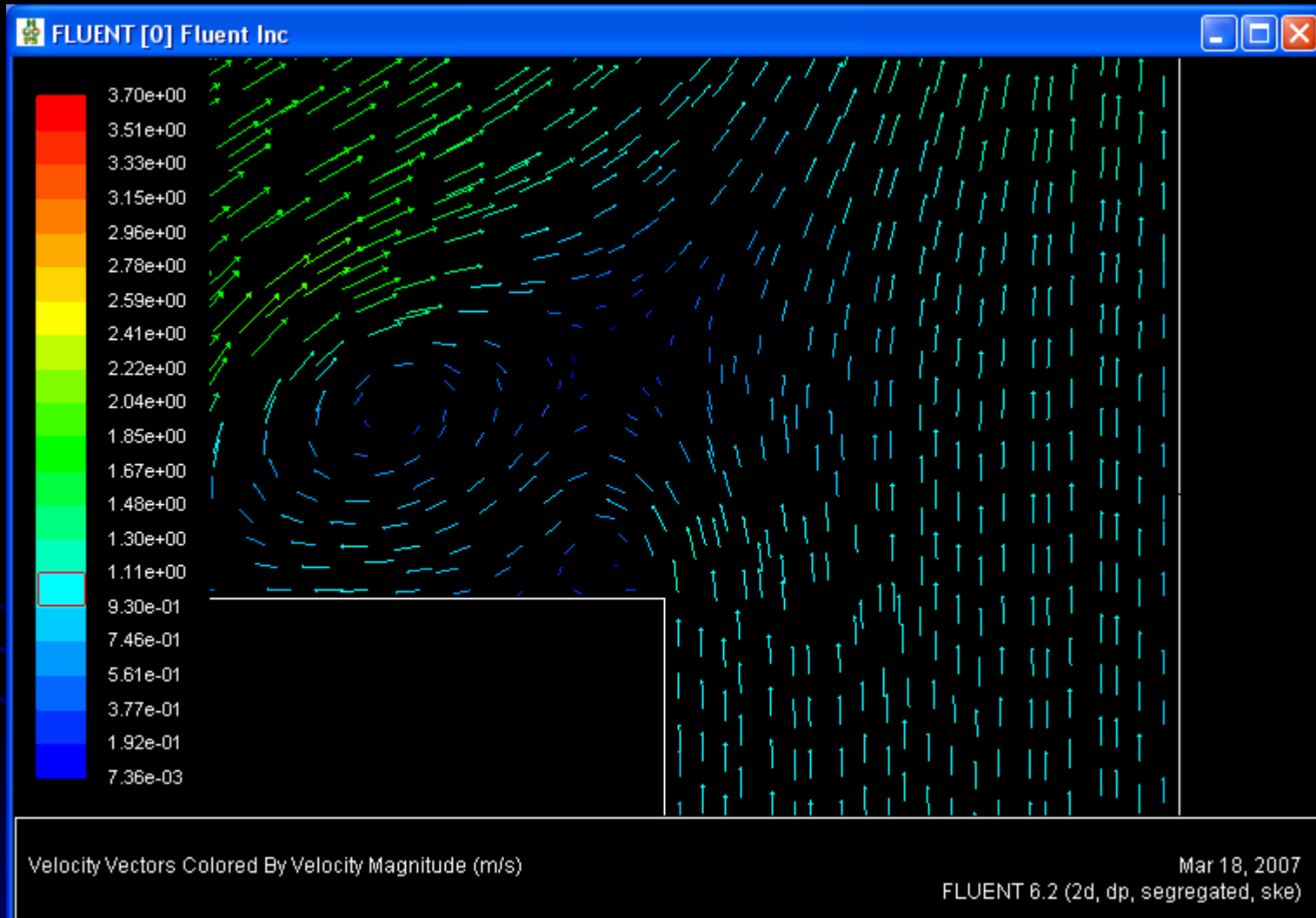
# Convergence of solution



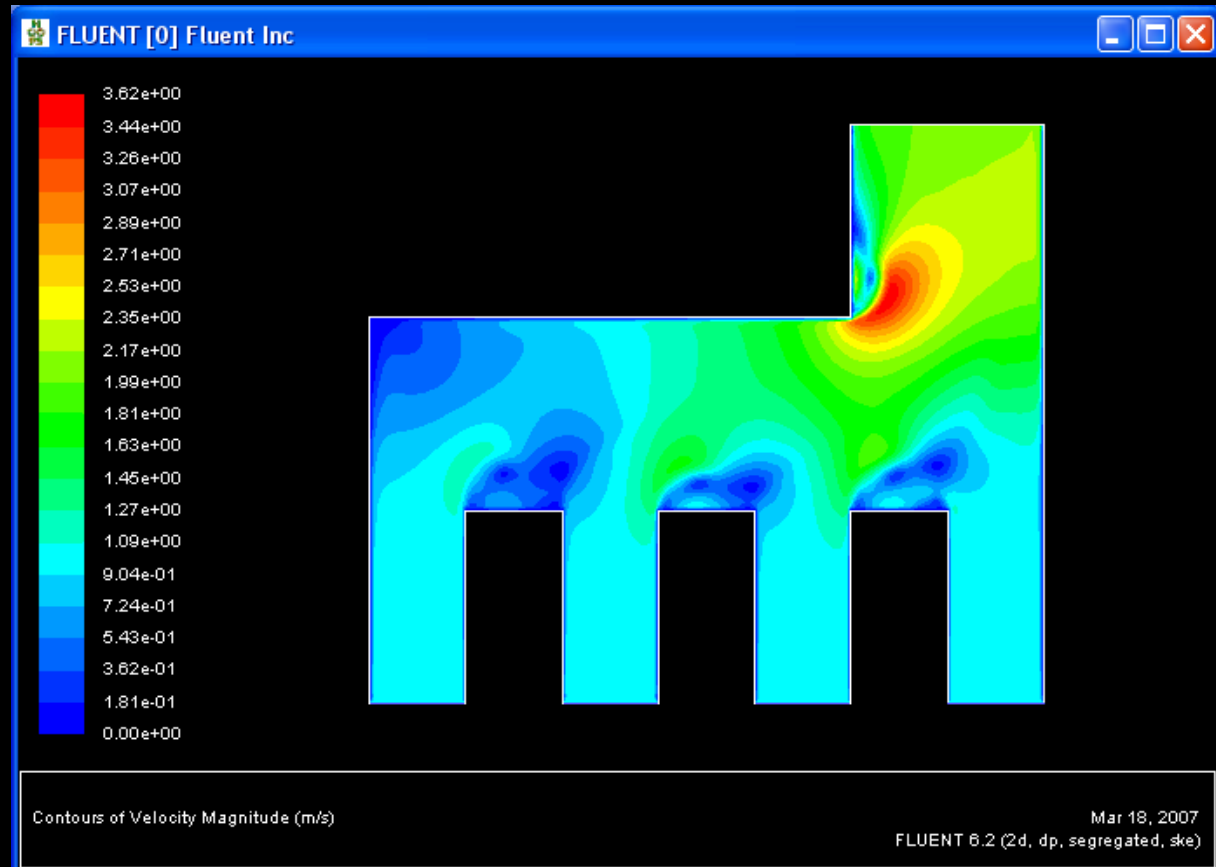
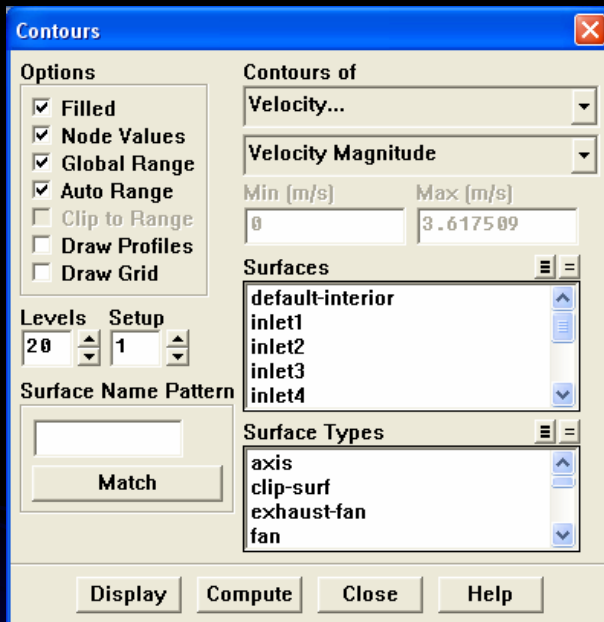
# Display of Vectors – Velocity Magnitude



# Display of Vectors – Velocity Magnitude



# Display of Contours – Velocity Magnitude



# Display of Contours - Vorticity

**Contours**

**Options**

- Filled
- Node Values
- Global Range
- Auto Range
- Clip to Range
- Draw Profiles
- Draw Grid

**Contours of**

Velocity...  
Vorticity Magnitude

Min [1/s]    Max [1/s]  
0.0006321744    54.94844

**Surfaces**

default-interior  
inlet1  
inlet2  
inlet3  
inlet4

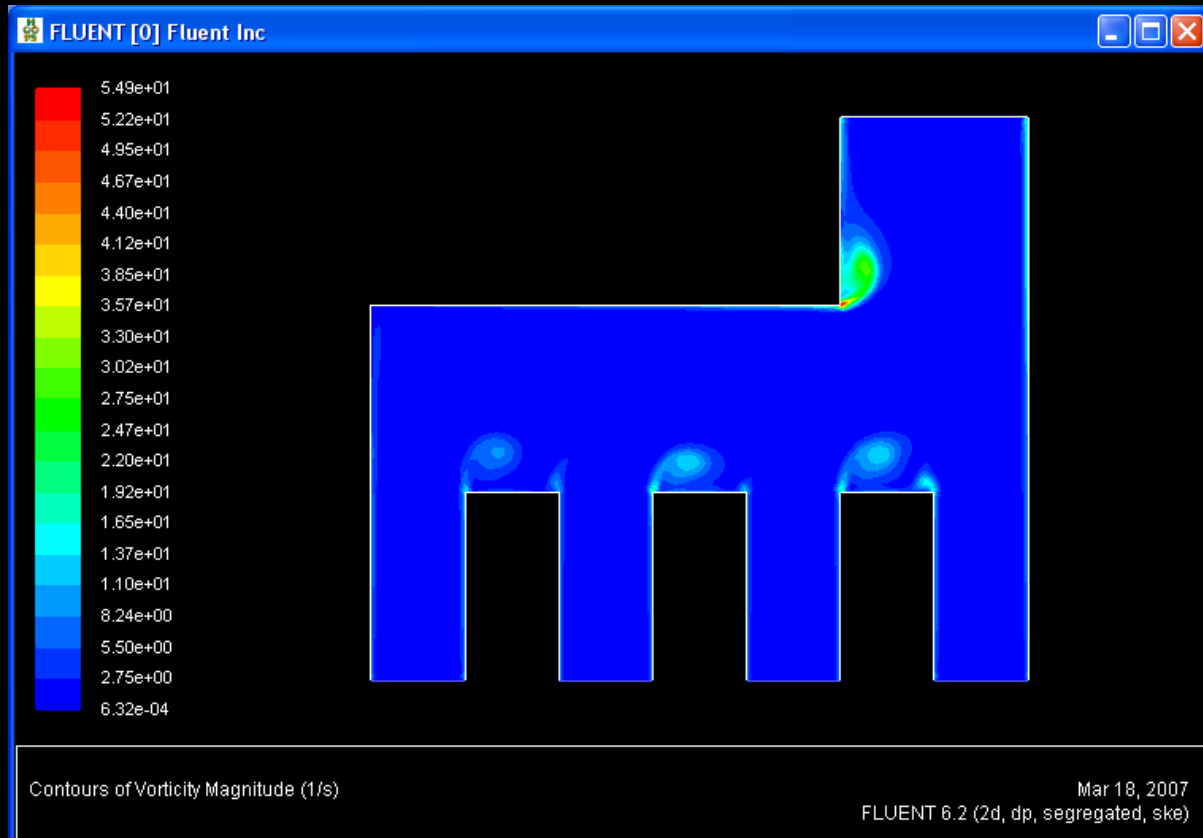
**Surface Types**

axis  
clip-surf  
exhaust-fan  
fan

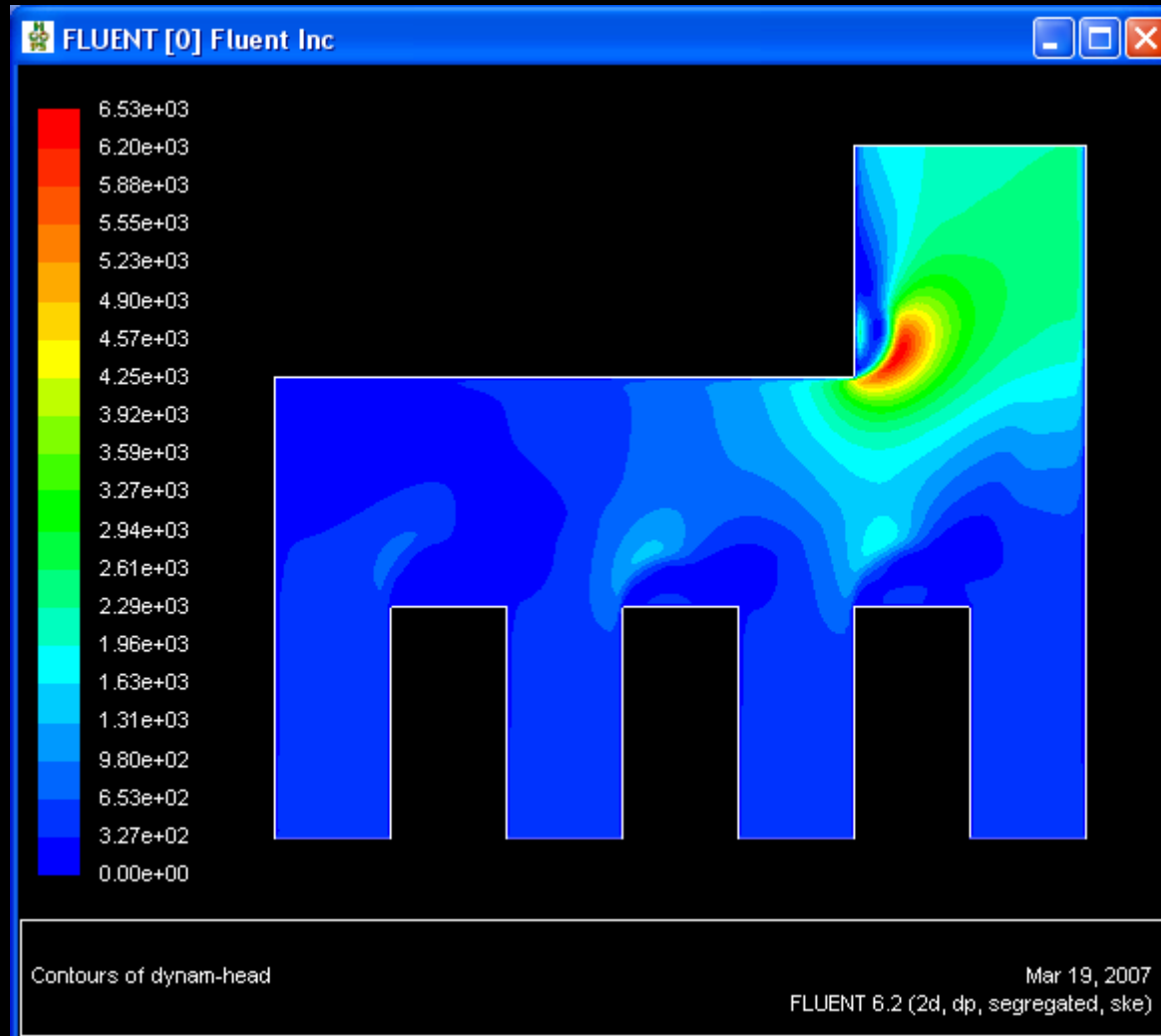
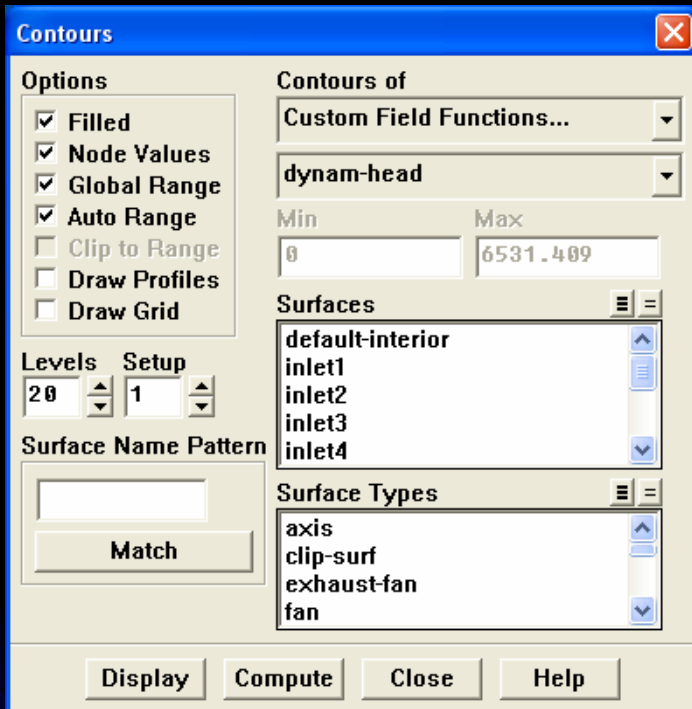
Levels    Setup  
20    1

Surface Name Pattern  
Match

Display    Compute    Close    Help



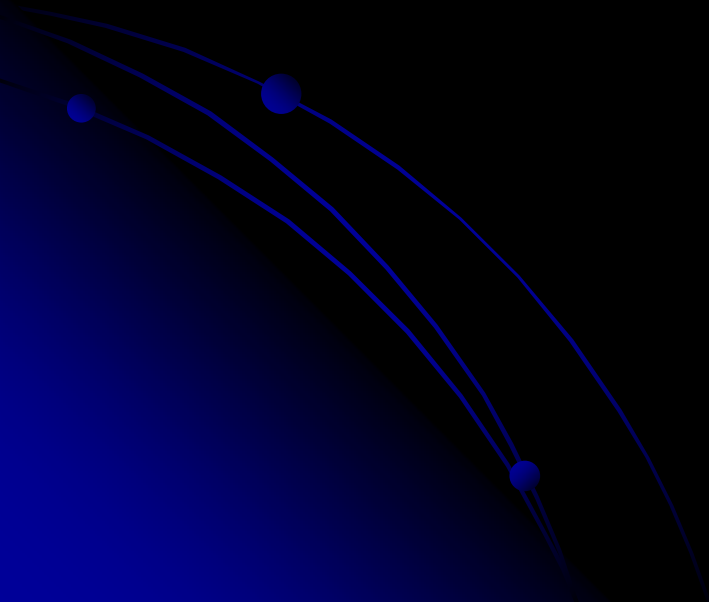
# Display of Contours – Dynamic Head





# Laminar Flow in Manifold

(By considering only input velocities)



# 1. Data

Fluid : water

Density = 998.2 kg/m<sup>3</sup>

Dynamic viscosity = 0.001003 kg/m.s

The flow is laminar

Re  $\approx$  100 ( at inlet)

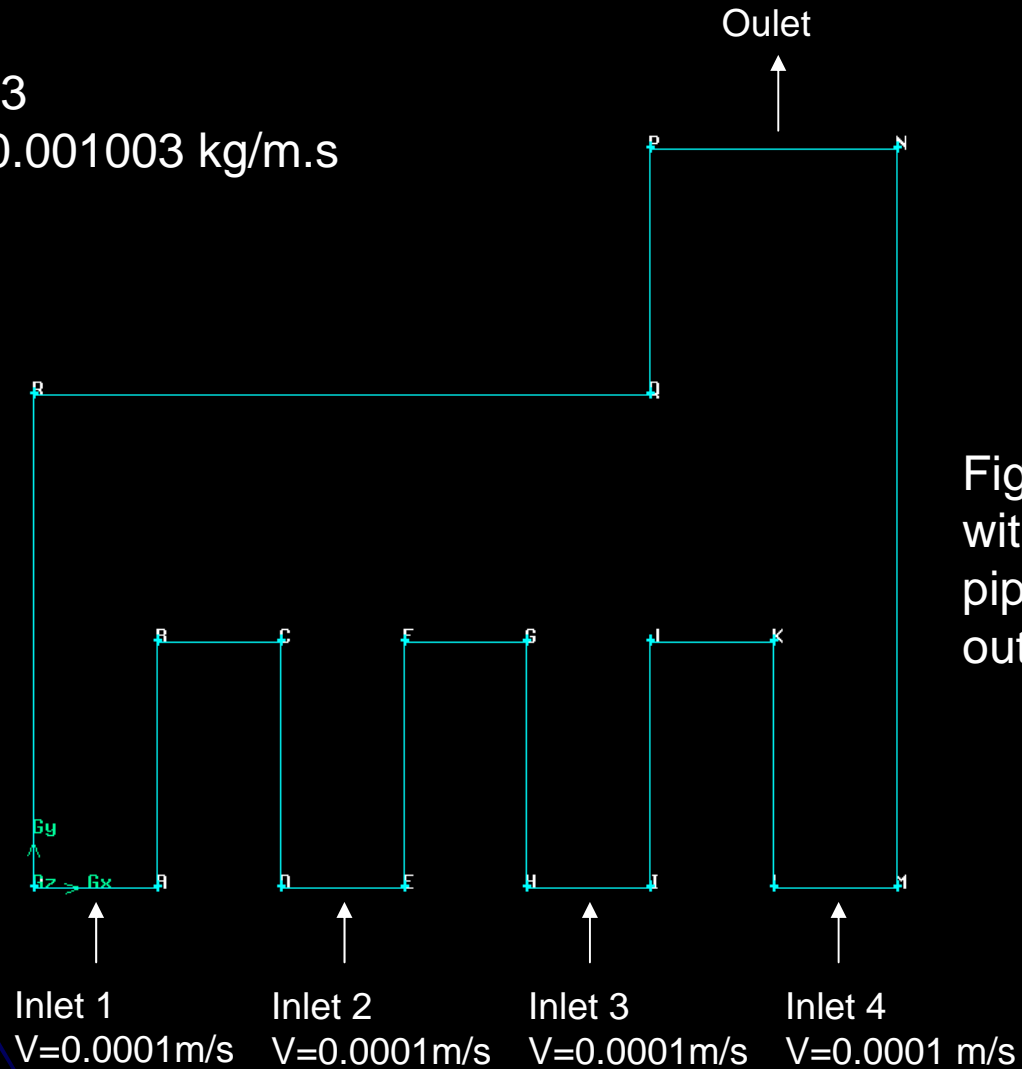
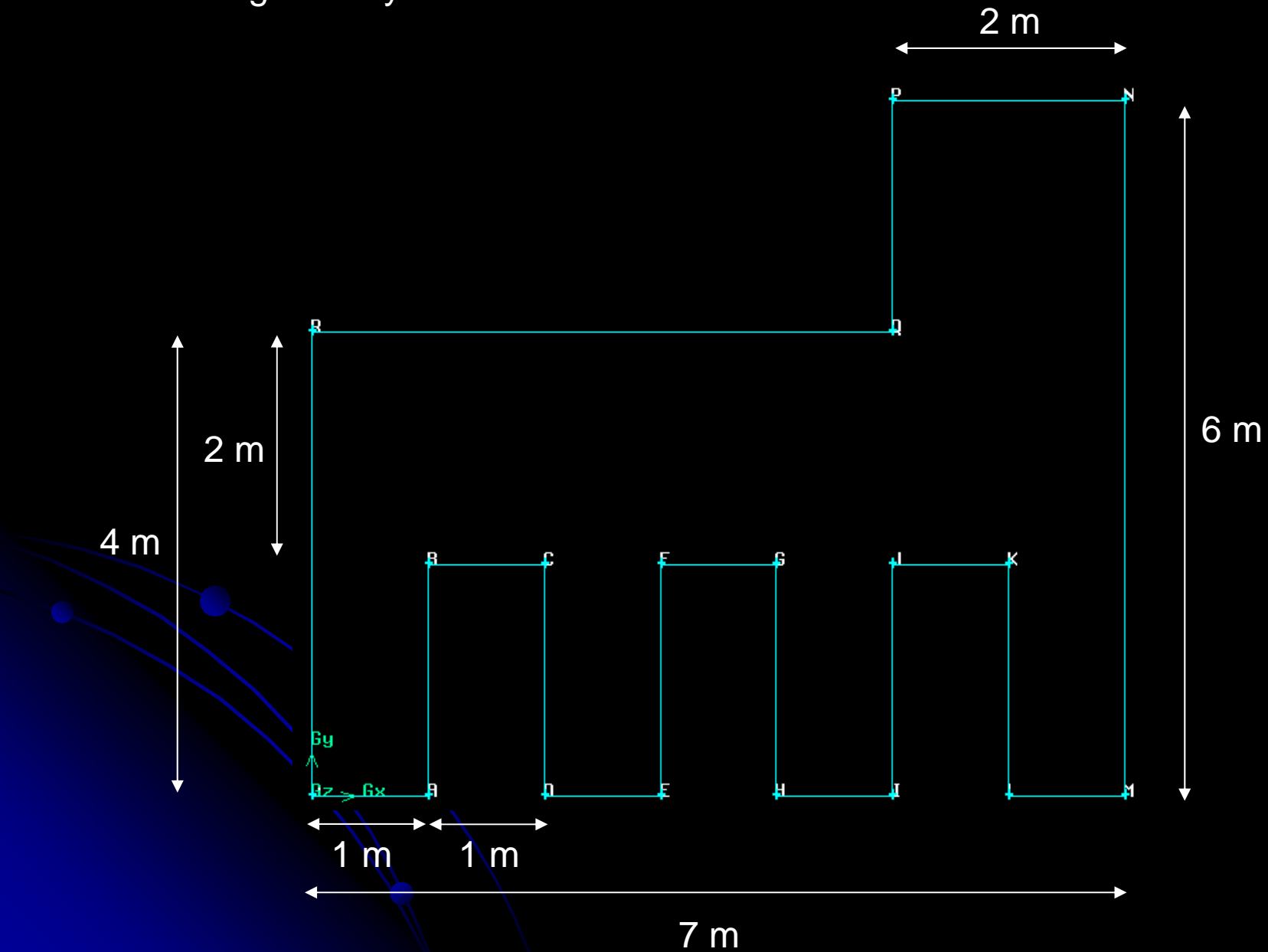
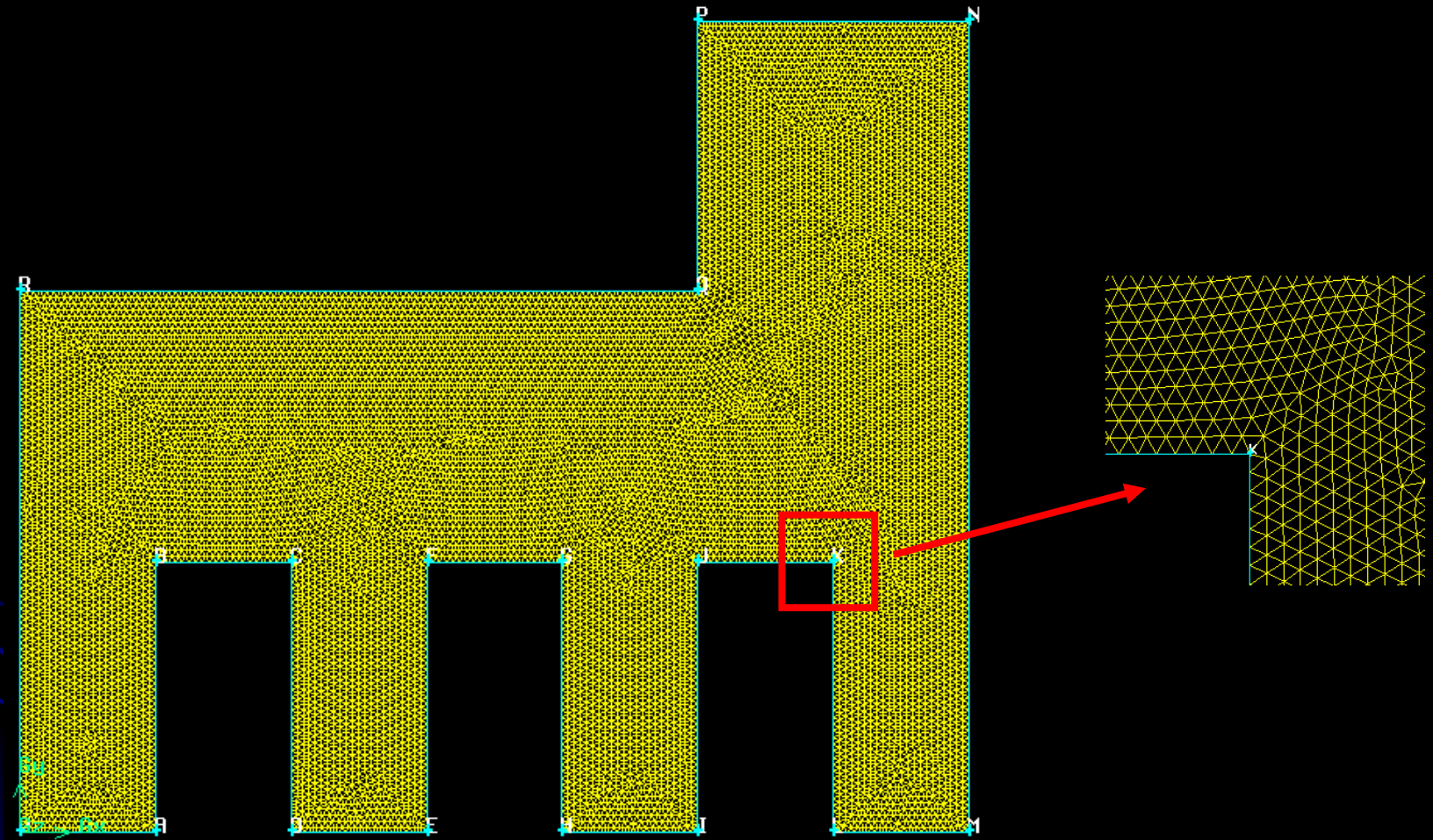


Fig. Manifold with 4 inlet pipes and 1 outlet pipe

# Manifold geometry



# Mesh generation with Gambit



**Fig. Triangular mesh created with Gambit**

# Define Solver and Viscous Model

**Solver**

**Solver**

Segregated  
 Coupled

**Formulation**

Implicit  
 Explicit

**Space**

2D  
 Axisymmetric  
 Axisymmetric Swirl  
 3D

**Time**

Steady  
 Unsteady

**Velocity Formulation**

Absolute  
 Relative

**Gradient Option**

Cell-Based  
 Node-Based

**Porous Formulation**

Superficial Velocity  
 Physical Velocity

OK Cancel Help

**Viscous Model**

**Model**

Inviscid  
 Laminar  
 Spalart-Allmaras (1 eqn)  
 k-epsilon (2 eqn)  
 k-omega (2 eqn)  
 Reynolds Stress (5 eqn)

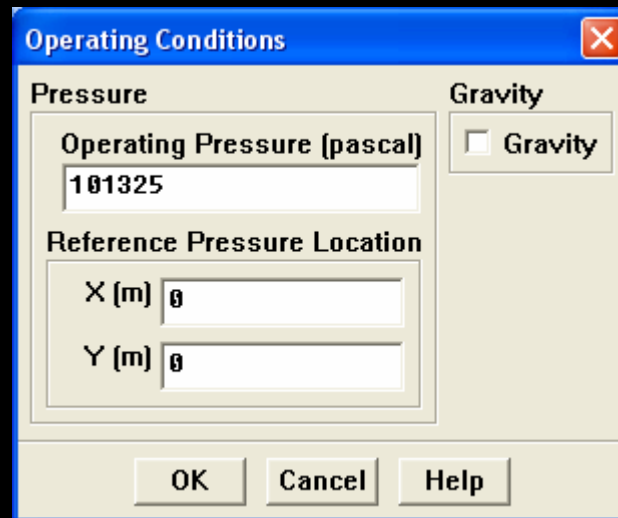
OK Cancel Help

# Define Fluid

The image shows a 'Materials' dialog box with the following fields and options:

- Name:** water-liquid
- Material Type:** fluid
- Chemical Formula:** h2o<1>
- Fluent Fluid Materials:** water-liquid (h2o<1>)
- Mixture:** none
- Order Materials By:** Name (selected), Chemical Formula
- Buttons:** Fluent Database..., User-Defined Database...
- Properties:**
  - Density [kg/m<sup>3</sup>]:** constant (dropdown), Edit... (button), 998.2 (text field)
  - Viscosity [kg/m-s]:** constant (dropdown), Edit... (button), 0.001003 (text field)
- Bottom Buttons:** Change/Create, Delete, Close, Help

# Define Operating Conditions



The image shows a software dialog box titled "Operating Conditions". It is divided into two main sections: "Pressure" and "Gravity".

**Pressure Section:**

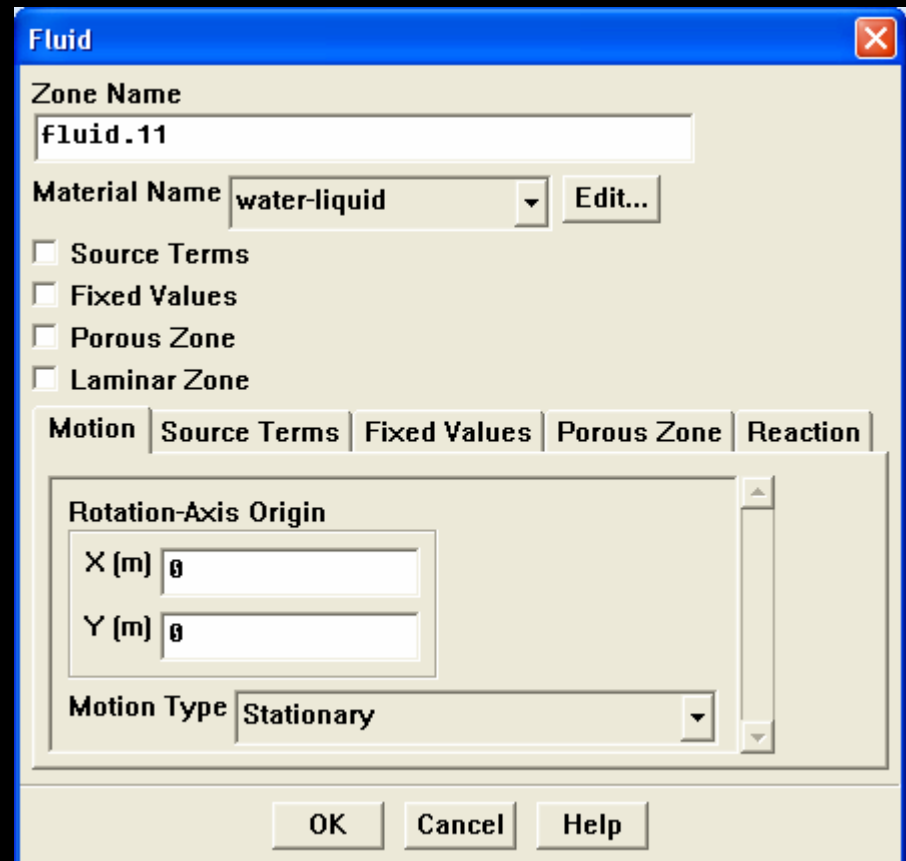
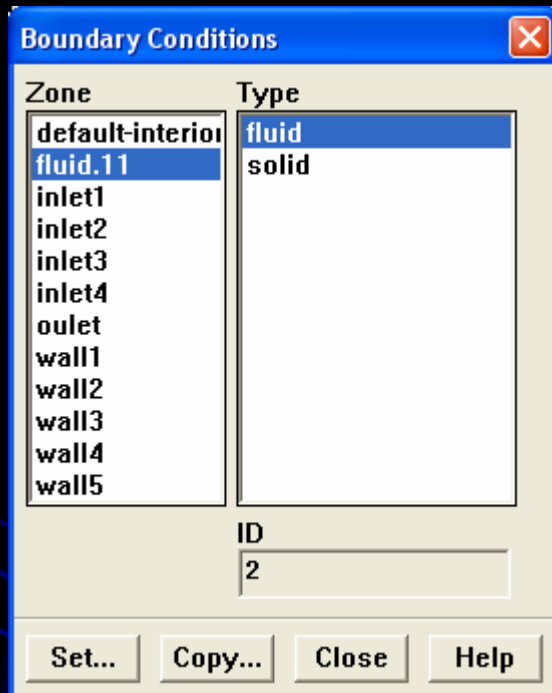
- Operating Pressure (pascal):** A text input field containing the value "101325".
- Reference Pressure Location:** A sub-section containing two text input fields:
  - X (m):** A text input field containing the value "0".
  - Y (m):** A text input field containing the value "0".

**Gravity Section:**

- Gravity:** A checkbox labeled "Gravity" which is currently unchecked.

**Buttons:** At the bottom of the dialog box, there are three buttons: "OK", "Cancel", and "Help".

# Define Boundary Conditions





Velocity Inlet

Zone Name  
inlet1

Velocity Specification Method Magnitude, Normal to Boundary

Reference Frame Absolute

Velocity Magnitude (m/s) 0.0001 constant

OK Cancel Help

Velocity Inlet

Zone Name  
inlet2

Velocity Specification Method Magnitude, Normal to Boundary

Reference Frame Absolute

Velocity Magnitude (m/s) 0.0001 constant

OK Cancel Help

**Velocity Inlet** ✕

Zone Name

Velocity Specification Method

Reference Frame

Velocity Magnitude (m/s)

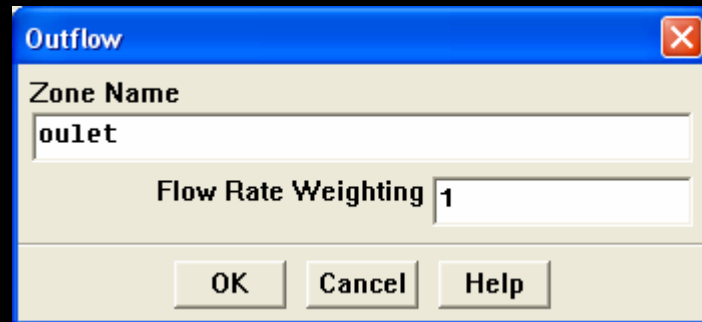
**Velocity Inlet** ✕

Zone Name

Velocity Specification Method

Reference Frame

Velocity Magnitude (m/s)

A dialog box titled "Outflow" with a blue header bar and a close button (X) in the top right corner. The dialog contains two input fields: "Zone Name" with the text "outlet" and "Flow Rate Weighting" with the value "1". At the bottom, there are three buttons: "OK", "Cancel", and "Help".

**Outflow** ✕

Zone Name  
outlet

Flow Rate Weighting 1

OK Cancel Help

**Wall** [Close]

Zone Name  
wall1

Adjacent Cell Zone  
fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion      Motion

Stationary Wall       Relative to Adjacent Cell Zone

Moving Wall

Shear Condition

No Slip

Specified Shear

Specularity Coefficient

Marangoni Stress

OK    Cancel    Help

**Wall** [Close]

Zone Name  
wall2

Adjacent Cell Zone  
fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion      Motion

Stationary Wall       Relative to Adjacent Cell Zone

Moving Wall

Shear Condition

No Slip

Specified Shear

Specularity Coefficient

Marangoni Stress

OK    Cancel    Help

Wall

Zone Name  
wall13

Adjacent Cell Zone  
fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion      Motion

Stationary Wall       Relative to Adjacent Cell Zone

Moving Wall

Shear Condition

No Slip

Specified Shear

Specularity Coefficient

Marangoni Stress

OK    Cancel    Help

Wall

Zone Name  
wall14

Adjacent Cell Zone  
fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion      Motion

Stationary Wall       Relative to Adjacent Cell Zone

Moving Wall

Shear Condition

No Slip

Specified Shear

Specularity Coefficient

Marangoni Stress

OK    Cancel    Help

Wall

Zone Name  
wall15

Adjacent Cell Zone  
fluid.11

Thermal | DPM | Momentum | Species | Radiation | UDS | Granular

Wall Motion      Motion

Stationary Wall       Relative to Adjacent Cell Zone

Moving Wall

Shear Condition

No Slip

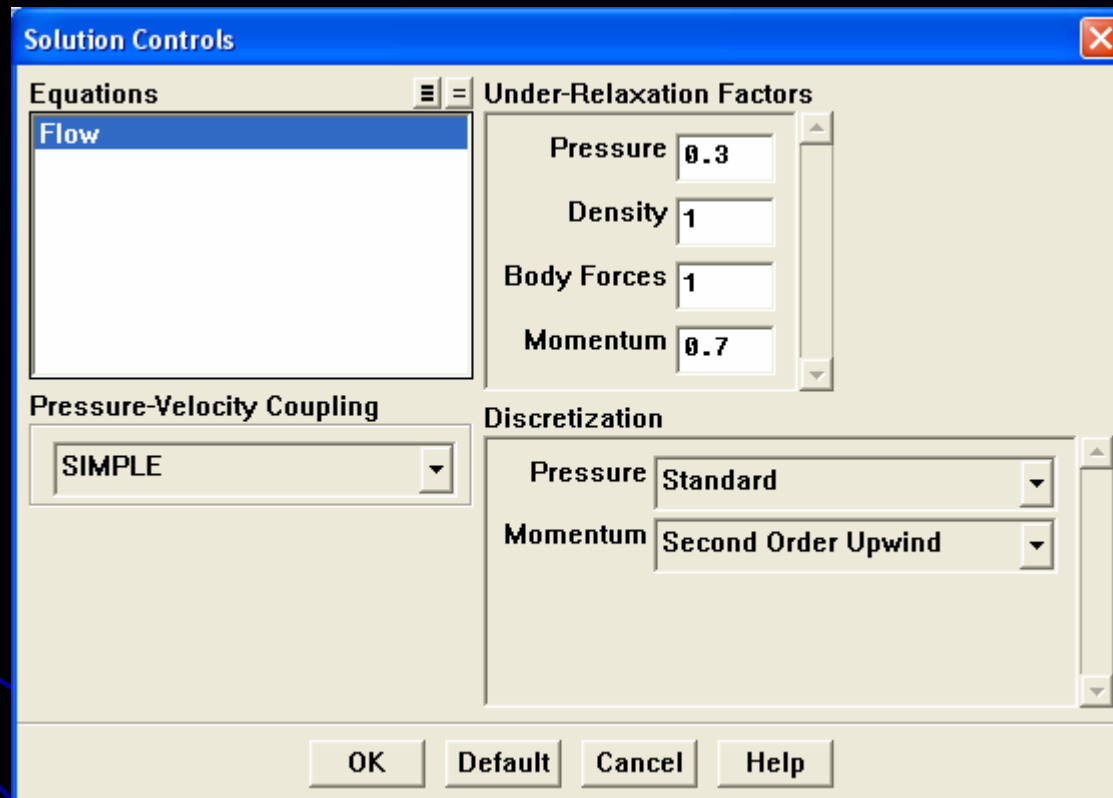
Specified Shear

Specularity Coefficient

Marangoni Stress

OK      Cancel      Help

## Solve control solutions



# Solve Solution Initialization and Residual Monitors

**Solution Initialization** [X]

Compute From: **inlet1**

Reference Frame:  
 Relative to Cell Zone  
 Absolute

Initial Values

Gauge Pressure (pascal)	0
X Velocity (m/s)	0
Y Velocity (m/s)	0.0001

Buttons: Init, Reset, Apply, Close, Help

**Residual Monitors** [X]

Options:  
 Print  
 Plot

Storage:  
Iterations: 1000

Normalization:  
 Normalize  Scale

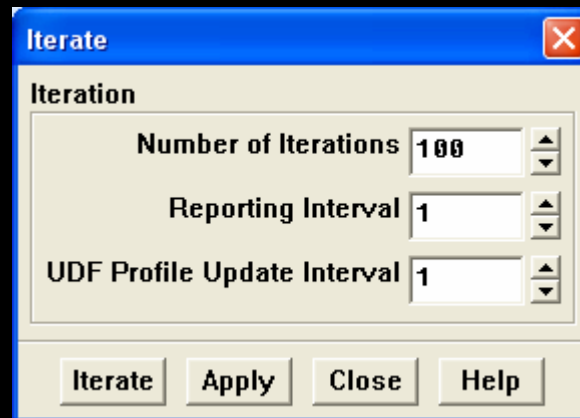
Plotting:  
Window: 0  
Iterations: 1000  
Buttons: Axes..., Curves...

Residual	Check Monitor	Convergence	Convergence Criterion
continuity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001
x-velocity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001
y-velocity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001

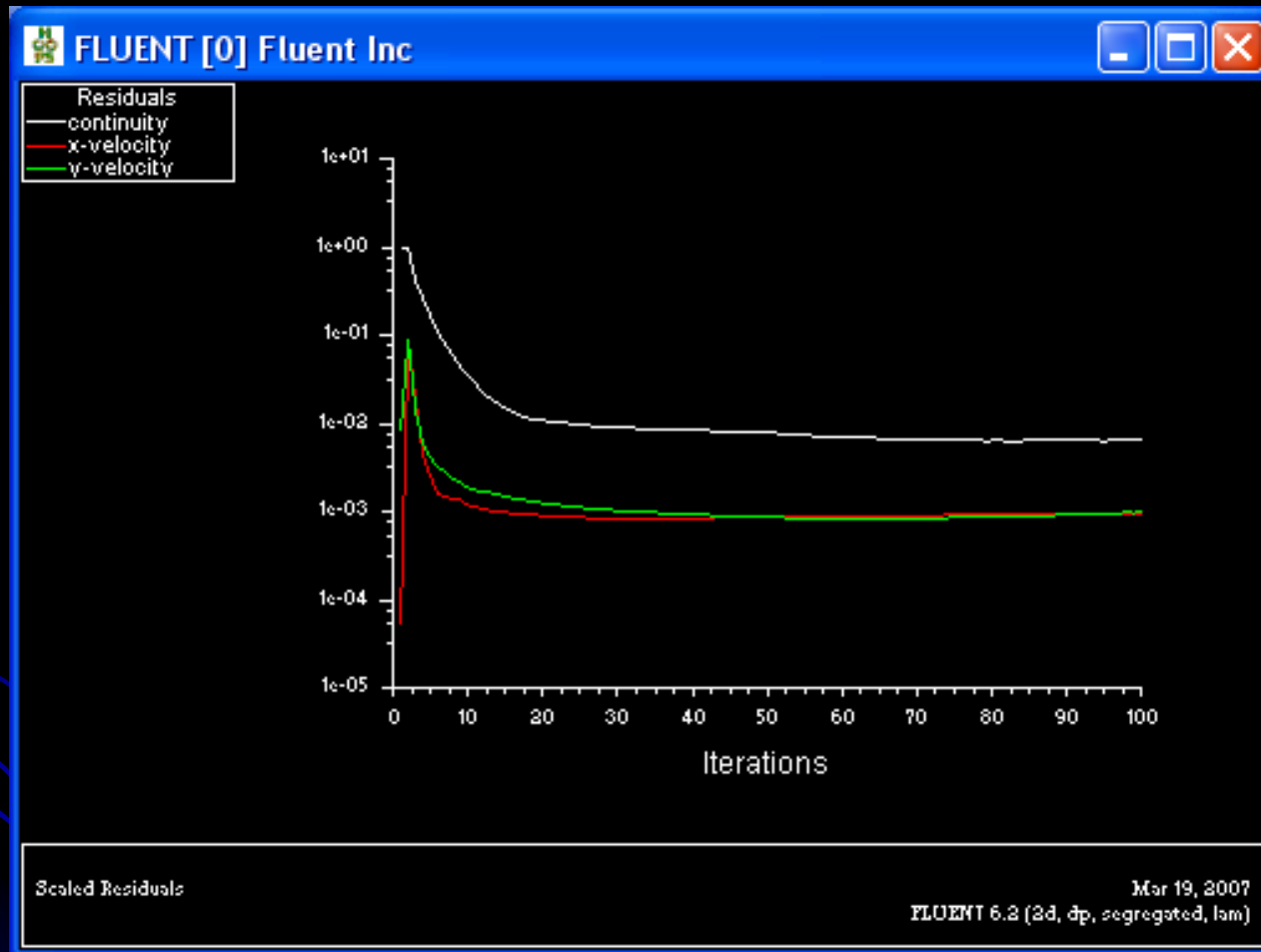
Buttons: OK, Plot, Renorm, Cancel, Help



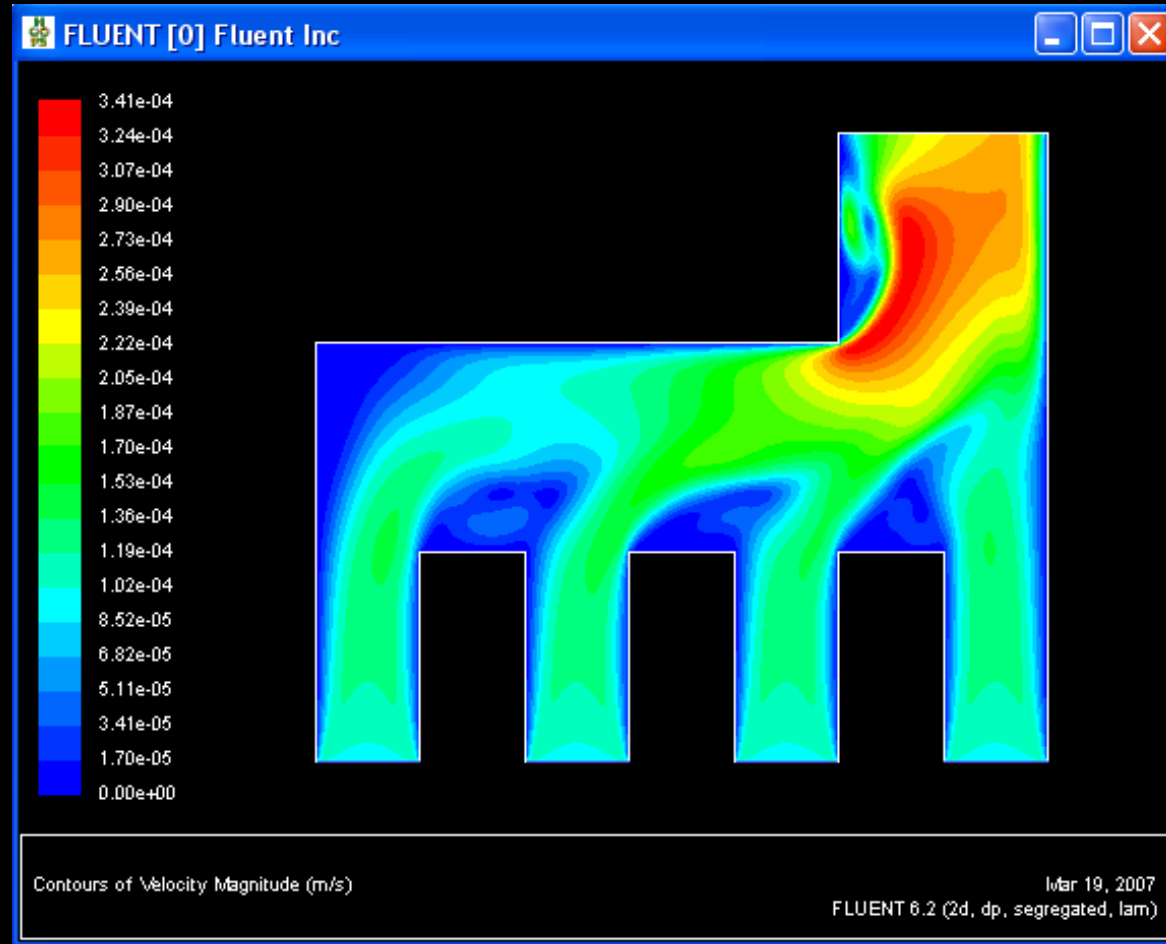
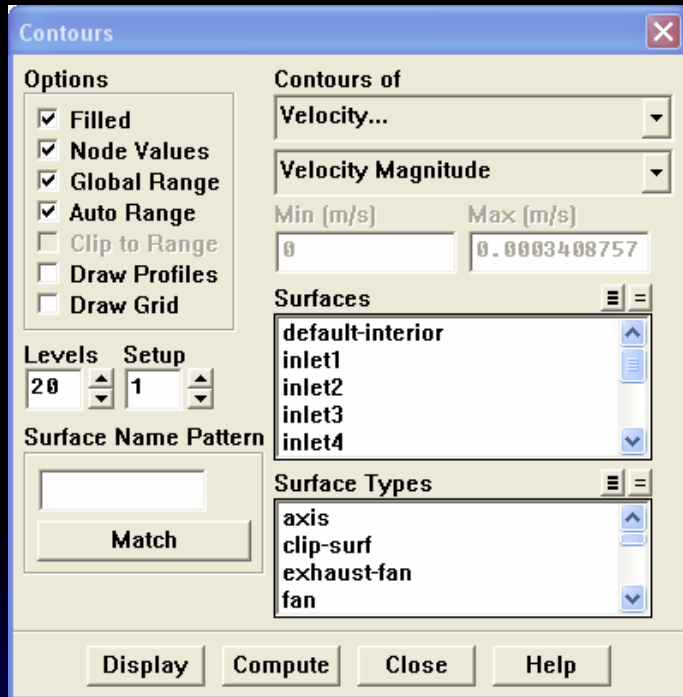
# Solve Iteration



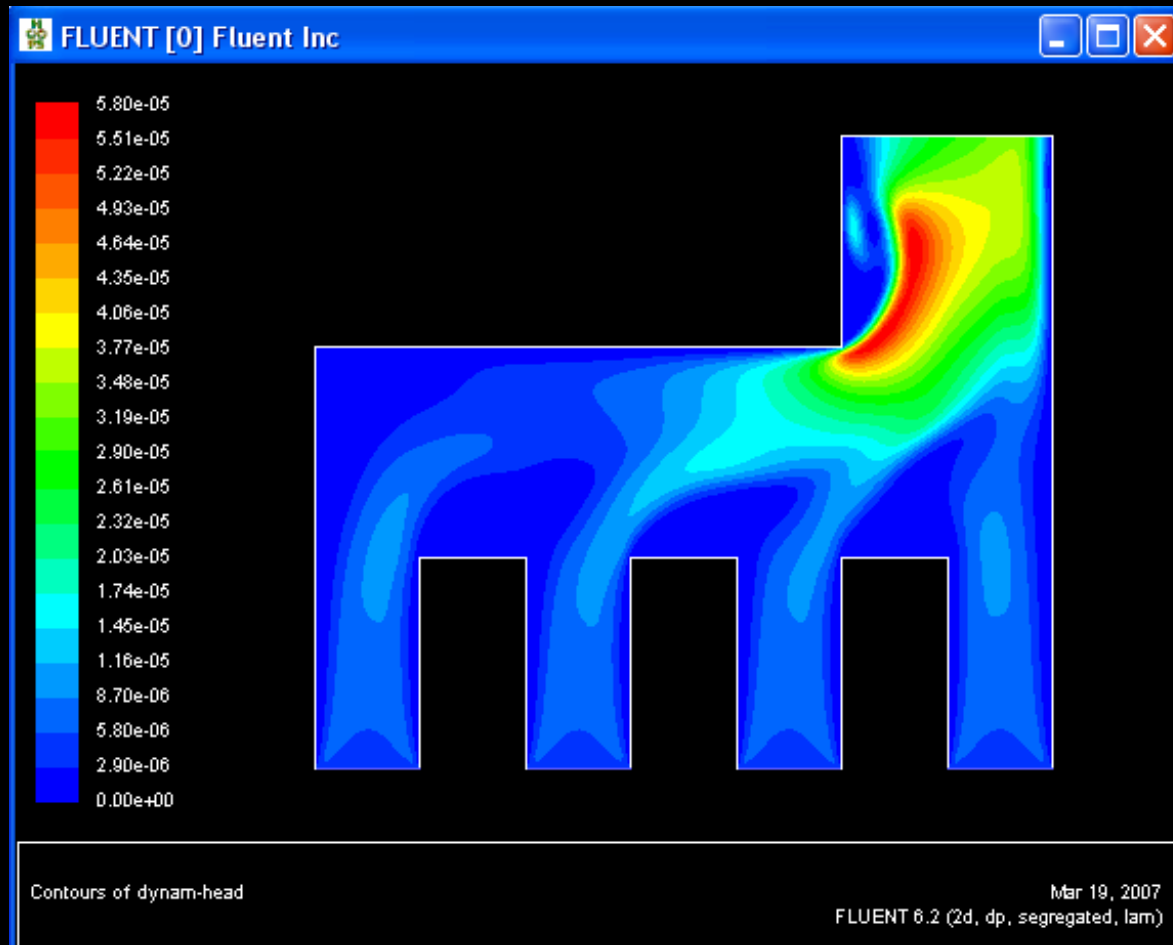
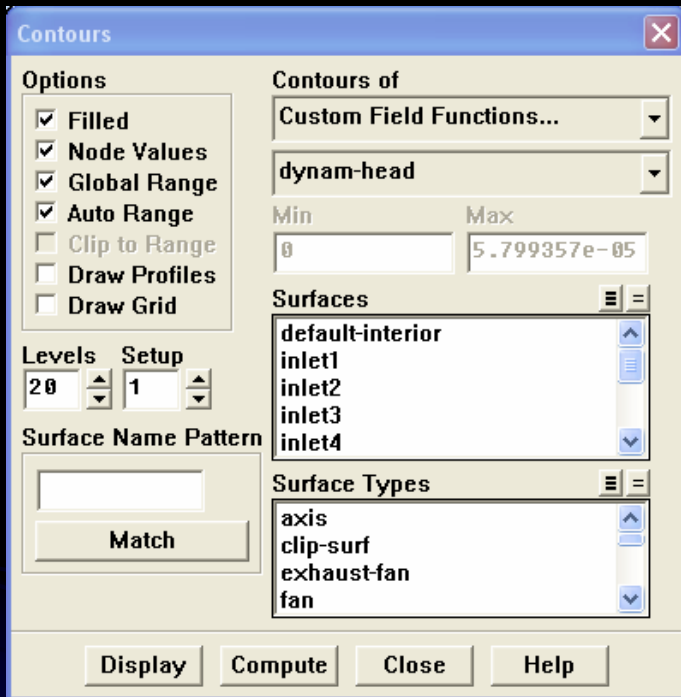
# Convergence of solution



# Display of Contours – Velocity Magnitude



# Display of Contours – Dynamic Head



# Display of Vectors – Velocity Magnitude

**Vectors** [Close]

**Options**

- Node Values
- Global Range
- Auto Range
- Clip to Range
- Auto Scale
- Draw Grid

**Vectors of**  
Velocity

**Color by**  
Velocity...  
Velocity Magnitude

Min [m/s] 1.989997e-08    Max [m/s] 0.0003444089

**Style** arrow

**Scale** 2

**Skip** 3

Vector Options...  
Custom Vectors...

**Surface Name Pattern**  
Match

**Surfaces**

- default-interior
- inlet1
- inlet2
- inlet3
- inlet4
- outlet

**Surface Types**

- axis
- clip-surf
- exhaust-fan
- fan

Display    Compute    Close    Help

