Contents

External

INTRODUCTION

This manual contains procedures for executing INSTED®/External Flow And Heat Transfer program. The input file options, primary tasks, required data, and the output results are discussed, as are the online utilities that are available within the program environment.

INSTED/External Flow consists of programs for analyzing the heat transfer rate for flow over a flat plate and other objects such as flow over a cylindrical, square, or hexagonal pipes etc. The programs will assist you in calculating the heat transfer rate associated with an external flow of cold or hot fluid over objects.

This manual also includes a summary of the procedures for carrying out the analysis of heat transfer in external flows using INSTED.

External

RUNNING INSTED®/External Flow And Heat Transfer Program

Starting the Program

Follow this procedure to execute INSTED®/External Flow Program.

1. Click on the Windows **Start** button
2. Select **Program**
3. Select **INSTED 3.0**
4. Select the **External Flow** icon
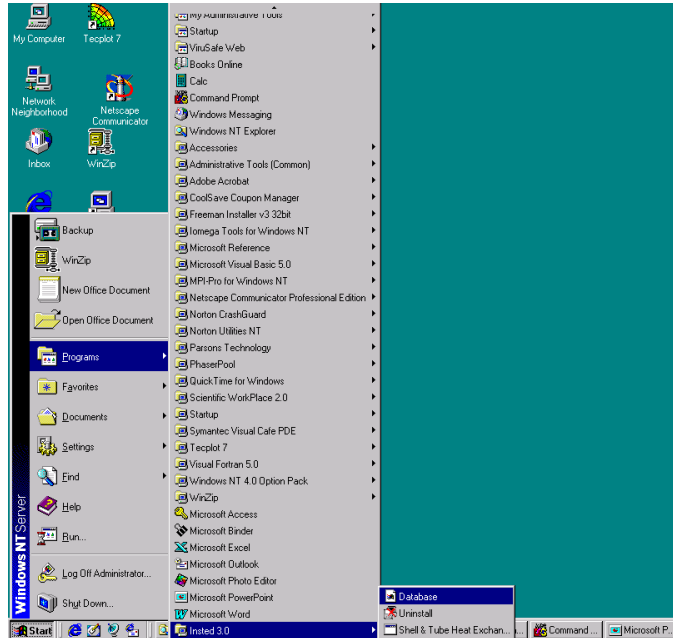
The Restart File
The External Flow program automatically loads the previous analysis if the program was terminated normally in the previous session. This is to allow interrupted sessions to continue naturally. However, to initialize all input fields, select the "New Project" option from the 'Project Admin' dialog box. This feature is explained in more details later in this manual.

External

PROGRAM ORGANIZATION

The INSTED®/External Flow and Heat Transfer program is organized into five
dialog boxes: the Main, Project Administration, Problem Description, Geometry,
Flat Plate Data, and the Cross Flow Data dialog boxes. The dialog boxes are
launched from the Main dialog box. Result presentation is done also via thee Main
dialog box. A detailed description of each dialog box is presented later in this
manual. The figure below shows the program interface.
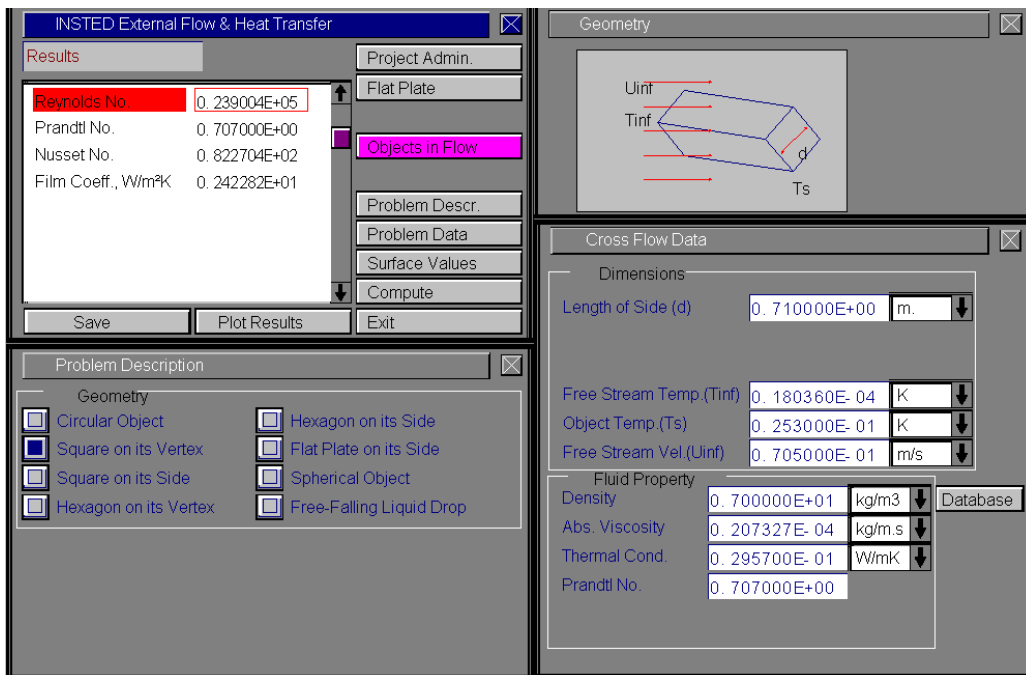
Data Required for Analysis

The minimum data required for analysis are:
- Object's dimensions (the table below shows the required dimension by object)
- Temperature of the object
- Free stream velocity, temperature and fluid thermophysical properties, including density, specific heat, thermal conductivity, and viscosity

Object	Required Dimensional Input
Flat plate	Length of the flat plate (calculations are per unit width)
Circular object	Diameter of object
Square on its aide	Length of a side
Square on its vertex	Length of a side
Hexagon on its side	Length of a side
Hexagon on its vertex	Length of a side
Flat Plate on its long side with its large surface normal to the flow	Vertical dimesnion
Spherical object	Diameter
Free-falling liquid drop	Approximate diameter of droplet Distance already traveled by droplet

Results of Flat Plate Analysis

- Flow Reynolds number
- Critical length (for onset of turbulent flow)
- Flow regime (laminar or turbulent)
- Flow boundary layer thickness
- Thermal boundary layer thickness
- Local skin friction coefficient
- Average skin friction coefficient
- Local Nusselt number
- Average Nusselt number

External

5 /17
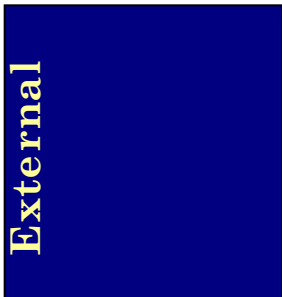
- Local heat transfer coefficient
- Average heat transfer coefficient
- Drag

Results for Analysis of Other Object in Cross Flow

- Flow Reynolds number
- Nusselt number
- Heat transfer coefficient

Characteristic Lengths for Objects in Cross Flow

The next set of figures illustrates the required input length for the objects in cross flow and heat transfer supported by INSTED/External Flow program.
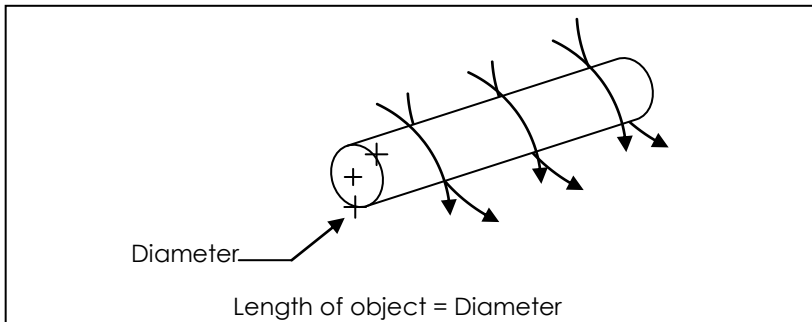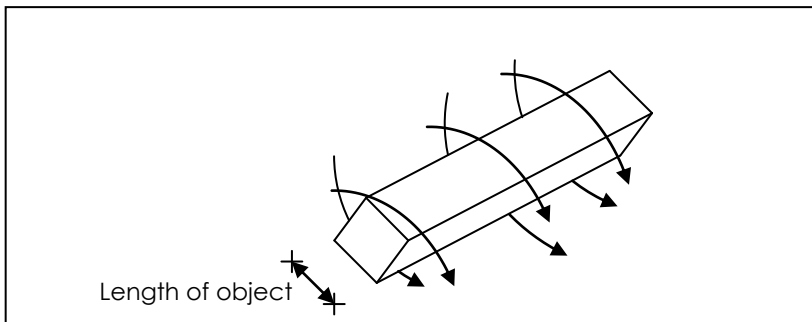

Diameter

Length of object = Diameter

Figure 1. Circular Object

Length of object

Figure 2. Square on its Vertex

External

6 /17

Length of object
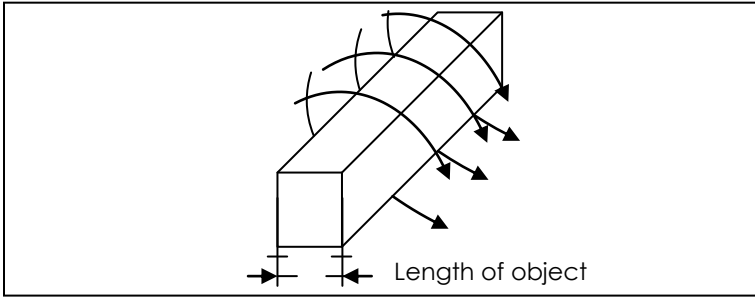
Figure 3. Square on its Side

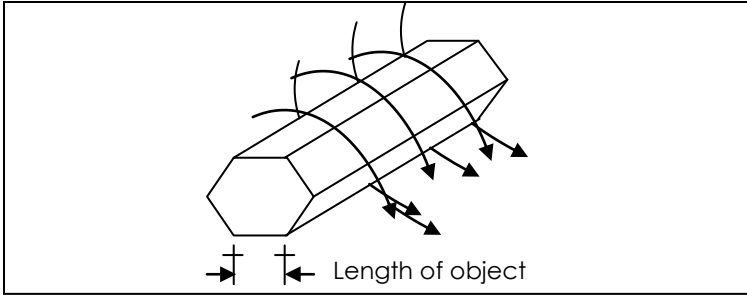Length of object
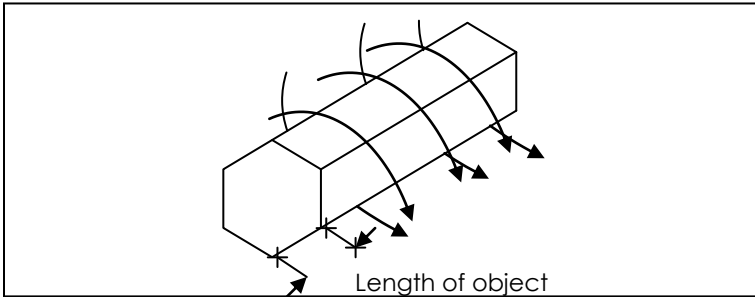
Figure 4. Hexagon on its Vertex

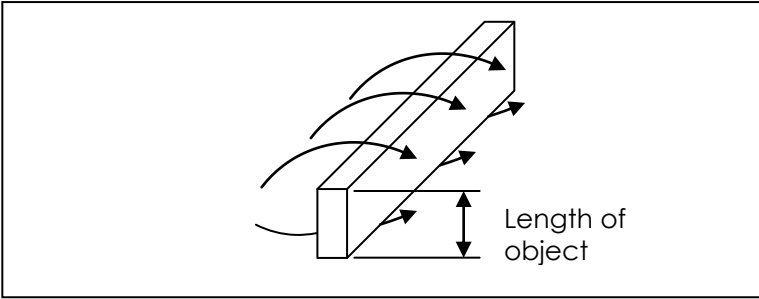Length of object

Figure 5. Hexagon on its Side

External

7 /17

Figure 6. Flat Plate on its Side
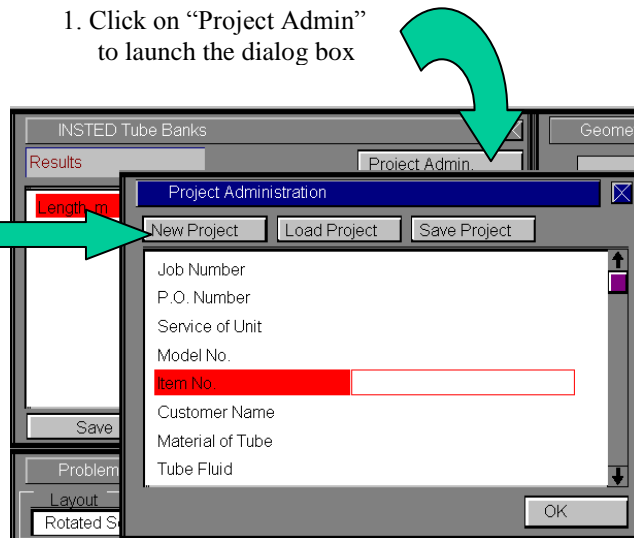
Starting a New Project

To start a new project:
1. Click on the "Project Admin." button on the Main dialog box
2. Click "New Project" on the 'Project Administration' dialog box
3. Fill in the administrative data for the editbox on the Project Administration dialog box, if desired.

Note that the Project Administration dialog is modal and needs to be closed before analysis can continue.

1. Click on "Project Admin" to launch the dialog box

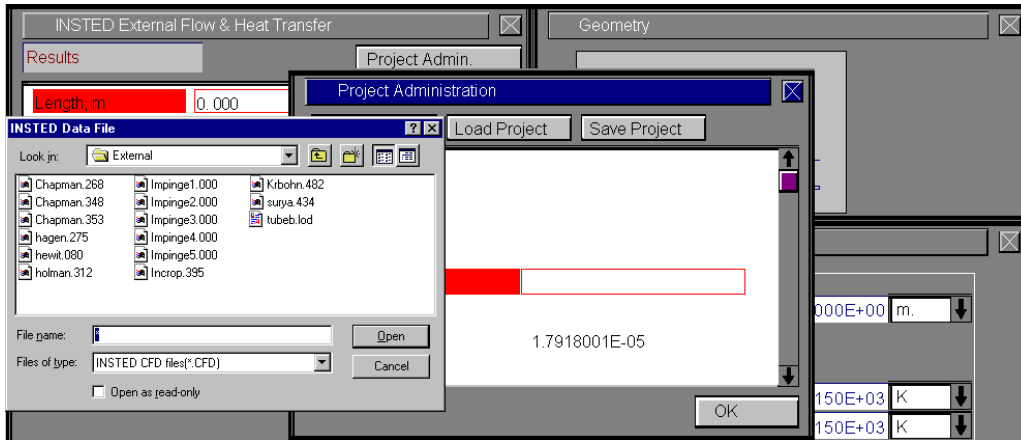2. Click "New Project" to start a new project

Loading an Old Project

To load an old project:
1. Click the "Project Admin." button on the Main dialog box
2. Click on the "Load Project" button
3. Locate the directory in which the project file resides
4. Type *.* in the file name text box on the Windows file menu which comes up
5. Press the Enter key

External

6. Select the file you wish to open by locating it on the Windows file open dialog box, which is shown below

Saving a New Project

To save a new project:
1. Click the "Project Admin." button on the Main dialog box
2. Click on the "Save Project" button
    $\Rightarrow$ A Windows 'File Save' dialog box will appear
3. Select the path where you wish to save the file
4. Type a name for the new project file

External

DESCRIPTION OF THE DIALOG BOXES

The following section describes the function of each dialog box in INSTED®/External Flow and Heat Transfer program.

The Main Dialog Box

This dialog box contains ten buttons. The functions of the ten buttons are described below:

Project Admin

This button opens the 'Project Administration' dialog box, which performs administrative functions, including loading and saving the session data and initializing all data fields for starting a new session.

Flat Plate

Click on the "Flat Plate" button to analyze the flow over a flat plate.

Objects in Flow

Click on the "Objects in Flow" button to analyze the heat transfer for flow over objects.
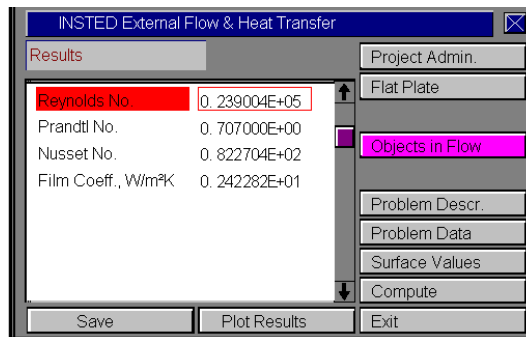
Problem Description

This button opens the 'Problem Description' dialog box, where you select the geometry of interest. The dialog box performs no function for a flat plate analysis.

Problem Data

This button opens up either the 'Flat Plate Data' or the 'Cross Flow Data' dialog box, depending on the selected analysis type.

Compute

The Compute button tells INSTED to compute the results. This assumes that all required input data for the task have been specified. If this is not the case, the computation may not be successful and the missing input is indicated, via a (warning) message box.

To Save

Click on the "Save" button, which is conveniently situated on the Main dialog box. To safeguard work done in the session, it is advisable to intermittently perform a save operation. Note that an error occurs if no project has been loaded and previously saved using the "Save Project" button in the 'Project Administration' dialog box. The procedure for saving a new project has been described in a previous section of this manual.

Exit

Press this button to close the program and end the current session. All session data are stored and are automatically retrieved on restarting the program.

External

The Project Administration Dialog Box

We have covered much of the functions of the 'Project Administration' dialog box in the previous section, including loading an existing project, saving a new project, or starting a new project.
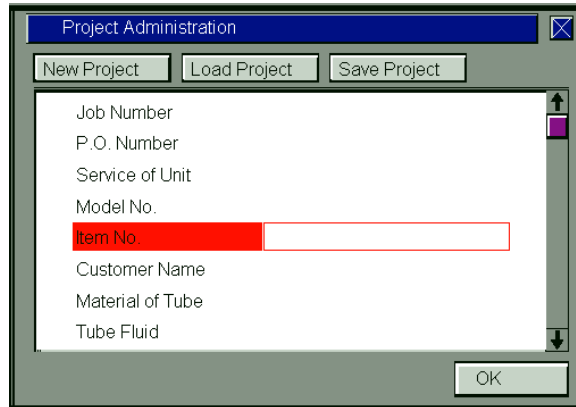

The Problem Description Dialog Box

This dialog box represents the interface for selecting the cross flow object geometry to be analyzed. The dialog box is available only for the "Objects in Cross Flow" option.

External
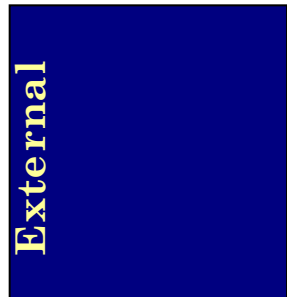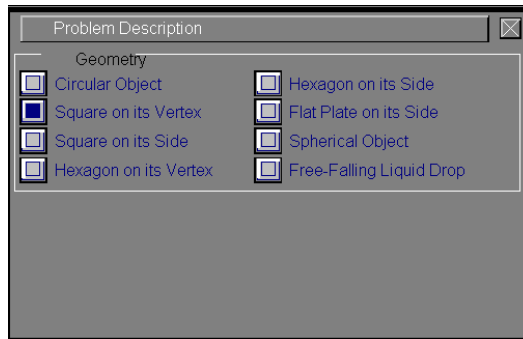
Cross Flow Data Dialog Box

Select the "Objects in Flow" option from the Main dialog box and specify the required data. For the free-falling spherical liquid drop, an additional input data is the distance already traveled by the drop.
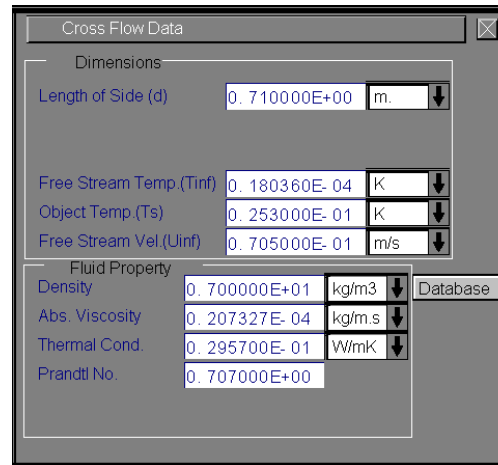
This dialog box also receives information about the incoming stream, such as the fluid velocity, temperature, and thermophysical properties. The thermophysical properties can be obtained from the database by pressing the "Database" button.

INSTED/Database contains the thermophysical properties for hundreds of fluid materials. It also allows you to edit the database to add your own fluid data into INSTED for use in all INSTED programs.
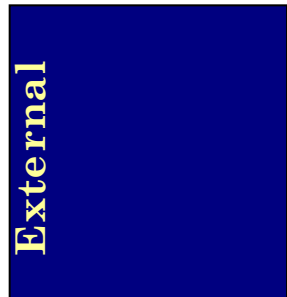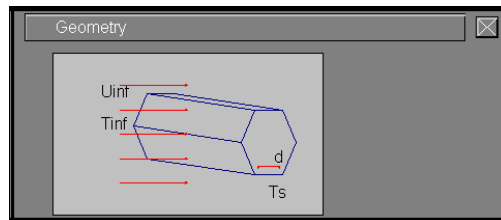
External

Flat Plate Data Dialog box

This dialog box is presented if the flat plate geometry option is selected from the Main dialog box. Enter the data for flat plate analysis in this dialog box. These include the same input data for the analysis of objects in cross flow – velocity, temperature, and thermophysical properties of the incoming stream. For a flat plate, the length of the plate and the wall temperature are also required. The thermophysical properties may be obtained from the database by pressing the "Database" button.
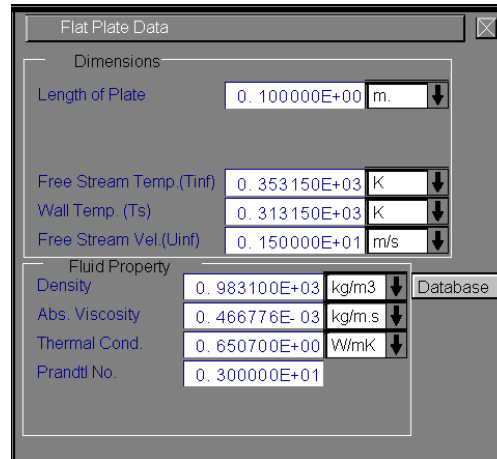
Geometry Dialog Box

This dialog box contains a schematic of the object being analyzed. The required geometric input variable is defined pictorially in this dialog box. Clicking on a label in the picture transfers you to the input field for the variable corresponding to the label.

External

RUNNING A SAMPLE PROBLEM

This section illustrates the use of the INSTED/External Flow and Heat Transfer program. A sample problem best illustrates the procedure.

Problem Statement

Atmospheric-pressure air flow with a velocity and temperature – 10m/s and 25°C normal to a circular cylinder of diameter 1.25 cm. The cylinder has a constant surface temperature of 125°C.

Estimate the average heat transfer coefficient.

Source

Alan J. Chapman, 1987. "Fundamentals of Heat Transfer". Macmillan Publishing Co., NY, Page 268.

Comments

- Use online unit conversion to convert from °C to K.
- Flow over a circular cylinder is considered.
- Use thermophysical properties given in the source. Absolute viscosity is taken from INSTED/Database ($\rho = 1.00116$ kg/m^3, $\mu = 0.207327$ x 10^{-4} Ns/m^2, $k = 0.029057$ W/mK. Pr $= 0.707$).

Name of Data

The input data for the present sample problem are contained in the file \insted30\concentric\external\Chapman.348.

Instructions for running a sample file

Sample files for INSTED/External Flow and Heat Transfer Analysis Program are located in the installation drive. To run the sample file 'Chapman.348', follow these procedures:

External

1. From the 'Project Admin' dialog box, click on the "Load Project" button
2. Locate the directory \insted30\external\samples\ on the installation drive
3. Type " *.* " in the filename position and press Enter
   → A list of the files present in the directory is displayed
4. Select the file 'Chapman.348' and click on the "Ok" button
5. Click on "Compute" in the Main dialog box.

External