

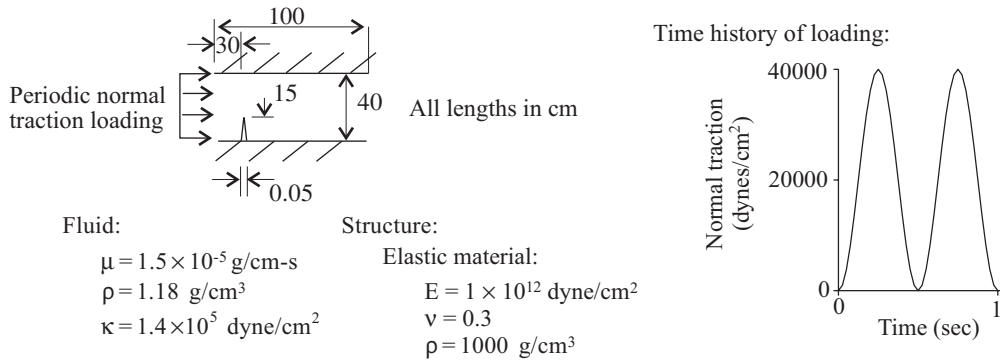
Problem 28

**Unsteady fluid flow over a
flexible structure in a channel**

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Problem description

We determine the fluid flow and the deformation of a very thin flexible structure within a two-dimensional channel, as shown:



This problem is very similar to primer problem 18. The differences are:

- 1) The downstream length is reduced (in order to save computation time)
- 2) The fluid material model is slightly compressible, with different material properties.
- 3) The structure material model is different (and not very realistic!)
- 4) The loading is sinusoidal.
- 5) The analysis is unsteady (transient).

Because this problem is so similar to primer problem 18, and because the emphasis of this problem is on postprocessing, we have set up the model geometry and the finite element definitions in a batch file (prob28_1.in). If you are interested in understanding the commands in this batch file, refer to the AUI Command Reference Manuals, Volumes I and III.

In this problem solution, we will demonstrate the following topics that have not been presented in previous problems:

- Particle tracing of an unsteady flow field.
- Creating a residence time distribution plot.

We assume that you have worked through problems 1 to 27, or have equivalent experience with the AUI. Therefore we will not describe every user selection or button press.

Before you begin

Please refer to the Icon Locator Tables chapter of the Primer for the locations of all of the AUI icons. Please refer to the Hints chapter of the Primer for useful hints.

This problem cannot be solved with the 900 nodes version of the ADINA System because the 900 nodes version of the ADINA System does not include ADINA-FSI.


You need to copy the file prob28_1.in from the folder samples\primer into a working folder before beginning this analysis.

Preprocessing


Invoking the AUI and choosing the finite element program

Invoke the AUI and choose ADINA Structures or ADINA CFD from the Program Module drop-down list.

Reading the model geometry and finite element definitions from a batch file

Click the Open icon , navigate to the working directory or folder, set the 'File type' field to 'ADINA-IN Command Files (*.in)', select the file prob28_1.in and click Open. The AUI processes the commands in the batch file.


For processing speed, we have not included any graphics commands in the batch file.

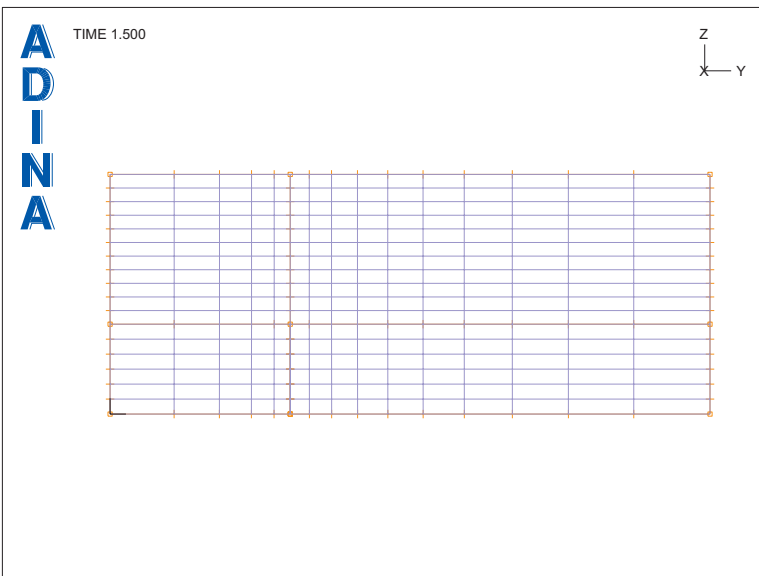
After the AUI processes the last batch command, click the Mesh Plot icon  to display the geometry and mesh. The graphics window should look something like the figure on the next page.

Running ADINA-FSI


Choose Solution→Run ADINA-FSI, click the Start button, select file prob28_f, then hold down the Ctrl key and select file prob28_a. The File name field should display both file names in quotes. Then click Start.

ADINA-FSI runs for 60 solution steps.



When ADINA-FSI finishes, close all open dialog boxes. Choose Post-Processing from the Program Module drop-down list (you can discard all changes), click the Open icon  and open porthole file prob28_f.



Examining the solution

Click the Model Outline icon  to display just the outline of the model.

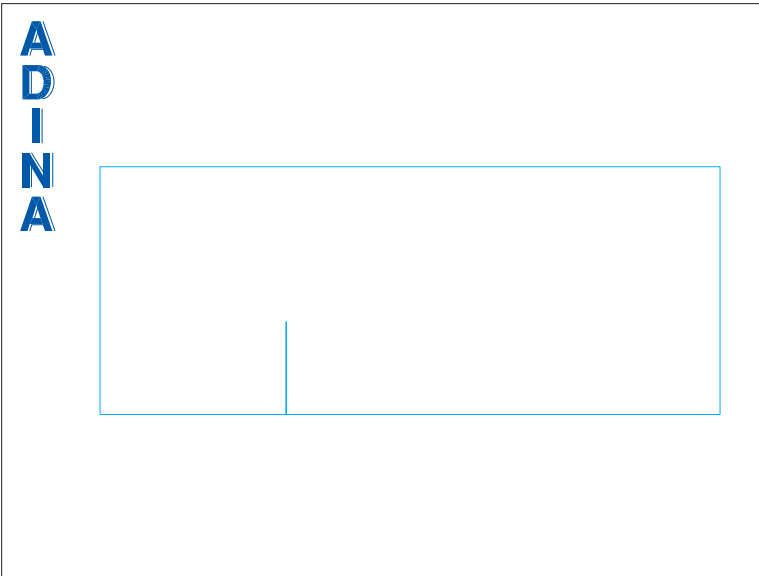
Preparing for unsteady particle tracing: In unsteady particle tracing, the particle time is the actual solution time, and the solution time is taken from the time used in the mesh plot. This means that the mesh plot time must be correctly set before starting the particle tracing.

Typically the mesh plot time should be set to the start time. Click the First Solution icon , then the Previous Solution icon  to set the mesh plot time to time 0.0.

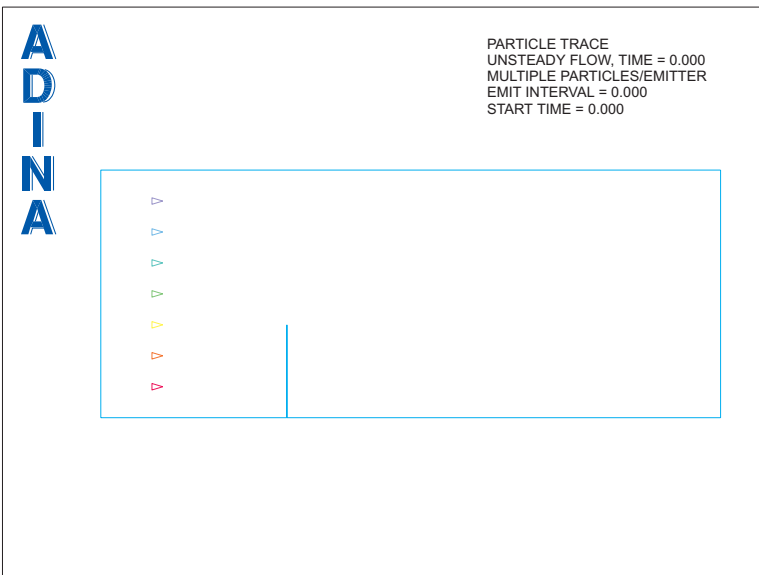
Use the mouse to remove the plotted axes and the TIME 0.000 text. The graphics window should look something like the top figure on the next page.

Creating a trace rake and initializing the trace plot: Choose Display→Particle Trace Plot→Create and click the ... button to the right of the Trace Rake field. In the Define Trace Rake dialog box, set the Type to Coordinates and click the Auto... button. In the Auto Generation dialog box, enter the following information into the table and click OK.


X	Y	Z
	10	5
		5
	10	35




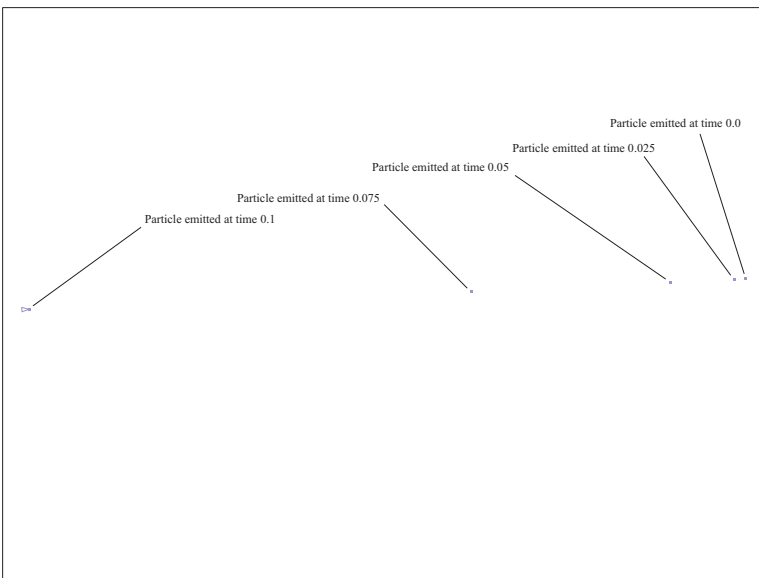
At this point, the table in the Define Trace Rake dialog box should contain 7 rows, in which $Z=5, 10, \dots, 35$. Click OK twice to close the Define Trace Rake dialog box and the Create Particle Trace Plot dialog box. Use the mouse to move the particle trace legend until the graphics window looks something like this:



Because the trace plot is created on a mesh plot with solution time 0.0, the reference time of the trace plot is also 0.0.

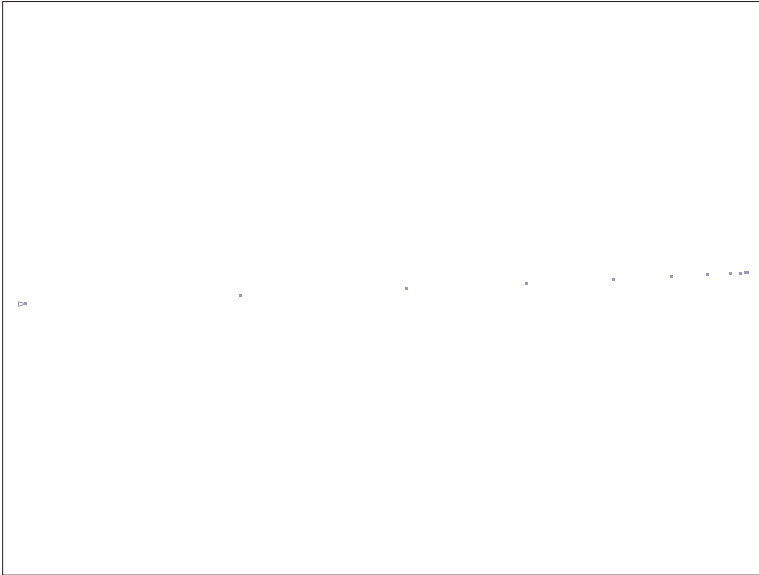
Updating the trace plot to solution time 0.1: Click the Next Solution icon  four times, until the time is 0.1. Notice that particles are being emitted from the injectors. Each time you change the solution time of the mesh plot, for example, by clicking the Next Solution icon, the AUI automatically updates the particle traces.

Use the Zoom icon  to enlarge the top left injector and its particles. The graphics window should look something like this:





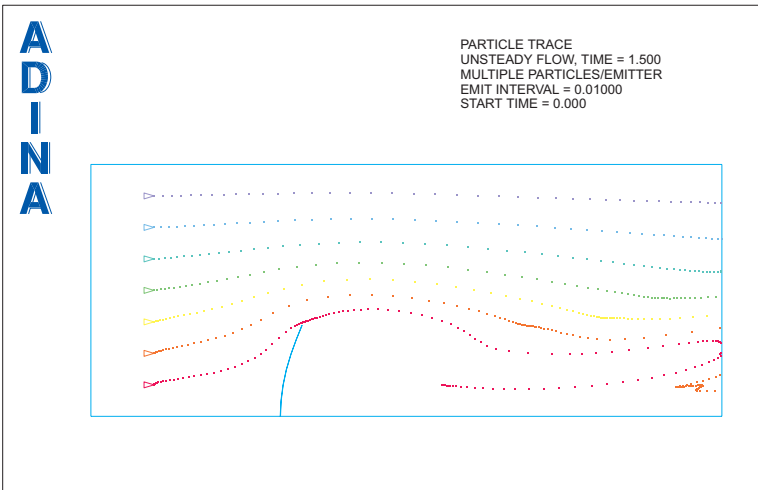
There are 5 particles emitted from this injector. The rightmost particle is emitted at time 0.0, the particle to its left is emitted at time 0.025, etc., and the last particle is emitted at time 0.1 and is currently at the injector.


Now we will change the time interval between the emitted particles. Choose Display→Particle Trace Plot→Modify and click the ... button to the right of the Trace Calculation field. Set the “Time Interval between Particle Emission” to 0.01 and click OK twice to close both dialog boxes. The graphics window should look something like the figure on the next page.






Now there are 11 particles emitted from this injector.

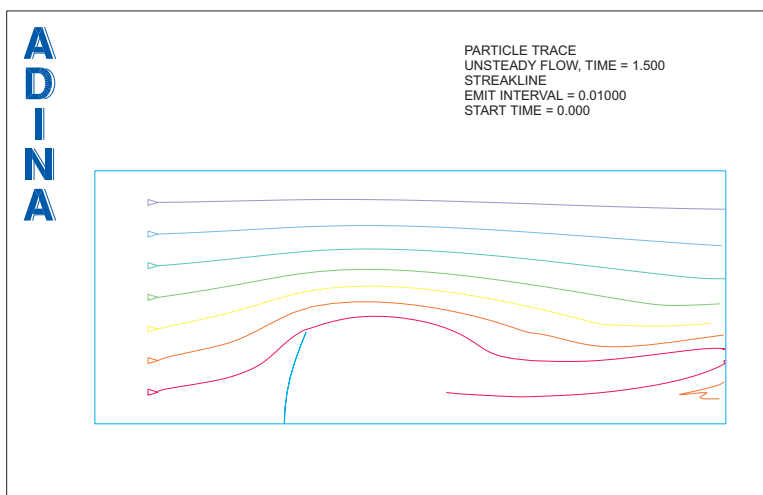
Updating the trace plot to solution time 1.5: Click the Unzoom All icon  to view the entire model. Then click the Last Solution icon  to display the mesh plot and the trace plot for the last computed solution. After the AUI computes the particle traces, the graphics window should look something like this:



Use the icons that change the solution time to study in detail how the particle traces evolve during the solution. Notice that the particles flow around the moving structure. When you are finished using these icons, click the Last Solution icon  to display the last solution.


Animating the particle traces: Click the Movie Load Step icon  to create a movie of the particle traces. Then click the Animate icon  to show the animation. When you are finished viewing the animation, click the Refresh icon  to clear the animation.

Viewing the streaklines: Choose Display→Particle Trace Plot→Modify and click the ... button to the right of the Trace Calculation field. Set the Trace Option to Streakline and click OK twice to close both dialog boxes. The graphics window should look something like this:

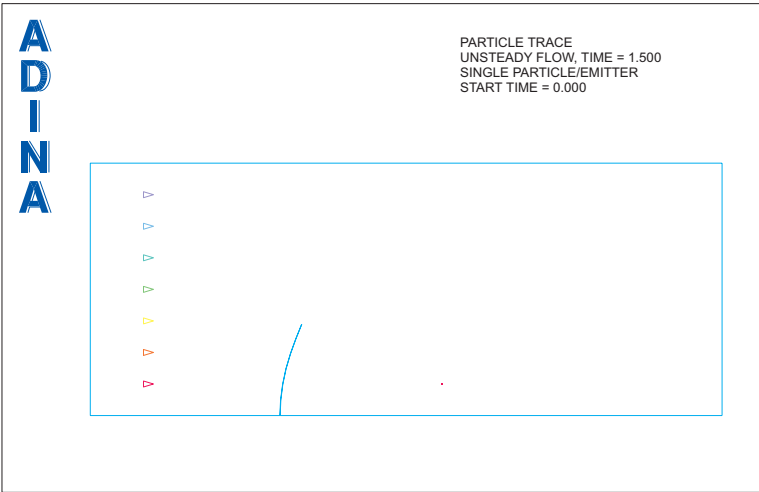


Residence time distributions: In some applications, it is useful to be able to count the number of particles that are currently in a region of the model.

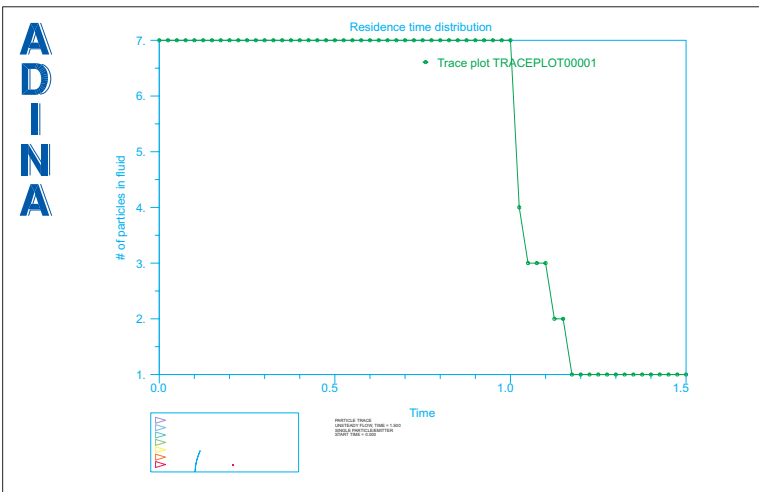
In order to demonstrate this feature, first we modify the trace plot to emit only one particle per injector. Choose Display→Particle Trace Plot→Modify and click the ... button to the right of the Trace Calculation field. Set the Trace Option to Single Particle and click OK twice to close both dialog boxes. The graphics window should look something like the figure on the next page.

Evidently most of the particles have left the flow domain by time 1.5. Click the Movie Load Step icon  to create a movie showing the particle motions. The particles flow from left to right, as expected. The lower particles travel more slowly because of the structure.

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Now choose Graph→Particle Distribution and click OK. Use the mouse to rearrange the graphics window until it looks something like this.



The graph shows that all of the particles are in the fluid until time 1.0, when 3 particles exit the fluid and 4 particles remain in the fluid. At time 1.175, only one particle remains in the fluid.

(Note: You cannot delete the mesh plot before creating the graph, because the graph uses the trace plot information. But you can delete the mesh plot after creating the graph.)

Exiting the AUI: Choose File→Exit to exit the AUI (you can discard all changes).