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National Applied Research Laboratories
National Center for
High-performance Computing

CFD in Cyber-Learning Platform at NCHC

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5/5/16

Cyber-Learning Platform at NCHC (http://www.emedu.org.tw)

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Characteristics of Cyber-Learning Platform at NCHC

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- Management System for Lectures and Students
- Modularization of Teaching Contents
- Multi-Media and Interactive Simulations as Supplemental Teaching Contents
- Learning Path Management System
- Evaluation System

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Goal

Enhance Learning Efficiency of Students in Thermal-Fluid Engineering Field through Multi-Media and Simulation Based Teaching Contents

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First-Phase Approaches

- Collection of Thermal-Fluid related Course Information from Universities in Taiwan
- Discussions/Meetings with Professors in Thermal-Fluid Engineering Education Platform to Define Current Educational Challenges, Needs & Wants
- Development of Supplemental Teaching and Software Contents

Multi-Media and Interactive Simulations as Teaching Contents

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- Simulation Animation with JavaScript Presentation
- Experimental Observation vs. Simulation Animation
- Interactive Simulations by Open Source Software
- Software Tools Development with JavaApplet/ JavaScript Presentation (Calculator)

Simulation Animation with JavaScript Presentation

- Timelines, Pathlines, Streaklines, and Streamlines
  - http://paintingwordnotebook.nchc.org.tw/FM_OK/En-FM00002_Timeline_Pathline_Streakline_Streamline.html
- No-Slip Boundary Condition
  - http://paintingwordnotebook.nchc.org.tw/FM_OK/En-FM00003_No_slip_BC.html

Experimental Observation vs. Simulation Animation

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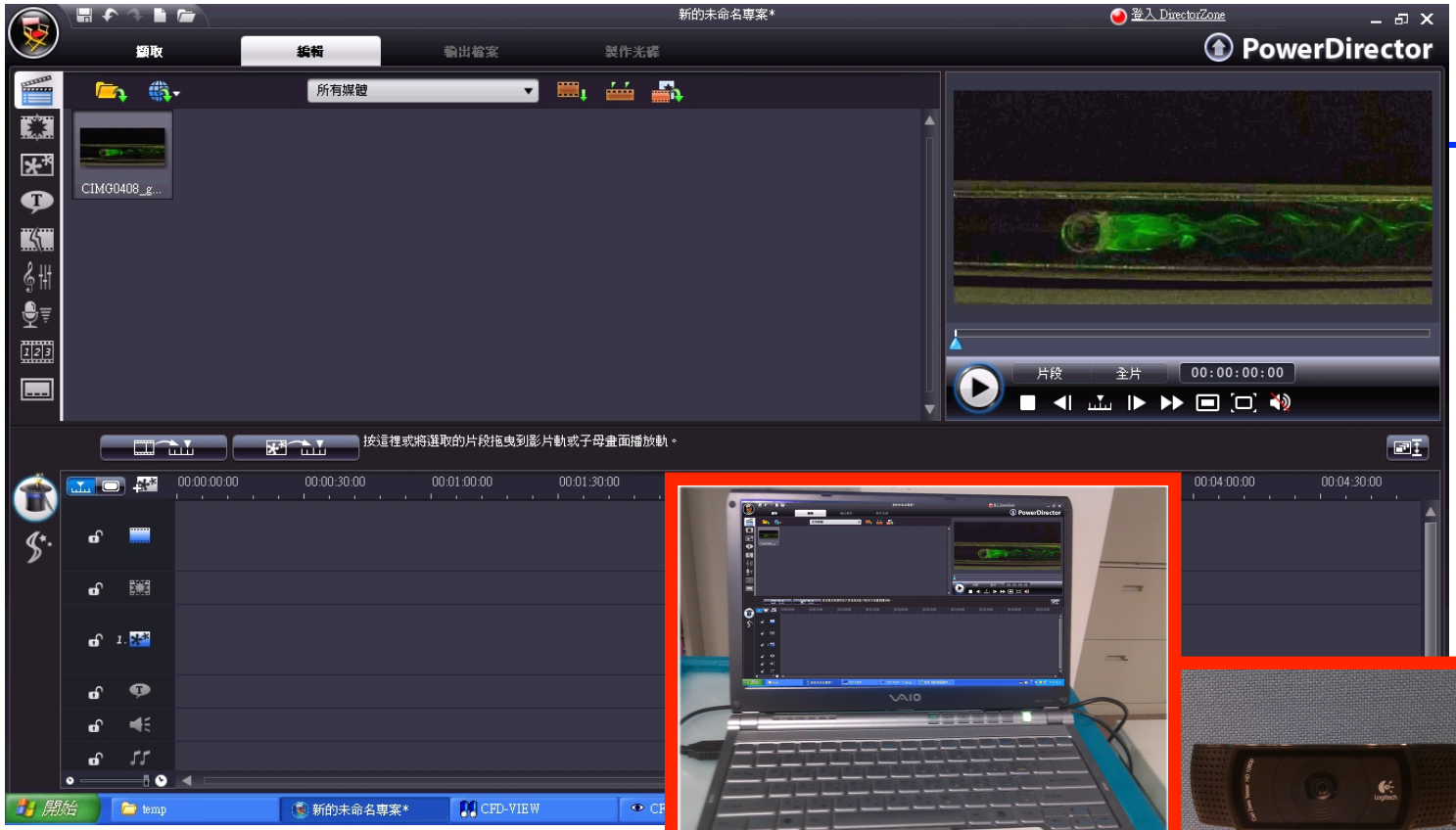
- Flow Over a Cylinder



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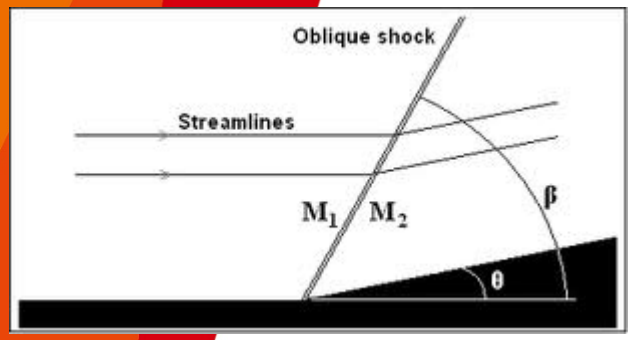
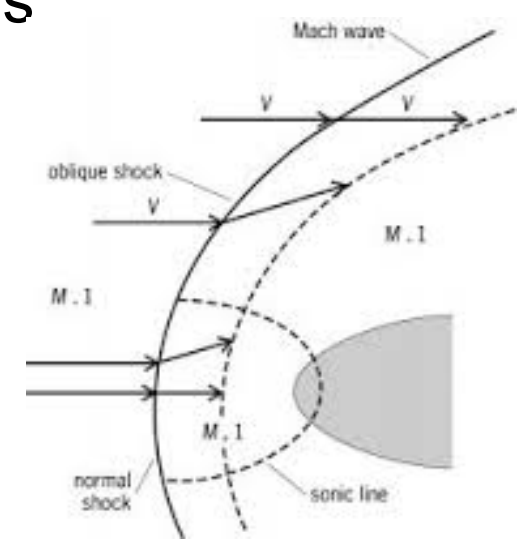
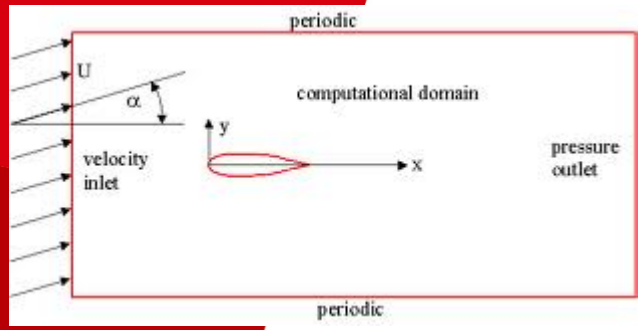
Simulation Based Teaching Contents (1/4)

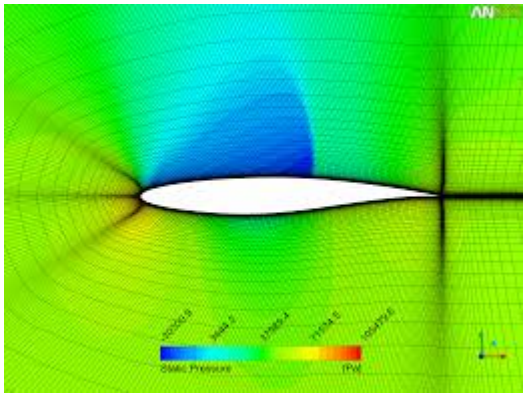
- Compressible Flows/Inviscid Flows
  - Oblique shock wave

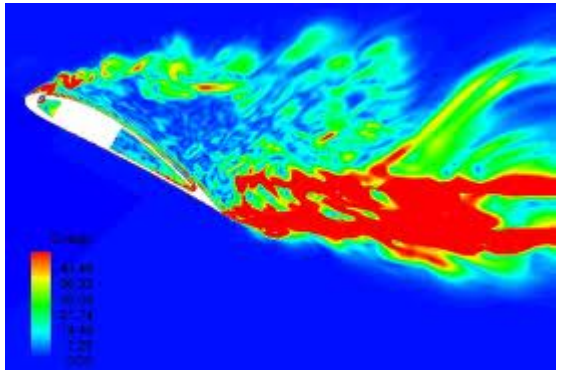




  - Flow over an airfoil (NACA0012)







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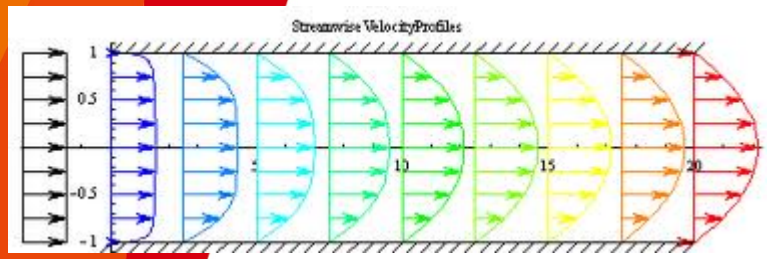
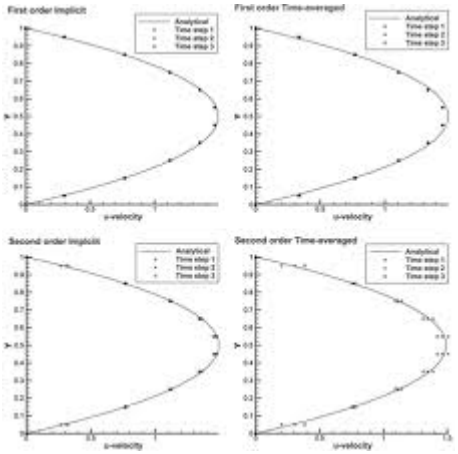
Simulation Based Teaching Contents (2/4)

- Incompressible Flows/Viscous Flows
  - Open channel flow





  - Back facing step flow

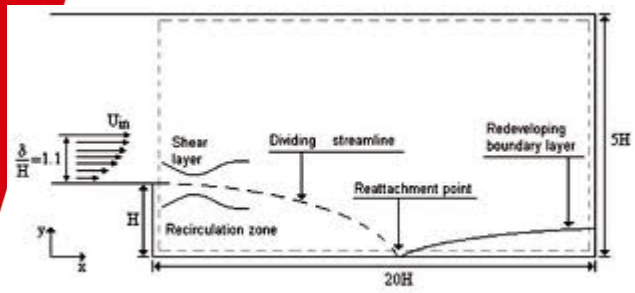
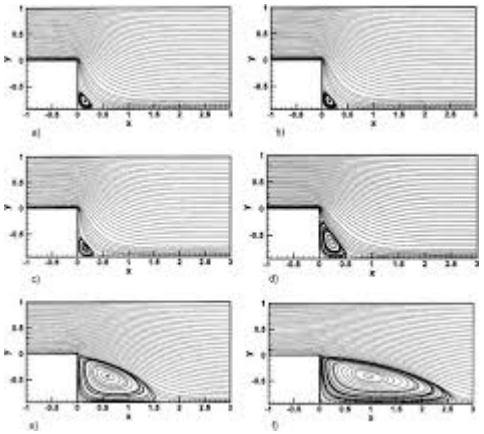


Figure 1. Back step geometry and computacional domain.



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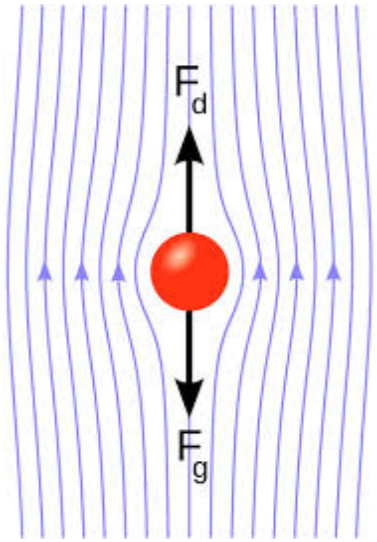
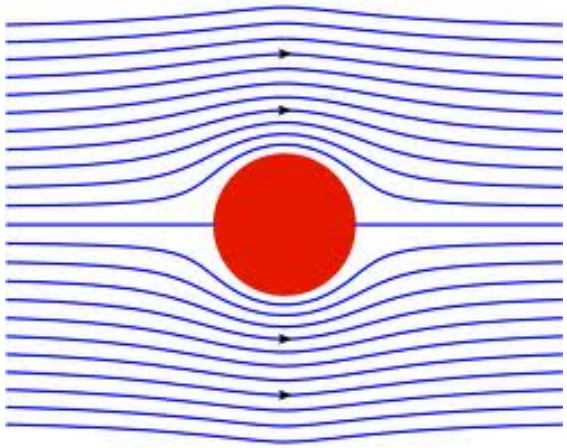
Simulation Based Teaching Contents (3/4)

- Incompressible Flows/Viscous Flows
  - Ball dropping



- Potential Flows
  - Flow over a cylinder



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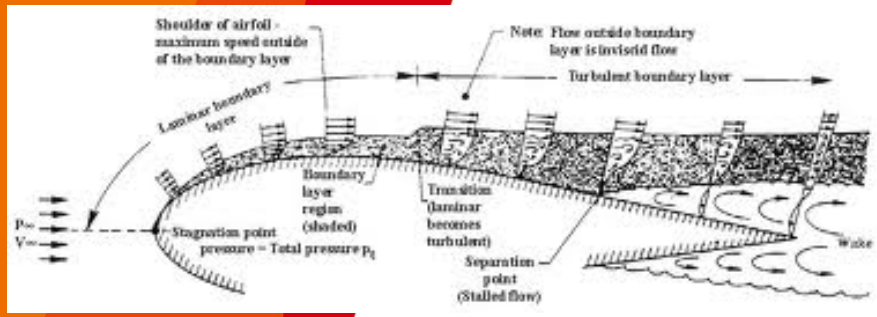
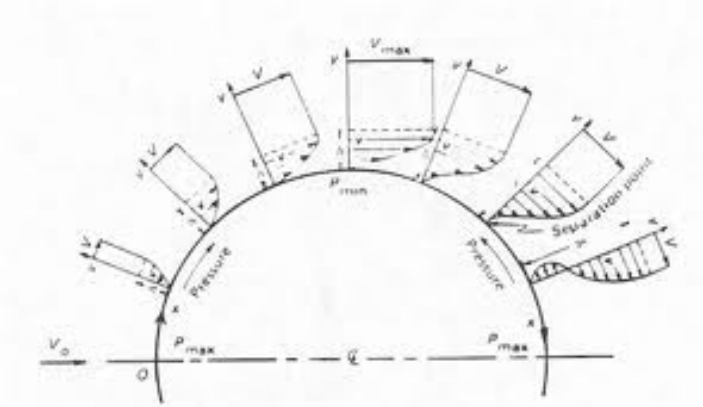
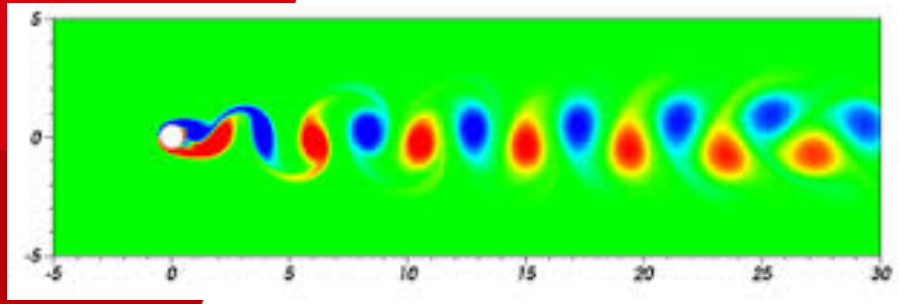
Simulation Based Teaching Contents (4/4)

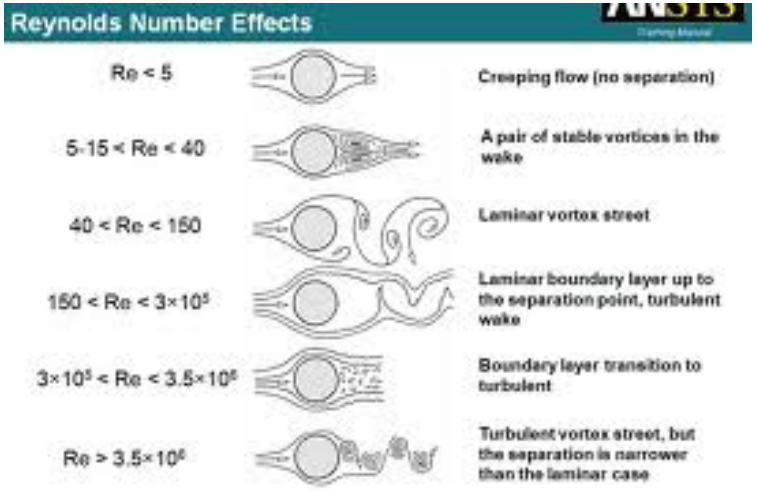
- Boundary Layer
  - Flow Separation





  - Vortex Shedding





Pipe Flow Calculator

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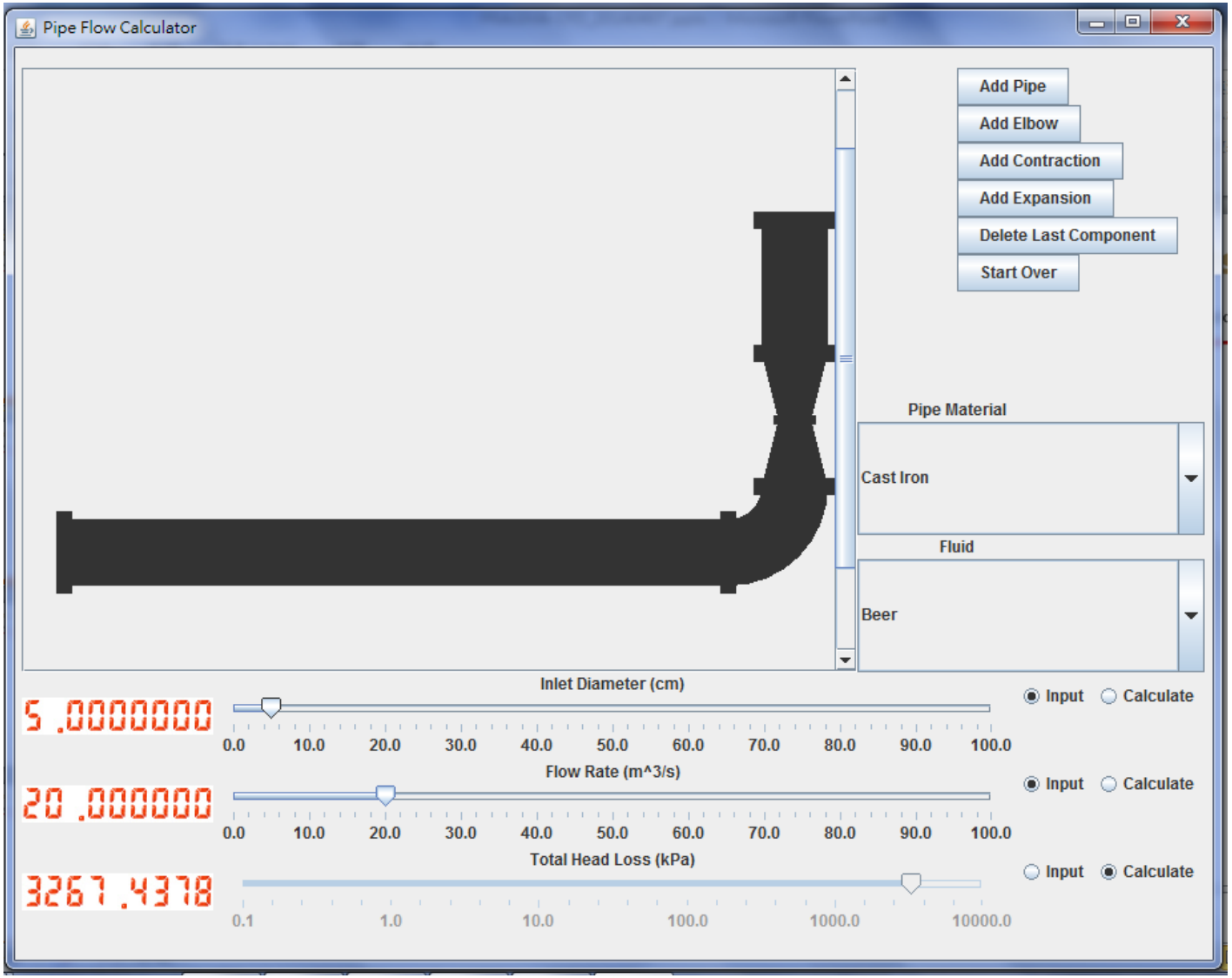

Interfacial Phenomena: Moving Boundary Problems

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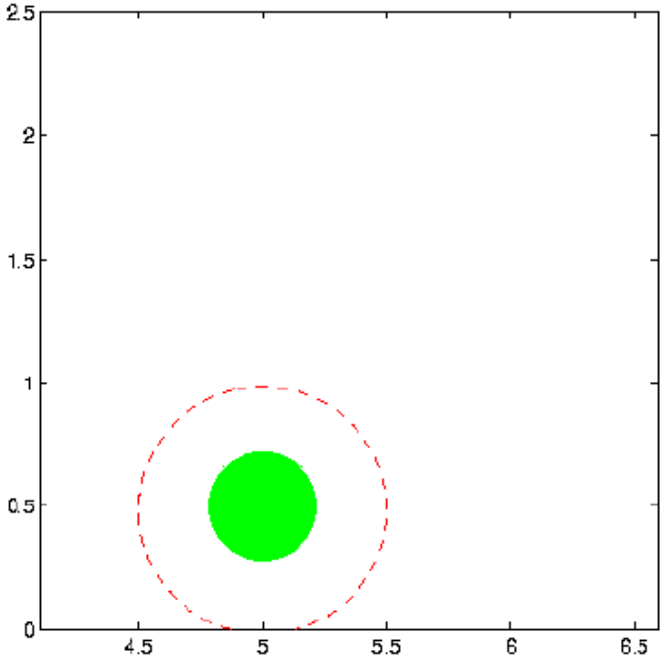

Multi-Media and Simulation Based Teaching Contents (1/2)

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The drag on a circular cylinder placed in a uniform flow can be determined by measuring either the pressure on the surface of the cylinder or a combination of the velocity profile in the wake and the pressure drop in the tunnel. This involves the use of two different control volumes, CV_1 and CV_2.

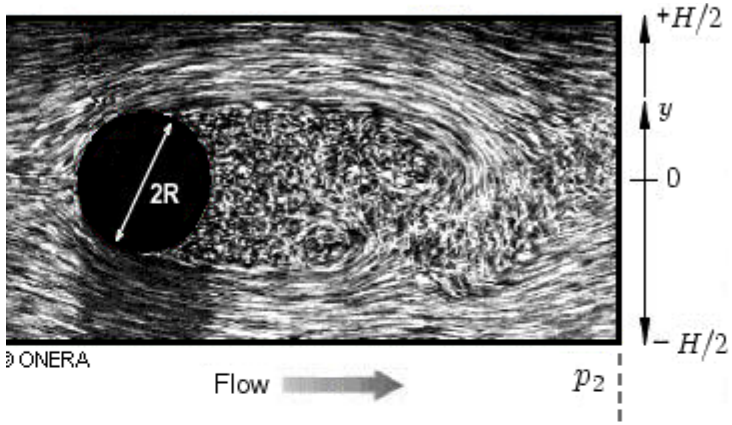
CV_1 encloses the cylinder. If we neglect the surface shear stress, the force on the cylinder is due entirely to the pressure integrated over the surface. The force per unit width is D_p, where

$$D_p = 2\int_0^{\pi} p\cos\theta R d\theta$$

CV_2 is inscribed within the tunnel walls. There are momentum fluxes through the upstream and downstream faces, associated with velocities V_1, which is constant, and V_2, which varies with y. There is also a pressure difference between the upstream and downstream faces $\Delta p = p_1 - p_2$. If we neglect the shear stresses acting on the wind tunnel walls, the force per unit width is D_m, where

$$D_m = (p_1 - p_2)H + \rho V_1^2 H - 2\int_0^{H/2} \rho V_2^2(y)dy$$

We usually express aerodynamic forces in terms of non-dimensional coefficients, so we define C_{D_p} and C_{D_m}. We expect $C_{D_p} = C_{D_m}$ for a given speed, i.e. for the same Reynolds number.



$\Delta p = p_1 - p_2$

R is the radius of the cylinder

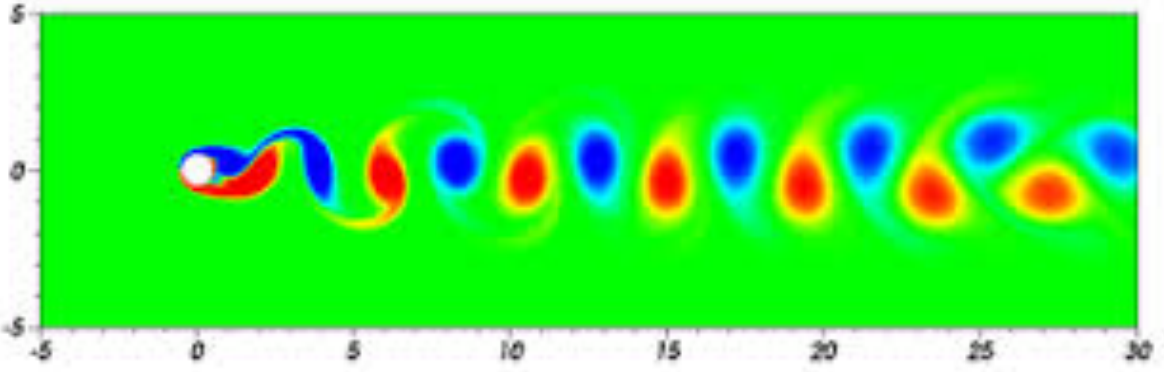
θ is the azimuthal angle

H is the height of the tunnel

y is measured upward from the centerline

$$C_{D_p} = \frac{D_p}{\frac{1}{2}\rho V_1^2(2R)}$$

$$C_{D_m} = \frac{D_m}{\frac{1}{2}\rho V_1^2 H}$$



Multi-Media and Simulation Based Teaching Contents (2/2)

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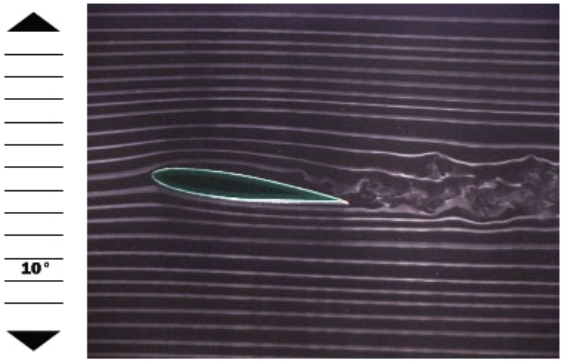

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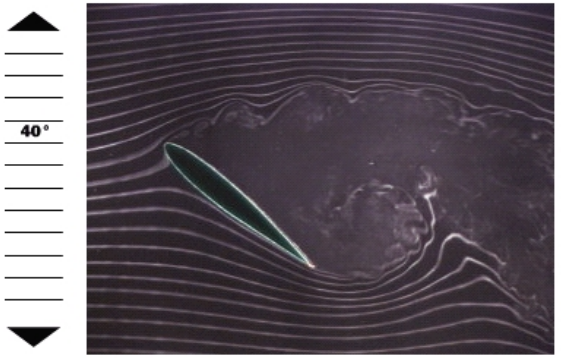

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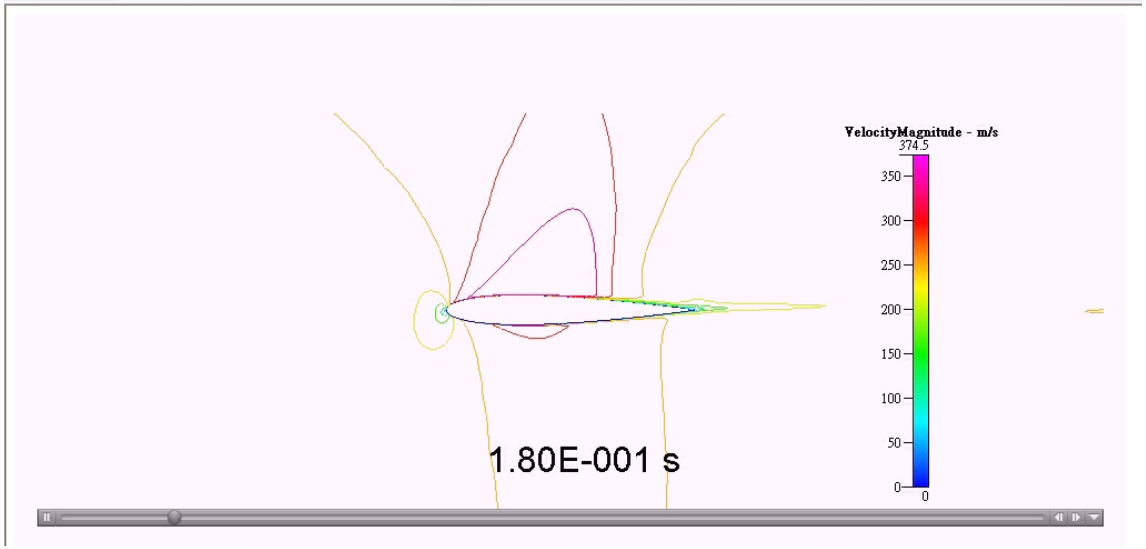

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Future Works

- Continue to Develop Interactive Simulation Cases as Supplemental Teaching Contents
- Integrate Learning Path Management System with Modularization of Teaching Contents
- Development of Applied Software Tools
- Promotion for Thermal-Fluid Engineering Education Platform

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