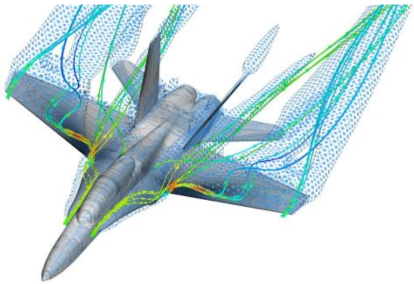
بسم الله الرحمن الرحيم

Fluid Mechanics I



Fayoum University

Faculty of Engineering
Mechanical Engineering Dept.

Lecture (1)
on

Theory and Fundamental of Fluid Mechanics

By

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2015 - 2016

Course Syllabus

Course: MPE 122 - Fluid Mechanics I – 1st year - Mech. Dept.

Course Description

This course is designed for 1st year students. It covers the Fluid Mechanics. Fluid Mechanics is defined as the science that deals with the behavior of fluids at rest (fluid statics) and in motion (fluid dynamics), and the interaction of fluids with solids or other fluids at the boundaries.

Course Outline

1. Introduction
2. Physical Properties of Fluids
3. Pressure Distribution in Fluids
4. Hydrostatic Forces on Surfaces Immersed in Fluids
5. Buoyancy Forces and Stability of Floating Bodies

Course Syllabus

Course Outline

6. Governing equation in integral from:
   - Continuity Equation
   - Momentum equation
   - Energy equation
   - Bernoulli Equation
   - Applications
7. Similarity, Dimensional Analysis and Modeling
8. Fluid flow measurement:
   - Velocity measurements
   - Volume flow rate measurements
9. Laminar and turbulent flows through pipes and calculation of friction and secondary losses
10. Pipe flow
11. Pipe network analysis and design
12. Turbomachinery.
13. Boundary layer for laminar and turbulent flows.

Course Syllabus

Course Objectives

After completing this course, you should be able to:

1. Classify fluid flow in terms of fluid properties, including viscosity, vapor pressure, velocity fields, surface tension, capillary effect, and cavitation.
2. Explain how hydrostatic forces act on submerged plane and curved surfaces and account for buoyancy and stability effects.
3. Use data from manometers such as the piezometer tube, the U-tube or the pitot-static tube to measure pressure differences and determine flows.
4. Derive Bernoulli's equation for steady, inviscid, incompressible flow using Newton's second law and conservation of energy principle.
5. Use Bernoulli's equation to solve problems involving confined flows, free jets, and flow-rate measurements (orifice, nozzle, venturi meter).
6. State Reynolds transport theorem for flow (steady and unsteady) through a control volume.

Course Syllabus

Course Objectives

7. Solve fluid flow problems where the flow is steady or unsteady using the Continuity equation and a fixed, non-deforming control volume.
8. Distinguish between laminar flow and turbulent flow in pipes.
9. Solve fluid flow problems using different piping networks.
10. State the three pump laws for centrifugal pumps and apply them to pump situations.
11. Explain the concept of drag and lift for flows over plane surfaces, cylindrical and spherical surfaces.
12. Describe how friction and pressure drag affects fluid flows inside and outside various fixed, non-deforming geometrical shapes.

Course Syllabus

References

1. Y. A. Çengel, J. M. Cimbala, Fluid Mechanics Fundamentals and Applications, 3rd ed., McGraw-Hill, 2006.
2. D. F. Young, B. R. Munson, T. H. Okiishi, W. W. Huebsch, A Brief Introduction to Fluid Mechanics, 5th ed., John Wiley & Sons, Inc., 2011.
3. P. J. Pritchard, J. C. Leylegian, Fox and Mcdonald's Introduction to Fluid Mechanics 8th ed. John Wiley & Sons, Inc., 2011.
4. M. C. Potter, D. C. Wiggert, B. Ramadan, T. P. Shih, Mechanics of Fluids, 4th ed., Cengage Learning, 2012.
5. Munson, Young and Okiishi, Fundamentals of Fluid Mechanics, 7th ed., John Wiley & Sons, Inc., 2011.
6. J. F. Douglas, J. M. Gasiorek, J. A. Swaffield, L. B. Jack, Fluid Mechanics, 5th ed., Pearson Prentice Hall, 2005.
7. E. J. Shaughnessy, I. M. Katz, J. P. Schaffer, Introduction to Fluid Mechanics, Oxford University Press, 2005.
8. F. A. Morrison, An Introduction to Fluid Mechanics, Cambridge University Press, 2013.
9. F.M. White, Fluid Mechanics, 8th ed., McGraw-Hill.

Course Syllabus

Course Prerequisites

- Dynamics.
- Linear Algebra and Differential Equations.
- General Physics (materials).

Text Books:	Lectures notes	
Evaluation:	• Homework; attendance and assignments; equivalent 16%. • Lab reports and experimental exam; equivalent 12%. • Midterm; equivalent 16%. • Final exam; equivalent 56%.	
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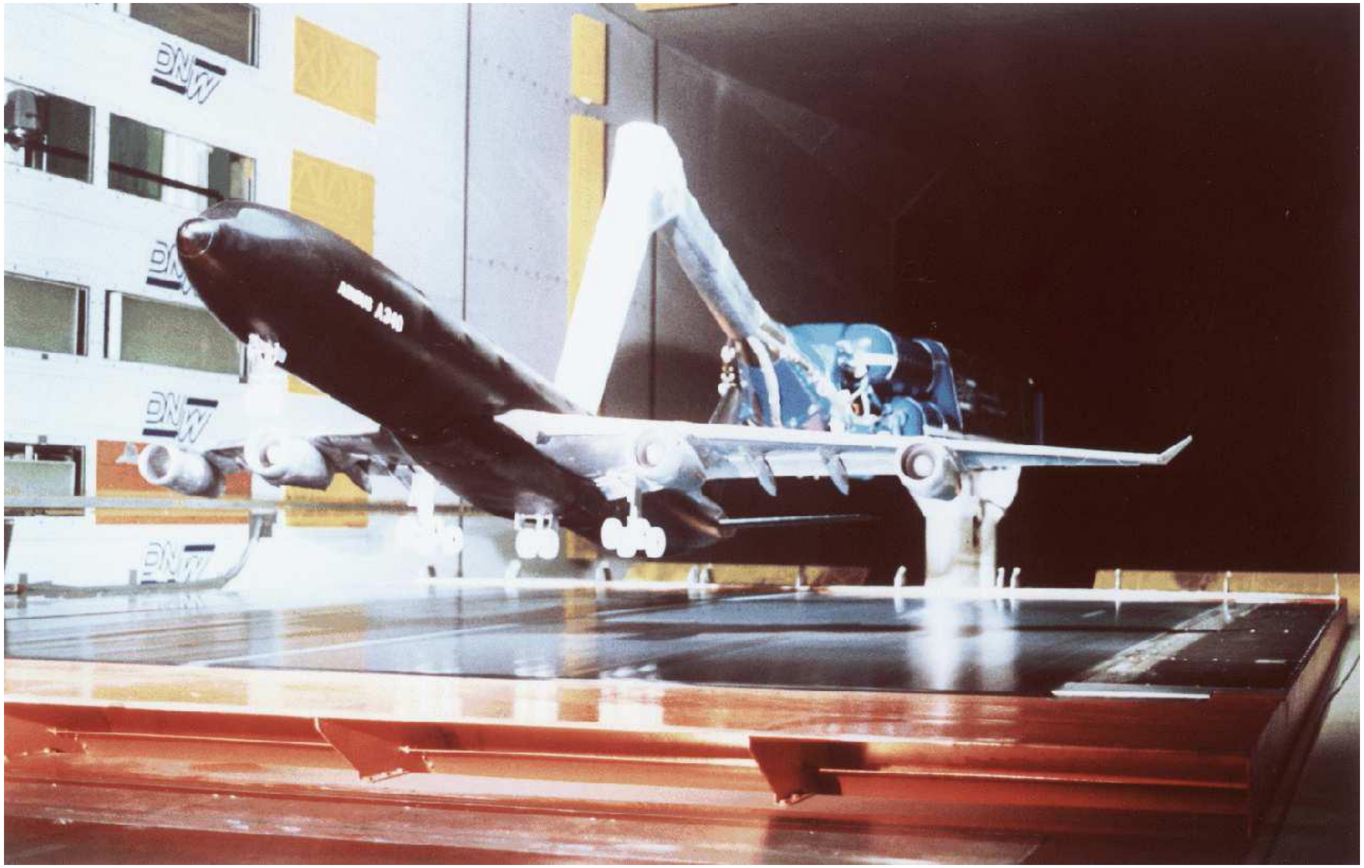
Flows in Technology

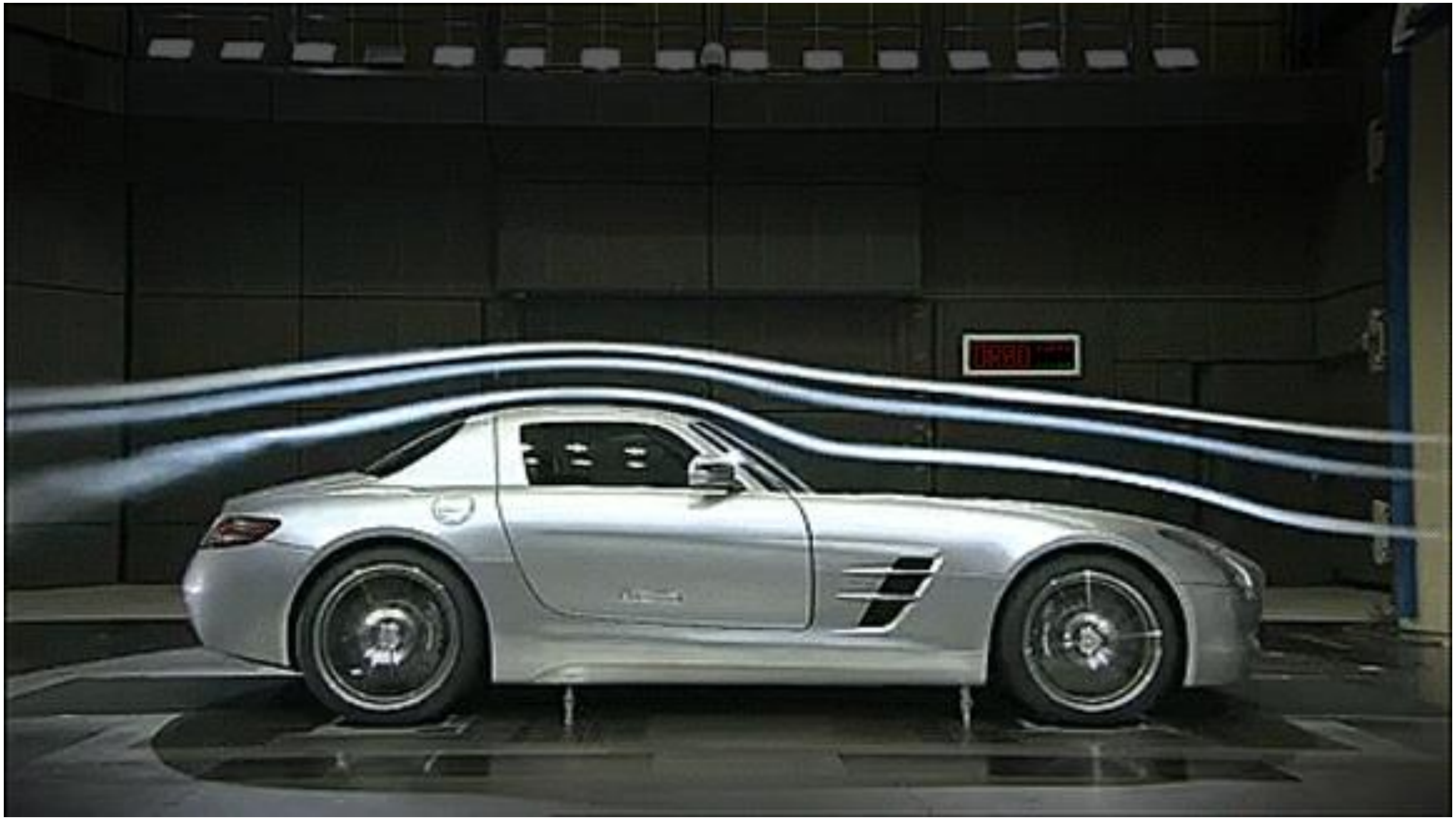
Development of airplanes and trains

Flows in Technology

Model of an Airbus A 340 in a wind tunnel

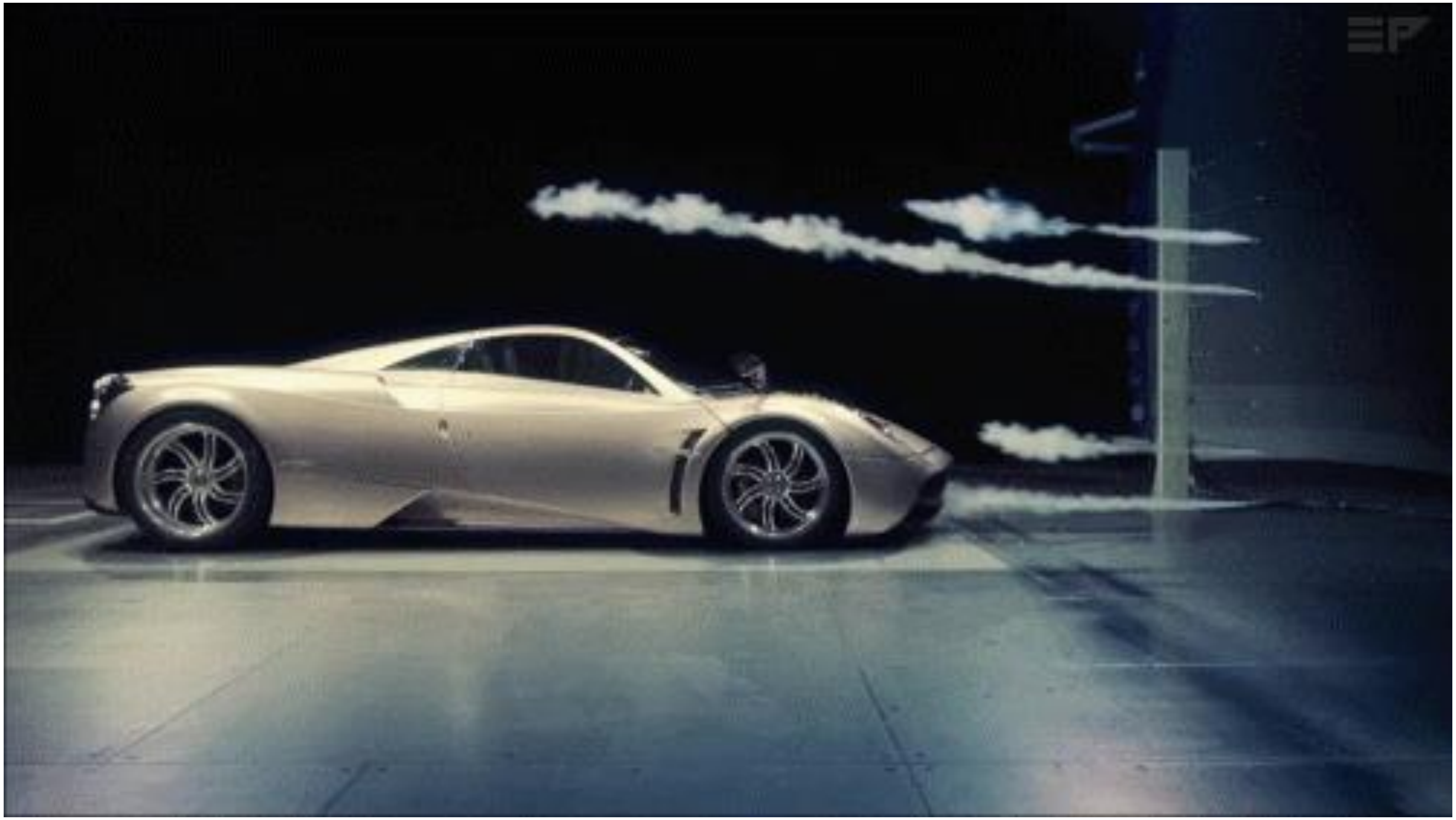


Flows in Technology



Actual model of a Car in a wind tunnel

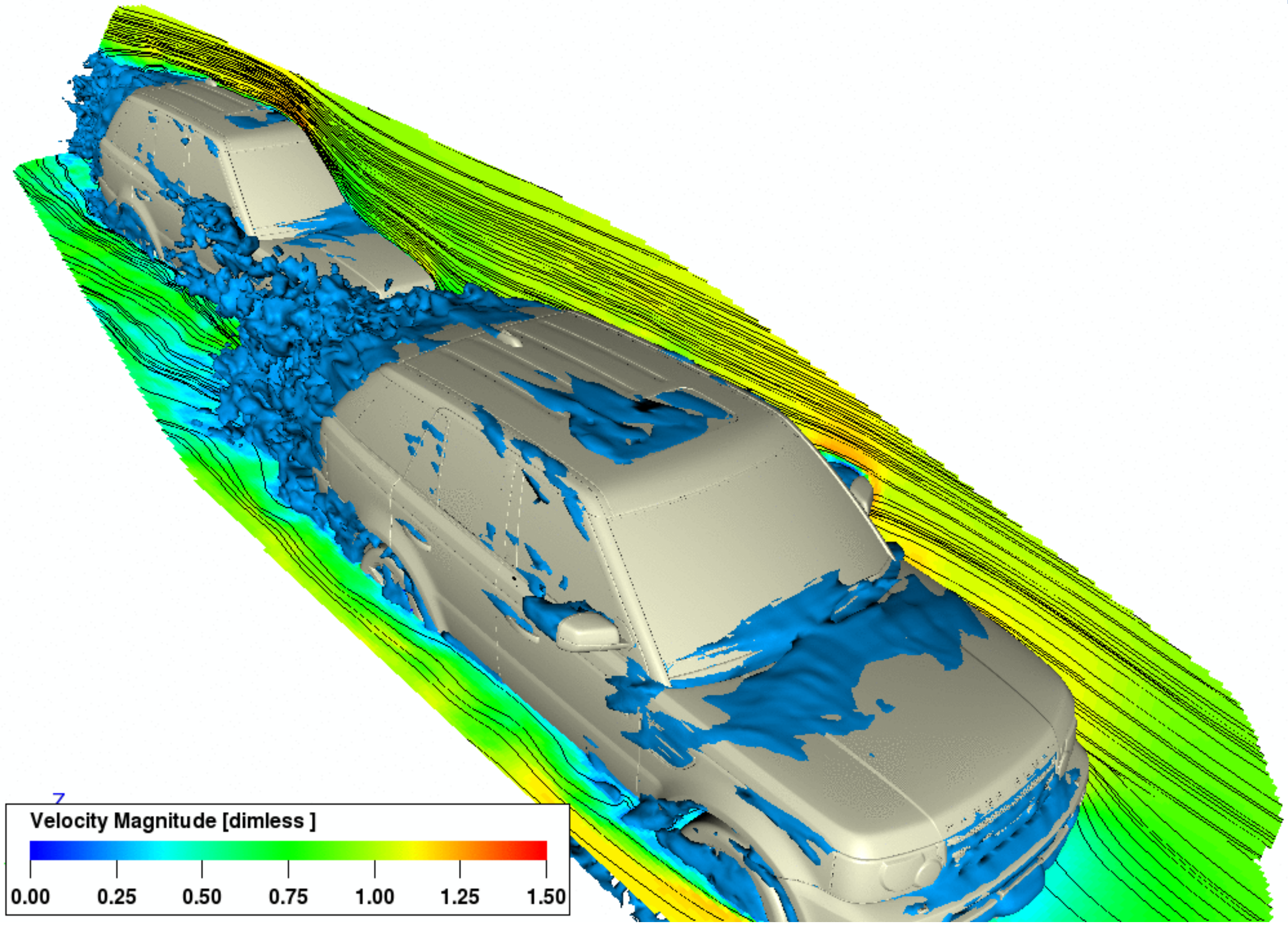
Flows in Technology



Actual model of a Car in a wind tunnel

Flows in Technology

Numerical Model of a car



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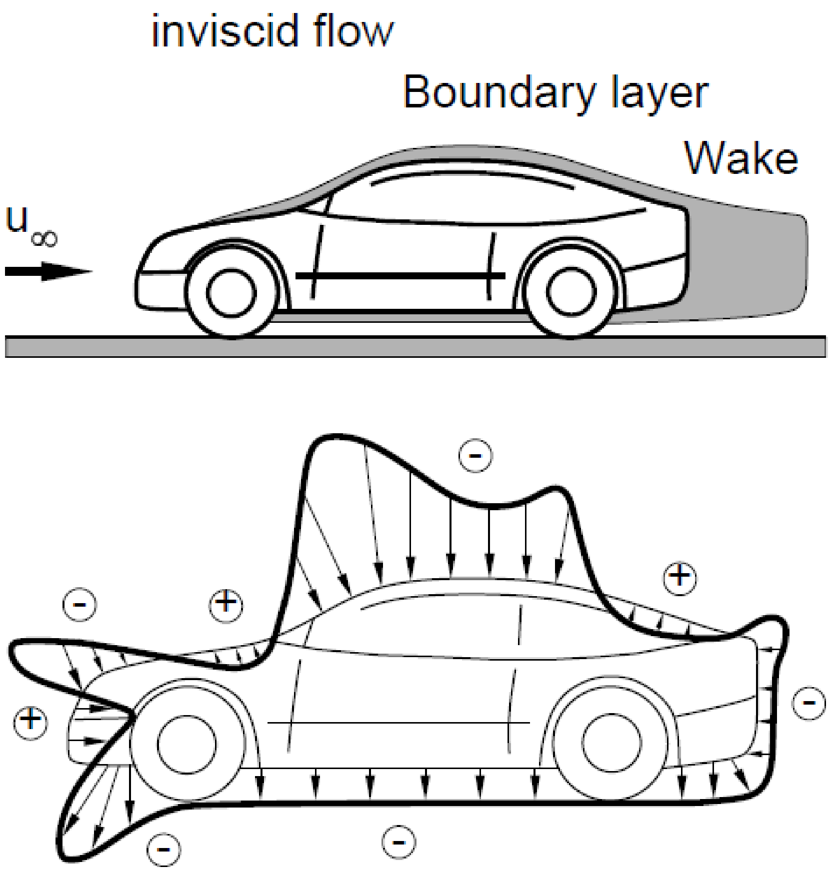
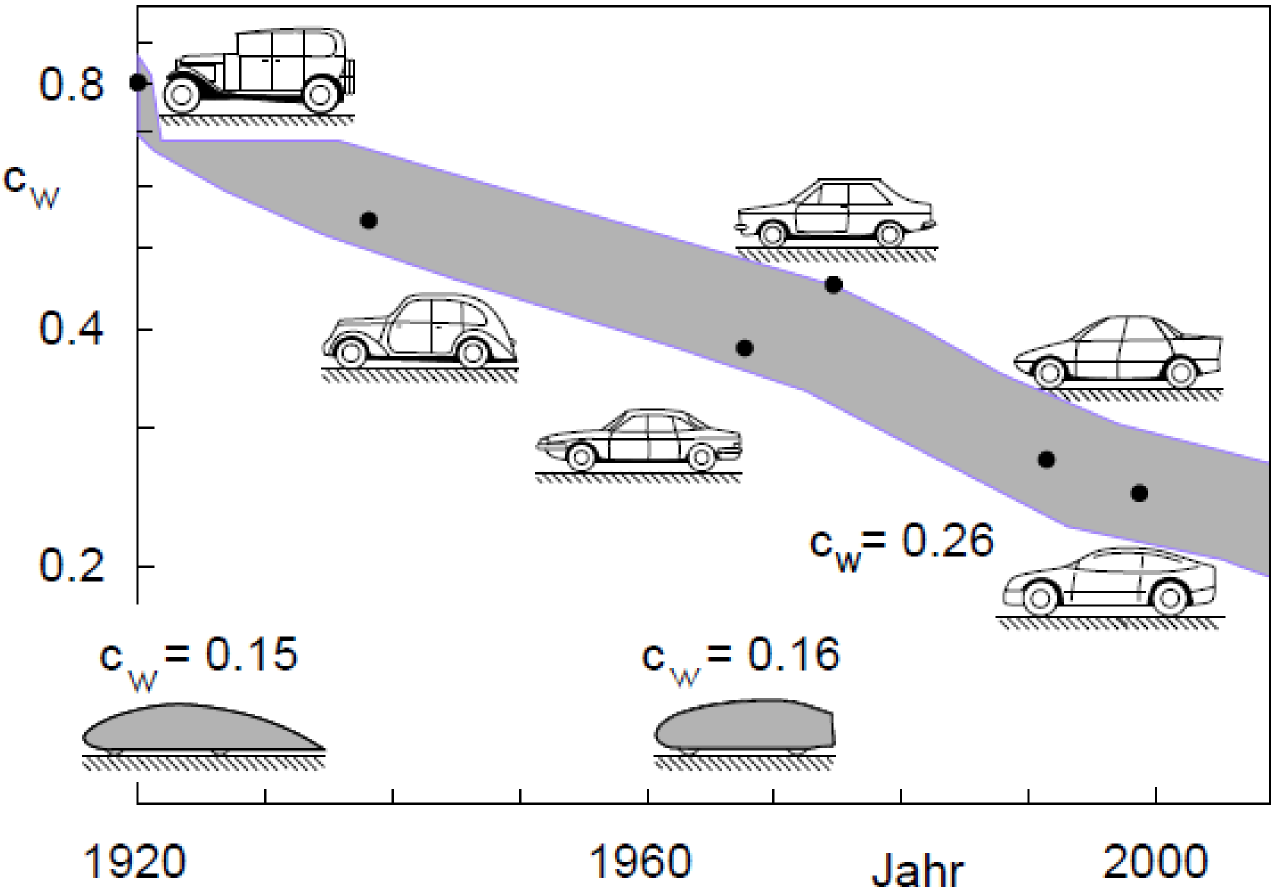


Flow regions and pressure force on a Car

Flows in Technology

Development of the drag coefficient c_W value of motor vehicles



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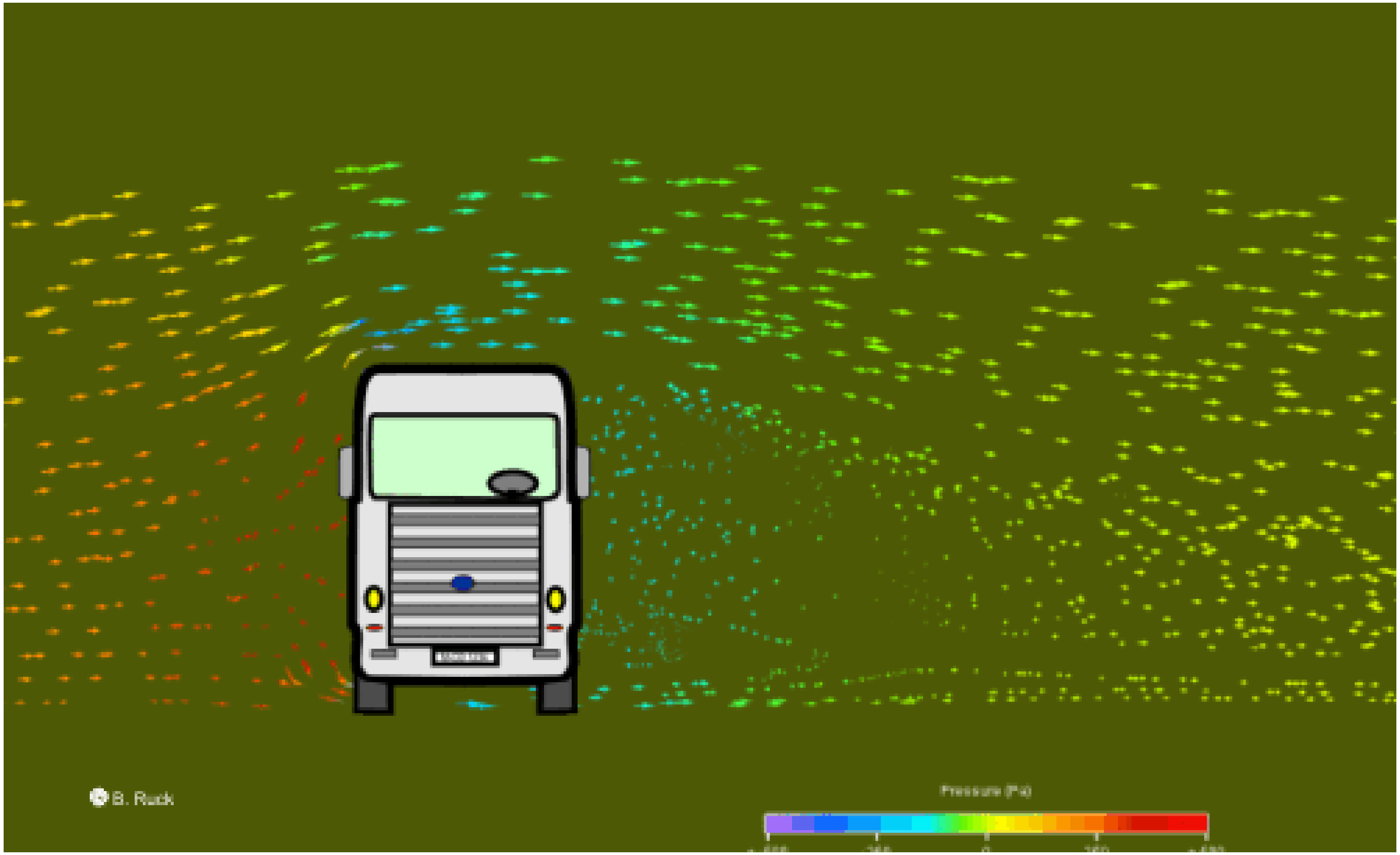

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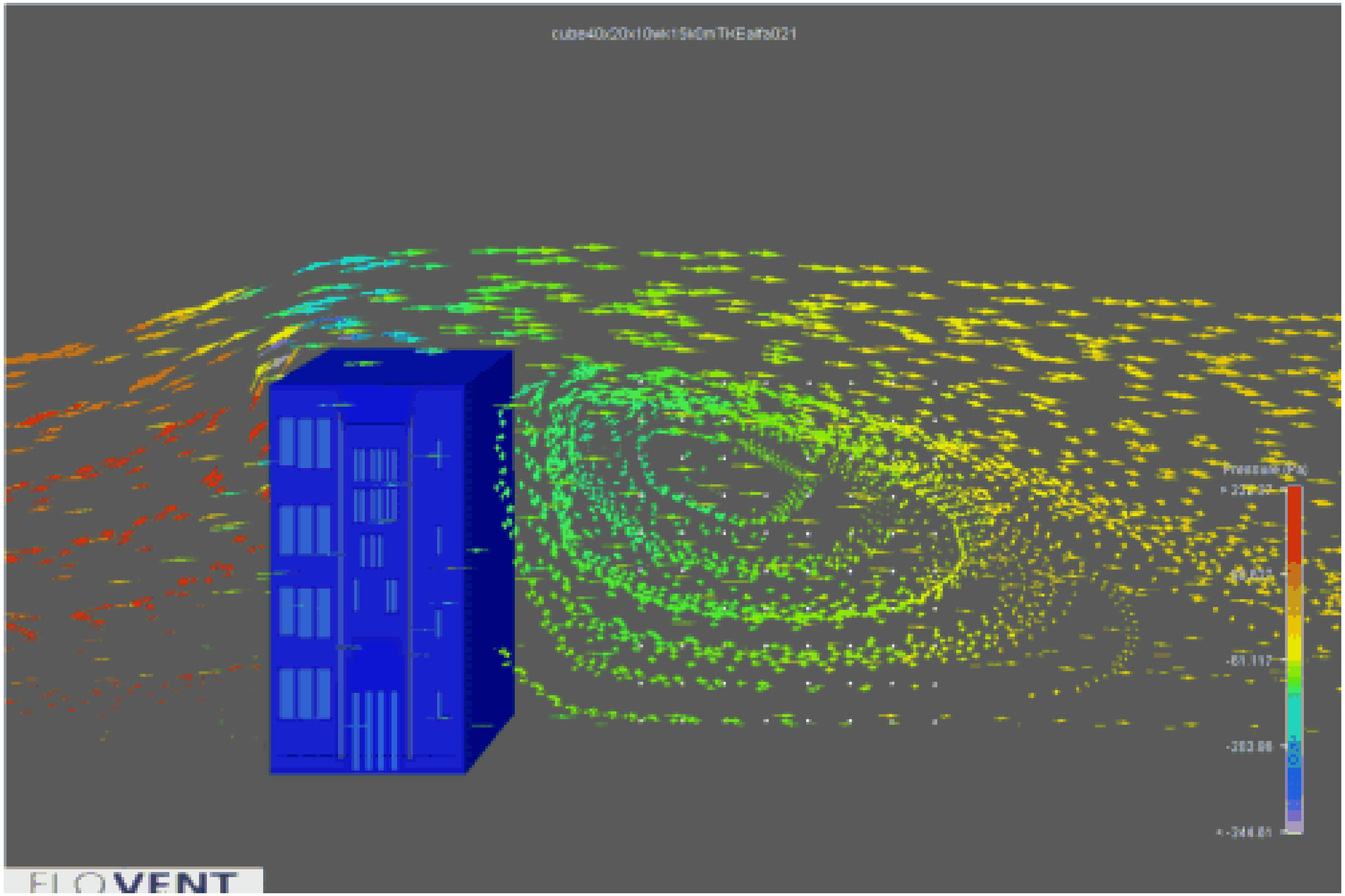

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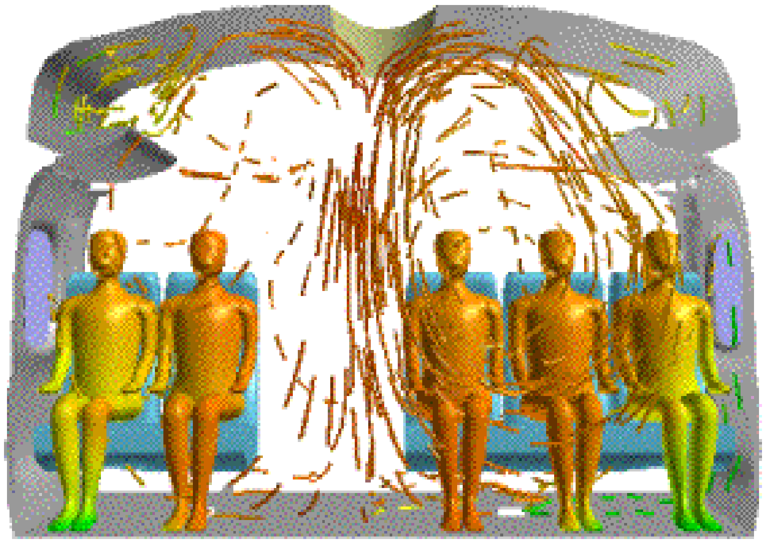

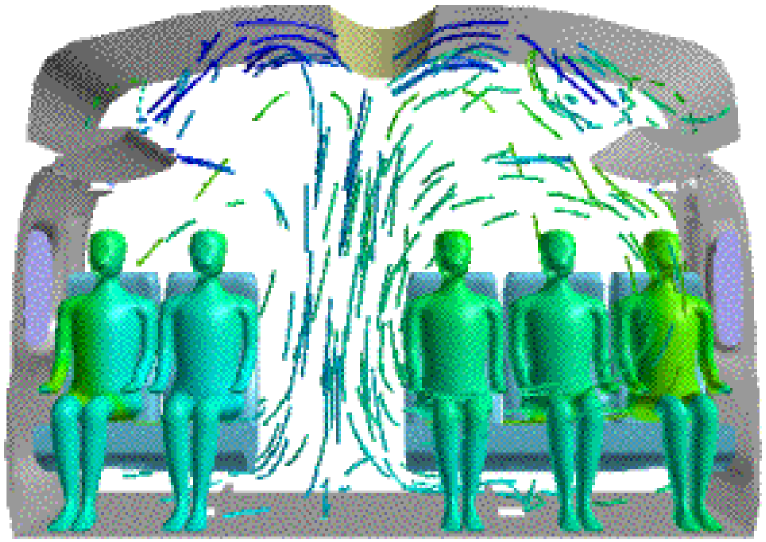

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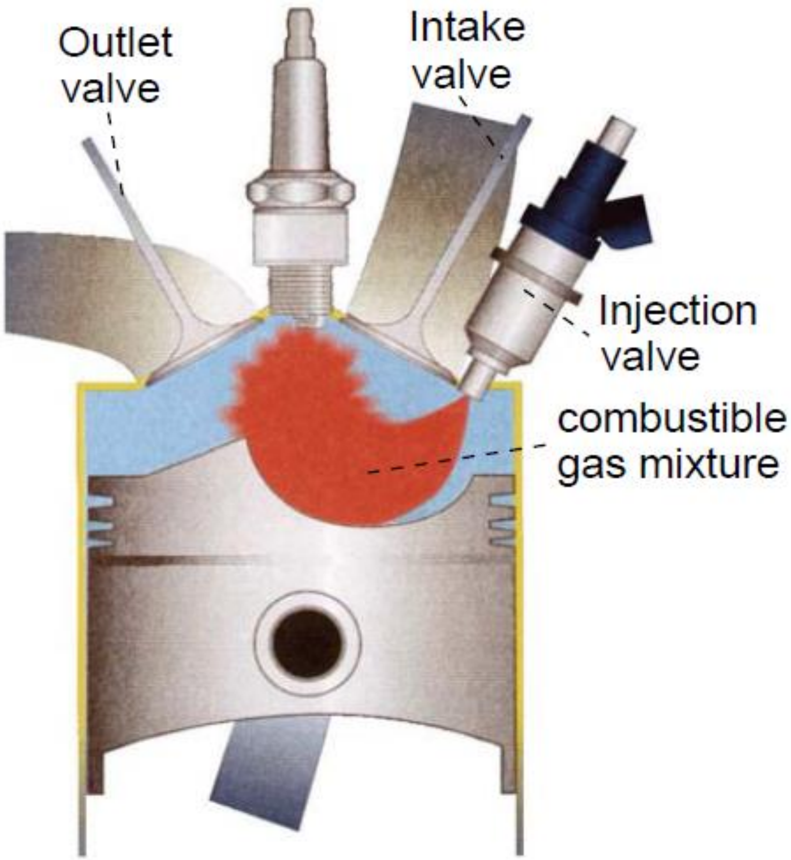
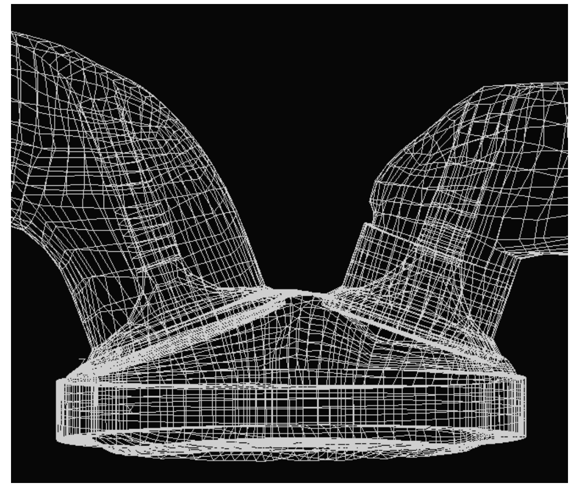
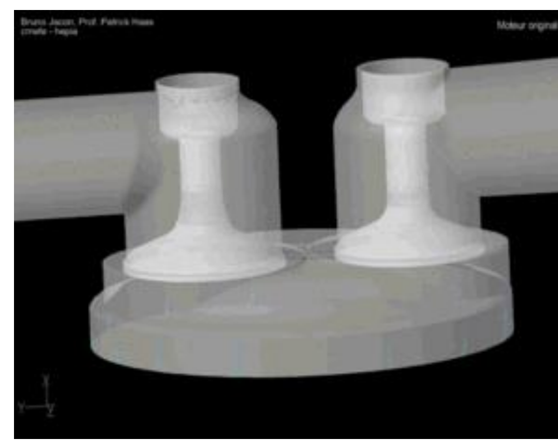
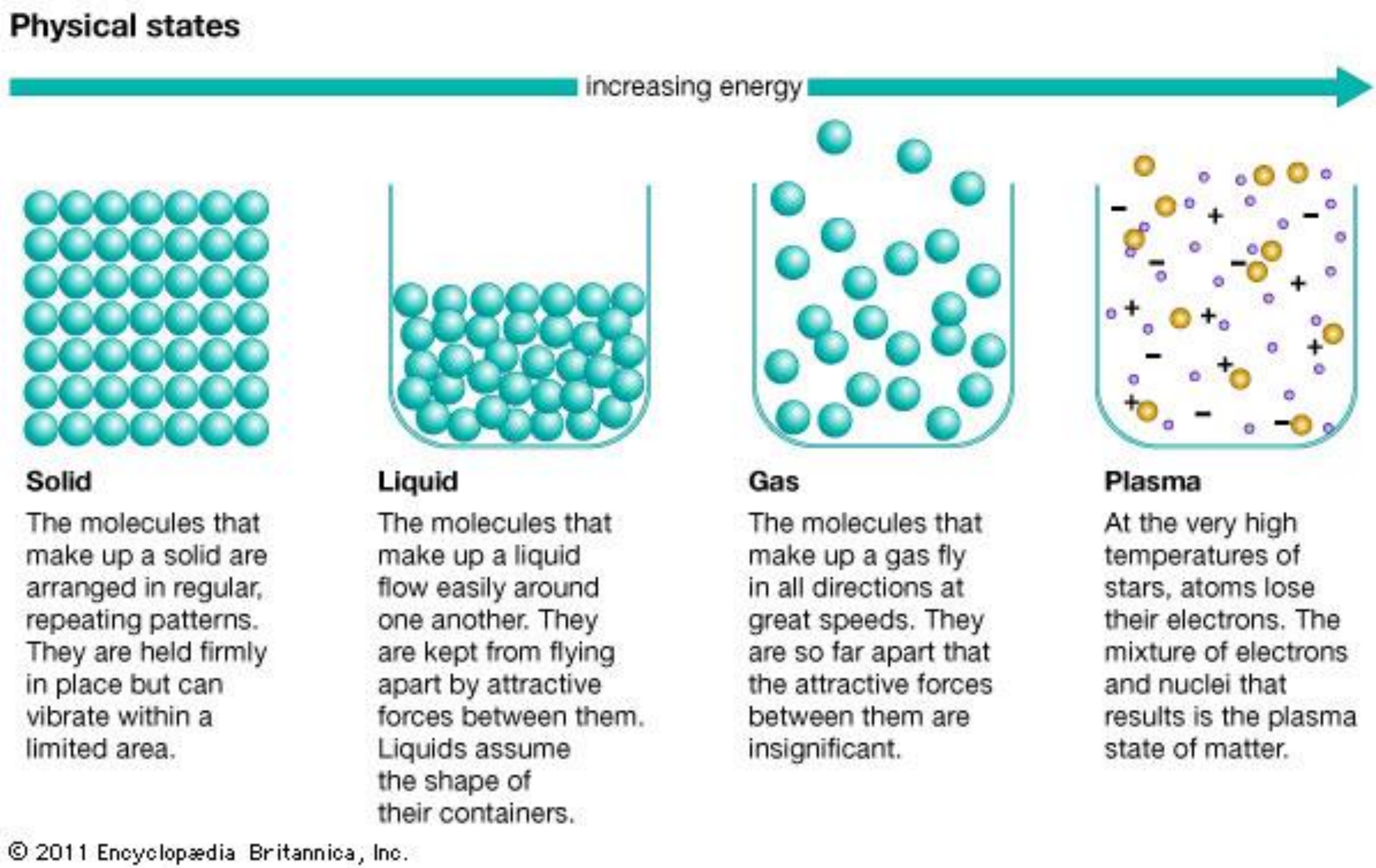






The Concept of a Fluid



Dimensions and Units

Primary Dimensions in SI and BG Systems

Primary dimension	SI unit	BG unit	Conversion factor
Mass $\{M\}$	Kilogram (kg)	Slug	1 slug = 14.5939 kg
Length $\{L\}$	Meter (m)	Foot (ft)	1 ft = 0.3048 m
Time $\{T\}$	Second (s)	Second (s)	1 s = 1 s
Temperature $\{\Theta\}$	Kelvin (K)	Rankine (°R)	1 K = 1.8°R

Secondary Dimensions in Fluid Mechanics

Secondary dimension	SI unit	BG unit	Conversion factor
Area $\{L^2\}$	m^2	ft^2	$1\ m^2 = 10.764\ ft^2$
Volume $\{L^3\}$	m^3	ft^3	$1\ m^3 = 35.315\ ft^3$
Velocity $\{LT^{-1}\}$	m/s	ft/s	1 ft/s = 0.3048 m/s
Acceleration $\{LT^{-2}\}$	m/s^2	ft/s^2	$1\ ft/s^2 = 0.3048\ m/s^2$
Pressure or stress $\{ML^{-1}T^{-2}\}$	$Pa = N/m^2$	lbf/ft^2	$1\ lbf/ft^2 = 47.88\ Pa$
Angular velocity $\{T^{-1}\}$	s^{-1}	s^{-1}	$1\ s^{-1} = 1\ s^{-1}$
Energy, heat, work $\{ML^2T^{-2}\}$	$J = N \cdot m$	$ft \cdot lbf$	$1\ ft \cdot lbf = 1.3558\ J$
Power $\{ML^2T^{-3}\}$	W = J/s	$ft \cdot lbf/s$	$1\ ft \cdot lbf/s = 1.3558\ W$
Density $\{ML^{-3}\}$	kg/m^3	$slugs/ft^3$	$1\ slug/ft^3 = 515.4\ kg/m^3$
Viscosity $\{ML^{-1}T^{-1}\}$	$kg/(m \cdot s)$	$slugs/(ft \cdot s)$	$1\ slug/(ft \cdot s) = 47.88\ kg/(m \cdot s)$
Specific heat $\{L^2T^{-2}\Theta^{-1}\}$	$m^2/(s^2 \cdot K)$	$ft^2/(s^2 \cdot °R)$	$1\ m^2/(s^2 \cdot K) = 5.980\ ft^2/(s^2 \cdot °R)$

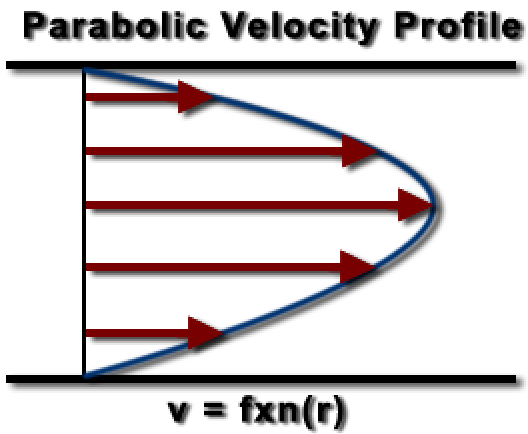
Fluid Properties

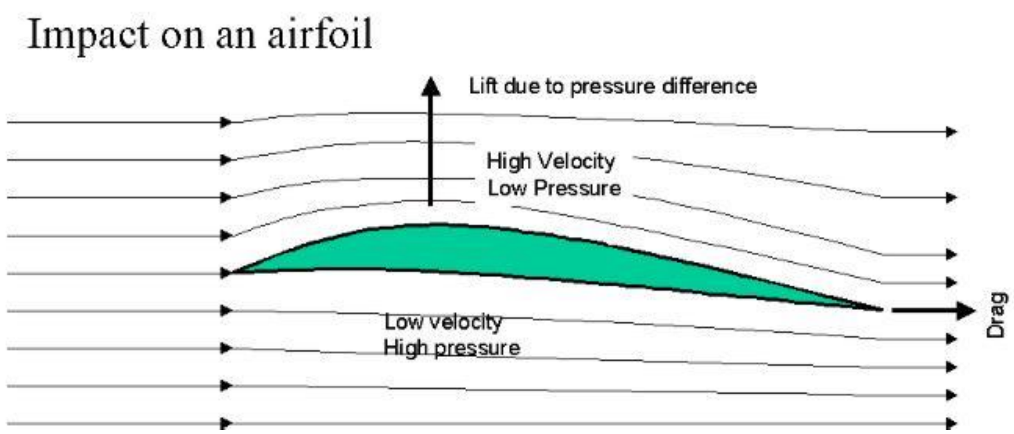
Velocity:

In general, velocity is a vector function of position and time and thus has three components u, v, and w, each a scalar field in itself:

$$\mathbf{V}(x, y, z, t) = \mathbf{i}u(x, y, z, t) + \mathbf{j}v(x, y, z, t) + \mathbf{k}w(x, y, z, t)$$

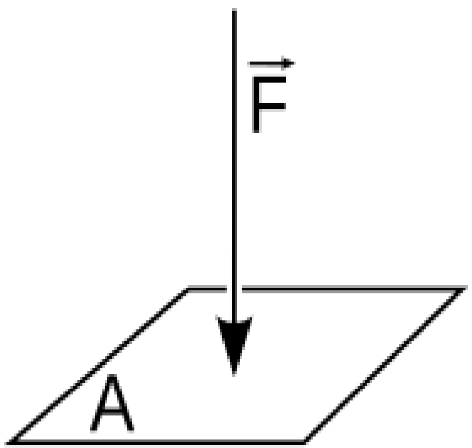
The use of u, v, and w instead of the more logical component notation Vx, Vy, and Vz is the result of an almost unbreakable custom in fluid mechanics.



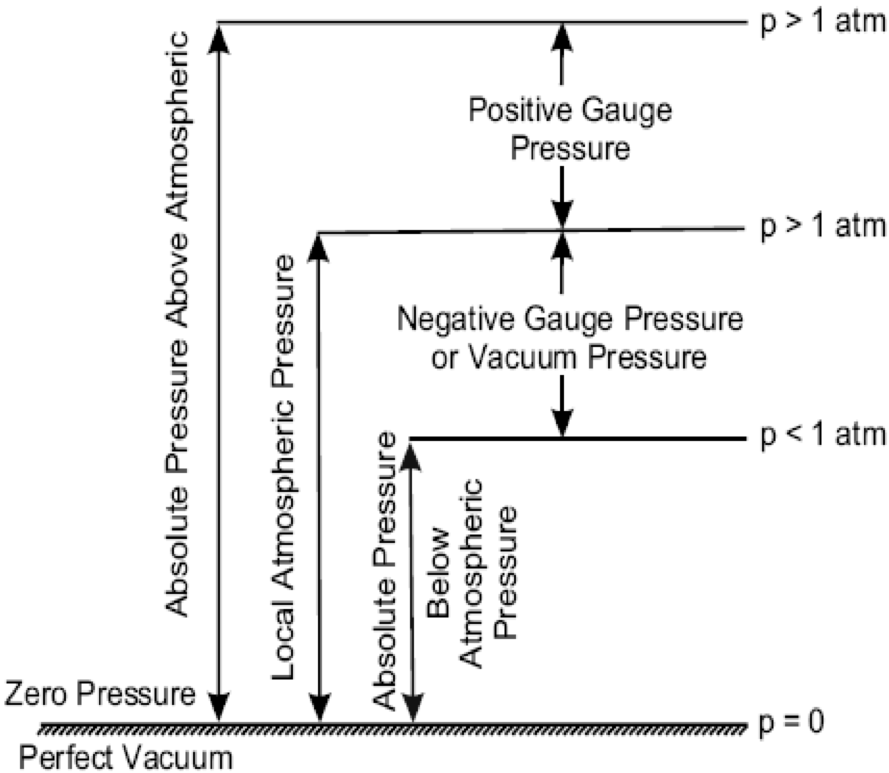


Pressure:

Pressure is the (compression) stress at a point in a static fluid



$$p = \frac{F}{A}$$



Fluid Properties

Temperature :

Temperature *T* is a measure of the internal energy level of a fluid

Density (ρ):

The density of a fluid, denoted by (lowercase Greek rho), is its mass per unit volume.

Specific weight (γ) :

The specific weight of a fluid, denoted by (lowercase Greek gamma), is its weight per unit volume, $\gamma = \rho g$

Specific gravity or Relative Density:

Specific gravity, denoted by SG, is the ratio of a fluid density to a standard reference fluid, water (for liquids), and air (for gases):

$$s = \frac{\rho}{\rho_{w\ at\ 4^{o}C}}$$

$$SG_{gas} = \frac{\rho_{gas}}{\rho_{air}} = \frac{\rho_{gas}}{1.205\ kg/m^3}$$

$$SG_{liquid} = \frac{\rho_{liquid}}{\rho_{water}} = \frac{\rho_{liquid}}{998\ kg/m^3}$$

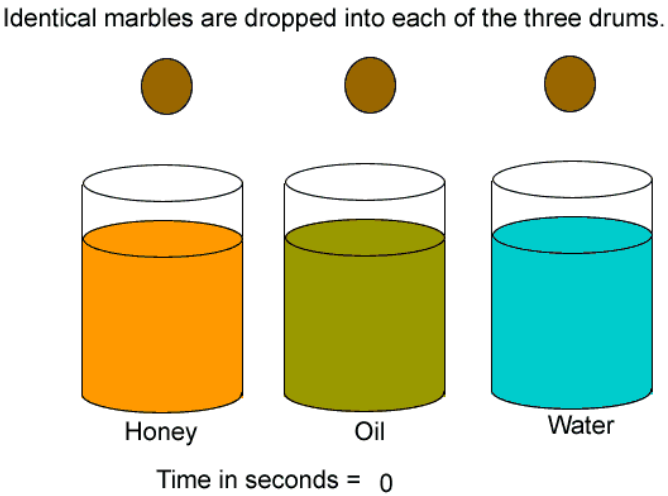
Viscosity

The amount of resistance of a fluid to a shearing force can be determined by the property of the fluid called viscosity.

Absolute or Dynamic viscosity, μ

Kinematic viscosity, v

$$v = \mu/\rho$$



The units of viscosity

Dynamic viscosity: Pa.s (Pascal second) in SI g/ (cm s) or poise in the CGS absolute system of units, 1 poise = 100 centipoises = 0.1 Pa s

Kinematic viscosity: m2/s in SI In the CGS system of units 1 cm2/s is called 1 St (stokes)