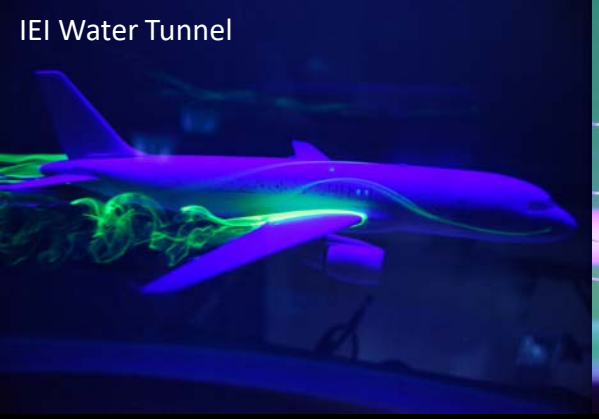
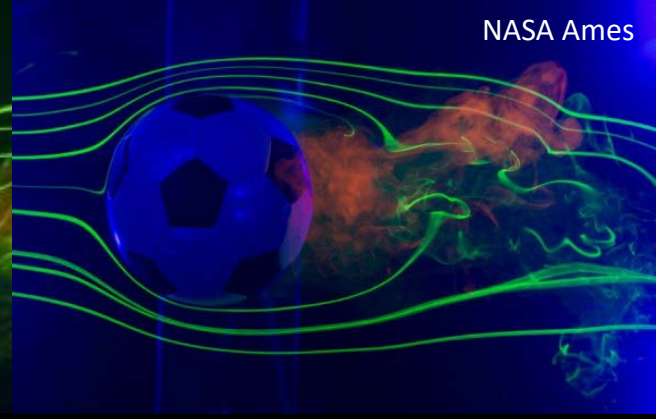

IEI Water Tunnel


NASA Ames

Aerodynamics Lab

Prof. Mitul Luhar

Feb 25, 2016

STEM Academy Visit

USC Viterbi
Department of Aerospace and Mechanical Engineering

Aerodynamics

Aerodynamics is part of a branch of physics called **FLUID DYNAMICS**

- Study of liquids and gases (‘fluids’) that are moving

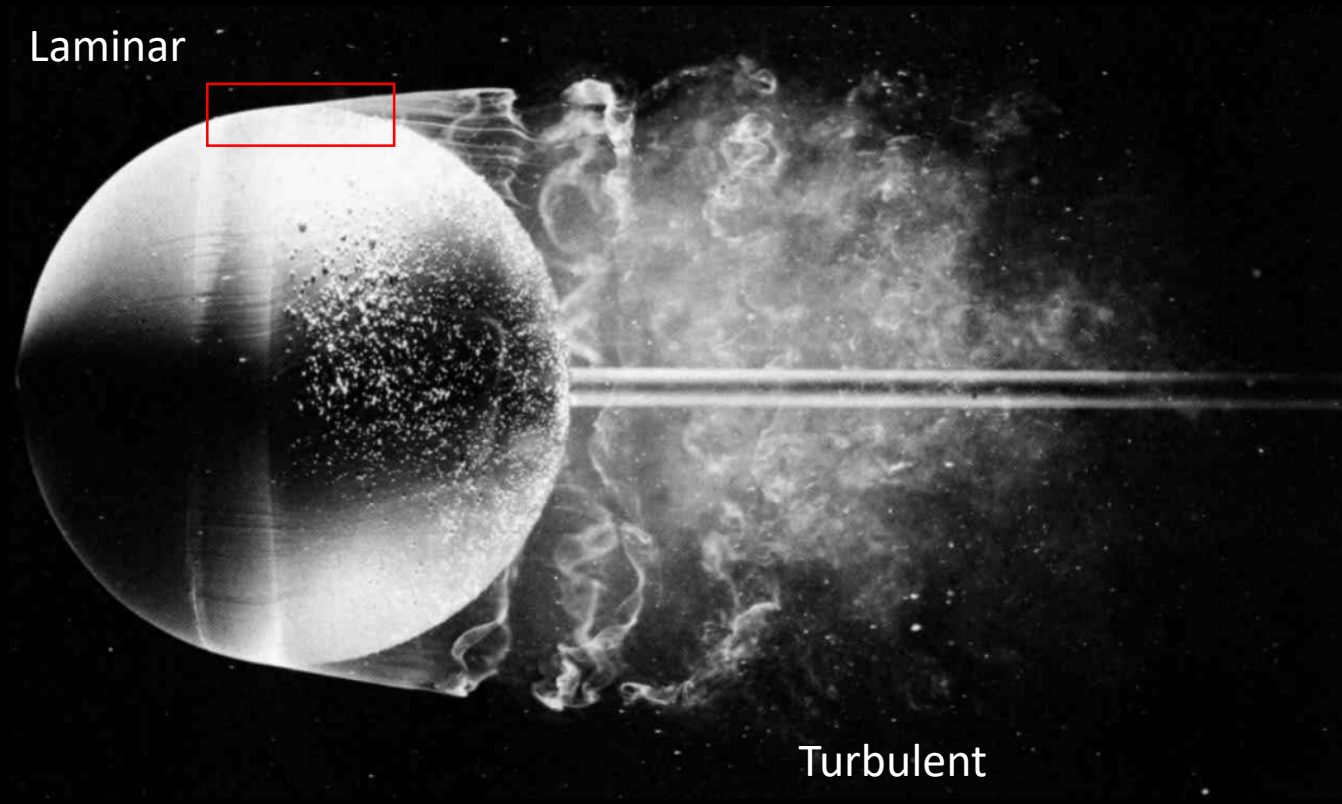
Despite their differences in density, most fluids move the same way and can be described by the same equations

Can involve complex math, but the basics are easy to understand

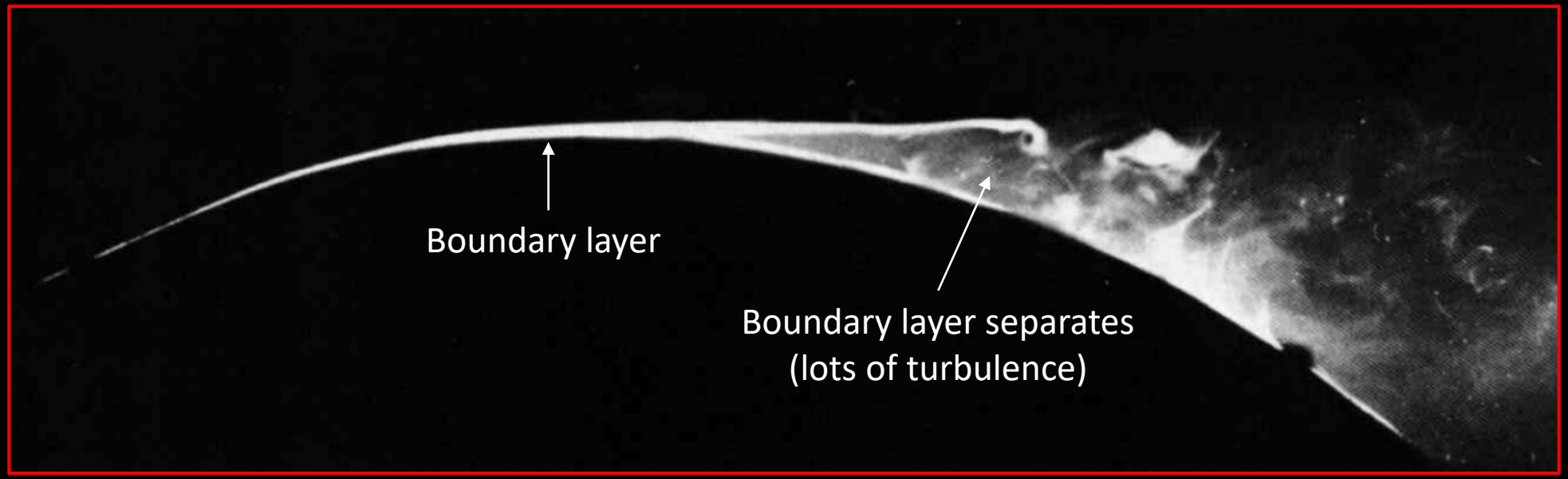
- Laminar and turbulent flow
- Boundary layers
- Drag

Laminar and Turbulent Flow

ONERA Photograph, Werle 1980. From van Dyke: Gallery of Fluid Motion

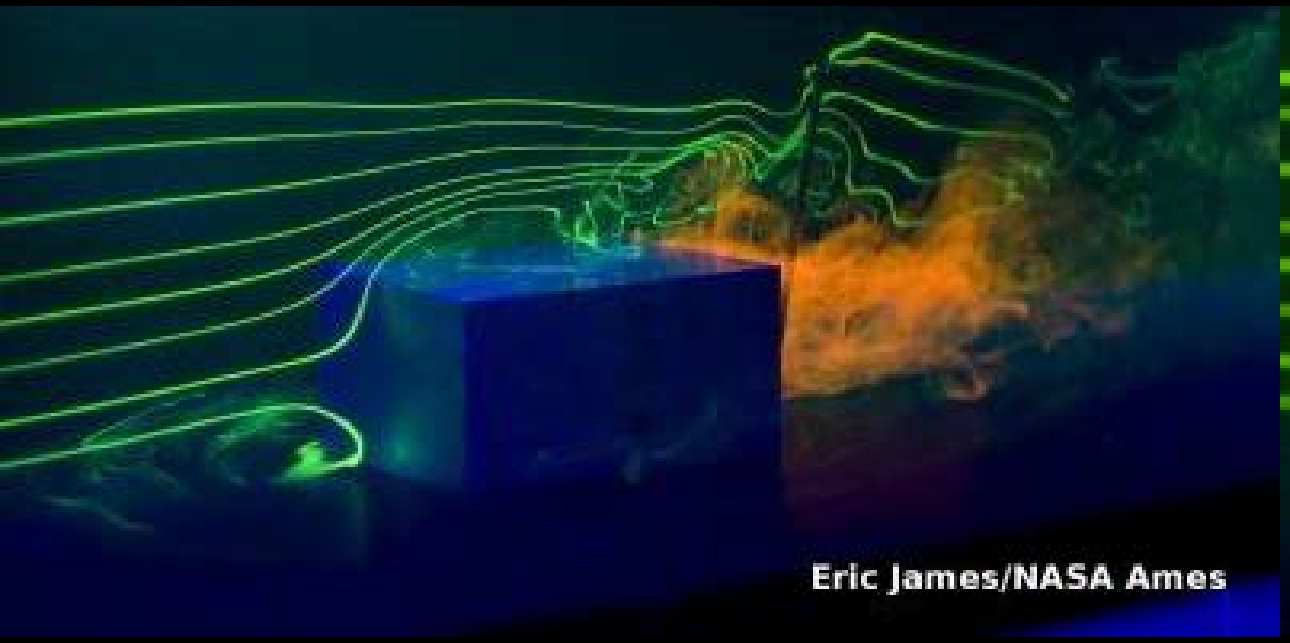


Boundary Layers and Separation

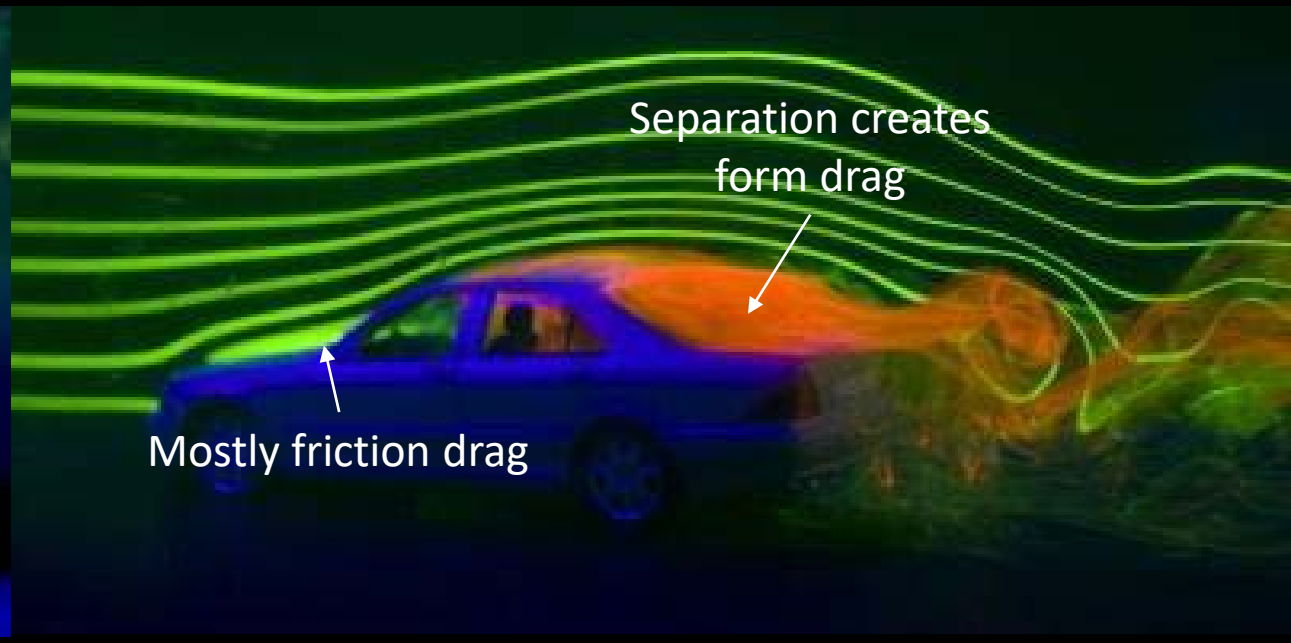


Head 1982. From van Dyke: Gallery of Fluid Motion

Friction Drag and Form Drag



Boxy shapes and sharp corners
→ Lots of turbulence and form drag (bad!)



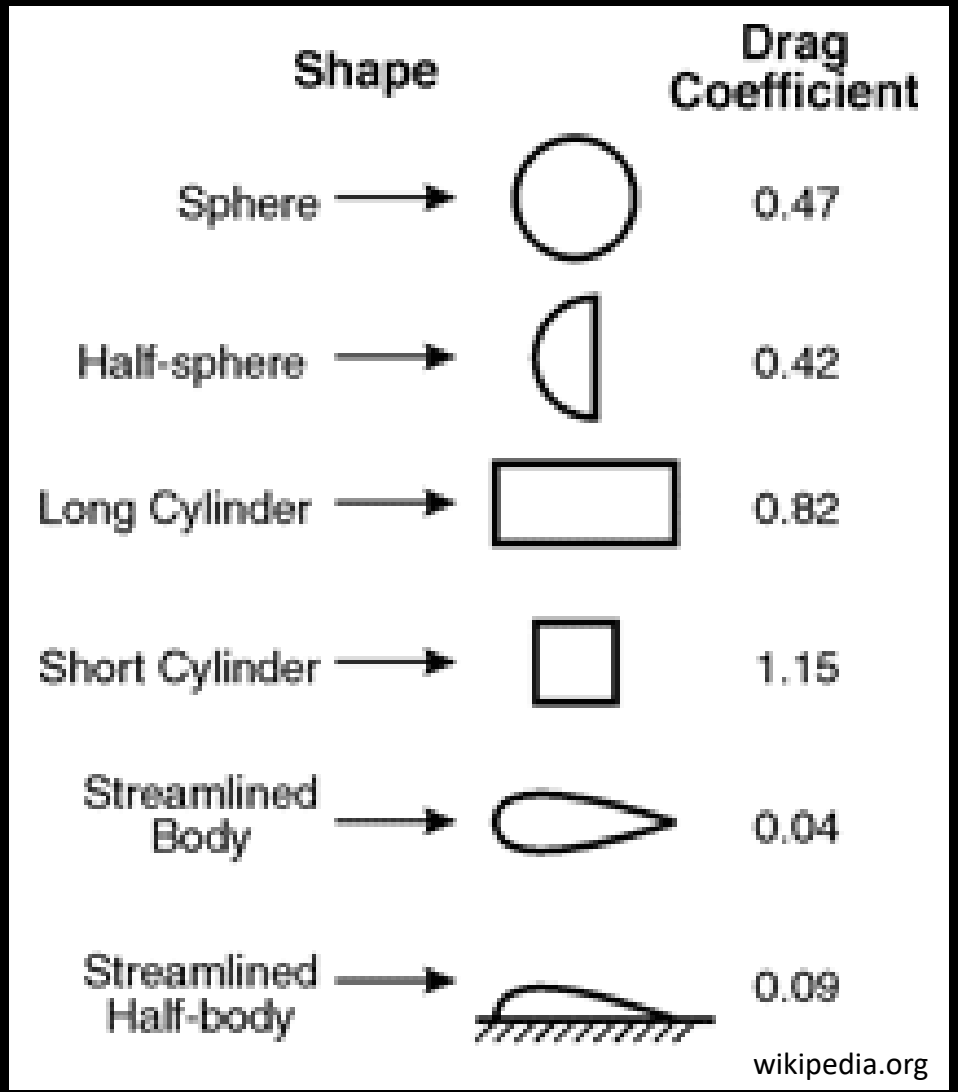
More streamlined shape
→ Reduced separation, turbulence, and form drag

Drag Coefficient, C_D

$$C_D = \frac{\text{Total Drag Force}}{(1/2) \times \text{Fluid Density} \times \text{Drag Area} \times \text{Speed}^2}$$

Photo: VW

Shape Effects on C_D



wikipedia.org

Airbus A380

Photo: Airbus

$$C_D < 0.03$$

Nuna 3 Solar Powered Car

$$C_D = 0.07$$

Photo: Hans-Peter van Velthoven

Volkswagen XL1

Photo: Thomas Wolf, www.foto-tw.de

$$C_D = 0.19$$

Volvo 740 Sedan

Photo: volvocars.com

$$C_D = 0.41$$

Hummer H2

Photo: cars.com

$$\mathbf{C_D = 0.57}$$

Today

1) Lab Tours:

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2) Experiments:

Dye injection tests and drag measurements for 1:24 scale models in water channel

- Original VW Beetle
- Mercedes S-Class
- Nissan Skyline GTR

Calculate C_D

Come up with ways to minimize drag on school bus

Good Scientific Practices

Results must be **objective** and **repeatable**

- Take multiple (at least 3) measurements

Characterize measurement **uncertainty**

- Calculate average and range of measurements

Be systematic when making design changes (one change at a time!)