Today, we will:

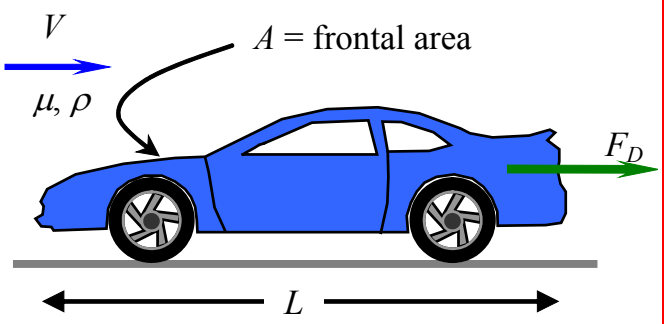
- Finish discussing the example problem from last lecture
- Do some more example problems – dimensional analysis
- Discuss experimental testing and incomplete similarity

Example: Dimensional analysis – Car drag

Given: The drag force F_D on a car is a function of four variables: air velocity V, air density ρ, air viscosity μ, and the length L of the car.

To do: Express this relationship in terms of nondimensional parameters.

Solution: We followed the six steps for the method of repeating variables.



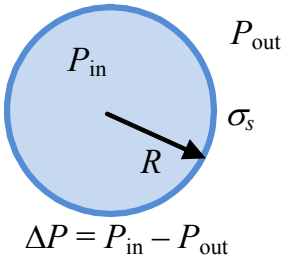
See previous lecture. We completed step 5, and had

$$\Pi_1 = \text{dependent Pi} = C_D = \text{drag coefficient} = \frac{F_D}{\frac{1}{2}\rho V^2 A}$$

$$\Pi_2 = \text{independent Pi} = \text{Re} = \text{Reynolds number} = \frac{\rho V L}{\mu}$$

Finally, Step 6 is to write the relationship between the Πs: $\Pi_1 = \text{func}(\Pi_2, \Pi_3, \ldots)$:

Example: Dimensional analysis – Soap bubble



Given: The difference in pressure ΔP between the inside and outside of a soap bubble is known to be a function of surface tension σ_s and soap bubble radius R.

To do: Use dimensional analysis to express the relationship between ΔP, σ_s, and R in dimensionless form.

Solution:

Step 1: (list the variables)

Step 2: (list the dimensions)

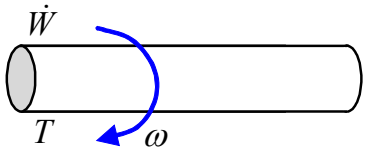
Step 3: (pick reduction j)

Step 4: (pick the repeating variables)

Step 5: (calculate the Πs)

Example: Dimensional analysis – shaft power

Given: The output power $\dot{W}$ of a spinning shaft is a function of torque T and angular velocity ω.



To do: Use dimensional analysis to express the relationship between $\dot{W}$, T, and ω in dimensionless form.

Solution:

Step 1: (list the variables)

Step 2: (list the dimensions)

Step 3: (pick reduction j)

Step 4: (pick the repeating variables)

Step 5: (calculate the Πs)