Today, we will:

- Finish external flow - lift and drag on cylinders and spheres (finish Chapter 11)
- Do some example problems – bicycle and truck drag
- Discuss lift on airplane wings

The "drag crisis" on cylinders and spheres

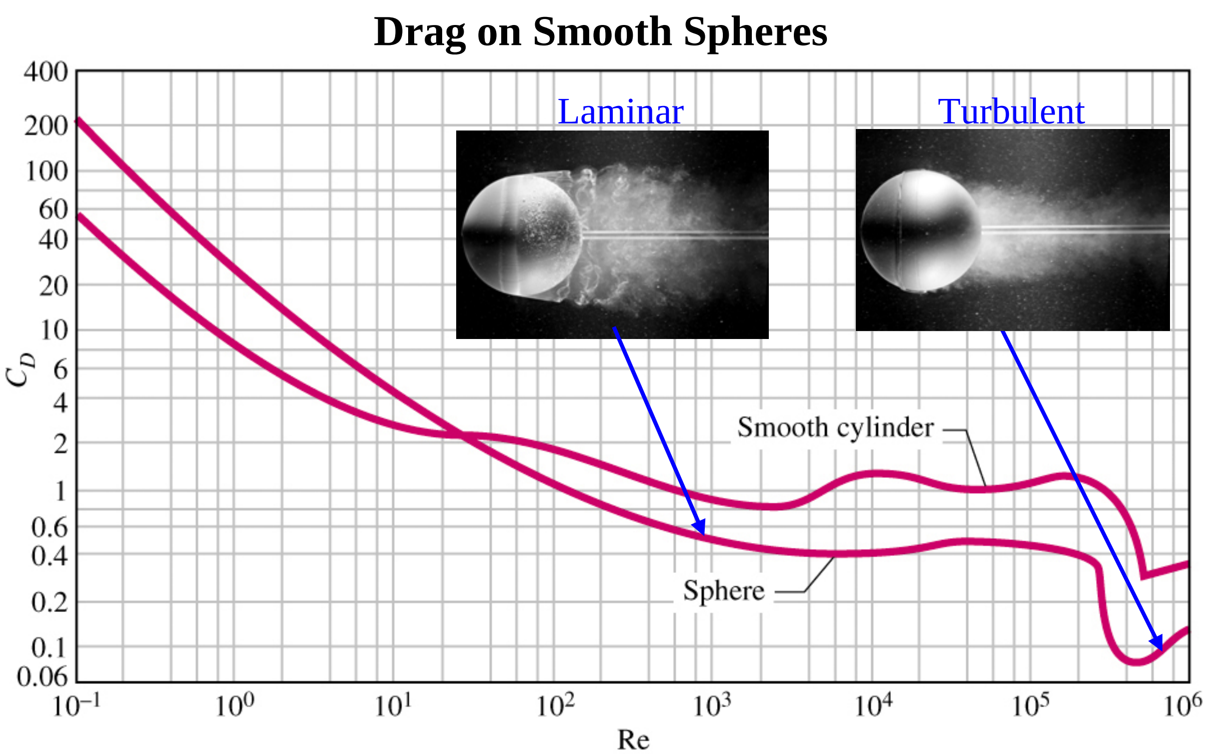


Figure 11-34 & 35. Average drag coefficient for cross-flow over a smooth circular cylinder and a smooth sphere.

Drag on Rough Spheres

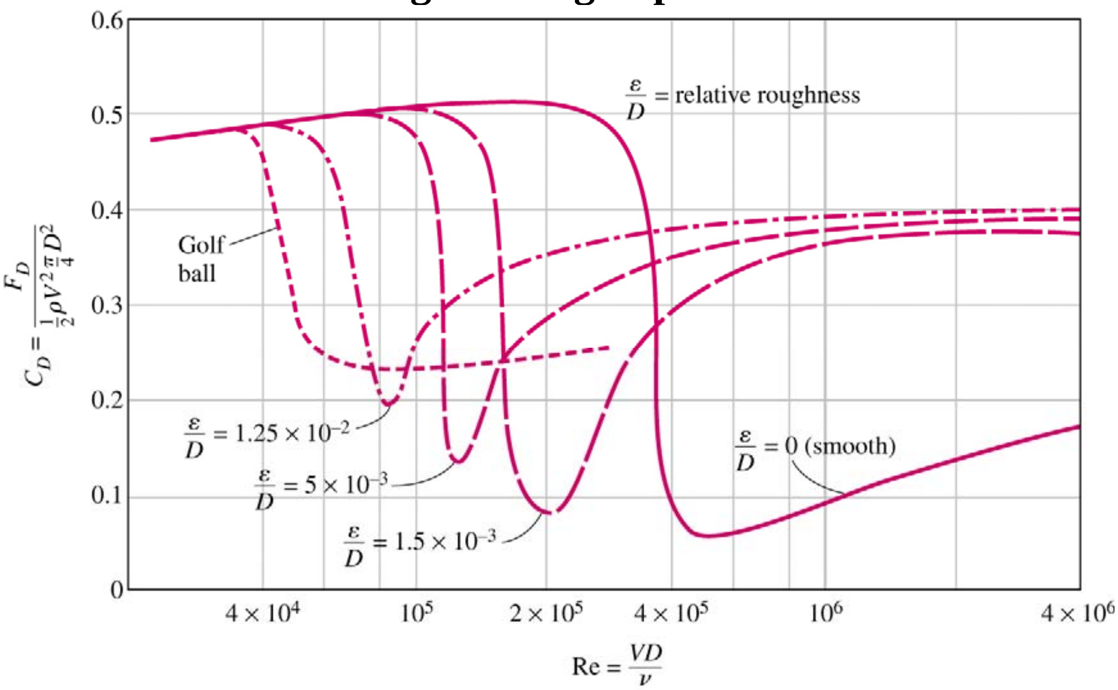
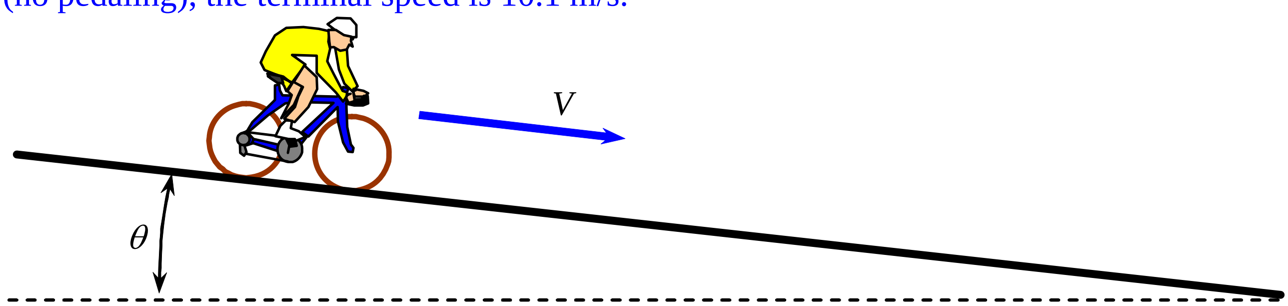


Figure 11-36. The effect of surface roughness on the drag coefficient of a sphere.

Example – Drag on a Bicycle Rolling Down a Hill

Given: A person coasts a bicycle down a long hill with a slope of 5° in order to measure the drag area of the bike and rider. The mass of the bike is 7.0 kg, the mass of the rider is 70.0 kg, and the rolling resistance of the bike is measured separately – it is 19.0 N. When the rider coasts down the hill (no pedaling), the terminal speed is 10.1 m/s.



(**a**) **To do**: Calculate the drag area C_DA of the rider/bicycle combination.

Solution: (to be completed in class)

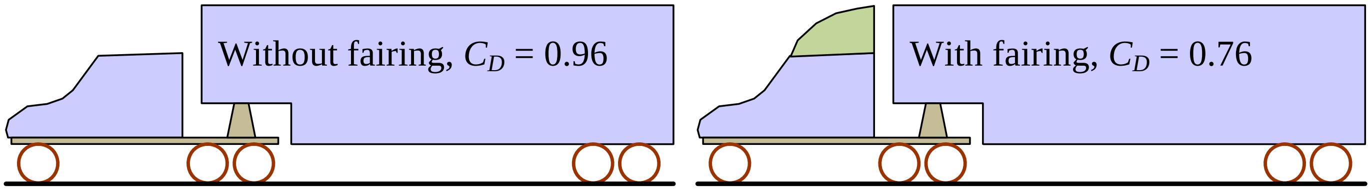
First draw a free-body diagram of the bicycle and rider, showing all forces acting.

(**b**) **To do**: Calculate how much power it would take for the person to ride this bike on a level road at the same speed (10.1 m/s).

Solution: (to be completed in class)

Example – Drag on an 18-Wheeler

Given: We compare the gas mileage and operating cost of an 18-wheeler driving at 60 mph (26.82 m/s) with and without an aerodynamic fairing. For both cases, the frontal area A = 8.5 m^2 and the rolling resistance is 2750 N. Take the density of the air to be 1.20 kg/m^3. The engine output is rated at E_o = 13.0 hp·hr/gal [for each gallon of diesel fuel used, the engine delivers 13 hp of useful shaft power to the wheels for one hour].



(**a**) **To do**: Calculate the power required to overcome the drag (rolling + aerodynamic) at a speed of 60 mph for both cases.

Solution: (to be completed in class)

(**b**) **To do**: Calculate the gas mileage (miles per gallon) for both cases at 60 mph, and the fuel cost savings provided by the fairing for a round trip cross-country trip (6000 miles). Assume fuel costs $4.00 per gallon.

Solution: (to be completed in class)