Lab X6 – Pipe Flow ΔP

2017 Rev 1

LAB X-1   Pressure changes with height in a gravity field

LAB X-2   Pressure Measurement using ΔP loss

LAB X-3   *Impact Force of a Jet….*

LAB X-4   Orifice and Free Jet – measured Cv and Cd

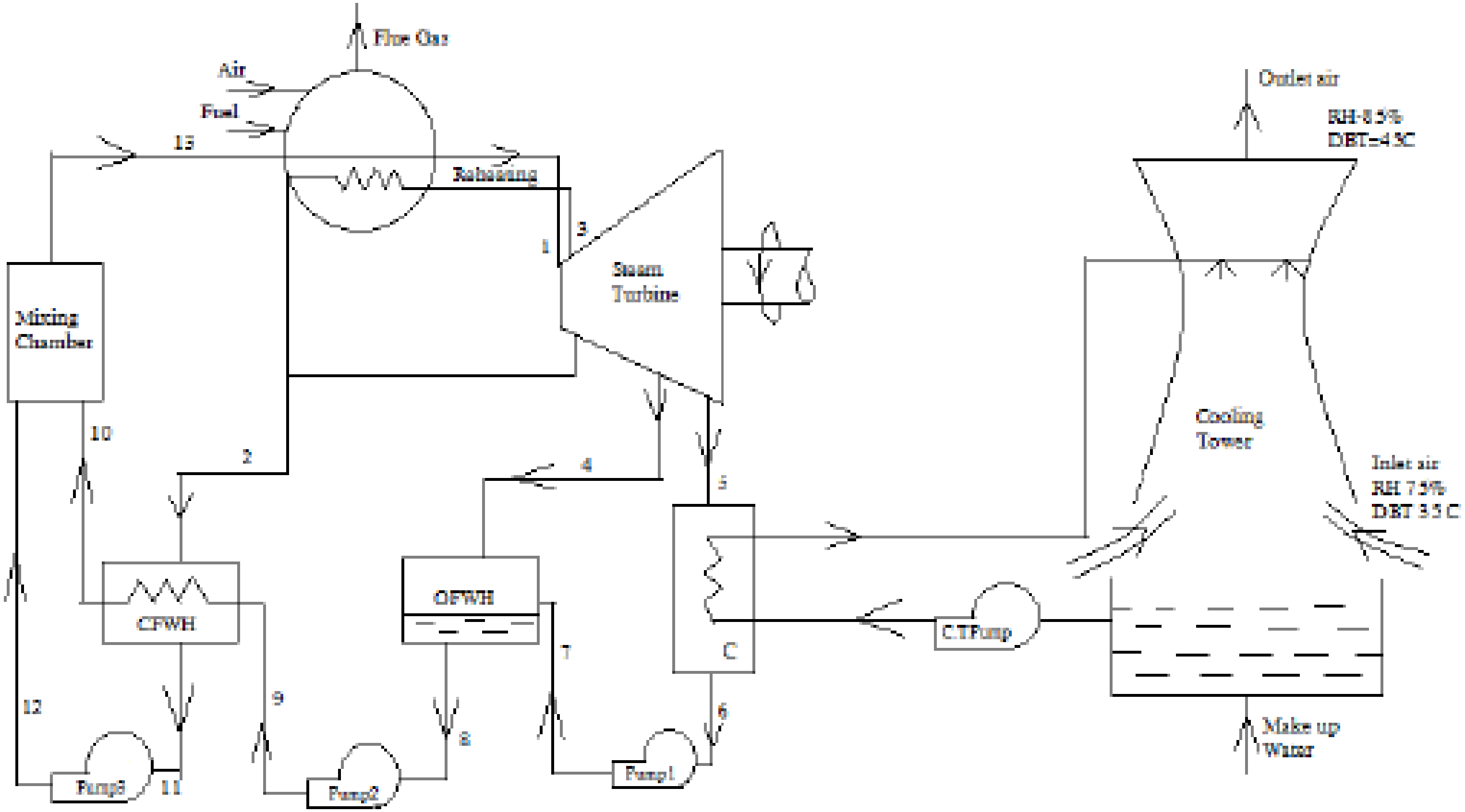
LAB X-5   Reynolds Number – Re and f vs flow rates

LAB X-6   Pipe flows

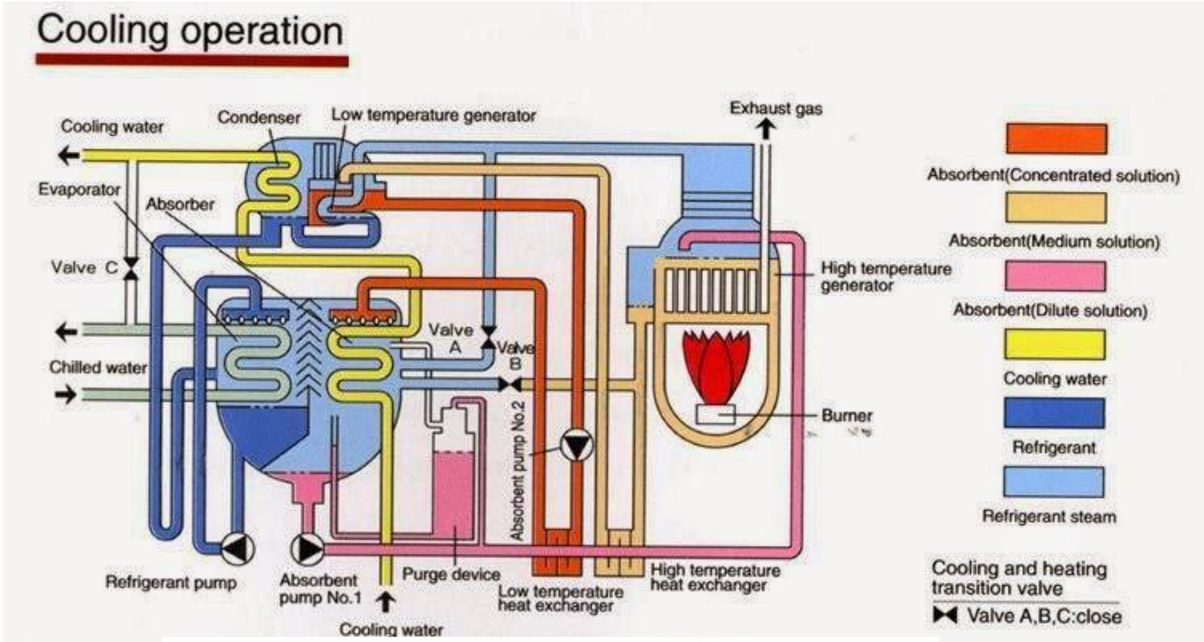
Fact- Fluid friction is always with you (or maybe against you)

Both flow and elevation ΔP involved

Different pipelines, different pressures – balance required



POWER PLANT ADDS STEAM TO THE MIX


Cooling operation
Cooling water
Condenser
Low temperature generator
Exhaust gas
Evaporator
Absorber
Valve C
Chilled water
Valve A
Valve B
Absorbent pump No.2
High temperature generator
Burner
Refrigerant pump
Absorbent pump No.1
Purge device
Cooling water
Low temperature heat exchanger
High temperature heat exchanger
Absorbent(Concentrated solution)
Absorbent(Medium solution)
Absorbent(Dilute solution)
Cooling water
Refrigerant
Refrigerant steam
Cooling and heating transition valve
Valve A,B,C:close

Quantifying Pressure Drops: The Darcy Friction Factor

- What should it depend on?

$$\Delta P = function(\rho, V, D, L, \mu, \epsilon \text{ (roughness)})$$

- 7 Variables, 3 Dimensions -> 4 dimensionless numbers

$$\frac{\Delta P}{\tfrac{1}{2}\rho U^2} = func\left(\frac{\rho U D}{\mu},\quad \frac{L}{D},\quad \frac{\epsilon}{D}\right)$$

- But intuition tells us that if we double the length of the pipe, then the pressure drop should double as well

$$\frac{\Delta P}{\tfrac{1}{2}\rho U^2} = \frac{L}{D} \quad * func\left(\frac{\rho U D}{\mu},\quad \frac{\epsilon}{D}\right)$$

Quantifying Pressure Drops: The Darcy Friction Factor

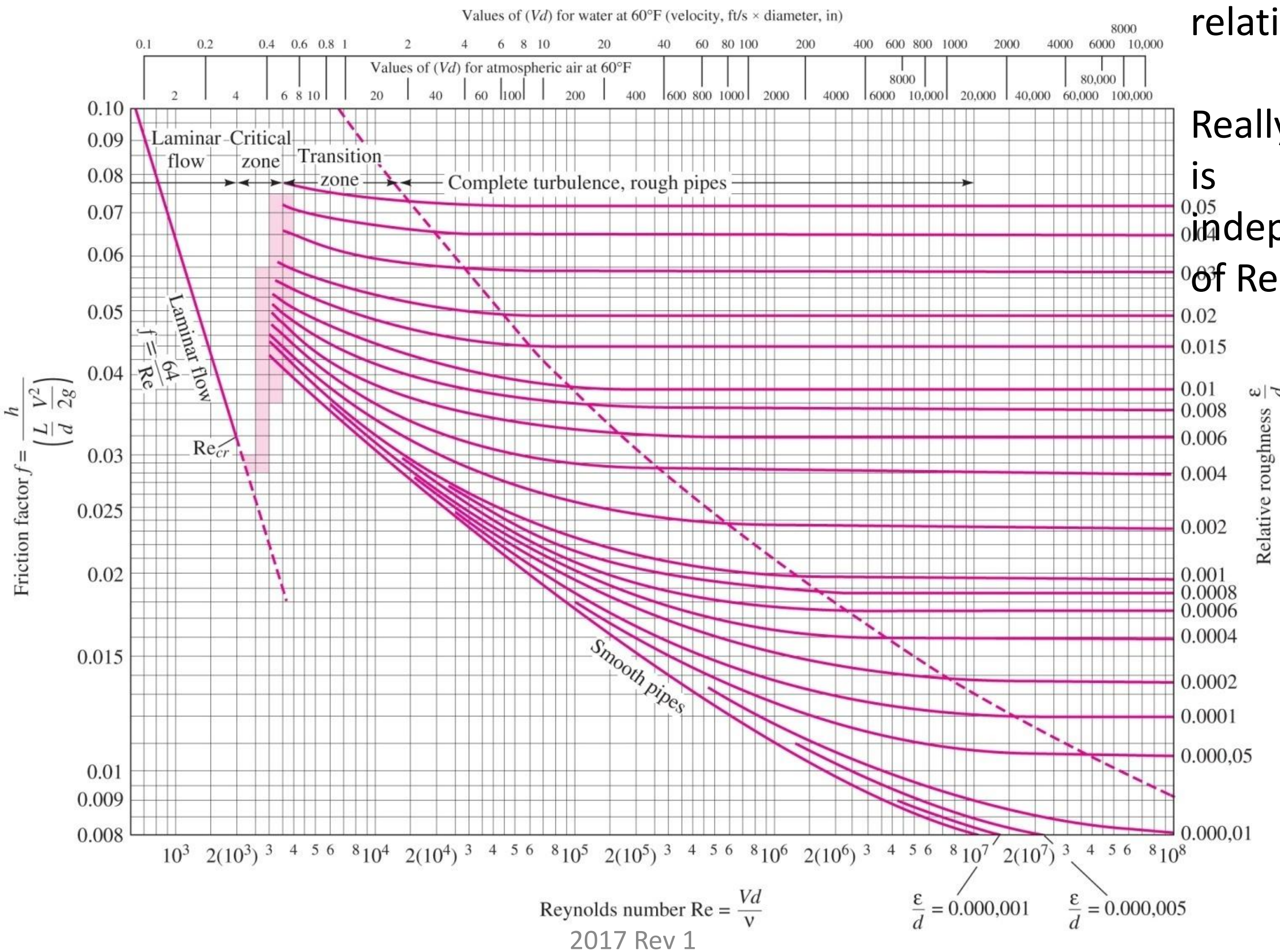
- Darcy "friction factor":

$$\boxed{f \equiv \frac{\Delta P}{\frac{1}{2}\rho U^2 (L/D)} = f\left(\mathrm{Re},\quad \frac{\epsilon}{D}\right)}$$

- If we knew $f\left(\mathrm{Re},\quad \frac{\epsilon}{D}\right)$ then we could calculate pressure drop for any flow condition

- This is usually presented as a ***Moody Diagram***

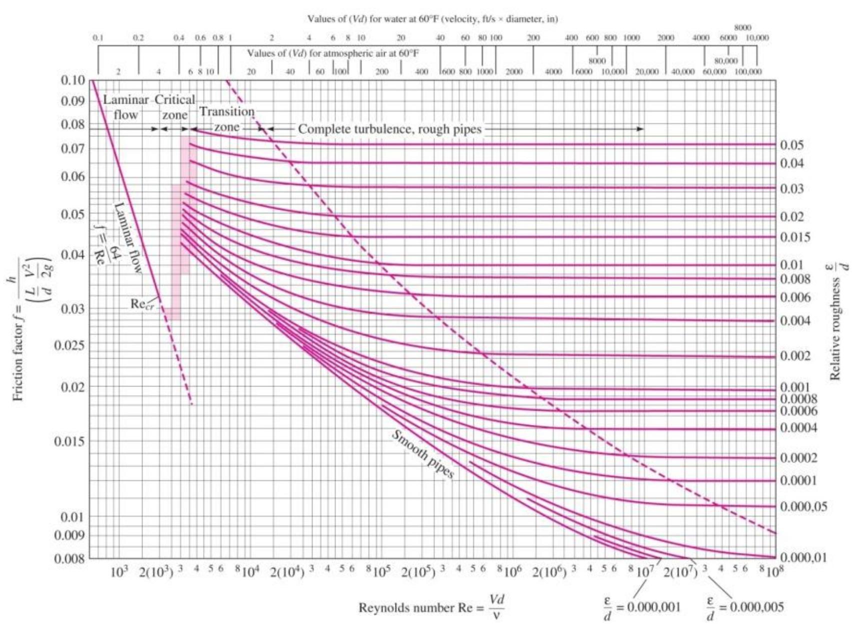
The Moody Diagram



Rough is relative.

Really rough, f is independent of Re

The Moody Diagram



- For ***smooth pipes***, things are a bit more simple, though:

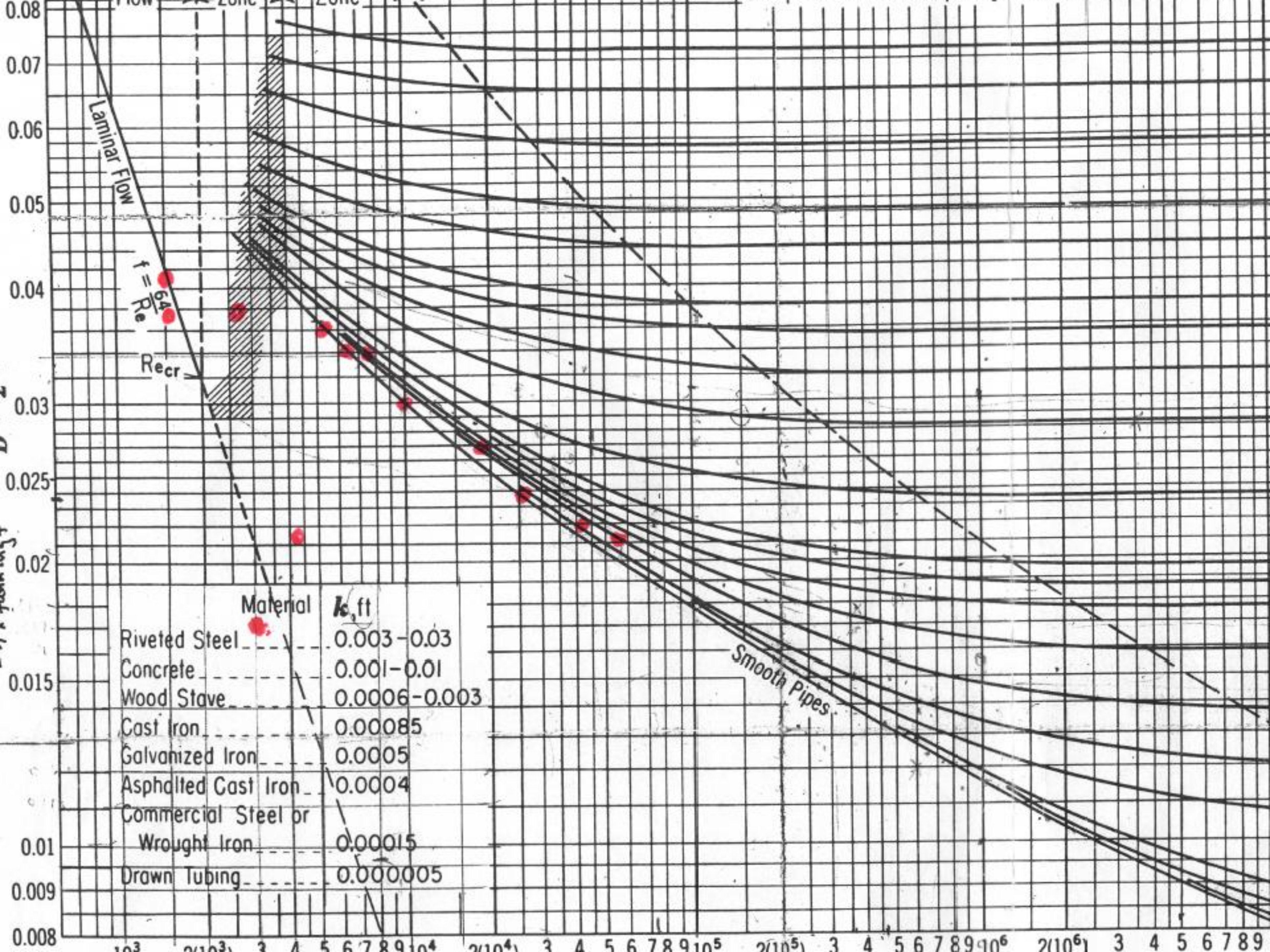
$$f = \begin{cases} 64 / \mathrm{Re}_D & \text{(laminar)} \\ 0.316\, \mathrm{Re}_D^{-1/4} & \text{(turbulent)} \end{cases}$$

The Moody Chart is a general plot of laminar, transition, and turbulent flow

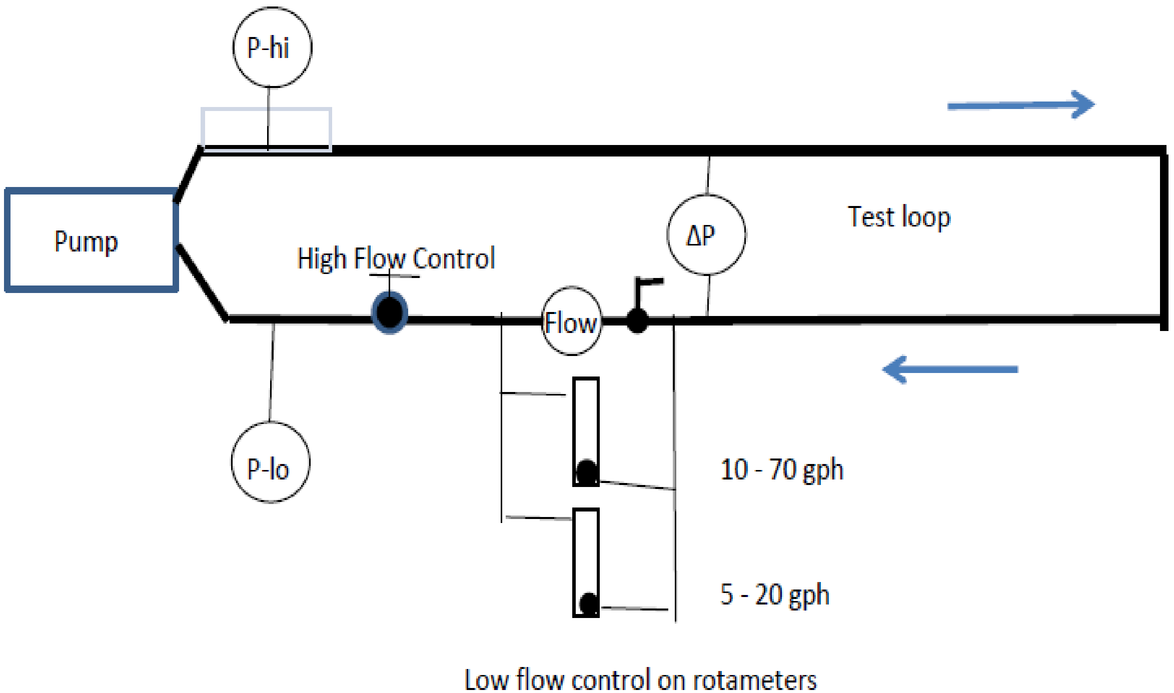
In lab, we will vary the flow rate through a relatively smooth tube.

But you cannot see it!
Calculate the Reynolds number at each observation and plot on the Moody Chart.

How well does your data fit the Moody chart?

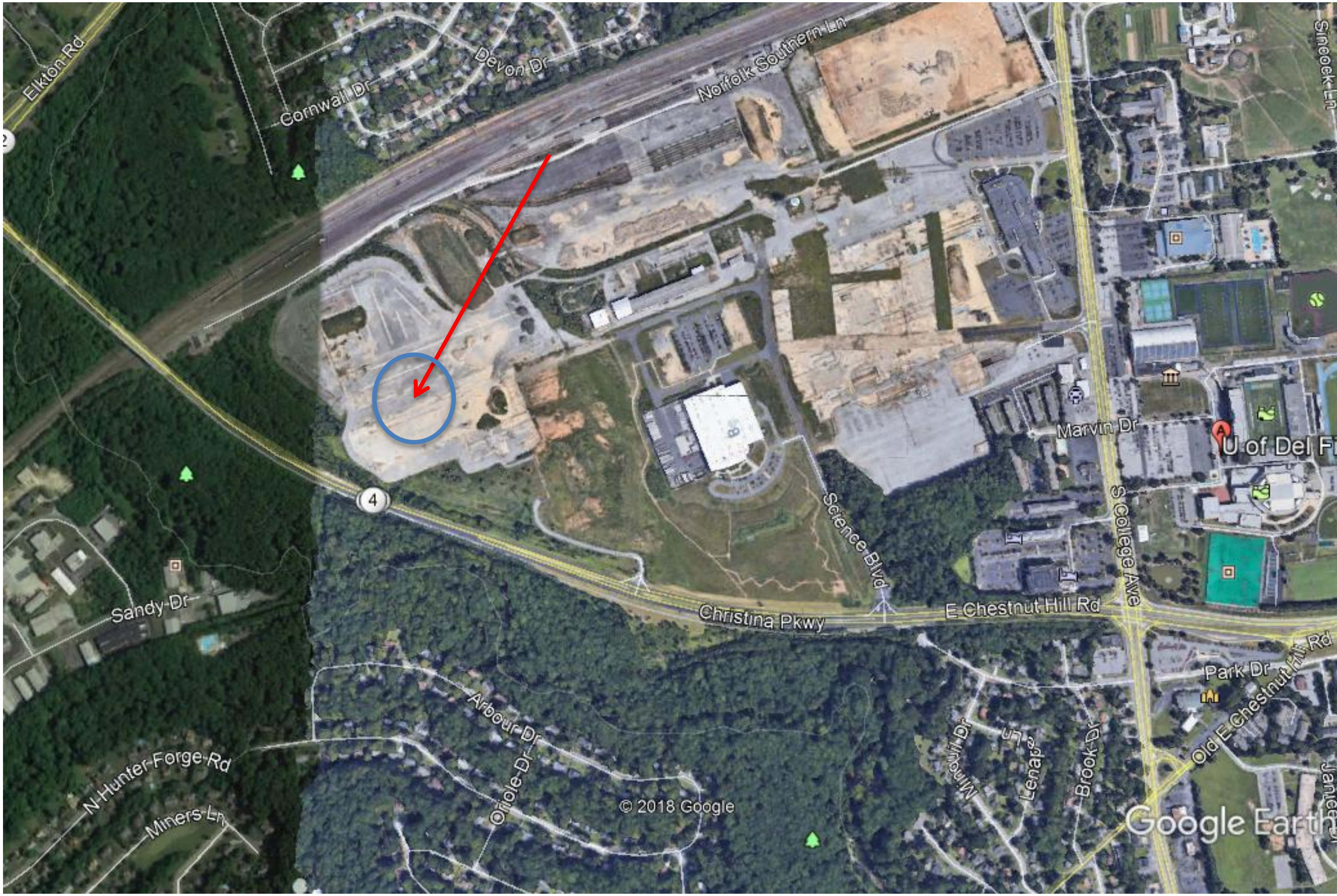

Laminar Flow
$f = \frac{64}{Re}$
Re_{cr}
Smooth Pipes
Material | k, ft
Riveted Steel 0.003–0.03
Concrete 0.001–0.01
Wood Stave 0.0006–0.003
Cast Iron 0.00085
Galvanized Iron 0.0005
Asphalted Cast Iron 0.0004
Commercial Steel or Wrought Iron 0.00015
Drawn Tubing 0.000005
0.08
0.07
0.06
0.05
0.04
0.03
0.025
0.02
0.015
0.01
0.009
0.008
10^3 $2(10^3)$ 3 4 5 6 7 8 9 10^4 $2(10^4)$ 3 4 5 6 7 8 9 10^5 $2(10^5)$ 3 4 5 6 7 8 9 10^6 $2(10^6)$ 3 4 5 6 7 8 9

Lab X-6 Test Apparatus



- Two identical loops
- Digital Flow, ΔP, and Temp instrumentation (at last)
- Pump loop operation basics

  Venting
  Dead heading
  Fittings
  Pumped fluid heating



Elkton Rd
Cornwall Dr
Devon Dr
Norfolk Southern Ln
Sincock Ln
Marvin Dr
U of Del Fie
S College Ave
Science Blvd
Christina Pkwy
E Chestnut Hill Rd
Sandy Dr
Park Dr
Old E Chestnut Hill Rd
Arbour Dr
Oriole Dr
N Hunter Forge Rd
Miners Ln
Minquil Dr
Lenape Ln
Brook Dr
Janice Dr
© 2018 Google
Google Earth