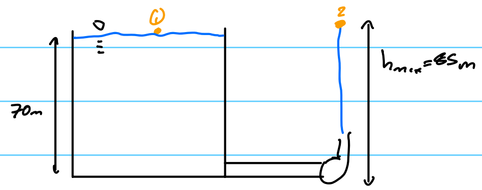
Trevor Swan **ECHE225: EXAM #2 // 11.13.24**

1-5) MC



free surface velocity = 0 ; $P_1=P_2=P_{atm}$; Steady, Assume const. jet height

6. $$\frac{\cancel{P_1}}{\rho_1 g}+\frac{\cancel{V_1^2}}{2g}+z+h_{pump,u}=\frac{\cancel{P_2}}{\rho_2 g}+\frac{\cancel{V_2^2}}{2g}+z_2+\cancel{h_{turbine,e}}+h_L$$

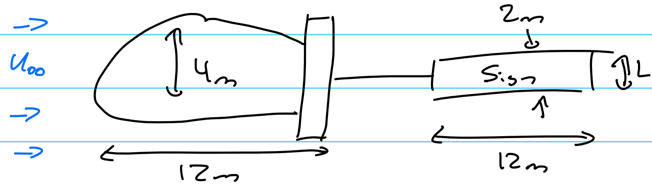
$$\boxed{z_1+h_{pump,u}=z_2+h_L}$$

- Incompressible, $\rho = 1000\ \frac{kg}{m^3}$
- $h_L = 6m$

7. $$h_{pump,u} = \underbrace{85m}_{z_2} - \underbrace{70m}_{z_1} + \underbrace{6m}_{h_L} = \boxed{21m}$$

8. $$\Delta P_{pump} = \rho g h_{pump,u} = 1000\ \frac{kg}{m^3} \cdot 9.81\ m/s^2 \cdot 21m = 206010\ \frac{kg}{m \cdot s^2} = Pa$$

$$\boxed{\Delta P = 206.01\ kPa}$$



$u_\infty = 0.4\ m/s$; $\rho_{air} = 1.2\ kg/m^3$

$D = 4m$, $L = 12m$ $\boxed{\text{Ellipsoid}}$

$Re = 1.05\times10^5$ Laminar!

For sign: $Re_L = 3.16\times10^5$

Drag is independent for each

9. $C_{D,Blimp}$?

Ellipsoid:

$A = \frac{\pi}{4}D^2 = 12.57\ m^2$

$\frac{L}{D} = \frac{12m}{4m} = 3m$ => Tables

$Re = 1.05\times10^5 < 2\times10^5$ so $\boxed{C_D = 0.3}$

10. C_D, blimp

$Re_{x,crit} = 5\times10^5$

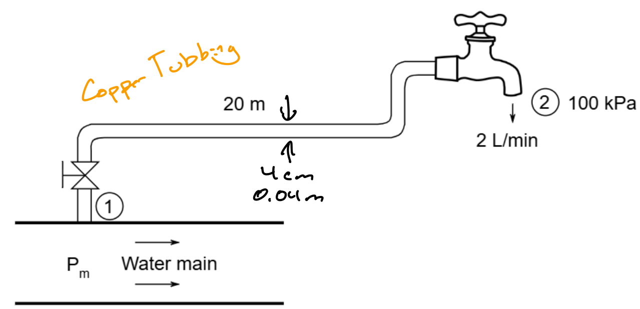
$Re_L = 3.16\times10^5$ => Laminar

$$C_f = \frac{1.33}{\sqrt{Re_L}} = \frac{1.33}{(3.16\times10^5)^{1/2}}$$

$$\boxed{C_f = 0.00237}$$

11. $$F_D = F_{D,blimp} + F_{D,sign}$$
$$= C_D \tfrac{1}{2}\rho u_\infty^2 A_1 + C_f \tfrac{1}{2}\rho u_\infty^2 A_2$$
$$= \tfrac{1}{2}\left(1.2\ \tfrac{kg}{m^3}\right)\left(0.4\ \tfrac{m}{s}\right)^2\left[(0.3\cdot 12.57\ m^2) + (0.00237\cdot 2(12m\times 2m)^2)\right]$$

$$\boxed{F_D = 0.624\ \frac{kg\cdot m}{s^2}}$$



- Valve: $K_L = 1.5$ when fully open
- Faucet: $K_L = 8$ when fully open
  ↳ 2 L/min
- Incoming water at P_m, exits at $P_{atm} = 100\,kPa$
- Elevation diff. btwn faucet & pipe is negligible
- Steady, incompressible, fully dev., entrance/exit negligible

$\rho_{water} = 1000\ kg/m^3$ and $\mu_{water} = 1\times10^{-3}\ \frac{kg}{m\cdot s}$

3 90° smooth threaded bends $\Big\}$ => Tables $K_L = 0.9$

$$P_1 = P_m \qquad P_2 = P_{atm} \qquad z_1 \approx z_2 \qquad h_L = \Sigma h_{L,major} + \Sigma h_{L,minor}$$

12. $$\frac{P_1}{\rho g} + \alpha\frac{V_1^2}{2g} + \cancel{z_1} = \frac{P_2}{\rho g} + \alpha\frac{V_2^2}{2g} + \cancel{z_2} + h_L \qquad h_{L,minor} = K_L \cdot \frac{V_{avg}^2}{2g}$$

$$\boxed{\frac{P_m}{\rho g} + \frac{V_1^2}{2g} = \frac{P_{atm}}{\rho g} + \frac{V_2^2}{2g} + h_{L,piping} + 3K_{L,bend}\frac{V_{avg}^2}{2g}}$$

13. $V_{avg} = \frac{\dot{V}}{A_c}$

$$\dot{V} = 2\frac{L}{min} \times \frac{1\,min}{60\,sec} \times \frac{1\,m^3}{1000\,L} = 3.33\times10^{-5}\ m^3/s$$
$$A_c = \frac{\pi}{4}(D^2) = \frac{\pi}{4}(.04\,m)^2 = 0.00126\ m^2$$
$\Big\}$ $\boxed{V_{Avg} = 0.0265\ m/s}$

14. $$Re = \frac{\rho V_{Avg} L}{\mu} = \frac{1000\ kg/m^3 \cdot 0.0265\ m/s \cdot 0.04\,m}{1\times10^{-3}\ \frac{kg}{m\cdot s}} = 1060 \qquad \boxed{Re = 1060}$$

15.(6) , $Re_{crit} = 1060$ for internal flow, past this, flow is turbulent

15. Copper Tubing => Tables $\varepsilon = 0.0015\ mm$

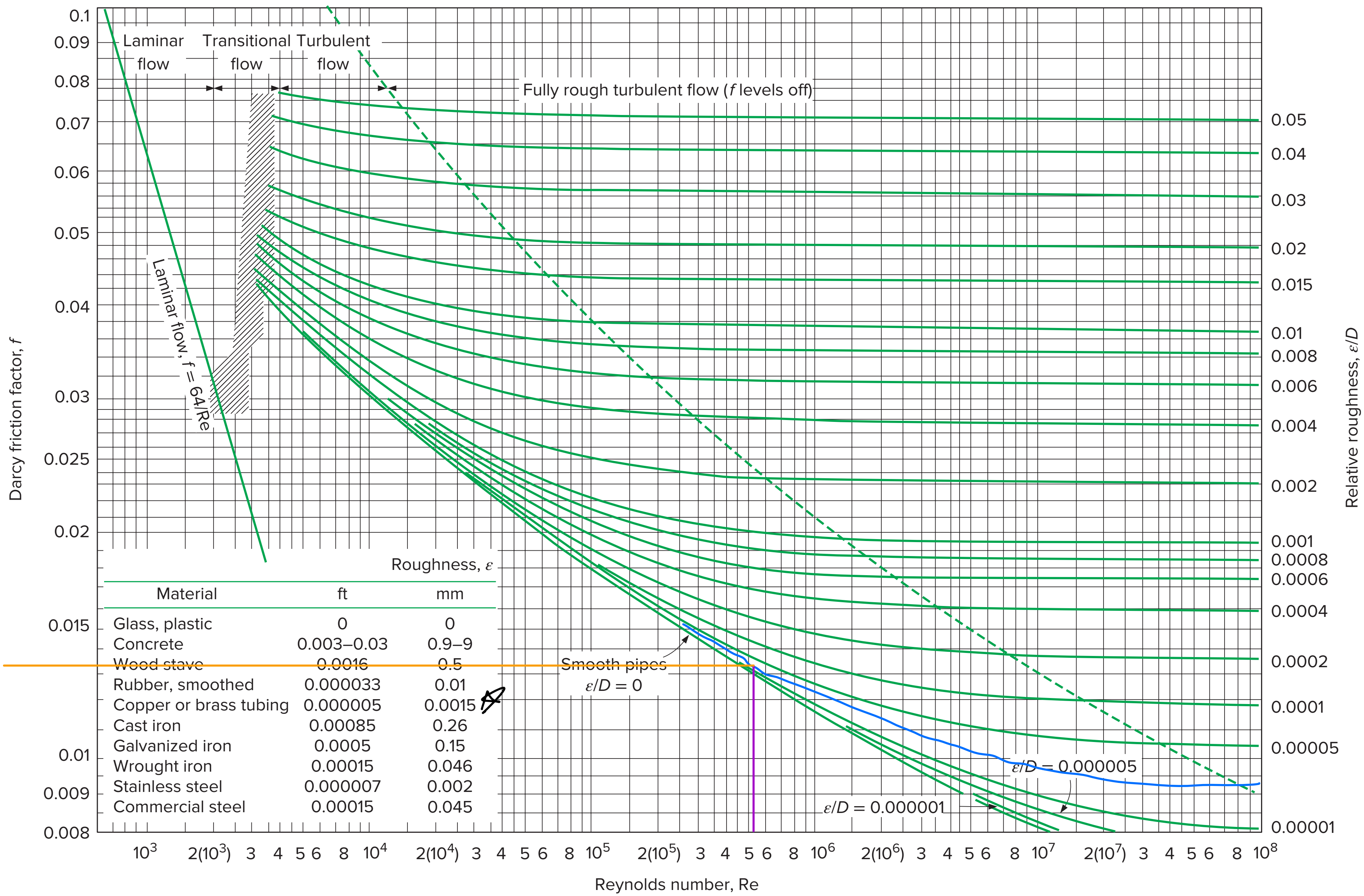
17. $$\frac{\varepsilon}{D} = \frac{0.0015\ mm}{40\,mm} = 3.75\times10^{-5}$$

18. $$f = \frac{64}{1060} = 0.0604$$

19. $$h_f = \frac{f L V_{avg}^2}{D 2g} = \frac{0.0604 \cdot 20 \cdot 0.0265\ m/s}{0.04 \cdot 2 \cdot 9.81\ m/s^2} = 0.00108$$

20. $h_{L,minor} = 3K_L \cdot \frac{v_{avg}^2}{2g} = \boxed{9.66 \times 10^{-5}\ m}$

21. Out of Time!!



	Roughness, ε	
Material	ft	mm
Glass, plastic	0	0
Concrete	0.003–0.03	0.9–9
Wood stave	0.0016	0.5
Rubber, smoothed	0.000033	0.01
Copper or brass tubing	0.000005	0.0015
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Wrought iron	0.00015	0.046
Stainless steel	0.000007	0.002
Commercial steel	0.00015	0.045

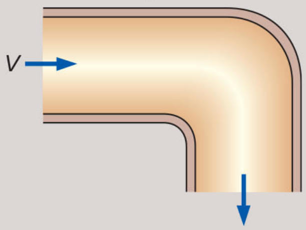
FIGURE A–27

The Moody chart for the friction factor for fully developed flow in circular pipes for use in the head loss relation $\Delta P_L = f\,\dfrac{L}{D}\,\dfrac{\rho V^2}{2}$. Friction factors in the turbulent flow are evaluated from the Colebrook equation $\dfrac{1}{\sqrt{f}} = -2\log_{10}\left(\dfrac{\varepsilon/D}{3.7} + \dfrac{2.51}{\mathrm{Re}\sqrt{f}}\right)$.

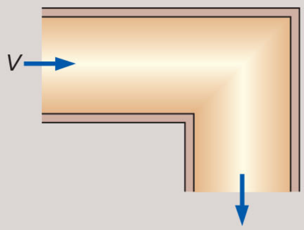
TABLE 14–4 (CONCLUDED)

Bends and Branches

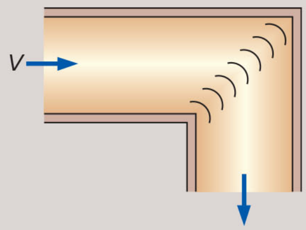
90° smooth bend:
Flanged: $K_L = 0.3$
Threaded: $K_L = 0.9$



90° miter bend
(without vanes): $K_L = 1.1$



90° miter bend
(with vanes): $K_L = 0.2$



45° threaded elbow:
$K_L = 0.4$

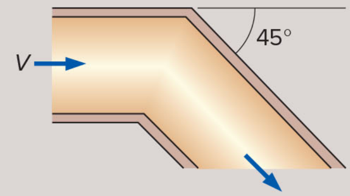
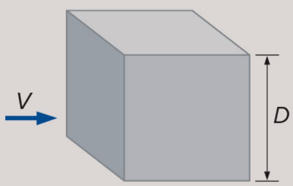


TABLE 15–2

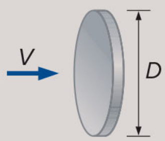
Representative drag coefficients C_D for various three-dimensional bodies based on the frontal area for Re $> 10^4$ unless stated otherwise (for use in the drag force relation $F_D = C_D A \rho V^2/2$ where V is the upstream velocity)

Cube, $A = D^2$



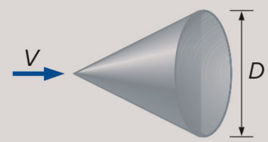
$C_D = 1.05$

Thin circular disk, $A = \pi D^2/4$



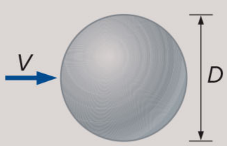
$C_D = 1.1$

Cone (for $\theta = 30°$), $A = \pi D^2/4$



$C_D = 0.5$

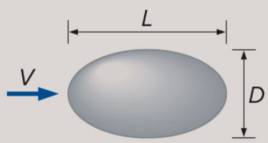
Sphere, $A = \pi D^2/4$



Laminar:
Re $\lesssim 2 \times 10^5$
$C_D = 0.5$
Turbulent:
Re $\gtrsim 2 \times 10^6$
$C_D = 0.2$

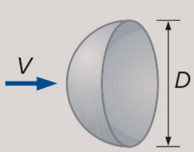
See Fig. 11–36 for C_D vs. Re for smooth and rough spheres.

Ellipsoid, $A = \pi D^2/4$

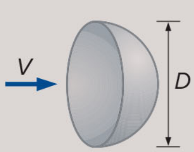


L/D	C_D Laminar Re $\lesssim 2 \times 10^5$	C_D Turbulent Re $\gtrsim 2 \times 10^6$
0.75	0.5	0.2
1	0.5	0.2
2	0.3	0.1
4	0.3	0.1
8	0.2	0.1

Hemisphere, $A = \pi D^2/4$

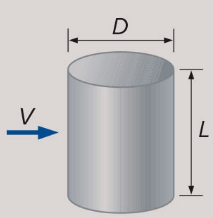


$C_D = 0.4$



$C_D = 1.2$

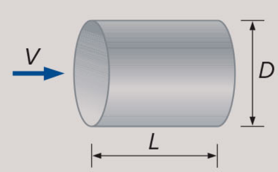
Finite cylinder, vertical, $A = LD$



L/D	C_D
1	0.6
2	0.7
5	0.8
10	0.9
40	1.0
∞	1.2

Values are for laminar flow
(Re $\lesssim 2 \times 10^5$)

Finite cylinder, horizontal, $A = \pi D^2/4$



L/D	C_D
0.5	1.1
1	0.9
2	0.9
4	0.9
8	1.0