MAE101B: Advanced Fluid Mechanics Winter Quarter 2020

http://web.eng.ucsd.edu/~sgls/MAE101B_2020/

Midterm

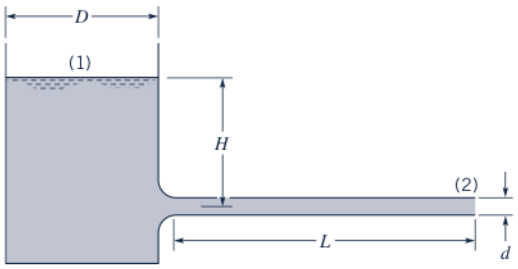
This is a 50 minute open-note exam. Please put your name on the top sheet. Answer all three questions. Explain your working and state any assumptions you have made.

1 (a) (4 points) How fast can you empty a 355 ml can of cola through a 5-mm diameter straw if the flow is to remain laminar? [Take the properties of cola to be the same as those of water.]

(b) (4 points) Using the Blasius results, compute the ratio of the drag forces acting on a flat plate of length 2 m and width 10 cm moving through (a) air at 100 ms^{-1}; (b) water at 10 ms^{-1}. Does the size of the plate matter?

2 (7 points) For a groundwater dome problem (see Barenblatt 2003; § 2.3), use dimensional analysis to construct a relation at time t between non-dimensional groups determined from the groundwater head: H, the initial head in the water stratum outside: H_i, time: t, the initial integral head of the dome: $I = \int_{-l}^{l} H(x,0)\,\mathrm{d}x$, a diffusivity parameter: κ, the initial half-length of the dome: l and position: x. Units: $[H] = ML^{-1}T^{-2}$, $[\kappa] = M^{-1}L^3T$.

3 (10 points) For the standpipe system shown below, calculate the flow rate for $H = 3.0$ ft, $D = 7.12$ in., $d = 0.14$ in., and L = 42 in. Assume steady flow and neglect the energy loss in the entrance nozzle. The pipe is commercial steel.



Useful values and parameters

Units and constants
1 hp $= 550$ lb ft/s. 1 in $= 2.54$ cm. Acceleration of gravity: 9.81 m/s^2

Material properties
Water: $\rho = 998$ and $\mu = 1.003 \times 10^{-3}$ at 20°C; $\gamma = 62.4$ lb/ft^3 and $\nu = 1.052 \times 10^{-5}$ ft^2/s.
Air: $\rho = 1.20$ and $\mu = 1.80 \times 10^{-5}$ at 20°C.

Equivalent roughnesses for new pipes

Pipe	Feet	Millimeters
Riveted steel	0.003–0.03	0.9–9.0
Concrete	0.001–0.01	0.3–3.0
Wood stave	0.0006–0.003	0.18–0.9
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Commercial steel or wrought iron	0.00015	0.045
Drawn tubing	0.000005	0.0015
Plastic, glass	0.0 (smooth)	0.0 (smooth)

Moody chart

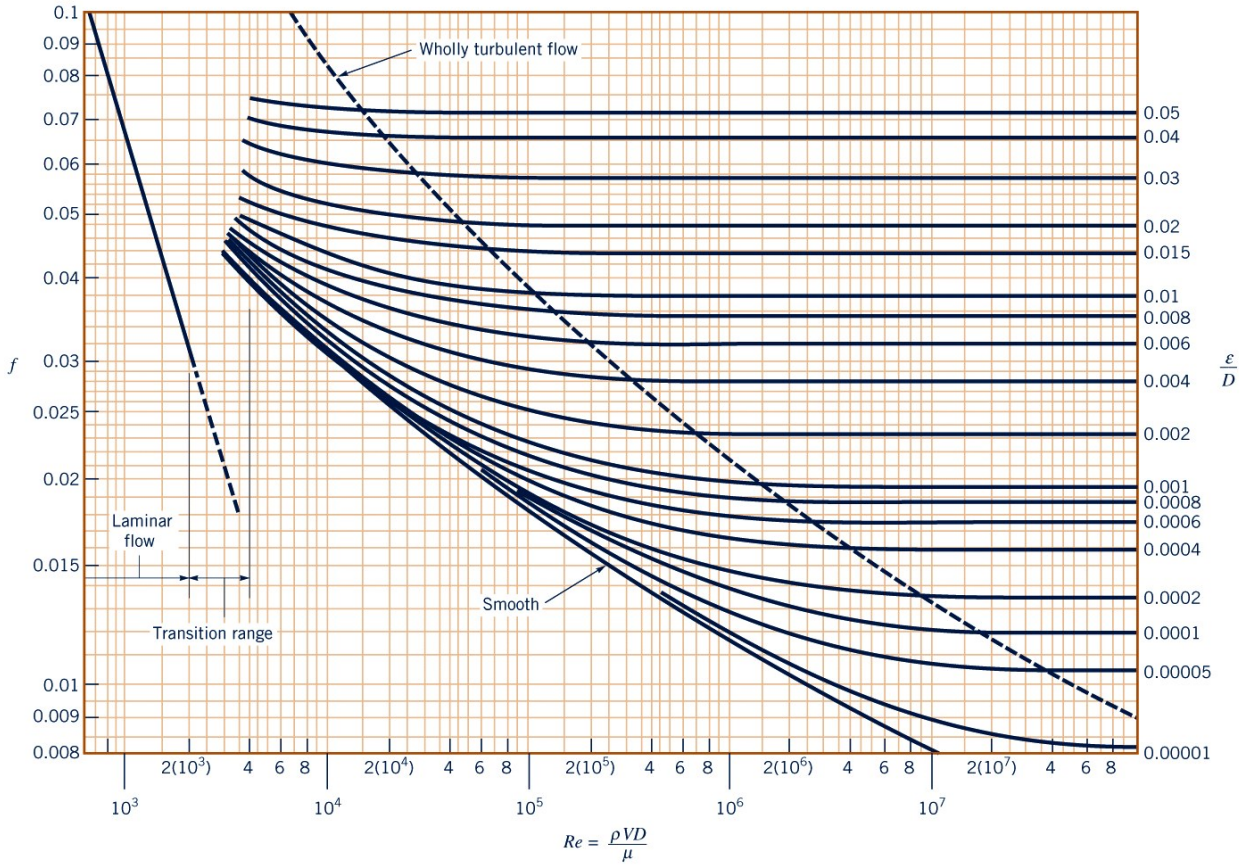


Figure 8.20