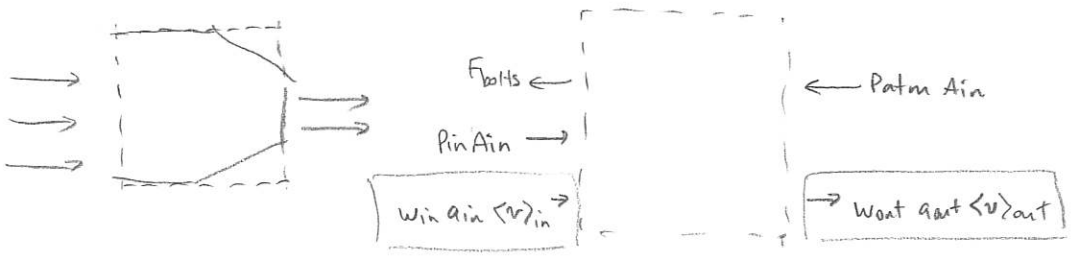
Final Exam Review

* ABET Evaluations ✓
* Student Ratings ✓
* Review Game
* Final thought

1. What assumptions did we make to get the engineering momentum balance from the general integral momentum balance? (Get 3 of 5).

   - discrete inlets & outlets
   - uniform density @ inlets & outlets
   - unidirectional flow @ I/O
   - small viscous stress @ I/O
   - fixed control volume

2. Complete the body force diagram for the momentum balance on the nozzle:



3. What are the steps in the engineering design process?

Analysis

Synthesis

Evaluation

4. Write down Bernoulli's engineering Equation for laminar incompressible flow with no pumps or turbines.

$$\frac{\Delta P}{\rho} + \Delta v^2 + g\,\Delta h = -\frac{Ev}{w}$$

↑ $b = 2$ for laminar

5. What does this term $\int_V \rho \underline{v}\, dV$ in the engineering balance? simplify to.

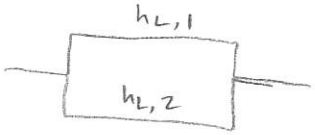
$$\frac{d}{dt}\int_V \rho \underline{v}\, dV = ?$$

$$= \frac{d(m\underline{v})}{dt}$$ accumulation of momentum.

6. The friction factor is part of major or minor losses?

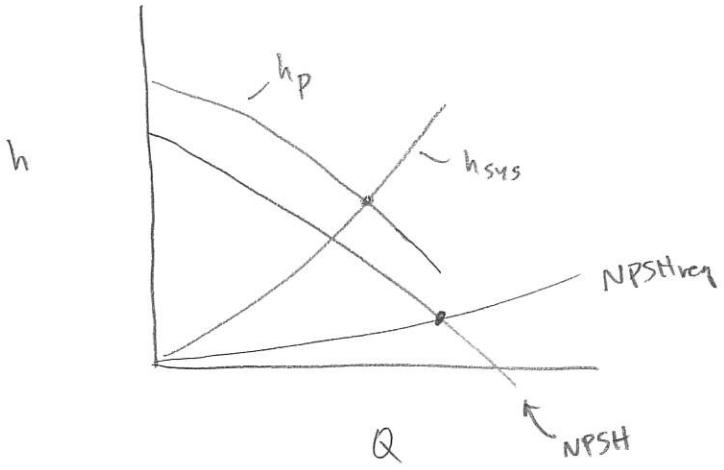
major losses

7. What is the total head loss of the two pipe elements?



$h_{L,tot} = h_{L,1} = h_{L,2}$ ↙ Same in parallel!

8. Will this system cavitate?



No.

9. Suppose $h_p = 5 - 3Q^2$ and $h_{sys} = 1 + \log Q + 2Q^2$.

What method could you use to find the operating point by hand?

Newtons method

$$f(Q) = 5 - 3Q^2 - 1 - \log Q - 2Q^2$$

$$x_n = x_{n-1} - \frac{f(x_n)}{f'(x_n)}$$

10. Suppose you are asked to design a single pipeline & you need to determine the pipe size, will this likely require iteration?

Yes. You need D to know Re.

11. Choked flow occurs in a converging nozzle when the velocity reaches what speed?

$v = c$, speed of sound

or

$Ma = 1$ Mach 1.

12. Name two types of on/off values.

Ball valve, Gate valve, Butterfly valve

13. True or false. The nominal size of a pipe is usually its outer diameter.

False. Tube is usually O.D.
Pipe is not systematic.

14. Give one pro/con of using an obstruction flow meter.

* Gives a pressure drop (con)
* Must be installed in pipe (con)
* No moving parts (Pro)
* Reliable (Pro)

15. Give one example of a positive displacement pump

Heard, bike, peristaltic pump.

16. Where do you get NPSH required?

Pump manufacturer.

17. What is this stress scale?

$\frac{\mu U}{D}$ viscous stress

18. Is this quantity a scalar, vector or tensor?

$\underline{\nabla}\,\underline{v}$

19. True or false. Friction loss in a pipe slows the fluid down.

False. It causes pressure drop / head loss.

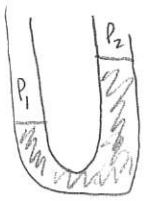
20. write down Newton's law of viscosity

$\tau = \mu \frac{\partial u_x}{\partial y}$ or $\underline{\underline{\tau}} = 2\mu\,\underline{\underline{\Gamma}} = \mu\left(\underline{\nabla}\underline{v} + \underline{\nabla}\underline{v}^T\right)$

21. What is the definition of the drag coefficient?

$$C_D = \frac{F_D / A_\perp}{\frac{1}{2}\rho u^2}$$

22. In the manometer, where is the pressure greater?



$P_1 > P_2$

23. What physical principle does this equation express?

$$\frac{d\rho}{dt} + \nabla \cdot (\rho \underline{v}) = 0$$

continuity equation
conservation of mass

24. What assumptions are needed to get the Navier-Stokes equation from the Cauchy momentum equation?

Incompressible & Newtonian (const ρ, μ)

25. Inviscid flow happens when $Re \ll 1$ or $Re \gg 1$?

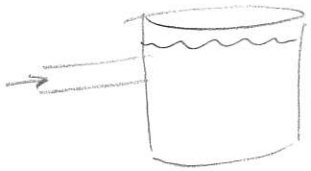
↑
creeping flow.

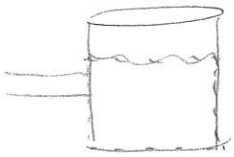
$Re \gg 1$

26. Why do macroscopic balances (integral balances), instead of differential ones?

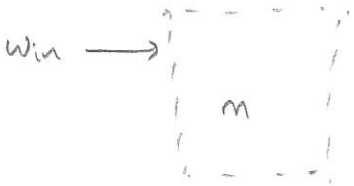
we can get rid of a lot of flow details.

27. what is a good control volume for this tank filling?





28. What is the engineering mass balance for this control volume



$$\frac{dm}{dt} = \dot{m}_{in}$$

29. what is a mass flux?

$\frac{\text{mass}}{\text{area} \cdot \text{time}}$ ↑ like a mass flow rate per area.

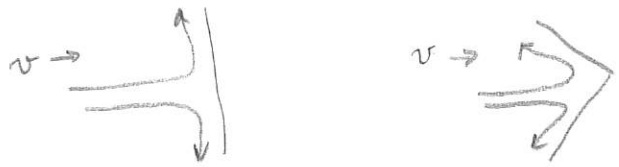
in math: $\underline{w} = \rho \underline{v} \cdot (-\underline{n} S)$

or

$\underline{w} = \rho (\underline{v} - \underline{u}) \cdot (-\underline{n} S)$

30. In which case will the force be greater if the velocity of the stream is the same?

why?



31. when is a viscous stress small at an inlet or outlet?

small	not small
pipe flow	sudden contractions
	" expansions
	fans, pumps, turbines
	turbulent wake

32. what is the engineering momentum balance?

$$\frac{d}{dt}(m\underline{v}) = \sum_{i}^{in} w_i a_i \underline{v}_i - \sum_{i}^{out} w_i a_i \underline{v}_i + \sum \underline{F}_i$$

33. when is the a_i or b_i not one when using a momentum or mechanical energy balance?

laminar flow: $a_i = 4/3$, $b_i = 2$

turbulent → ok, close enough: $a_i = \frac{50}{49}$, $b_i = 1.06$

34. True or false. For subsonic flows, a converging nozzle increases the speed of a fluid.

True. If $Ma < 1$, then it can speed up to $Ma = 1$.

35. Mechanical energy includes which of the following pieces?

- Thermal / internal energy (U)
- Kinetic energy } Those two
- potential energy
- energy from surface tension

36. What assumptions do we need to go from the "Engineering Mechanical Energy Balance" to the "Engineering Bernoulli's Equation"

- steady
- single inlet & outlet

37. What does the term W_m contain in the E.B. EQ?

- shaft work → moving parts like pump / turbine impellers/runners.

38. What does the term E_v contain in the E.B. EQ?

- viscous losses, i.e. major & minor losses.

39. In which step in the engineering design process do we decide whether or not our design meets our goals?

Evaluation (ASE)

40. What is a loss coefficient?

- viscous loss not related to pipe length

$$K_L = \frac{E_v}{\frac{1}{2}\rho u^2}$$

41. What is an entrance length?

The distance down a pipe before the flow profile becomes fully developed.

$\frac{L_E}{D} \approx 200$ for turbulent flow.

42. Do loss coefficients depend on Re?

Tricky: In principle - at low Re, yes. and at high Re - no.

However, most are simply tabulated at high Re.

43. If you are asked to find the flow rate in a single pipeline, will you likely need to iterate?

Yes, $Re = f(Q)$.

44. If you are asked to find the length of a pipeline, are you likely to need to iterate?

No. $Re \neq f(L)$.

45. What is the system demand curve?

$h_{sys} = h_L + \Delta H$ = total head needed for the system.

46. What are the two key principles for serial networks?

$Q_A = Q_B = Q$ ← same flow rates

$h_{L,tot} = h_{L,A} + h_{L,B}$ ← head losses sum

47. What are the two key principles for parallel networks?

$Q_{,tot} = Q_A + Q_B$ ← flow rates sum

$h_L = h_{L,A} + h_{L,B}$ ← same head losses.

48. What does a check valve do?

Prevents back flow

49. Name two ways to measure flow rate?

Bucket fill, Orifice flow meter, PD flow meter, turbine flow meter, Rotameter, ultrasonic/Electromagnetic flow meter.