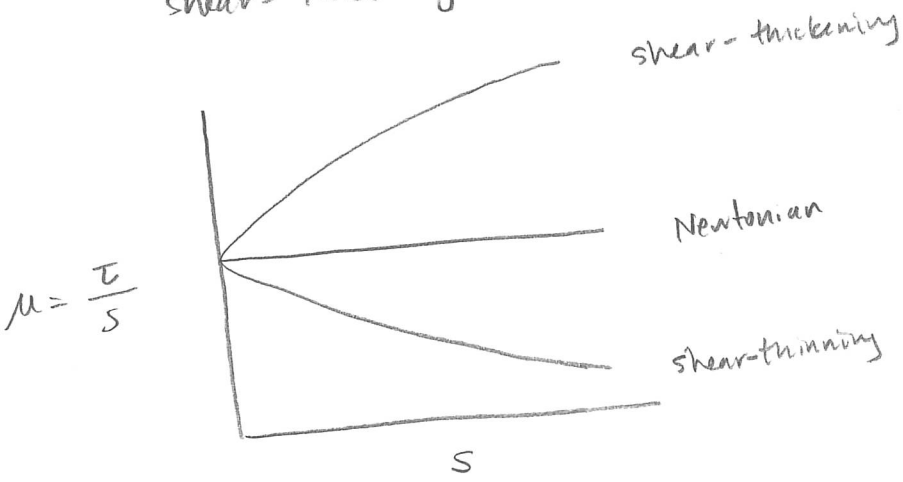
Exam 1 Review

* Go over Review sheet, Equation sheet, Concept Map,
* Go over Exam cover sheet & exam mechanics
* TA reviews, practice problems, etc.
* Take any questions

I. Review Game.

1. which is shear-thinning, Newtonian, and shear-thickening?



2. which stress scale is ρu^2, $\rho g D$?

(inertial) (gravitational)

3. which stress scale is this: $\mu U/D$, γ/D

($\mu U/D$: viscous; γ/D: capillary)

4. The friction factor is a ratio of which stress scales?

$$\frac{\text{wall shear stress}}{\text{inertial stress}}$$

5. If $Re >> 1$, which stress scale is big?

inertial stress

6. In pipe flow, what Reynold's number signals transition from laminar to turbulent flow?

About 2×10^3

7. In external flows, what Re signals transition from a laminar wake to a turbulent wake?

$Re \approx 10^2$

8. In external flow, what Re signals the transition from a laminar BL to a turbulent B.L.?

$Re \approx 3 \times 10^5$

9. What is the friction factor for a smooth pipe at $Re = 10^6$? (use moody chart)

$f = 0.003$

10. what is the friction factor for a pipe with roughness $k/D \approx 10^{-3}$ at $Re = 10^6$?

$f = 0.005$

11. What is the difference between:

$f = \frac{16}{Re}$ & $f = \left[3.6 \log\left(\frac{Re}{6.9}\right)\right]^{-2}$?

when are each valid?

laminar flow ($Re < 2100$)

(turbulent flow, $Re > 2100$)

12. What is the difference between C_D & C_f?

C_D: total drag on a blunt object

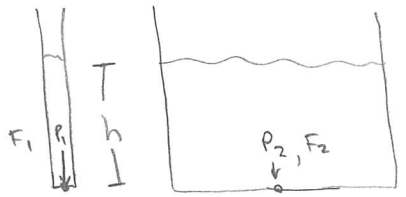
C_f: friction drag on a flat plate.

13. What is the difference between form drag & friction drag?

form = pressure = ΔP object

friction → τ_w on surface

14. In this picture:



is P_1 >, =, < P_2 ?

$P_1 = P_2$

15. Is F_1 >, =, < F_2 ?

16. If my variables are u, L, t, how many independent dimensions do I have?

2

17. How many pi groups do I expect if I have variables u, L, t?

$1, \frac{ut}{L}$

18. What are the 5 steps to making an equation dimensionless?

(i) Find variables & parameters

(ii) Find the number of independent dimensions

(iii) Pick a scale for each dimension

(iv) use scales to define dimensionless variables

(v) Substitute definitions of variables into original Eq. & solve

19. what are the steps to finding Pi groups w/out an equation?

(i) Find vars & params

(ii) Find # of ind. dimensions

(iii) Take ratios of scales (stress, len, time) to get groups.

20. What are the steps to solving an implicit equation?

(i) Put in standard form $f(x)=0$

(ii) make a guess, x_0

(iii) use Newton's method to find x_1

(iv) Iterate until x stops changing.

21. Without looking, what is the formula for Newton's method?

$$x_{n+1} = x_n - f(x_n)/f'(x_n)$$

22. What is similarity? What does it have to do w/ the Reynolds number?

23. If water is flowing at 10 m/s in a 10 cm diameter pipe, how fast must the water go in a 1cm pipe to give identical behavior?

$$Re = \frac{UD}{\nu} \qquad Re = \frac{0.1 \cdot 10}{10^{-6}} = 10^6$$

$$U = \frac{10^{-6} \cdot 10^6 \, m^2/s}{0.01 \, m} = 100 \, m/s$$

$$\boxed{100 \, m/s}$$

24. What are the steps to calculate a pressure drop w/ a height change?

(i) set Re

(ii) $Re \rightarrow f$

(iii) $f \rightarrow \Delta \mathcal{P}$ $\qquad \mathcal{P} = P + \rho g h$

(iv) $\Delta \mathcal{P}$ & $h \rightarrow \Delta P$

25. How do I solve terminal velocity problems?

(i) Body force diagram

(ii) ~~Solve for $Re^2 C_D = f(Ar)$~~ Guess C_D

~~(iii) use Ar to guess C_D equation~~ (iii) solve for u

~~(iv) Solve for Re (confirm C_D eq.)~~ (iv) calculate Re then check if compatible with C_D

~~(v) Solve for u.~~

26. What is $\underline{\nabla}$ = ?

$$\underline{\nabla} = \left(\frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z}\right)$$

27. What is $\underline{a} \cdot \underline{b}$?

$$a_x b_x + a_y b_y + a_z b_z$$

28. Is $\underline{\nabla} \times \underline{v}$ a vector, scalar or tensor?

vector

29. Convert between slugs, lbm & lbf?

$$32.174 \frac{\text{lbm}}{\text{ft s}^2} = 1 \text{ lbf} \qquad \frac{1 \text{ slug ft}}{s^2} = 1 \text{ lbf}$$

30. Viscosity units in English system?

$$\frac{\text{lbf} \cdot s}{ft^2}, \quad \frac{\text{lbm}}{\text{ft} \cdot s}, \quad \frac{\text{slug}}{\text{ft} \cdot s}, \quad \text{psi} \cdot s$$

same!

31. what is the static pressure equation & what does it tell us?

$\nabla P = \rho \underline{g}$, pressure varies with height

32. what is Pascals law?

- Pressure is isotropic, compressive, and a scalar

33. what is the change in pressure due to height in a manometer?

$\Delta P = -\rho g \Delta z$

34. How do you calculate a force on a surface from pressure?

$F = -\underline{n} P A$ ← simple surface
- Constant pressure on surface

$d\underline{F} = -\underline{n} P dS$ ← complex surface
or pressure varies along it.

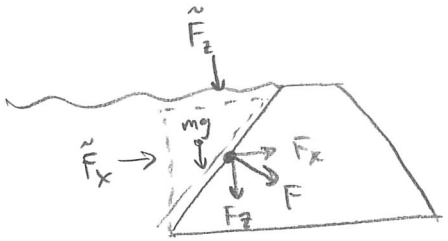
35. what is Archimedes law? How is this different than $F_{gravity}$?

Buoyancy Force = $\rho g V$ (against gravity)
↑ ρ_{liquid}.

$F_g = -\rho g V$
↑ down
↑ ρ_{object}.

36. How do you calculate a force on a complex surface?

- Break it into components:



$$F_z = \tilde{F}_z + mg$$

$$F_x = \tilde{F}_x$$

37. what type of force balance did we use to derive the static pressure equation?

A differential force balance. AKA a shell balance.

38. How can you tell if a flat surface will have a boundary layer?

$Re > 100$ is needed.

39. How can you tell if a B.L. is turbulent?

$Re > 3 \times 10^5$. If L is long enough!

↑ B.L. is always laminar first.

40. what are the primary dimensions in various unit systems that are used in mechanics? length, mass, time

what is a secondary dimension? m, kg, s

↳ e.g. $N = kg\,m/s^2$ ft, lbm, s