5.8) Given:

Sg of oil = .90

submerged volume = 40 in^3

$$\text{Specific gravity} = \frac{\text{specific weight of fluid}}{\text{density of water}} = \frac{\gamma_f}{62.4\ lb/ft^3}$$

$+\downarrow \sum F_z = 0$

$$W - F_b - F_{spring} = 0$$

use Buoyancy formula to get $F_b = \gamma_f V_d$

$$W - \gamma_f V_d - F_{spring} = 0$$

$$- F_{spring} \quad - F_{spring}$$

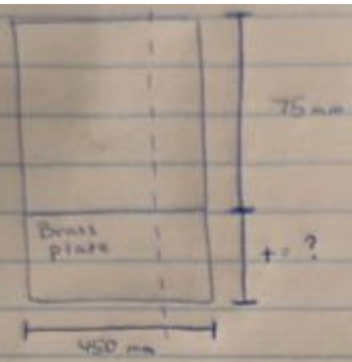
$$W - \gamma_f V_d = F_{spring}$$

fill in values

$$= 14.6 - (.90)(62.4)(40)\left(\frac{1}{1728}\right)$$

$$\boxed{= 13.3\ lb_f}$$

5.24)



Water is at 95°C

450 mm to .45 m

boyant force is equal to the weight of water displaced by cylinder when submerged.

weight of cylinder = 6.46 KN/m^3

weight of water at 95°C = 9.44 KN/m^3

Weight of water displacement = volume of water displaced × γ_w

$$= \left(\frac{750 + t}{1000}\right) \times \frac{\pi}{4} \times (.45)^2 \times 9.44$$

weight of cylinder with brass plate

$$= \frac{750}{1000} \times \frac{\pi}{4} \times (.45)^2 \times 6.46 + \frac{t}{1000} \times \frac{\pi}{4} \times (.45)^2 \times 84$$

$$\left(\frac{750 + t}{1000}\right) \times \cancel{\frac{\pi}{4}} \times \cancel{(.45)^2} \times 9.44 = \frac{750}{1000} \times \cancel{\frac{\pi}{4}} \times \cancel{(.45)^2} \times 6.46 + \frac{t}{1000} \times \cancel{\frac{\pi}{4}} \times \cancel{(.45)^2} \times 84$$

$$\frac{9.44\,(750 + t)}{1000} = \frac{6.46 \times 750}{1000} + \frac{84 \times t}{1000}$$

$$7080 + 9.44t = 4845 + 84t$$

$$(84 - 9.44)t = 7080 - 4845 = 2235$$

$$t = \frac{2235}{74.56} = \boxed{29.97\ mm}$$

5.41

~~1) Locate cb = center of buoyancy~~
~~→ it's located at the center of the displaced volume of water~~

1. Write the equation for the buoyant force $\quad \gamma_{seawater} = 64.00 \text{ lb}/\text{ft}^3$

$$F_b = W = 450{,}000\text{lb} = (\gamma_{fluid})(V_{disp})$$

2. Locate the center of buoyancy
→ located @ center of displaced volume

$$V_{disp} = (450{,}000\cancel{\text{lb}})/(64.00\cancel{\text{lb}}/\text{ft}^3) = 7031.25\text{ft}^3$$

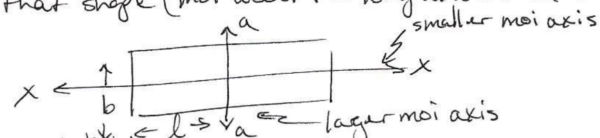
$$V_{disp} = (\text{x-height})(b)(l)$$

$$= (x)(20\text{ft})(50\text{ft}) = 7031.25\text{ft}^3$$

x-height = $\underline{\underline{7.03\text{ft}}}$ from bottom edge of boat to top of water

$\therefore Y_{cb}$ = center of buoyancy from bottom edge $= \frac{x}{2} = \boxed{3.52\text{ ft} = Y_{cb}}$

3. Determine shape of area @ fluid surface (bird's eye view) & compute the smallest moi for that shape (moi about the long axis will be smaller than moi about ~~small~~ axis)



$$I = \frac{b \cdot h^3}{12} = \frac{l \cdot b^3}{12} = \frac{(50)(20)^3}{12} = 33333.3\text{ft}^4$$

4. $MB = I/V_d = \dfrac{33{,}333.3\text{ft}^4}{7031.25\text{ft}^3} = 4.74\text{ft}$ = distance from center of buoyancy to metacenter

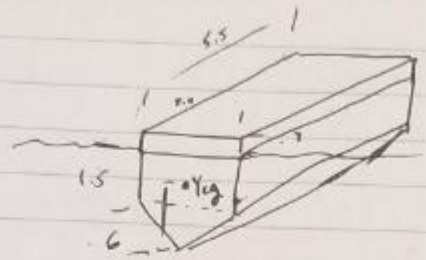
5. $Y_{mc} = MB + Y_{cb}$ = dist from bottom edge to metacenter $= 4.74\text{ft} + 3.52\text{ft}$

$$Y_{mc} = 8.26\text{ft}$$

6. If $Y_{mc} > Y_{cg}$ then stable $\Rightarrow$ $8.26\text{ft} > 8.00\text{ft}$ $\therefore$ stable (but barely...)

If $Y_{mc} < Y_{cg}$ then unstable

5.61



boat $w = 2.4m$

boat $h = 1.8$

boat $L = 5.5m$

water displaced height = 1.5m.

$A_t = A_R + A_\Delta$

$= (1.2 \times 2.4) + (\frac{1}{2} \times 2.4 \times .6)$

$A_{total} = 3.6\ m^2$

$$y = \frac{A_1 y_1 + A_2 y_2}{A_{total}}$$

$A_{submerge} = (.9 \times 2.4)(\frac{1}{2} \times 2.4 \times .6$

$A_{sub} = 2.88\ m^2$

$$y = \frac{\left(\frac{1}{2} \times 2.4 \times .06\right) \times \frac{2(.6)}{3} + \left((1.2 \times 2.4) \times \left(.6 + \frac{1.2}{2}\right)\right)}{3.6}$$

$$\boxed{y_{cg} = 1.04m}$$

$$y_{cb} = \frac{A_1 y_1 + A_2 * y_2}{A_{tot\ sub}}$$

$$y = \frac{\left(\left(\frac{1}{2} \times 2.4 \times .6\right) \times \left(\frac{2(.6)}{3}\right)\right) + \left((.9 \times 2.4) \times \left(.6 + \frac{.9}{2}\right)\right)}{2.88}$$

$$\boxed{y_{cb} = .8875m}$$

$V_{disp} = A_{sub} \times B$

$= 2.88 \times 5.5$

$$\boxed{V_d = 15.84m}$$

$$I = \frac{BH^3}{12}$$

$$I = \frac{55 \times 2.4^3}{12} \qquad I = 6.336\ m^4$$

$MB = 6.336 / 15.84$

$MB = .4m$ = center of Boyancy

$y_{mc} = y_{cb} + MB$

$y_{mc} = .8875 + .4$

$y_{mc} = 1.2875\ m$

$$\boxed{y_{cg} = 1.04\ m \qquad y_{mc} = 1.2875\ m}$$

Boat is stable because the $y_{mc} > y_{cg}$

17.11)

Covert rpm to m/s

$$\frac{1\,rev}{min} = \frac{2\pi L}{60}\ m/s$$

$$v = \frac{20\,(2\pi L)}{60} \qquad L = .075m$$

$$= \frac{20\,(2 \times \pi \times .075)}{60} = .157\ m/s$$

Area of the sphere $A = \left[\frac{\pi(.025)^2}{4}\right]$

$$A = \left[\frac{\pi D^2}{4}\right] \qquad = .00049\ m^2$$

Reynolds number table $v = .000016\ m^2/s$

$$R_e = \frac{PvD}{\eta} = \frac{(.157)(.025)}{.000016} = 245.3$$

or

$$\frac{vD}{v}$$

calculate drag force coefficent = 1.35

density of air at 30°C = $e = 1.164\ kg/m^2$

$$F_d = c_D\,(ev^2/2)A = \frac{(1.35)(1.164)(.157)^2(.00004908)}{2}$$

$$= .0000095\ N$$

Torque produced

$$T = 4F_D r = (4)(.0000095)(.075)\ \boxed{.00000285\ N\ per\ m}$$

gasoline at 20°C density of gasoline at 20°C = $680\ kg/m^3$

$$F_d = C_D\,(ev^2/2)A = \frac{(1.35)(680)(.157)^2(.0004908)}{2}$$

$$= .0056N$$

Torque Produced

$$T = 4F_d r = (4)(.0056)(.075) = \boxed{.0017\ N\ per\ m}$$

Problem 17.14) A wing on a race car is supported by two cylindrical rods. Compute the drag force exerted on the car due to these rods when the car is moving through still air at -20°F at a speed of 150 mph.

Rods: dia: 2" = 0.167 ft
L: 32" = 2.67 ft
2× Rods

Car: 150 mph

Air: -20°F;
$\rho = 2.8 \times 10^{-3}\ \frac{slugs}{ft^3}$ (tables)
$\nu = 1.17 \times 10^{-4}\ \frac{ft^2}{s}$

$$F_D = C_D \left(\frac{\rho v^2}{2}\right) \times A$$

- Area, $A = DL$
$A = (0.167\ ft) \times (2 \times 2.67\ ft)$
$A = 0.89\ ft^2$

- Velocity, $v = 150$ mph
$150\ \frac{mi}{hr} \times \frac{5280\ ft}{1\ mi} \times \frac{1\ hr}{3600\ s} = 220$
$v = 220\ \frac{ft}{s}$

- Find N_R (cylindrical)

$$N_R = \frac{vD}{\nu} = \frac{(220)(0.167)}{(1.17 \times 10^{-4})} = 314017 = 3.14 \times 10^5 \quad \left[\frac{\frac{ft}{s} \cdot ft}{\frac{ft^2}{s}}\right]$$

$N_R = 3.14 \times 10^5$

↳ From Fig 17.4 "Drag Coefficients for spheres and cylinders)

↳ $C_D = 0.9$

- Compute Drag Force

$$F_D = C_D \left(\frac{\rho v^2}{2}\right) A$$

$$= (0.9)\left(\frac{(2.8 \times 10^{-3})(220)^2}{2}\right)(0.89) \quad \left[\left(\frac{\frac{slugs}{ft^3} \cdot \frac{ft^2}{s^2}}{2}\right) \times (ft^2)\right]$$

$$\underline{F_D = 54.4\ lb} \quad \left[\frac{slug \cdot ft}{s^2} = 1\ lb\right]$$

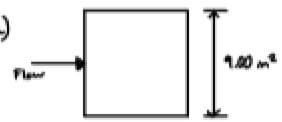
Problem 17.16) The four designs for the cross section of an emergency flasher lighting system for police vehicles are being evaluated. Each has a length of 60 in and a width of 9.00 in. Compare the drag force exerted on each proposed design when the vehicle moves at 100 mph through still air at -20°F.

Constants: • $v = 100 \frac{mi}{hr} \times \frac{5280\,ft}{1\,mi} \times \frac{1\,hr}{3600\,s}$ • Air @ -20°F: $\rho = 2.80 \times 10^{-3}\ \frac{slugs}{ft^3}$

$v = 146.67\ \frac{ft}{s}$ $\nu = 1.17 \times 10^{-4}\ \frac{ft^2}{s}$

Area = $3.75\ ft^2$ (projected area)

a)



• For C_D, Table 17.1 provides C_D of square cylinder with "Flow is perpendicular to the flat front face."

$C_D = 1.60$

$A = 60 \times 9 = 540\ in^2$

$540\ in^2 \times \frac{1\,ft}{12\,in^2} = 3.75\ ft^2$

• $F_D = C_D\left(\frac{\rho v^2}{2}\right)A$

$= (1.60)\left(\frac{(2.80\times10^{-3})(146.67)^2}{2}\right)(3.75)$ $\left[\frac{slugs}{ft^3} \times \frac{ft^2}{s^2} \times ft^2 = \frac{slugs \cdot ft}{s^2}\right]$

$\underline{F_D = 180.7\ lb}$

b)

• $N_R = \frac{vD}{\nu} = \frac{(146.67)(0.75\ (\sin(45°))}{(1.17\times10^{-4})}$

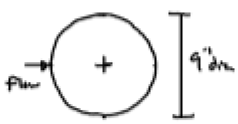
$N_R = 6.6 \times 10^5$

↳ $C_D = 2$

• $F_D = 2\left(\frac{(2.80\times10^{-3})(146.67)^2}{2}\right)(3.75)$

$\underline{F_D = 225.8\ lb}$

c)



• $N_R = \frac{vD}{\nu} = \frac{(146.67)(0.75)}{(1.17\times10^{-4})}$ $\left[\frac{\frac{ft}{s} \cdot ft}{ft^2/s}\right]$

$N_R = 9.4 \times 10^5$

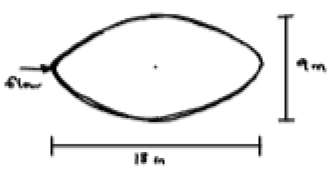
↳ $C_D = 0.5$

• $F_D = C_D\left(\frac{\rho v^2}{2}\right)A$

$= (0.50)\left(\frac{(2.80\times10^{-3})(146.67)^2}{2}\right)(0.75)$

$\underline{F_D = 56.4\ lb}$

d)



• $N_R = \frac{vL}{\nu} = \frac{(146.67)(1.5)}{(1.17\times10^{-4})}$ $\left[\frac{\frac{ft}{s} \cdot ft}{\frac{ft^2}{s}}\right]$

• $N_R = 1.88 \times 10^6$

↳ $C_D = 0.08$

• $F_D = C_D\left(\frac{\rho v^2}{2}\right)A$

$= (0.08)\left(\frac{(2.80\times10^{-3})(146.67)^2}{2}\right)(3.75)$

$\underline{F_D = 9\ lb}$

#17.26 | A small, fast boat has a specific resistance ratio of 0.06 (see Table 17.2) and displaces 125 long tons. Compute the total ship resistance and the power required to overcome drag when it is moving @ 50 ft/s in seawater @ 77°F.

→ 1 longton = 2240 lb

→ specific resistance ratio = R_{st}/Δ = ~~spec~~ total ship resistance / longtons → lbs conversion (displacement of the ship)

$$0.06 = R_{st} \Big/ \frac{125\,LT}{} \Big| \frac{2240\,lb}{1\,LT} =$$

(a) ⇒ $\boxed{R_{st} = 16{,}800\ lb}$

→ P_E = power required to overcome drag = $R_{st} \cdot v$ = (total ship resistance)(velocity)

(b) ⇒ $P_E = 16{,}800\,lb \cdot 50\,ft/s = 840{,}000\,lb \cdot ft/s$

17.20 Airfoil chord length = 1.4 M = c
span = 6.8 m = b
speed = v = 200 km/h

$V = 200 \times 1000 \times \frac{1}{3600} \quad V = 55.55 \ m/s$

$\alpha = 10°$

$C_D = \frac{F_d/A}{\frac{1}{2}\rho V^2}$

$F_d = C_D (\rho v^2/2) A$

$F_L = C_L (\rho v^2/2) A$

$C_L = \frac{F_L/A}{\frac{1}{2}\rho V^2}$

$A = cb = 1.4m \times 6.8m \quad A = 9.52 m^2$

$C_D = .05$ ~~[illegible]~~

$C_L = .9$ ~~[illegible]~~

$h = 200 \ m \quad \rho = 1.202$ @200m $\quad F_D = \frac{(.05)\times(1.202)\times(55.55)^2 \times(9.52)}{2}$

$\boxed{F_D = 882.77 \ N}$ @ 200m

$F_L = (.9)(1.202)\times(55.55)^2\times(9.52)$

$\boxed{F_L = 15889.9 N}$ @ 200 m

$h = 10{,}000 \quad \rho = .4135 \ kg/m^3$

$\boxed{F_D = 303.683 \ N}$ @ 10,000 m

used calculator

$\boxed{F_L = 5.466 \ kN}$ @ 10,000 m