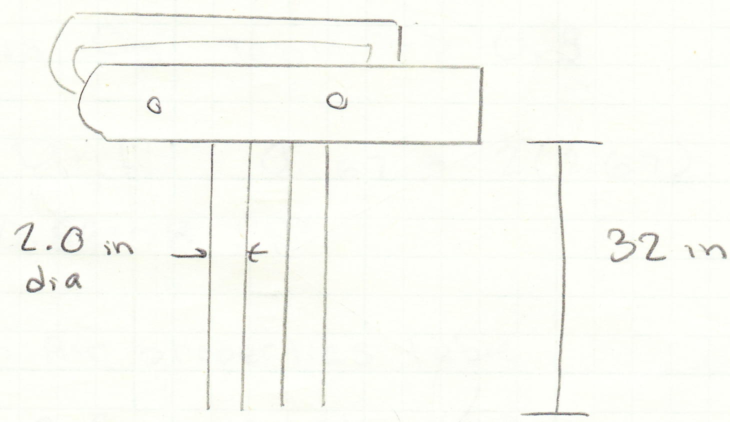
17-14 Compute drag force due to rods



- Still air @ - 20° F
- spd = 150 mph

$L = 2.67$ ft

$D = 0.167$ ft

$T = -20°$ F

$V = 150 \frac{mi}{hr} \times \frac{5280 \text{ ft}}{1 \text{ mi}} \times \frac{1 \text{ hr}}{3600 \text{ sec}}$

$V = 220$ ft/s

Drag force : $F_D = C_D A \frac{1}{2} \rho V^2$

Reynolds number for smooth spheres + cylinders

$$N_R = \frac{\rho V D}{\eta} = \frac{VD}{\nu}$$

From Appendix E

air @ - 20°F → $\nu = 1.17 \times 10^{-4}$ ft²/s

$$N_R = \frac{VD}{\nu} = \frac{(220)(0.167)}{1.17 \times 10^{-4}} = 314017$$

N_R vs C_D Table => 0.8

$A = D \times L = 0.167 \times 2(2.67)$

$A = 0.89178 \text{ ft}^2$

From Air properties table

$\rho = 2.8 \times 10^{-3}$ slugs/ft^3

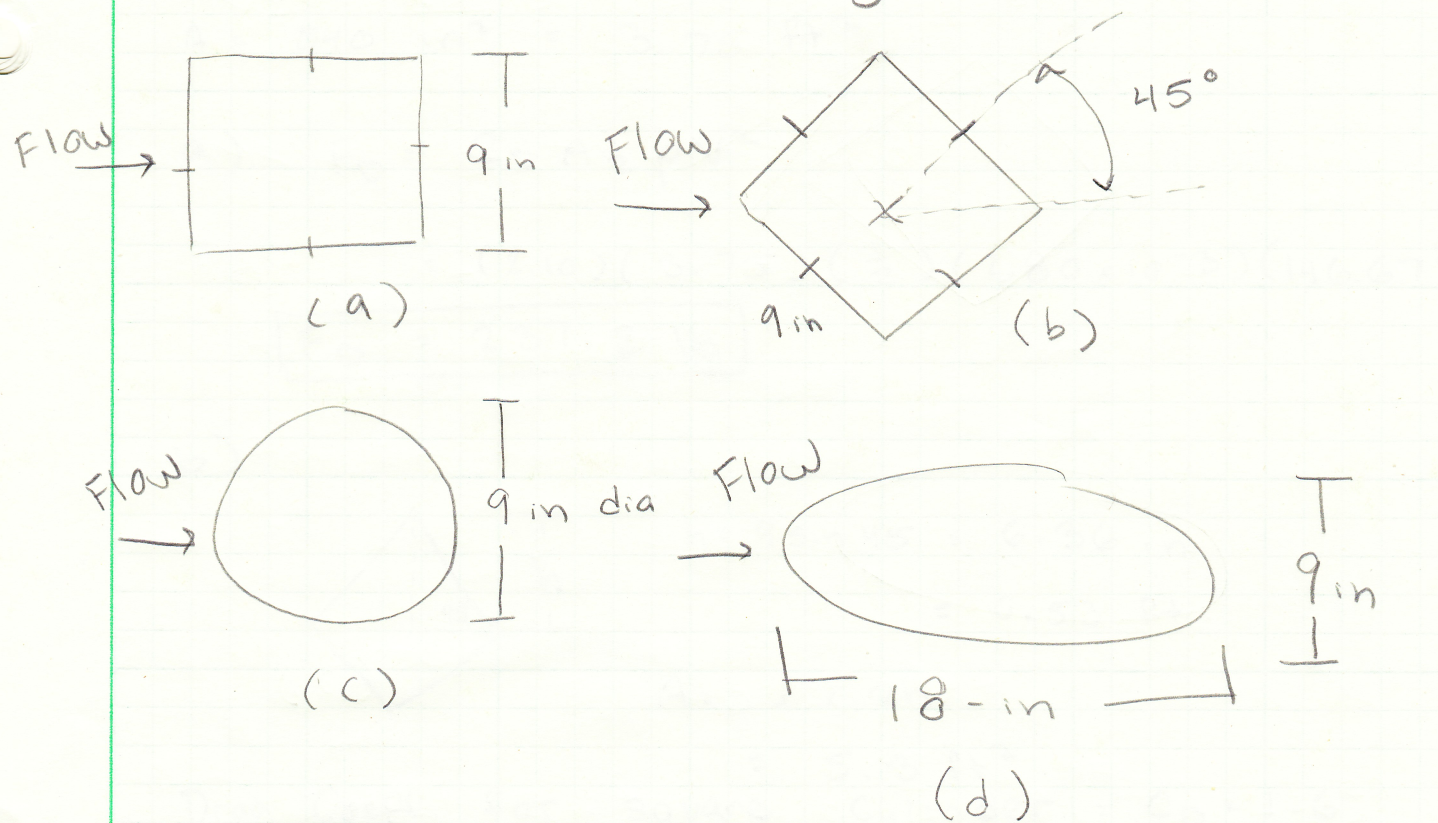
Drag Force

$$F_D = C_D A \tfrac{1}{2} \rho V^2$$

$$F_D = (0.8)(0.89178)\tfrac{1}{2}(2.8 \times 10^{-3})(220^2)$$

$$\boxed{F_D = 48.3 \text{ lb}}$$

17-16 Compare drag force



Each lengh = 60 in   100 mph = 146.67 ft/s

width = 9.0 in   − 20 °F

$b = 9 \text{ in} = 0.75 \text{ ft}$ $\rho = 2.80 \times 10^{-3}$ slugs/ft^3

$\ell = 60 \text{ in} = 5 \text{ ft}$ $\nu = 1.17 \times 10^{-4}$ ft^2/s

Stream flow Reynolds number

$$N_R = \frac{Vb}{\nu} \rightarrow \frac{(146.67)(0.75)}{1.17 \times 10^{-4}}$$

$$\rightarrow 9.4 \times 10^5$$

$$\rightarrow C_D \quad 2.10$$

All C_D => From N_R vs C_D Chart

$A = bl = 60 \times 9$

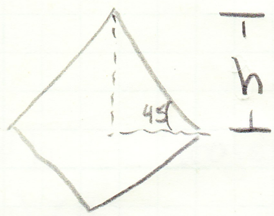
$A = 540 \text{ in}^2 = 3.75 \text{ ft}^2$

a) $F_D = C_D A \frac{1}{2} \rho V^2$

$= (2.10)(3.75)(\frac{1}{2})(2.80 \times 10^{-3})(146.67^2)$

$$\boxed{F_D = 237.2 \text{ lb}}$$

b)



$h = 9 \sin 45 = 6.36 \text{ in}$

$= 0.53 \text{ ft}$

$A = l \times 2h$

$= 5.3 \text{ ft}^2$

Drag Coeff. for square cylinder $= C_D = 1.6$

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

$= (1.6)(5.3) \frac{1}{2} (2.8 \times 10^{-3})(146.67^2)$

$$\boxed{F_D = 225.5 \text{ lb}}$$

c) Projected area $= bl \rightarrow 60 \times 9$

$= 540 = 3.75 \text{ ft}^2$

Reynolds number

$N_R = \frac{VL}{\nu} = \frac{(146.67)(0.75)}{1.17 \times 10^{-4}}$

$= 940192$

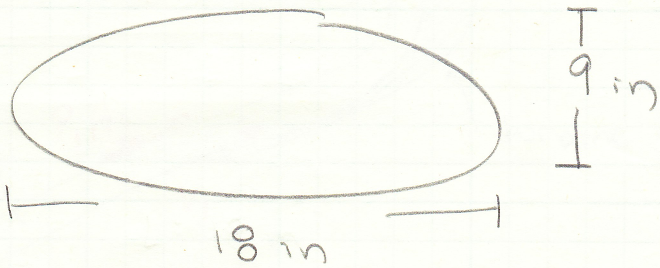
$C_D = 0.3$

$$F_D = C_D A \tfrac{1}{2} \rho V^2$$

$$= 0.3(3.75)\,\tfrac{1}{2}(2.8\times10^{-3})(146.67^2)$$

$$\boxed{F_D = 33.9 \text{ lb}}$$

d)



$= 0.75$ ft

$= 1.5$ ft

$A = lb$ Projected Area

$(60)(9) = 540 \text{ in}^2 = 3.75 \text{ ft}^2$

Reynold's number

$$N_R = \frac{VL}{\nu} = \frac{(146.67\ \frac{ft}{s})(1.5\ ft)}{(1.17\times10^{-4})\ \frac{ft^2}{s}}$$

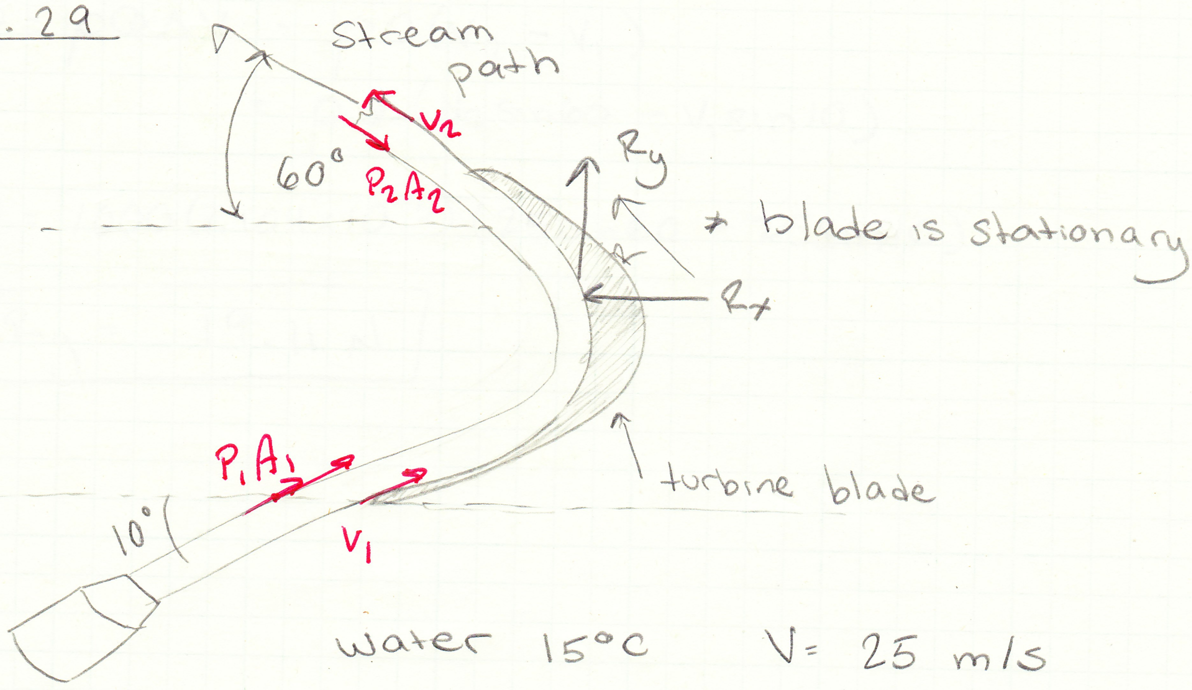
$N_R = 1.88\times10^6 \qquad C_D = 0.27$

$$F_D = (0.27)(3.75)\tfrac{1}{2}(2.8\times10^{-3})(146.67^2)$$

$$\boxed{F_D = 30.5 \text{ lb}}$$

HW 2.2

16.29



water 15°C V = 25 m/s

7.50 mm dia. = 0.0075 m

Compute force on blade

$$\Sigma x = \rho Q \Delta V = \rho Q (V_2 - V_1)$$

$$\rho Q[(V_2 \cos 60) + (V_1 \cos 10)]$$

ρ_w @ 15°C = 1000

$Q = AV$

$$A = \frac{\pi d^2}{4} = \frac{\pi\, 0.0075^2}{4} = 0.000044\ m^2$$

$$Q = (4.4 \times 10^{-5})(25) = 0.001104$$

$$\Sigma x = 1000(1.104 \times 10^{-3})(25\cos 60 + 25 \cos 10)$$

$$\boxed{R_x = 40.98\ N}$$

1

$$\Sigma Y = \rho Q \Delta V = \rho Q (V_2 - V_1)$$
$$= \rho Q (V_2 \sin 60 - V_1 \sin 10)$$

$$\Sigma Y = 1000(1.104 \times 10^{-3})(25 \sin 60 - 25 \sin 10)$$

$$\boxed{R_y = 19.11 \text{ N}}$$