PART A —

(1)

X	0	0	0	0	X
0	X	0	0	0	0
0	0	X	X	0	0
0	0	X	X	0	0
0	0	0	0	0	0
X	0	0	0	0	X

(3)

-X	0	0	0	0	-X
0	-X	0	0	0	-X
0	0	-X	+X	+X	0
0	0	+X	-X	0	0
0	0	+X	0	-X	0
-X	-X	0	0	0	-X

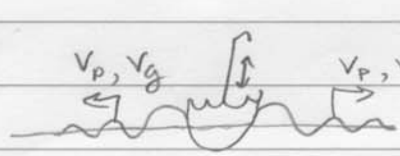
(2) $\underline{\underline{\omega_s}} = 16.75 \text{ rad/s}$, $(f_s = 2.67 \text{ Hz})$

$$\omega_s = \omega_n = \sqrt{\frac{k}{M + M_a}}$$ lock in —

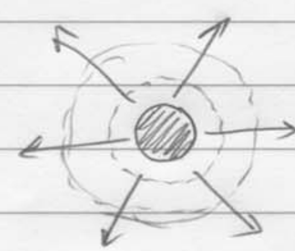
(4)

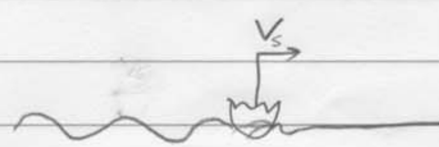
$Re = 20$ $Re = 120$ $Re = 5 \times 10^5$

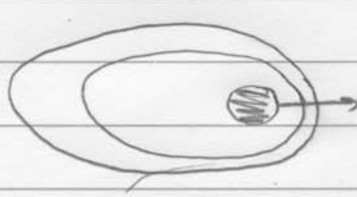
(5)



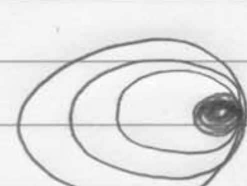
SIDE







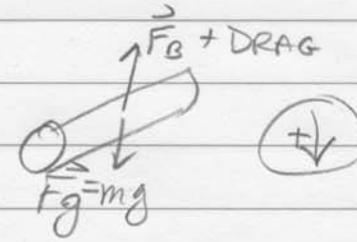
$V < V_g$



$V > V_g$

there is always some form of bow wave...

PART B–



(1) a) Terminal Velocity

$F_{DRAG} = \frac{1}{2}\rho U^2 C_D A$

$F_B = \rho_w g \forall$ $\quad\quad A = dL$

$F_g = 1.5\rho_w g \forall$ $\quad\quad \forall = \frac{\pi d^2}{4} L$

@ Terminal Vel $\Sigma F = ma = 0$

$$\Sigma F = \vec{F_g} - \vec{F_B} - \vec{F_D} = 0$$

$$\vec{F_D} = \vec{F_g} - \vec{F_B} = \frac{1}{2}\rho_w g \forall = 157N$$

$$u^2\left(\cancel{\tfrac{1}{2}}\cancel{\rho_w} C_D \cancel{d}\cdot \cancel{L}\right) = \cancel{\tfrac{1}{2}}\cancel{\rho_w} g\, \frac{\pi d^{\cancel{2}}}{4} \cancel{L}$$

$$u = \sqrt{\frac{\pi g d}{4 C_D}} = \sqrt{1.57/C_D}$$

laminar $C_D = 1.2$ $\quad u = 1.14\ m/s$ $\quad Re = 228{,}000$

turb $\quad C_D = 0.6$ $\quad u = 1.62\ m/s$ $\quad Re = 324{,}000$

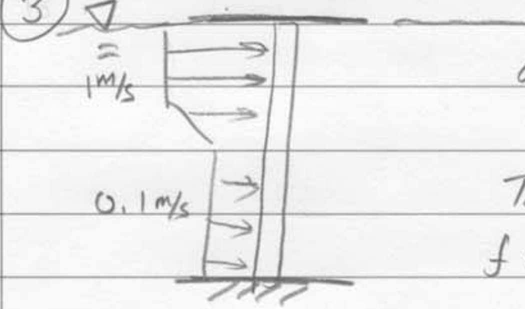
wow! v. close could be either so it ultimately depends on cylinder roughness – either answer gets credit–

b) @ $u = 1.14\ m/s$ $\quad f = 1.14\ hz$; $\quad f = \frac{S u}{d} = \frac{0.2}{0.2} u$

$u = 1.62\ m/s$ $\quad f = 1.62\ hz$

PART B

③



assume $S = 0.2 = \frac{fd}{u}$

Top

$f = \frac{0.2 \cdot 1.0}{0.5}$

$f_{top} = 0.4\ Hz$

bottom

$f_{bot} = 0.1 * f_{top}$

$f_{bot} = 0.04\ Hz$

b) frequency of drag is 2·freq of vortex shedding

freq. of lift is = freq of vortex shedding

therefore it directly correlates w/ flow velocity.

c) The structure will tend to vibrate more at top exciting forced motion @ bottom. In Both cases frequency is Low so it's not going to be too violent.
Shear will complicate shedding & make flow more 3 dimensional

d) Flexible cylinder

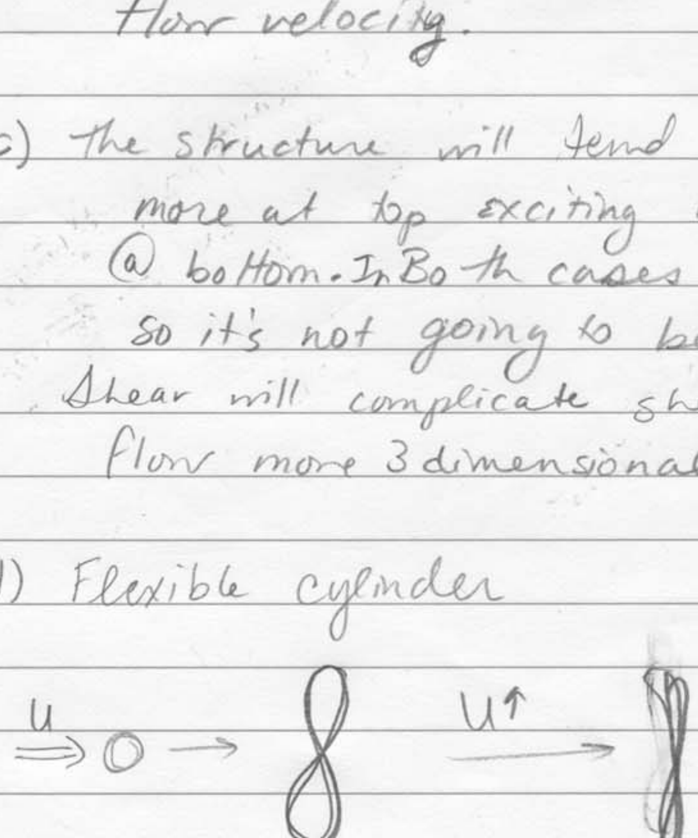


figure "8" motion

higher vel, Tension ↑ and inline vibe ↓