A pipe is 50 cm in ∅ & carries water @ a rate of 0.5 m³/sec. $Z_2 = 40\,m$ $Z_1 = 30\,m$ $p_1 = 70\,kPa$

What power in kW & horsepower must be supplier to the flow by the pump if $p_2 = 350\,kPa$.

Assume: $h_L = 3\,m$ $\alpha_1 = \alpha_2 = 1$ $h_t = 0$ (no turbine)

Pt. 1	Pt 2
$V_1 = \frac{0.5\,m^3/sec}{\pi\,(0.25\,m)^2} = 2.55\,m/sec$	$V_2 = 2.55\,m/sec$
$p_1 = 70\,kPa$	$p_2 = 350\,kPa$
$Z_1 = 30\,m$	$Z_2 = 40\,m$
$h_p = ?$	$h_t = 0$
	$h_L = 3\,m$

Energy Equation

$$\frac{V_1^2}{2g} + \frac{p_1}{\gamma} + Z_1 + h_p = \frac{V_2^2}{2g} + \frac{p_2}{\gamma} + Z_2 + h_L$$

$$h_p = \overset{0}{\cancel{\left(\frac{V_2^2 - V_1^2}{2g}\right)}} + \left(\frac{p_2 - p_1}{\gamma}\right) + (z_2 - z_1) + h_L$$

$$h_p = 280\,kPa \left| \frac{m^3}{9810\,N} \right. + 10\,m + 3\,m$$

$$h_p = \underbrace{28.5\,m}_{\text{increase in pressure}} + \underbrace{10\,m}_{\text{water to a higher elev.}} + \underbrace{3\,m}_{\text{head loss}} = 41.5\,m$$

(in terms of head)

Calc. h_p in terms of kWatts

$$P = \overset{h_p}{(42\,m)}\overset{\gamma_1}{\left(\frac{9810\,N}{m^3}\right)}\overset{Q}{\left(\frac{0.5\,m^3}{sec}\right)} = 206K\ \frac{N\cdot m}{sec} = \underline{206\ kWatts}$$

$$\boxed{P = 206\ kWatts}$$

Calculate h_p in terms of horsepower

$$P = \frac{206K\ watts}{} \Bigg| \frac{hp}{746\ watts} = 276\ HP$$

$$\boxed{P = 276\ HP}$$

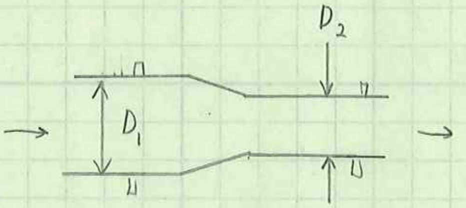
Forces on Transitions

Ex 7-6

Contraction

$Q = 0.707\ m^3/sec$

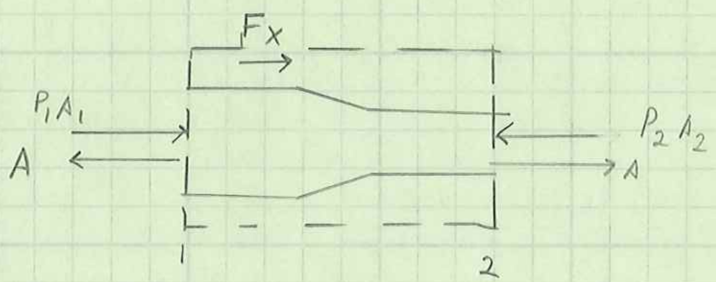
$$h_L = \frac{0.1\ V_2^2}{2g} \text{ (given)}$$



$D_1 = 30\text{-}cm$
$D_2 = 20\text{-}cm$

$p_1 = 250\ kPa$

What horizontal force is required to hold the transition in place?



Determine velocities

$$V_1 = \frac{Q}{A_1} = \frac{0.707\ m^3/sec}{\pi\ (0.15m)^2} = 10.0\ m/sec \qquad A_1 = 0.0707\ m^2$$

$$V_2 = \frac{Q}{A_2} = \frac{0.707\ m^3/sec}{\pi\ (0.10\ m)^2} = 22.5\ m/sec \qquad A_2 = 0.0314\ m^2.$$

Solve for head loss due to contraction

$$h_L = \frac{0.1\ V_2^2}{2g} = \frac{(0.1)\ (22.5\ m/sec)^2}{(2)(9.81\ m/sec^2)}$$

$h_L = 2.58\ m$

Use Energy equation to solve for p_2

$$\frac{V_1^2}{2g} + \frac{p_1}{\gamma} + \cancelto{0}{z_1} = \frac{V_2^2}{2g} + \frac{p_2}{\gamma} + \cancelto{0}{z_2} + h_L$$

$$\frac{P_1 - P_2}{\gamma} = \frac{V_2^2 - V_1^2}{2g} + h_L$$

$$\frac{P_1 - P_2}{\gamma} = \frac{22.5^2 - 10.0^2}{(2)(9.81)} + 2.58\ \text{m}$$

$$\frac{P_1 - P_2}{\gamma} = 23.3$$

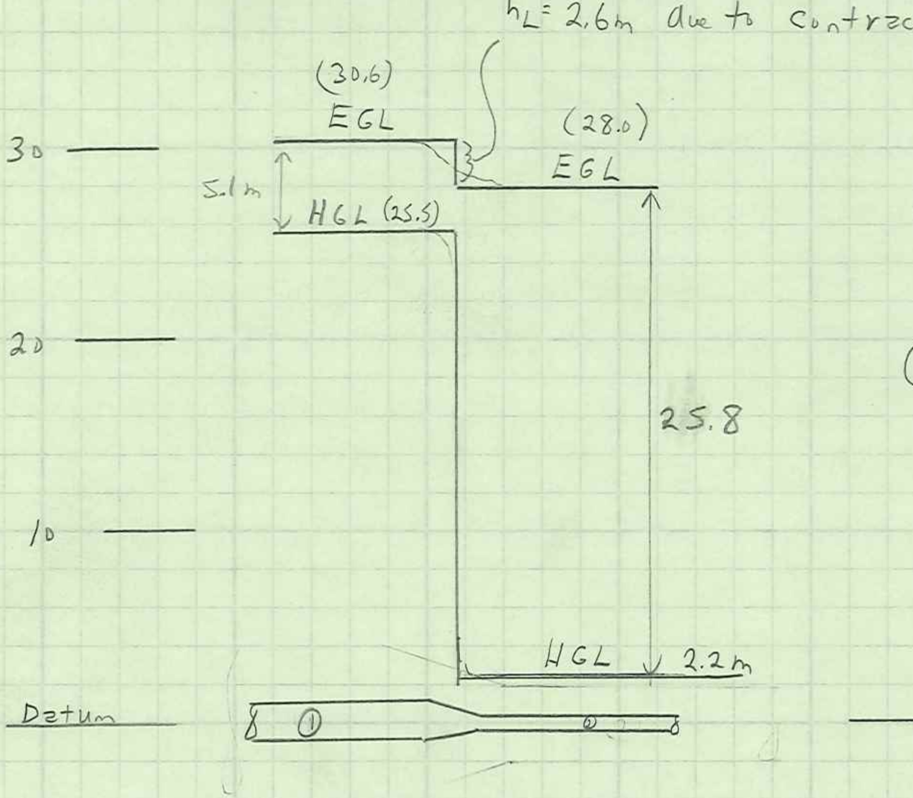
$$P_1 - P_2 = (9810\ \text{N/m}^3)(23.3\ \text{m})$$

$$P_2 = P_1 - (9810)(23.3)$$

$$P_2 = 250\ \text{kPa} - 228\ \text{kPa}$$

$$P_2 = 22\ \text{kPa}$$

EGL/HGL 7-6



Notes:

① EGL would normally be sloped due to pipe friction

② EGL/HGL are curves in vicinity of contraction; but represented as straight lines in practice

Datum

$$\frac{V_1^2}{2g} = \frac{10^2}{(2)(9.81)} = 5.1m$$

$$\frac{P_1}{\gamma} = \frac{250\,kP}{9810\,N/m} = 25.5$$

$$EGL @ 1 = 30.6$$

$V_1 = 10\ m/sec$

$P_1 = 250\ kPa$

$Z_1 = Z_2 = \text{datum}$

$h_L = 2.6m$ (due to contraction)

↑ difference is due to head loss

$V_2 = 22.5\ m/sec$

$P_2 = 22\ kPa$

$$\frac{V_2^2}{2g} = \frac{(22.5)^2}{(2)(9.81)} = 25.8\ m$$

$$\frac{P_2}{\gamma} = \frac{22{,}000\ PA}{9810\ N/m} = 2.2\ m$$

$$EGL @ 2 = 28.0\,m$$

A pump draws water from a reservoir, where the WSE = 520 ft, and forces the water through a pipe 5000 ft long & 1 ft in Ø.

The pipe then discharges the water into a reservoir w/ WSE = 620 ft. The flow rate is 7.85 cfs & the head loss in the pipe is $0.01(L/D)(V^2/2g)$

Determine the head supplied by the pump h_p & the power supplied to the flow.

Draw the HGL & EGL for the system. Assume the pipe is horizontal & is 510 ft in elevation.

Energy Equation

$$\underbrace{\cancel{\frac{p_1}{\gamma}}}_{0} + \underbrace{\cancel{\frac{V_1^2}{2g}}}_{0} + z_1 + h_p = \underbrace{\cancel{\frac{p_2}{\gamma}}}_{0} + \underbrace{\cancel{\frac{V_2^2}{2g}}}_{0} + z_2 + h_L$$

$$h_L = (0.01)\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$$

$$\text{vel} = \left(\frac{7.85\ ft^3}{sec}\right)\left(\frac{1}{\pi(0.5m)^2}\right) = 10.0\ ft/sec$$

$$h_L = (0.01)\left(\frac{5000\ ft}{1\ ft}\right)\left(\frac{(10\ ft/sec)^2}{(2)(32.2\ ft/sec^2)}\right)$$

↑ [illegible] γ?

$$h_L = 77.6\ ft$$

$$h_p = z_2 - z_1 + h_L$$

$$h_p = \overbrace{620 - 520}^{\text{elev. diff}} + \overbrace{77.6}^{\text{head loss}}$$

$$\boxed{h_p = 177.6\ ft}$$

head supplied by the pump

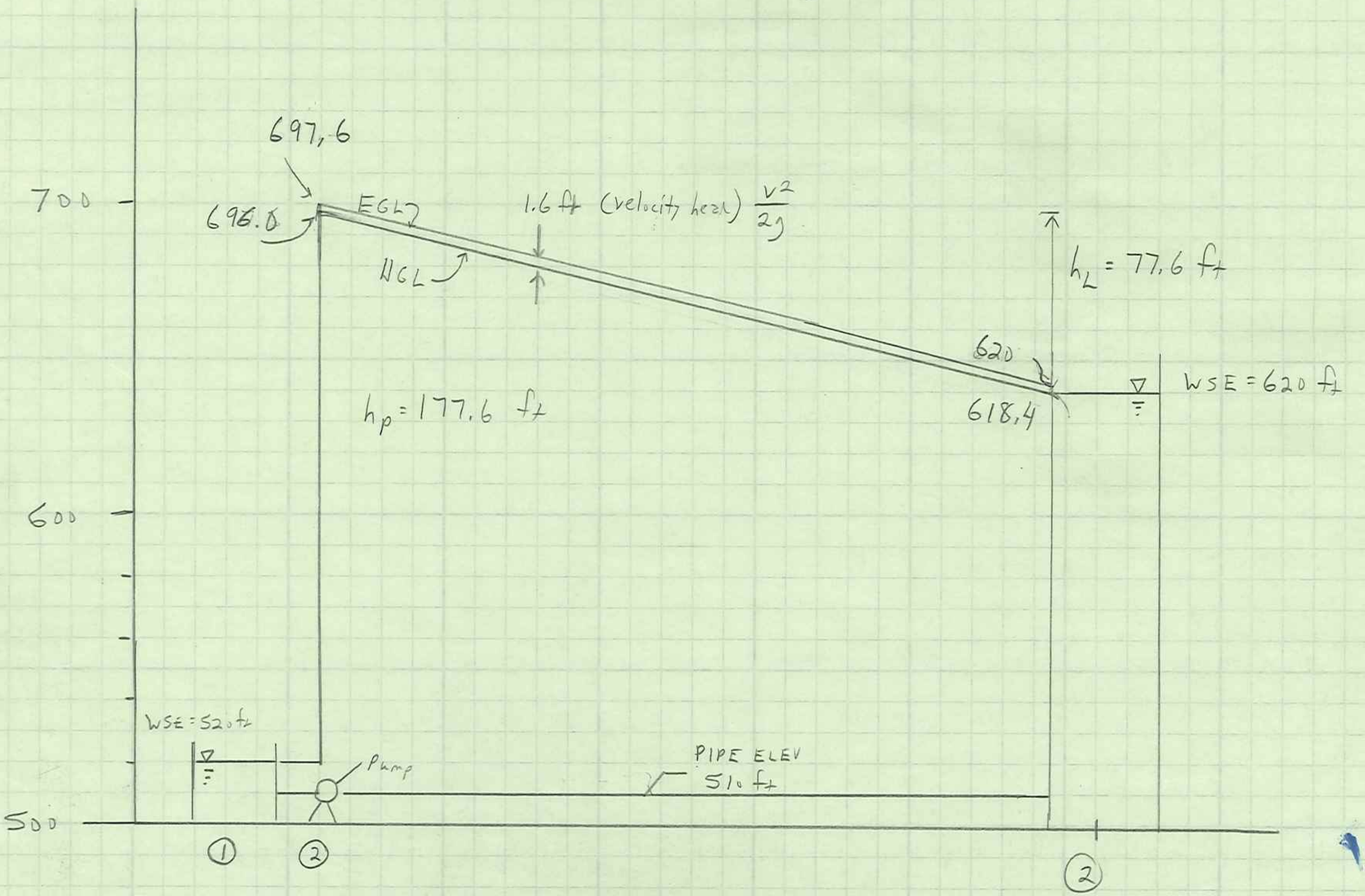
$$\text{Power Supplied by the pump} = (h_p)Q\gamma = (177.6\ ft)\left(\frac{7.85\ ft^3}{sec}\right)\left(\frac{62.4\ lbf}{ft^3}\right)\left(\frac{hp}{550\ \frac{ft \cdot lb}{sec}}\right)$$

$$\boxed{\text{Power} = 158\ hp}$$

7.7

2/2

velocity head $= \frac{v^2}{2g} = \frac{(10\ fps)^2}{(2)(32.2\ fps^2)} = 1.6$ ft



520
177.6 (PUMP)
697.6 EGL
−1.6
696.0 HGL