Adam Chase | Test 2 | MET330

Purpose: Design a Lazy river. The width must fit at least two Lazy river tubes. The depth should be safe enough for a 3 year old to stand.

The slope is 0.1%. Determine the water flow rate required.

What would the drag force be on a 5 year old (assume cylinder)

Determine how deep in the water the tube will go with a 250 lbs person on it. Is it stable with the person on it

Sources: Mott & Untener. Applied Fluid Mechanics 7th Edition. Pearson. 2015

Design considerations:

1. Assume kid to be a cylinder.
2. Float finish concrete $n = 0.015$
3. Rectangular Channel
4. Tube assumed to be hollow short cylinder.

Data & Variables:

$Q = \left(\frac{1.00}{n}\right) A R^{2/3} S^{1/2}$

$S = 0.1\% = 0.001$

$n = 0.015$

$D = 60\,cm = 0.60\,m$

$W = 288\,cm = 2.88\,m$

$A = 1.728\,m^2$

$R =$

5 year old waist Diameter = 18cm

Avg 3 year old height = 36"

Safe water depth = 60 cm

diameter of 5 year old =

$N_R = \frac{VR}{V}$ $\quad R = \frac{A}{WP}$

$A = WD$ $\quad WP = W + 2D$

Tube Data

OD = 96cm $\quad$ mass = 1.9 kg

ID = 35cm

~~R = 15.45cm~~

h = 30.50 cm

Procedure: 1. After determining the depth and width of the channel. We can calculate R, A, and Q

$A = WD \quad R = \frac{A}{WP} \quad WP = W + 2D$

Calculate the normal discharge - SI

$Q = \left(\frac{1.00}{n}\right) A R^{2/3} S^{1/2}$

Manning's # $n = 0.015$ for float finished concrete.

2. Use measurements for 5 year old assume smooth cylinder.

Find Drag Force

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

From Chart
$T = 30°C$
$\rho = 996 \ kg/m^3$
$v = 8.03 \times 10^{-7} \ m^2/s$

$N_R = \frac{vR}{v}$ use to look up C_D → From C_D Chart

3. Find depth with 25016 weight, is it stable?

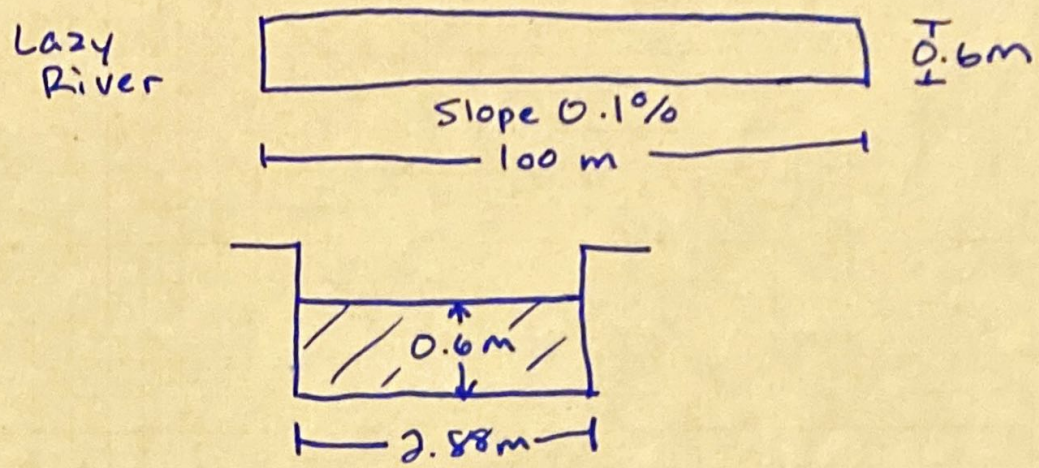
depth of submersion

$x = \frac{4W}{\pi D^2 \gamma_{water}} \quad V_d = \pi r^2 x \quad I = \frac{\pi D^4}{64}$

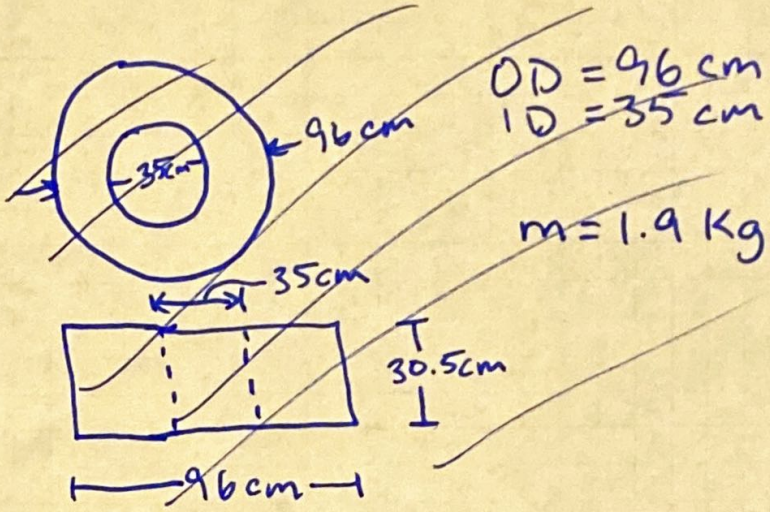
Find MB $Y_{mc} = Y_{cb} + MB$

$Y_{cb} = x/2 \quad MB = \frac{I}{V_d}$

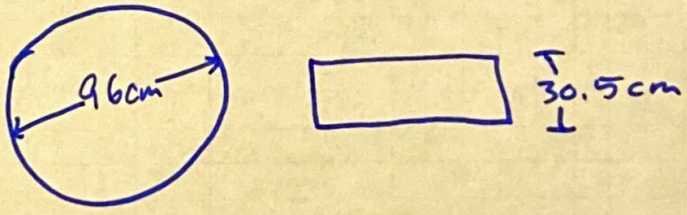
Drawings: Straight Lazy river. Rectangular channel



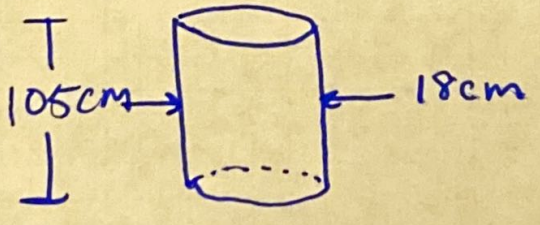
Tube



Assume hollow short cylinder



5 year old



Calculations: $A = WD = (2.88m)(0.6m)$

$A = 1.728 m^2$

$WP = W + 2D = (2.88m) + 2(0.6m)$

$WP = 4.08m$

$R = \frac{A}{WP} = \frac{1.728m^2}{4.08m} = 0.4235m$

$Q = \left(\frac{1.00}{n}\right) A R^{2/3} S^{1/2}$

$Q = \left(\frac{1.00}{0.015}\right)(1.728m^2)\left(\frac{1.728m^2}{4.08m}\right)^{2/3}(0.001)^{1/2}$

$Q = 2.05 m^3/s$

1. Water flow rate $\boxed{Q = 2.05 m^3/s}$

2. Drag force on Five year old

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

$F_D = 1.25\left(\frac{(996 kg/m^3)(1.186 m/s)^2}{2}\right)(1.728m^2)$

$\boxed{F_D = 1513.05 N}$

C_D

$N_R = \frac{vR}{v}$

$N_R = \frac{(1.186 m/s)(0.4235m)}{8.03 \times 10^{-7} m^2/s}$

$N_R = 6.25 \times 10^5$

C_D From Chart

$C_D = 1.25$

3. $x = \frac{4(1.131 kN)}{\pi(0.96m)^2(9.77 kN/m^3)}$

$x = 16cm$

tube (cylinder)

$W = 1.131 kN$

$I = \frac{\pi D^4}{64} = \frac{\pi(0.305)^4}{64} = 0.000425 m^4$

$V_d = \pi(15.25)^2(16) = 11.69 cm$

$MB = \frac{0.000425}{0.1169} = 0.036m = 3.6cm$

$y_{cb} = x/2 = 8cm$

$y_{mc} = y_{cb} + MB = 8cm + 3.6cm$

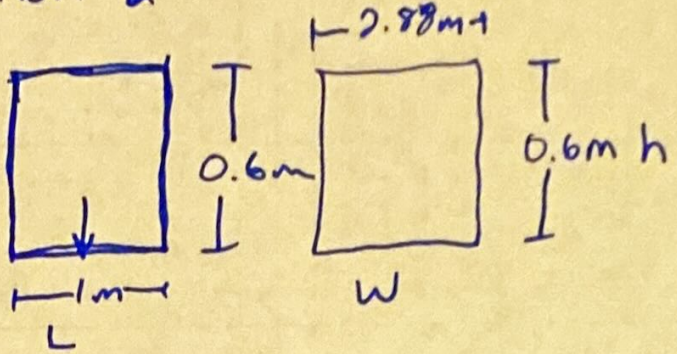
$= 11.6cm$

$Cg = 16cm \quad y_{mc} = 11.6cm$

tube is unstable be center of gravity is above the metacenter height.

Calculations:

4. Force magnitude in a 1-m length section



Floor Force

$A = LW$

$A = (1m)(2.88m) = 2.88\ m^2$

$\Delta p = \gamma h$

$\Delta p = (9.81 \frac{KN}{m^3})(0.6m)$

$= 5.886$ KPa

$F = pA$

$= (5.886\ KPa)(2.88m^2)$

$F = 16.95\ KN$

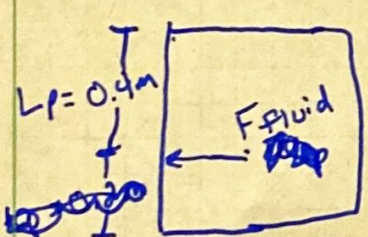
Wall Force

$F_{fluid} = \gamma h_c A \qquad A = (1m)(0.6m)$

$h_c = \frac{0.6}{2} = 0.3m$

$F_{fluid} = (9.81 \frac{KN}{m^3})(0.3m)(0.6m)$

$F_{fluid} = 1.766\ KN$



Summary: A lazy river 2.88m wide and 0.6m deep at a 0.1% slope will give a water flow rate of $Q = 2.05 m^3/s$. A 5 year old will feel a drag force of 1513 N The inner tube with a 250lb person would not be stable due to the metacenter being below the center of gravity.
The Force Magnitude on the floor of the 1m section is 16.95 KN
The Force on the wall is 1.766 KN at a height of 0.2m.

Analysis: The design of the Lazy River was similar to the average speed for most lazy rivers at 1.186 m/s
The tube dimentions was unstable with the weight added.