Name: ____.

MET 330 Fluid Mechanics
Dr. Orlando Ayala
Spring 2024
Test 2

Take home – Due Friday March 15th 2024 before midnight.

READ FIRST

1. RELAX!!!! DO NOT OVERTHINK THE PROBLEMS!!!! There is nothing hidden. The test was designed for you to pass and get the maximum number of points, while learning at the same time. HINT: THINK BEFORE TRYING TO USE/FIND EQUATIONS (OR EVEN FIND SIMILAR PROBLEMS)

2. The total points on this test are one hundred (100). Ten (10) points are from your HW assignments, and ten (10) other points are based on the basis of technical writing. The other eighty (80) points will come from the problem solutions. For the technical writing I will follow the attached rubric.

3. There is a total of seven questions distributed in two different problem. Each question is worth 80/7 of the total grade.

4. What you turn in should be only your own work. You cannot discuss the exam with anyone, except me. Call me, skype me, text me, email me, come to my office, if you have any question.

5. I do not read minds. You should be explicit and organized in your answers. Use drawings/figures. If you make a mistake, do not erase it. Rather use that opportunity to explain why you think it is a mistake and show the way to correct the problem.

6. You have to turn in your test ON TIME and ONLY through CANVAS. You must submit only one file and it has to be a pdf file. For the ePortfolio (which is optional) you are supposed to upload this artifact to your Google drive. I will provide more instructions later.

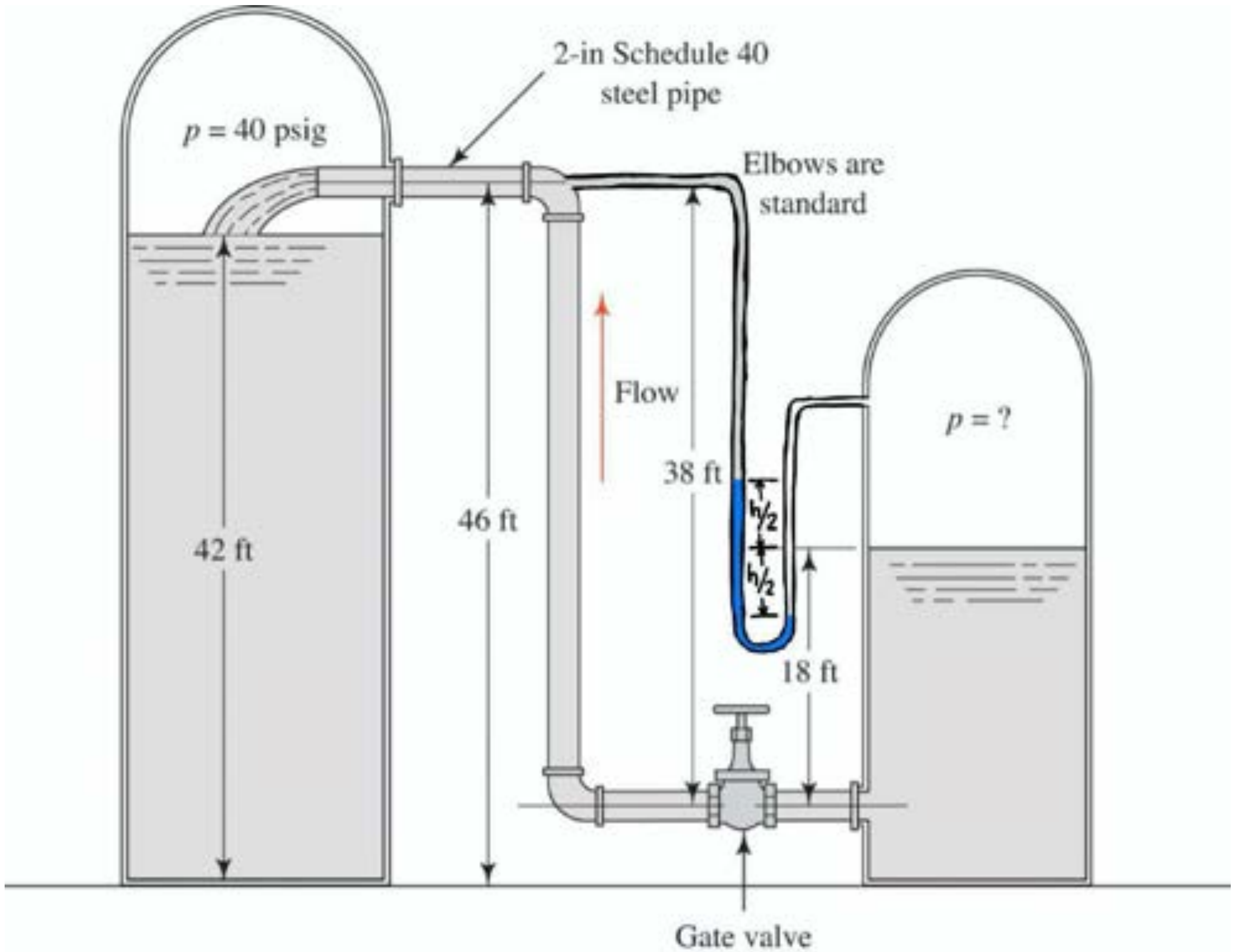
7. Do not start at the last minute so you can handle anything that could happen. Late tests will not be accepted. Test submitted through email will not be accepted either.

8. Cheating is completely wrong. The ODU Student Honor Pledge reads: "I pledge to support the honor system of Old Dominion University. I will refrain from any form of academic dishonesty or deception, such as cheating or plagiarism." By attending Old Dominion University, you have accepted the responsibility to abide by this code. This is an institutional policy approved by the Board of Visitors. It is important to remind you the following part of the Honor Code:

    IX. PROHIBITED CONDUCT
    A. Academic Integrity violations, including:
    1. *Cheating*: Using unauthorized assistance, materials, study aids, or other information in any academic exercise (Examples of cheating include, but are not limited to, the following: using unapproved resources or assistance to complete an assignment, paper, project, quiz or exam; collaborating in violation of a faculty member's instructions; and submitting the same, or substantially the same, paper to more than one course for academic credit without first obtaining the approval of faculty).

With that said, you are NOT authorized to use any online source of any type, unless is ODU related.

A. The system shown below is used to transport ethyl alcohol from one tank to the other. The temperature is 77 F. The length of pipe for each of the horizontal sections is 36 ft. The manometric fluid is mercury. Pressurized air controls the pressure in the tanks.



1. What is the force magnitude and location on a blind flange to be installed on the opposite side of the pipeline inlet in the tank on the right? The blind flange is 2 inches in diameter. The flow of ethyl alcohol is 150 gpm.

2. The pipe needs to be supported. Your civil engineer colleague requires to know the relevant forces for the support design. Calculate the total horizontal and vertical forces in the whole pipe-elbows-valve system (from tank to tank). Note: you need the pressure at the inlet of the pipeline and at outlet of the pipeline for this task.

3. It is proposed to use a flow nozzle to measure the flow. For a nozzle diameter to pipe diameter ratio of 0.5, what is the pressure drop across the nozzle?

4. It is also important to verify the design in case of the occurrence of water hammer and/or cavitation. If the valve in the pipe closes suddenly, what is the pressure increment after the

sudden closing? The modulus of elasticity of steel is 200 GPa. Would the pipe fail? To answer this question, you must use equation 11-9 in the book, and then compare the thickness you get out of that equation to the actual thickness of the pipe you selected. Also, verify that there is no cavitation in the system.

B. You are hired to design a lazy river in a water park. You are required to fit at least two lazy river tubes (side-by-side) of the ones shown in:

https://www.aquatec-europe.com/en/waterpark/pear-tubes-and-river-tubes-for-waterparks/82-zrt42ye-single-tube

The water depth should be such as a 4-year-old kid can stand in the river without danger. The slope should be 0.1%. Assume (with logic) any dimension not given but that you need for this design.

5. What is the water flow rate required?

6. What would be the drag force a 4-year-old kid would experience? Assume the kid to be a cylinder.

7. For a person whose weight is 220 lbs, how deep into the water the lazy river tube would go? Assume the lazy river tube shape to be a hollow short cylinder with the dimension given in the website. Is the lazy river tube with the person on it stable? Prove it.

Problem solution rubric

	Exceeds Standard 4 10 points	Meets Standard 3 7 points	Approaches Standard 2 4 points	Needs Attention 1 0 points
1. Purpose **5%**	The purpose of the section to be answered is clearly identified and stated.	The purpose of the section to be answered is identified, but is stated in a somewhat unclear manner.	The purpose of the section to be answered is partially identified, and is stated in a somewhat unclear manner.	The purpose of the section to be answered is erroneous or irrelevant.
2. Drawings & Diagrams **10%**	Clear and accurate diagrams are included and make the section easier to understand. Diagrams are labeled neatly and accurately.	Diagrams are included and are labeled neatly and accurately.	Diagrams are included and are labeled.	Needed diagrams are missing OR are missing important labels.
3. Sources **5%**	Several reputable background sources were used and cited correctly.	A few reputable background sources are used and cited correctly.	A few background sources are used and cited correctly, but some are not reputable sources.	Background sources are cited incorrectly.
4. Design considerations (assumptions, safety, cost, etc) **10%**	Design is carried out with applicable assumptions and full attention to safety and cost, etc.	Design is generally carried out with assumptions and attention to safety, cost, etc.	Design is carried out with some assumptions and some attention to safety, cost, etc.	Assumptions, safety and cost were ignored in the design.
5. Data and variables **5%**	All data and variables are clearly described with all relevant details.	All data and variables are clearly described with most relevant details.	Most data and variables are clearly described with most relevant details.	Data and variables are not described OR the majority lack sufficient detail.
6. Procedure **25%**	Procedure is described in clear steps. The step description is in a complete and easy to understand short paragraph.	Procedure is described in clear steps but the step description is not in a complete short paragraph.	Procedure is described in clear steps. The step description is in a complete short paragraph but it is difficult to understand.	Procedure is not described in clear steps at all.
7. Calculations **20%**	All calculations are shown and the results are correct and labeled appropriately. The units of all values are shown.	Some calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results labeled appropriately.	No calculations are shown OR results are inaccurate or mislabeled.
8. Summary **5%**	Summary describes the design, the relevant information and some future implications.	Summary describes the design and some relevant information.	Summary describes the design.	No summary is written.
9. Materials **5%**	All materials used in the design are clearly and accurately described.	Almost all materials used in the design are clearly and accurately described.	Most of the materials used in the design are clearly and accurately described.	Many materials are described inaccurately OR are not described at all.
10. Analysis **10%**	The design is discussed and analyzed. Argumentative predictions are made about what might happen in case of change in the operation and how the design could be change.	The design is discussed and analyzed. Argumentative predictions are made about what might happen in case of change in the operation.	The design is discussed and analyzed. No argumentative predictions are made about what might happen in case of change in the operation and how the design could be change.	The design is not discussed and analyzed.

(A) PURPOSE

In the system shown below, we would like to compute:

1) The force (magnitude and location) on a blind flange to be installed attached to the tank and located across the pipeline inlet.
2) The forces the pipeline experiences due to the moving fluid.
3) The pressure drop across a flowmeter of the flow nozzle type with $\beta = 0.5$.
4) The water hammer pressure increase if it occurs. Also check that the pipe will not burst if it happens. Also check whether this is cavitation in the system

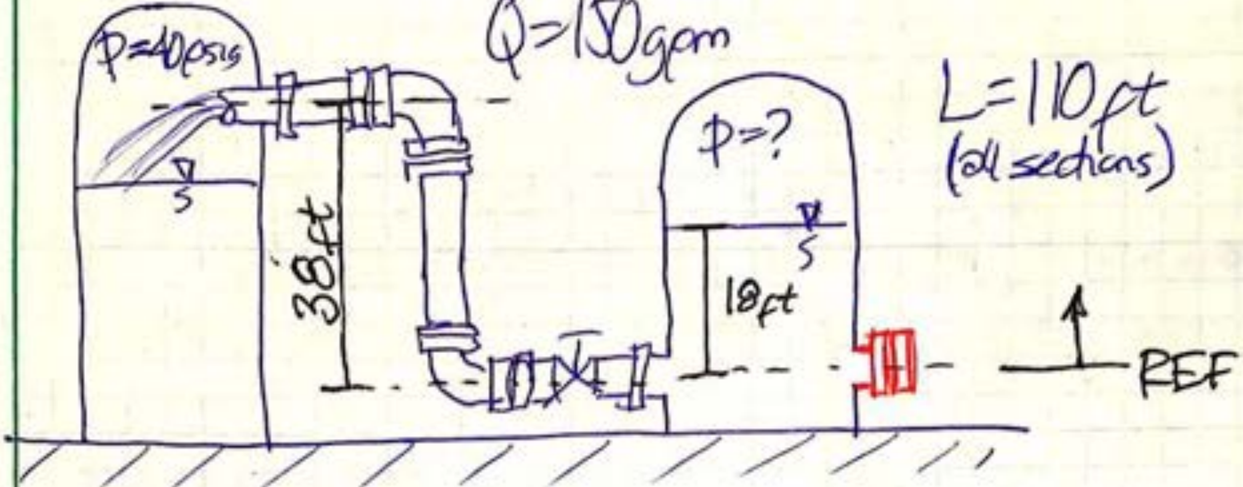
SOURCES

Mott, R., Untener, J.A, "Applied Fluid Mechanics", 7th edition, Pearson Education Inc. (2015)

DESIGN CONSIDERATIONS

- Constant properties
- Incompressible fluids
- Isothermal conditions

DRAWINGS & DIAGRAMS



MATERIALS

- Ethyl alcohol @77°F
- Mercury @77°F
- Air @77°F

DATA & VARIABLES

All dimensions in the figure

- $\gamma_a = 49.01\ lb/ft^3$ $\rho_a = 1.53\ \frac{slugs}{ft^3}$
- $\nu_a = 1.37\times10^{-5}\ ft^2/s$ $E_a = 896\ MPa$
- $D_i = 0.1723 ft$
- $A_i = 0.0233 ft^3$
- $\delta = 3.91\times10^{-3} m$

} Table A-7

- $\varepsilon = 1.5\times10^{-4}\ ft$ table 8-2
- $E_{steel} = 200\ GPa$
- $\beta\left(=\frac{d_1}{d_2}\right) = 0.5$ (flow nozzle)
- $S = 20\times10^3\ psi$
- $Y = 0.40$

} pipe properties

$\Delta z = 20 ft$

$Q = 150 gpm = 0.334201\ \frac{ft^3}{s}$

$P_2 = 40 psig = 5{,}760\ \frac{lbf}{ft^3}$

$K_{valve} = 8 f_T$

$K_{elbow} = 30 f_T$ (2 of them)

$K_{ent} = 0.5$

PROCEDURE + CALCULATIONS

C

1) To compute the force in the blind flange, we need to first convert the pressure above the fluid into a piezometric head $h' = P/\gamma$.
We need the pressure. Using the graph we produced in the previous test, I get that the pressure is $P = 64\ psi = 9{,}216\ lb/ft^2$.

The force can be compute with

$$F = \gamma h_c A$$

But $h_c = 18\,ft + h'$

$$= 18\,ft + \frac{P}{\gamma_a} = 18\,ft + \underbrace{\frac{9{,}216\ lb/ft^2}{49.01\ lb/ft^3}}_{188.04\,ft}$$

$$\underline{h_c = 206.04\,ft}$$

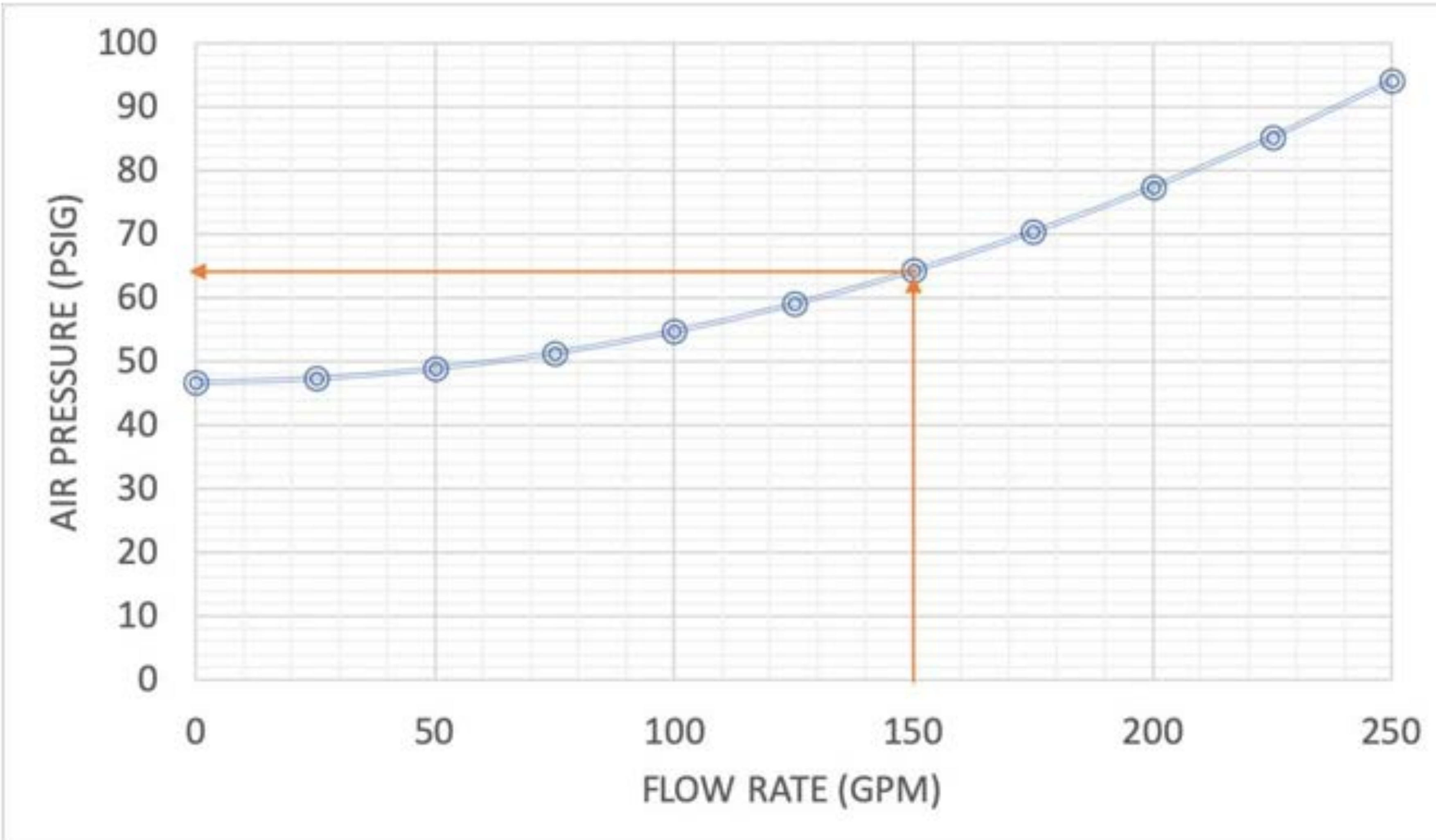
Thus

$$F = 49.01\,\frac{lb}{ft^3} \times 206.04\,ft \times 0.02333\,ft^2$$

$$\boxed{F = 235.59\,lb}$$

As for the location, we will use:

$$h_p = h_c + \frac{I_c}{h_c A}$$



AIR PRESSURE (PSIG)
100
90
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FLOW RATE (GPM)

D

$$I_c = \frac{\pi D_i^4}{64} = \frac{\pi (0.1723 ft)^4}{64} = 6.9219 \times 10^{-4} ft^4$$

So,

$$h_p = 206.04 ft + \underbrace{\frac{6.9219 \times 10^{-4} ft^4}{206.04 ft \times 0.02333 ft^2}}_{1.44 \times 10^{-4} ft}$$

$$h_p = 206.040144 ft$$

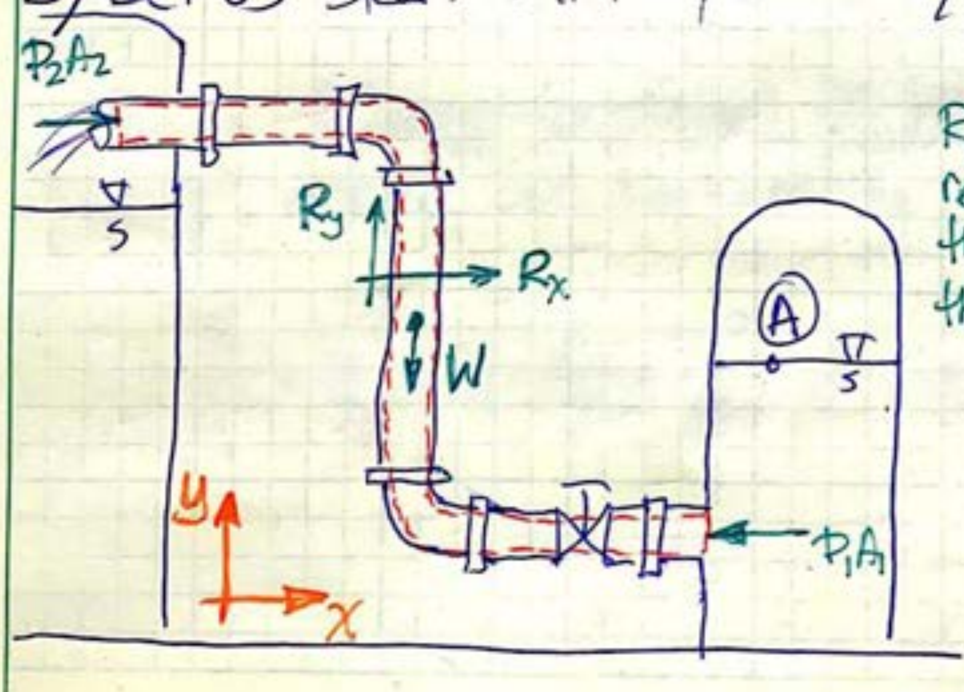
Or, if from the liquid surface:

$$h_p = 18.000144 ft$$

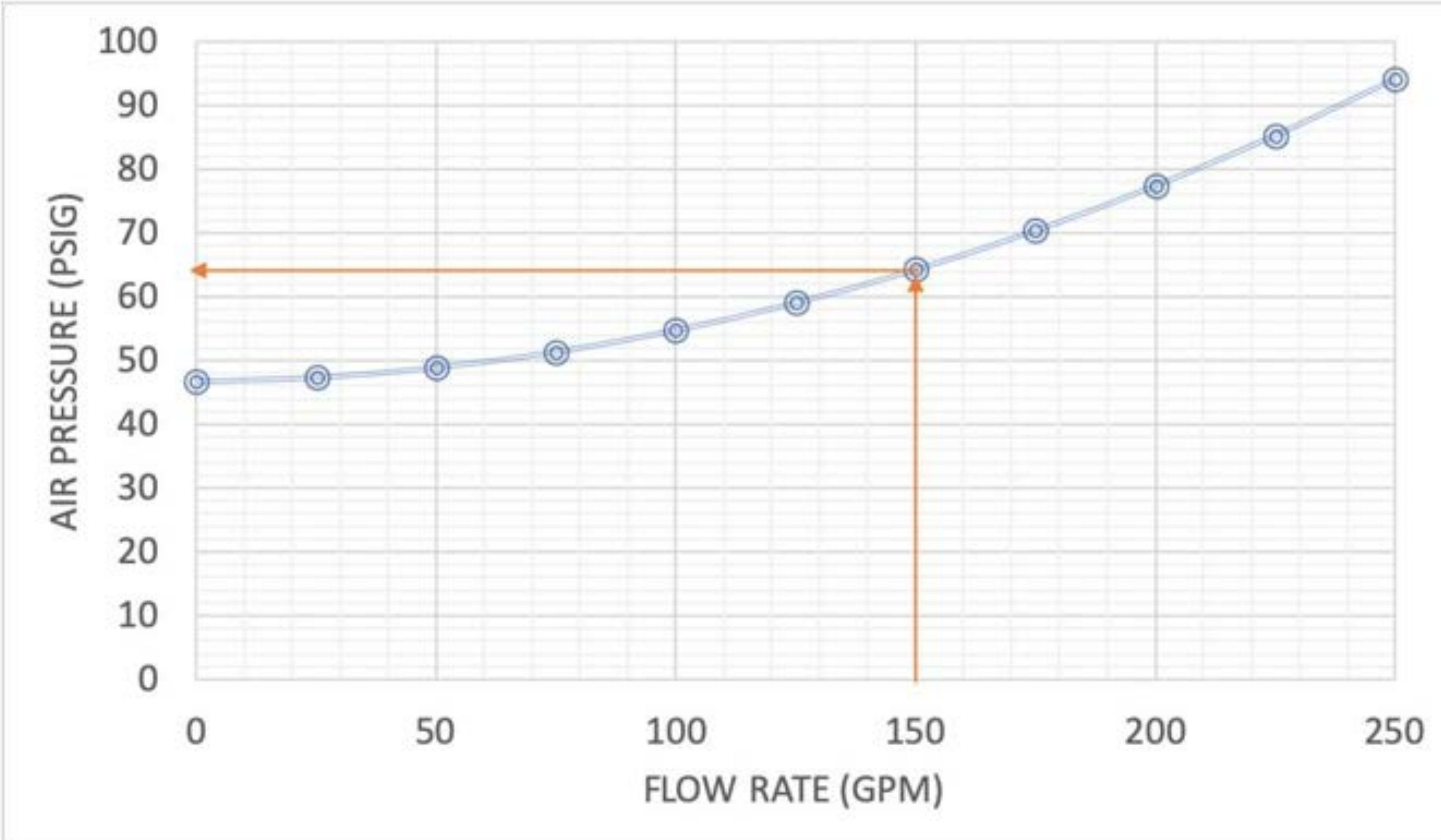
This means that basically:

$$\boxed{h_p = h_c}$$

2) Let us start with a free-body-diagram:



R_x & R_y are the reaction forces of the pipe against the fluid.


AIR PRESSURE (PSIG)
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FLOW RATE (GPM)

E

Now, applying the equation:

$$\sum \vec{F} = \rho Q(\vec{V}_2 - \vec{V}_1)$$

to axis x and y:

$\underline{\underline{x}}$ $\quad \sum F_x = \rho Q(V_{2x} - V_{1x})$

Since pipe diameter and flow rate is the same: $V_{2x} = V_{1x}$, thus

$$\sum F_x = 0$$

From the FBD:

$$P_2 A_2 - P_1 A_1 + R_x = 0$$

Solving for R_x:

$$R_x = (P_1 - P_2) A$$

P_2 is 40 psig (or $5{,}760 \frac{lbf}{ft^2}$) but we do not have P_1. Let us use Bernoulli's to compute it:

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + z_A = \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 + K_{ent} \frac{V_1^2}{2g}$$

$$P_1 = P_A + \gamma_a \left[\underbrace{(z_A - z_1)}_{18\,ft} - (1 + \underset{0.5}{K_{ent}}) \frac{V_1^2}{2g} \right]$$

F

$$V_1 = \frac{Q}{A} = \frac{0.334201\ ft^3/s}{0.02333\ ft^2}$$

$$V_1 = 14.325\ ft/s$$

$$P_1 = 9{,}216\,\frac{lb}{ft^2} + 49.01\,\frac{lb}{ft^3} \left[18\,ft - (1+0.5) \underbrace{\frac{(14.325\ ft/s)^2}{2 \times 32.2\ \frac{ft}{s^2}}}_{3.1864\,ft} \right]$$

$$\boxed{P_1 = 9{,}863.93\,\frac{lb}{ft^2} = 68.499\ psi}$$

Now,

$$R_x = (9{,}863.93 - 5{,}760)\,\frac{lb}{ft^2} \times 0.02333\ ft^2$$

$$\boxed{R_x = 95.745\ lb}$$

<u>y</u>

$$\Sigma F_y = \rho Q (\cancel{V_{2y}} - \cancel{V_{1y}})$$

$$R_y - W = 0 \longrightarrow R_y = W$$

We can calculate weight with $W = \gamma \times \forall$, and the volume can be calculated with $\forall \cong A \times L$

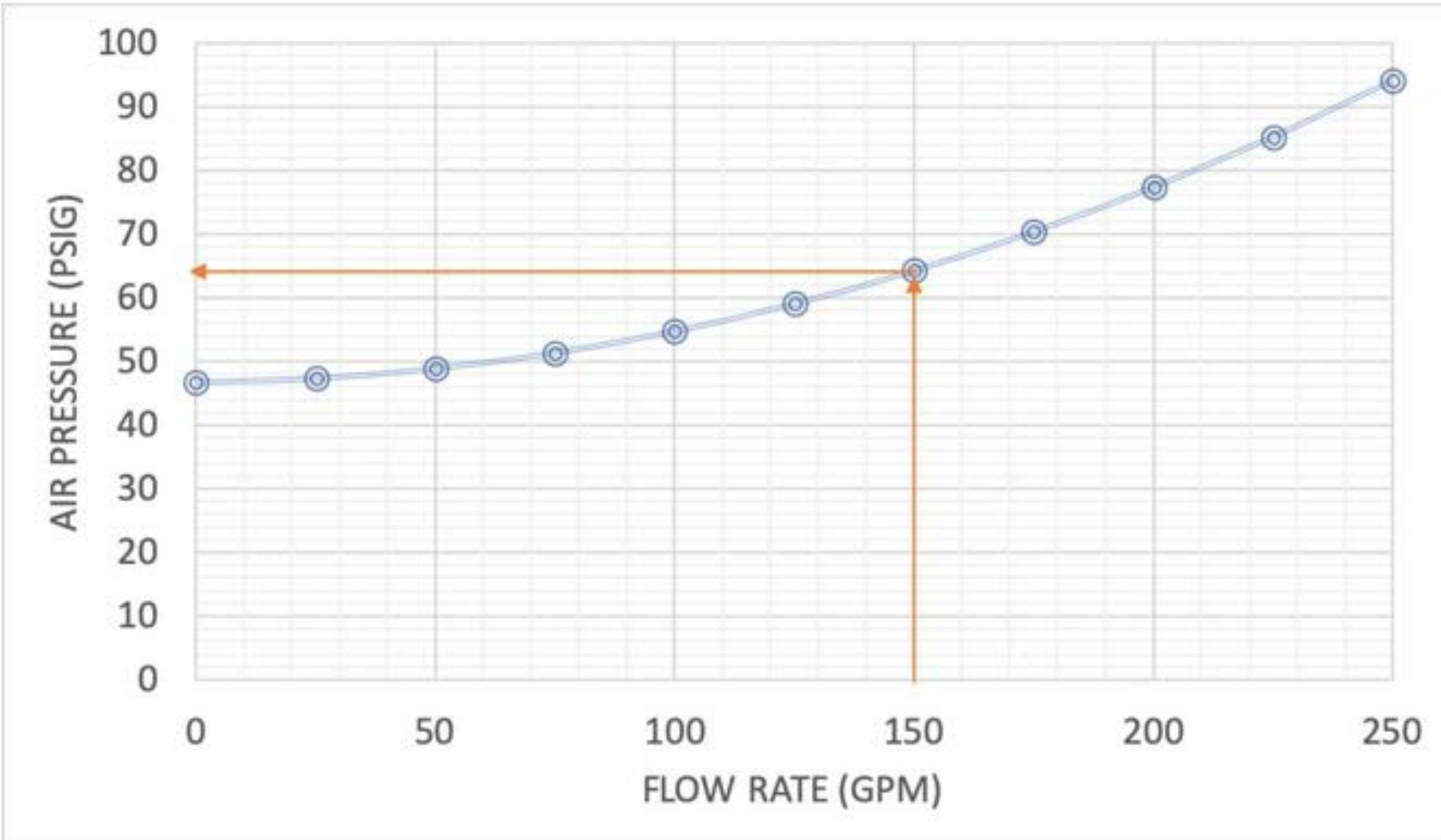
$\forall = 0.02333\,ft^2 \times 110\,ft$

$\forall = 2.5663\,ft^3$

$W = 49.01\,\frac{lb}{ft^3} \times 2.5663\,ft^3$

$W = 125.774\,lb$

$$\boxed{R_y = 125.774\ lb}$$



AIR PRESSURE (PSIG)
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FLOW RATE (GPM)

3) Let us use the equation for flowmeter of [G] the nozzle type:

$$Q = CA_1\sqrt{\frac{2g\frac{\Delta P}{\gamma_a}}{(A_1/A_2)^2-1}}$$

$$\frac{A_1}{A_2} = \frac{d_1^2}{d_2^2} = \left(\frac{d_1}{d_2}\right)^2 = \left(\frac{1}{\beta}\right)^2 = 4$$

Solving for ΔP

$$\Delta P = \frac{\gamma_a}{2g}\frac{Q^2}{C^2A_1^2}\left[\left(\frac{A_1}{A_2}\right)^2-1\right]$$

$$= \underbrace{\frac{49.01\frac{lb}{ft^3}}{2\times32.2\frac{ft}{s^2}}}_{0.761\frac{lb\cdot s^2}{ft^4}}\underbrace{\frac{(0.334201\,ft^3/s)^2}{0.986^2(0.02333\,ft^2)^2}}_{211.0733\frac{ft^2}{s^2}}\underbrace{\left[4^2-1\right]}_{15}$$

$$\boxed{\Delta P = 2{,}409.48\frac{lb}{ft^2} = 16.733\ psi}$$

4) The equations for water hammer are:

$$\Delta P = \rho CV$$

$$C = \frac{\sqrt{E_o/\rho}}{\sqrt{1+\frac{E_oD}{E\delta}}}$$

H

$$C = \frac{\sqrt{\dfrac{0.896\times10^{9}\,Pa}{788.53\,\frac{Kg}{m^3}}}}{\sqrt{1+\dfrac{0.896\,GPa \times 0.0525\,m}{200\,GPa \cdot 3.91\times10^{-3}\,m}}}$$

$\rho = 1.53\,\frac{slugs}{ft^3} = 788.53\,\frac{Kg}{m^3}$

$D = 0.1723\,ft = 0.0525\,m$

$$C = \frac{1{,}065.97\sqrt{\dfrac{\frac{Kg\,\frac{m}{s^2}}{m^2}}{\left(\frac{Kg}{m^3}\right)}}}{1.02964} = \frac{1{,}065.95\,m/s}{1.02964}$$

$$\underline{C = 1{,}035.267\,m/s}$$

Now,

$V = 14.325\,\frac{ft}{s} = 4.36626\,m/s$

$$\Delta P = 788.5296\,\frac{Kg}{m^3} \times 1{,}035.267\,\frac{m}{s} \times 4.36626\,\frac{m}{s}$$

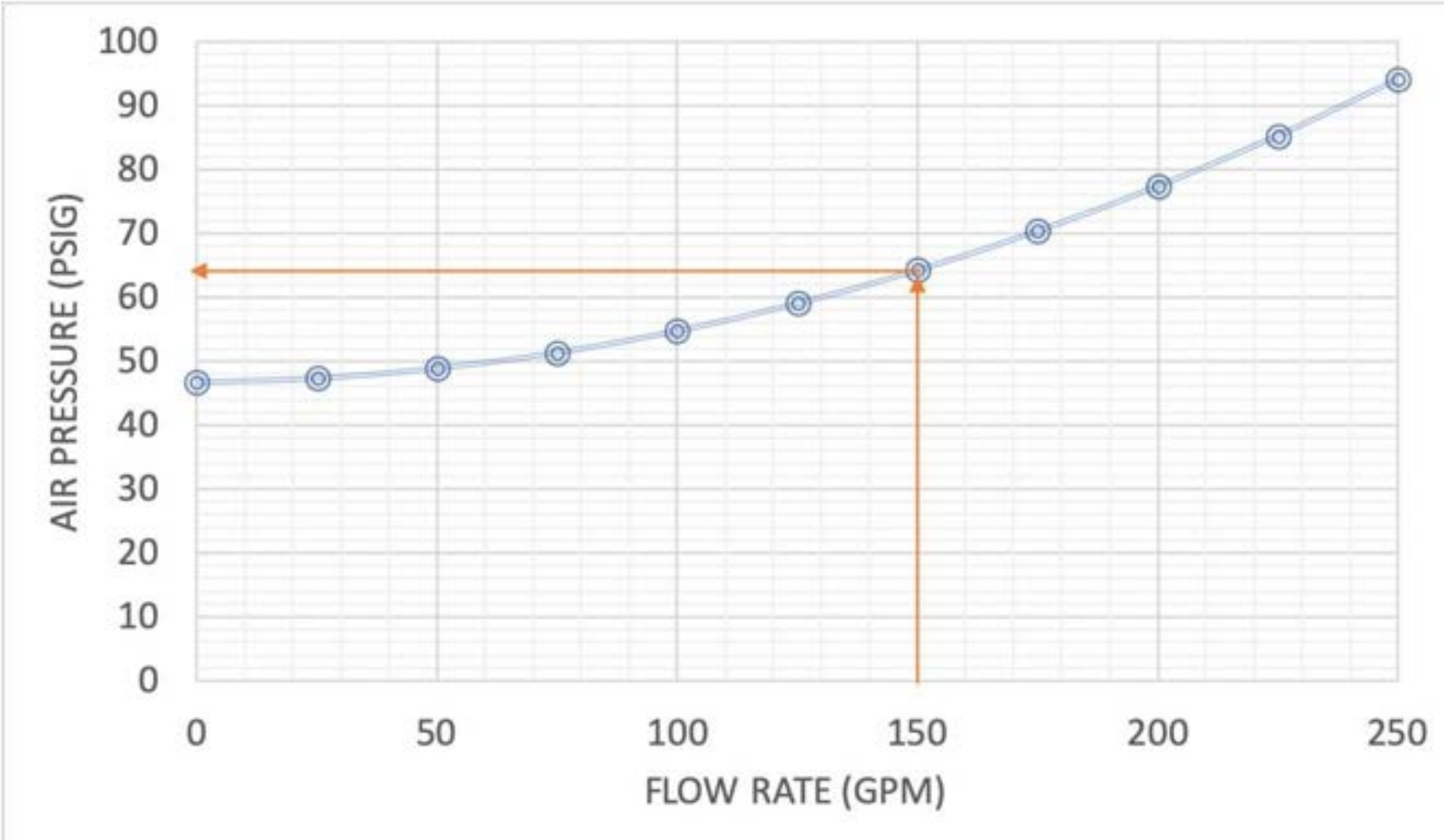
$$\underline{\Delta P = 3.564\,MPa = 516.9145\,psi}$$

This is a increment of pressure due to water hammer and is on top of the operating pressure. Thus, the max pressure is:

$$P_{max} = P_{operat} + \Delta P$$

The highest pressure in in the right tank at the pipe inlet. The pressure there is 68.499 psi, thus

$$P_{max} = 68.499\,psi + 516.9145\,psi$$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FLOW RATE (GPM)

I

$$\boxed{P_{max} = 585.4135\ psi}$$

Now, let us compute pipe thickness using eq 11-9 from the book

$$t = \frac{PD}{2(SE+PY)} = \frac{585.4135\ psi \times 0.1723\ ft}{2(20\times10^3\ psi \times 0.85 + 585.4135\ psi \times 0.40)}$$

$$= \frac{100.8667\ psi \times ft}{34{,}468.3308\ psi}$$

$$\boxed{t = 0.00277\ ft = 0.03324\ in}$$

The actual pipe thickness is 0.154 in, which is larger than the minimum required thickness we just computed of 0.03324 in. Thus, the pipe will not burst if there is a water hammer.

→ Regarding cavitation, the lowest pressure in the system is 40 psig (or 54.7 psia), which is very well above the ethyl alcohol saturation pressure at 77°F. Thus, there will be no cavitation at all.

SUMMARY

J

The force on the blind flange is 235.59 lb and it is located at the centroid of the blind flange. The forces the pipeline experience due to the fluid moving is $R_x = 95.745$ lb and $R_y = 125.774$ lb. The pressure drop across the flow nozzle is 16.73 psi. The pipe will not fail if there is water hammer and there will be no cavitation at all.

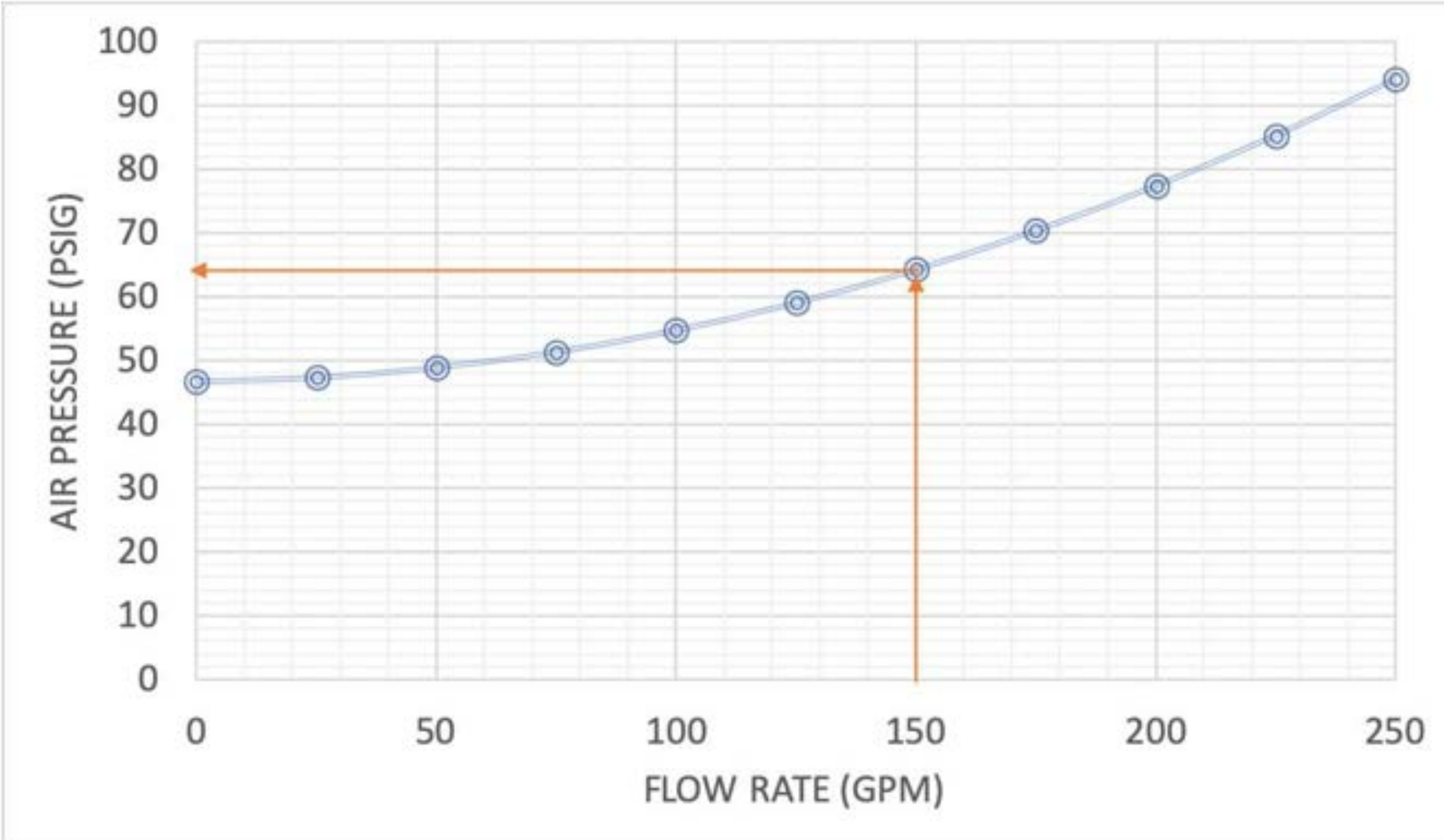
ANALYSIS

The center of pressure in the blind flange is basically at the centroid of area of the blind flange because of the large distance to the centroid (h_c) due to the pressure above the fluid in the right tank.

For our civil engineers they need the values of R_x and R_y we calculated but they also need to consider the pipe weight. Note that the horizontal force is on the same order of magnitude as R_y, so it is not negligible. A support is really required.

For the flow nozzle, we could reduce the pressure drop by reducing β. Note that the 16.733 psi is also part of the energy losses, which were not considered

The water hammer could be dangerous if flow rate is increase to about 700 gpm.



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FLOW RATE (GPM)

Ⓑ PURPOSE

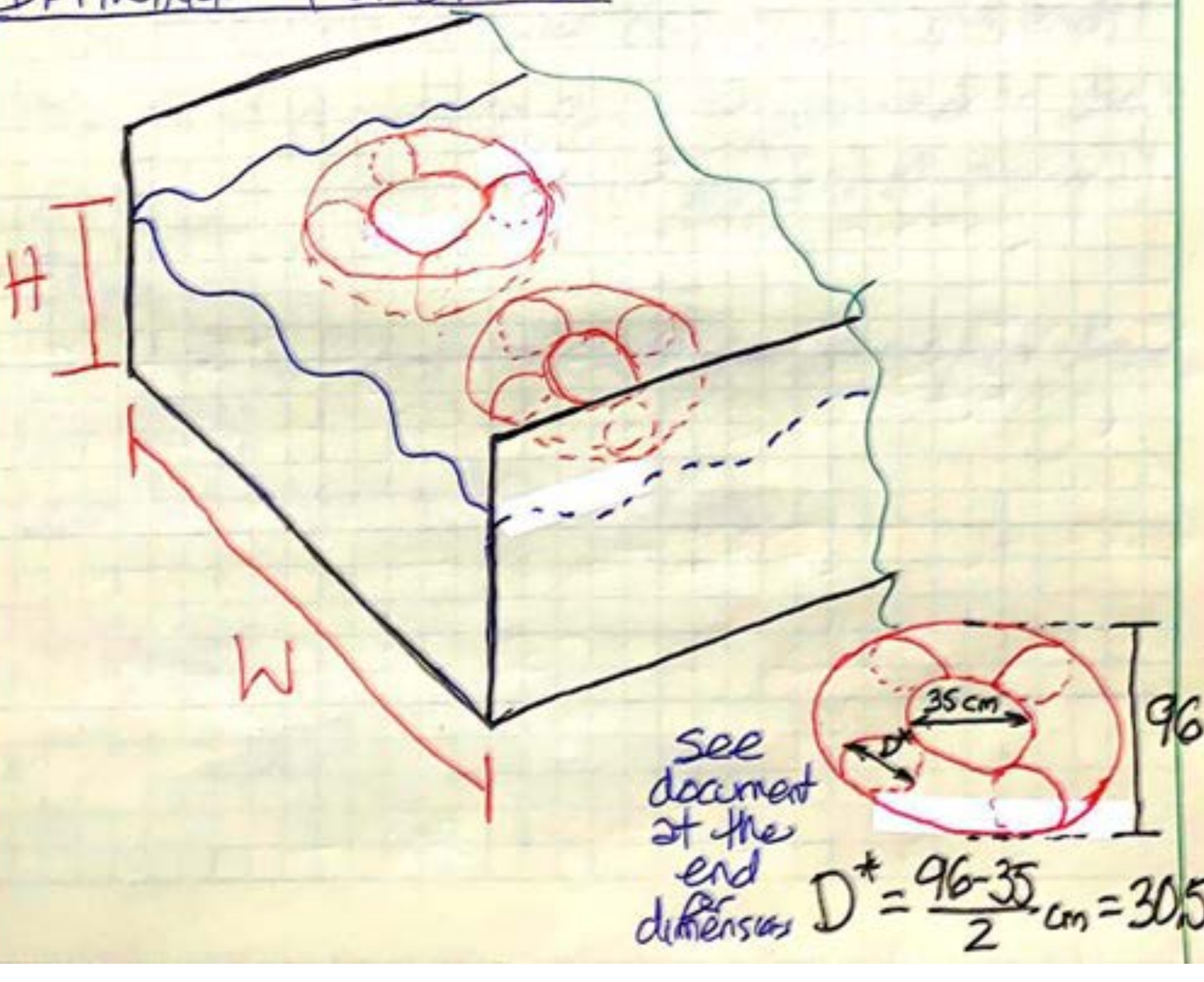
K

Design a lazy river for a water park. The lazy river must feet two tubes and should be safe for a 4-year-old kid. We will determine dimensions, water flow rate requirement, drag force in a kid, and the buoyancy and stability of the lazy river tubes.

SOURCES

Mott, R., Untener, J.A., "Applied Fluid Mechanics," 7th edition, Pearson Education Inc. (2015)

DRAWINGS & DIAGRAMS

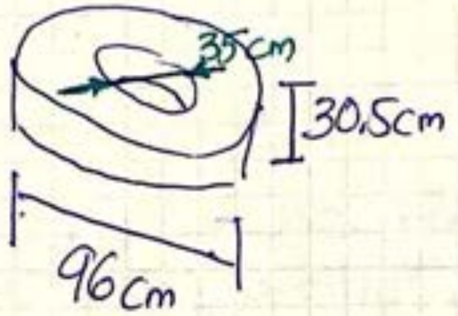


see document at the end for dimensions

$$D^* = \frac{96-35}{2}\,cm = 30.5\,cm$$

DESIGN CONSIDERATIONS

- Lazy river must fit two tubes and be compatible for a 4-year-old kid.
- Water at constant temperature (incompressible & constant properties)
- Tube can be modelled as a hollow cylinder:



$W_{tube} = 1.9\,kg$

- A small 4-year-old is about 95 cm tall (use CDC website, see documents at the end)
- The chest dimension of a 4-year-old is about 24 in (see typical kid dimensiona at the end)
- Slope is 0.1%
- Use trowel finish concrete for the open channel ($n = 0.013$)
- Use dimensions in the drawing.

MATERIALS

Water @ 30 °C

DATA & VARIABLES

M

- Dimensions in the drawing and design considerations
- $S = 0.001$, $n = 0.013$
- $\rho = 996 \frac{kg}{m^3}$ $\qquad W_{person} = 220\,lb = 99.7903\,kg$
- $\nu = 8.03 \times 10^{-7}\, m^2/s$
- $\gamma = 9.77 \frac{kN}{m^3}$

PROCEDURE + CALCULATIONS

5) Let us determine the lazy river dimensions first. The width (W) should be enough to fit 2 tubes. Each tube diameter is 96 and adding 20% to the dimension, we get:

$$W = \underbrace{1.2}_{extra}(2 \times 96\,cm) = 230.4\,cm$$

$$\boxed{W = 2.304\,m}$$

As per the height, it should be such as a 4-year-old feels compertable. Assuming the water should cover just 2/3 of the kid's body and knowing the shortest the could be is 95.00 cm (24 in), we get:

$$H = \frac{2}{3} 95\,cm = 63.333\,cm$$

$$\boxed{H = 0.6333\,m}$$

Now, the flow rate can be calculated with the equation for open channels: N

$$Q = \frac{1.0}{n} S^{1/2} R^{2/3} A$$

$n = 0.013$
$S = 0.001$

$A = H \times W$
$= 2.304\,m \times 0.6333\,m$
$A = 1.4591\,m^2$

$R = \frac{A}{WP}$

$WP = 2H + W$
$= 2 \times 0.6333\,m + 2.304\,m$
$WP = 3.5706\,m$

$R = \frac{1.4591\,m^2}{3.5706\,m}$
$R = 0.4086\,m$

So
$$Q = \frac{1.0}{0.013} (0.001)^{1/2} \times (0.4086\,m)^{2/3} \times 1.4591\,m^2$$

$$\boxed{Q = 1.9544\,\frac{m^3}{s} = 30{,}977.87\,gpm}$$

6) To compute the drag force, I use $\boxed{0}$

$$F_D = C_D\left(\frac{\rho V^2}{2}\right)A_{projected}$$

For V:

$$V = \frac{Q}{A} = \frac{1.9544\ m^3/s}{1.4591\ m^2} = 1.3394\ m/s$$

For Ap:

$$A_{projected} = D \times H = \underbrace{0.6096\,m}_{chest} \times \underbrace{0.6333\,m}_{water\ height}$$

$$A_{projected} = 0.3861\ m^2$$

For C_D, I use fig 17.4. We need Re

$$Re = \frac{VD}{\nu} = \frac{1.3394\ m/s \times 0.6096\ m}{8.03\times10^{-7}\ m^2/s} = 1.0168\times10^{6}$$

Reading $\longrightarrow$ $C_D \cong 3$

Now,

$$F_D = 3.0\left[\frac{996\ \frac{kg}{m^3}(1.3394\ m/s)^2}{2}\right]\times 0.3861\ m^2$$

$$\boxed{F_D = 1.0348\ kN = 232.63\ lb}$$

7)

$D_o = 0.96\,m$
$D_i = 0.35\,m$

P

We know the tube floats when:

$$F_b = W$$

Now, the wegth is the weight of the person plus the one of the tube:

$$W = (99.7903\,kg + 1.9\,kg) \times 9.81\,\frac{m}{s^2} = 997.58\,N$$

And the buoyancy force is

$$F_b = \gamma_w \times \forall_{displaced}$$

$$\forall_{displaced} = \frac{\pi}{4}(D_o^2 - D_i^2) \times h$$

$$\gamma_w = 9.77\,kN/m^3$$

Now,

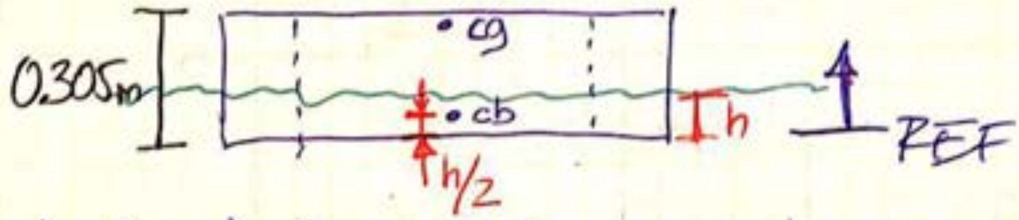
$$9.77\,\frac{kN}{m^3} \times \underbrace{\frac{\pi}{4}\left[(0.96\,m)^2 - (0.35\,m)^2\right]}_{0.7991\,m^2} \times h = 0.99758\,kN$$

Solving for "h":

$$h = \frac{0.99758\,kN}{9.77\,\frac{kN}{m^3}} \times \frac{4}{\pi}\,\frac{1}{0.7991\,m^2}$$

$$\boxed{h = 0.163\,m = 16.3\,cm}$$

Now, to probe if it is stable $\boxed{Q}$



A floating body is stable if center of gravity is below the metacenter:

$$L_{cg} < L_{mc}$$

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

$$L_{cg} < L_{cb} + MB$$

Now,

$$MB = \frac{I}{V_d} \qquad I = \frac{\pi (D_o^4 - D_i^4)}{64}$$

$$V_d = \frac{\pi}{4}(D_o^2 - D_i^2)h$$

$$MB = \frac{\frac{\pi}{64}(D_o^4 - D_i^4)}{\frac{\pi}{4}(D_o^2 - D_i^2)h} = \frac{1}{16}\frac{(D_o^4 - D_i^4)}{(D_o^2 - D_i^2)}\frac{1}{h}$$

$$= \frac{1}{16}\frac{[(0.96m)^4 - (0.35m)^4]}{[(0.96m)^2 - (0.35m)^2]}\frac{1}{0.163m} = \frac{1}{16}\frac{0.8343m^4}{0.7991m^2}\frac{1}{0.163m}$$

$$MB = 0.4m$$

R

$$L_{mc} = \frac{0.163}{2} m + 0.4m$$

$$\boxed{L_{mc} = 0.4818 m}$$

This implies that the metacenter is always above the tube. Thus regardless of the center of gravity, it will always be true that

$$L_{cg} < L_{mc}$$

because the center of gravity will be in the tube, while the metacenter is even above the tube.

SUMMARY

The lazy river should be of at least 2.304m by 0.633m and requires a flow rate of 30,978gpm

The force that the kid will feel if he/she tries to stand is 232.63 lb

The tube will always be stable and it gets 16.3 cm under the water with a person of 220 lb.

ANALYSIS

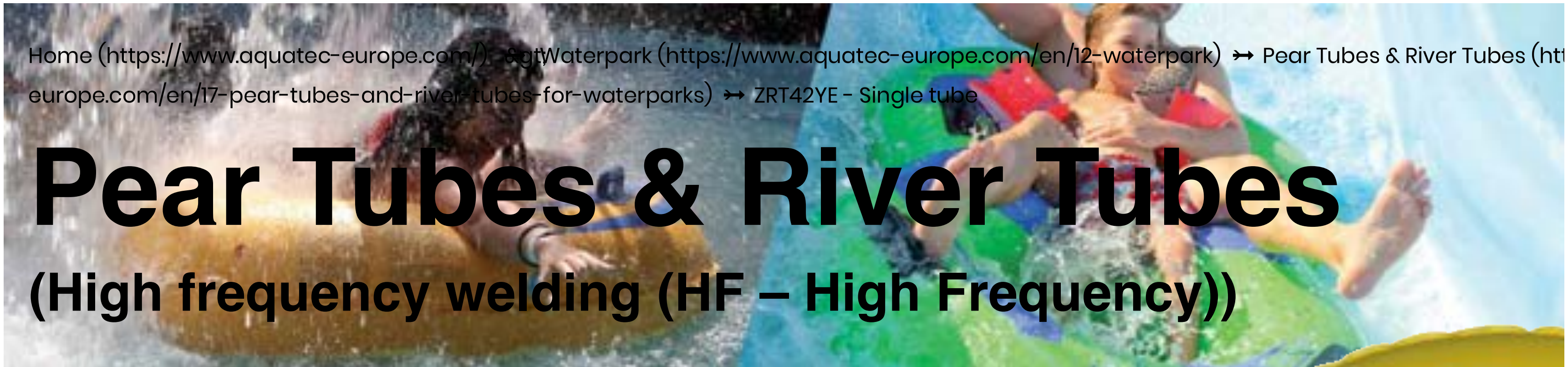
The force in the child is even larger than his/her weight. The design should be revised lowering flow velocity by increasing dimensions.

The tube is amaizingly always stable.

(https://www.aquatec-europe.com/)

Pear Tubes & River Tubes

(High frequency welding (HF – High Frequency))



ZRT42YE - Single tube

River float tube diameter 96cm in PVC material. Inside hole : diameter 35cm. Great for river tubing. Double air chamber (DIN) each with its own valve. Extra strong gusset 10cm. Two handles 10 and 2 o'clock. Colour (PVC/printing): yellow/green.

96	35	1	1.9	2
10+2	6			

Dimensions inflated and in CM

2 to 20 years: Boys
Stature-for-age and Weight-for-age percentiles

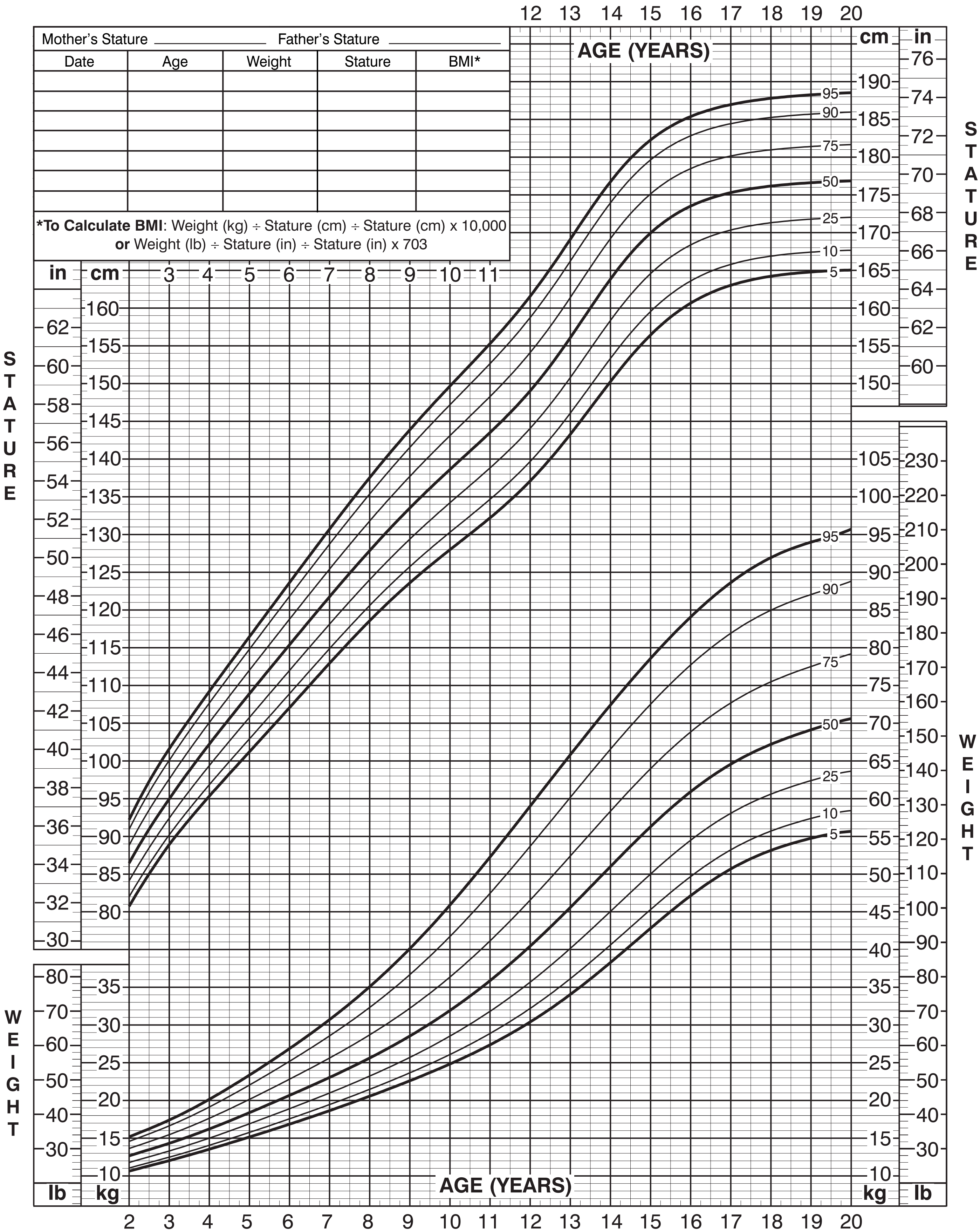
NAME ______________________

RECORD # ______________

Mother's Stature ______________ Father's Stature ______________

Date	Age	Weight	Stature	BMI*

***To Calculate BMI**: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



Published May 30, 2000 (modified 11/21/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

Click here to shop **Kid's Clothing** https://www.boscovs.com/ast/clothing-kids-and-teens

Children's Standard Apparel Size Charts

Newborn – 24 Months							
Size	**Newborn**	**0-3 Months**	**3-6 Months**	**6-9 Months**	**12 Months**	**18 Months**	**24 Months**
Height (in.)	20-22	22-24	24-26	26-28	28-30	30-32	32-34
Weight(lbs.)	5-8	8-12	12-16	16-20	20-24	24-27	27-30
Chest (in.)	16	16-17	17-18	18-19	19-20	20-21	21-22
Waist (in.)	17	17-18	18-19	19-20	20-21	21-22	22-23
Seat (in.)	16-17	17	18	19	20	21	22
Size Chart is a general guide and may include sizes that are unavailable for this item.							

Toddlers				
Size	**2T**	**3T**	**4T**	**5T**
Height (in.)	34-36	36-38	38-41	41-43
Weight (lbs.)	29-31	31-34	34-38	38-42
Chest (in.)	20-21	22-23	23-24	24-25
Waist (in.)	20-22	23-24	24-25	25-26
Seat (in.)	20-21	23	24	25
Size Chart is a general guide and may include sizes that are unavailable for this item.				

Preschool Boys & Girls				
	S	**M**	**L**	**XL**
Size	4	5	6	6x
Height (in.)	39-41	42-44	45-46	47-48
Weight (lbs.)	32-37	37-42	42-47	47-54
Chest (in.)	22-23	23-24	24-25	25-26
Waist (in.)	21-21.5	21.5-22	22-22.5	22.5-23
Hips (in.)	22-23	23-24	24-25	25-26
Size Chart is a general guide and may include sizes that are unavailable for this item.				

Click here to shop **Kid's Clothing** https://www.boscovs.com/ast/clothing-kids-and-teens

Girls 7-16						
	S	**M**	**L**		**XL**	
Size	7	8	10	12	14	16
Height (in.)	50	52	56	58.5	61	62
Chest (in.)	23	24	25.5	27	28.5	30
Waist (in.)	21	21.5	22	22.5	23	23.5
Hips (in.)	24	25	26.5	28	29.5	31
Back-Waist (in.)	11.5	12	12.75	13.5	14.5	15.5
Size Chart is a general guide and may include sizes that are unavailable for this item.						

Girls Tights & Pantyhose				
	S	**M**	**L**	**XL**
Size	4-6x	7-10	12-14	16-18
Height (in.)	39-48	49-55	56-60	61-63
Weight (lbs.)	32-54	54-74	75-96	96-124
Size Chart is a general guide and may include sizes that are unavailable for this item.				

Girls Bodysuits & Leotards				
	S	**M**	**L**	**XL**
Size	4-5	6-7	8-10	12-14
Height (in.)	39-44	45-51	52-55	56-60
Weight (lbs.)	32-42	42-60	60-74	75-96
Size Chart is a general guide and may include sizes that are unavailable for this item.				

Boys 8-20							
	S	**M**		**L**		**XL**	
Size	8	10	12	14	16	18	20
Height (in.)	47-50	51-54	55-58	59-61	62-64	65-66	67-68
Chest (in.)	26-27	27-28	29-30	30-32	32-33	34-35	35-36
Waist (in.)	23-24	24-25	25-26	26-27	27-28	28-29	29-30
Seat (in.)	25-27	27-28	29-30	30-32	32-34	34-35	36-37
Inseam (in.)	21	23	26	27	29	29	30
Size Chart is a general guide and may include sizes that are unavailable for this item.							

2 to 20 years: Boys
Stature-for-age and Weight-for-age percentiles

NAME ______________________

RECORD # ____________

Mother's Stature ____________ Father's Stature ____________

Date	Age	Weight	Stature	BMI*

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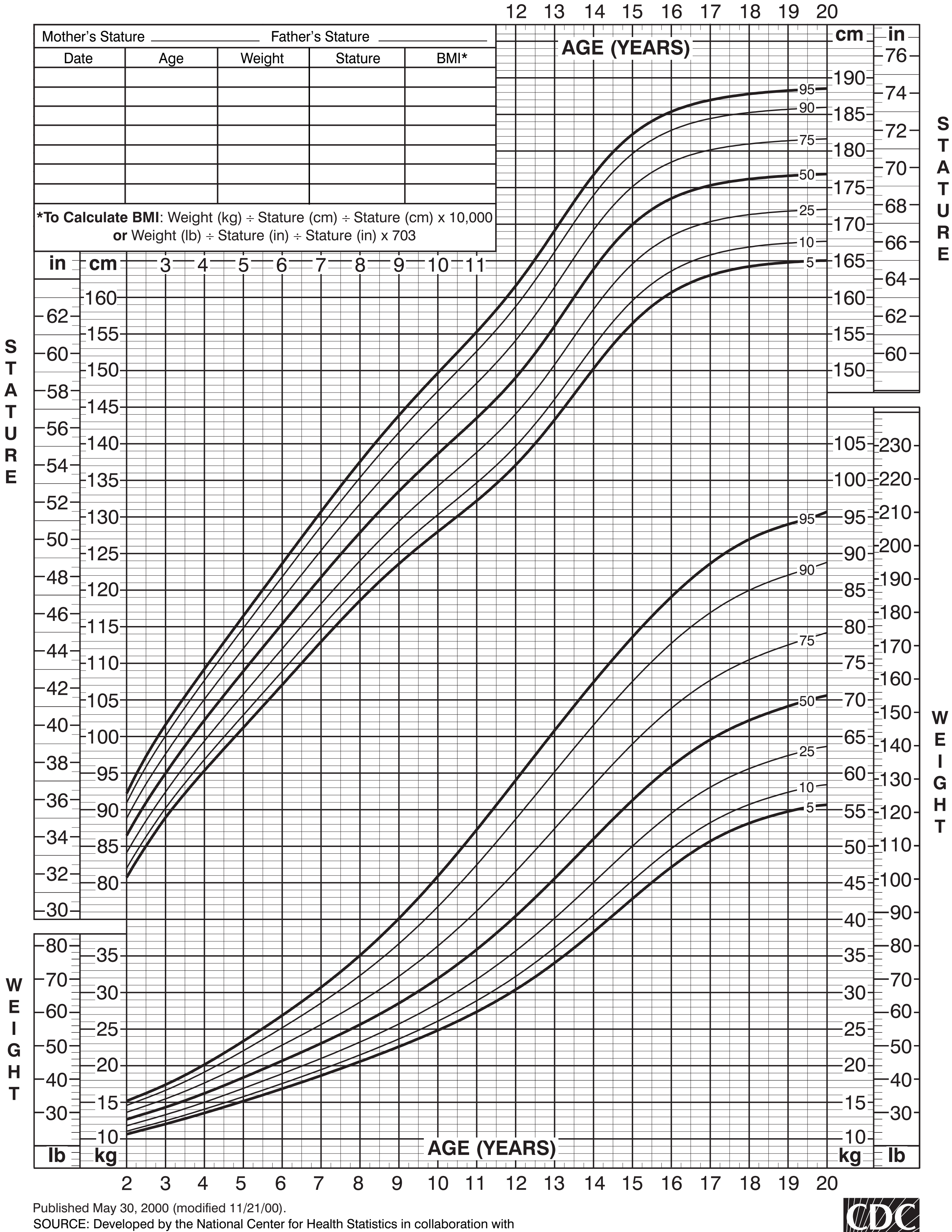

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