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Exam 3

CM3110 Spring
Thursday 18 March 2021

Name: _____

Rules:

- Closed book, closed notes.
- Two-page 8.5" by 11" study sheet allowed, double sided; you may use a calculator; you may not search the internet or receive help from anyone.
- Please text clarification questions to Dr. Morrison 906-487-9703. I will respond if I am able.
- All work submitted for the exam must be your own.
- Do not discuss the contents of the exam with anyone before 11:59pm Thursday, 18 March 2021.
- *Please copy the following Honors Pledge onto the first page of your exam submission and sign and date your agreement to it.*

Honor's Pledge:

On my honor, I agree to abide by the rules stated on the exam sheet.

Signature _____

Date _____

Exam Instructions:

- You may work on the exam for up to two hours and 30 minutes (150 minutes).
- Please submit your exam work within 150 minutes of downloading the exam.
- Please be neat. Only neat answers will be granted partial credit. Please use a dark pencil or pen so that your work is readable once scanned.
- Significant figures always count.**
- Please box your final answers.
- Submit your work as a single PDF file; put your name on every page. (Genius Scan is a free app that can create a PDF from photos taken by your phone)
- Submit your exam study sheet as a separate PDF file; put your name on the first page (at a minimum)

- (20 points) Water ($25^{\circ}C$) flows steadily in horizontal smooth copper tubing at 3.1gpm (*gallon per minute*). What is the pressure drop in $2.5 \times 10^2\text{m}$ of copper tubing of inner diameter 0.015m ? Give your answer in Pa .
- (20 points) What is the drag on a 2014 Toyota Prius going $7.0 \times 10^1\text{mph}$ ($= 102.6667\text{ft/s}$)? Information on this model is given below. The density of air is $0.0766 \frac{\text{lb}_m}{\text{ft}^3}$. Give your answer in lb_f and show how you arrive at your answer.

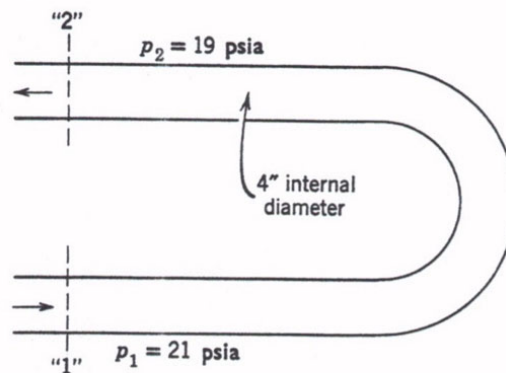
Vehicle	2014 Chevrolet Volt	2014 Toyota Prius
Drag Coefficient	0.28	0.26
Frontal Area	23.7 square feet	23.9 square feet

Ref:
<https://www.caranddriver.com/features/a15108689/drag-queens-aerodynamics-compared-comparison-test/>

- (20 points) Consider the three geometries described below.
 - What is the hydraulic diameter for each?
 - In laminar flow, what is the Fanning friction factor for each geometry as a function of Reynolds number?

- Circular pipe of radius R
- Equilateral triangle of side length a
- Wide, narrow slit of gap H and width W

- (20 points) List and describe three of the seven flow regimes for a fluidized bed. Which regime is the most desirable for chemical engineering purposes? Please limit your answer to about seven sentences at most.
- (20 points) What is the magnitude of the horizontal force on the fluid in the 180° bend (return bend) shown in the figure below? The fluid in the bend is water at $68^{\circ}F$ of density $62.4 \frac{\text{lb}_m}{\text{ft}^3}$, and viscosity $1.0\text{cp} = 0.67197 \times 10^{-3} \frac{\text{lb}_m}{\text{ft}\cdot\text{s}}$, flowing at $3.0\text{ft}^3/\text{s}$. The bend is made of tubing with a circular cross-sectional area of 0.0872665ft^2 (inner diameter = 4.0in). You may neglect the effect of gravity. The entrance pressure is 21psia and the exit pressure is 19psia . The flow is steady. Show how you arrive at your answer. Give your answer in lb_f .



Ref: Bird, Stewart, and Lightfoot, 1960

Fig. 7.D. Flow in a U-bend; both arms of bend are at the same elevation.