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Thermodynamics
MET 300

Instructor: Nathan Luetke

Test 1

Summer 2024

Take home – Due June 10 at 11:59 pm.

- ***Late tests will be penalized 20% and not accepted after 6:00 am June 11***

- **Upload your completed test to Canvas as a single word document or pdf file and include your name on the first page – you will lose 5 points if either of these requirements are not met. It is your responsibility to verify that it is not corrupted and can be open. Be sure that when you scan it in it is dark enough to be read when printed out. Be sure to hit SUBMIT once you have uploaded it.**

90 points – Solutions to the three test problems
10 points – Homework 1.1 through 1.3

1. What you turn in should be only your own work. You cannot discuss the exam with anyone, except me. Email me if you have any questions.

2. This is intended to be open book/open notes.

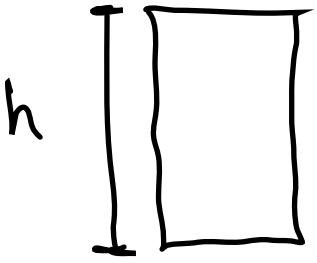
3. You should be explicit and organized in your answers, I can only grade what I see on the paper. Use drawings and figures when needed and clearly identify your final answers

4. 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).

Problem 1 (30 points)

The atmospheric pressures at the top and the bottom of a building are read by a barometer to be 731 mmHg and 759 mmHg respectively. If the density of air is 1.17 kg/m^3, determine the height of the building.



Pressure top = 731 mmHg

$\rho = 1.17\ kg/m^3$

$731\ mmHg \cdot \frac{133.3\ Pa}{1\ mmHg} = 97442.3\ Pa$

Pressure Bottom = 759 mmHg

$759\ mmHg \cdot \frac{P_A}{1\ mmHg} = 101174.7\ Pa$

$\Delta P = P_{BOTTOM} - P_{TOP} = \rho g \Delta h$ $\qquad 1Pa = \frac{1N}{m^2} = \frac{\frac{1kg \cdot m}{s^2}}{m^2}$

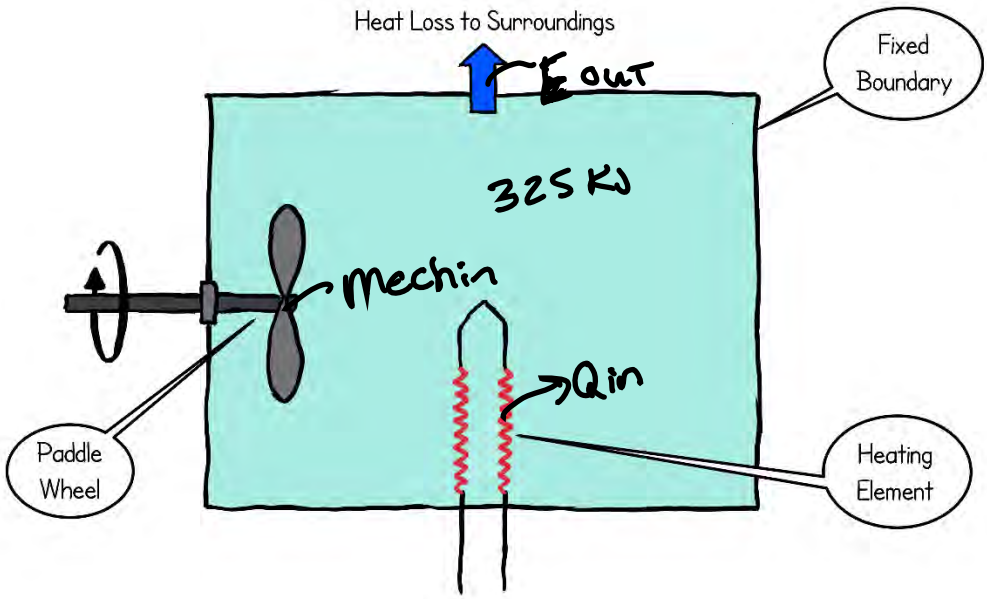
$\Delta h = h$

$(101174.7 - 97442.3)\ \frac{\frac{1kg \cdot m}{s^2}}{m^2} = 1.17\ \frac{kg}{m^3} \cdot 9.81\ m/s^2 \cdot \Delta h$

$\Delta h = \frac{3732.4}{11.4777} \cdot \frac{\frac{kg \cdot m \cdot \frac{1}{s^2}}{m^2}}{\frac{kg}{m^3} \cdot \frac{m}{s^2}} = \boxed{325.187\ m}$

Problem 2 (30 points)

Refer to the figure below and calculate the rate of energy supplied to the electric heating element in Watts using the information provided in the table.



The initial energy of the system is 325 kJ U
The final energy of the system after 1.5 hours is 4200 kJ E_{tot}
The paddle wheel stirs the system continuously for 1.5 hours at 600 RPM with 30 N·m of torque
Heat is lost to the surroundings at a rate of 55 kJ per minute E_{out}

$$E_{tot} = U + \dot{Q}_{in} - \dot{E}_{out} + \dot{M}_{echin} \quad 1.5\,hrs \cdot \frac{3600\,s}{1\,hr} = 5400\,s$$

$$4200\,KJ = 325\,KJ + (Q \cdot 5400s) - \left(\frac{55\,KJ}{60\,s} \cdot 5400s\right) +$$

$$\left(5400s \cdot 2\pi \cdot 600\,\frac{rev}{m} \cdot 30\,N.m \cdot \frac{1\,min}{60s} \cdot \frac{1\,KJ}{1000\,N.m}\right)$$

$$Q = \frac{4200\,KJ - 325\,KJ + 4950\,KJ - 10178.76\,KJ}{5400\,s} = -.25\,\frac{KJ}{s}$$

$$Q = -250\,W$$

Since paddles mechanical energy is high, no energy or watts need to be provided by the heating Element

$$\boxed{0\,W}$$

Problem 3 (30 points)

Complete following table for H_2O

	T (°C)	P (kPa)	u (kJ/kg)	h (kJ/kg)	Phase description
A	20	2.3392	2402.3	2537.4	Sat vapor
B	305	9209.4	1624.42	1675.2	Sat mix
C	100	750	419.06	419.17	Compress liquid
D	700	10,000	3434.0	3870.0	Super Heated vapor
E	777.59	1800	3617.08	4100.2	Super heated vapor

B. $h = h_f + x(h_{fg})$ $\quad x = \frac{h - h_f}{h_{fg}} = \frac{1675.2 - 1373.1}{1366.3} = .2211$

$u = u_f + x(u_{fg}) = 1360 + .2211(1195.9) = 1624.42$

E. $\frac{T - 700}{800 - 700} = \frac{4100.2 - 3919.4}{4152.4 - 3919.4}$

$T = (.776 \cdot 100) + 700 = 777.59\ ^\circ C$

$\frac{u - 3472.6}{3658.8 - 3472.6} = \frac{4100.2 - 3919.4}{4152.4 - 3919.4}$

$u = (.776 \cdot 186.2) + 3472.6 = 3617.08$