¹ Department of Materials Engineering, Faculty of Applied Science, UBC Vancouver and ² School of Engineering, Faculty of Applied Science, UBC Okanagan **Creation of Programming-based Problem Bank for Introductory hermodynamics**

Project Scope

Thermodynamics is an essential topic in many university programs, such as engineering, physics and chemistry. In the Faculty of Applied Sciences, it is offered to students in the materials, mechanical, civil, electrical engineering and manufacturing programs.

The objectives of this project include:

- Use open sources programming languages such as Python and Jupyter to revolutionize the approach to teach thermodynamics.
- Develop a problem bank to accompany Dr. Claire Yan's open textbook published on BCcampus ^[1] (Figure 1).

Features of the Problem Bank

- A total of 10 questions for each of the six chapters from the e-textbook has been created ^[2]. The outline of the Problem bank ^[3] is shown in Figure 2.
- The source code of all questions are openly accessible, permitting students and instructors to experiment with various input parameters for learning and teaching key concepts in thermodynamics.

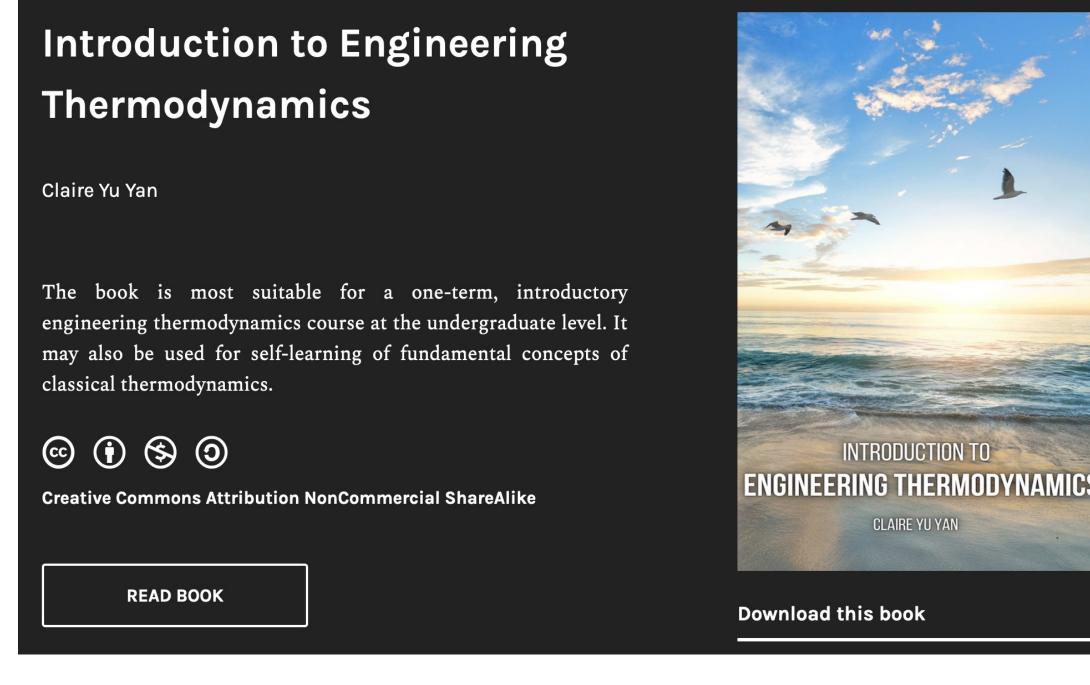


Figure 1: Open textbook Introduction to Engineering Thermodynamics by Dr. Yan



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Work in progress

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At present, work is being done to show some interactive property diagrams so that students can appreciate the plethora of diagrams that can be drawn for a given fluid.

Figure 4 shows a P-v diagram for Water and Ammonia^[4] fluids, a textbox will be added for a (x, y) point to appear on the interactive plot. This will help get students get a visual sense of which state the fluid is in.

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With the university of particular condent Improvide the university of particular condent Improvide the university of the universi	 Copen Education Resources (Introduction to Engineering) This is a project that extends the original e-textbook written by Dr. Claire Yu Y Engineering Thermodynamics. The main goals for this project are as follows: (1) To provide students with a list of questions that can be done in their laptops as CoolProp, numpy and matplotilib. (11) To reinforce the concepts learnt from e-textbook and to get a better appreci- thermodynamic calculations. (111) To provide a starting point for Thermodynamics courses in other disciplines their courses. Acknowledgements Acknowledgements Acknowledgements Defining Variables: Properties of Ideal Gases as use case Modules 1. Basic Concepts and Definitions 2. Thermodynamic Properties of a Pure Substance 3. Ideal and Real Gases 4. The First Law of Thermodynamics for Closed Systems 5. The First Law of Thermodynamics for a Control Volume
 Thermodynamics for a Control Volume 6. Entropy and the Second Law of ∽ Thermodynamics 	6. Entropy and the Second Law of Thermodynamics Interactive Diagrams Property Diagrams
Interactive Diagrams	
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Figure 2: Problem bank website as a Jupyter book found here: <u>Webpage link</u>



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Yan in UBC Okanagan campus: Introduction to with the help of some Python packages such

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to adopt a more computational approach fo

Acknowledgements

##plotting P_V
#import the libraries we'll need import numpy as np import matplotlib.pyplot as plt #defining arrays of V values for 1-2 /_vals12 = np.linspace(V_1, V_2, 1000) # define an array of values for volume (v) for the process 1 t #calculating pressure (P) for the array of volume values (V_vals12) P_vals12 = m * R * T_1 / V_vals12 tdefining arrays of V values for 2-3 _vals23 = np.linspace(V_2, V_3, 1000) # define an array of values for volume (v) for the process 2 to associated constant pressure for the process 2-3 P_vals23 = np.linspace(P_2, P_3, 1000) efining arrays of P values for 3-1 vals31 = np.linspace(P_3, P_1, 1000) # define an array of values for pressure (P) for the process 2 associated constant volume for the process 3-1 _vals31 = np.linspace(V_3, V_1, 1000) lt.plot(V_vals12, P_vals12,label='isothermal') # plot pressure vs. volume >lt.plot(V_vals23, P_vals23,label='isobaric' plt.plot(V_vals31, P_vals31, label='isochoric') olt.ylabel("Pressure [kPa]") # give y axis a label lt.xlabel("Volume [m3]") # give x axis a labe add—ons to illustrate process path plt.xlim(0.4, 0.9) plt.ylim(80, 220) plt.text(0.88, 87, '1', fontsize = 15) lt.text(0.88, 207, '3', fontsize = 15 .plot(V_vals23[0], P_vals23[0], 'ro lt.plot(V_vals31[0], P_vals31[0], 'ro'

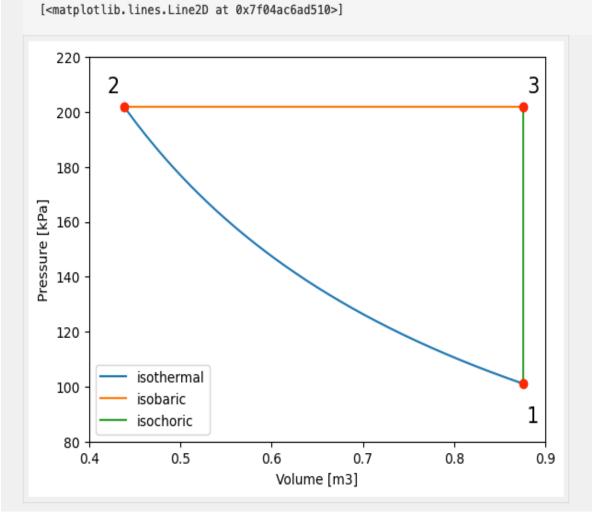


Figure 3: A typical example of working code and a plot to visualize the thermodynamic states

References

- Retrieved from here
- Zenodo. DOI
- February 09). Retrieved from here
- Chem. Res., 53(6), 2498–2508. DOI

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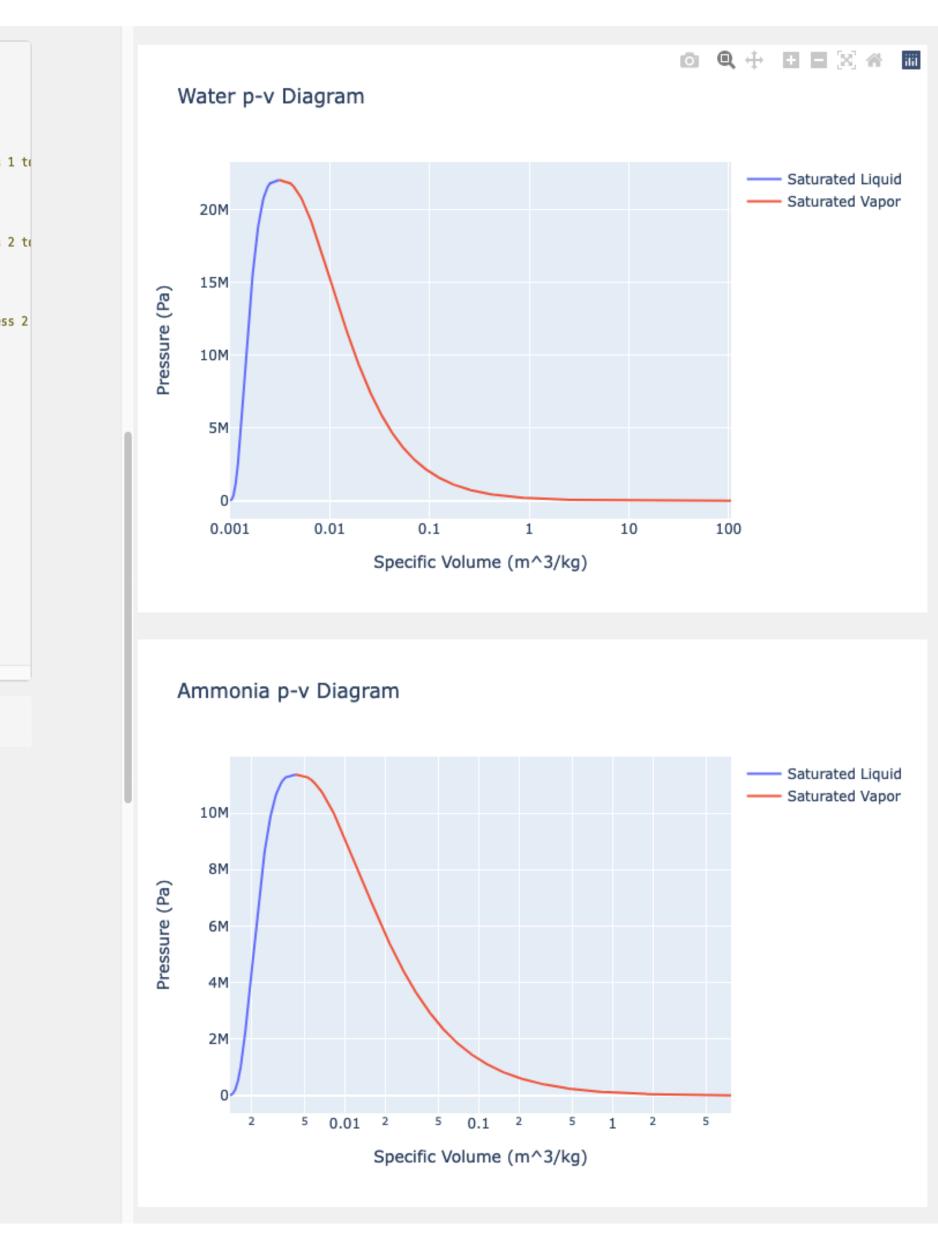


Figure 4: Interactive thermodynamic property diagrams

1. Yan, C. Y. (2022). Introduction to Engineering Thermodynamics.

2. Executable Books Community. (2020). Jupyter Book (v0.10).

3. Open Education Resources (OER): Introduction to Engineering Thermodynamics — OER Engineering Thermodynamics. (2024,

4. Bell, I. H., Wronski, J., Quoilin, S., & Lemort, V. (2014). Pure and Pseudo-pure Fluid Thermophysical Property Evaluation and the Open-Source Thermophysical Property Library CoolProp. Ind. Eng.