Share and Learn Discussion Notes: March 16th, 2022 1-2pm EST

Adam St. Jean, PhD; University of Massachusetts Lowell

Teaching Thermodynamics to Biomedical Engineers

Survey Results:

1) Split results of dedicated thermodynamics vs. taught within other courses (e.g. Transport courses)
    a. Often taught at 2nd year (sophomore year)
2) Textbooks Used:

Which text (title and author) do you use?
Yunus A. Cengel & Michael A. Boles, "Thermodynamics, An Engineering Approach", 9th Edition, McGraw Hill, 2019
Thermodynamics - An Engineering Approach, 9th ed. Çengel, Y., Boles, M., Kanoglu, M. McGraw-Hill, 2019
Bioengineering Fundamentals (for first law) and Thermodynamics, an Engineering Approach (first and second law)
Fundamentals of engineering thermodynamics, 9th edition, Moran, Shapiro, Boettner, Bailey, Wilson; Wiley.
Bioengineering Fundamentals - Saterbak et al.

3) Other Resources Used:

Do you use other resources (Publisher resources Open Educational Resources, course packets, etc.) in your course? If yes, please describe.
M.J. Moran & H.N. Shapiro, "Fundamentals of Engineering Thermodynamics", 9th Edition, John Wiley & Sons, 2020
No
no
I pull examples from other books and articles, mostly about biomedical applications of thermodynamics.
I use journal articles and some textbooks like biological thermodynamics. I am teaching this class for the 1st time and I struggle with what materials to cover in thermo. The course has three modules- transport, kinetics, and thermo. I am looking to see what others use and what do they cover in thermo.

4) Topics Typically Covered:
    a. Mass Balances
    b. Energy Balances
    c. Systems and Control Volumes
    d. Ideal Gas Law
    e. 1^{st} and 2^{nd} Law of Thermodynamics

5) Challenges with Teaching Thermodynamics:
    a. Access to Textbooks, Biological Examples, and What Topics to Cover

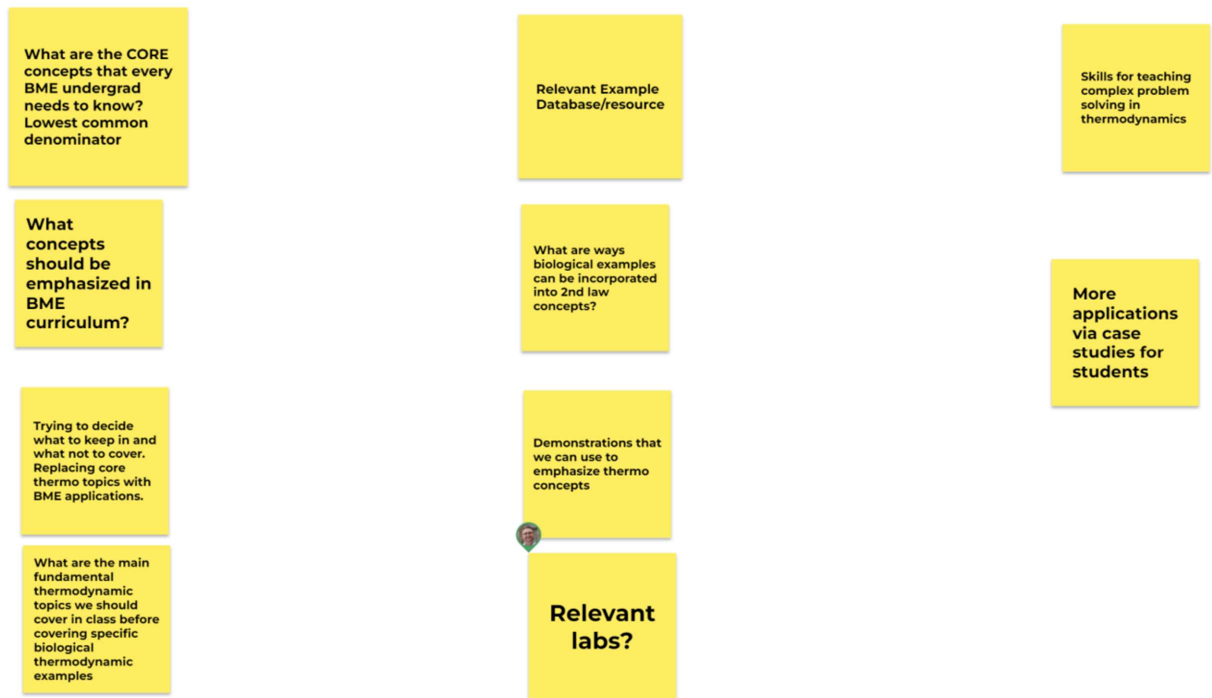
Difficult class, not a favorable course for students. This may be true for all disciplines in engineering.
I would like to have a thermodynamics textbook appropriate for Biomedical Engineering students. The engineering thermodynamics textbooks that I find appropriate for engineering undergraduate students either are mechanical engineering oriented or chemical engineering oriented. Recently I found a textbook (Biothermodynamics – Principles and Applications Ozilgen, M., Sorgüven, E., CRC Press, 2017) that has what I consider an appropriate approach to thermodynamics aspects of biological systems (in chapter 4). I find challenging finding enough time during the semester to teach the fundamentals of thermodynamics and then cover some thermodynamic aspects of biological principles. I would like to learn what are the topics covered by other professors when teaching a 1-semester course to Biomedical Engineering students.
Yes, I'd like to fit in more gibbs/chemical potential work and would like to learn if there's a simple approach to implement/teach it. We have a 10 week quarter that I have to fit a lot into, including mass balances which students have not learned before. I'd be interested in learning more about what are the most necessary concepts people feel should be covered in any thermo course.
It would be great to have a textbook that does an in depth application of thermodynamics to biological systems. Most of what I can find in articles requires simplification and generalization to be appropriate for our students. Most thermodynamics books include high temperature and pressure examples which don't apply to the human body.

Please note: My answers are all on the undergraduate level. Graduate coursework is different, and I didn't talk about it here. Challenges: getting enough content to appreciate the complexity without overwhelming the students, balancing the ability to do it early in the curriculum with the lack of other knowledge to support complex problems.
What concepts are important to teach for biomedical engineers since we have students from non-engineering background as well. Textbooks that could be used without overwhelming the students :)

Breakout Discussion:

What topics are you interested in talking about?

Jamboard:
https://jamboard.google.com/u/0/d/15uBBebK6xX1LY6vZj6m9zC6FdTPXOtENIvHMzGUyWfY/viewer?usp=sharing



Discussed Topics: Topic Generation of Core Concepts, Relevant Examples

Topics:

Systems Covered (Neil Rothman): Cardiovascular, Respiration, Renal System

2nd law of entropy – Neil uses Cardiovascular and 2nd Law but entropy hardest to include

Neha Kamat – uses online tutorials via Kahn Academy for entropy/kinetic energy, wants to work through a 1st law problem, plug into 2nd law problem, and use laws of entropy to show how something is not possible given conditions

Mary Staehle – doesn't cover 2nd law and entropy in class

Neha Kamat – 1st law treats heat and work as the same – why is heat so much worse (e.g. can put a blowtorch on a block and it won't move uphill)

Adam St. Jean – entropy is such a complex topic, so it is difficult to connect it to examples, and how to connect to chemical laws like Gibbs law that requires knowledge of 2nd law to give relevant examples that are understandable by sophomores

Ines Seabra – students get lost unless you solve problems in class, but this loses time between explaining concepts

Neil Rothman – in biological applications, the students can't handle anything beyond treating it as ideal system where we can apply governing equations to, the required assumptions and conditions are too many – hard to make leap between ideal systems and biological systems and how to simplify problems, and how to provide best foundation level to be able to know how to learn more to increase complexity. e.g. conservation of energy applied to complex biological system such as cardiac work – how much flow energy heart is making in terms of pressure and movement of blood, but what about energy within the muscle? How do make a simplified application?

Adam St. Jean – property tables, equations of state, should we take them out even though they are fundamentals in basic engineering?

Neil Rothman – instead of covering all stuff in general engineering, but focus on applying what you learned and how to go to find things you don't know – how to apply thermo topics is more important by taking a problem and how to dissect it to apply the theory (e.g. how to apply properties)

Mary Staehle – uses same approach, uses a 5 point process on how to solve problems in general (Given, Assumptions, Governing Equations, How to Simplify using Givens/Assumptions, How to then Solve)

Neha Kamat – uses Ann Saterbak's Fundamentals of Bioengineering book – how to apply fundamental principles (conservation of energy, mass, etc) – should make a second law of Thermo chapter!

Neil Rothman – depends on how is timed in curriculum with chemistry, physics, and biology and if students have been exposed to them yet to be able to apply Ann Saterbak's book examples

Examples:

Mary Staehle – Ann Saterbak's book is on bioengineering and not biomedical engineering, so some examples may not (E.g. developing pharmaceuticals/plant based processes) fit the goals of a biomedical engineering curriculum as well

Book: https://www.amazon.com/Bioengineering-Fundamentals-2nd-Ann-Saterbak/dp/0134637437

ISBN – 13, 978-0-13-463743-3

Interactive Zybook: Fundamentals of Engineering Thermodynamics Zybook: https://www.zybooks.com/

There is no good textbook for this class! Is there a way to collaborate on a problem set book on biological examples? Come with consensus on what's required