What's the Point? An Analysis of Non-Cartesian Coordinate Systems in Upper Division Physics Textbooks

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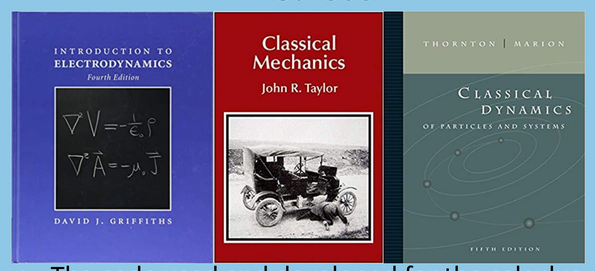
Introduction

- Research shows there is a gap in understanding between physics and math[1,2]
- Physics students know how to integrate a function well when it is set up[1]
- Yet these students struggle to set up an integral from a given physics problem[1]
- Similar issues exist with other math concepts, including non-Cartesian coordinate systems
- Where does this gap lie for non-Cartesian coordinate systems? How can we gauge the fluency in math that is expected of upper-division physics students?

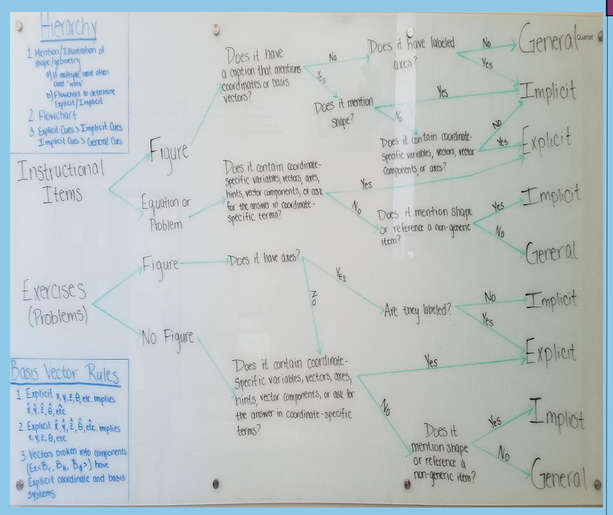
Methods



- The code used and developed for the calculus books would not apply to the physics books, as the language was different
- A new code was developed and applied to upper division physics books, looking for their use of coordinate systems, basis vectors and implicit or explicit language

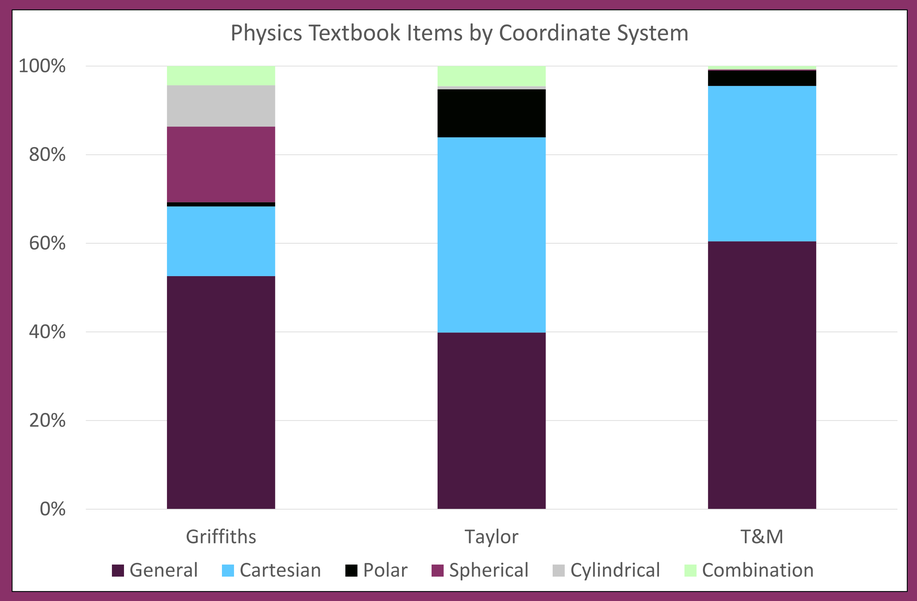
Q1	Are there explicit instructions about which coordinate system to use? If so, which one(s)?
Q2	Are there explicit instructions about which set of basis vectors to use? If so, which one(s)?
Q3	Is there an implied coordinate system? If so, which one(s)?
Q4	Is there an implied set of basis vectors? If so, which one(s)?

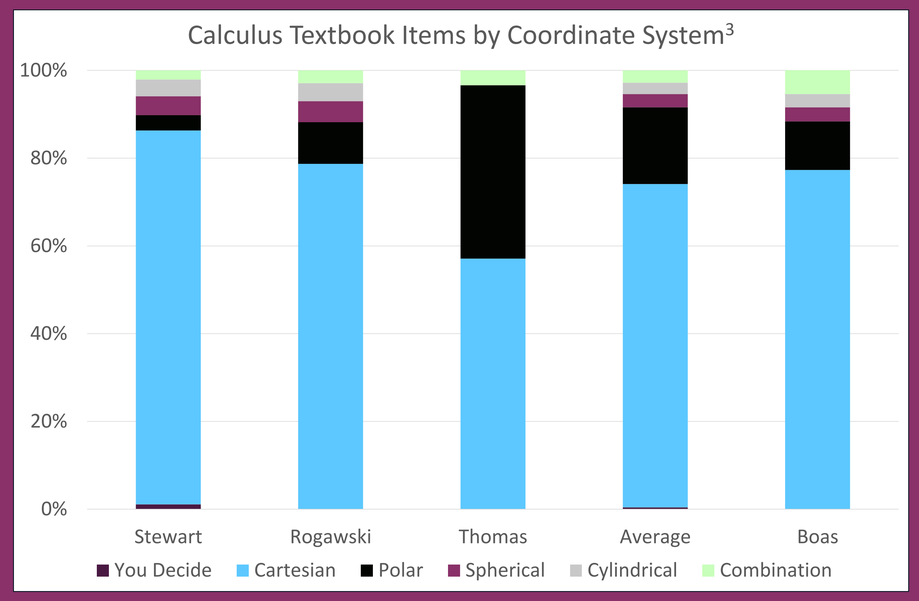
- We defined explicit and implicit, and created a few more rules in order to raise our IRR



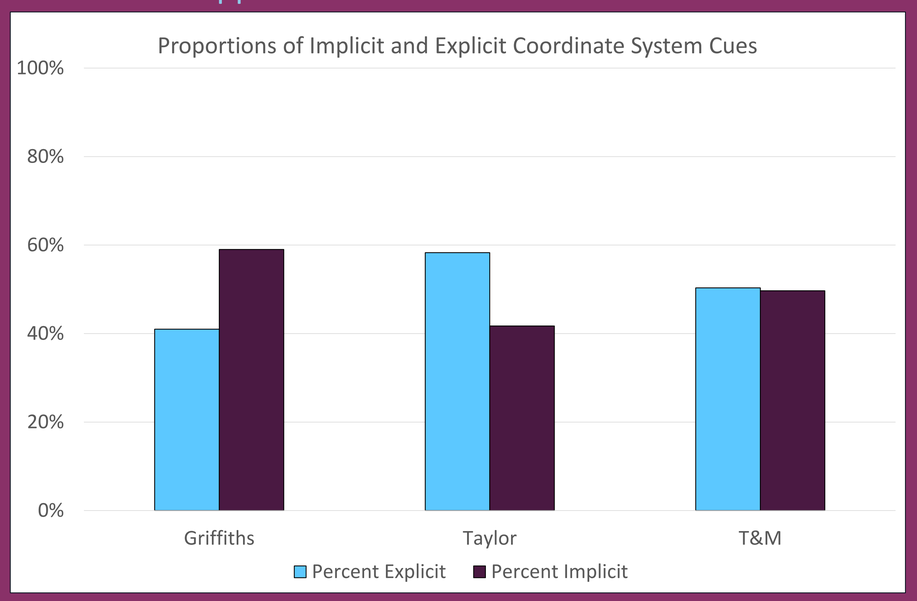
- Our IRR came out to 94%

Upper-level physics texts use more implicit language and do not contain as much content on XY-coordinates as calculus texts, creating a knowledge gap for physics students.





It is clear there is little focus on anything other than Cartesian coordinates in the math books, yet this is not the case in the physics books. In the physics books, there is a large amount of content that is non-Cartesian, which students will be less familiar with, due to the rarity with which it appears in their calculus textbooks.



The calculus books do not have an analysis of implicit or explicit content, because nearly all of their content was explicit; the only thing comparable to implicit language in the calculus books would be the "You Decide" category. This change in language, from explicit to implicit, increases the difficulty for students applying the math concepts in physics contexts.

Discussion

- Students coming from calculus are not prepared to use the math expected of them in their upper-level physics courses
- Unit vectors are used more in physics than math
- Our need to code unit vectors separate from coordinate systems shows this
- Leads to a gap in students' understanding of what basis vectors are and what basis vectors mean in a physical context
- There is a large instructional gap that needs to be filled in order to better prepare students for upper-division physics courses

Future Work

- A math methods course can be developed, bridging the knowledge gap between calculus and physics
- Research to find more concepts that students know well or do not know well after calculus
- Research on what students know of unit vectors after calculus could be conducted
- Specific troubles for each math concept need to be explored so the math methods course helps bridge the two disciplines, rather than repeat calculus
- A similar analysis could be done with Quantum Physics and Linear Algebra courses

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References

[1] Nguyen, et al.
[2] Vega, et al.
[3] Dalton, et al. in prep