Modeling Student Understanding of Period, Frequency, and Angular Frequency

Nicholas T. Young and Andrew F. Heckler
Department of Physics, The Ohio State University, Columbus, OH, 43210

Introduction

- Determining and understanding period, frequency, and angular frequency are essential skills and concepts in physics.
- Multiple representations are an important operational way of measuring skills and "understanding."
- In pilot studies, we found students have difficulty extracting information from graphical representations and performing calculations involving the period (T), frequency (f), and angular frequency (ω).

- **Goal: Classify student understanding according to the skills they have mastered and search for possible hierarchies in their knowledge.**

Methodology/Results

		ω=2πf	
		No	Yes
T=1/f	No	152	12
	Yes	275	151

		ω=2π/T	
		No	Yes
T=1/f	No	116	48
	Yes	189	237

		ω=2πf	
		No	Yes
ω=2π/T	No	296	9
	Yes	131	154

Tables 1a, b, c: Cross tabulation of the number of students who demonstrated mastery of the indicated equations (no = not mastered, yes = mastered).

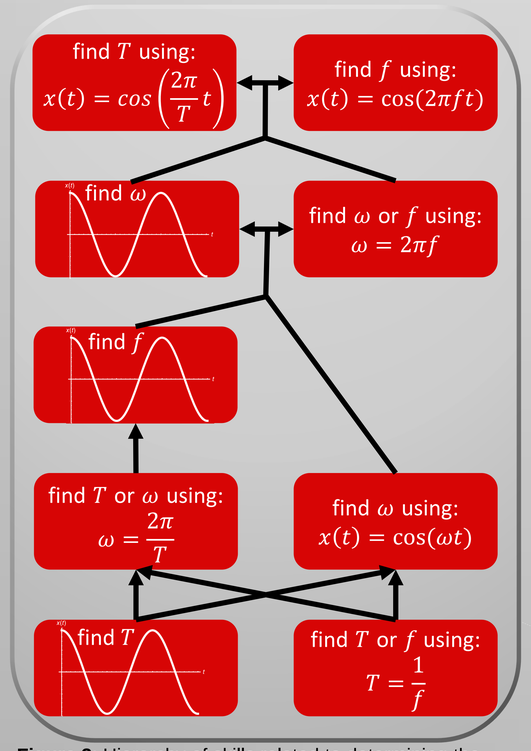
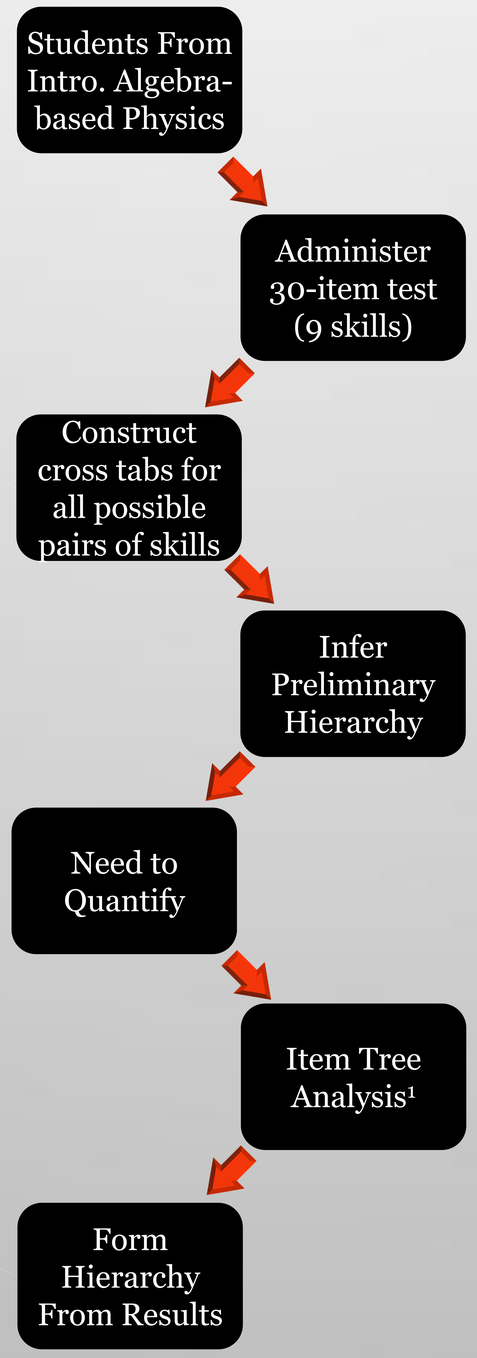
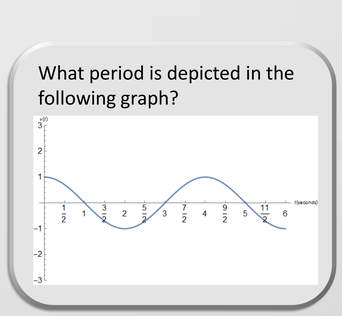


Figure 3: Hierarchy of skills related to determining the period, frequency, and angular frequency generated from item tree analysis[1]





The equation $x(t) = 7\cos(\frac{2\pi}{5}t + 3)$ describes the motion of a mass on a spring. What is the angular frequency of this motion?

A harmonic oscillator has a frequency of 1/4 Hz. What are the angular frequency and the period?

Figures 1a-1c: Sample graphical and equational questions and a sample calculation from the 30-item test.

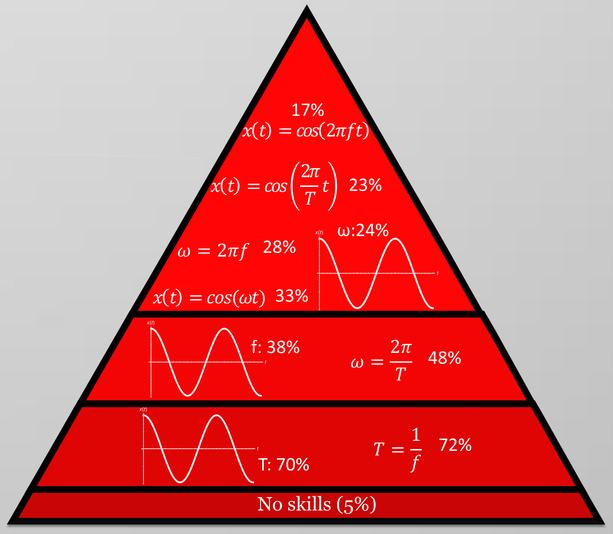


Figure 2: Preliminary hierarchy of skills related to determining the period, frequency, and angular frequency. Percentage of students who demonstrated mastery of each skill is indicated.

Conclusions

- **Student understanding of the period, frequency, and angular frequency can be modeled as a multi-layer hierarchy.**
- Post instruction, less than a quarter of the students are at the top level, indicating a need for essential skills training.
- Understanding the period and frequency relationship is a prerequisite to understanding any relationship involving the angular frequency.
- Strong correlation between score on calculation questions and scores on graphical and equational questions

Future Research

- Extend investigation to calculus-based Physics students. Preliminary investigations indicate similar hierarchy and level of mastery.
- Optimize our online Essential Skills practice platform to account for hierarchy of skills

Acknowledgements

We would like to thank Nathaniel Amos, Ryan Badeau, Abby Bogdan, and Daniel White for their assistance and feedback throughout this project. Funding for this research was provided by the Center for Emergent Materials: an NSF MRSEC under award number DMR-1420451.

References

[1]Unlü, A., & Sargin, A. (2010). DAKS: an R package for data analysis methods in knowledge space theory. *Journal of Statistical Software*, *37*(2), 1-31.