Teaching Relativity to undergraduates in North Dakota.

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Our focus here is on undergraduate instruction especially at the sophomore level. It seems very little relativity is taught at the introductory level. We will explore relativity taught at BSC and Modern Physics courses at North Dakota's Research Institutions.

Relativity at UND/NDSU

The University of North Dakota (UND) has a month relativity taught at Grad level EM II(Jackson) and Phys 253(Modern Physics) at undergrad. At North Dakota State University (NDSU)Undergrads take Modern Physics (Phys 350) as an introduction to Special Relativity. Terry Pilling taught a graduate course at NDSU in Relativity as a Special topics course but there are no specific Graduate courses in Relativity at NDSU. Graduate students are likely to have some relativity in E&M.

-Bill Schwalm and Tim Young presented a series of talks on the UND Campus on Relativity 2005/2011 that were well received.

-Tipler and Llewellyn in their Modern physics book include General Relativity and Gravitational waves.

-Relativity at Junior level barely touches on general relativity. E&M (Phys 328)goes deeper into relativity.

Relativity at BSC

- At Bismarck State College (BSC) Physics II Electricity & Magnetism has had little to no relativity in the last 6 years
- Almost 4 years a go a student expressed her frustration at the kind of physics in University Physics I think she was hoping for more pizzazz-Where was all that stuff about black holes ,worm holes and $E=MC^2$?
- So began the journey to "Modernize" University Physics and add some pizzazz
- Matter and Interactions (M&I) is the curriculum I adopted last Fall. Modern Physics is a thread throughout the entire text. I find the emphasis on micro and macroscopic aspects of something like K (spring constant) to be unique & useful to BSC students.

Questions

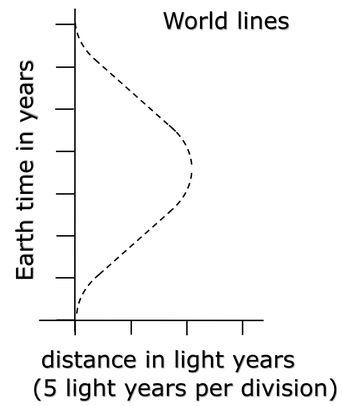
1. Is it worthwhile to teach relativity at the sophomore level to pre-engineering students or should we teach more relevant physics like AC Circuits etc.?

2. How can we teach relativity such that it dovetails well with Newtonian physics?

3. If you teach relativity in Phys 252 do you give it a week and how well does that work ?

Only 6 weeks……..(Tipler and Llewellyn-Modern Phys.)

- WK1- Intro to relativity, Michelson-Morley experiment (1-1)
- WK2-Lorentz transformation, time dilation &Twin paradox (1-3,1-4,1-6)
- WK3- Length contraction, pole-barn paradox (1-4,1-6)
- WK 4- Relativistic momentum and energy (2-1, 2-2,2-3)
- WK 5-Inelastic collisions,4-vectors,invariant mass (2-1, 2-2,2-3)
- WK 6-Introduction to curved space and general relativity (2-5)



A thread…..(e.g. Chabay and Sherwood M & I)

First Semester

- Momentum at high speeds $\vec{P} = \gamma m\vec{v}$
- The principle of relativity (Section 1.12 page 33 M&I)
- Momentum principle and energy principle (page 216-220 M&I) start off with relativistic underpinnings
- The mass of a multiparticle system & Nuclear Binding /fission etc.(page 258-262 M&I)
- Relativistic Momentum and energy : Collisions (Page 400-404 M&I)

Second semester

- "On the electrodynamics of moving objects": Alice, Bob and Einstein (page 824- 826 M&I)
- Relativistic field Transformations (page 846-850 M&I)
- Twin Paradox is never explored in this curriculum-where would it fit??

Alice and Bob

-Alice and Bob observe two moving protons. Bob is at rest while Alice moves alongside the two protons
-Alice sees pure electric repulsion while Bob sees electric repulsion and some magnetic attractive force
-Alice's timer advances slower than Bob's timer

Concluding Remarks

UND/NDSU future directions

- Modern Physics will be modern physics ☺
- Graduate level Cosmology(with general relativity) in the works at UND.
- University Physics sequence might have some relativity for a week (depending on the Instructor).

BSC future directions

- Matter and Interactions: Spend more time in Week 1 and week 2 on principle of relativity
- Expose students to gravitation (a'la)/au Einstein. (page 116 M&I)
- Possibility of teaching relativity to pre-biology/ pre-med students.
- Inject more conceptual General relativity in the Intro to Astronomy sequence.

References

1. Matter and Interactions R. W. Chabay and B. A. Sherwood (2015)

2. Fundamentals of Physics Extended Edition 9th Edition Halliday and Resnick and Walker.

3. Modern Physics P.A. Tipler and R.A. Llewellyn 6th Edition (2012)

4. Introduction to Electrodynamics, D.J. Griffiths 4th Edition (2013)

5.Six Ideas that shaped Physics Unit R: The laws of Physics are Frame-Independent, T.A. Moore 2nd Edition

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