PHYS 518
Advanced Topics: An Introduction to Spacetime Physics

Truman State University - Fall 2000

Meetings: ?? MW 12:30p-1:20p, Th 4:30p-5:20p Barnett Hall ???

Instructor: Rob Salgado
office: Barnett Hall 263
voice: (660)-785-4072
email: `rsalgado@truman.edu` ⟵ "the BEST way to reach me"
WWW: `http://www2.truman.edu/~rsalgado/`

Office hours: consult the webpage above
or DROP BY MY OFFICE or MAKE AN APPOINTMENT (by email).

Description: This course is intended to provide a thorough physical and mathematical presentation of Special Relativity and an introduction to various topics in relativistic physics (e.g., relativistic particle-mechanics and electrodynamics).
[Prerequisite: Calculus and General Physics I and II. Some linear-algebra and vector-calculus would be helpful.]

Textbook: *A Traveler's Guide to Spacetime (Moore)*, which will be a source of problems. Additional materials will be available from the website.

If you are not happy with the textbook, find another one from the library! (I did this for every class I took!)

Electronic Materials: I will maintain a webpage that lists the assigned problems and solutions. Please refer to:
`http://www2.truman.edu/~rsalgado/SpacetimePhysics/`

Exams: There are TWO exams, tentatively scheduled as

- FIX this

Exam 1 Week 6, in class + takehome

Exam 2 Week 11, in class + takehome

Grades:

- 55% Homework
- 20% Exams
- 25% Final Project and Presentation

This class is not graded on a curve.
A=90ish, B=80ish, C=70ish, D=60+, F<60.

Course outline

- **What is relativity?** A parable about Three Surveyors.
  The **Aristotelian Spacetime**, its Causal Structure (Absolute Time), and Absolute Space. Learning to read this Spacetime Diagram.
  A sophisticated review of **Euclid's Geometry** from a Trigonometric, Analytic, and Vectorial viewpoint. The Euclidean Metric Tensor and The Euclidean Rotation Transformations.

- **Galileo's Principle of Relativity** and the fall of Absolute Space.
  The Galilean Spacetime and its Causal Structure (Absolute Time). A gentle introduction to Galilean Physics from a new Trigonometric, Analytic, and Vectorial viewpoint. Learning to read this Spacetime Diagram. The Galilean Metric Tensor and The Galilean Boost Transformations.
  A **vector-calculus review** of **Maxwell's Equations of Electrodynamics** and the **Wave Equation** (Light). Its conflict with Galilean Relativity. The Michelson-Morley experiment.

- **Einstein's Principle of Relativity** and the fall of Absolute Time.
  The Einstein-Minkowski Spacetime and its Causal Structure. The Light Cone and THE universal speed limit. The Light Clock. Discussion of "Time dilation", "Length contraction", "Doppler effect", and "Twin paradox" using the *Radar-Method* and the *Bondi K-calculus* (Say NO to γ!).

- The Einstein-Minkowski Metric Tensor and The Lorentz Transformations.
  Discussion of the above effects and paradoxes and their nonrelativistic limits using *Minkowskian-trigonometry* and 4-*vectors*. Covariant techniques for unambiguous frame-independent calculations. Velocity and Acceleration. The Thomas Precession.

- SHORT EXAM #1

- "From vector calculus to **tensor calculus**."
  Introduction to **Relativistic Particle-Mechanics**. Worldlines. Mass. "$F = ma$". Energy-Momentum and its conservation. "$E = mc^2$". Relativistic Rockets. (2 weeks)

- Introduction to **Relativistic Electrodynamics**—a classical field theory.
  Lorentz Force, Maxwell's Equations and the Wave Equation in tensorial form. The Vector Potential A_a and the Maxwell Tensor-Field F_{ab}. The Stress-Tensor T_{ab}. The Action Principle. (2 weeks)

- SHORT EXAM #2

- (Time-Permitting) Introduction to **General Relativity**. Metric and Curvature Tensor-Fields. Geodesics. The Einstein Field Equation $G_{ab} = 8\pi\kappa T_{ab}$. Causal Structure. A pictorial discussion of observers near the event horizon of a black hole.

- STUDENT PRESENTATIONS