

HSSP: Relativity Syllabus

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This syllabus is tentative, especially the last lecture.

1. Review: Classical Mechanics and Matrices

- Newton's Laws
- Conservation of momentum and energy for non-interacting and interacting systems
- Galilean transform and reference frames
- Matrices: vector spaces, matrix multiplication, etc.

2. Foundations of Relativity: The Lorentz transformation

- Reference Frames
- Derivation of the Lorentz transformation
- Invariant interval (timelike, spacelike, lightlike intervals)
- Low velocity limit

3. Properties of the Lorentz Transformation

- Length contraction
- Time dilation
- Velocity addition
- Simultaneity
- Doppler shift

4. Spacetime Diagrams and Relativistic Paradoxes

- Spacetime diagrams (with a focus on how to change frames)
- Another look at length contraction, time dilation, etc.
- Using spacetime diagrams to interpret the pole-in-barn paradox and twin paradox

5. 4-vector formulation

- 4-vectors
- Invariant inner product
- Proper time and 4-velocity
- 4-acceleration

6. Relativistic Dynamics

- Covariant equations
- 4-Force = $m \cdot$ 4-acceleration
- Energy, momentum, and mass
- Massless particles
- Conservation laws

7. Beyond Relativity: Accelerating Reference Frames and Curved Space (Subject to change)

- Physics in an accelerating frame
- Gravity and acceleration
- General relativity and the curvature of space