Spring Quarter 2026 – UCSB Physics 25
Homework 2
Due Friday, April 17, 5 pm

- **Problem 1**

  Consider a system S and a system S' moving with velocity v with respect to S in the positive x-direction. Imagine a light pulse emitted in the positive y direction in the S frame. Use the law for the relativistic transformation of velocities to show that the speed of the light pulse in S' is also c.

- **Problem 2**

  Consider systems S and S' as defined in Problem 1. Let an object in S travel with velocity $\vec{u}$ with $u < c$. Take $v < c$. The velocity of this object in S' is $\vec{u}'$. Show that in all cases $u' < c$.

  Hint: show that $c^2 - u'^2 > 0$.

- **Problem 3**

  A star is known to be moving away from earth at a speed of 4×10^4 m/sec. This speed is determined by measuring the shift of the H_α line ($\lambda = 656.3$ nm). By how much and in what direction is the shift of the wavelength of the H_α line.

- **Problem 4**

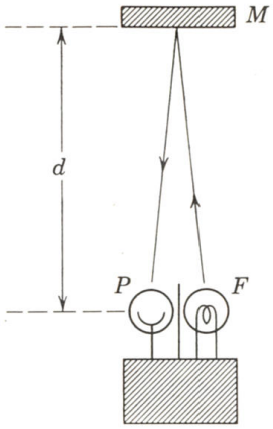
  A stationery observer on earth sees spaceships A and B moving in the same direction toward earth. Spaceship A has speed $0.50c$ and spaceship B has speed $0.80c$. Determine the velocity of A as measured by an observer at rest in B.

- **Problem 5**

  In frame S particle 1 is at rest and particle 2 is moving to the right with velocity u. Now consider a frame S' which, relative to S, is moving to the right with velocity v. Determine the value of v such that the two particles appear in S' to be approaching each other with equal and opposite velocities.

- **Problem 6**

  A possible clock is shown in the figure below. It consists of a flashtube F and a photocell P shielded so that each views only the mirror M, located a distance d away, and mounted rigidly with respect to the flashtube-photocell assembly. The electronic innards of the box are such that, when the photocell responds to a light flash from the mirror, the flashtube is triggered with a negligible delay and emits a short flash towards the mirror. The clock thus "ticks" with a peiod $2d/c$ when at rest.

  (a) Suppose that the clock moves with a uniform velocity v, perpendicular to the line from PF to M, relative to an observer. Using the second postulate of relativity, show by explicit geometrical or algebraic construction that the observer sees the relativistic time dilatation as the clock moves by.

  (b) Suppose that the clock moves with a velocity v parallel to the line from PF to M. Verify that here, too, the clock is observed to tick more slowly, by the same time dilatation factor.