Problem R1

For this exercise, assume that velocity of light is 5 miles per hour.

Dave starts from home at 6 am and walks down a long straight road at 1 mile per hour. His friend Erin starts (from the same home) 9 hours later (at 3 pm) and follows Dave, walking at 2 miles per hour. Draw their world lines (to scale) on a suitable spacetime diagram, and determine graphically the coordinates of the event E: Dave and Erin meet.

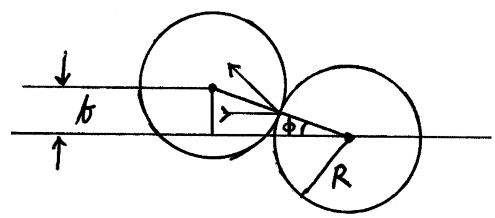
Their dog Fido leaves home just when Erin does, pursuing Dave at 4 miles per hour, meets Dave, reverses direction and returns to Erin (also at 4 miles per hour), reverses to Dave, etc., until the event E. How far does Fido walk? Now Dave, Erin and Fido each carry ordinary clocks, all of which have been synchronized at 6 am, the moment when Dave leaves. What are the readings of each of the 3 clocks at the event E, when they are all back together again? (Partial answer: Erin's clock reads 11:15 pm.)

Problem R2

Derive the scattering formula,

$$b = 2R\cos\left(\frac{\theta}{2}\right),$$

for two solid spheres of radius R. The figure might be of some help.



Problem R3

How quickly does an electron orbiting a proton spiral into the proton? In other words, how long should hydrogen atoms survive, from a classical point of view? The electron radiates energy at a rate given by the Larmor formula, named after Joseph Larmor (1857-1942) who first derived it in 1897,

$$P = \frac{2}{3c^3}\frac{e^2}{4\pi\epsilon_0}\frac{v^4}{r^2}.$$

As it radiates, its orbital radius r decreases, and to answer the question above we will need to know the rate at which r changes. Since the chain rule gives

$$P \equiv \frac{dE}{dt} = \frac{dE}{dr}\left(-\frac{dr}{dt}\right),$$

if you can obtain the relationship $E(r)$, then you can obtain a differential equation involving dr/dt, which can then be solved for $r(t)$. The minus sign denotes the fact that as the electron radiates, r decreases with time. (The answer is about 10^{-11} s.)

Problem R4

Enumerate the lowest 15 energy levels in a three-dimensional symmetric box (along with their quantum numbers). There should be one level that is accidentally degenerate. Which one is it?