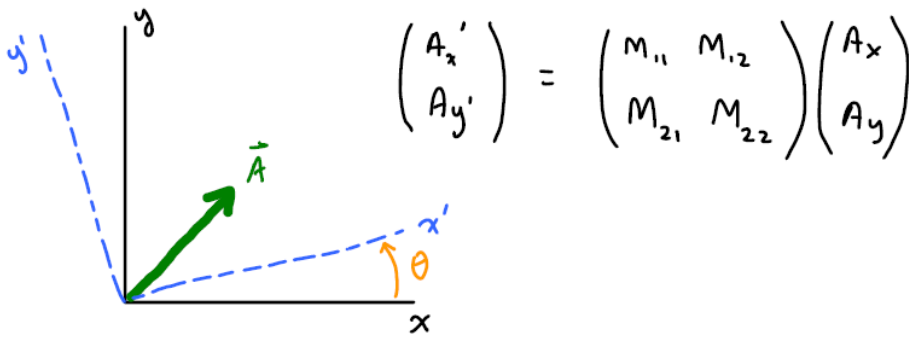


Physics 123 – Spring 2013 – Workshop module 2

1. Two event in frame S occur at coordinates give by spacetime 4-vectors $A = (x_0=5, x_1=3, x_2=6, x_3=-2)$ and $B = (x_0=2, x_1=5, x_2=4, x_3=-2)$, respectively. Is it possible that these events are causally connected? (units in meters and seconds)
2. Find the elements of the matrix that rotate the 2d vector \vec{A} (in the x-y plane) clockwise by angle θ about the z axis. The elements of the rotated vector are denoted by primes. (This is equivalent to the rotation of the axes counter-clockwise from the unprimed to the primed axes as I have drawn.) *Hint: The elements will each be $\pm\sin\theta$ or $\pm\cos\theta$.*



3. How would the Lorentz transformation matrix that we used in class change if the relative motion between the two reference frames were along the y direction instead of the x direction?
4. An optics major who has been watching too much Big Bang Theory argues in court that he went through a red light ($\lambda=650$ nm) because he was going so fast that the light appeared green ($\lambda=550$ nm). How fast did the optics major need to drive in order for this argument to be true?
5. In beta decay, a neutron decays into a proton and an electron. What kinetic energy would you expect the electron to have in such a decay (ignoring effects due to the surrounding nucleus)? In reality, the kinetic energy distribution is smeared out and has a maximal value which is what you calculate in the first part of this problem. Can you imagine a reason for this to be true?
6. A helium nucleus is made up of two protons and two neutrons. Yet, if you measure the mass of a helium nucleus you will find it to be less than that of the sum of its constituents. (Prove this to yourself by doing the calculation.) Why should this be and what does it mean?