Oscillations of a Cart with Springs and Variable Mass

This is an ambitious laboratory exercise. Your goal is determine the mass of one of the frictionless carts and also the (effective) spring constants for the springs holding the cart on either side, by measuring the oscillation frequency as a function of mass that is added to the cart. Of course, as always, report your results for the cart mass and the spring constant along with an estimate of their uncertainties.

Your cart has two springs attached, one on each side. A metal strip magnetically attached to the cart, extending to one side, will intercept the beacon of the sonic ranger. Some of you have springs with different spring constants, and there are more of everything in the bins at the front of the classroom. You also have the long, black metal weights which you can add to the cart. This setup is fraught with sources of systematic error. Pay attention to your data and think about what you should be checking up on.

Again, your goal is to determine both the mass of the cart and the spring constant, just from a measurement of the oscillator frequency. Try to come up with a relationship between the frequency and the "added" mass, and use this to figure out how to plot your data so that you can determine the mass of the cart and also the spring constant.

Here is a list of the sort of things you should be doing.

- For one pair of springs, measure the frequency for different "added" masses.
- Make a plot of $1/\omega^2$ as a function of "added mass" showing a straight line dependence.
- Determine values for the "spring constant" k and the mass of the cart, derived from slope and intercept of the straight line above. Try to come up with values for the uncertainties on these quantities, from your estimate of the uncertainty on the slope and intercept.
- Make an independent measurement of k from the extension of the spring from some hanging mass(es). Estimate the uncertainty in k from the extension measurements. (This is the same idea as last week's lab.)
- Make an independent measurement of the cart mass, using one of the scales in the classroom.

After all this is done, you should have discovered two things. First, the spring constants you measured above should differ from each other by a factor of two. Why? You should explain your answer by using the equation of motion for the cart, and not just say its because there are two springs. Correcting for the factor of two, are the results the same within your uncertainties? Did you measure the spring constant of each of the two springs, or did you make the assumption that they were identical? If the latter, maybe you wantto check and see how good is that assumption.

Your second discovery should be that the mass of the cart you derive from the straight line is more than that you got from the scale(s). Maybe 10% larger, maybe more, but in any case, well outside your experimental uncertainties. Can you think of a reason for that? Can you think of a way (or ways) to check your reasoning, at least to see if it is a plausible explanation?