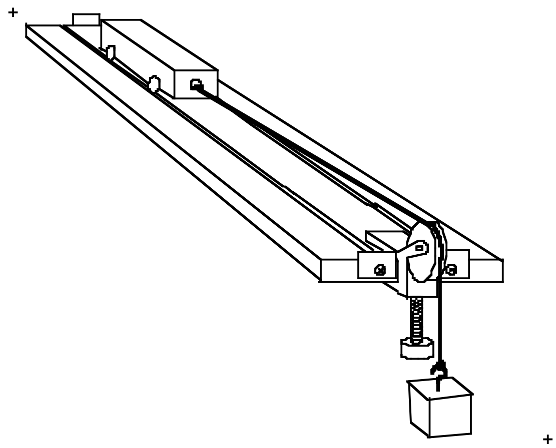
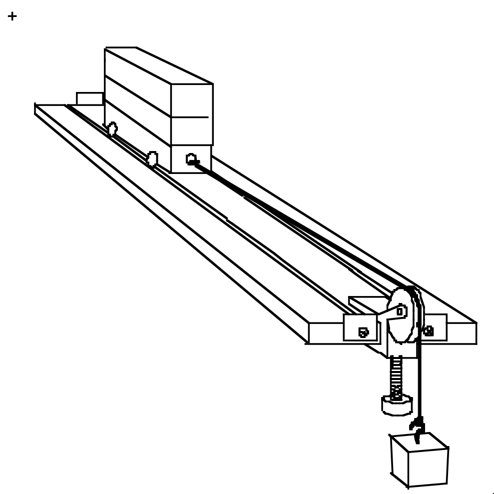
Revised track apparatus with a pulley to demonstrate Newton's laws.

If you already have the collision cart and track demonstration apparatus for showing momentum and energy conservation during collisions, it can be easily revised with the addition of a pulley and hanging mass to demonstrate popular two mass problems that illustrate Newton's laws. The basic apparatus is illustrated below:



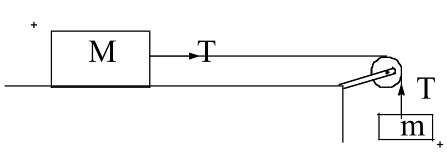
In order to fit the pulley on one end, the single bumper on that end will have to be removed, split in half and reattached to make room to install the pulley. A hanging mass is provided that is about half the mass of the cart, or of one of the 2x4 masses. The supplied string is long enough to accelerate the cart nearly the full length of the track as the hanging mass falls to the floor. One end of the string is attached to a hook on the hanging mass and the other end is "attached" to the cart with a steel washer that can be held by the magnet on the cart. (In the illustration the pulley is drawn larger to show its attachment but actually the string will stretch parallel to the surface of the track.)

On the right is shown the apparatus with two of the 2x4 masses on the cart. In this case, if we call the hanging mass "m", then the rolling mass will be "6m". The argument to find the acceleration of the rolling mass and the hanging mass can be easily found by recognizing that the nearly frictionless pulley with its relatively small moment of inertia allows stating that the tension is nearly the same on either side of the pulley.* (A common student mistake when first solving this situation is to simply say the force accelerating the rolling mass is the weight of the hanging mass, but it must be appreciated since the hanging mass is also accelerated, the tension in the string attached to it must be reduced by ma. (That is, T = mg –ma)



As an actual lab experiment, a horizontal distance along the track can be marked and measured, and then the time for the accelerating mass (from rest) can be measured for several runs. Using this time and distance the acceleration can be calculated. With the illustration on the right above, the acceleration should be: a = g/7. (The mass "m" falls out.) Depending upon the units used in the time and distance measurements, the acceleration can be computed in terms of g.

* Simple argument for sliding and hanging mass acceleration problem by equating tensions:



(Assuming frictionless surface, acceleration to the left of M is: T = Ma. Acceleration of m downward is given by (make downward a positive): - T + mg = ma or T = mg - ma.
Equating tensions: Ma = T = mg - ma, solving for a:
a = mg/(M + m) in the case above M = 6m hence a = g/7