6. TOTALLY INELASTIC COLLISIONS

Equipment List:

- One air track, blower, blower hose and power cord
- One digital photogate and one accessory photogate
- Two gliders
- One flat plastic accessory kit
- Digital Pan Balance (or just a triple beam pan balance)

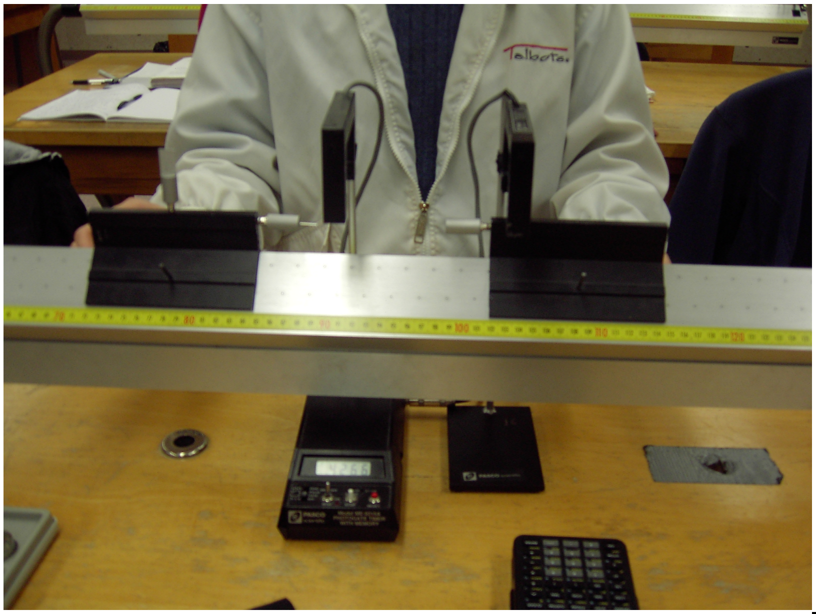
Purpose:

In this lab you will investigate momentum conservation and kinetic energy losses in a totally inelastic collision.

Procedure:

After setting up your track, leveling it, finding the effective lengths, getting your photogates optimally spaced, and all other relevant aligments, take some practice runs before taking actual data. When you are ready, perform five runs. A "run" consists of gently pushing the first glider and letting go before it goes through the first photogate (its velocity through the gate should be less than 1 m/s and even less than 0.1 m/s for best results; you don't want any "clatter" when the two gliders collide). The second glider should have zero velocity before the collision. The two gliders collide, stick together, and then go through the second photogate. The photogates should be as close together as possible to minimize systematic errors. The second photogate should record its time as soon *after* the collision as possible and the first photogate should measure its time *just before* the collision as much as is possible. The initial velocity of the first glider does not have to be the same for each run because the analysis, as discussed below, is concerned only with the *difference* between the initial and final momentum.

To have the gliders stick together, use two special cylinders from your accessory kit. One cylinder has some wax in one end; another cylinder has a small needle covered with a protective cork cover. Together, the needle and the wax cylinders allow the gliders to stick together after they collide. It doesn't matter which glider has which cylinder.



In the photograph above, glider 1 (on the left) has the only flag. Its flag triggers the left photogate for the glider's time before the collision. Then very soon after the collision, the same flag on glider 1 will trigger the right photogate. You can see how close the two photogates can be to one another (which is desirable) when using this method.

Theory:

Derive a formula that predicts the fractional loss in the total kinetic energy of both gliders after the collision compared to before the collision in terms of the two masses only.

Data:

Record the mass of each glider, including all attached cylinders. Find the effective length for each photogate with the flag that goes through it. Perform your runs and record the times. Use gate mode and 0.1 mS resolution. The numerical distance between the photogates is irrelevant.

Calculations:

Calculate the initial and final momentums and initial and final kinetic energies for both gliders for all five runs. For each run, calculate the change in momentum (remember to use the units of kg m/s) between the initial and final conditions. If the momentum is conserved, you would expect this change to be zero. Because of real dissipative external forces, the actual momentum change will tend to be negative. Use the "statistical method" to find the average **fractional** change in momentum and its absolute uncertainty. By "fractional" change in momentum, it is meant the change in momentum divided by the initial momentum; this gives a sense as to how large the momentum change is relative to the initial value. Also, due to random flucuations in your measurements, you may find your change in momentum to be sometimes positive and sometimes negatve, this is acceptable. Calculate the fractional percent loss of kinetic energy for each run. Then calculate the average fractional kinetic energy loss and its uncertainty by the statistical method. From the derivation in the theory section above, you can see how close your experimental loss is to the theoretical loss. Would you expect the experimental loss in energy to be greater or less than the theoretical? Why?

Analysis:

Compare your experimental results to your theoretical predictions for the momentum and the kinetic energy of your collsions.

Conclusion:

Well, how did it go? Suggestions for improvements?

Sample Collsion in AVI format (the arrangement shown could be improved, do you see how?)

Tips:
1. To make sure you are not making blunders, one check is to see that if the gliders are of equal mass (and they are pretty close), then from momentum conservation, you would expect the final velocity to be half the initial. This means that you would expect your second time to be twice your first time.
2. Use "Gate" mode on your phototimer, but to get the second time interval after the collision, you have to **subtract** the final readout on the photogate from the first readout (where the first readout gave you the first time).
3. To minimize some systematic errors, do a few ones in one direction on the track and then do the same number in the opposite direction. That is, have the first glider, before the collision, be going in the opposite direction. This technique will tend to eliminate the systematic errors introduced by a non-level track.
4. Using uncertainty propagation, you can also generate an absolute uncertainty for the expected fractional decrease in the kinetic energy. This will then give you two most probable ranges to check for an overlap agreement. One from the experimental kinetic energy loss, the other for the expected loss.