EXPERIMENT #8 - PHYSICS230

Linear Air Track

OBJECT: To study one dimensional motion on a linear air track, find a coefficient of restitution, and use it to study the effects of a partially elastic collision.

EQUIPMENT: linear air track, two air cars, timing device, balance scale, meter stick

GENERAL DIRECTIONS:

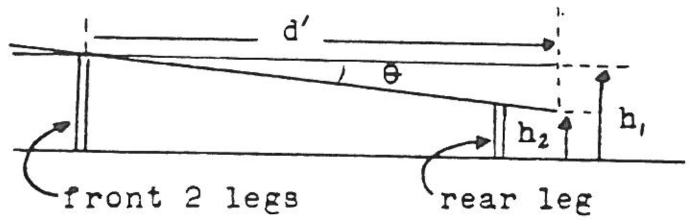
A. Determinining the coefficient of restitution:

1. Adjust the air track so that it is level. The track is level if an air car remains stationary on the track.

2. Record the height, h_1, of some point on the end of the track (supported by only the single leg) relative to the table directly below the point. Also, record the distance d' from the line joining the two support legs at the beginning of the track to the point used to measure h_1. The distance d' should be parallel to the air track.

3. By adjusting the single leg at the end of the track (or by using the metal elevation blocks), raise or lower the end of the track by about one inch. Record the new height, h_2, of the same point that was used to find h_1.

4. Compute the angle of the track by using trigonometry.



5. By releasing an air car (initial velocity is zero) for a distance d down the air track and recording the time to go this distance, compute the acceleration a' where $d = \frac{1}{2}a' t^2$. The value of d should be about the length of the track. The time may be found by a stop watch or by some other suitable means.

6. Compute the gravitational acceleration component of $a = g \sin \theta$ along the track.

$$g = 9.80 \text{ m/sec}^2$$

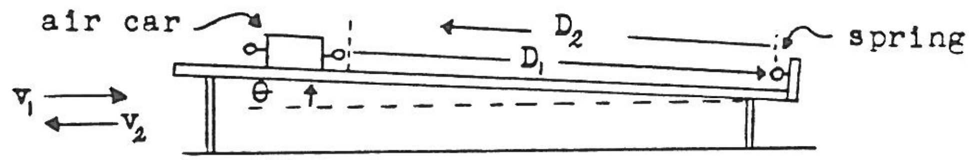
Calculate the acceleration difference of $\Delta a = a - a'$, and find the mass of the air car on a balance scale. Using this information compute the average drag or frictional force acting on the air car. Compute the per cent change in the acceleration a due to friction

$$\text{change} = \frac{\Delta a}{a} \times 100\%$$

Is this a significant change? Is this an accurately measured change?

7. As done before, release the air car from rest at the beginning of the track. Let it go the whole length of the track, hit the spring at the other end, and return. The car should come to a temporary stop on its return trip at a distance less than the distance the car traveled down the track.

Record carefully the distance D_1 the car traveled down the track and the distance D_2 the car traveled up the track before coming to a stop and reversing its direction.



8. Using the values for a', D_1, and D_2 and the equations of motion for constant acceleration, find the speed v_1 of the car just before hitting the spring and find the speed v_2 of the car just after hitting the spring.

9. Find the per cent of energy lost in the spring during the collision by comparing the energy lost to the kinetic energy just before the collision.

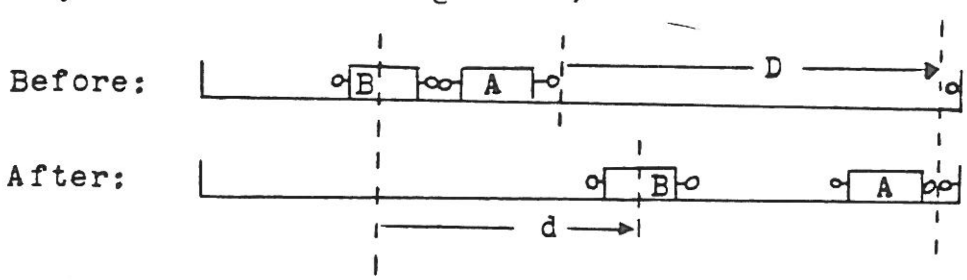
10. Calculate the coefficient of restitution, e, for the spring system where, in general,

$$e = - \frac{v_f - V_f}{v_i - V_i}$$

where
- v_i = velocity of body A before collision
- V_i = velocity of body B before collision
- v_f = velocity of body A after collision
- V_f = velocity of body B after collision

B. Collision of two air cars:

1. Adjust the air track so that it is level. Place one air car (car A) near the center of the track. Push the other car (car B) towards car A for a collision.* After the collision car A moves a distance D until it hits the end of the track. When this occurs, measure the distance d that car B has gone. (If car B moves backward, then d will be negative.)



Do this experiment at least three times and use the best value of d or an average value.

*Since it is assumed that the coefficient of restitution for part B is the same value that was calculated for part A, you should try to choose the air cars for part B so that the colliding springs are very similar to the colliding springs in part A.

2. Using the best (or average) d value and the measured value of D along track, compute the ratio of the masses of the cars.

$$\frac{M}{m} = \frac{D - d(1+e)}{De} \quad \cdots\cdots\cdots \quad \begin{cases} M = \text{mass of car A} \\ m = \text{mass of car B} \\ e = \text{coefficient of restitution} \end{cases}$$

3. Weigh car A and B on a balance scale and find M and m. Compute the error where

$$\text{error} = \frac{\left(\frac{M}{m}\right)_{\text{track}} - \left(\frac{M}{m}\right)_{\text{scale}}}{\left(\frac{M}{m}\right)_{\text{scale}}} \times 100\%$$

4. Derive the equation $\frac{M}{m} = \frac{D - d(1+e)}{De}$.