AE405 LAB-3 Laws of collision/ demonstration track

Fig.1: Experimental Setup

PRINCIPLE AND TASK

The velocities of two carts, moving on a demonstration track, are measured before and after collision, for both elastic and inelastic collision. The goal of this experiment is to demonstrate the laws of collision.

1.*Elastic collision*: A cart collides with a second resting cart at a constant velocity. A measurement series is conducted by varying the mass of the resting cart: The corresponding velocities of the first cart before the collision and the velocities of both carts after it are to be measured. Plot the following parameters as functions of the mass ratio of the carts.

2.*Inelastic collision*: A cart collides with a constant velocity with a second resting cart. A measurement series with different masses of the resting cart is performed: the velocities of the first cart before the collision and those of both carts, which have equal velocities, after it are to be measured.

Equipment

Tube with plug

Needle with plug

Fork with plug

Rubber bands for fork with plug, 10pcs

Plate with plug

Magnet w.plug f.starter system

Slotted weight, black, 10 g

Slotted weight, black, 50 g

Light barrier

PHYWE Timer 4-4

Portable Balance, OHAUS CX2200

Demonstration track, aluminium, 1.5 m

Cart, low friction sapphire bearings

Starter system for demonstration track

Weight for low friction cart, 400 g

Shutter plate for low friction cart, width: 100 mm

Holder for light barrier

End holder for demonstration track

Connecting cord, 32 A

THEORY

In the elastic collision of two bodies having masses m_1 and m_2 , kinetic energy and momentum are conserved:

$$\frac{\vec{p}_1^{\,2}}{2m_1} + \frac{\vec{p}_2^{\,2}}{2m_2} = \frac{\vec{p'}_1^{\,2}}{2m_1} + \frac{\vec{p'}_2^{\,2}}{2m_2}$$

$$\vec{p}_1 + \vec{p}_2 = \vec{p'}_1 + \vec{p'}_2$$

Where, $\overrightarrow{p_1}$, $\overrightarrow{p_2}$ are the moments before the collision and $\overrightarrow{p_1'}$, $\overrightarrow{p_2'}$ those after the collision.

Due to the unidimensional sequence of movement, we will dispense with the vectorial notation. For a central elastic with $p_2 = 0$.

$$p_1' = \frac{m_1 - m_2}{m_1 + m_2} \cdot p_1 = -\frac{1 - \frac{m_1}{m_2}}{1 + \frac{m_1}{m_2}} \cdot p_1$$

$$p_2' = \frac{2m_2}{m_1 + m_2} \cdot p_1 = \frac{2}{1 + \frac{m_1}{m_2}} \cdot p_1$$

From the contribution of the impulse p, the energies E are calculated with $E = p^2/2m$

$$E_1' = -\left(\frac{1 - \frac{m_1}{m_2}}{1 + \frac{m_1}{m_2}}\right)^2 \cdot E_1$$

$$E_1' = -\frac{4}{(1 + \frac{m_1}{m_2})^2} \cdot \frac{m_1}{m_2} \cdot E_1$$

In an inelastic collision, only the momentum is conserved. In addition, the velocities after the collision are equal:

$$p_1' = \frac{m_1}{m_2} \cdot p_2'$$

Therefore; $p_1' = \frac{1}{1 + \frac{m_2}{m_1}} \cdot p_1$

$$p_2' = \frac{1}{1 + \frac{m_1}{m_2}} \cdot p_1$$

The following is obtained for the energies of the two carts after the collision:

$$E_1' = \frac{1}{\left(1 + \frac{m_2}{m_1}\right)^2} \cdot E_1 \qquad E_2' = \frac{1}{\left(1 + \frac{m_1}{m_2}\right)^2} \cdot \frac{m_1}{m_2} \cdot E_1$$

SETUP AND PROCEDURE

The experimental set-up is performed as shown in Fig. 1. The starting device serves to start the cart; three defined and reproducible initial energies can be selected with the various latch positions. It is recommended that the second position is used for all measurements.

Connect the light barriers with input jacks 1 and 3 on the timer [connect jacks having the same colours (red and yellow) and the two earth (ground) jacks to each other]. Select the "Collision experiments" operating mode (2 double arrows printed on the front panel). In this mode, up to two shading periods are measured and displayed for each light barrier. When varying the mass ratios, ensure that the additional masses are added symmetrically in each case. Before initiating the measurements, check the track's adjustment. The momentum is determined by measuring the velocity of the cart. For this purpose, the time during which the screen fitted on the cart impinges on the light barrier is used, in accordance with:

$$v = \frac{\Delta s}{\Delta t}$$

($\Delta s = length\ of\ screen, \Delta t = shading\ time$)

EVALUATIONS

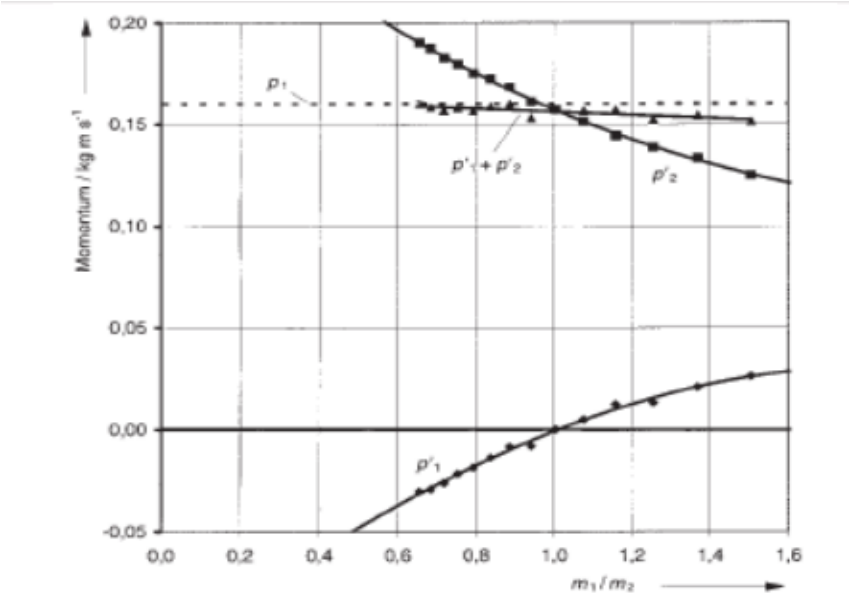

Fig.2: Elastic collision: moment after the collision as functions of the mass ratio of the carts.

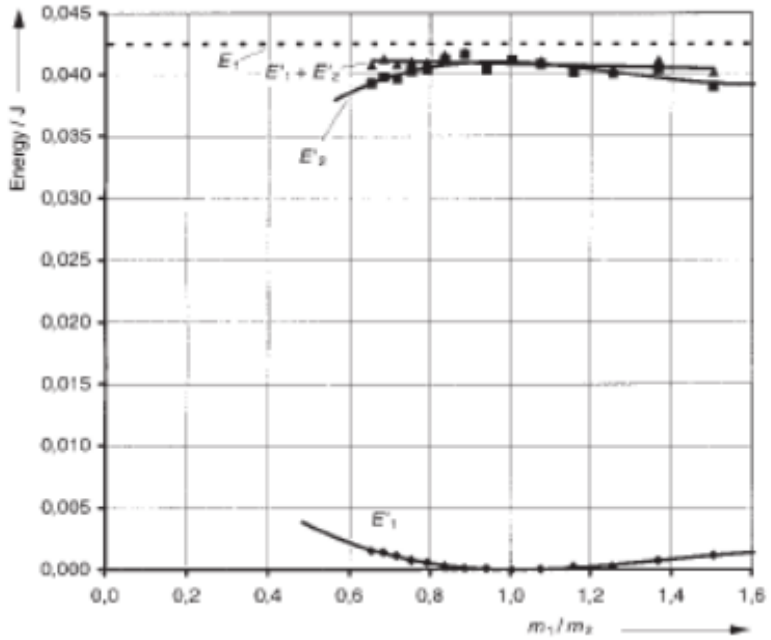

Fig.3: Elastic collision: energy after the collision as functions of the mass ratio of the carts.

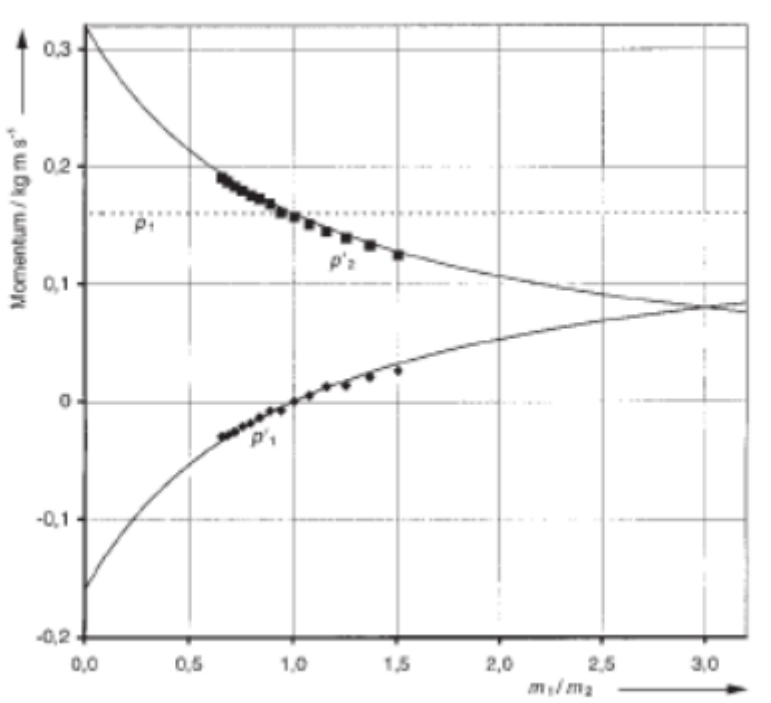

Fig.4: Elastic collision: calculated momenta after the collision as functions of the mass ratio of the carts.

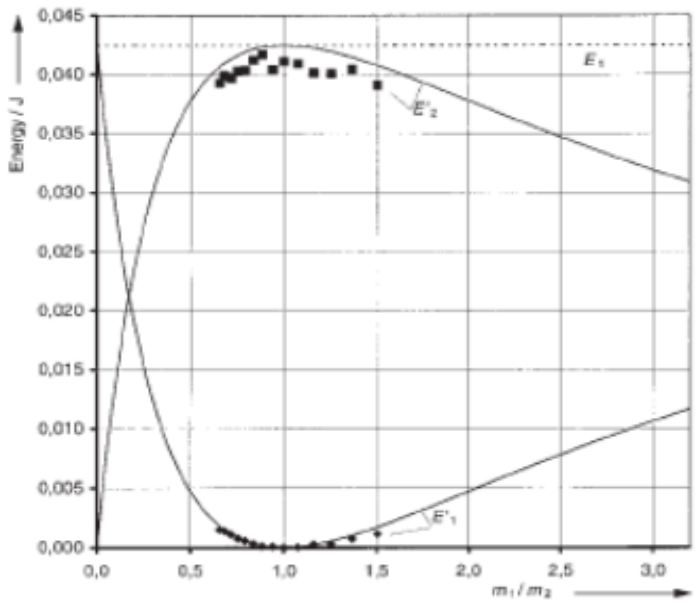

Fig.5: Elastic collision: calculated energies after the collision as functions of the mass ratio of the carts.

The evaluation of a sample measurement (Fig. 6 and Fig. 7) shows that also for an inelastic collision, the total impulse is conserved; whereas, depending on m1/m2, a substantial energy loss occurs.

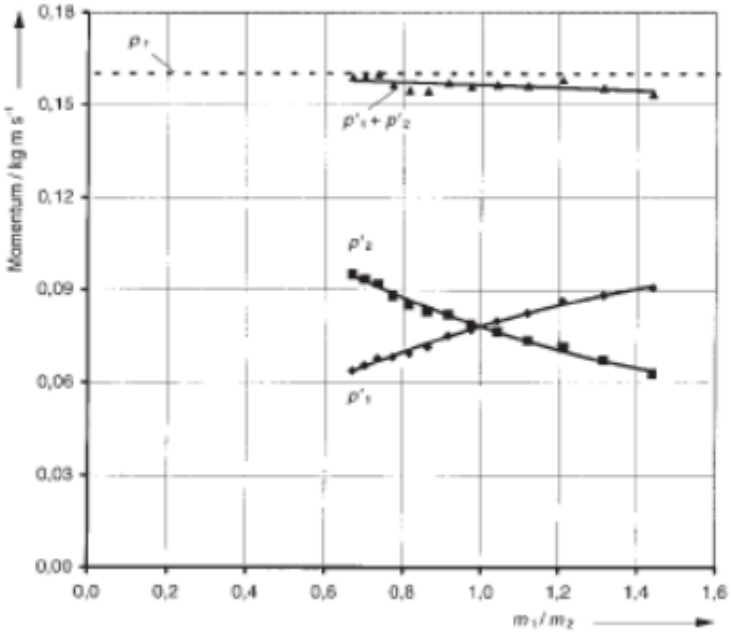

Fig.6: Inelastic collision: momenta after the collision as functions of the mass ratio of the carts.

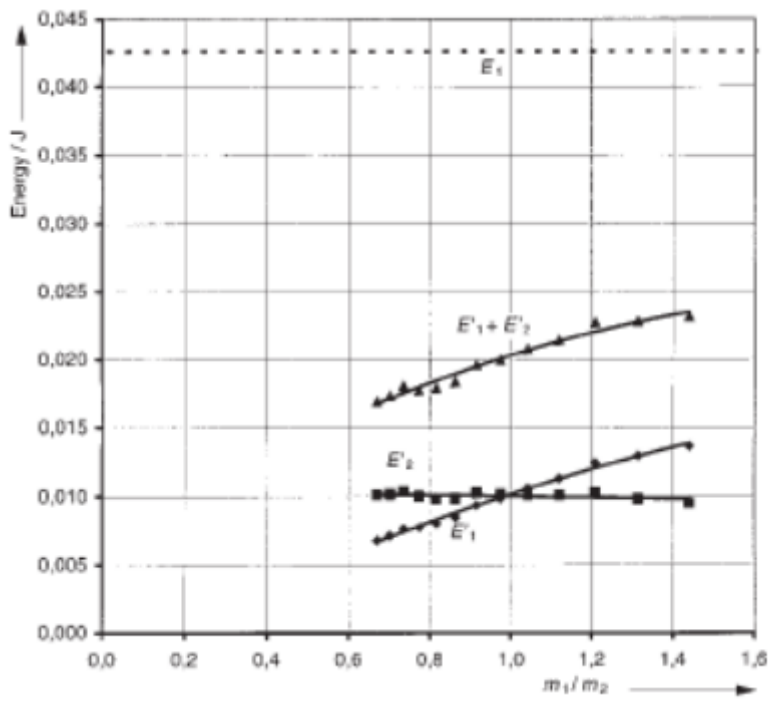

Fig.7: Inelastic collision: energy after the collision as functions of the mass ratio of the carts.

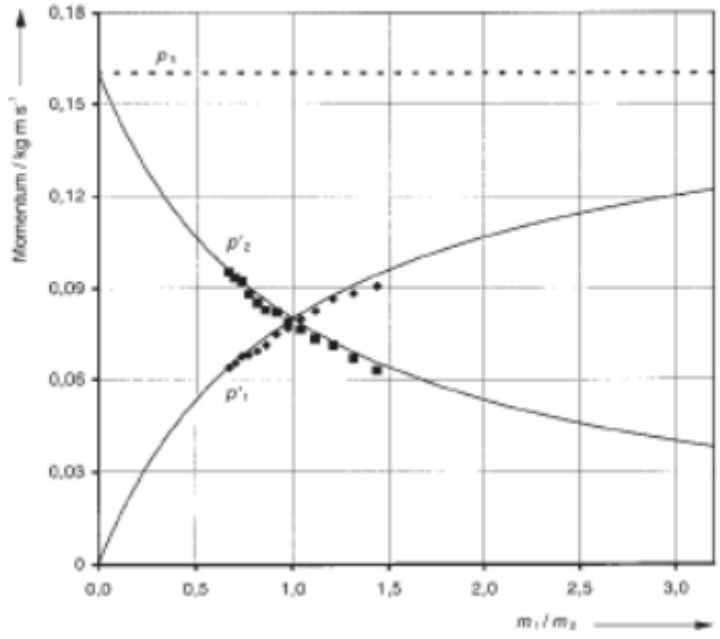

Fig.8: Inelastic collision: calculated moment after the collision as functions of the mass ratio of the carts.

CALCULATIONS

Mass ratio	Velocity before the collision m/s	Velocity after the collision m/s	Momentum before the collision kgm/s	Momentum after the collision kgm/s	Kinetic energy before the collision Nm	Kinetic energy after the collision Nm