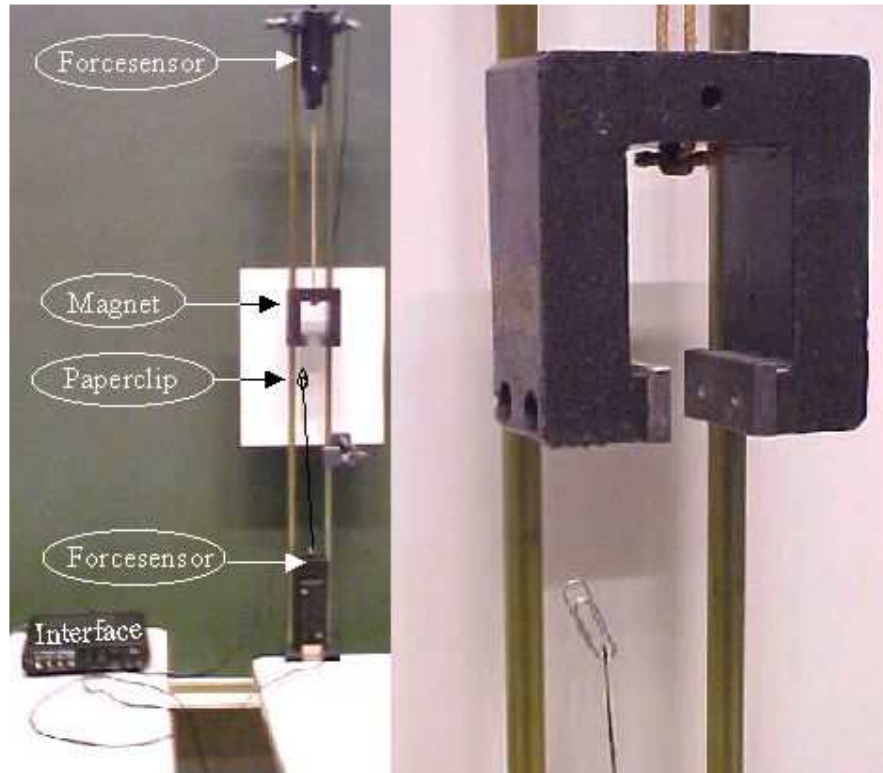


Strong magnet, weak paperclip?

Aim: To show that also in a complicated situation Newton's third law is valid.

Subjects: 1H10 (Action and Reaction)

Diagram:



- Equipment:
- Strong horseshoe-magnet, attached to a rope.
 - Paperclip, attached to a string.
 - Two force-sensors. (We use PASCO-CI6537.)
 - Bars (aluminium) and clamps to build the set-up (see Diagram).
 - Interface and computer with data-acquisition software. (We use PASCO Science Workshop.)
 - Camera and largescreen monitor.
 - Beamer to project the graphs.

Strong magnet, weak paperclip?

Presentation: The demonstration is presented as a tug-of-war between a heavy, strong horseshoe-magnet and a light paperclip. After showing how strong our magnet is, the demonstration is set up as shown in the Diagram. By means of a camera the magnet and paperclip are presented in more detail on a large monitorscreen. The graphs, still blank, are projected by means of a beamer (see Figure1).

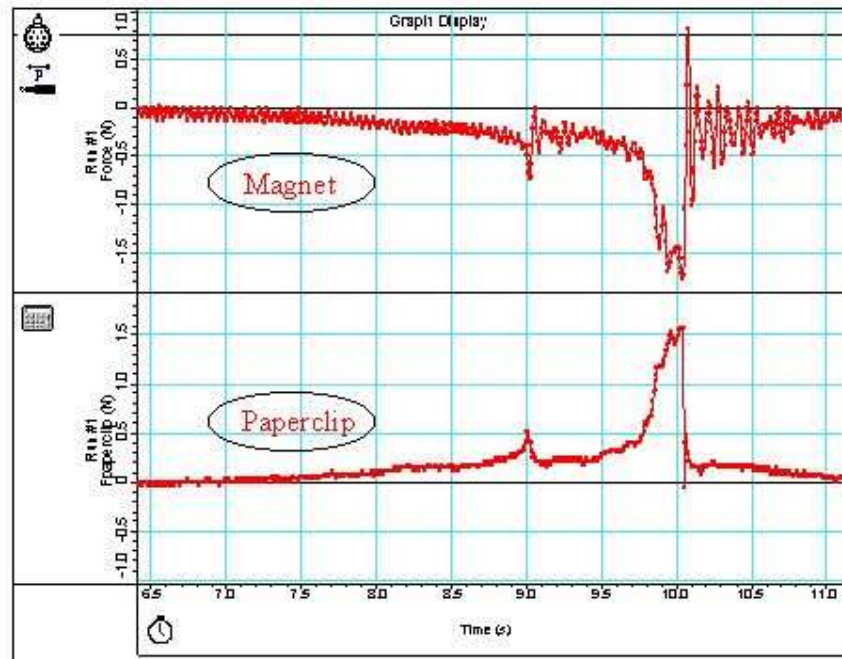


Figure 1

First, the forcesensors are zeroed. Students see this in the projected graph while we use the monitor mode of the data-collection program. The effect of pulling by hand on the forcesensors is shown. (We make the graphs in such a way that when pulling the magnet downwards its graph goes negative and when pulling the paperclip upwards, its graph goes positive.)

Then data-collection in the recording mode is started and by sliding the lower forcesensor upward along the aluminium bars, the paperclip is brought closer to the magnet until it touches one of the poles. Then the lower force-sensor is lowered again (loosening the paperclip from the magnetpole) to its starting position. Data-collection is stopped.

The recorded data are discussed now; a region of interest can be selected (see Figure1). It can be observed that the force-time relationship is a complicated one, but nevertheless Newton's third law is valid: at every moment in time we see $F_{\text{paperclip}} = -F_{\text{magnet}}$.

Explanation: There is no explanation here, since Newton's laws are just a set of hypotheses which appear to be in accordance with everyday experience. Our demonstration adds another experience to the validity of the third law.

Strong magnet, weak paperclip?

- Remarks:
- In the demonstration inevitable vibrations arise, especially in the data of the forcesensor with the heavy magnet. An appropriate sampling rate and data-averaging should be selected to minimize these vibrations in the presented data. But students can also visually mean the presented graph of the magnet and see that it is in very good accordance with the graph of the paperclip.
- Sources:
- [The Physics Teacher](#), Vol.39, October2001, pag. 392-393