Energy Losses in Commercial Hammers.
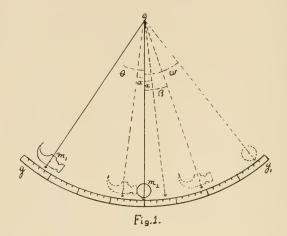
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It is a well-known principle of mechanics that, in case a moving object impinges against another object, that the total momentum before impact is equal to the total momentum after impact. In other words, "That momentum is conserved in all impacts, be it between elastic or inelastic objects." This law does not permit us to infer, however, that there are no energy losses in impacts. In fact the kinetic energy is always less after impacts than before impacts of two impinging objects. By testing this out by ordinary laboratory methods we find these energy losses to vary from as high as eighty per cent in case of inelastic impacts to as low as two per cent in elastic impacts.

In teaching this subject I have for a number of years attempted to illustrate and fasten these principles in the mind of the student by such questions as the following: Suppose a carpenter is employing a number of men in a mechanical process, such as the driving of nails with a hammer, would it be of importance for him to look into the grade of hammers used? Or again: Suppose a railroad company is retracking its line and it is necessary to drive thousands of spikes, does it matter whether the sledge hammers used are made of cast iron or a high grade of steel?

It so happened that my present class inquired as to whether it would be possible to try these conditions out in an experimental way. After a moment's reflection I informed them that it would be a very simple matter to make tests by substituting a hammer for one of the steel spheres in our impact machine. This has been done in the case of four hammers with considerable care.

The apparatus used was similar to that employed in Experiment 6, page 62, in Millikan's Mechanics, Molecular Physics, and Heat. One of the steel spheres was removed and the hammer to be tested was substituted in its place as shown in Fig. 1. In order to support the different hammers as nearly as possible under the same conditions, a frame was suspended by four adjustable cords, to which the hammers could be

rigidly bolted. The experiment consists in displacing the hammer to a certain angular position to one side the normal position and allowing it to drop and impinge upon the steel sphere, noting the maximum angular displacement of both the steel sphere m_1 and the hammer after impact.

Fig.1.

The following equations are applicable:

The Coefficient of Restitution $= \xi = \dfrac{\sqrt{(1 - \cos \omega)} - \sqrt{(\cos \alpha - \cos \beta)}}{\sqrt{(\cos \alpha - \cos \theta)}}$, (1).

The percentage loss of K.E. $= 1 = (1 - \xi^2)\dfrac{m_2}{m_1 - m_2}$, (2)   The values of α, β, θ, and ω are measured directly upon the graduated scale gg_1.

TABLE I.

	Mass of Sphere. m_2	Mass of Hammer.	Mass of Suspending Frame.	Total Mass. m_1.	α In Deg.	β In Deg.	θ In Deg.	ω In Deg.	ξ From Equation 1.	1 From Equation 2.	Average 1.
No. 1	232.9	659.0	123.3	782.3	2.97	6.08	10.0	14.4	.9539	2.063	.....
No. 1	232.9	659.0	123.3	782.3	2.97	6.63	11.0	15.9	.9405	2.645	2.354
No. 2	232.9	518.8	123.3	634.1	3.27	5.82	10.5	13.8	.8981	5.493	.....
No. 2	232.9	518.8	123.3	634.1	3.27	6.29	11.5	15.2	.8945	5.364	5.297
No. 3	232.9	332.6	123.3	455.9	3.00	4.70	9.9	11.8	.8618	8.693	.....
No. 3	232.9	332.6	123.3	455.9	3.00	5.71	13.0	15.5	.8406	9.921	9.307
No. 4	232.9	245.6	123.3	368.9	3.02	5.95	15.0	15.2	.6829	20.65	.....
No. 4	232.9	245.6	123.3	368.9	3.02	4.91	12.0	15.3	.7265	18.27	19.46

Hammer No. 1 was a high-grade machinist hammer.

Hammer No. 2 was a claw hammer purchased as a high-grade tool.

Hammer No. 3 was a lower-grade machinist hammer.

Hammer No. 4 was a cast-iron hammer purchased at a five and ten cent store.

The steel sphere used in the above experiment, when tested with a similar sphere, gave an average of approximately two per cent energy loss.

Conclusion: The experiment justifies the conclusion that high-grade steel hammers conserve to a much larger degree the kinetic energy of a blow than low-grade cast-iron hammers.