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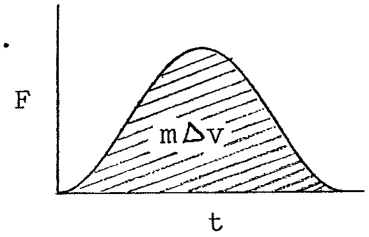
Impulse, the momentum changer - Impulse (Ft) is a force times how long it is being applied to a mass to change its motion (Δv), thus, its momentum ($m\Delta v$).
Impulse occurs during collisions or contacts between objects. Because the forces involved are rarely constant throughout the collision or contact, we conveniently use an "average" force (F ave) instead. Thus, the final equation is F ave t = $m\Delta v$.
If we rewrite the equation slightly, we arrive at Newton's second law or F = m a.

$$F_{ave}\, t = m\Delta v \qquad F_{ave} = m\Delta v/\Delta t = m\, a$$

Obviously, Newton was on the threshold of the concept of momentum (m v). Its final formulation by other thinkers would follow shortly and evolve into the first great conservation law, the Law of Conservation of Momentum. See the topic, "Conservation of linear momentum", elsewhere on this website.
With today's high tech apparatus, quality quantitative analysis is possible, but its cost may be prohibitive. An alternative approach to the topic is qualitative, i.e., the use of several simple, but informative (even dramatic) demonstrations and some "chalk talk" that have been successful.

(a) Start with a thick (4") foam cushion and your fist. With the cushion against a wall or on a table top, press your fist into the cushion as far as you can. Note that the force required becomes greater the deeper you go into the cushion. Relax and let the cushion repel your fist back out. (Think of doing the same on a bathroom scale.) Now draw an <u>ideal</u> graph of what just happened. It should be the familiar bell-shaped curve of F vs t (1.).

1.



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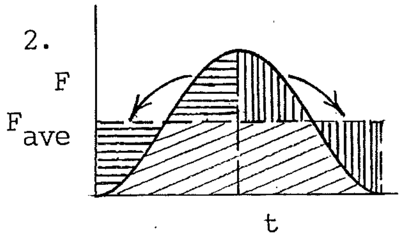

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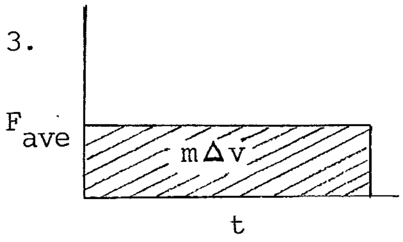
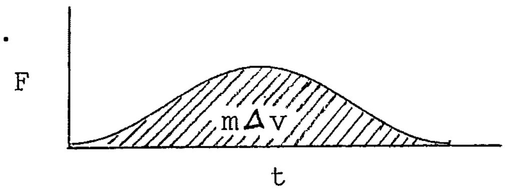


At this point, introduce the special physics meaning of the mathematical concept of area under the curve. Normally, the solution to this area-under-the-curve problem would require the use of calculus. Instead, we can estimate an "average" force of F ave and conveniently relocate the upper areas of the bell curve into a rectangle (2.); thus, we have a simple solution to the approximate area under the curve, and this solution equals the change in momentum $m\Delta v$ in physics (3.). It is just another nice example of physics and mathematics working together that students can easily understand.

(b) Time for a demo with a little drama. Using the same cushion, drop a raw egg on it from a height of 4 feet or higher. Choose a student athlete, if possible, as a catcher after the bounce. Practice with a golf ball first so the student knows what to expect. The graph of the drop might look like (4.)
Now drop the raw egg into a plastic container from 2 or 3 feet above. Now the graph of the drop might look like (5.). Note that in each case the egg's downward momentum was stopped by a force. In (4.) the stopping force is greatly reduced by lengthening out the time of contact. In (5.) on the otherhand, the contact time is extremely short so the stopping force must be extremely high, breaking the egg shell.

4.



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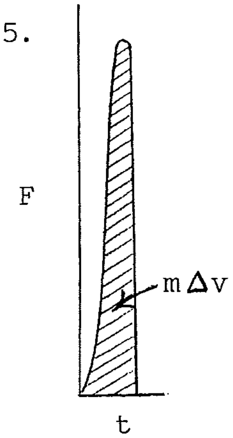


The lesson learned is that all padding, cushioning, "crunch zones", shock absorbers, and the like are designed to lengthen the times of contact and thus, decrease the forces, usually destructive, during collisions of all kinds. Even <u>we</u> have some cushioning to protect our bones but require more in contact sports, especially around our heads which have little flesh.

(c) A popular demo with the same theme as (b) is the use of an old, fitted sheet, a raw egg, and three students; hopefully, one might be a baseball or softball pitcher. Two students hold up a slightly slack sheet some distance from the thrower. When ready, the pitcher throws the egg as hard as he or she can at the center of the sheet. The sheet should "give" or cushion the impact so it doesn't break. Once again the "give" of the sheet stretches out the time to stop the egg, thus, reducing the stopping force involved. Note that a fitted sheet has a "trough" at the bottom edge to keep the egg from falling (rolling?) out of the sheet and possibly breaking on the floor.

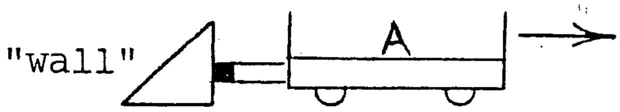
Speaking of stretching (lengthening time), mountain climbing ropes are made to stretch a certain amount before breaking to safely "arrest" a climber if he or she falls. So not all ropes are the same; as you might expect, special safety ropes cost more but could save your life.

(d) The small, high tech lab carts of today demonstrate impulse very well. A less expensive alternative, however, is an old pair of PSSC carts of equal mass, one which has a compression spring. They can show, qualitatively, examples of impulse quite well.

1) Simply start with the "spring" cart A cocked and against a "wall". Hit the trigger, and the spring provides the impulse to give cart A its momentum (6.).

2) Propel cart B against the spring of cart A which is at rest. Due to the spring, you have a truly "elastic" collision and an impulse that is shared between the two carts (7.). The impulse brings cart B to rest and accelerates cart A up to approximately cart B's original velocity before the collision. Any further explanation of these motions enters the "realm" of the law of conservation of linear momentum. See the topic,"Conservation of linear momentum",elsewhere on this website.

6.



7.