Damage in Collisions

Ian Jacobs, Physics Advisor, KVIS, Rayong, Thailand

By *damage* we mean the rearrangement of parts: what happens when eggs fall on a tiled floor. The human body has evolved as a compromise: strong enough to play Rugby, which some would describe as a battle, and light enough to run after a bus.

In full charge: not easy to stop. Image Fanny Schertzer.
https://commons.wikimedia.org/w/index.php?curid=31943806

Imagine that you were to run into a tree at maximum speed (10 m/s). You might expect to lose a little skin, collect a few bruises and perhaps break something like a collar bone or your nose, but would you die? Probably not. Now suppose you were to fall five metres from the roof of a house. Would you expect to live? Probably: perhaps with a broken ankle. Your speed at the ground would be 10 m/s. You are designed to survive that impact but not this one.

OOPs! Image: https://commons.wikimedia.org/wiki/File:Car_crash_1.jpg

Project

Drop weights from given heights and measure the distortion of clay (plasticene blocks) to show that damage (the distortion of the clay) in this simple case is proportional to the kinetic energy on impact, not, as some might suppose, the momentum on impact mv.

Crash testing

Crash testing can be done by dropping cars as shown in these images from a New Zealand physics text. A crash at 100 km/h is likely to do something like four times the damage of one at 50 km/h because of the velocity squared dependence of kinetic energy.

No driver required

Myth busters did another sort of crash test the same way. They dropped dead pigs of the same weight from the same heights on to water and pavement. They found that an impact on pavement caused more fractures and disruption than the same impact on water, but from 150 m it wouldn't make much difference: death follows in both cases.

See https://www.youtube.com/watch?v=E408JigEcFI

Damage in simple laboratory collisions (compression of clay blocks when hit by falling weights), is proportional to KE loss but damage to a complex body depends on the details. For instance, occasionally people survive spectacular falls if the landing time is extended and or the person is protected in some way to keep the applied forces below the yield points of the bones and attachments that make up the body.

A no-parachute landing

Click the link to open a video that shows a safe landing after a fall from an aircraft. Luke Aikins went into the net at 200 m/s - (terminal velocity) - the speed at which drag due to air resistance had increased to equal his weight *mg* and no further acceleration was possible.

The video from which these screen captures were taken is here …
https://www.youtube.com/watch?v=6qF_fzEI4wU

Sudden kinetic energy loss if he had hit water or pavement would of course have been fatal, but the net extended his collision time and both reduced and distributed the forces. He suffered no injuries. The same thing is seen when throwing eggs at a blanket. The force applied to remove KE is relatively small and there are no sharp points of contact. The egg survives intact.

Warren throwing eggs with M4.

Other landings

People who survive without a parachute are usually young and strapped in a seat, protected from sharp points. Impact times are extended, either by falling into deep snow on an incline, Vesna Vulovi: falling through trees onto soft ground, Juliane_Koepcke: or crashing through the glass roof of a railway station, Alan Magee.

The best of the lot!

In one remarkable story Frane Selak claims to have fallen from a plane and landed safely in a haystack.

Did that really happen? Many people think not.
http://skeptics.stackexchange.com/questions/20472/did-frane-selak-survive-a-fall-from-a-plane

"… Plane accidents are very well documented on several sites. If you look at the year 1963 at PlaneCrashInfo there is no mention of a crash that involved 19 deaths and one or more survivors. Digging further, there appears to be no crash record that mentions losing a door during free fall in 1963. I am not saying it is impossible to survive such a fall, weird accidents and survivals happen, but I would say that his story is fabricated. …. what really seems to point in the direction of fabrication is the lack of detail: what airline, what country, what flight number ….?"

> Stories that make no reference to original documents are very often false. "*Mother told me*." … "*It's on the web*."…. "*It's in our physics text*" …. How often have you heard these apologies for thinking?

Advice …

Head impact can be life-threatening even at low energy. A person can die in a fall from a horse, or slipping on pavement and hitting their head on a step. Rotation on impact lessens the forces involved. If you find yourself falling down stairs, curl up, roll, and put your arms over your head.