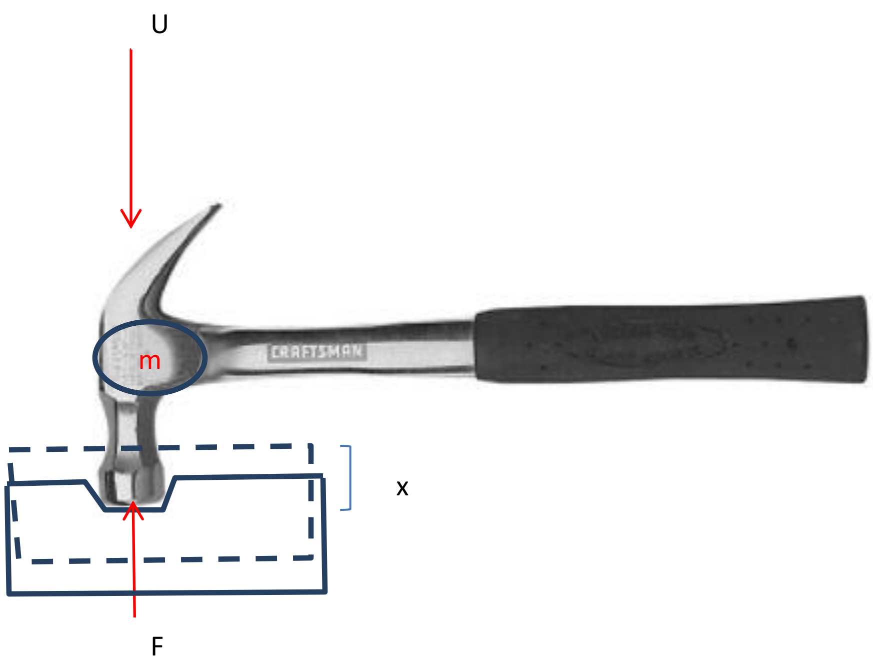
Hammer Physics



When a hammer strikes an object it decelerates at a rate of a (m/s^2) from its initial impact speed U (m/s) to a speed of zero over a distance of x. The distance x includes the lateral/vertical displacement of the object as well as the maximum indentation (deflection) achieved on the object.

If x and U are known the deceleration rate can be determined from the following equation:

$$a = \frac{U^2}{2x}$$

The above equation can be derived from the Newton's equation of motion, which states:

$$V^2 = U^2 - 2ax$$

V – Final speed (= 0 m/s)
U – Initial Impact Speed
a – Deceleration
x – Distance travelled

The force acting on the hammer to bring about this deceleration is given by Newton's Second Law of Motion:

$$F = m.a$$

$$F = \frac{m.U^2}{2x}$$

What can we learn from this equation?

The smaller the distance over which the hammer head stops the greater the force that acts on the hammer, AND the higher the impact speed the greater the force that acts on the hammer. In both cases the hammer is subjected to more STRAIN.

Thus striking a rigid, hard and unyielding object that would allow only small displacements and deflections would result in larger forces (and resulting strain) on a hammer compared with a softer and more yielding object – even if both objects are hit with the same hammer, at the same speed and kinetic energy.

Say we have two identical hammers, striking two objects at the same impact speed, and the first hammer decelerates to zero over a distance of x1 and the second hammer over a distance of x2 where x1 < x2.

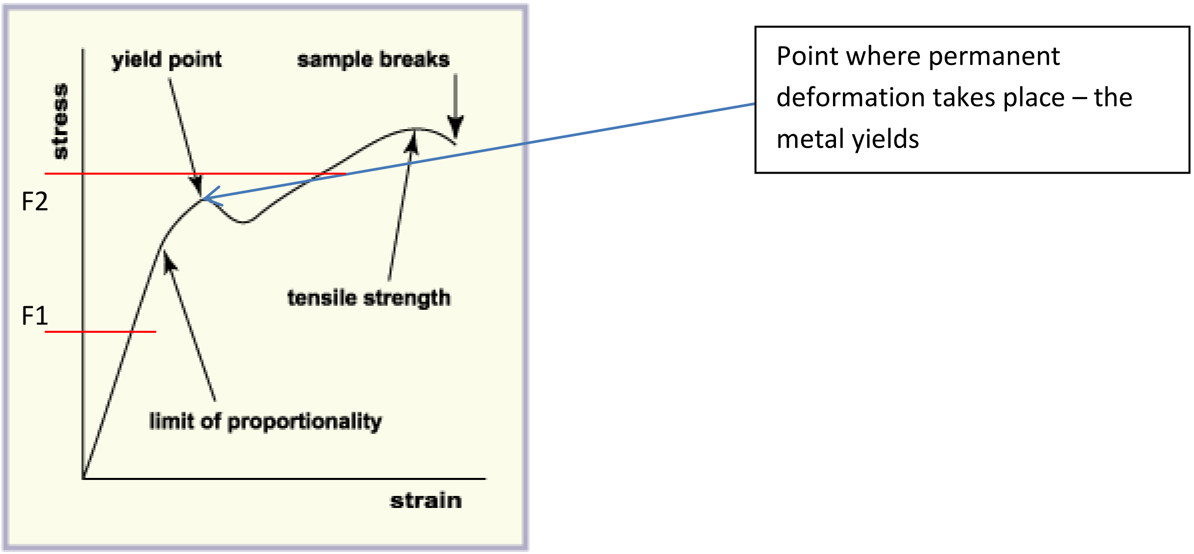
How much more is the force on hammer 1 than on hammer 2?

$$\frac{F1}{F2} = \frac{x2}{x1}$$

Say total deflection experienced by hammer 1 is 5 mm and total deflection by hammer 2 is 10 mm it means that the force on hammer 1 was twice the size of the force on hammer 2. If x2 is three times x1 the force on hammer 2 would be a third of the force on hammer 1, etc. The bigger the force the bigger the resulting strain.

When an upward force acts on the hammer's head it causes a bending moment in the handle of the hammer. This bending moment would cause a tensile stress in the bottom part of the handle. Below is a typical example of a stress-strain curve for mild steel. For any material there is a tensile stress below which the handle would return to its original state, and above which the stress would cause permanent deformation i.e. bending.

Stress-Strain Graph for Mild Steel



Source: http://www.ejsong.com/mdme/memmods/MEM30006A/Elasticity/Elasticity.html

Strain – Measure of deformation
Stress – Measure of force applied

Inge's head was resting on a soft armrest of a sofa. The majority of blows were to the side of her head. Any blow would have caused the head to rotate radially around the neck, as well as to be pushed into the sofa. The applied load would have been dissipated. The depth of the head wounds as well as the amount of elastic deformation of the skull also needs to be considered.

Compare this to a pig's head resting on a metal table, hit directly from above onto the thickest part of the pig's skull where elastic deformation will be less than that of a domed and thinner and more elastic human skull (saturas and muscle layers also play a role – thus the location of the blow on the human's head is also significant).

If we can accept that the total deflection on a human head could have been three times more than what was achieved in a pig's head (e.g. 3 cm vs. 1 cm) it means that the strain on the hammer striking the pig could have been <u>three times</u> the strain the hammer experienced on the human head. This could easily put the hammer's handle beyond the yield-point where permanent deformation will occur.

Also have to consider the potential differences in impact speeds. An impact speed of for example 8 m/s would result in strain <u>four times</u> greater than at an impact speed of 4 m/s.

We do not know the speed of the hammer that landed on Inge's head, and we don't know the speed of the hammer that landed on the pig's head – we do not know the lateral displacement and deflections – we do not have enough information to make the court believe that the hammer could not have been the murder weapon simply because it bent on a pig's head.