Theory of deformation and the expression to find it 2

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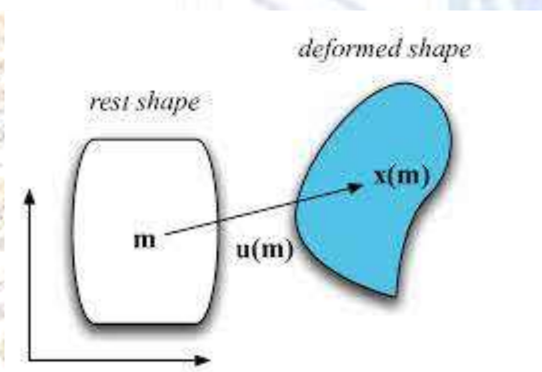
When we hit a certain body with Force F, it absorbs a certain amount of force which results in the change of shape of the body getting hit or in simple words the body deforms. Absorption of force by the body getting hit results in the motion of the hitting object being not periodic.

- What causes deformation?

  Ans: Deformation is a physical property which is possessed by every single particle with a mass m. Another property possessed by all particles is the capacity to absorb forces, which leads to deformation.

  For example: let's say a person with a hammer weighing 5 kg hits a wall with a certain acceleration , it will result in the wall getting deformed or in simple words it will be broken. The reason the wall breaks because it absorbs a certain amount of force from the object hitting it. If an object absorbs a certain amount of force from an external agent it will either result in the displacement or the deformation of the object getting hit.



- Is deformation directly proportional to absorption?

Ans: The short answer would be yes. Let us consider an example, let's say a kid weighing 40 kg hits a car window with a force F1 and a fully grown adult weighing 100 kg does the same thing with a force of F2. Which will most likely result in the breaking the car window? Any person with basic common sense would say the man weighing 100 kg has a higher probability of breaking the car window than the kid weighing 40kg.

- Why is the probability higher in the man's case?
- Ans: Lets us assume in both scenario the acceleration was the exact same. Let us consider it a_1. Still the man would be able to produce a higher magnitude of force due to more mass as force is directly proportional to mass as well as acceleration. So if the man produces a higher magnitude of force, the car window will also absorb more amount of force comparatively which will result in more vibration of the car window and if the magnitude of force produced by the man makes the car window vibrate beyond a certain extent it will deform or simply break.
- Let us consider another example, let's say a man hits a brick wall with a hammer that weighs m and with an acceleration of a. If the man hits a titanium metal cube with the same force, which is going to deform more? The simple answer would be the brick wall, the reason there will be close to no deformation on the titanium cube is because it has a higher density. It has an approx. density of 4.5 g/cm^3, which means that it has a huge number of molecules packed up in a very small area which results in it being stronger. So, it won't absorb a lot of force which will result in a higher rebound distance of the hammer. Titanium refuses to absorb a good amount of force, so the deformation would also be very less and the vibration on the titanium will also be very less. So, we can say that deformation of a body is inversely proportional to its density.

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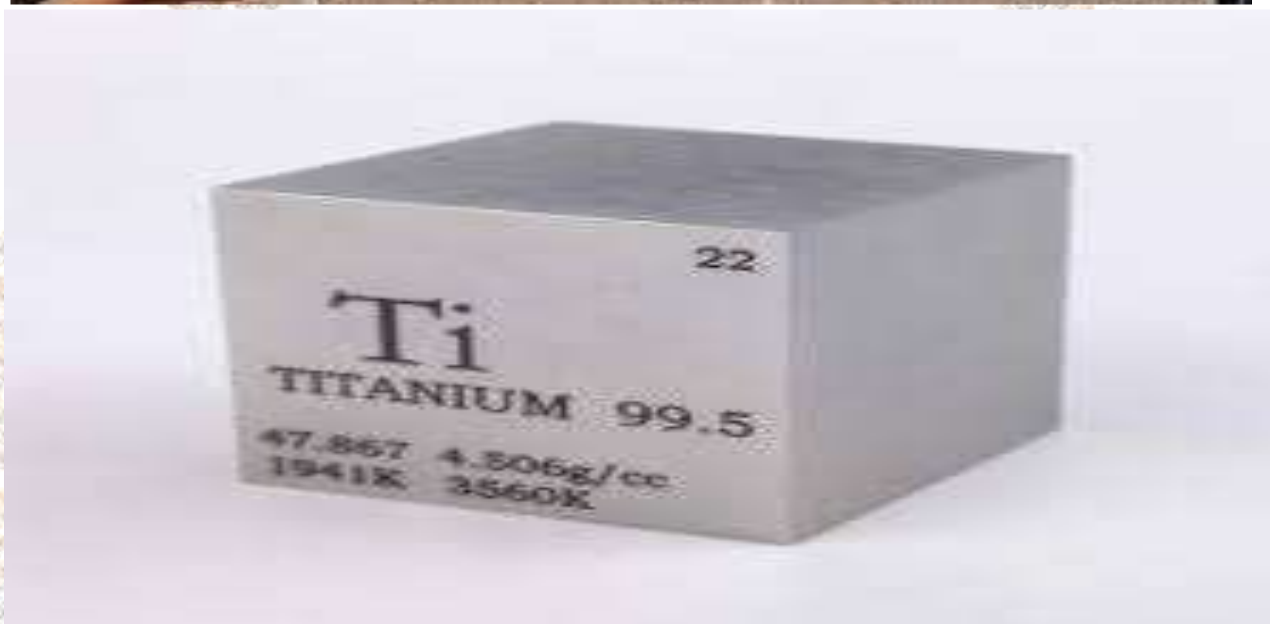
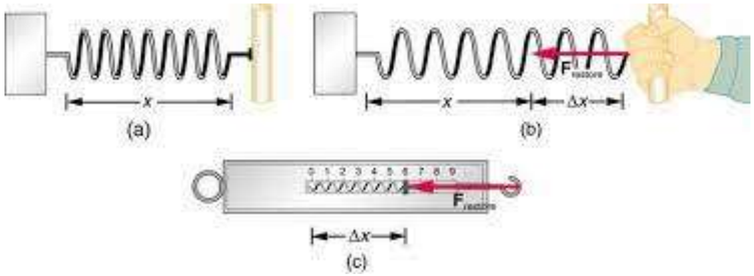
- 

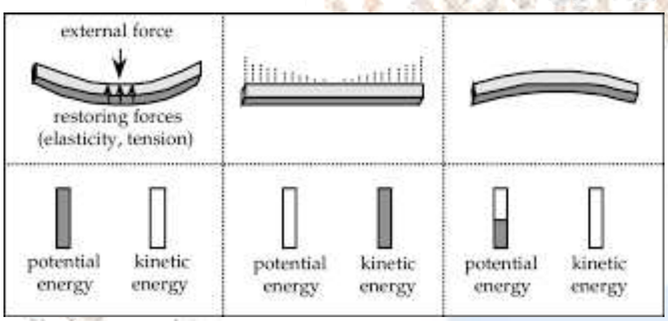
- Now, let us consider the factors on which the deformation depend on , the first one is density as we have discussed before , the second is the mass of the object which is used to hit. A 5 kg hammer with acceleration a will be able to produce more vibration which will result in more deformation than a hammer which weighs 2.5 kg. Next factor is the displacement of the object which , this the reason labour swing their hammer before hitting the , more distance will allow more space to accelerate which will result in more magnitude of force getting transferred. Next one is the velocity of the object (hammer) while striking, more velocity will ensure a higher vibration, which will lead to a higher deformation, a bullet hitting a wall won't be the as a cotton ball hitting the (velocity difference plays a major role in this case).The last one is the cross sectional area of the hammer which we are using to hit, less area will ensure more pressure, which again will ensure more absorption (vibration) and will automatically result in a higher deformation.

- Anirudh's Constant: Let us consider an example; We hit a plastic lunch box using a hammer with a moderate force of f_1, what do you think would happen? The face of the plastic box where the hammer lands would go through a co-axial displacement and would come back to its initial position due to a term called restoring force. Now, if we take a comparatively denser substance (glass) and hit it with a hammer using the same force the glass would break even after being substantially denser. This is due to glass having close to no restoring force as compared to the plastic box. So, even though the glass is way denser than any plastic box but shows a higher magnitude of deformation. There are many real life examples like this which would directly question Anirudh's deformation equation (due to various restoring forces possessed by substances) which states that deformation would always be inversely proportional to the density of the object. So, in order to determine precise deformation of various objects, a constant has been introduced (@) in order to determine the deformation rate of different object having various restoring forces. The value of Anirudh constant would differ with the structure of the object, every object would have different value of Anirudh's constant just like every substance has different refractive indices. So, in some cases just like in this example, the value of Anirudh's constant would approach absolute zero as no deformation taking place in the plastic box due to restoring force of plastic.

  What does restoring force mean?

  Ans: In physics, the restoring force is a force that acts to bring a body to its equilibrium position. The restoring force is a function only of position of the mass or particle, and it is always directed back toward the equilibrium position of the system. The restoring force is often referred to in simple harmonic motion. The force responsible for restoring original size and shape is called the restoring force.



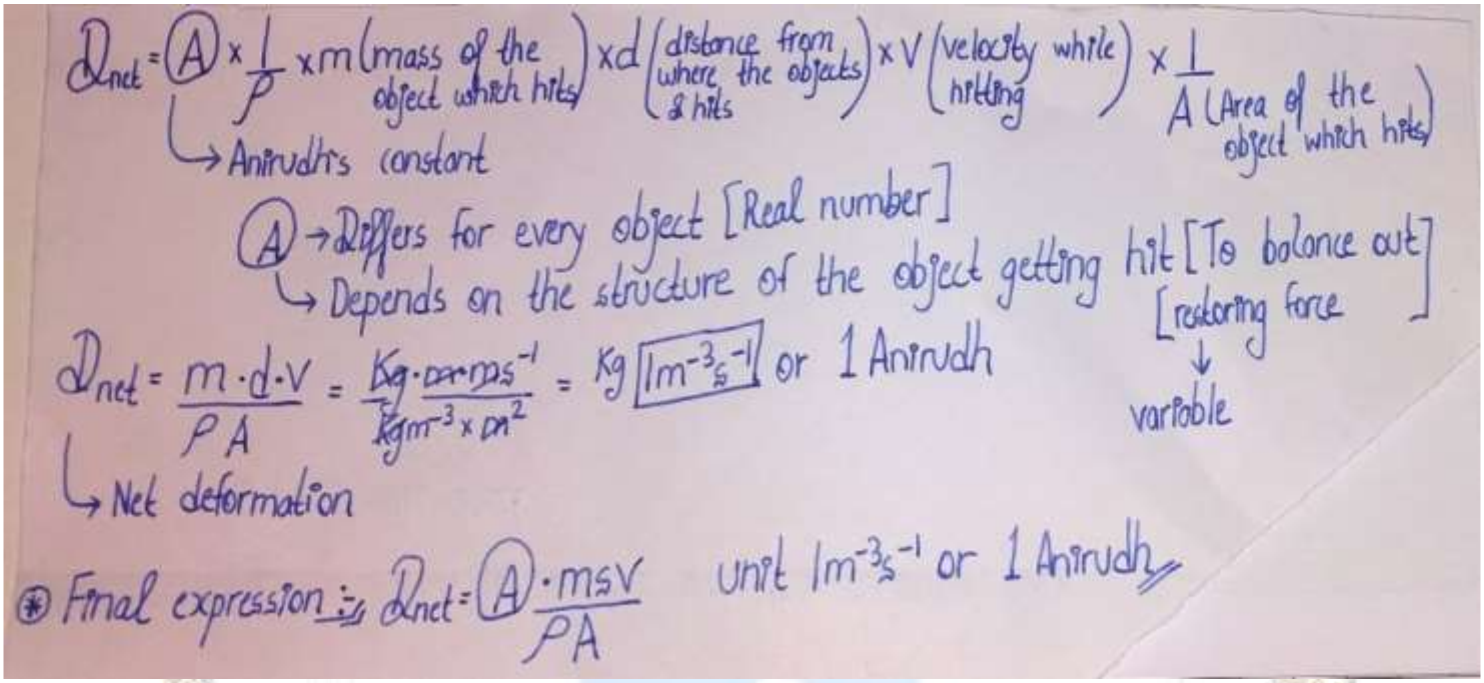


Let us see the expression : Here D_{net} denotes the net deformation , which is equal to deformation constant times ,mass times distance to accelerate times velocity/ density of the object getting hit times area of the object which hits. Unit: Anirudh

Define one Anirudh.

Ans: 1 Anirudh is when an object(having Anirudh's constant value of 1)of density $1m^3$is hit by a body with 1Kg mass with the accelerating distance of 1m , with a striking velocity of $1ms^{-1}$ and a cross sectional area of $1m^2$ of the object which hits.

Expression



$D_{net} = (A) \times \frac{1}{\rho} \times m$ (mass of the object which hits) $\times d$ (distance from where the objects & hits) $\times V$ (velocity while hitting) $\times \frac{1}{A}$ (Area of the object which hits)

↳ Anirudh's constant

(A) → Differs for every object [Real number]

↳ Depends on the structure of the object getting hit [To balance out [restoring force ↓ variable]]

$D_{net} = \frac{m \cdot d \cdot V}{\rho A} = \frac{Kg \cdot m \cdot ms^{-1}}{Kg m^{-3} \times m^2} = Kg \; \boxed{1 m^{-3} s^{-1}}$ or 1 Anirudh

↳ Net deformation

⊛ Final expression :- $D_{net} = (A) \cdot \frac{msV}{\rho A}$ unit $1 m^{-3} s^{-1}$ or 1 Anirudh

Bibliography:

Images: Google