Deformation of Solids

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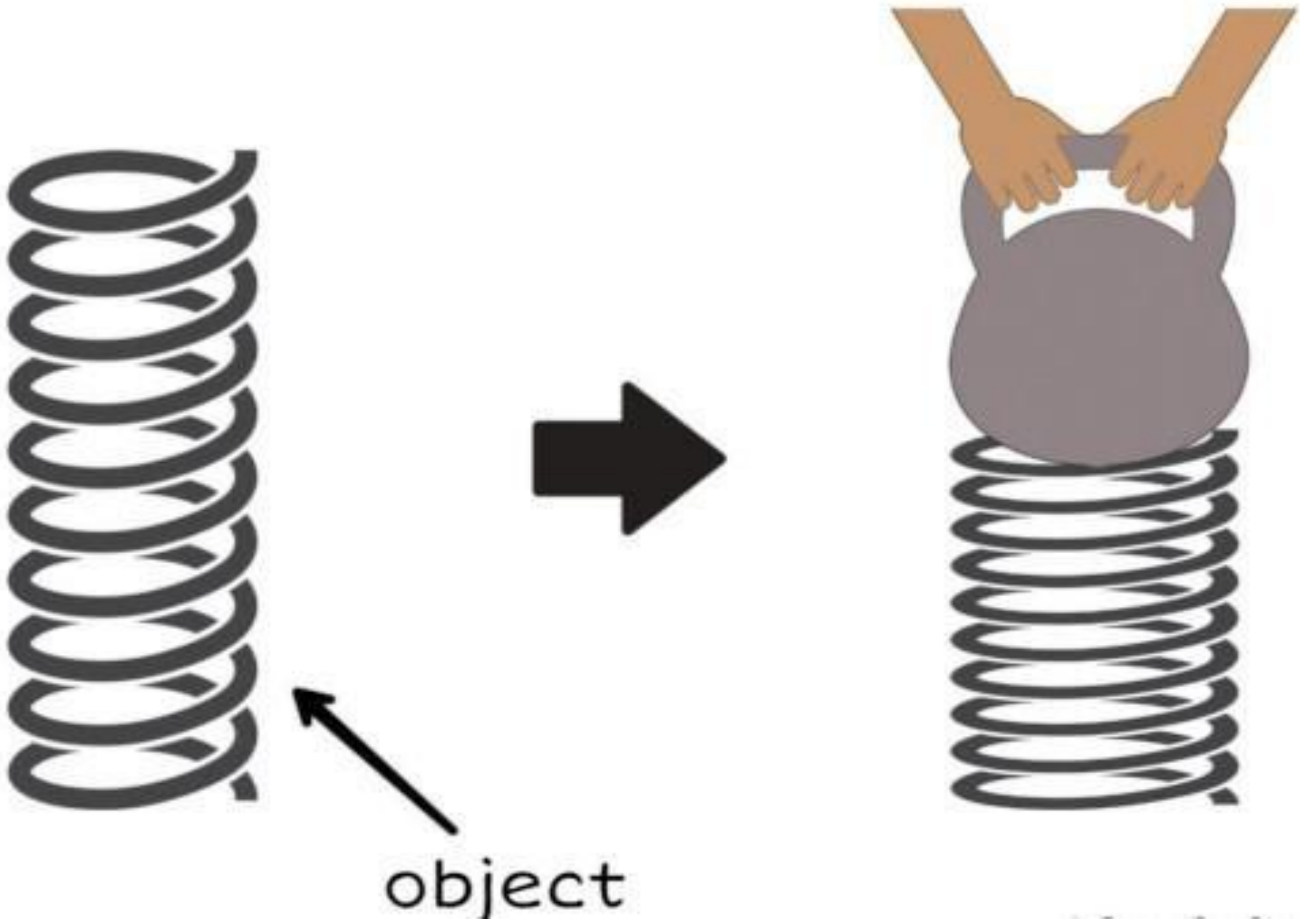
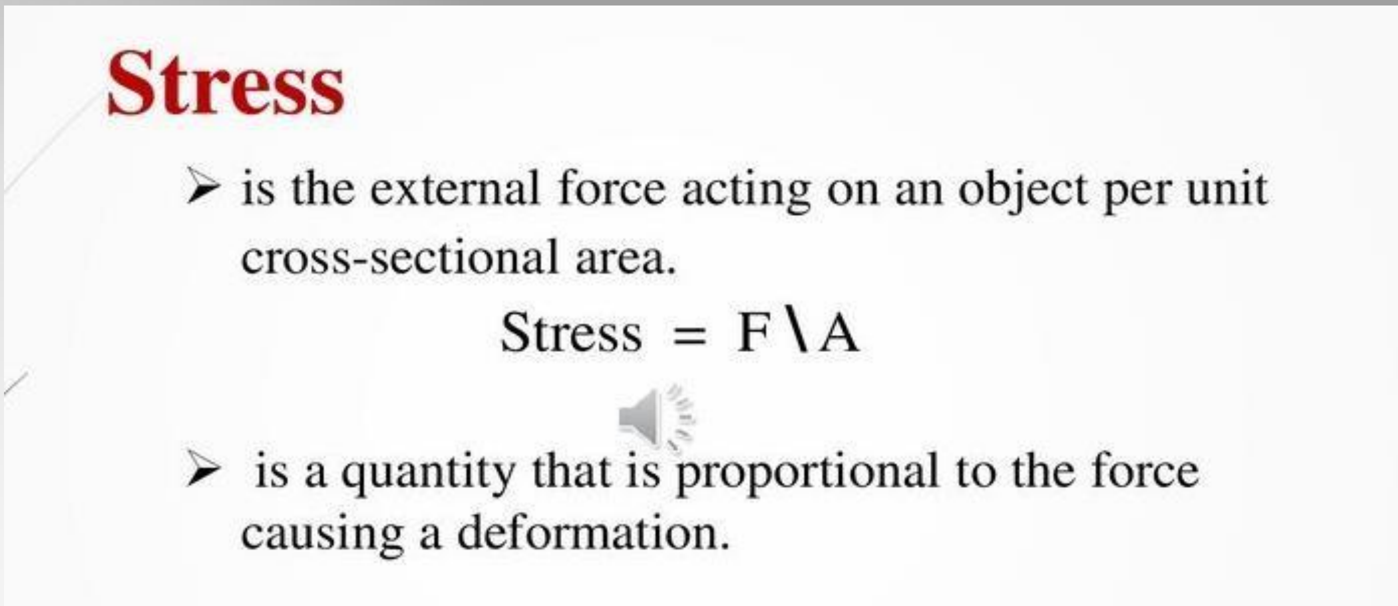
A force can change the shape and size of an object




Stress

- is the external force acting on an object per unit cross-sectional area.

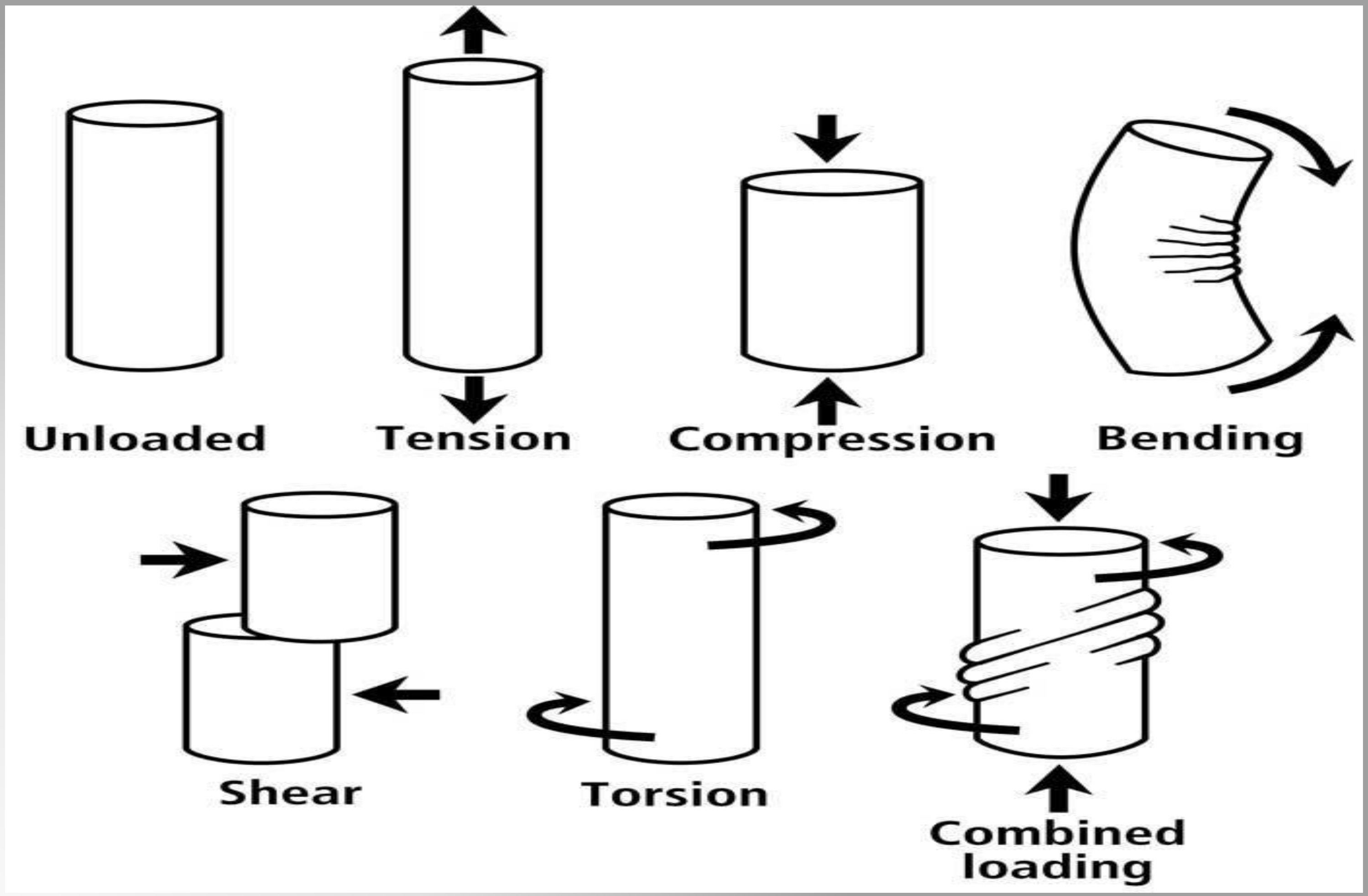
$$\text{Stress} = F \backslash A$$

- is a quantity that is proportional to the force causing a deformation.

Types:-

1) Direct stress
   a)Tensile stress b) Compressive stress c) Shear stress

2) Indirect stress
3) Combined stress


Unloaded
Tension
Compression
Bending
Shear
Torsion
Combined
loading

Strain

Measure of amount of deformation

$$\text{Strain} = \frac{\text{Change in length}}{\text{Original length}}$$

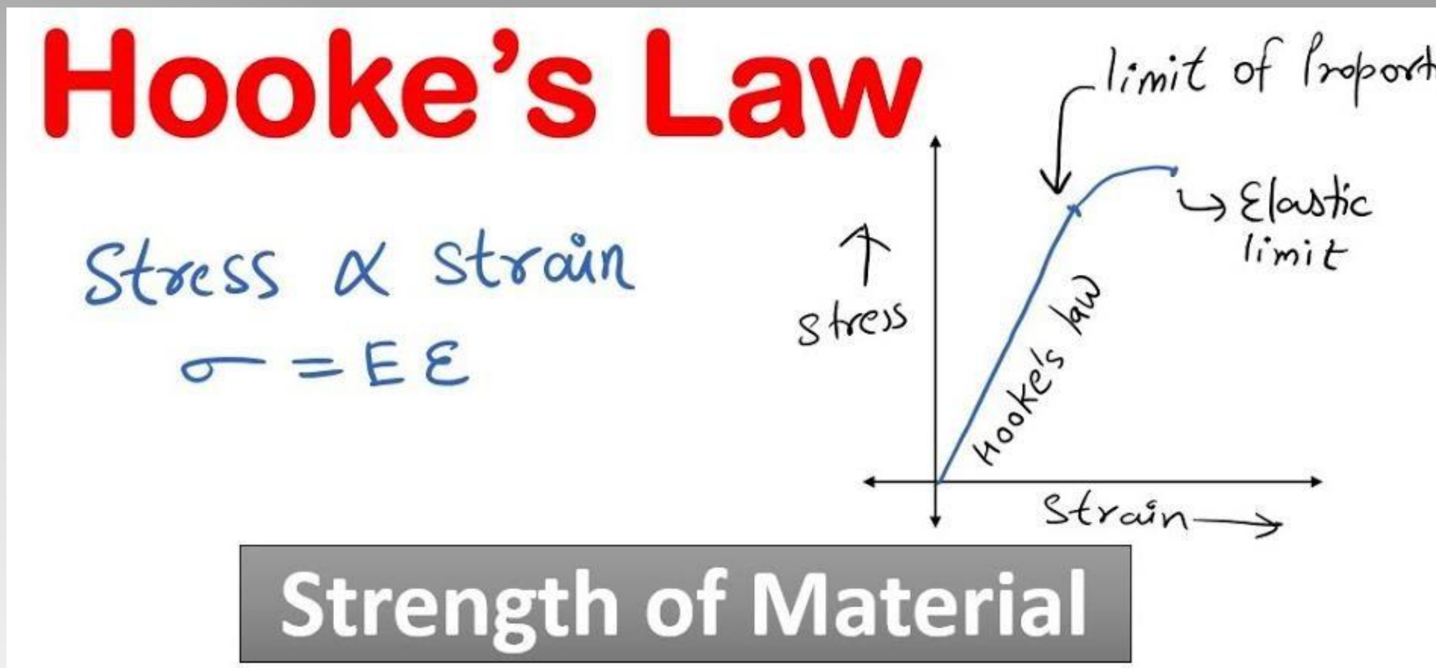
or

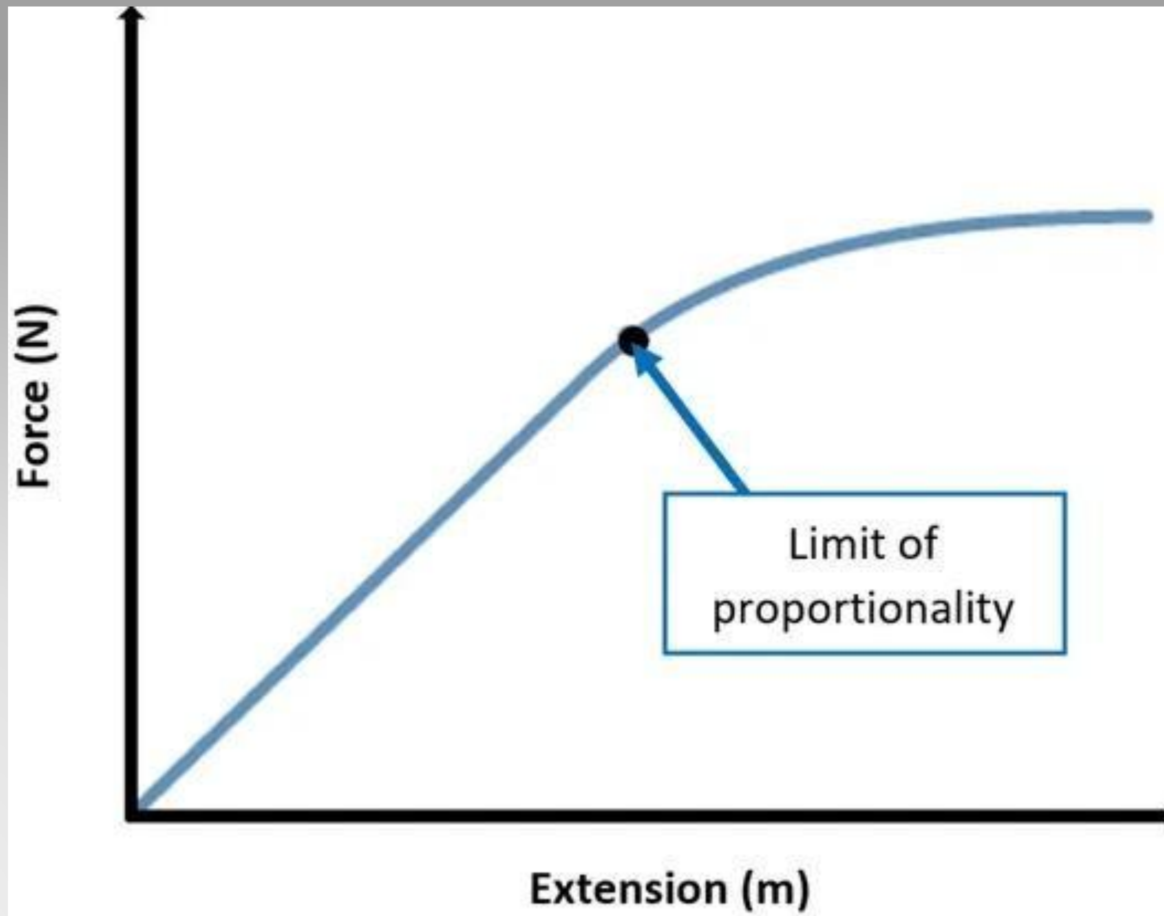
$$\varepsilon = \frac{\Delta L}{L}$$

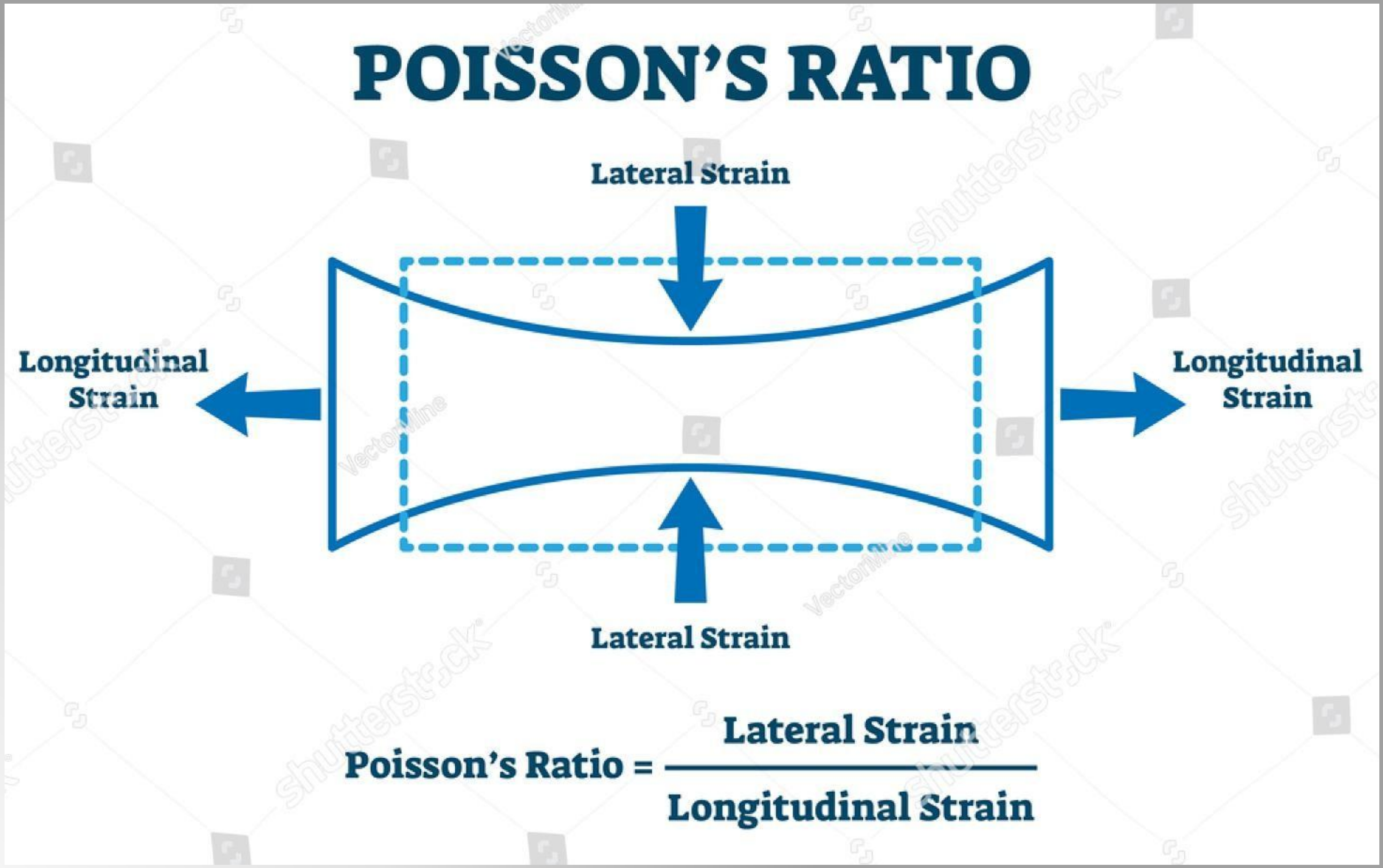
3 types:-

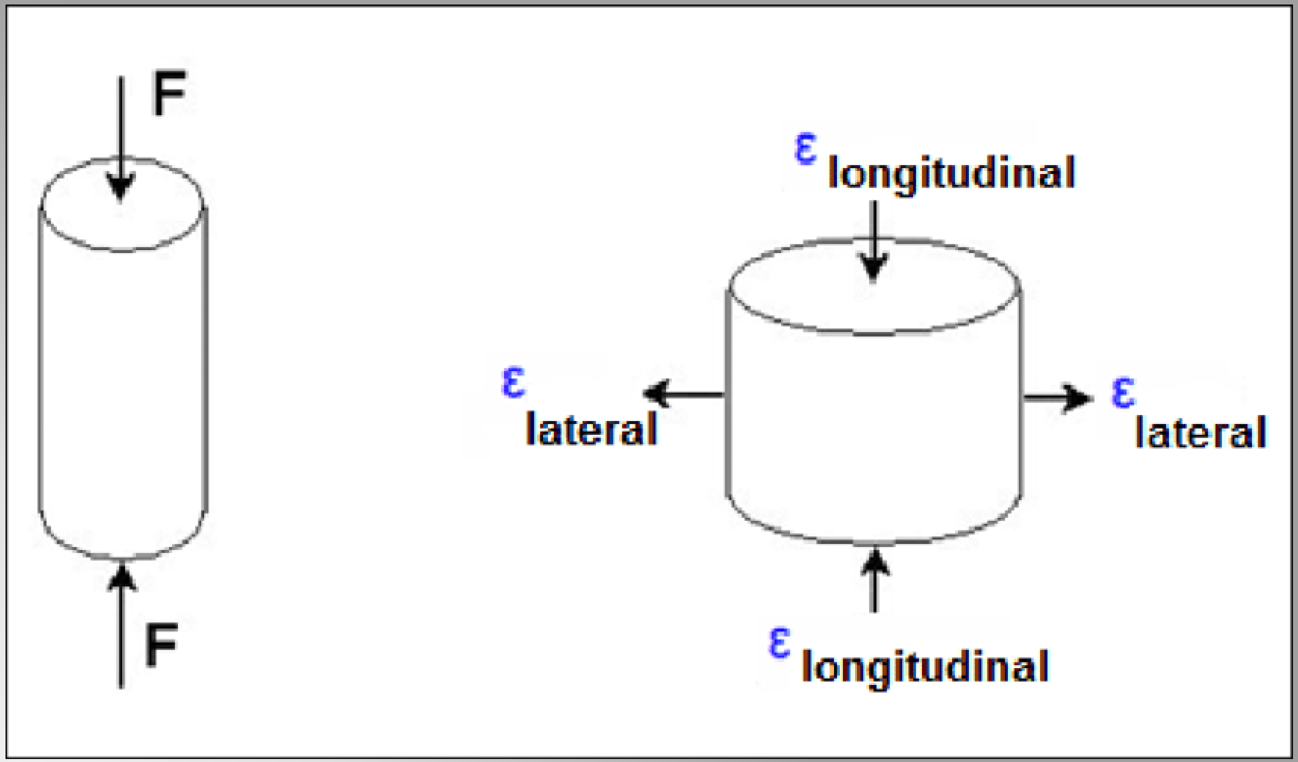
a) Tensile strain
b) Compressive strain
c) Shear strain

- *Stress* is the force per unit area and *strain* is the fractional deformation due to the stress. *Elastic modulus* is stress divided by strain.
- The proportionality of stress and strain is called *Hooke's law*.


Hooke's Law
Stress α strain
σ = E ε
limit of Proportio
Elastic limit
stress
Hooke's law
Strain
Strength of Material


Force (N)
Limit of proportionality
Extension (m)


POISSON'S RATIO
Lateral Strain
Longitudinal Strain
Longitudinal Strain
Lateral Strain
Poisson's Ratio = Lateral Strain / Longitudinal Strain


F
F
ε longitudinal
ε lateral
ε lateral
ε longitudinal

ELASTIC DEFORMATION VERSUS PLASTIC DEFORMATION

ELASTIC DEFORMATION	PLASTIC DEFORMATION
Elastic deformation is the deformation that disappears upon the removal of the external forces, causing the alteration and the stress associated with it	Plastic deformation is the permanent deformation or change in shape of a solid body without fracture under the action of a sustained force
Reversible	Irreversible
Non-permanent; the substance can resume the initial state back	Permanent; the substance stays unchanged after removing the stress
Causes the chemical bonds of the substance to undergo stretching and bending	Cause some of the chemical bonds of the substance to undergo breakage

Thank You!!!!

Rheology

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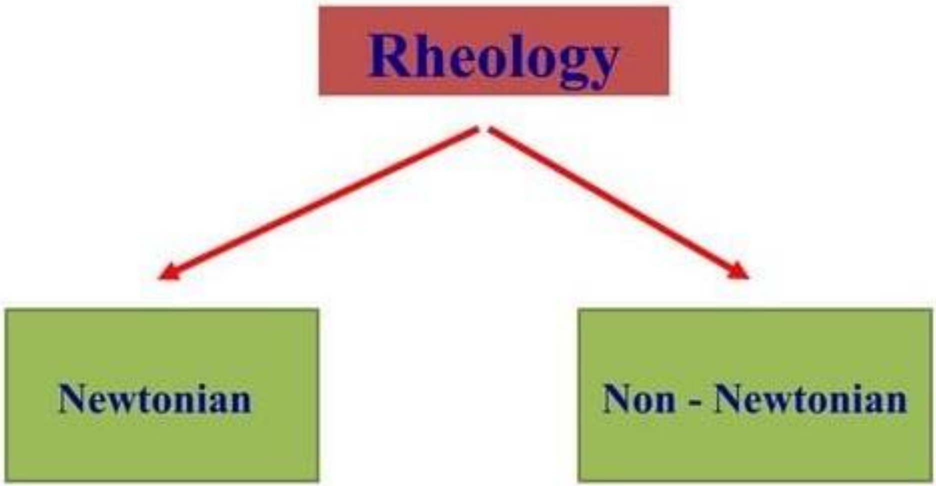
- Rheology is the science/physics that concerns with the flow of liquids and the deformation of solids.

- Study of flow properties of liquids is important for pharmacist working in the manufacture of several dosage forms, viz., simple liquids, gels, ointments, creams, and pastes.

- These systems change their flow behavior when exposed to different stress conditions.

i. **Manufacturing of dosage forms:** Materials undergo process such as mixing, flowing through pipes, filling into the containers etc. Flow related changes influence the selection of mixing equipment.

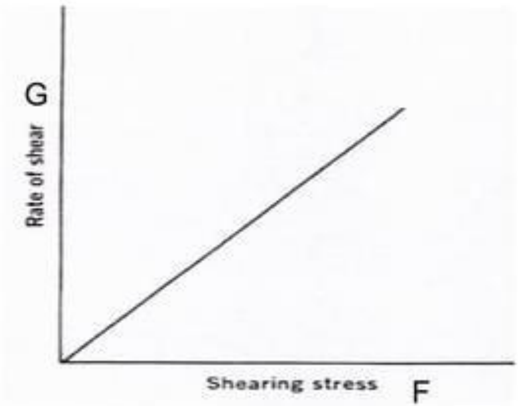
ii. **Handling of drugs for administration:** The syringibility of the medicines, the pouring of the liquids from containers, extrusion of ointment from tubes, all depend on the changes in flow behavior of dosage forms.


Rheology
Newtonian
Non - Newtonian

Newtonian Flow

- Newton was the first to study the flow properties of liquids in quantitative terms. Liquids that obey Newton's law of flow are called as *Newtonian fluids.*

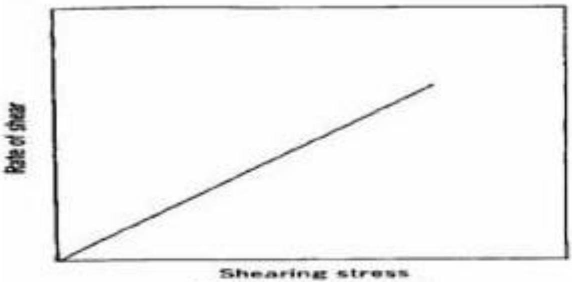
$F = nG$



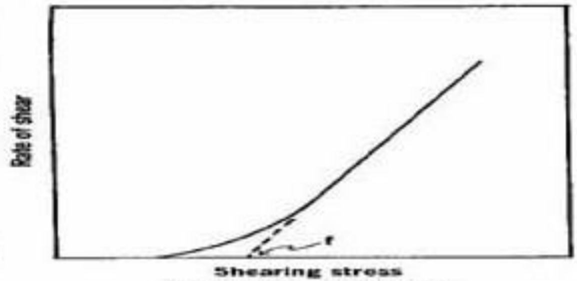
- Non - Newtonian bodies are those substances, which fail to follow Newton's law i.e. liquid & solid , heterogeneous dispersions such as colloidal solutions, emulsions, liquid suspensions and ointments.

They are classified into 3 types of flow:

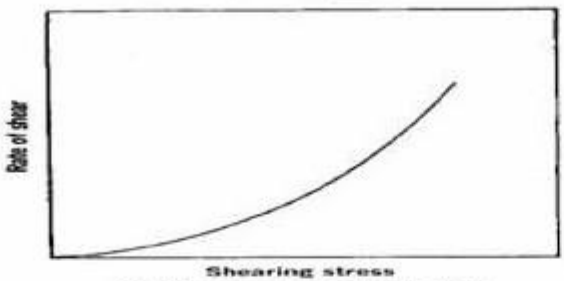
- Plastic.
- Pseudoplastic.
- Dilatant.



(a) Newtonian flow



(b) Simple plastic flow

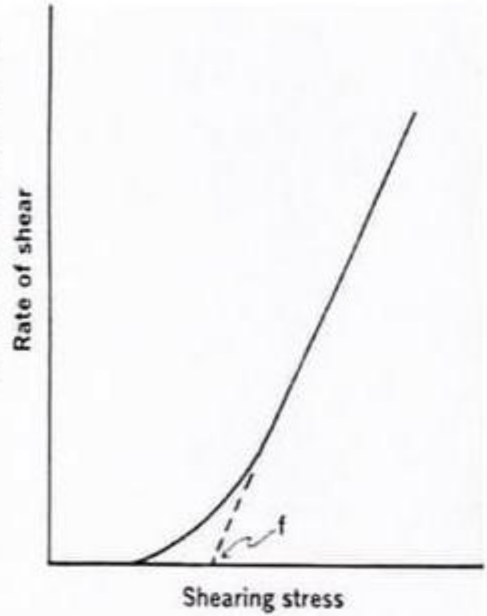


(c) Simple pseudoplastic flow

(d) Dilatant flow

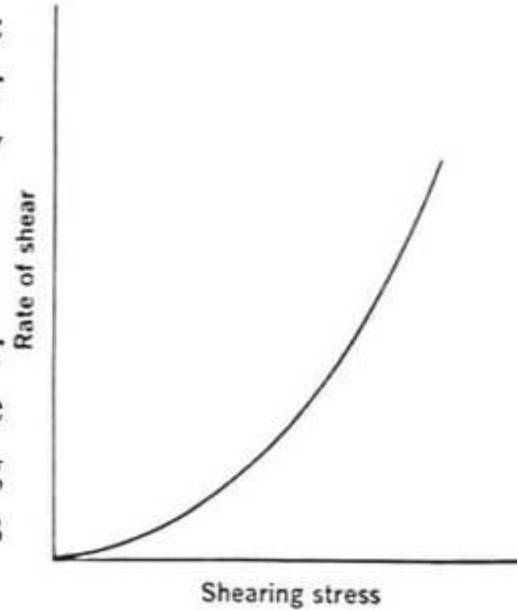
Plastic Flow

- The plastic flow curve does not pass through the origin & it intersects the shearing stress axis (or will if the straight part of the curve is extrapolated to the axis) at a particular point referred to as ***yield value***. (f).



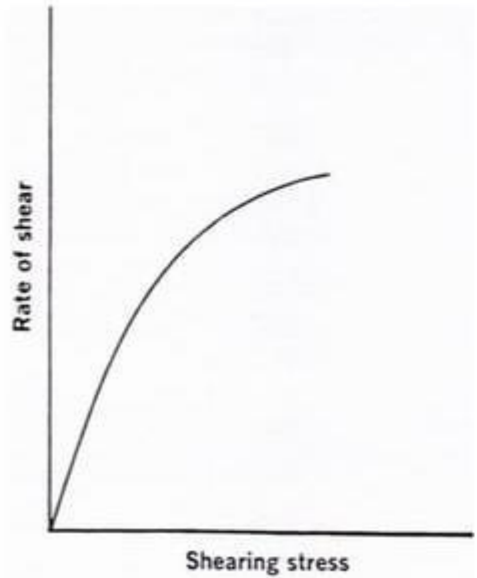
Pseudoplastic Flow

- The curve for a pseudoplastic material begins at the origin (or at least approaches it at low rates of shear).
- The curved rheogram for pseudoplastic materials is due to shearing action on the long chain molecules of materials such as linear polymers.



Dilatant Flow

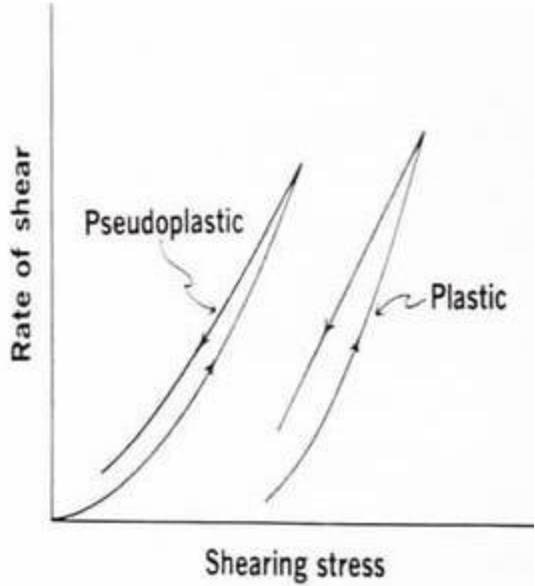
- Certain suspensions with a high percentage of dispersed solids exhibit an in resistance to flow with increasing rates of shear.
- Such systems actually increase in volume when sheared & are called dilatant.
- Dilatant materials "shear thickening systems."
- When the stress is removed, a dilatant system returns to its original state of fluidity.



Thixotropic Behaviors

- It is a comparatively slow recovery, on standing of a material which lost its consistency through shearing."

- Thixotropy is only applied to shear-thinning systems. This indicates a breakdown of structure (shear-thinning), which does not reform immediately when the stress is removed or reduced .



Instrumentation

Viscometer	
Single/One point: At a single rate of shear one point on the curve	**Multipoint:** Several rates of shear many points on the curve
Equipment: 1) Ostwald viscometer 2) Falling sphere viscometer	**Equipment:** 1) Cup and bob 2) Cone and plate
Applications: • Newtonian fluids	**Applications:** • Non-Newtonian fluids • Newtonian fluids

“One point" instruments

- Provide a single point on the rheogram.
- Extrapolation of a line through this point to the origin will result in the complete rheogram.
- Used for Newtonian fluids.
- Since the rate of shear is directly proportional to the shearing stress.
- The capillary and falling sphere are for use only with Newtonian materials.

Ostwald Viscometer

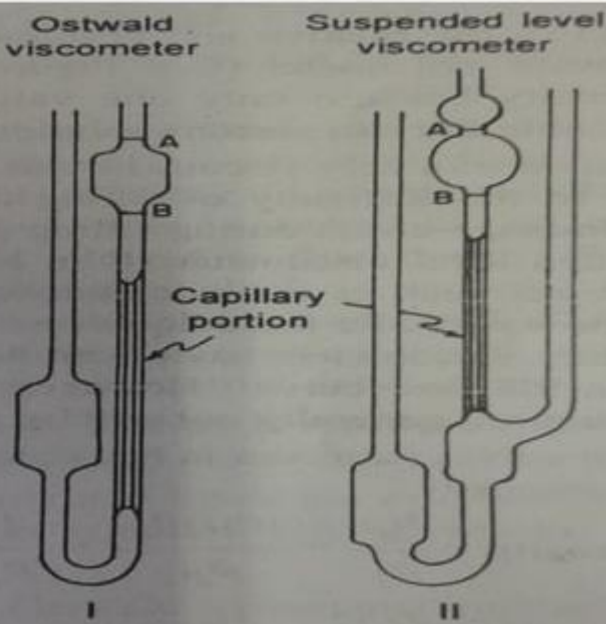
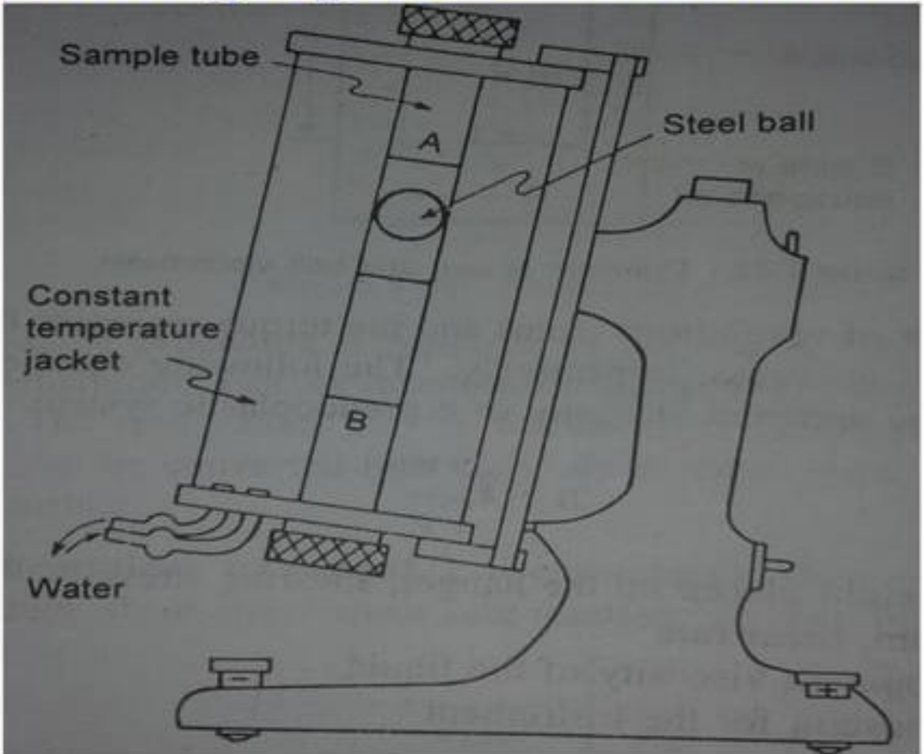


Figure 7-16. Capillary viscometers. Ostwald viscometer (I) and suspended level viscometer (II).

- Ostwald viscometer is used to determine the viscosity of a Newtonian liquid. Both dynamic and kinematic viscosities can be obtained.

- When a liquid flows by gravity, the time required for the liquid to pass between two marks (A and B shown in Figure) through a vertical capillary tube is determined.

Falling Sphere Viscometer

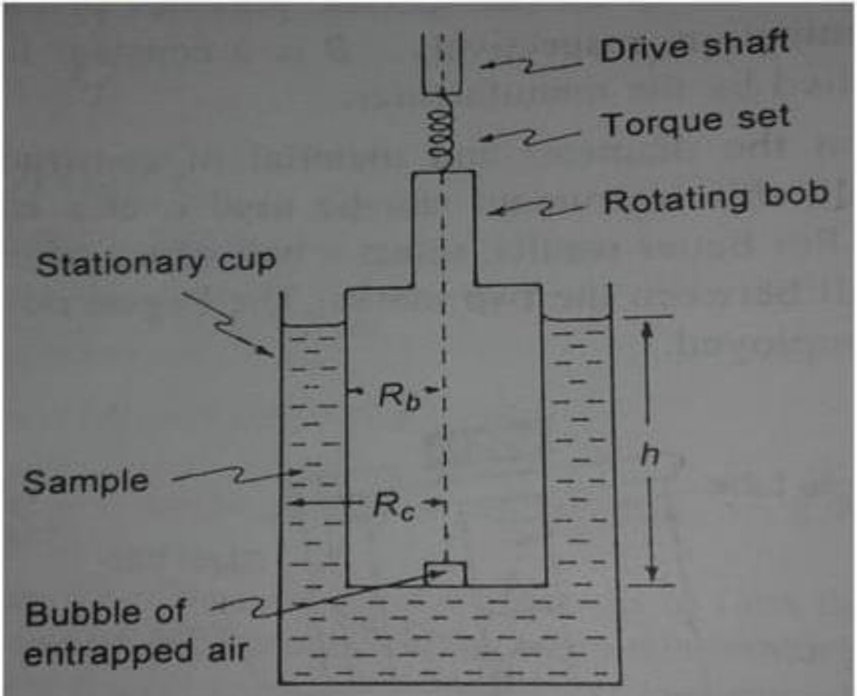


- The sample & ball are placed in the inner glass tube & allowed to reach temperature equilibrium with the water in the surrounding constant temperature jacket.
- The tube & jacket are then inverted, which effectively places the ball at the top of the inner glass tube.
- The time for the ball to fall between two marks is accurately measured & repeated several times.

“Multi-point" instruments

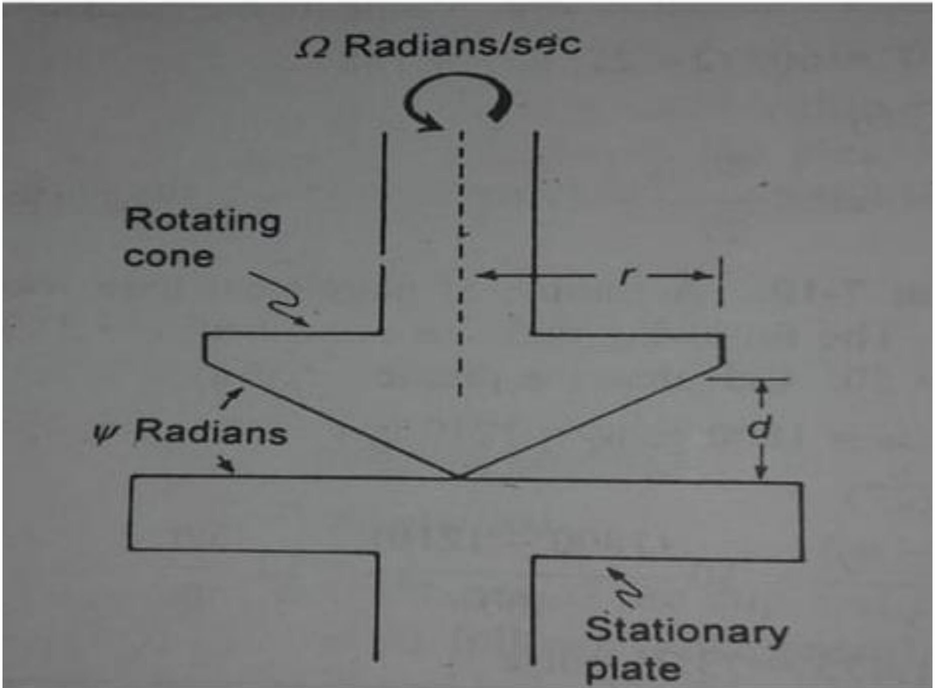
- Used with non-Newtonian systems.
- The instrumentation used must be able to operate at a variety of rates of shear.
- Cup and Bob , Cone and Plate viscometers may be used with both types of flow system.

Cup and Bob Viscometer



- This is a multipoint viscometer and belongs to the category of rotational viscometers.
- The sample is placed in the cup and the bob is placed in the cup up-to an appropriate height.
- The sample is accommodated between the gap of cup and bob.
- Cup or bob is made to rotate and the torque (shearing stress) from the viscous drag is measured by a spring or sensor in the drive of the bob.

Cone and Plate Viscometer



- The sample is placed at the center of the plate which is then raised into position under the cone.
- The cone is driven by a variable speed motor & the sample is sheared in the narrow gap between the stationary plate and the rotating cone.
- The rate of shear in rev./min. is increased & decreased by a selector dial & the torque (shearing stress) produced on the cone is read on the indicator scale.
- A plot of rpm or rate of shear versus scale reading (shearing stress) may be plotted.

1. The viscosity of creams and lotions may affect the rate of absorption of the products by the skin.
2. A greater release of active ingredients is generally possible from the softer, less viscous bases.
3. The viscosity of semi-solid products may affect absorption of these topical products due to the effect of viscosity on the rate of diffusion of the active ingredients.
4. The rate of absorption of an ordinary suspension differs from thixotropic suspension.
5. Thixotropy is useful in the formulation of pharmaceutical suspensions and emulsions. They must be poured easily from containers (low viscosity)

Thank You!!!!