RHEOLOGY

Fluid Mechanics

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Rheology is the science of flow and deformation of matter and describes the interrelation between force, deformation and time. The term comes from Greek rheos meaning to flow. Rheology is applicable to all materials, from gases to solids.

RHEOLOGY

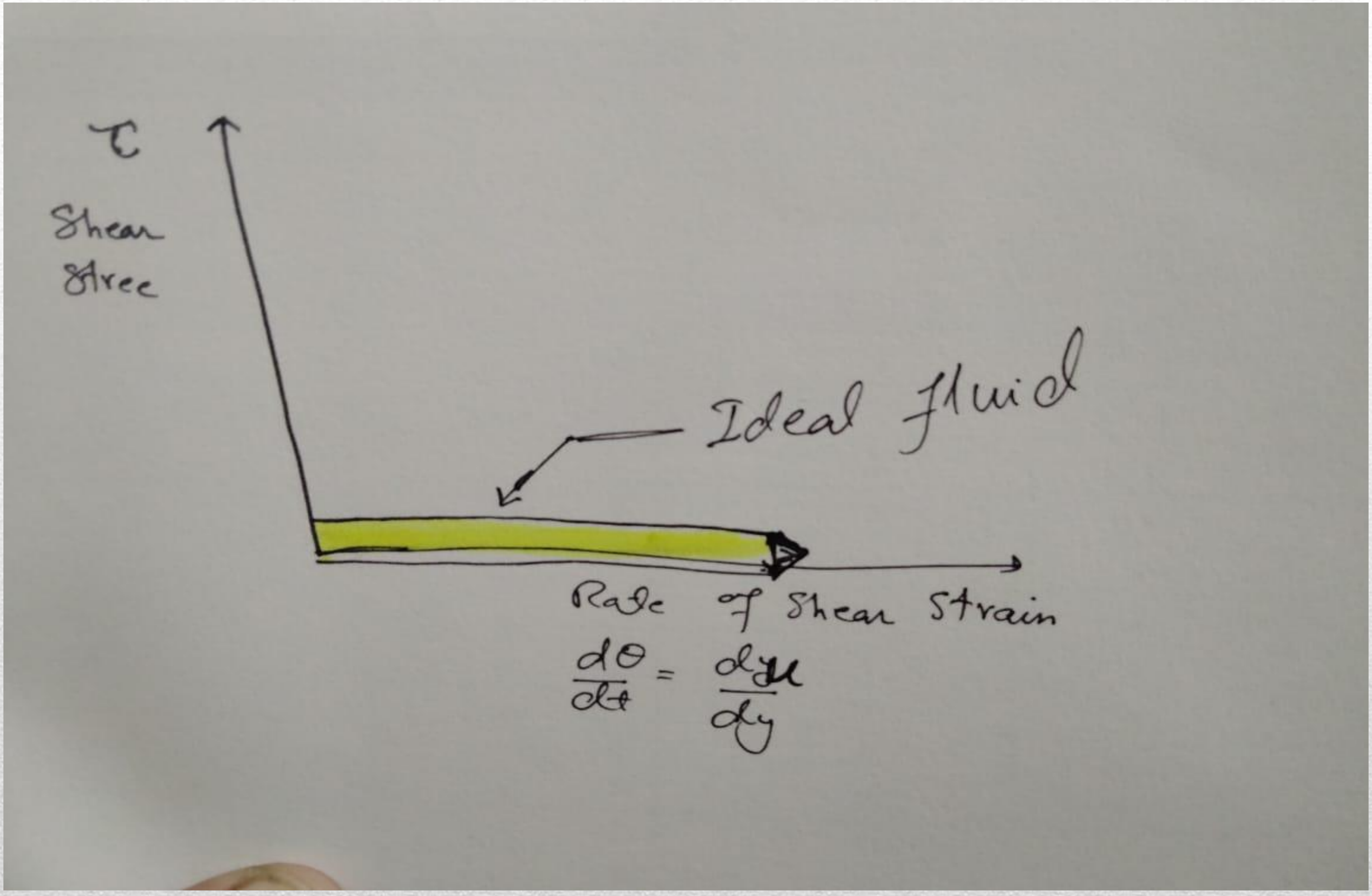
Rheology is the study of the flow of matter, primarily in a liquid or gas state, but also as "soft solids" or solids under conditions in which they respond with plastic flow rather than deforming elastically in response to an applied force. Rheology is a branch of physics, and it is the science that deals with the deformation and flow of materials, both solids and liquids.

RHEOLOGY

I. IDEAL FLUID
II. NEWTONIAN FLUID
III. NON-NEWTONIAN FLUIDS
   - Dilatant fluids
   - Pseudo plastic fluids
   - Bigham Plastic fluids
   - Herschel Bulkely

IDEAL FLUID

- Inviscid
- Incompressible
- No shear stress
- Constant normal stress

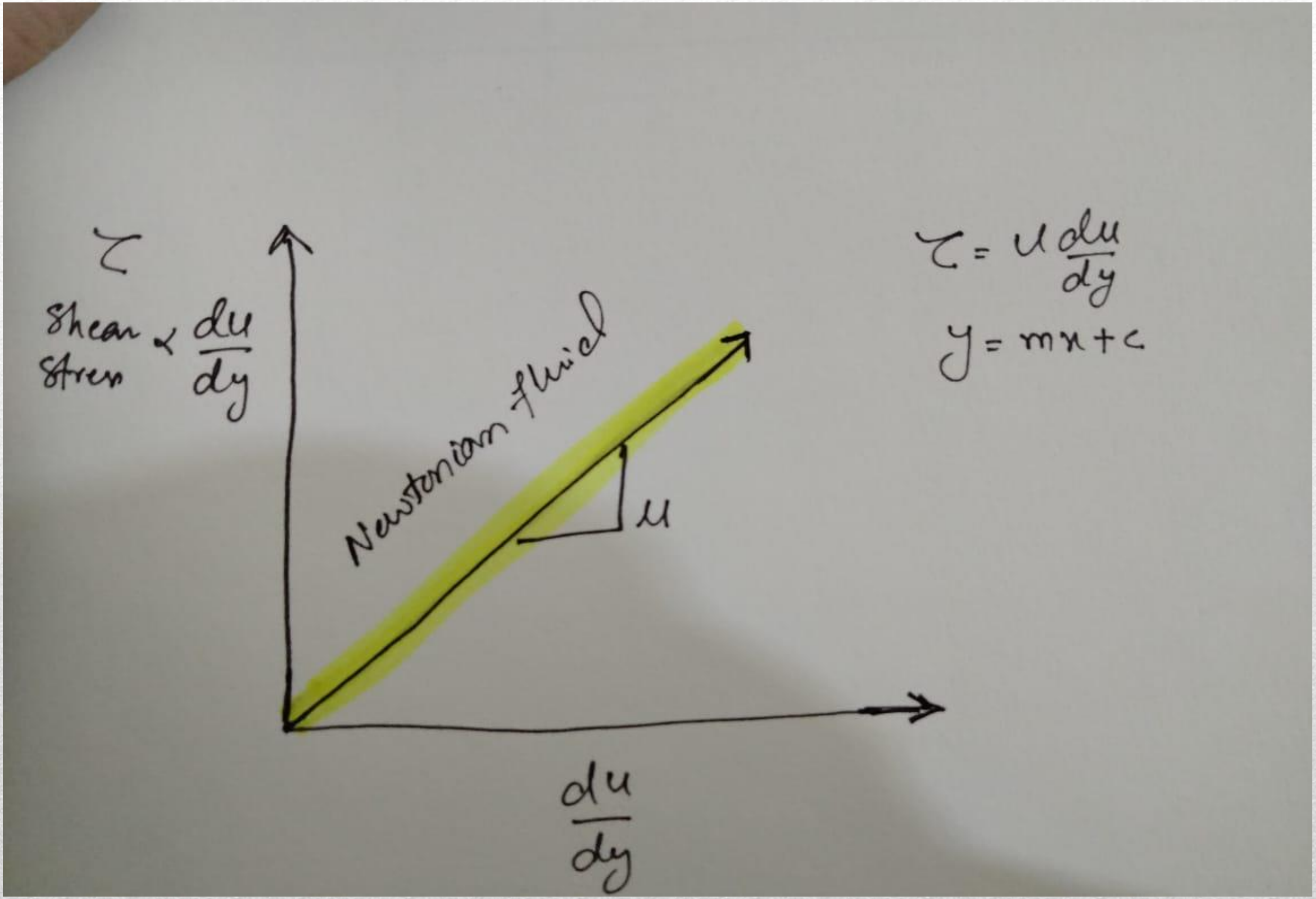

τ
Shear
Stree
Ideal fluid
Rate of Shear Strain
$\frac{d\theta}{dt} = \frac{du}{dy}$

NEWTONION FLUID

A Newtonian fluid is a fluid in which the viscous stresses arising from its flow, at every point, are linearly correlated to the local strain rate—the rate of change of its deformation over time.

Water and honey

$$\tau = \mu \frac{du}{dy}$$



τ
Shear stress ∝ du/dy
Newtonian fluid
μ
du/dy
τ = μ du/dy
y = mx + c

NON- NEWTONION FLUID

- In reality most fluids are non-Newtonian, which means that their viscosity is dependent on shear rate (Shear Thinning or Thickening) or the deformation history (Thixotropic fluids). In contrast to Newtonian fluids, non-Newtonian fluids display either a non-linear relation between shear stress and shear rate (see Figure 1), have a yield stress, or viscosity that is dependent on time or deformation history (or a combination of all the above!).

NON- NEWTONION FLUID

$$\tau = m\left(\frac{du}{dy}\right)^{n}$$

m= consistency index

n= flow index

If n > 1 (dilatant fluid)

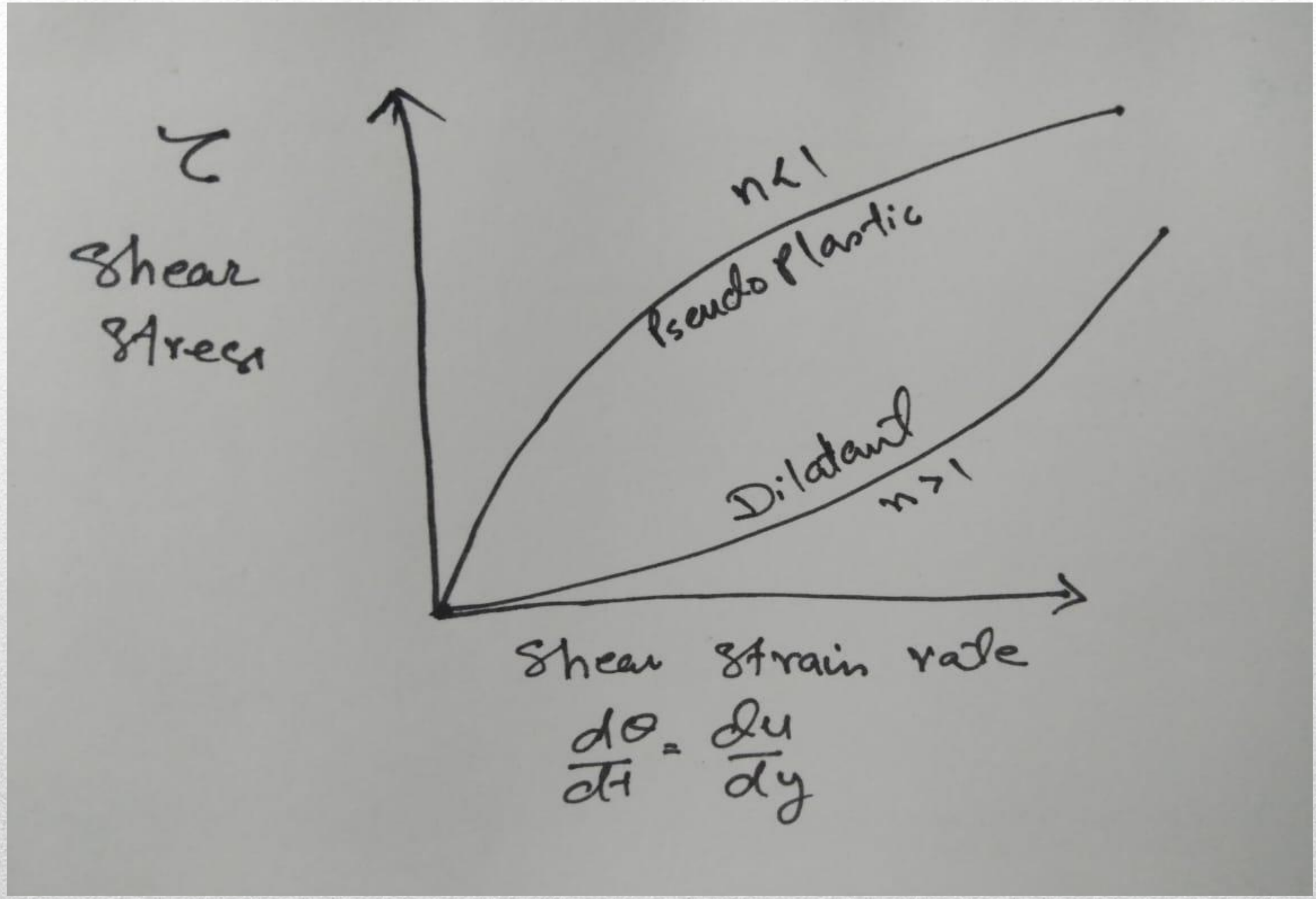
If n< 1 (pseudo plastic fluid)

If $n < 1$ (dilatant fluid)

- Shear thickening fluids
- A fluid is shear thickening if the viscosity of the fluid increases as the shear rate increases (see Figure 2). A common example of shear thickening fluids is a mixture of cornstarch and water. You have probably seen examples of this on TV or the internet, where people can run over this kind of solutions and yet, they will sink if they stand still.
- Ex: starch suspension

If n > 1 (pseudo plastic fluid)

- Shear thinning fluids
- shear thinning if the viscosity decreases as the shear rate increases. Shear thinning fluids, also known as pseudo-plastics, are ubiquitous in industrial and biological processes. Common examples include ketchup, paints and blood.
- Ex: blood

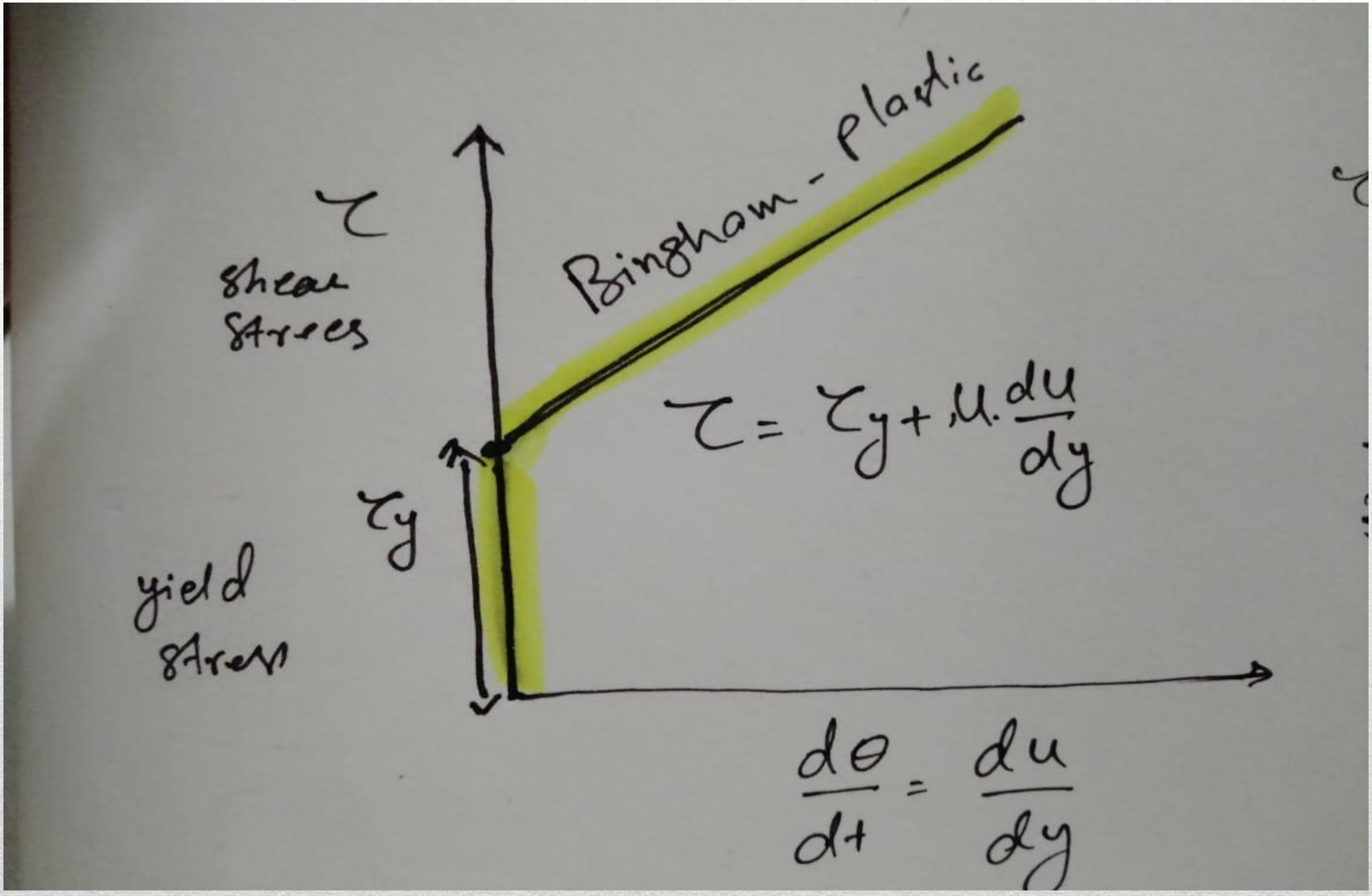

τ
Shear
Stress
n<1
Pseudo Plastic
Dilatant
n>1
Shear strain rate
dθ/dt = du/dy

BINGHAM PLASTIC FLUID

$$\tau = \tau_y + \mu \cdot \frac{du}{dy}$$

τ_y = yield stress

Example : tooth paste

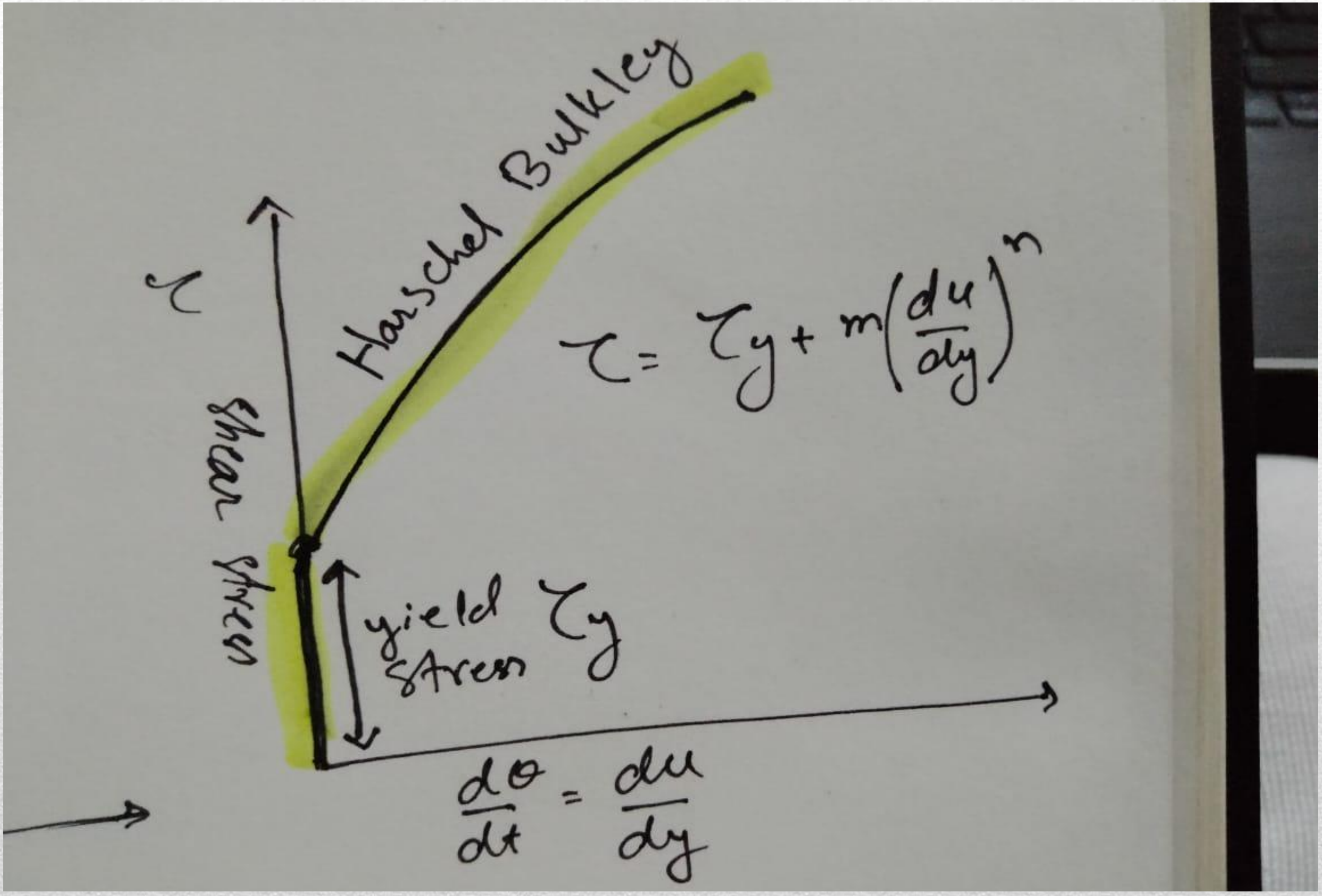

τ
shear stress
Bingham - plastic
$\tau = \tau_y + \mu \cdot \frac{du}{dy}$
τ_y
yield stress
$\frac{d\theta}{dt} = \frac{du}{dy}$

HERSCHEL BULKLEY

$$\tau = \tau_y + m\left(\frac{du}{dy}\right)^n$$

τ_y = yield stress

Example : tooth paste


Harschel Bulkley
τ
Shear stress
$\tau = \tau_y + m\left(\frac{du}{dy}\right)^n$
yield stress τ_y
$\frac{d\theta}{dt} = \frac{du}{dy}$