NOTES CLASS 11-28-2017

Is water viscoelastic?

$t_R \times \omega \ll 1$ LIQUID BEHAVIOR

$t_R \times \omega \gg 1$ SOLID BEHAVIOR

$t_R \simeq 10^{-12}$ seconds.

$10^{-12} \times \omega \gg 1$ SOLID BEHAVIOR

$\omega \geq \cancel{10^{13}}\ 10^{12}$ Hz [Hertz]

Maximum you can achieve for mechanical characterization of materials 10^6 Hz

↑

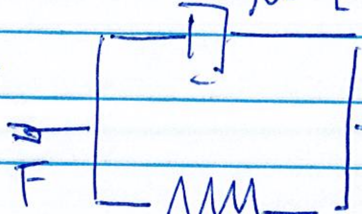
<u>ULTRASOUND</u>

MODELS

Viscoelastic Kelvin Void Model.

μ [viscosity of liquid part

Pa.s



F

F

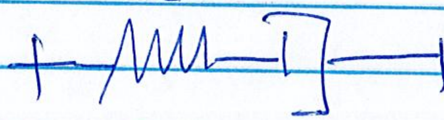
MODEL EQUATION ?

G [Elasticity of the elastic part)

Pa

Viscoelastic material Maxwell Model.

G μ



MODEL EQUATION ?

RHEOLOGY

stress

SIMPLE MODEL

constant of rubber band.

PURE ELASTIC

$\sigma = G\,\gamma$ strain.

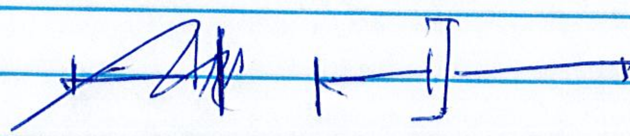
$F = K\,L$

HOOKE MODEL

Force

length of rubber band

PURE VISCOUS MATERIAL (LIQUID)



$$F = \mu \frac{dL}{dt}$$

$$\sigma = \mu \frac{d\gamma}{dt} = \mu \dot{\gamma}$$

Newton EQUATION

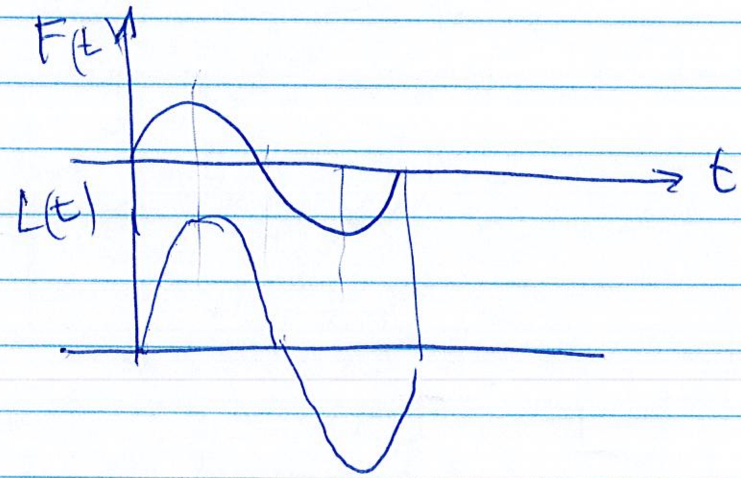
~~PURE~~ PURE ELASTIC MATERIAL

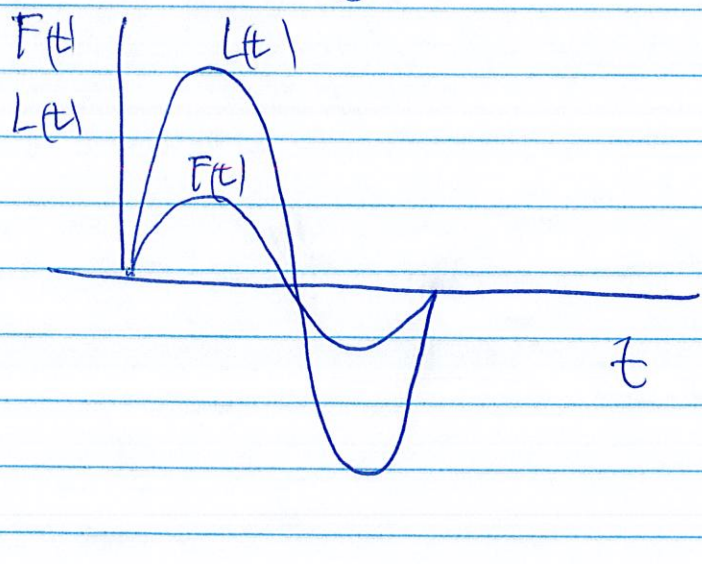
Simple $F(t) = K\,L(t)$

$$\Downarrow$$

RHEOLOGY $\sigma(t) = G\,\gamma(t)$

$L(t) = L_0 \sin \omega t$





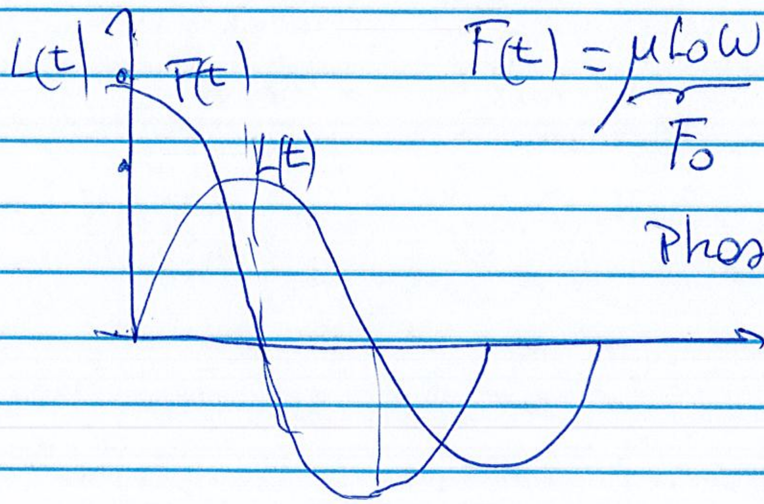
PURE LIQUID MATERIAL

Simple Rheology

$$F(t) = \mu \frac{dL(t)}{dt}$$

$$\sigma(t) = \mu \frac{d\gamma(t)}{dt}$$

$$L(t) = L_0 \sin \omega t$$

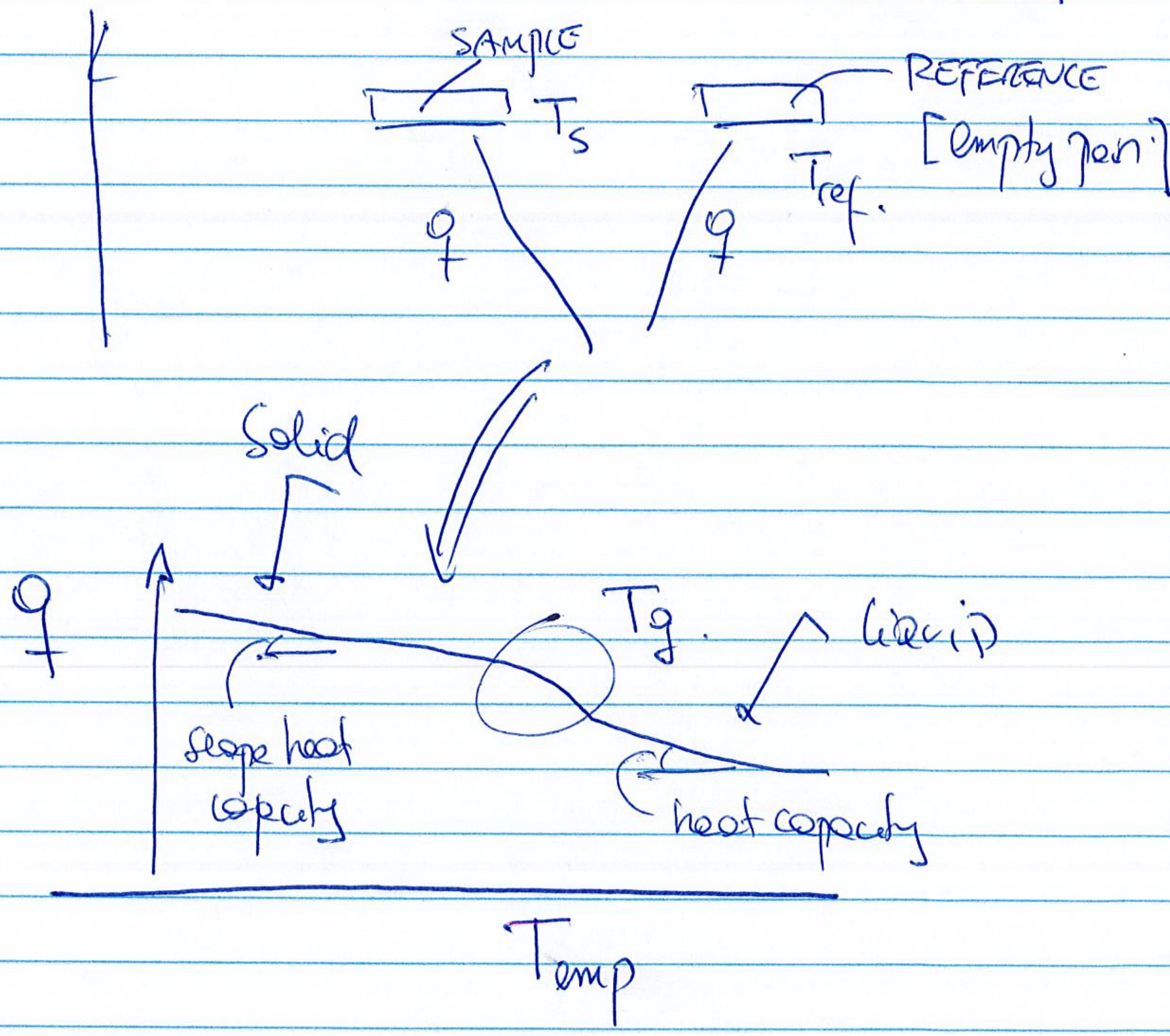


$$F(t) = \underbrace{\mu L_0 \omega}_{F_0} \cos \omega t$$

$$\text{Phase} = \frac{\pi}{2} \text{ or } \underline{90^\circ}$$

GLASS TRANSITION TEMPERATURE T_g (5)

T_g can be measured by DSC [Differential Scanning Calorimeter]



$$\Delta C_p = C_{p_{sol.}} - C_{p_{liq}} \approx 5\%$$

Difficult to detect for complex systems.

RHEOLOGY

Tg using DMA technique (Dynamic Mechanical Analysis)