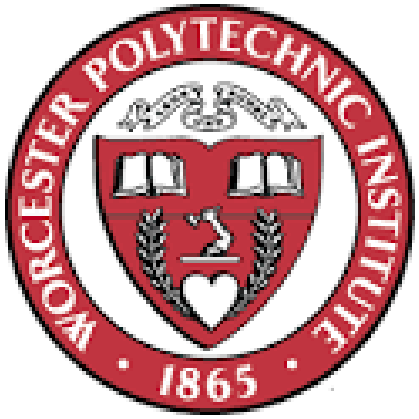
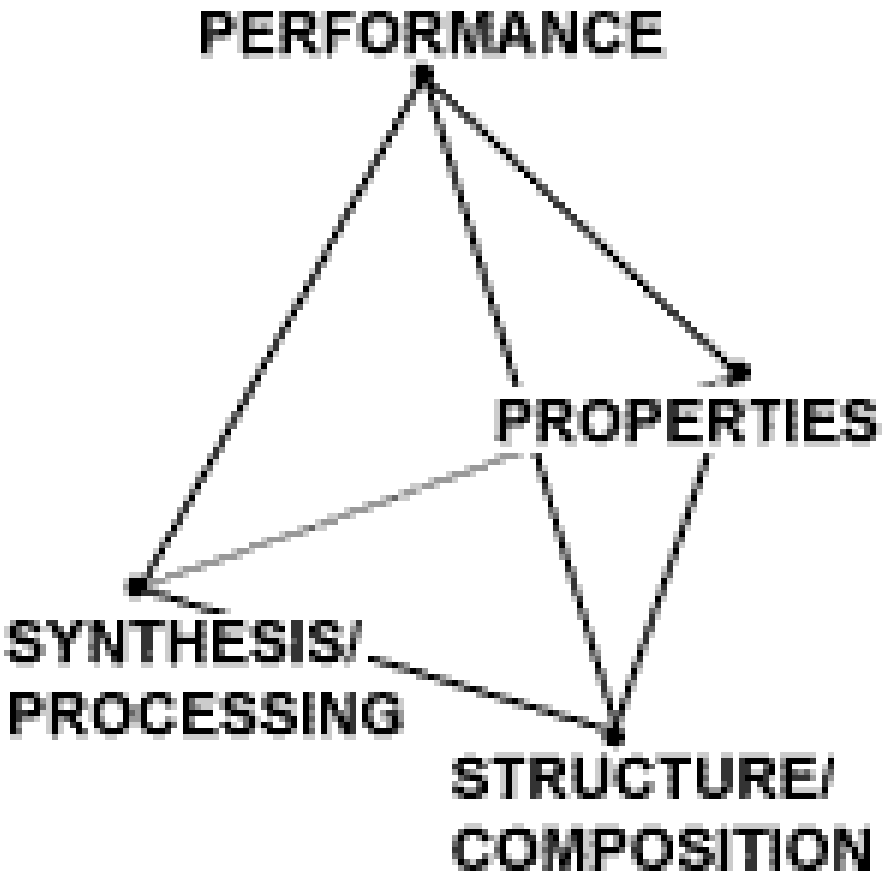


Mathematics and Science in Schools in Sub-Saharan Africa

MATERIAL SCIENCE

Introduction to Material Properties

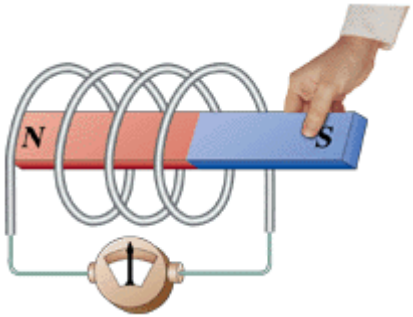
What Material Scientists Do



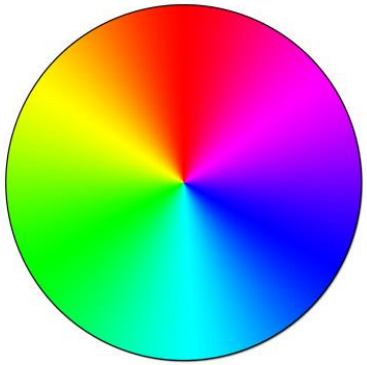
Physical Properties

Melting & Boiling Points

Magnetism

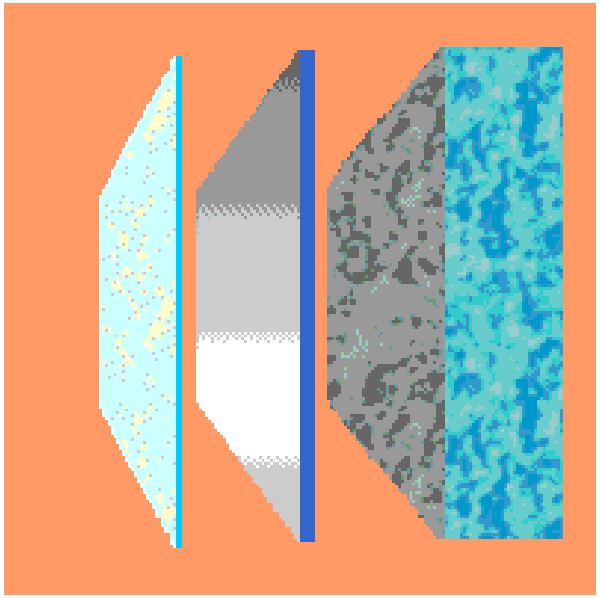


Color

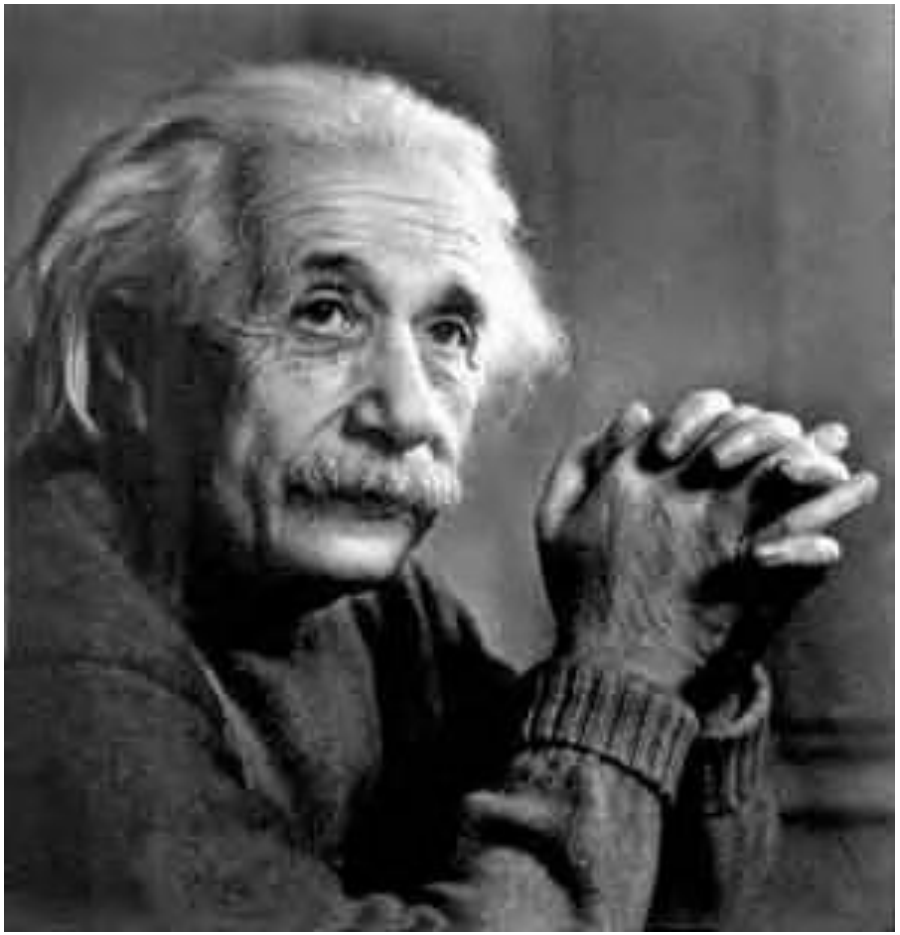


Physical Properties

Density



Lab: Density Determination



Lab: Density Determination

Data Chart

Material Sample	Density (g/ml)	Material Sample	Density (g/ml)
A		H	
B		I	
C		J	
D		K	
E		L	
F		M	
G		N	

Lab: Density Determination

Material Density Chart

Material Sample	Density (g/ml)	Material Sample	Density (g/ml)
Walnut	0.64	Phenolic	1.32
Oak	0.75	PVC	1.37
Maple	0.77	Acetyl	1.42
Polypropylene	0.90	PTFE	2.20
Polyethylene	0.92	Aluminum	2.71
Nylon	1.15	Brass	8.56
Acrylic	1.17	Copper	8.91

Lab: Density Determination

Analysis Chart

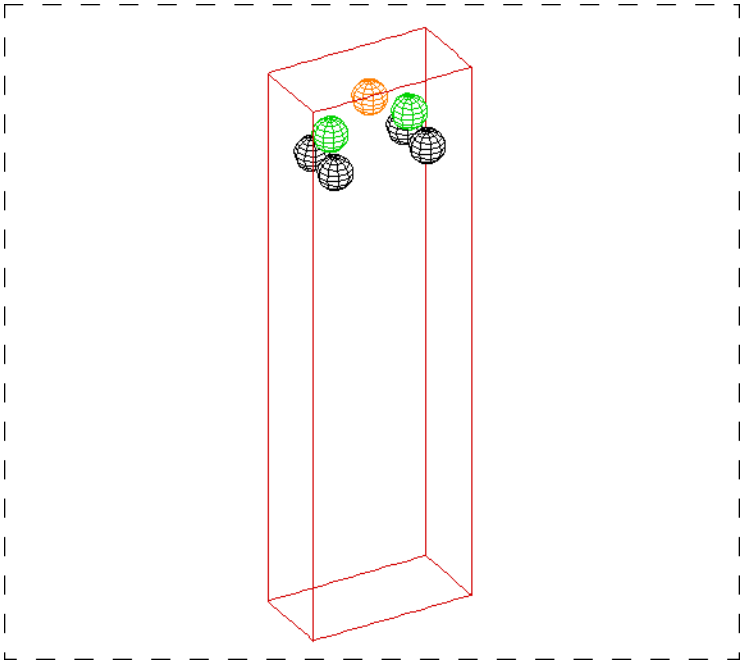
Material Sample	Material Identity	Material Sample	Material Identity
A		H	
B		I	
C		J	
D		K	
E		L	
F		M	
G		N	

Density

Density = Mass/Volume

Physical Properties

Viscosity



Viscosity **is an internal property of a fluid that offers resistance to flow .**

Thickness

Viscosity Determination

Calculations

Viscosity = π = 2(Δp)ga^2/9v

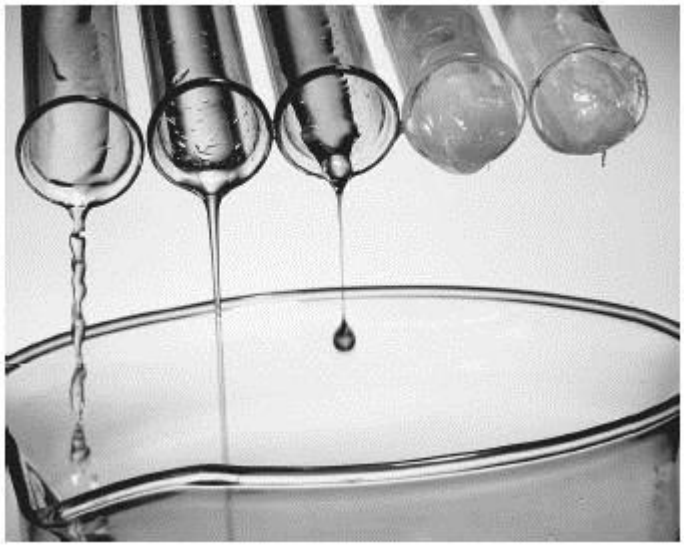
Δp = difference in density between glass marble and test liquid

g = rate of free fall = 9.81 m/s^2

a = radius of sphere

v = velocity

Viscosity Testing



Viscosity Testing

Viscosity Units

International Standards Organization

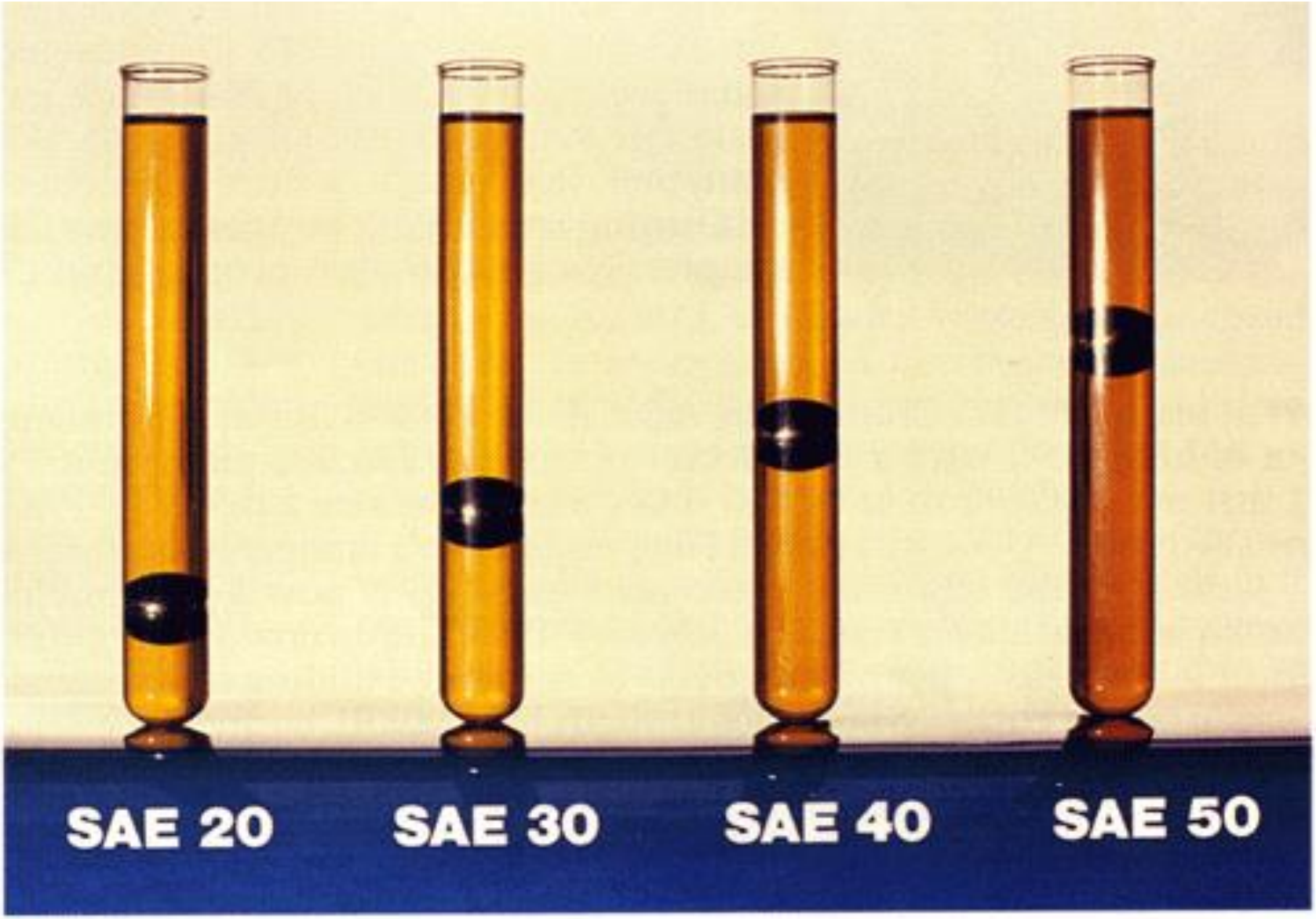
Viscosity Grade Numbers

ISO

Society of Automotive Engineers

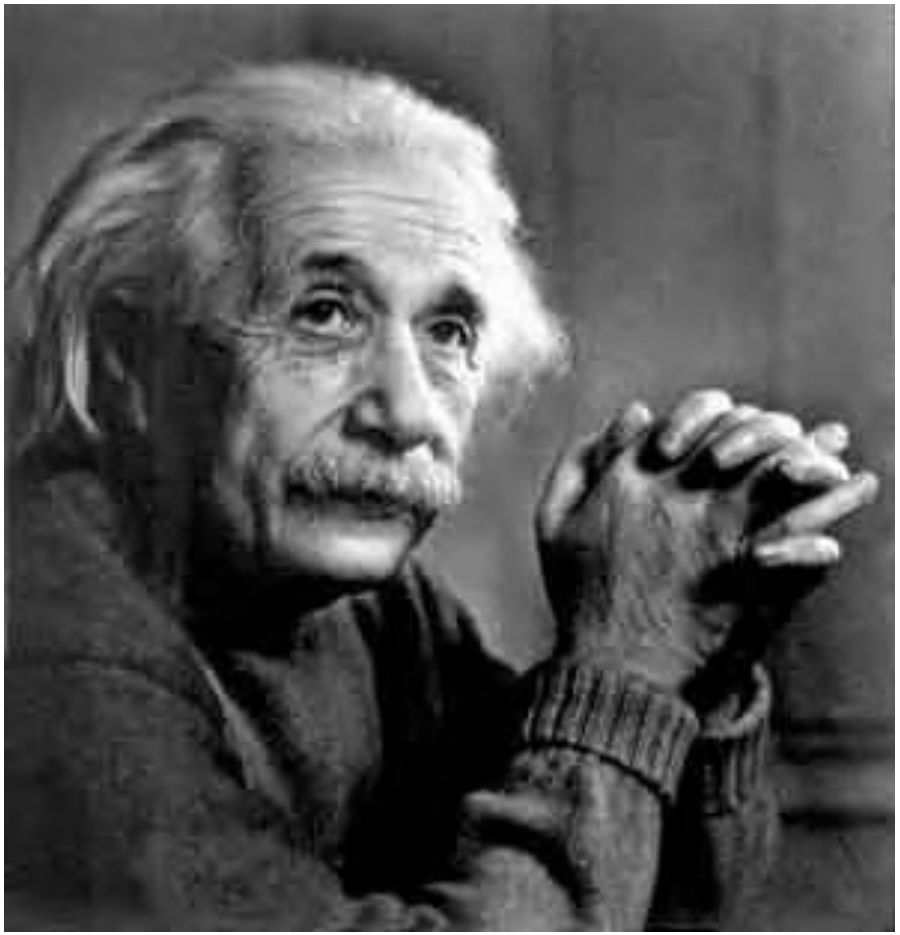
Viscosity Grade Numbers

SAE



Steel balls of equal weight dropped into test tubes filled with motor oils fall at different rates. Their rate of fall depends on the viscosity of the oil. The ball travelling through the light SAE 20 oil has travelled farthest, while the ball in the heavy SAE 50 has travelled least.

Lab: Viscosity Determination



Viscosity Testing

Made in USA

Lab: Viscosity Determination

Data Chart

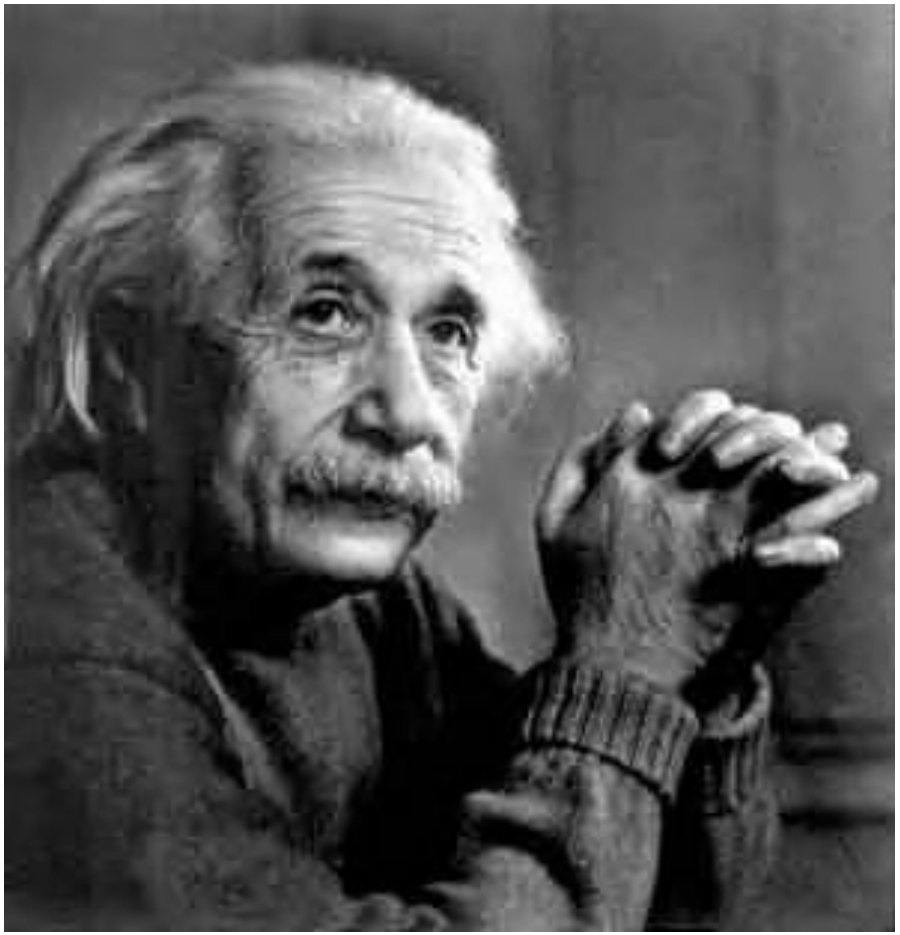
Tube	*Time (s)*
Red	
Blue	
Green	
Grey	
Black	

Lab: Viscosity Determination

Calculations

Tube	ISO
Red	10
Blue	32
Green	46
Grey	
Black	

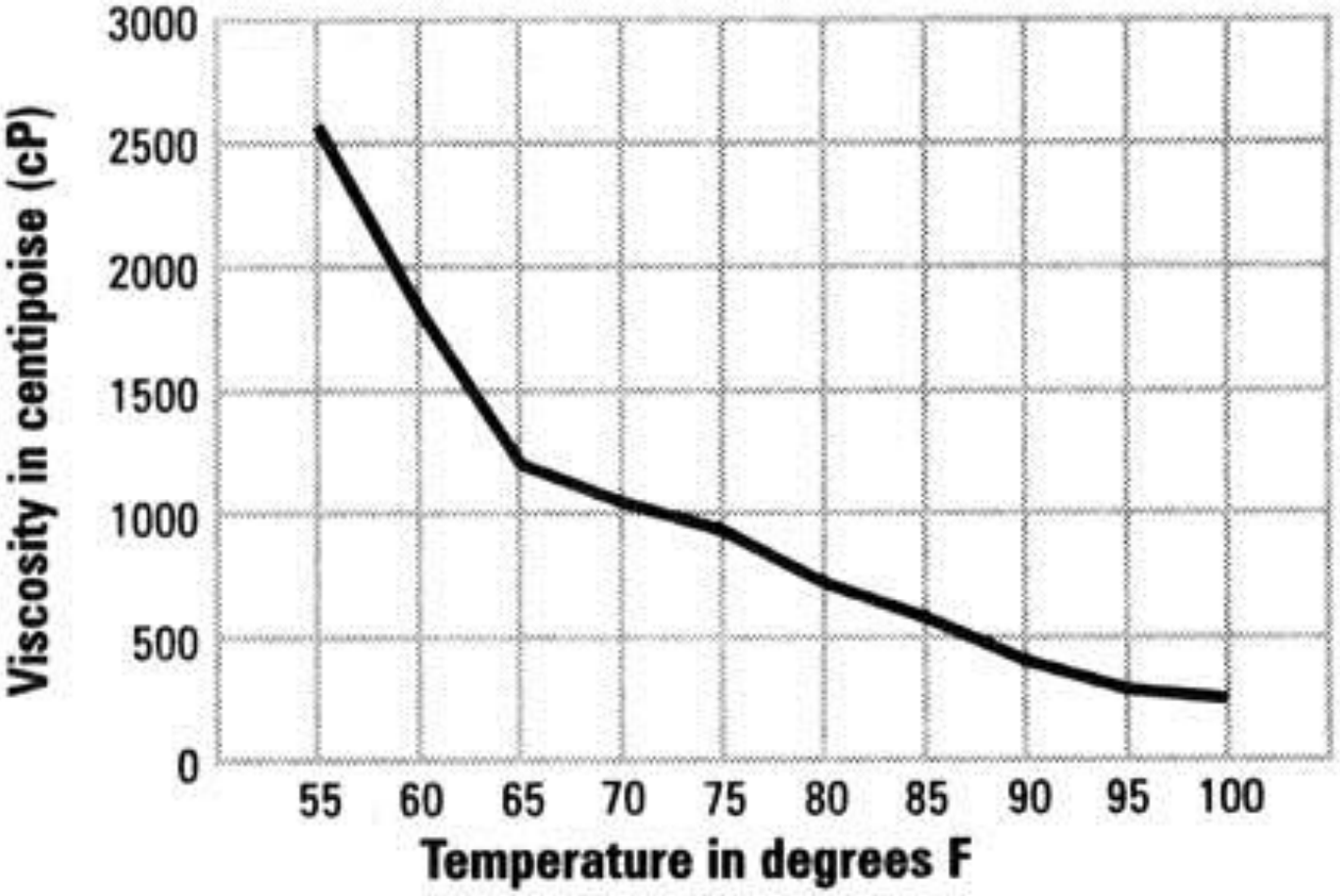
Lab: Viscosity Explorer



Lab: Viscosity Explorer

Data Chart

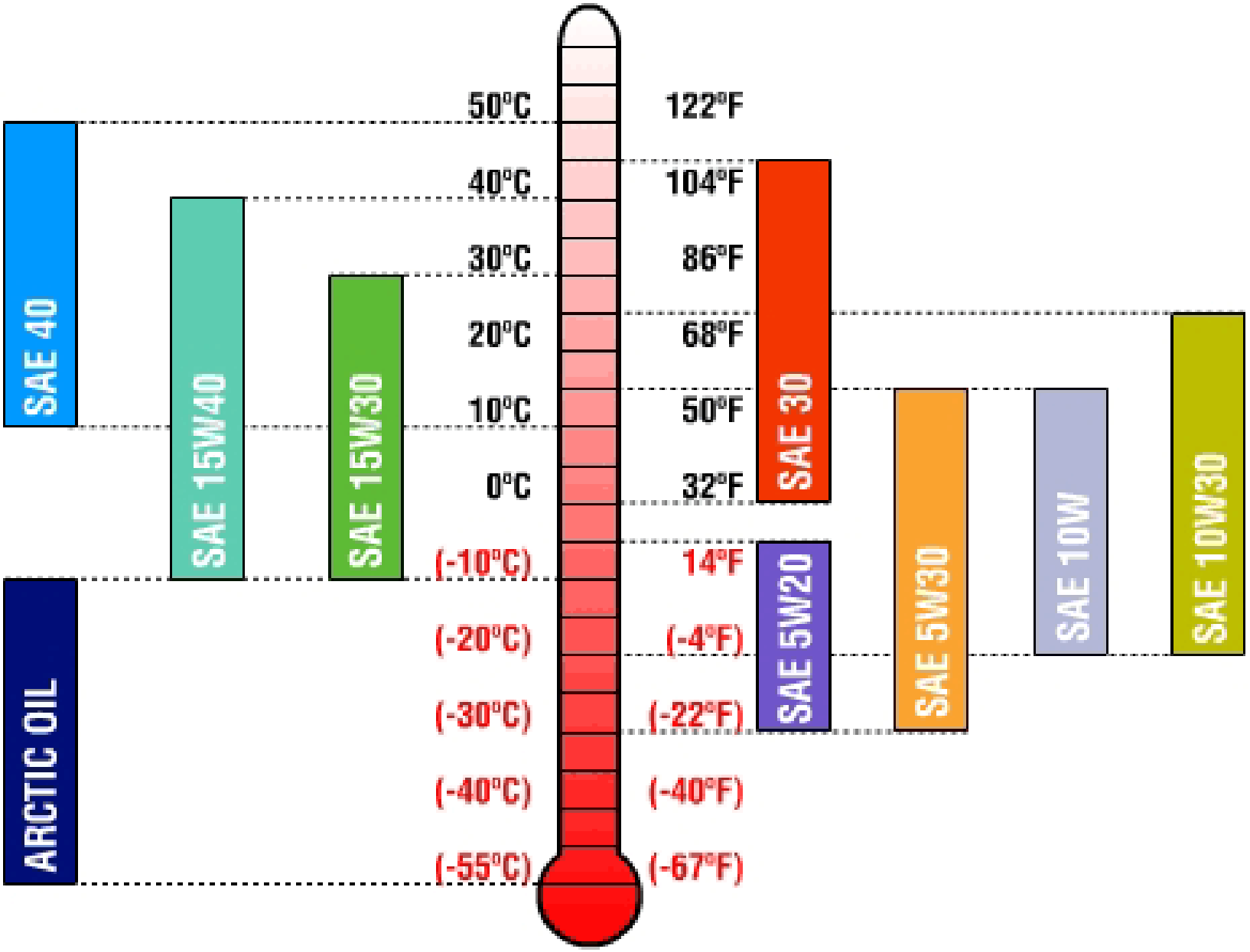
Olive Oil Temperature	Drop Time
0° C	
10° C	
20° C	
30° C	
40° C	
50° C	
60° C	
70° C	
80° C	
90° C	


Viscosity in centipoise (cP)
3000
2500
2000
1500
1000
500
0
55
60
65
70
75
80
85
90
95
100
Temperature in degrees F

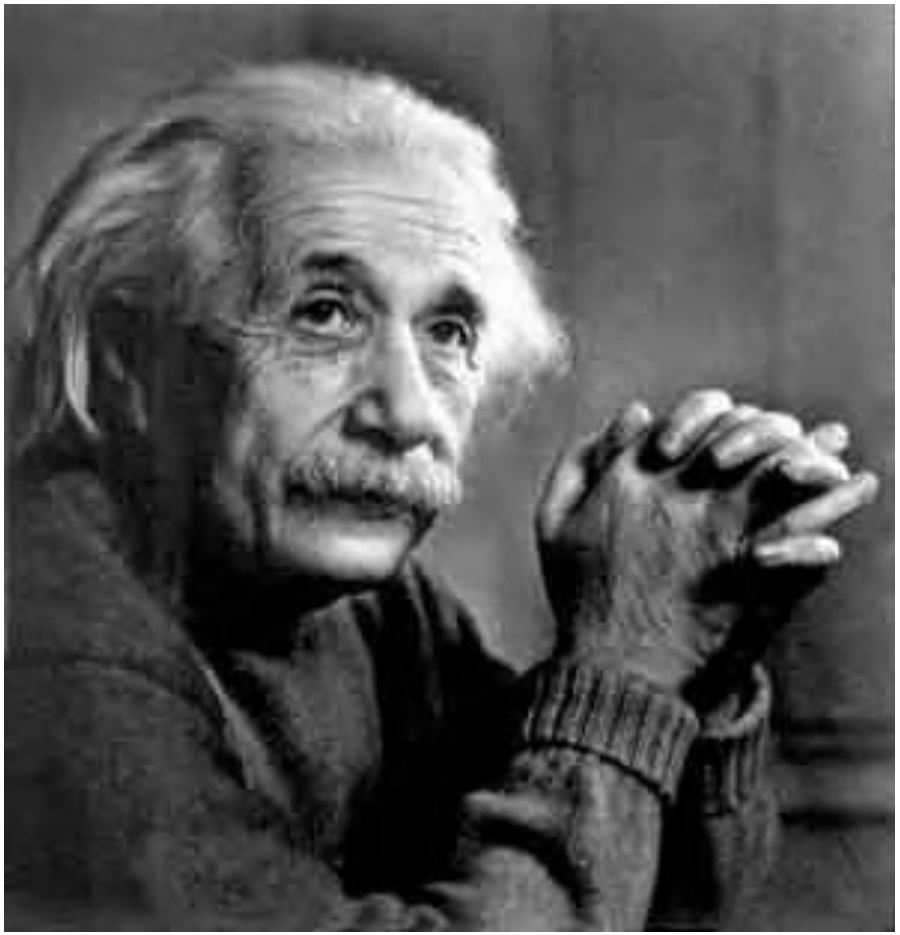
10W-40

10W = Oil's Viscosity at 0° F

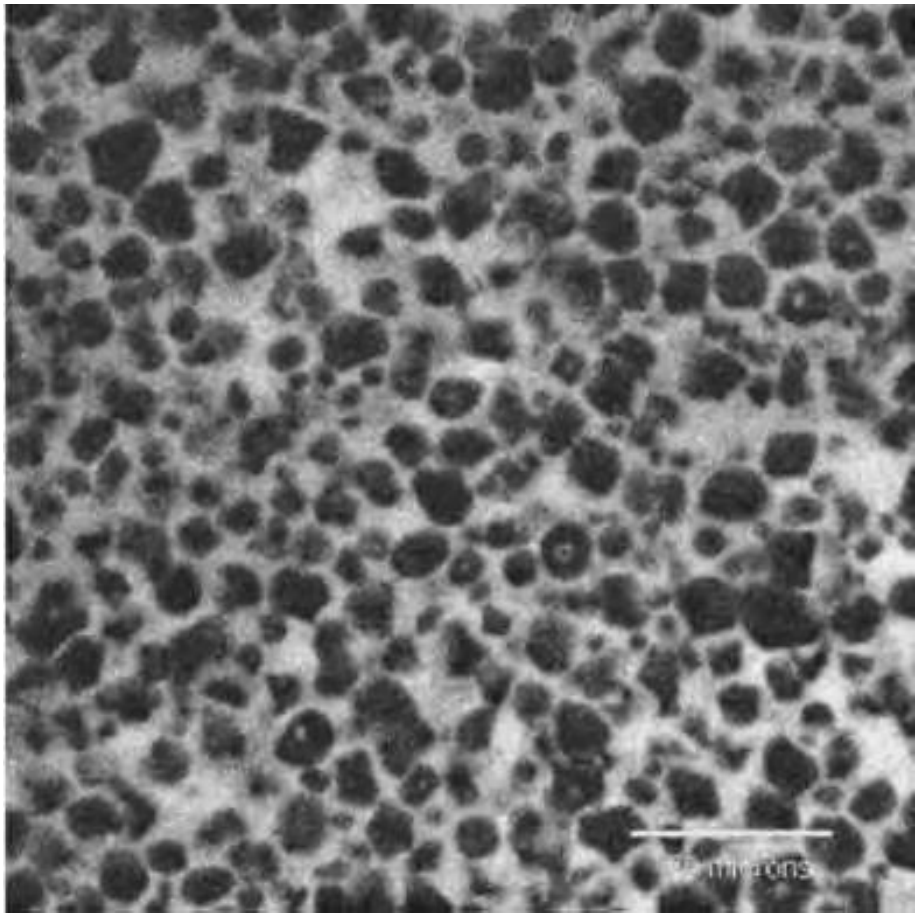
40 = Oil's Viscosity at 212° F


50°C
122°F
40°C
104°F
30°C
86°F
20°C
68°F
10°C
50°F
0°C
32°F
(-10°C)
14°F
(-20°C)
(-4°F)
(-30°C)
(-22°F)
(-40°C)
(-40°F)
(-55°C)
(-67°F)
SAE 40
SAE 15W40
SAE 15W30
SAE 30
SAE 5W20
SAE 5W30
SAE 10W
SAE 10W30
ARCTIC OIL

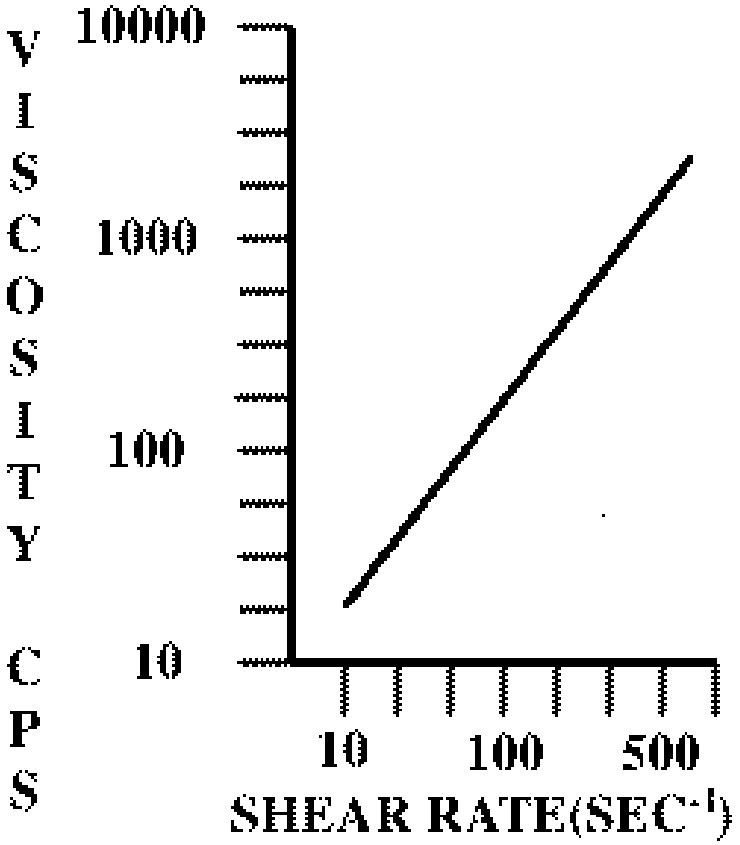
Lab: Dilatant Material



Dilatant Material



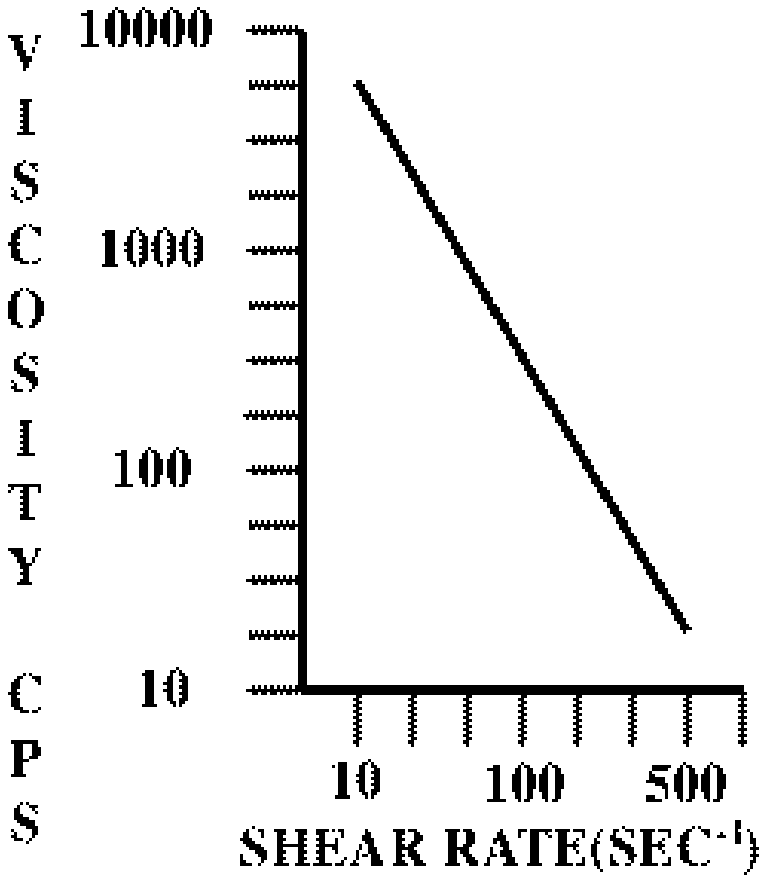
Dilatant Material



Silly Putty

Automotive

Thixotropic

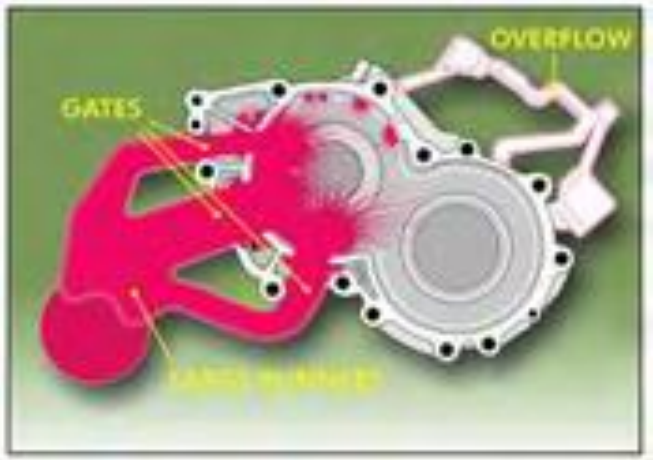


Thixotropic

Construction

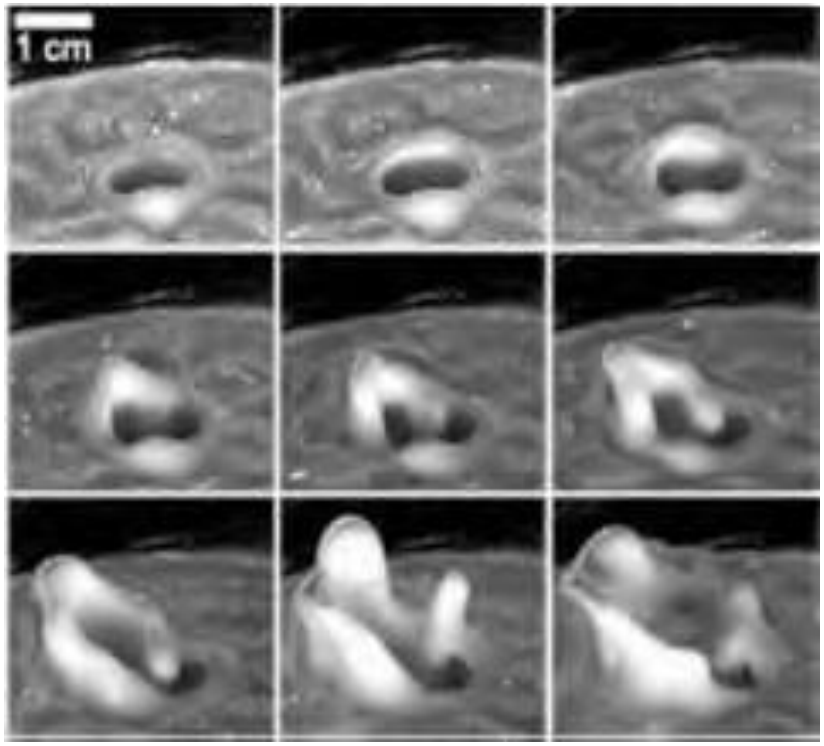

SUPER X
SUPER X
SUPER X
SUPER X

Advanced Thixotropic Metallurgy



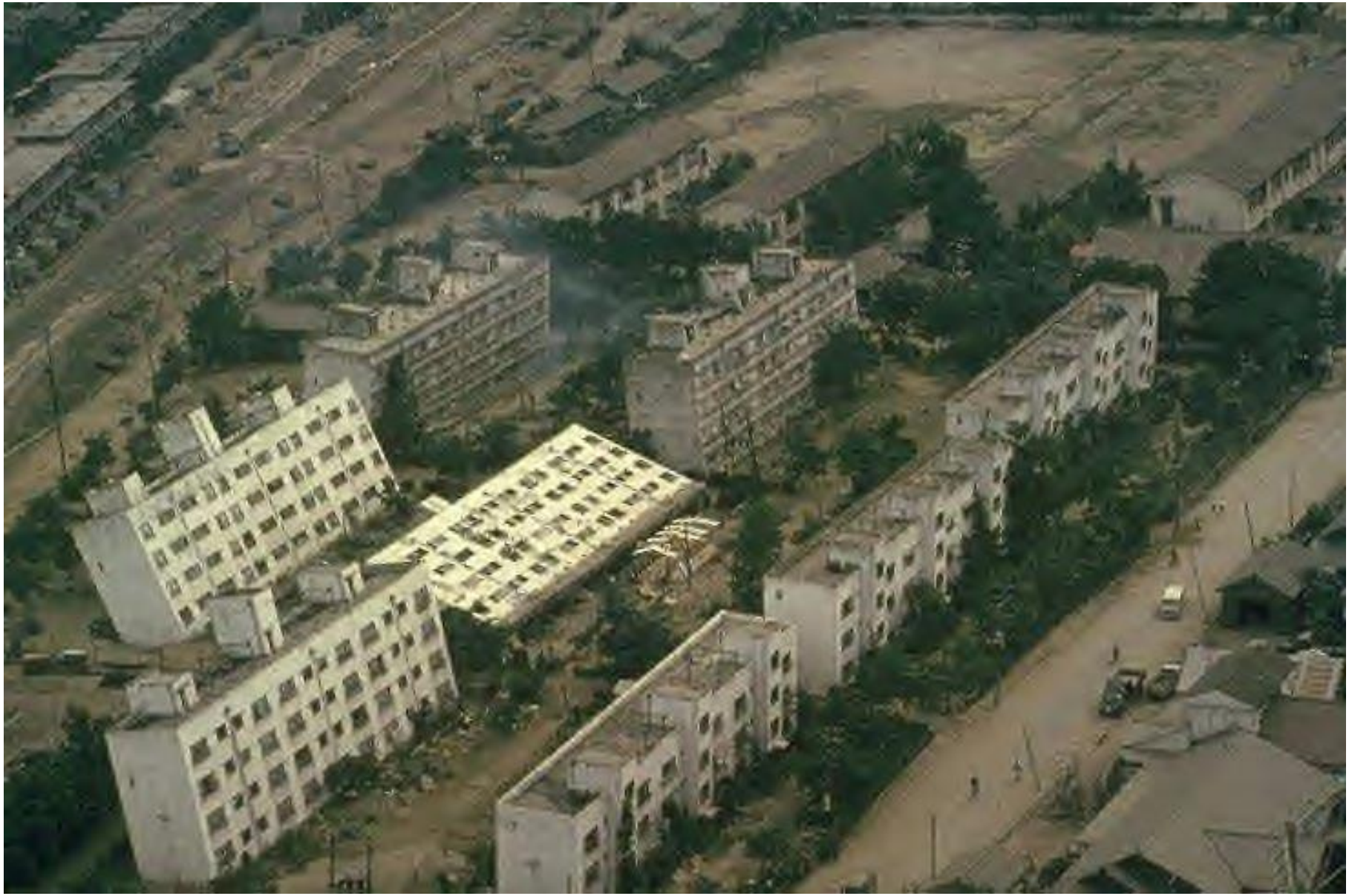
Military


Thickening Fluid
(poly)ethylene glyco
silica nanoparticles

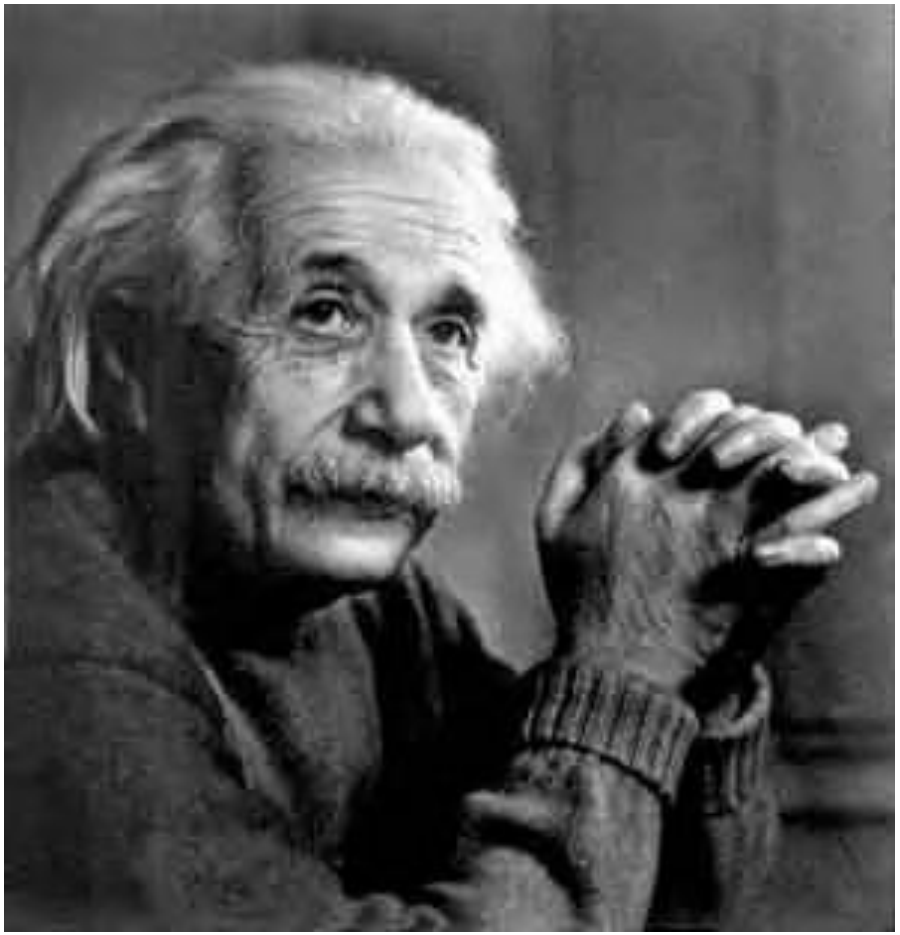

1 cm

Medicine

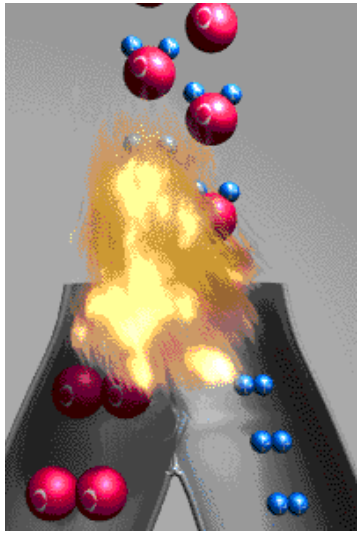
Nasya™
gel at rest



Lab: Japan Sand



Chemical Properties



Burning

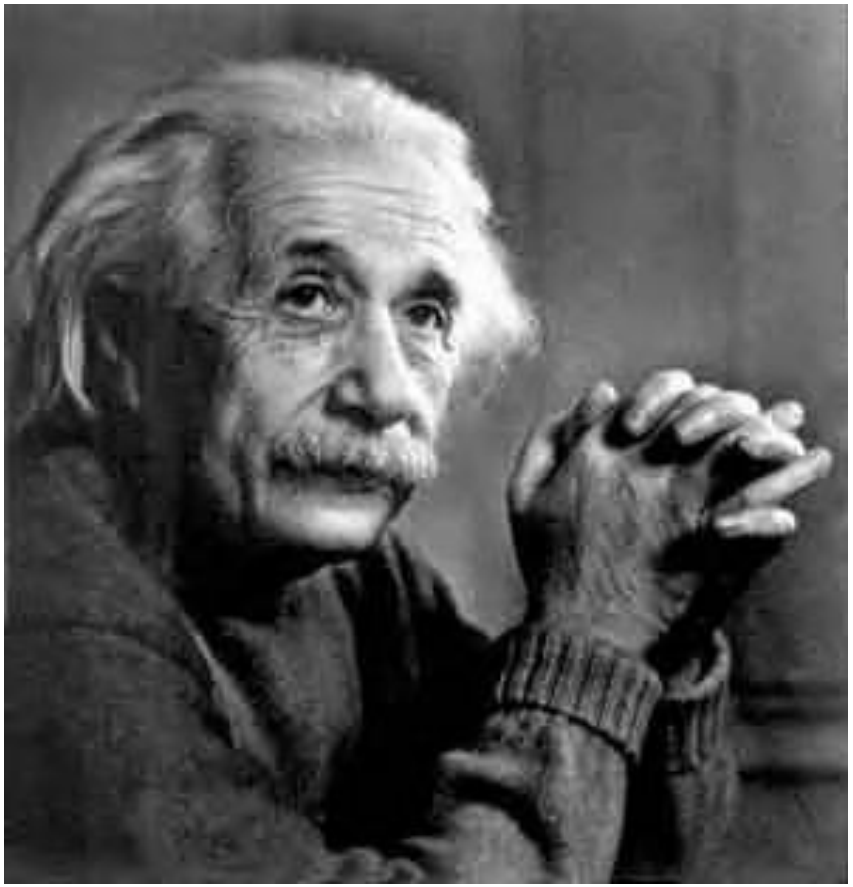
Corrosion

Reaction to Acids & Water

Thermal Properties

Conductivity

Lab: Macho Conduction



Lab: Macho Conduction

Lab: Macho Conduction

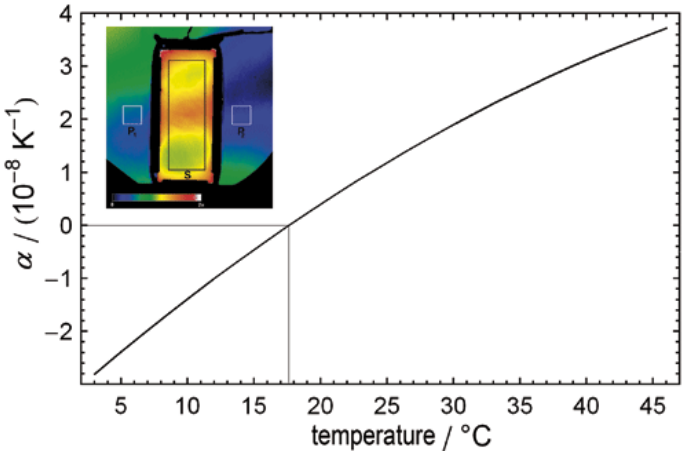
Data Chart

Metal	Time (s)
Aluminum	
Brass	
Copper	
Steel	
X	

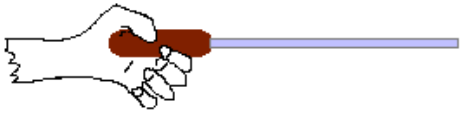
Thermal Properties

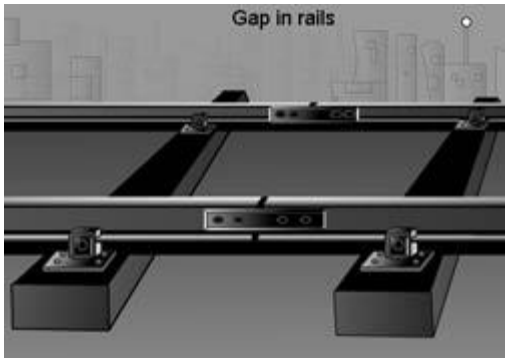
Conductivity

Thermal Expansion

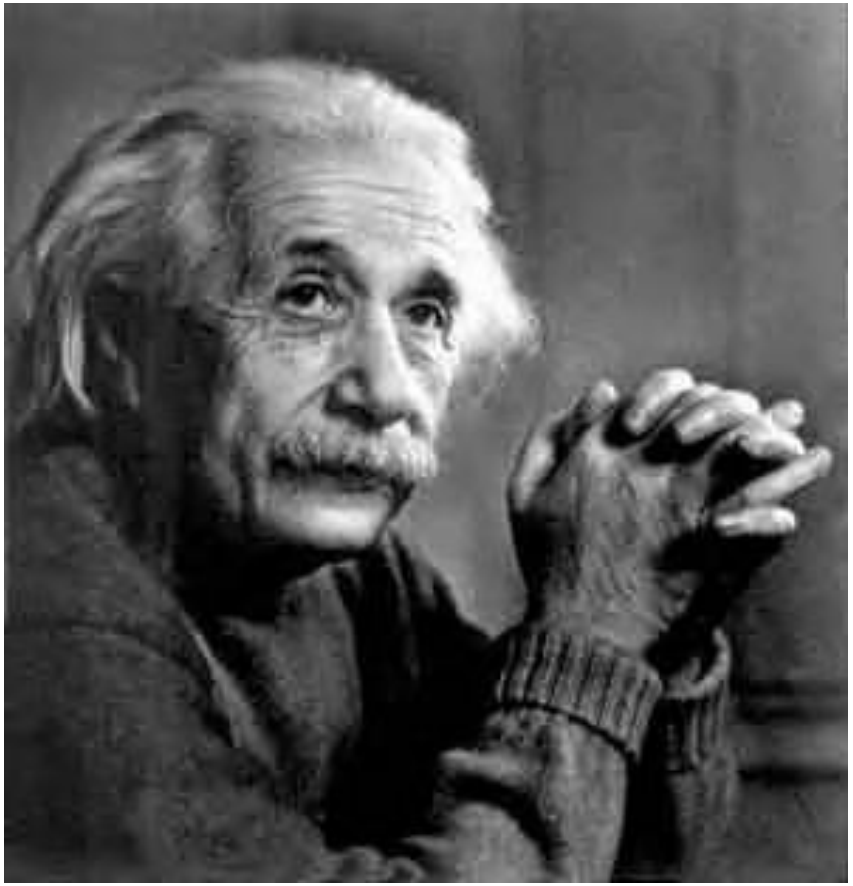


Thermal Expansion





Lab: Linear Expansion of a Metal



Lab: Linear Expansion of a Metal

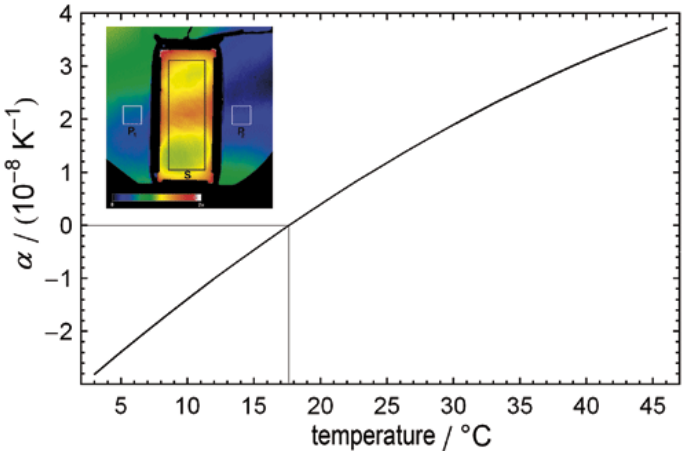
Data Chart

Metal Sample	*Expansion after 10 minutes*
Aluminum	
Brass	
Steel	

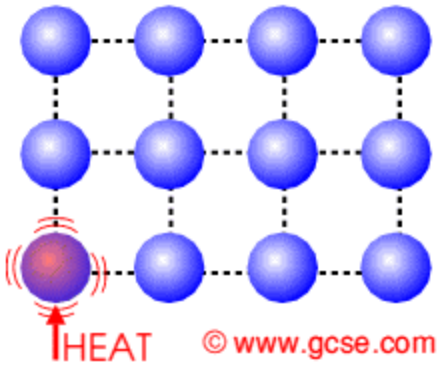
Thermal Properties

Conductivity

Thermal Expansion

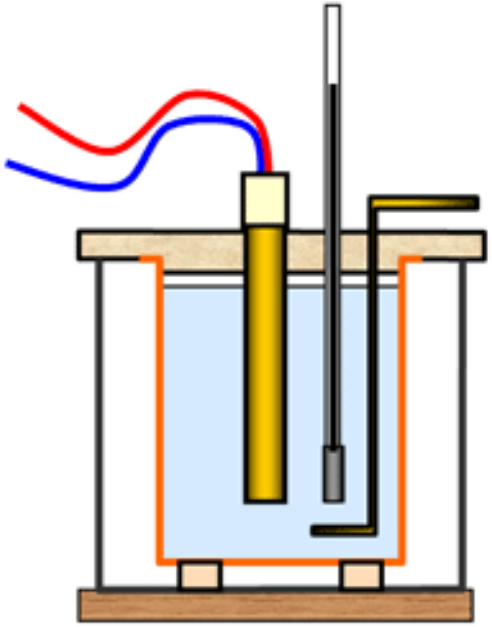


Specific Heat



Specific Heat

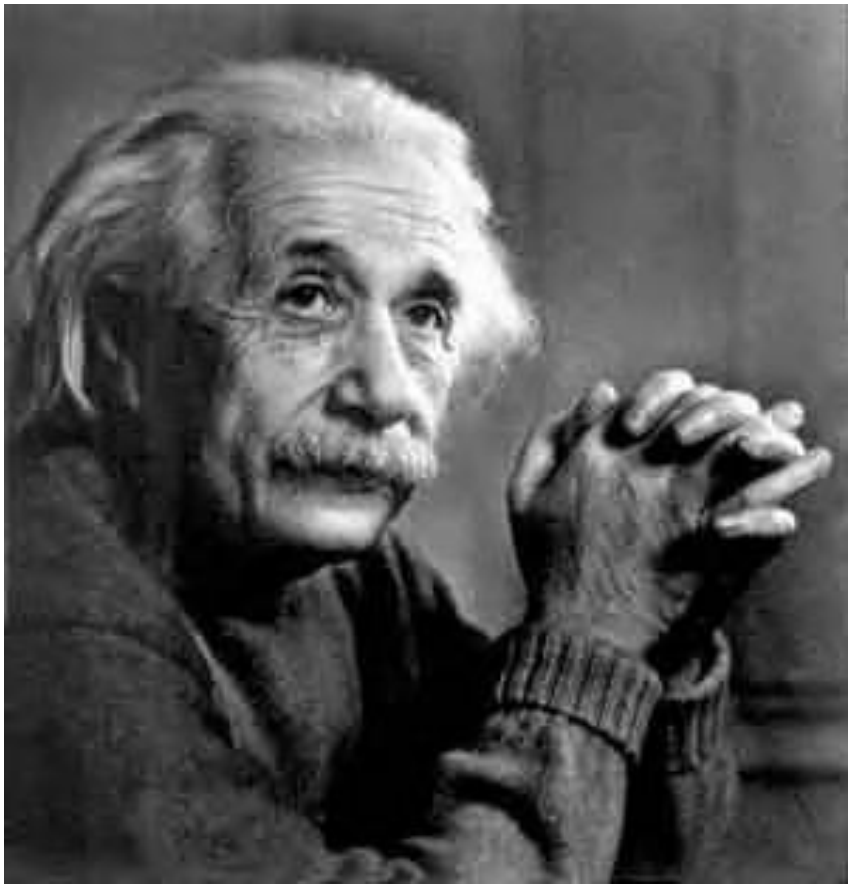
4.187J/Kg° C



3,470 J/Kg° C

0.217 J/Kg° C

Lab: Heat Capacity of Metals



Lab: Heat Capacity of Metals

Data Chart

Metal Sample	*Mass (g)*	*Δtemp (° C)*	*Water Mass (g)*	*Δtemp (° C)*
Silver	20.0		30.0	
Gold	20.0		30.0	
Copper	20.0		30.0	
Iron	20.0		30.0	
X	20.0		30.0	
Y	20.0		30.0	

Lab: Heat Capacity of Metals

Calculation Table

Metal Sample	*Heat Gained (joules)*	*Heat Lost (joules)*	*Specific Heat (J/g x K)*
Silver			
Gold			
Copper			
Iron			
X			
Y			

Lab: Heat Capacity of Metals

Calculations

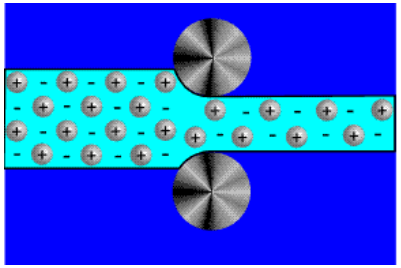
Heat Gained by Water =
Mass X Δtemp X 4.18

Heat Energy Gained by Water =
Heat Energy Lost by Metal

$$\textit{Specific Heat of Metal} = \frac{\textit{Heat Energy Gained}}{\textit{Mass X } \Delta\textit{temp}}$$

Mechanical Properties

Hardness



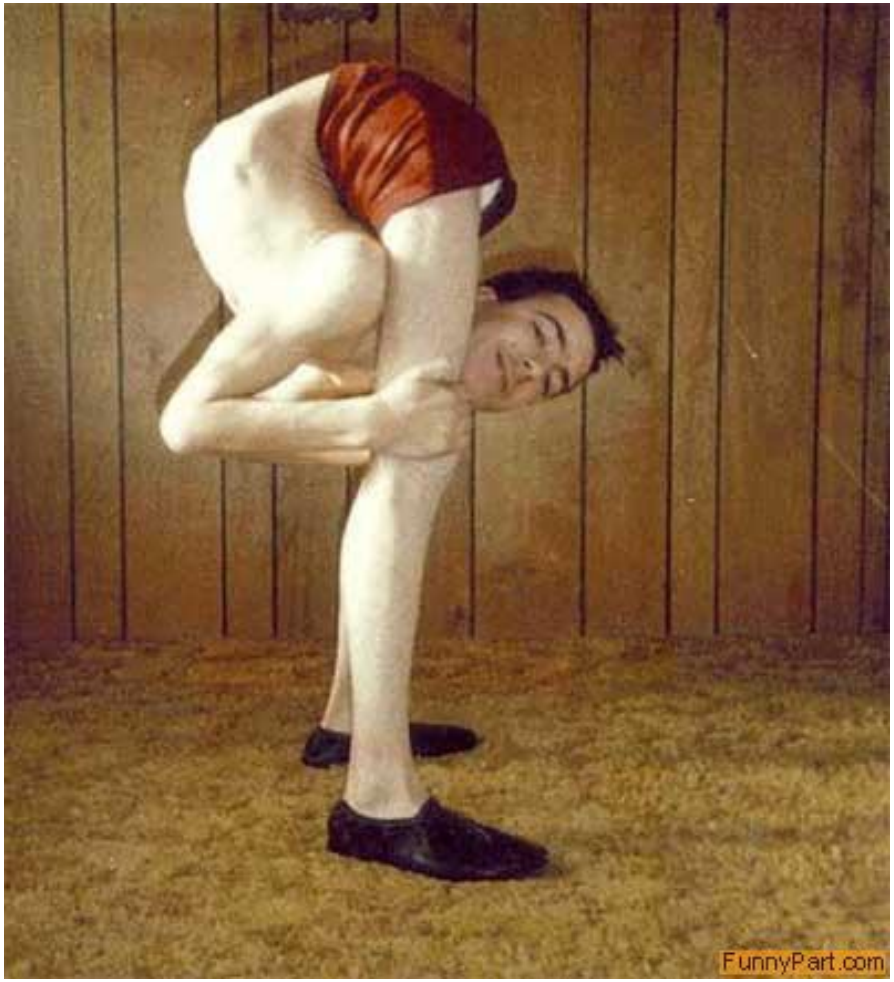
Workability

Mechanical Properties

Strength

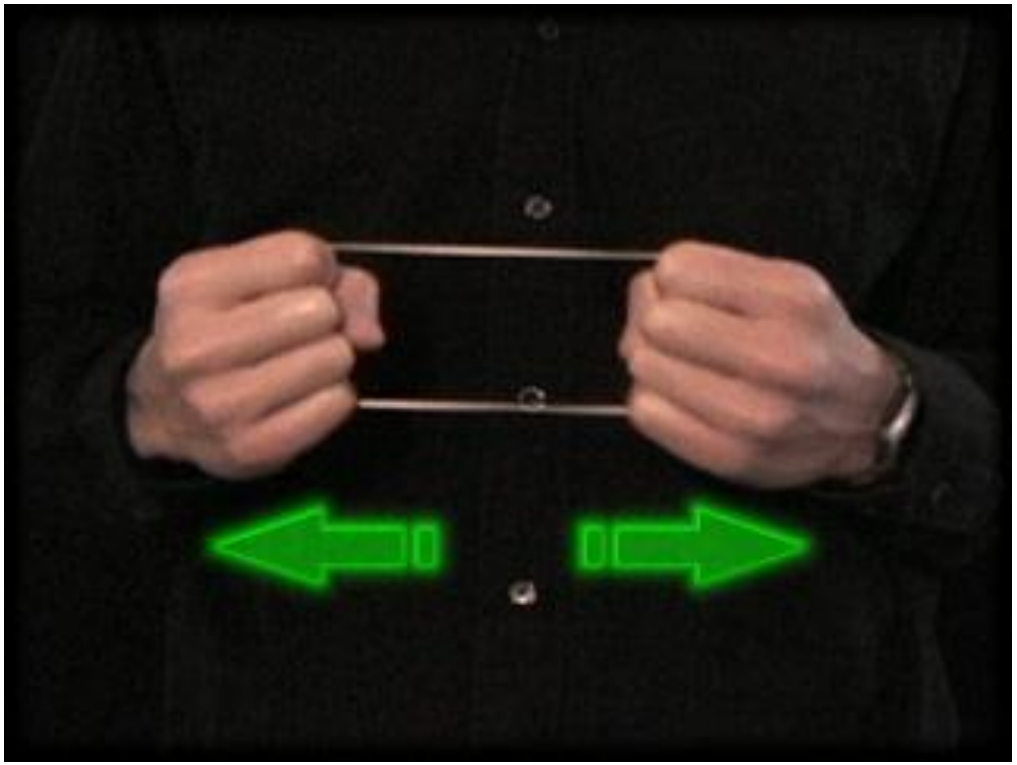
Elasticity

Elasticity is not Flexibility



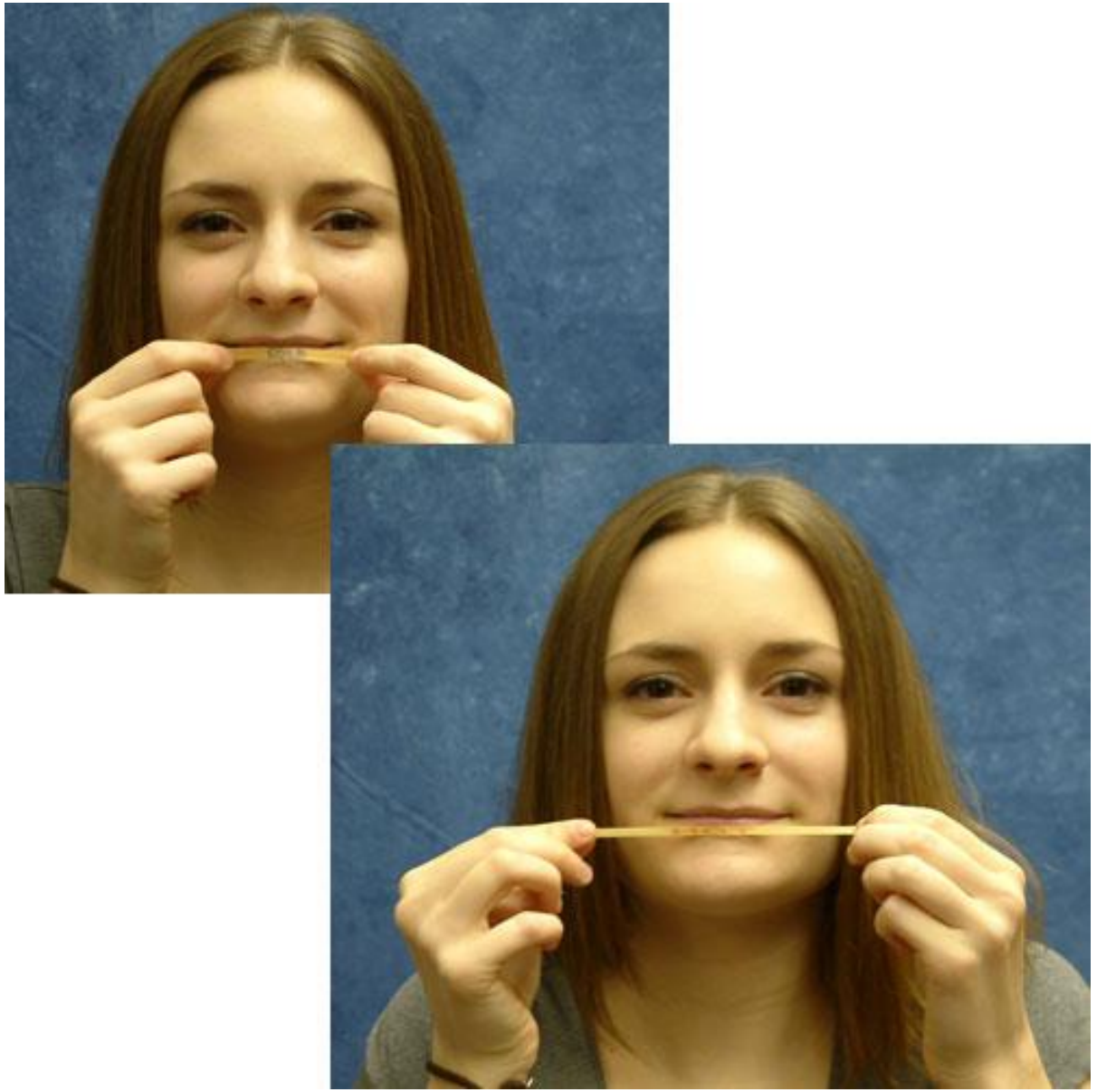
Elasticity is not Stretch-ability

Elasticity

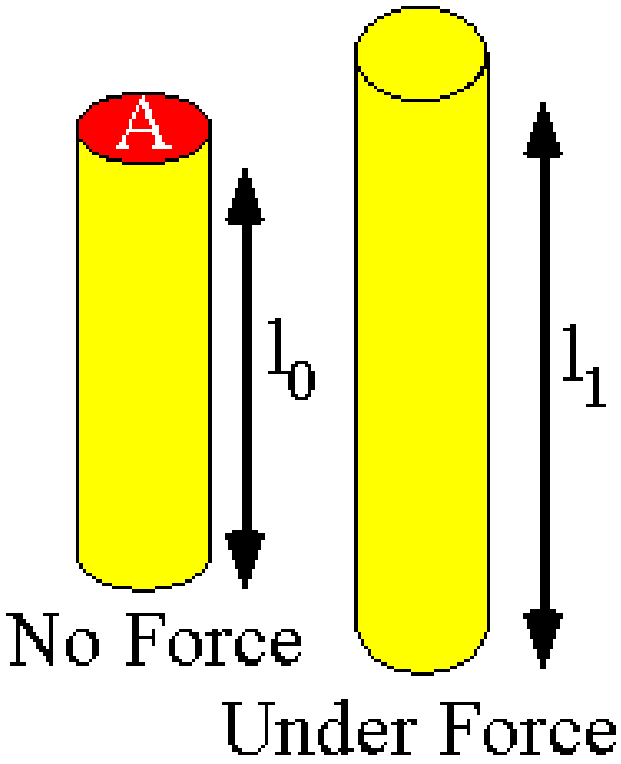


A material's ability to return to its original shape after being deformed.

Vocabulary

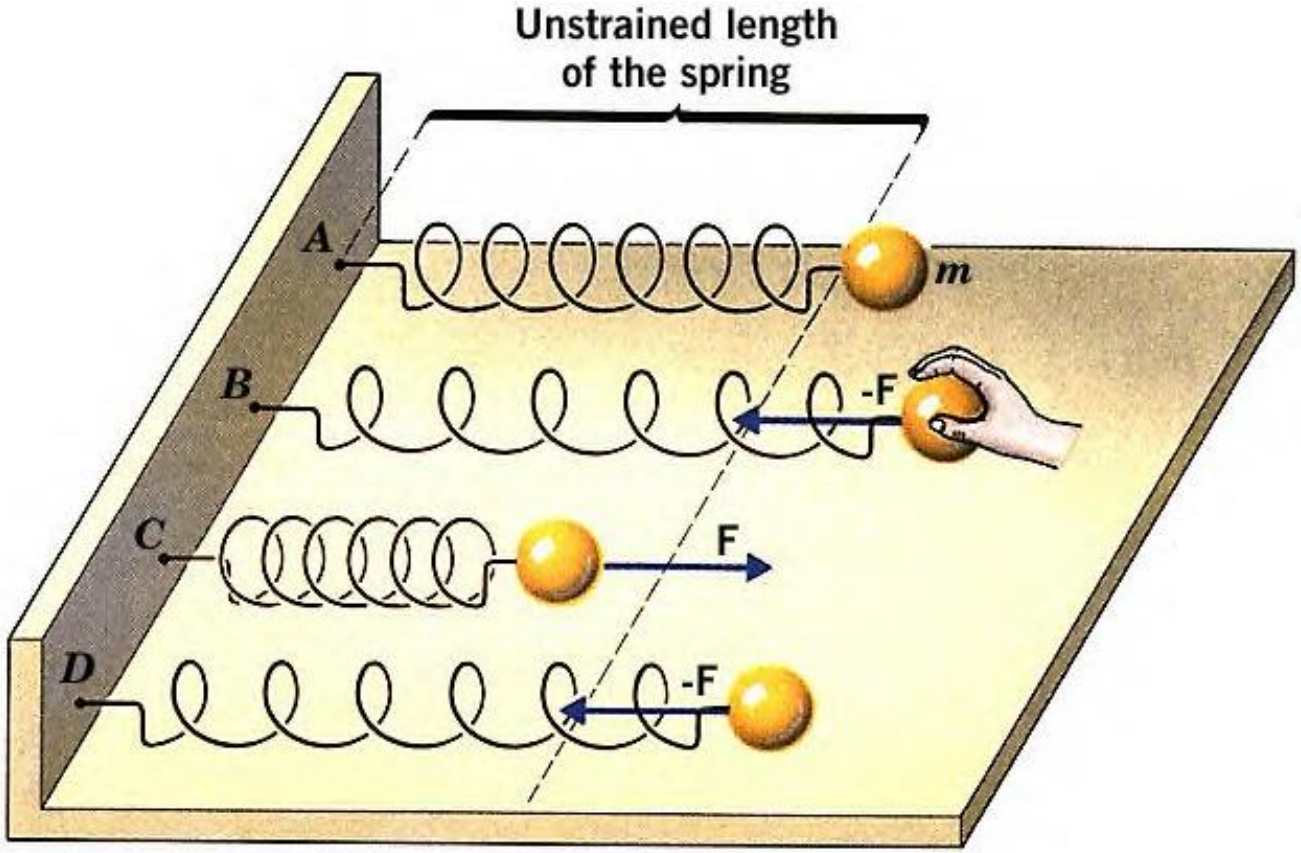


Deformation

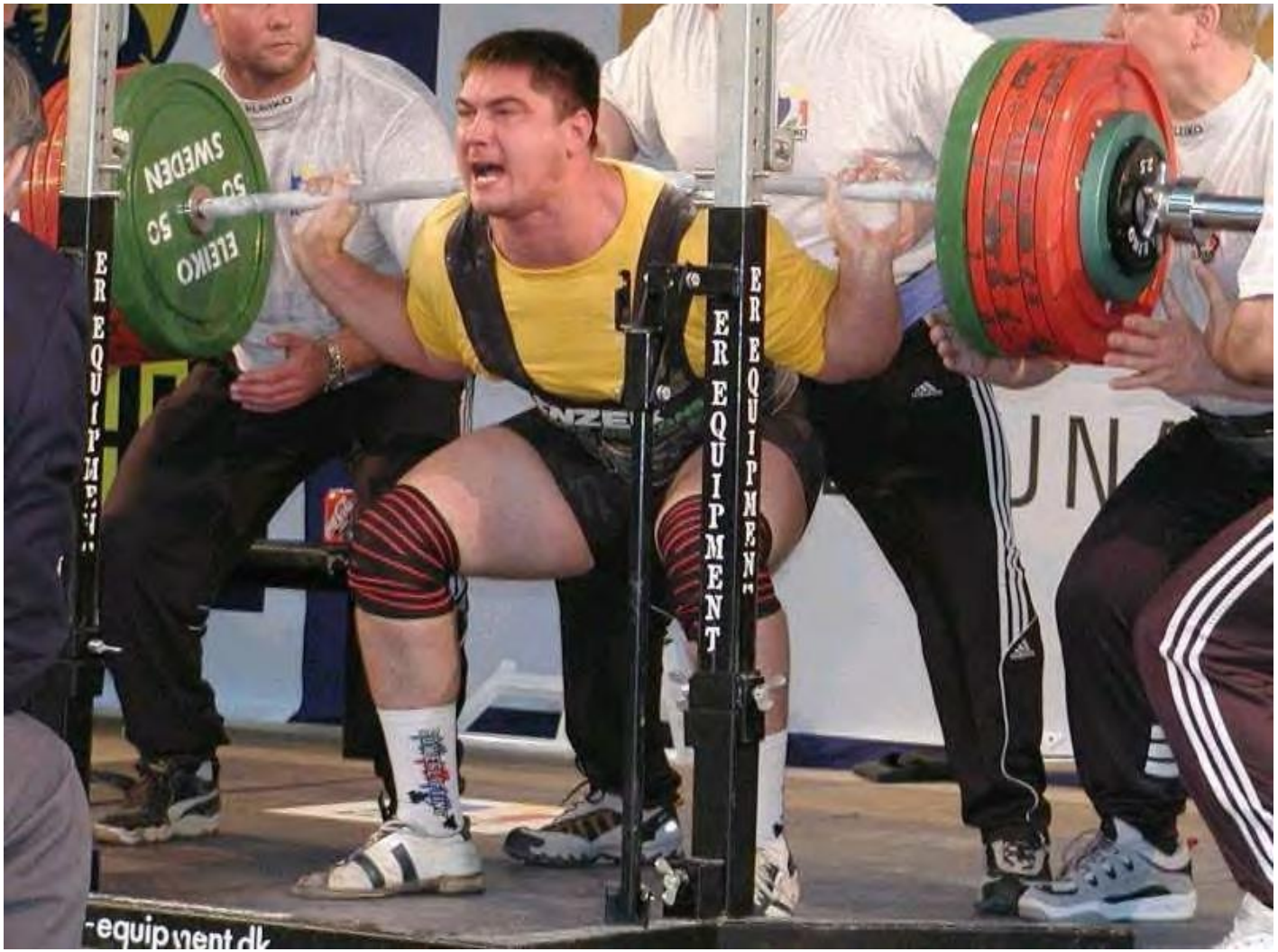


Change in shape of an object.

Strain

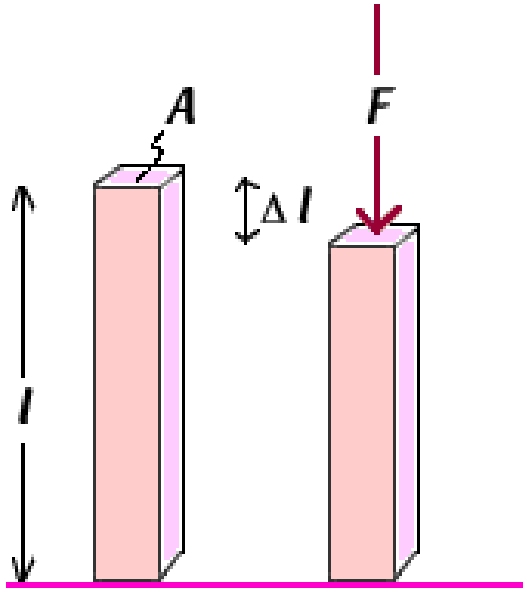


Stress

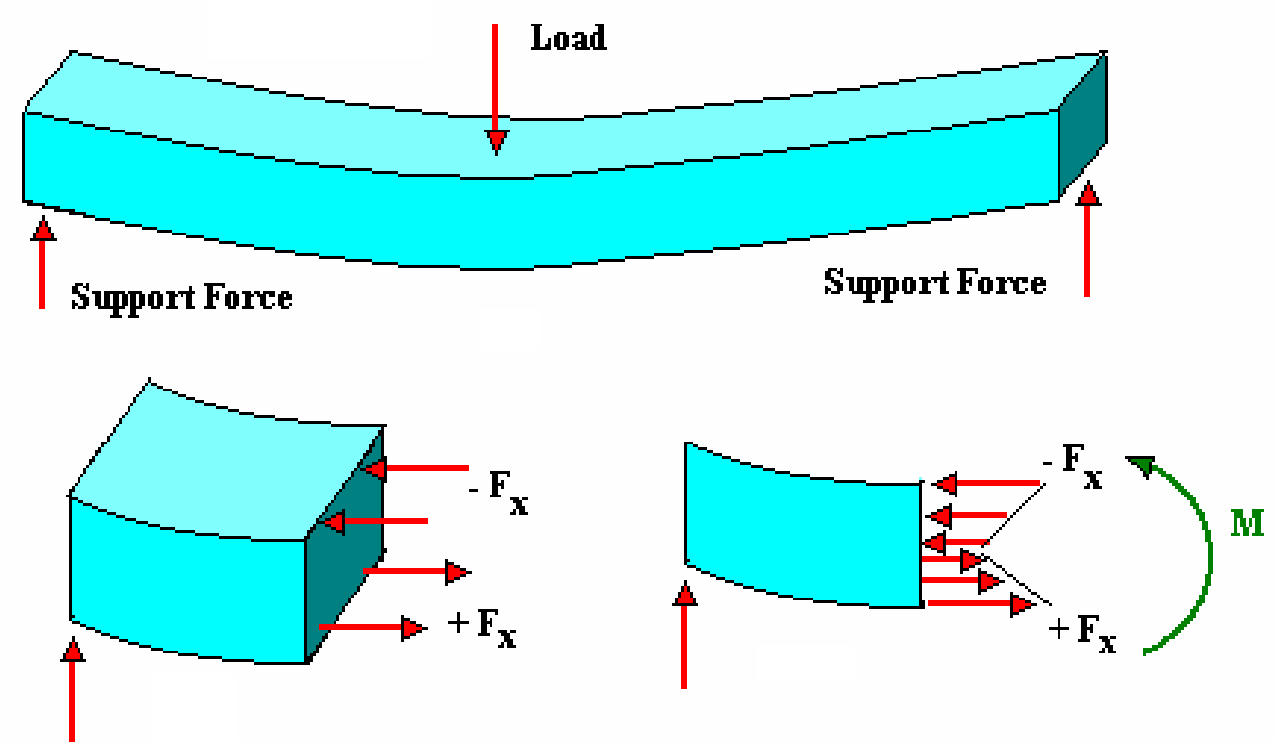


Applied Force / Original Area

Tension & Compression

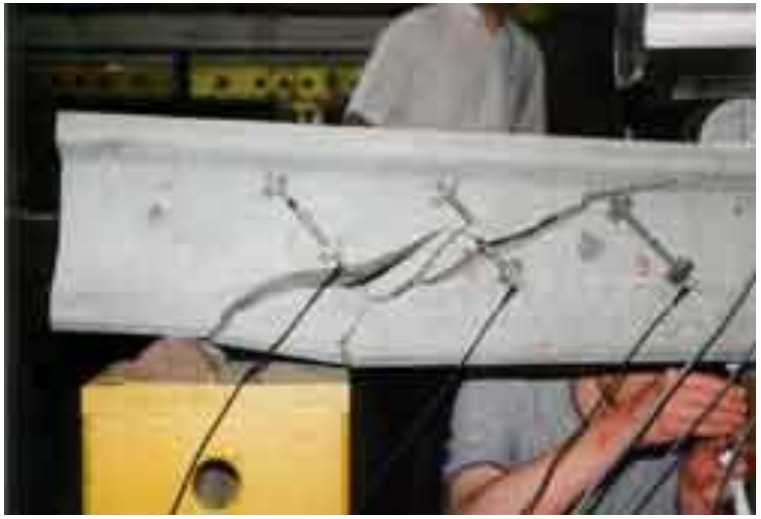


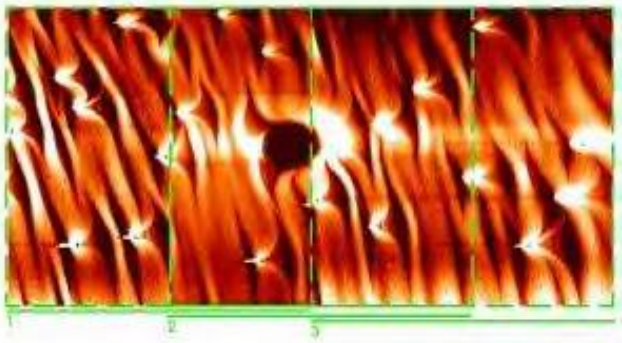
Shear



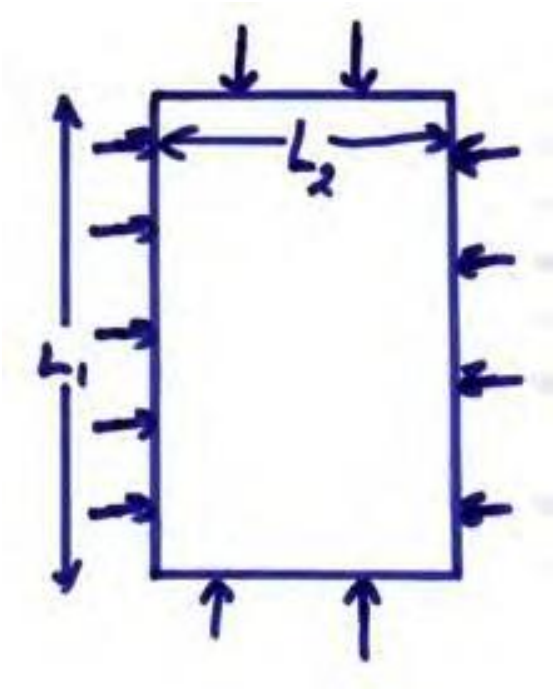
When 2 forces, acting like a pair of shears, cut a body between them.

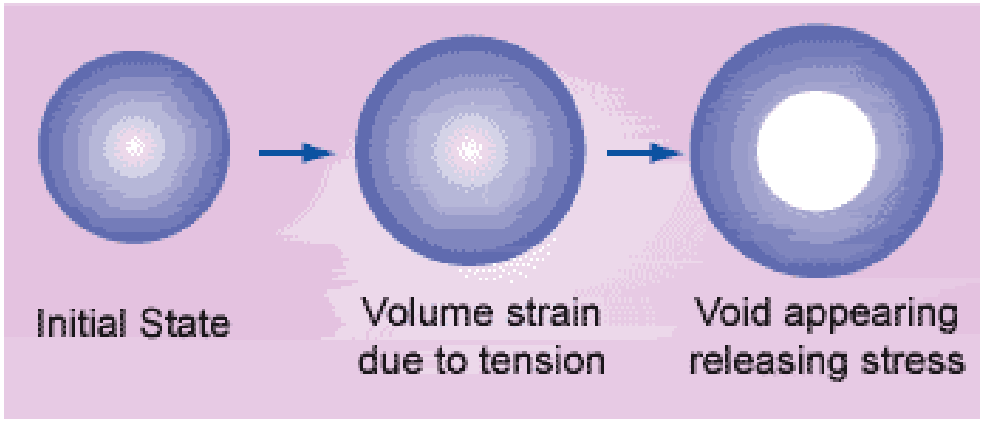
Shear Testing





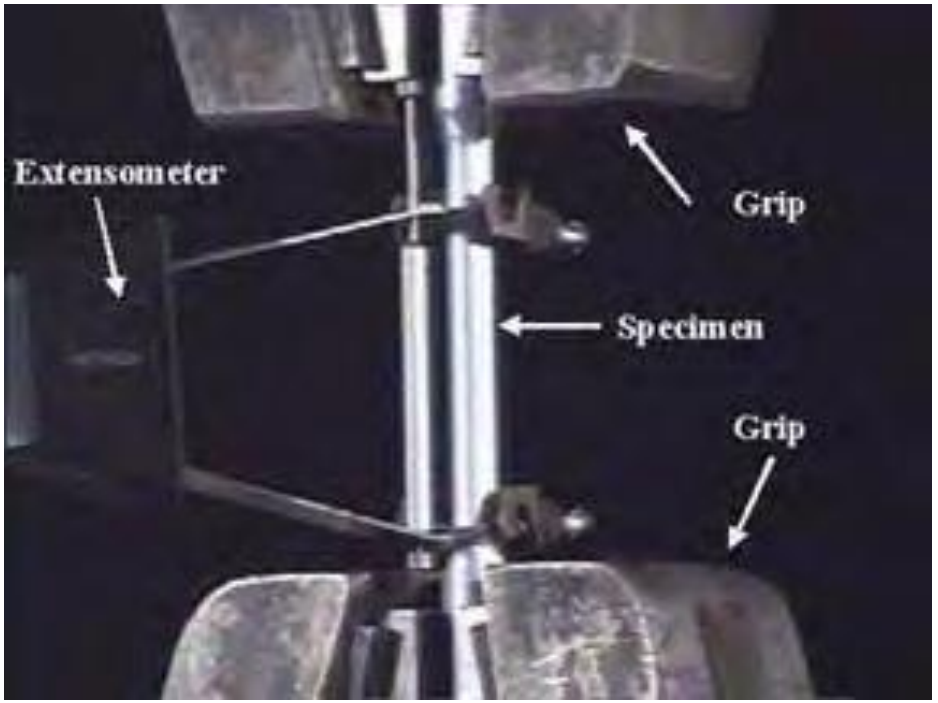
Hydrostatic





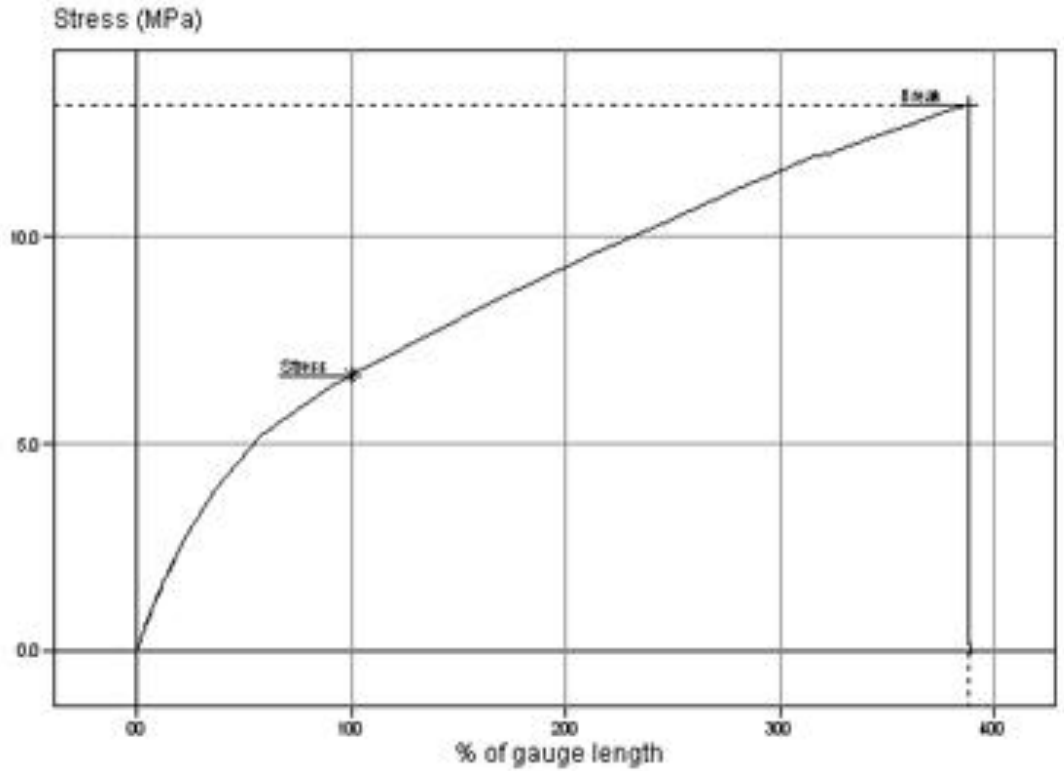
Stress unilaterally applied to an object.

Material Testing Device



Extensometer

Extensometer

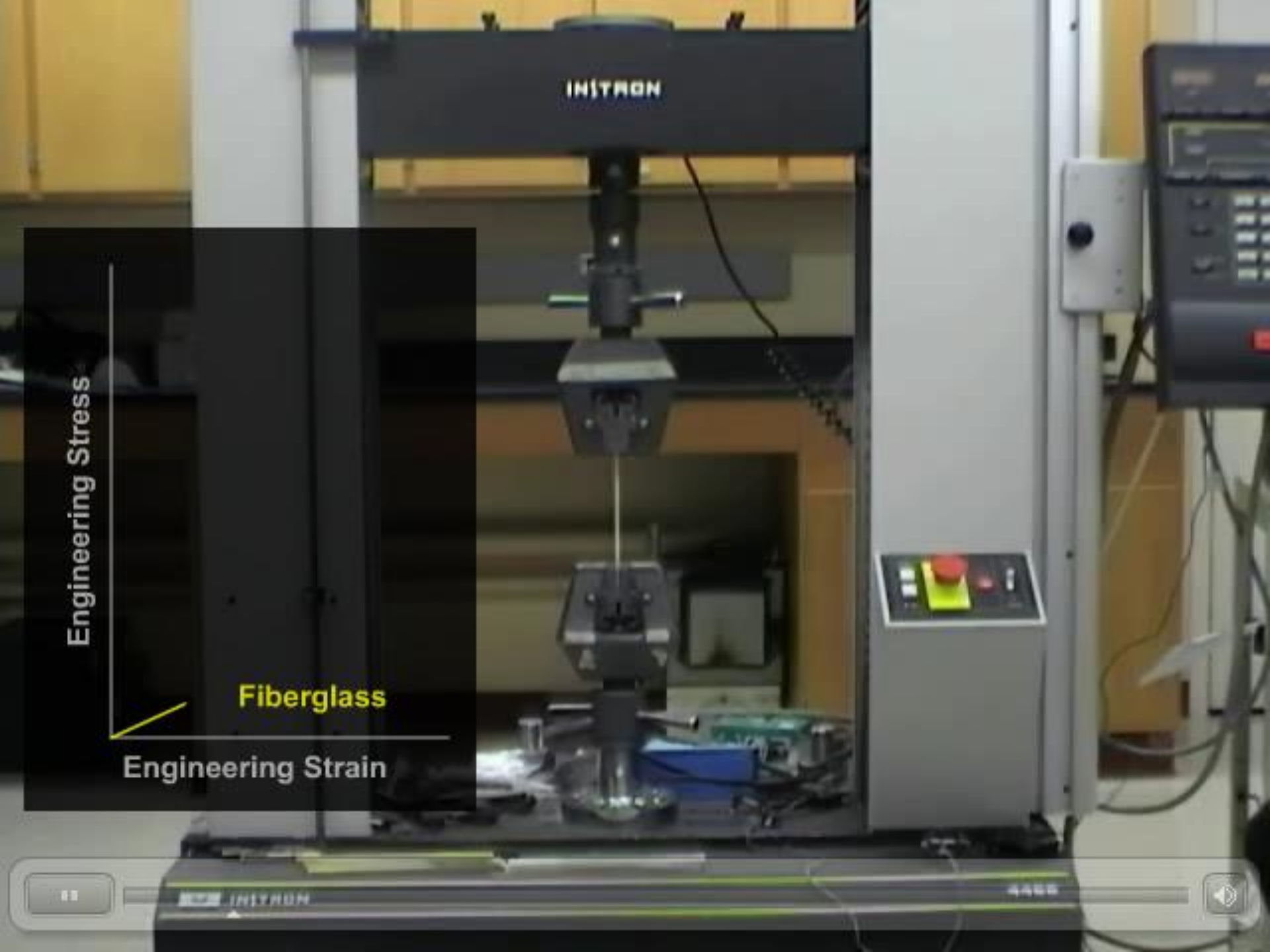


An extensometer measures the elongation of a material while applying tension.

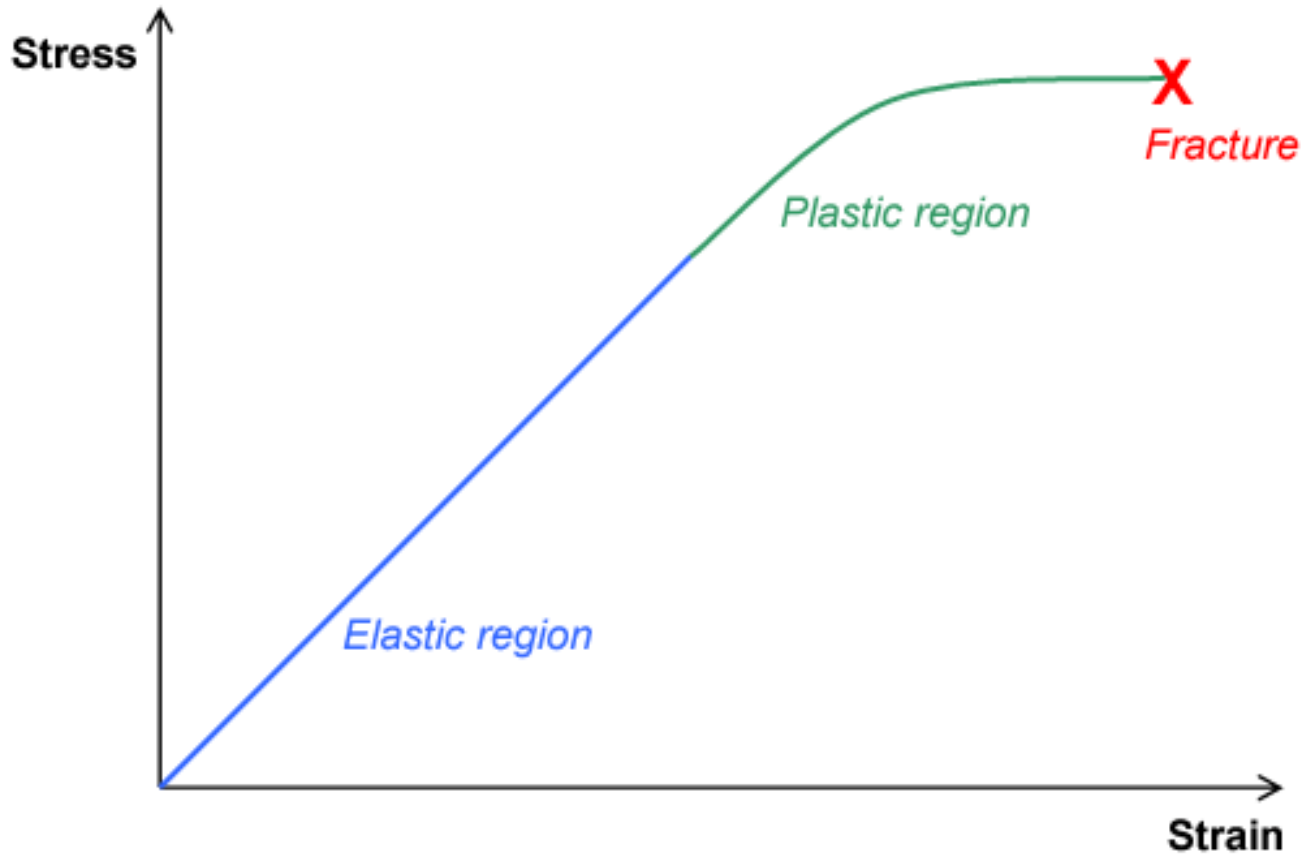
Instrom


LOAD
EXTENSION
STRAIN
RESET PEAKS
PEAK BRAKE
BREAK
PEAK
TRACK
ELECTRONIC LIMITS
CROSSHEAD ACTION
OFF
STOP
RETURN
CYCLE
AREA
SPEED
ENTER
PRINT
STOP
RTN

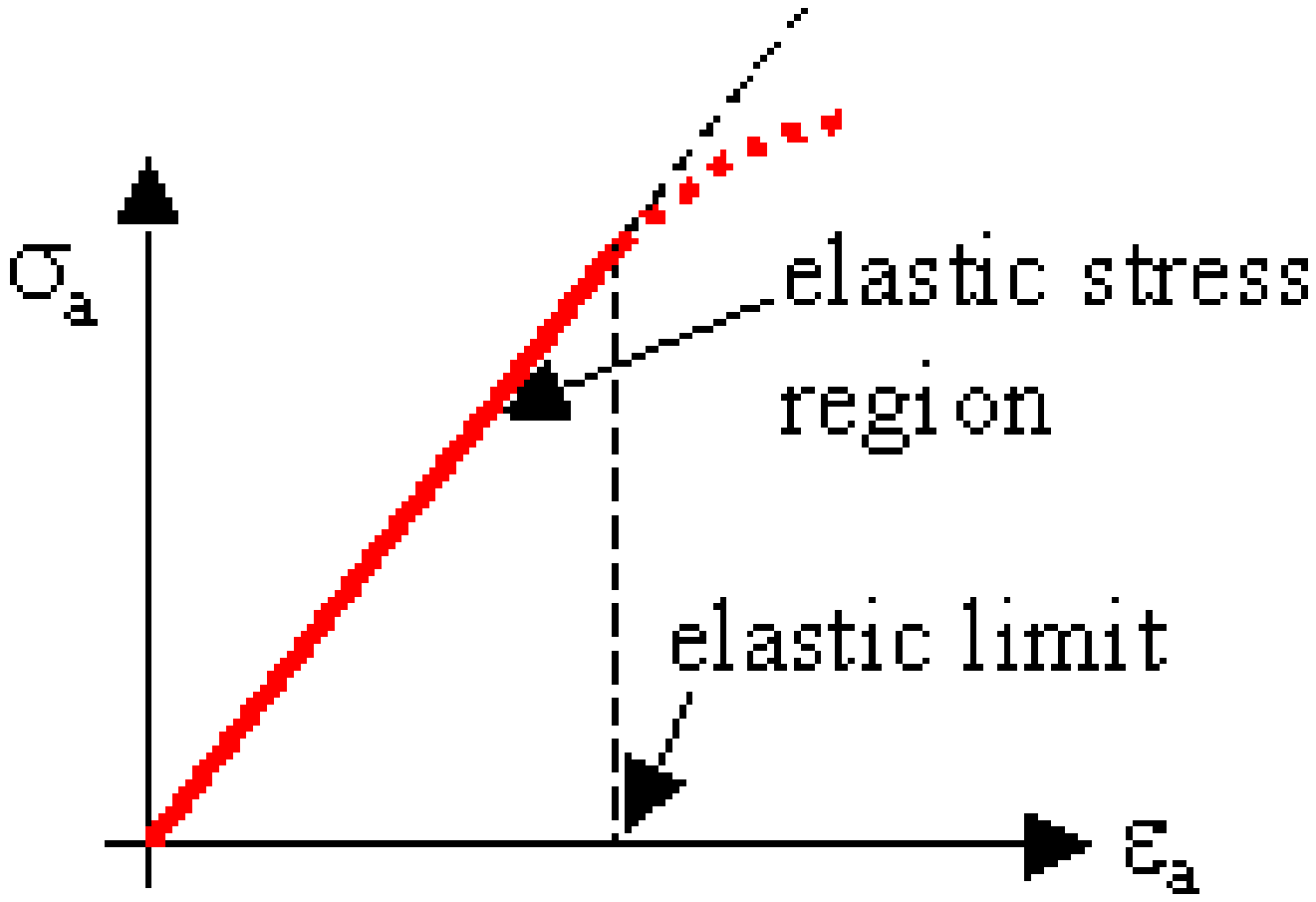
Instrom


INSTRON
Engineering Stress
Fiberglass
Engineering Strain
INSTRON

Stress Strain Curve

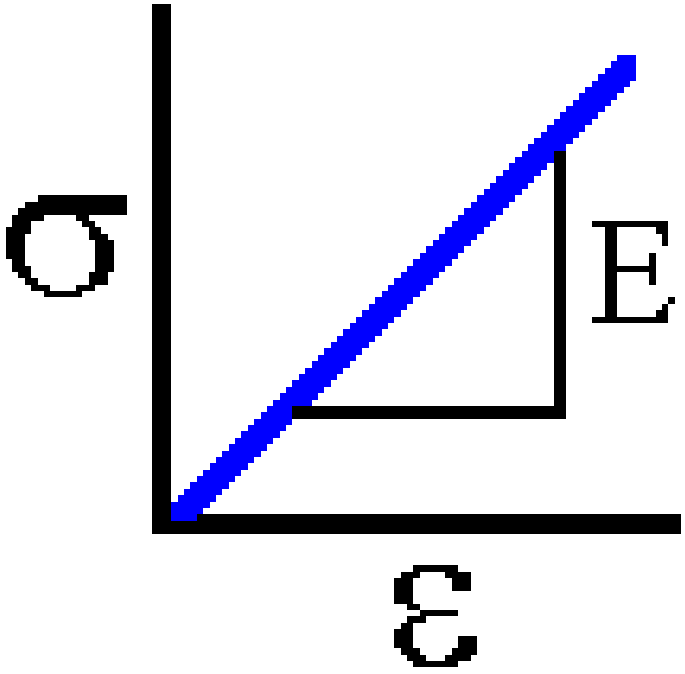


Elastic Limit



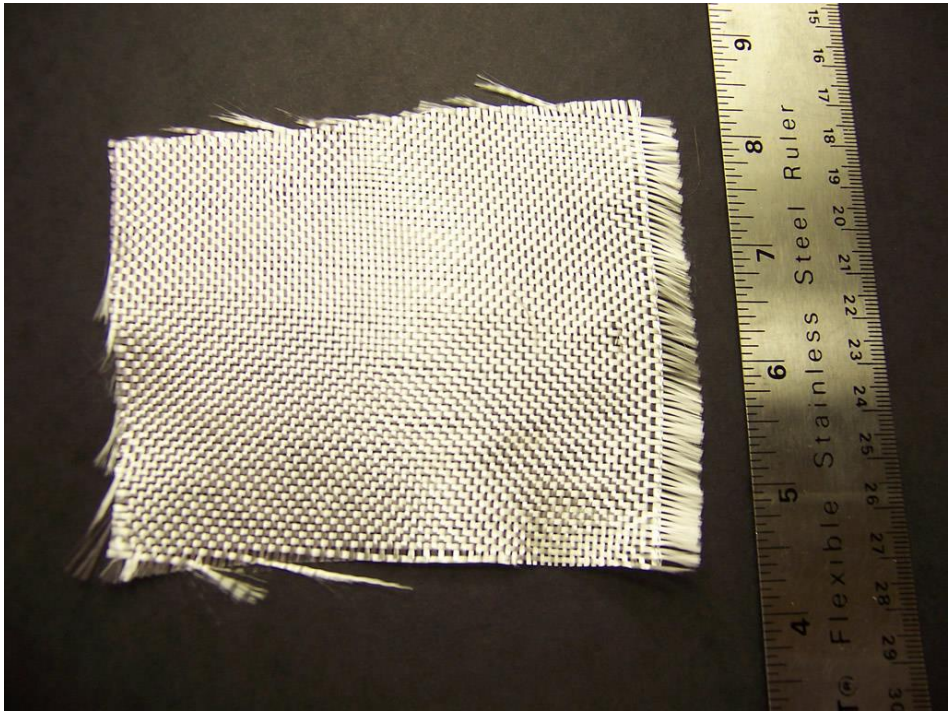

WEIGHT
LIMIT
10
TONS

Young's Modulus

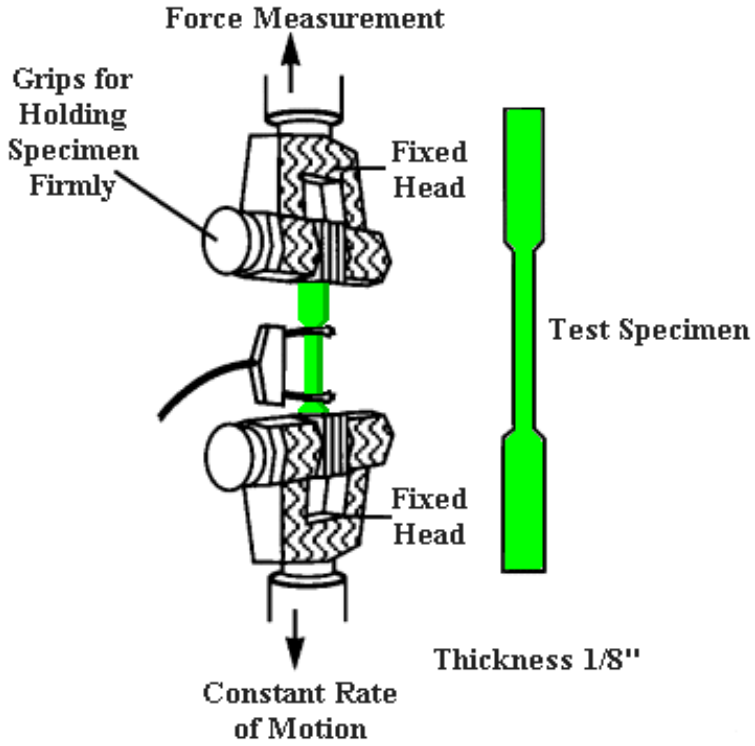


$$\sigma = E\varepsilon$$

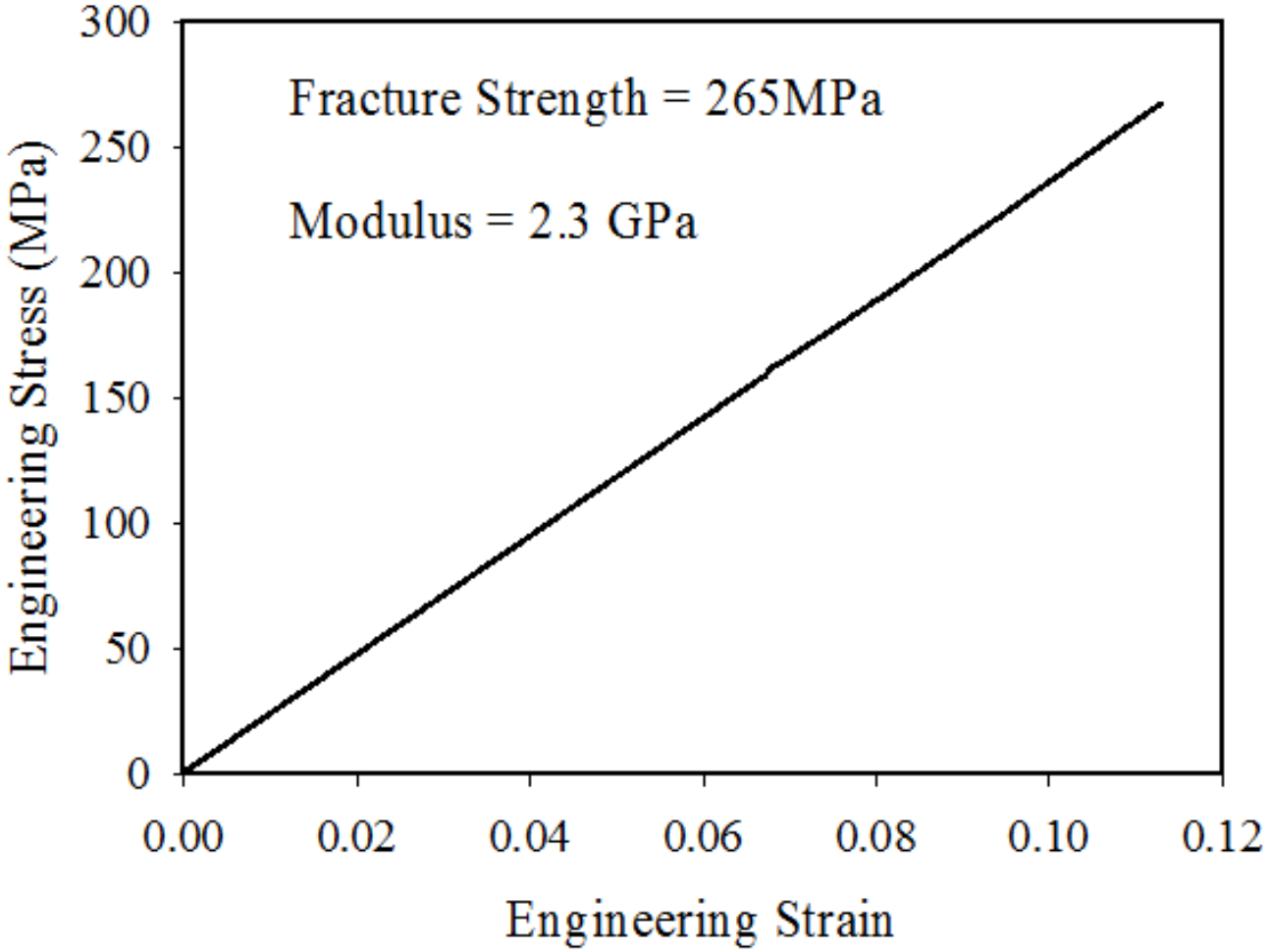
Composite Material Testing



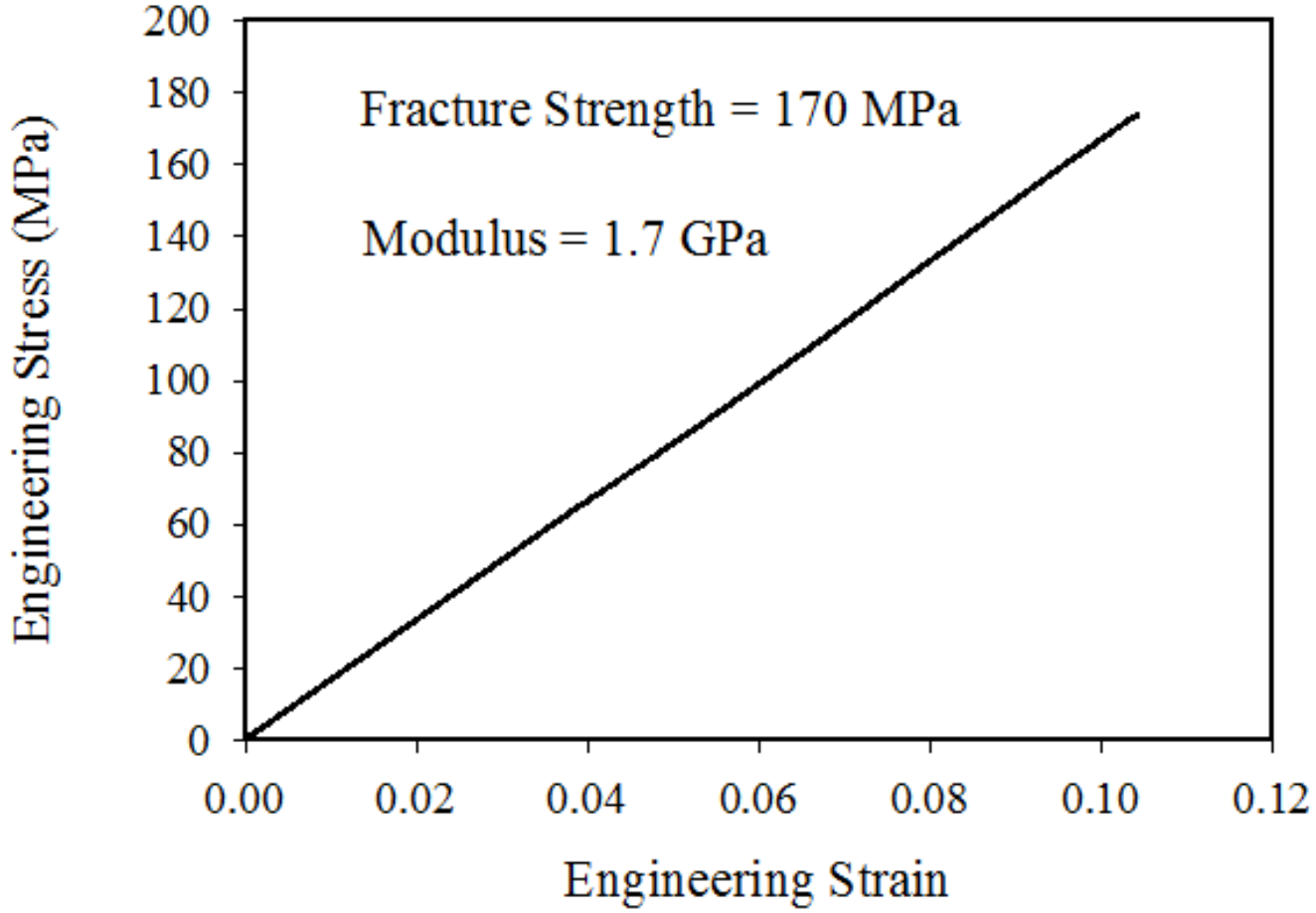
Fiberglass, Kevlar & Carbon Fiber


Force Measurement
Grips for Holding Specimen Firmly
Fixed Head
Test Specimen
Fixed Head
Thickness 1/8"
Constant Rate of Motion

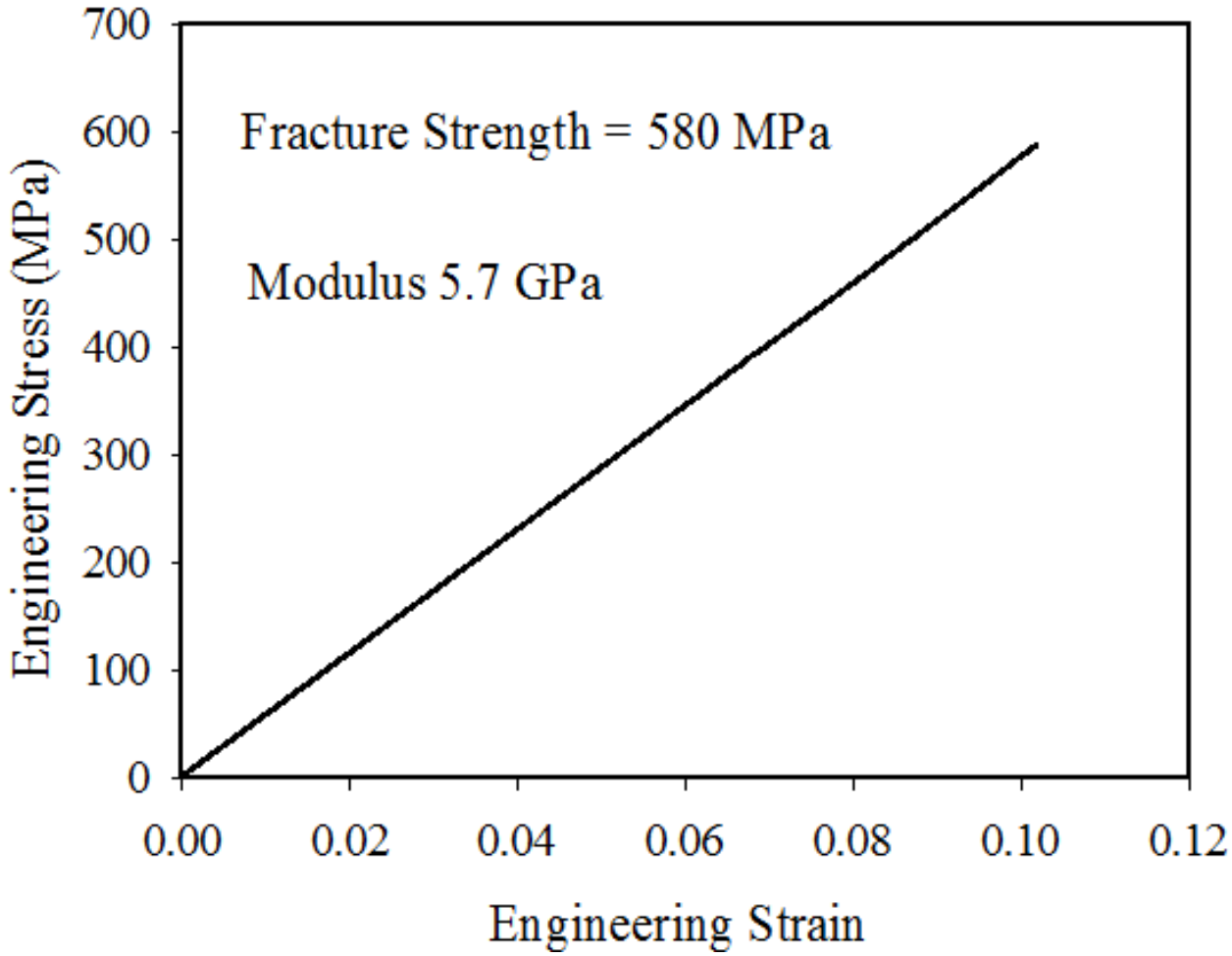
Kevlar


Fracture Strength = 265MPa
Modulus = 2.3 GPa
Engineering Stress (MPa)
300
250
200
150
100
50
0
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Engineering Strain

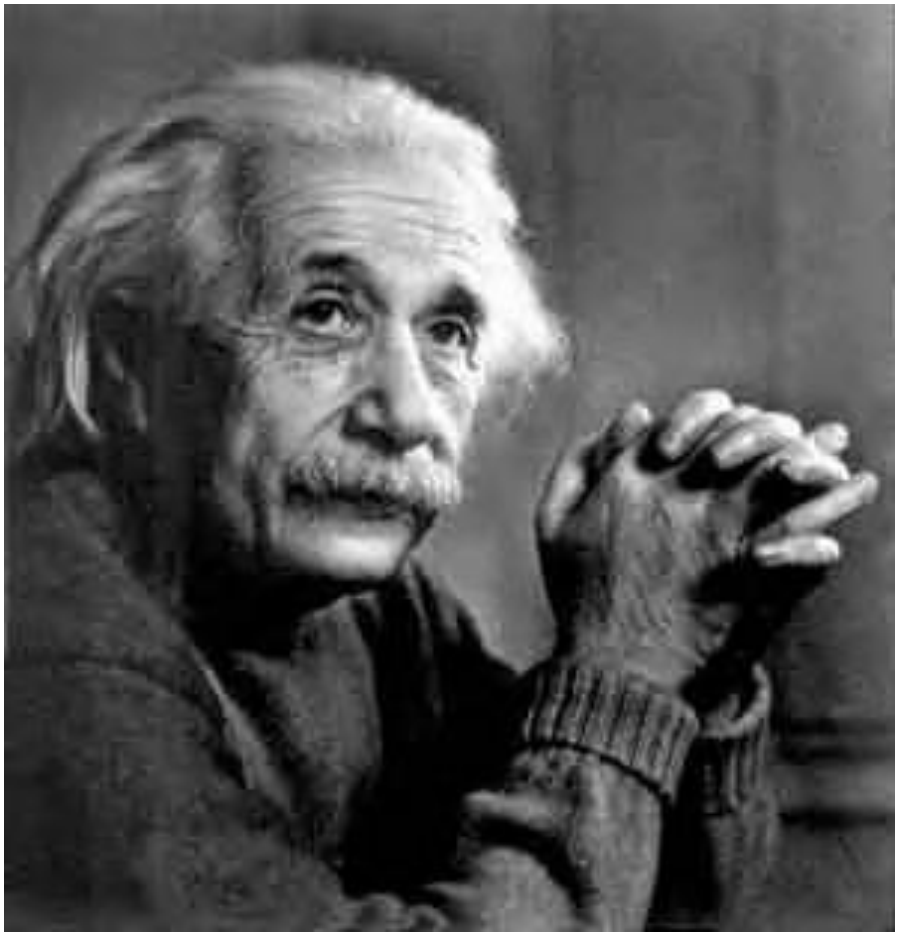
Fiberglass


Fracture Strength = 170 MPa
Modulus = 1.7 GPa
Engineering Stress (MPa)
200
180
160
140
120
100
80
60
40
20
0
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Engineering Strain

Carbon Fiber



Lab: Youngs’ Modulus of a Spring

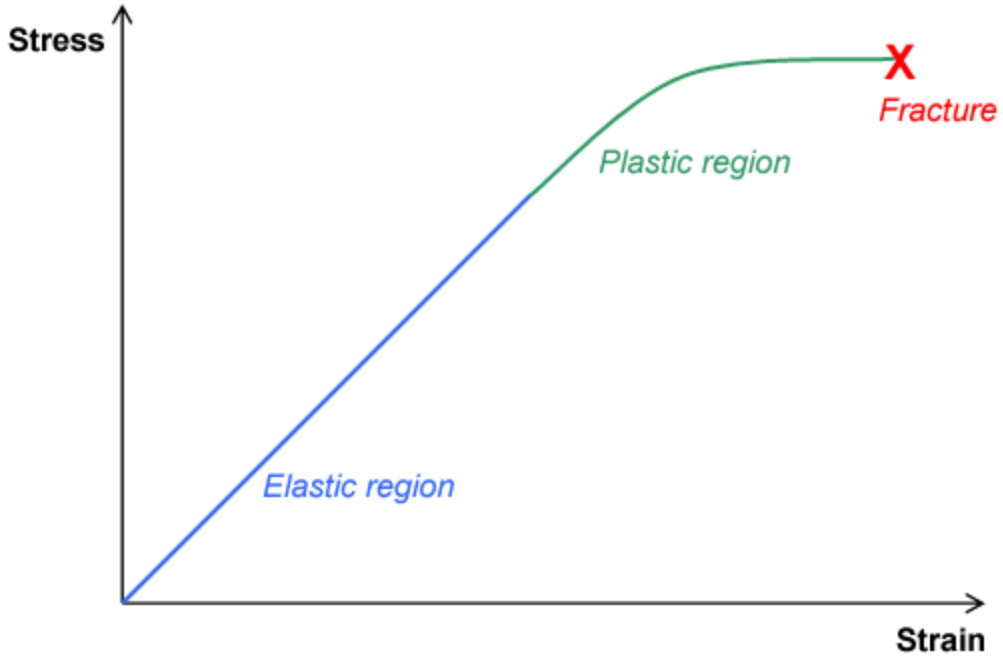


Lab: Youngs' Modulus of a Spring

Data Chart

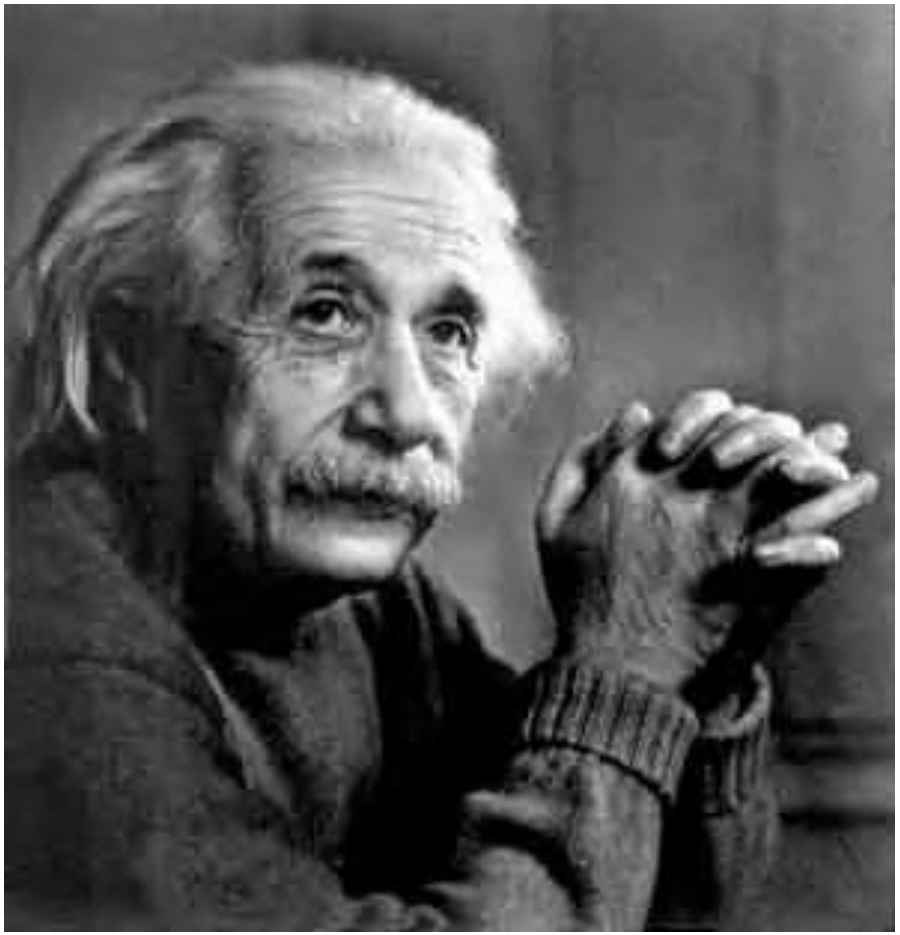
Stress	Strain

Stress Strain Curve



Ultimate Stress

Lab: Ultimate Stress



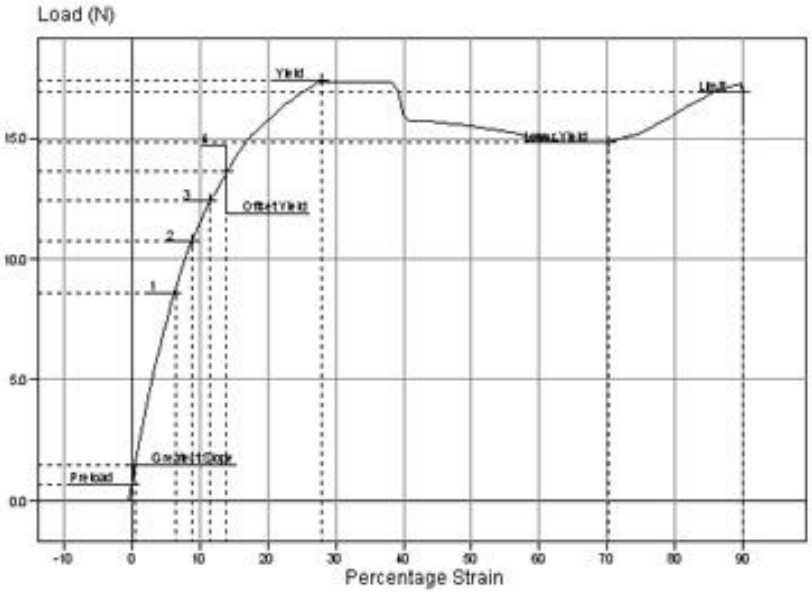
Lab: Ultimate Stress

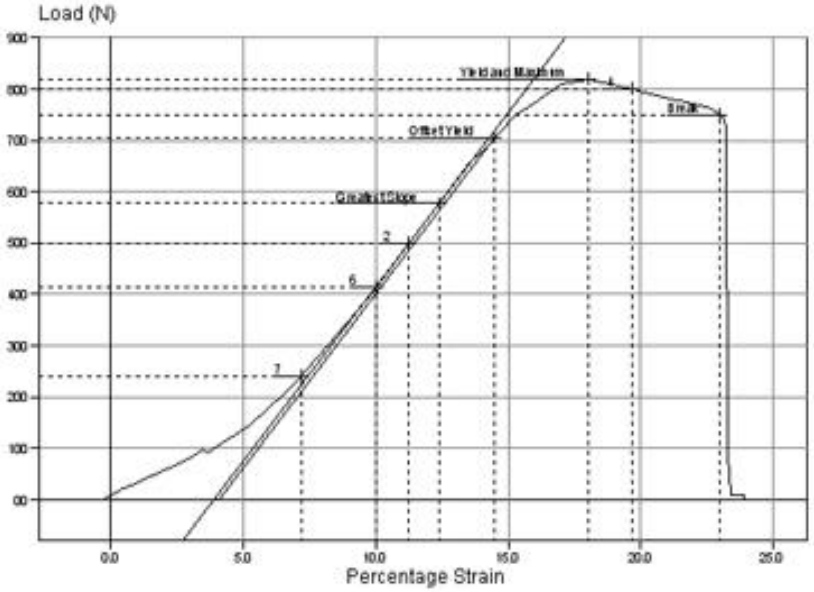
Data Chart

Stress	Strain

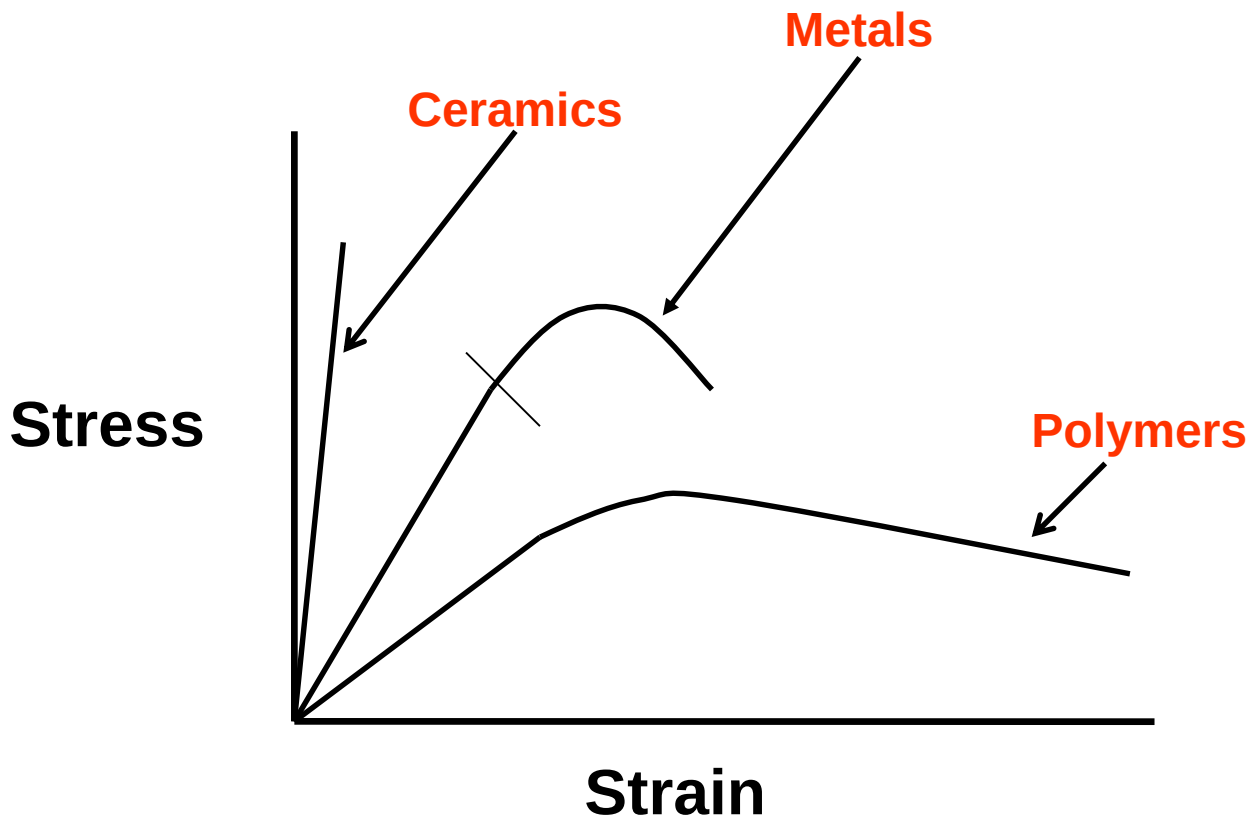
Tensile Strength

Tensile strength is defined as the highest stress a material can withstand before failure occurs.

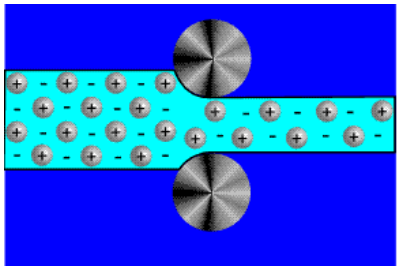

Load (N)
Yield
Offset Yield
Preload
Percentage Strain


Load (N)
Yield and Maximum
Break
Offset Yield
Percentage Strain

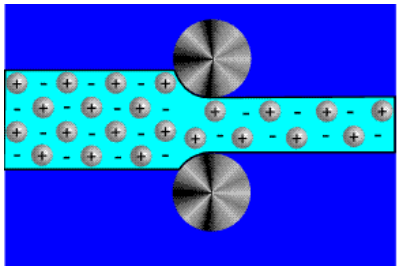
Stress Strain Curve Interpretation

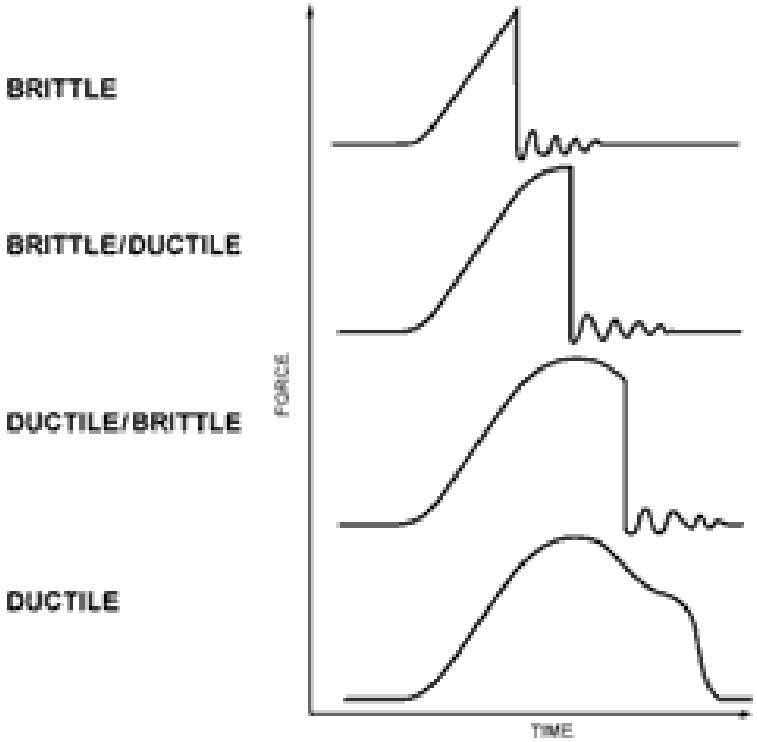


Demo

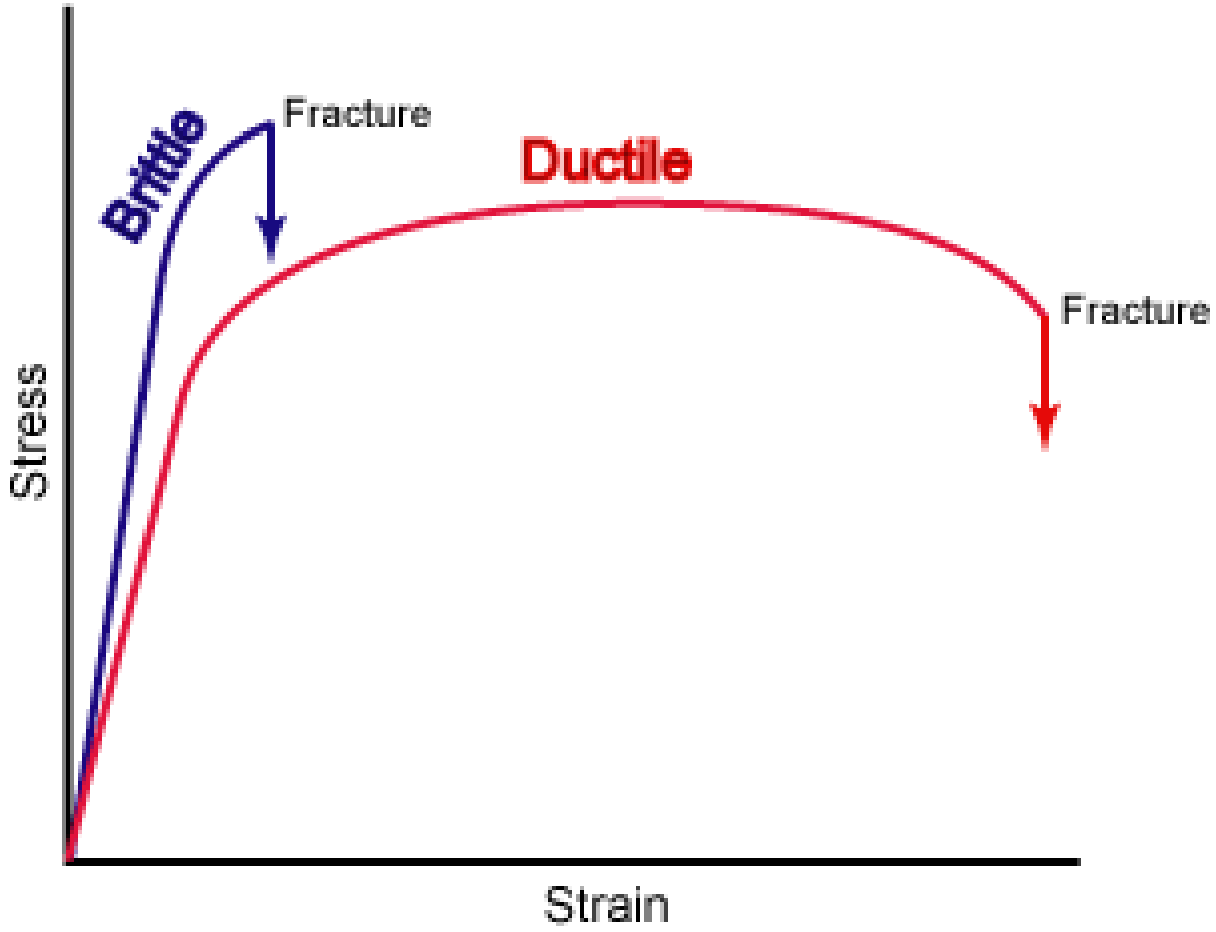


Ductility

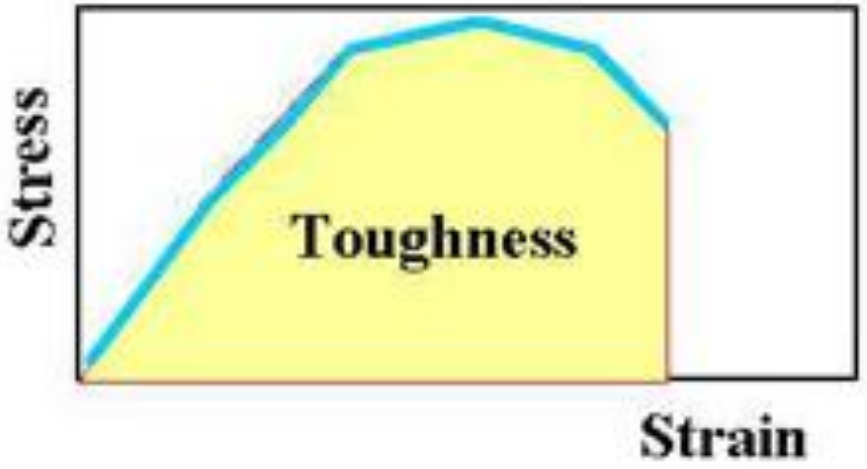




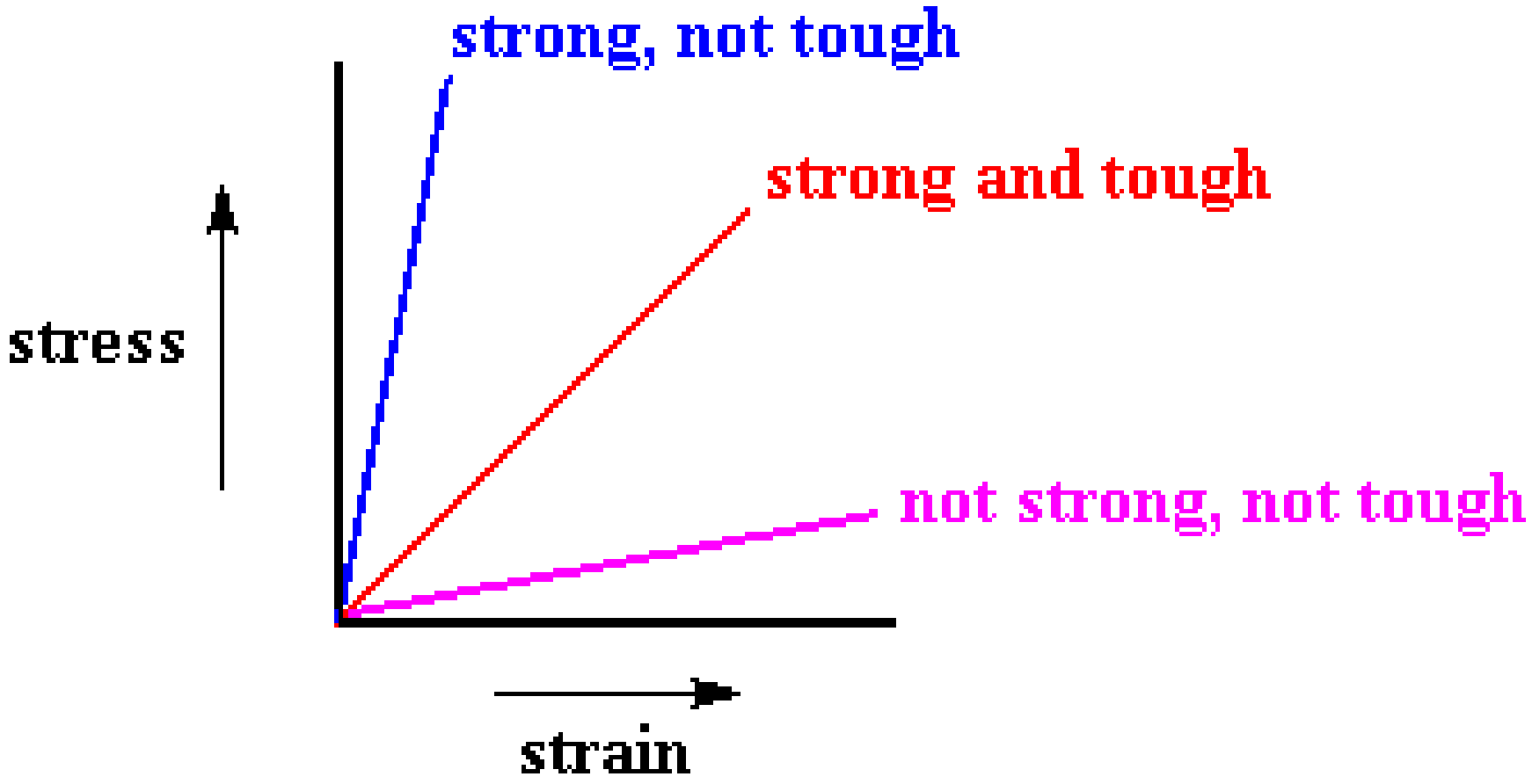
Ductility is measured by the amount of elongation that can be applied to a material before failure occurs.

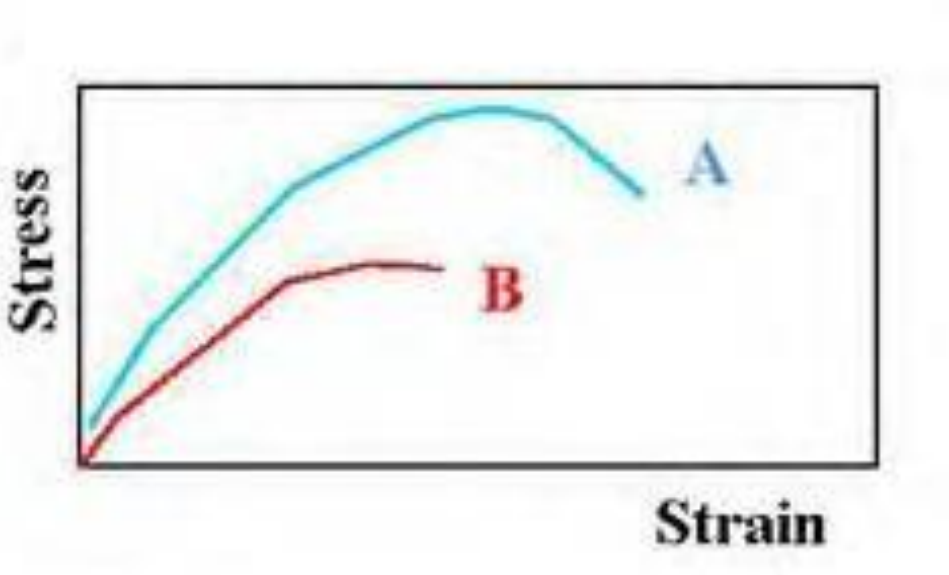

Brittle
Fracture
Ductile
Fracture
Stress
Strain

Toughness



Toughness is defined as the total area under the stress strain curve. It indicates the amount of energy absorbed before failure.


strong, not tough
strong and tough
not strong, not tough
stress
strain

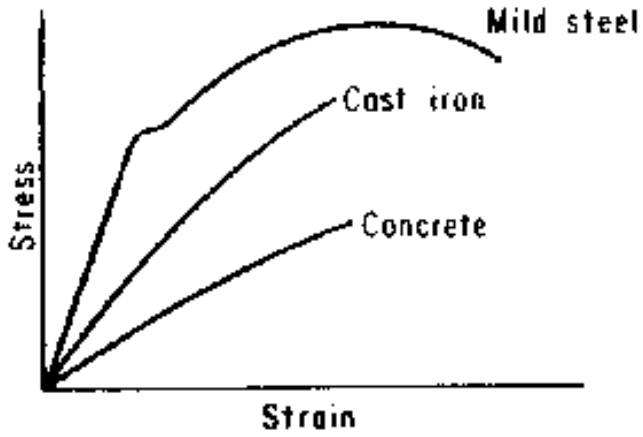


Which Material Is Stronger?

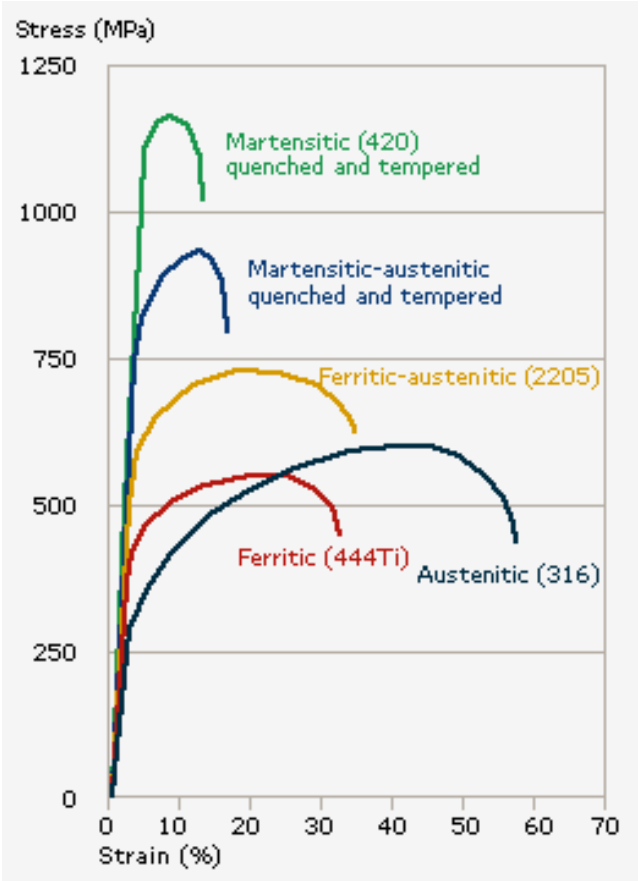
Which Material Is Tougher?

Which Material Is More Ductile?

Stress Strain Curve Interpretation

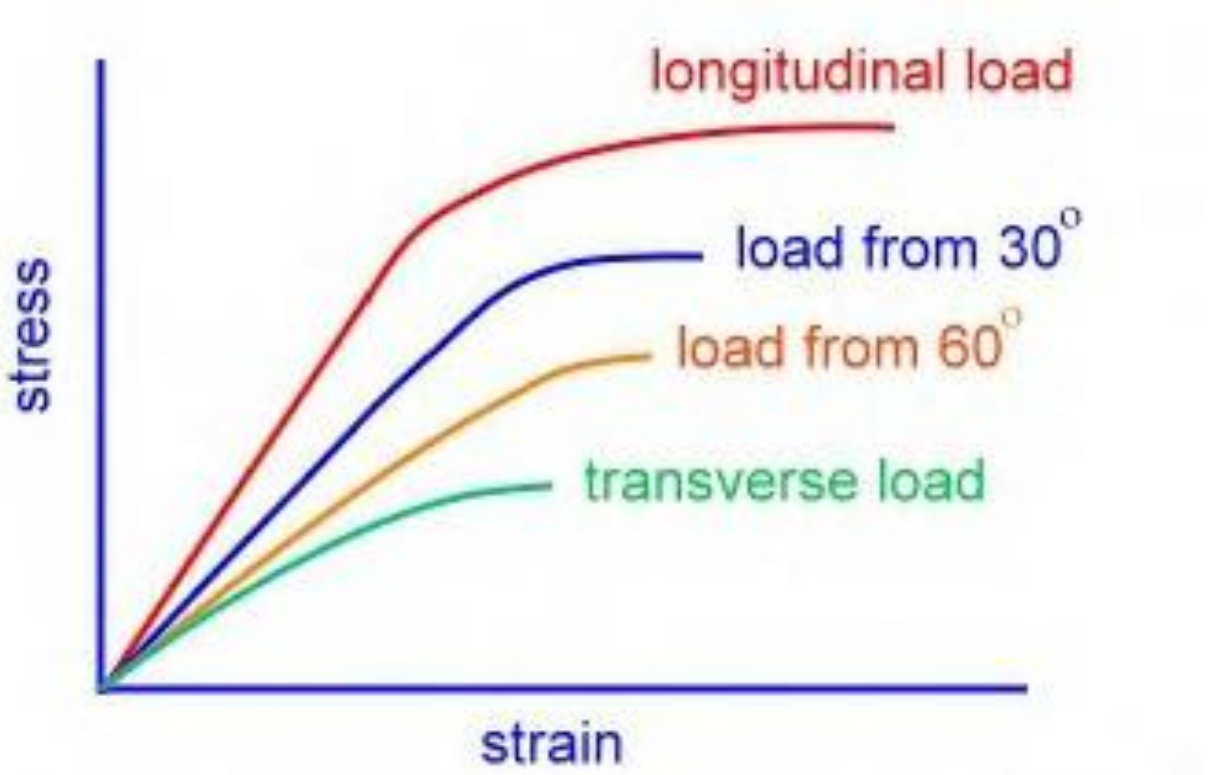


Construction Materials



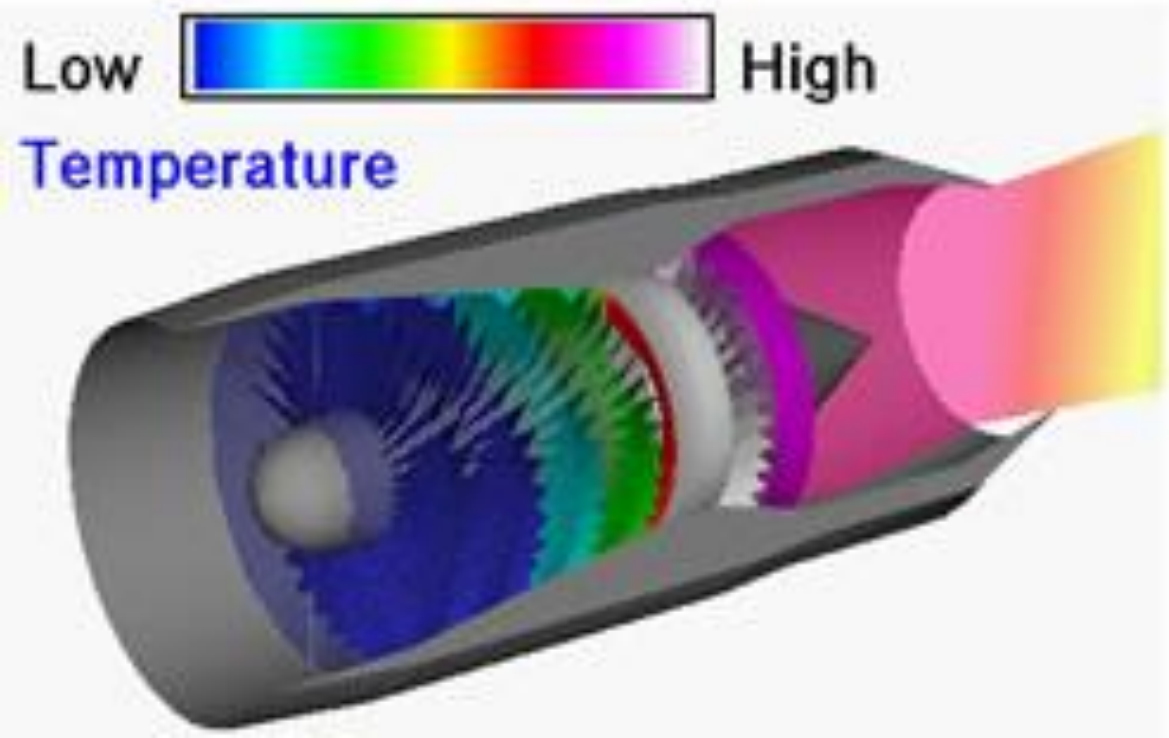
Stainless Steel

Stress Strain Curve Interpretation



Anisotropic Behavior of Bone

Creep



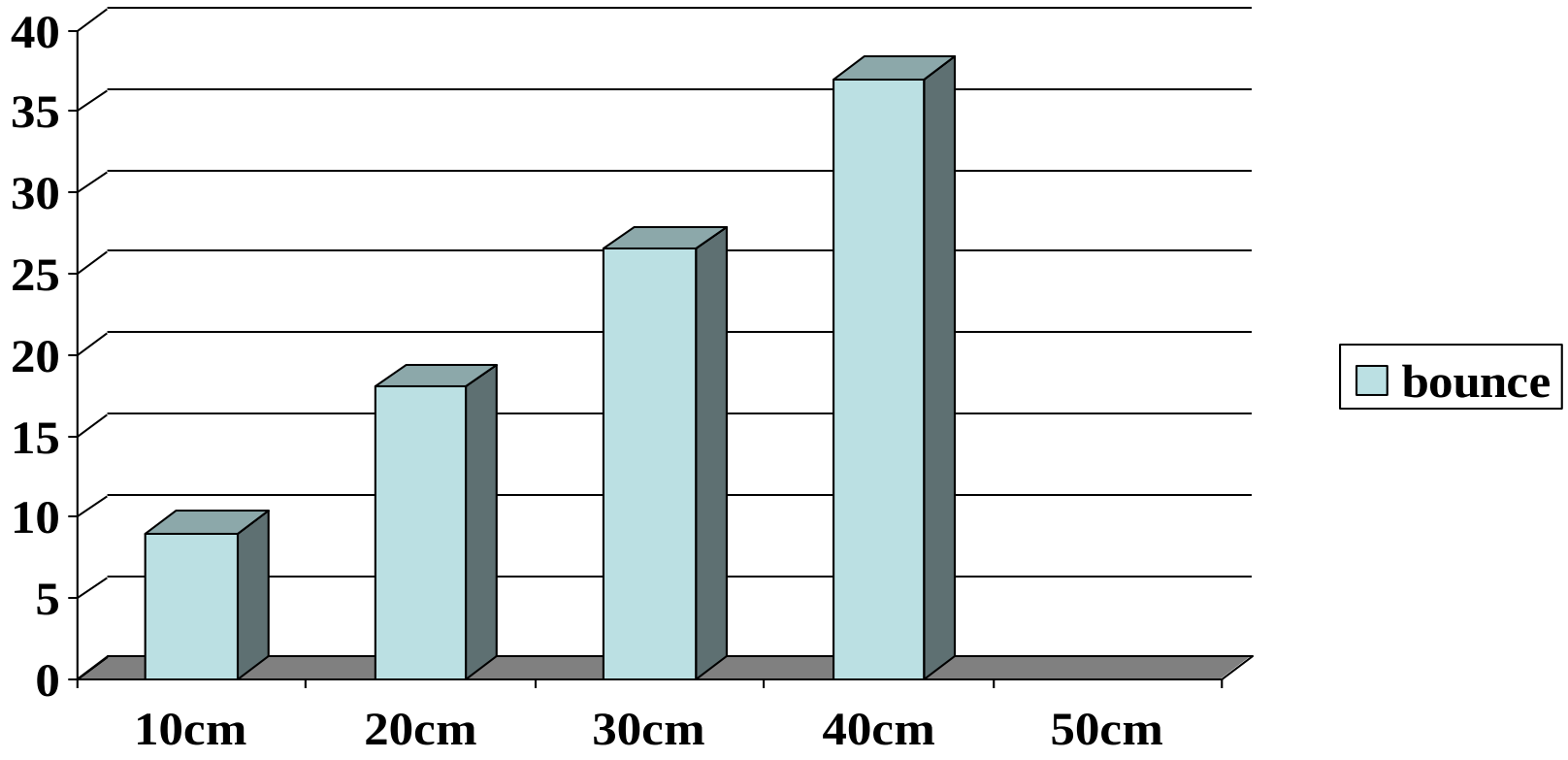
The deformation that occurs at elevated temperature under constant load.

Demo

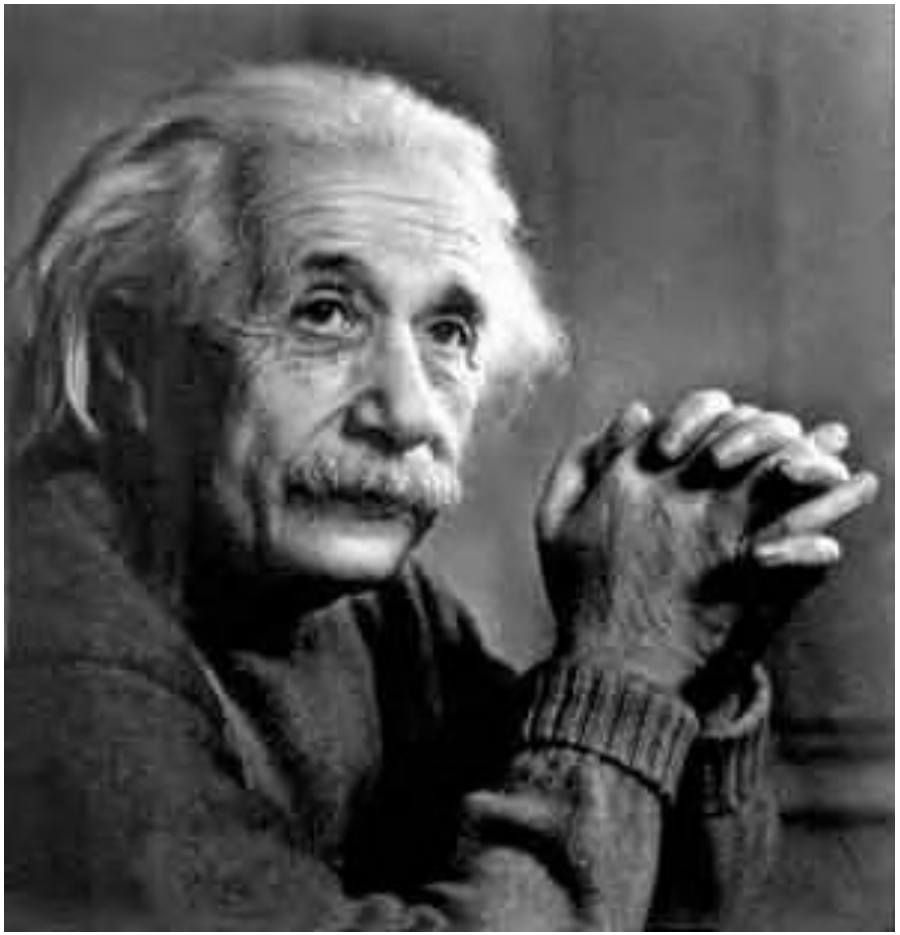
Testing Energy Absorption

Coefficient of Restitution

Coefficient of Restitution



Lab: Core of Restitution

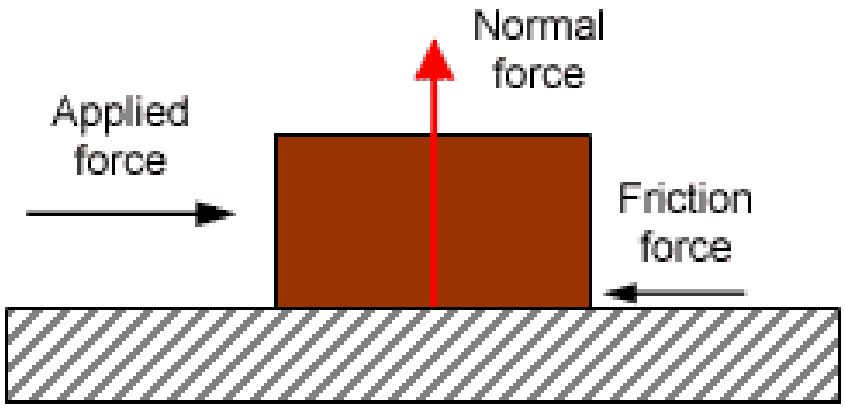


Lab: Core of Restitution

Data Chart

Ball	Drop Height	Rebound Height	COR
Soccer			
Golf			
Tennis			
Basketball			
Racket			
Field Hockey			
Ping Pong			
Wiffle			
Softball			
Baseball			
Happy Ball			
Sad Ball			

Friction

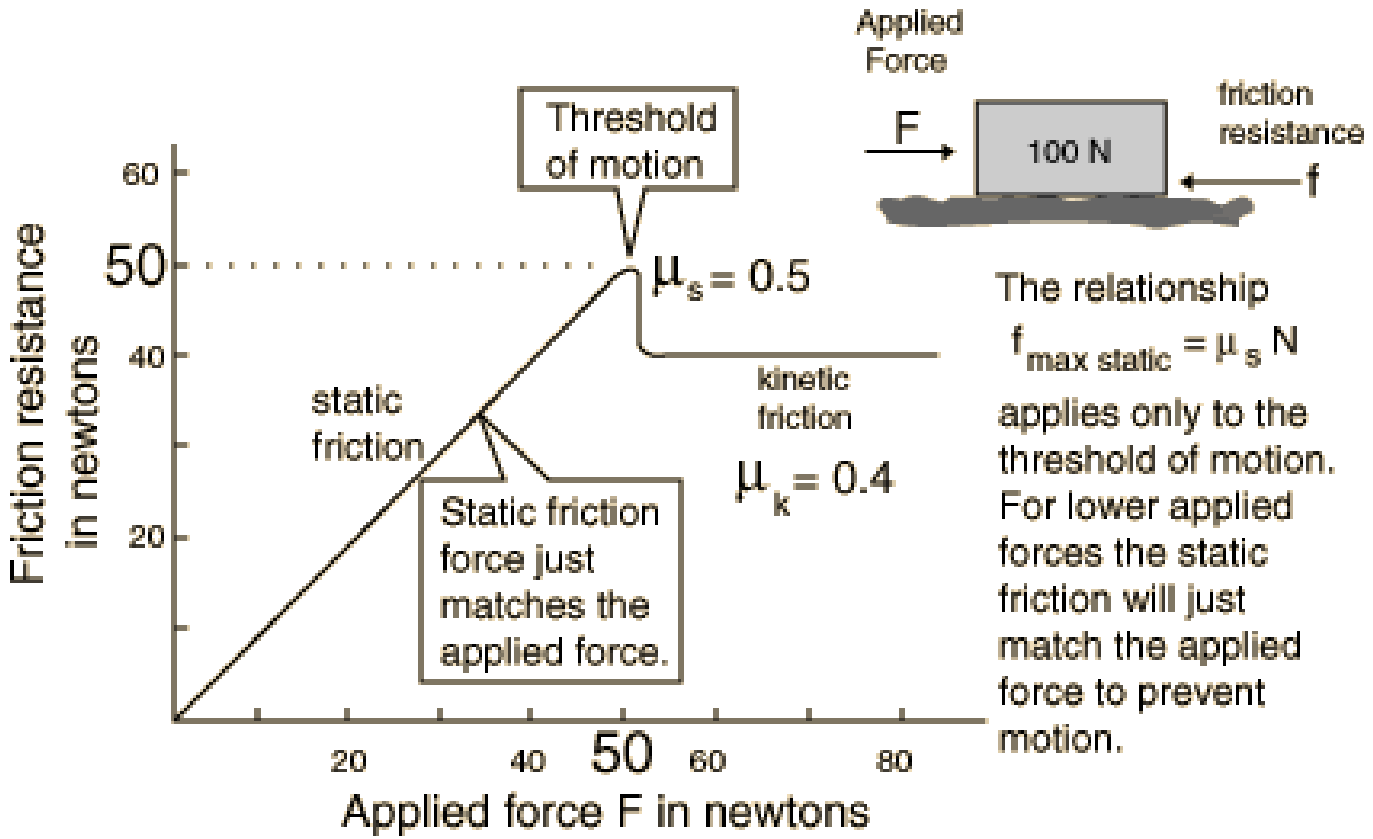


Force that opposes motion.

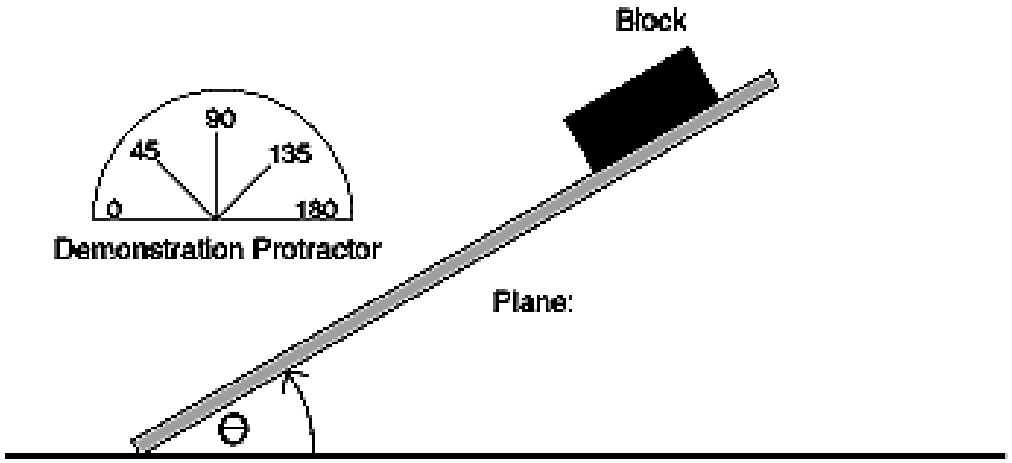
Resistance caused by 2 objects in contact with each other.

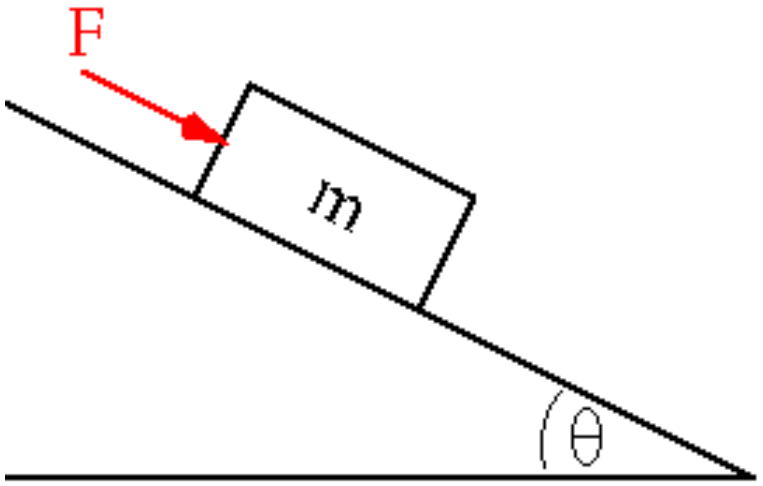
Static Friction

Friction between 2 nonmoving objects.

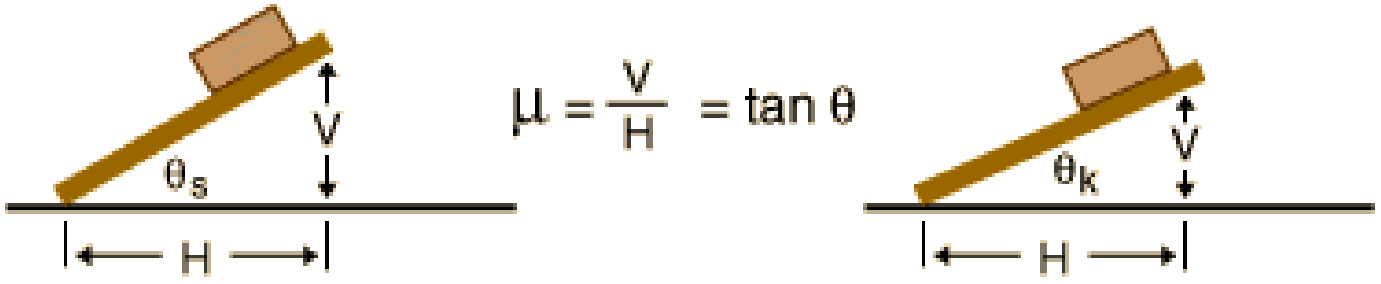


Coefficient of Static Friction

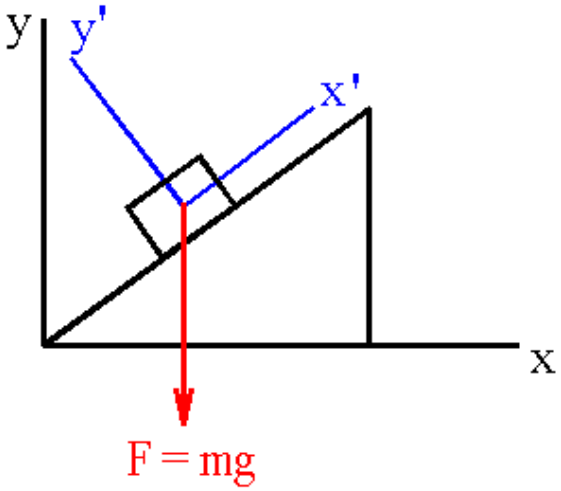




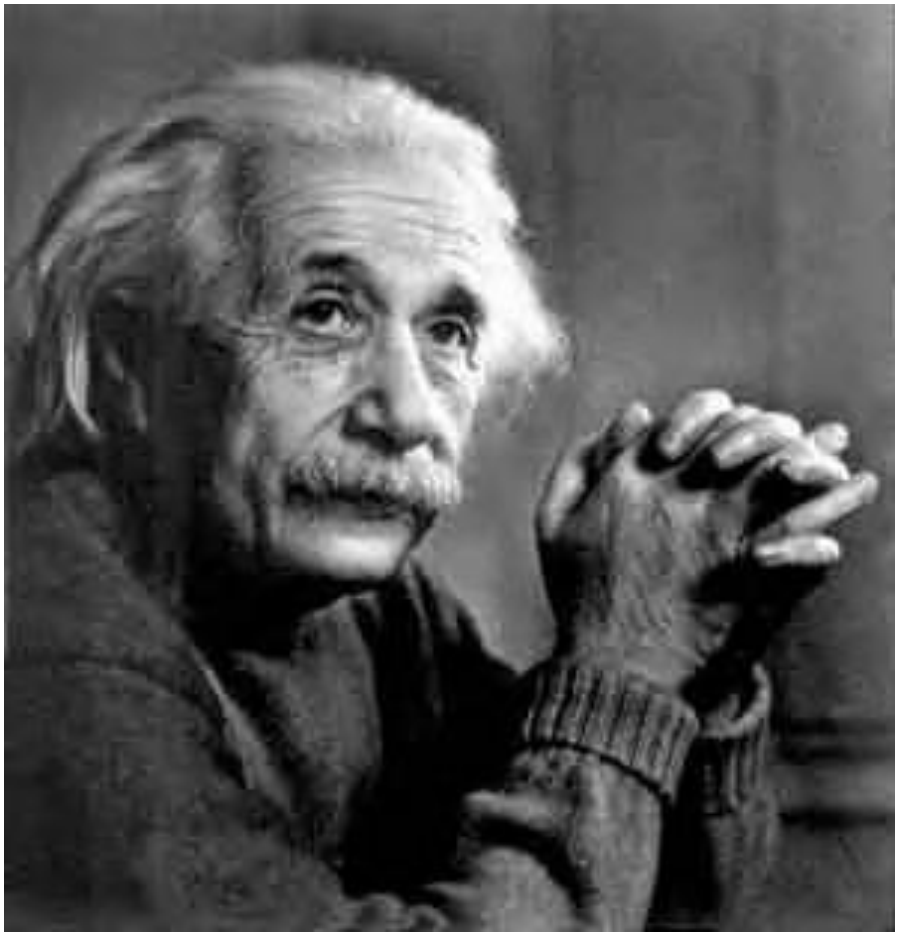
Coefficient Determination



μ static = tan (angle of tilt)



Lab: Static Friction



Lab: Static Friction

Data Chart

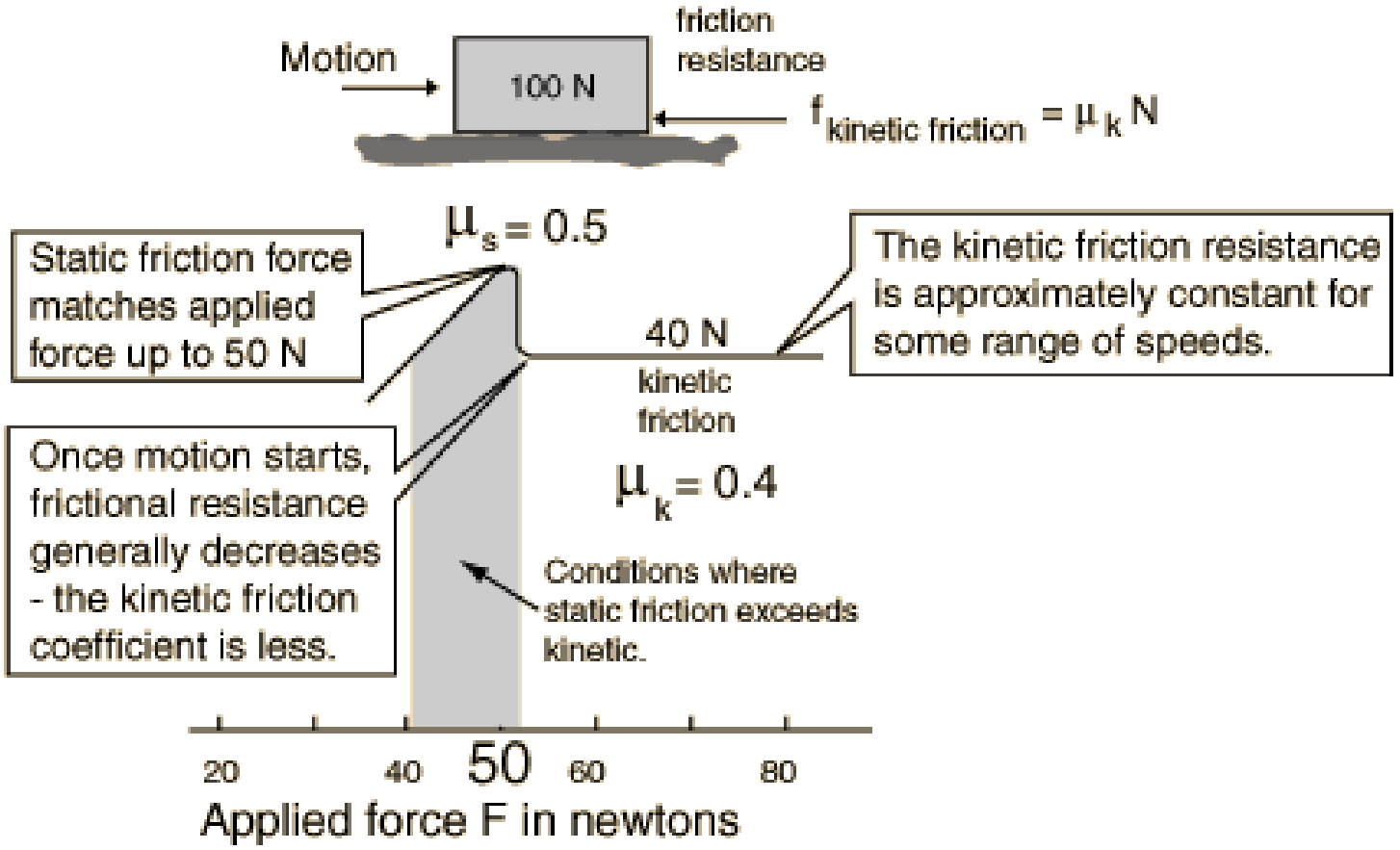
Type of Footwear	*Angle of Elevation*	*Coefficient of Static Friction*

Sliding Friction

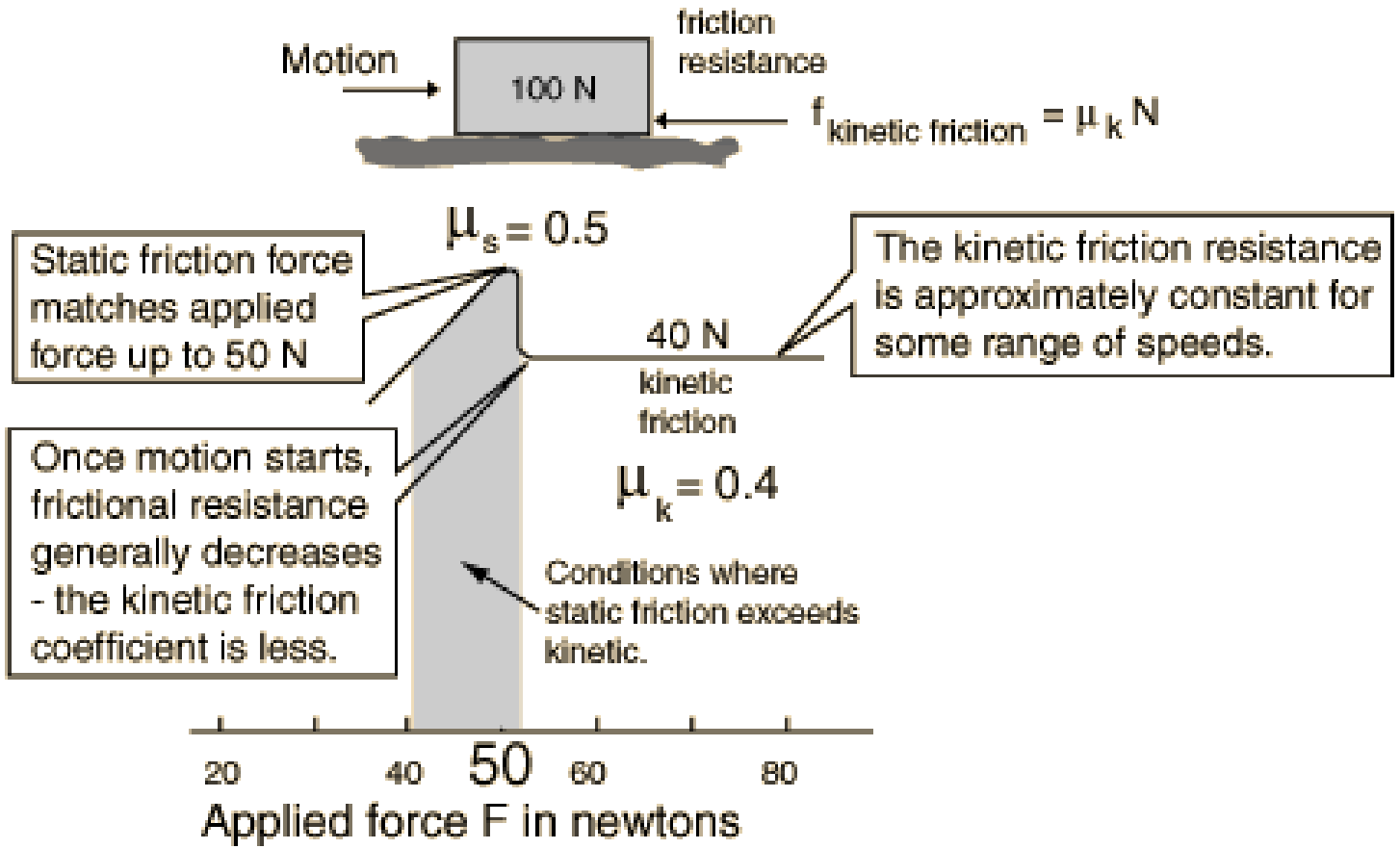
Kinetic Friction

Sliding Friction

Friction between moving object(s).



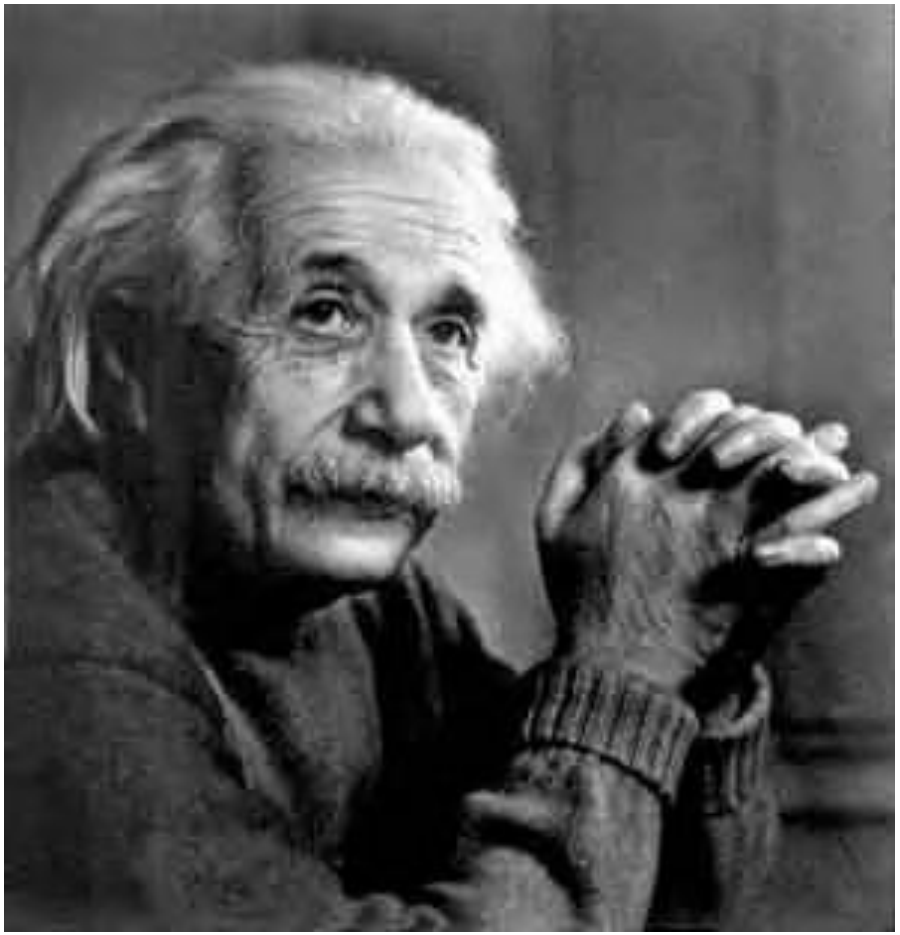
Coefficient of Kinetic Friction



Wood

Asphault

Lab: Sliding Friction

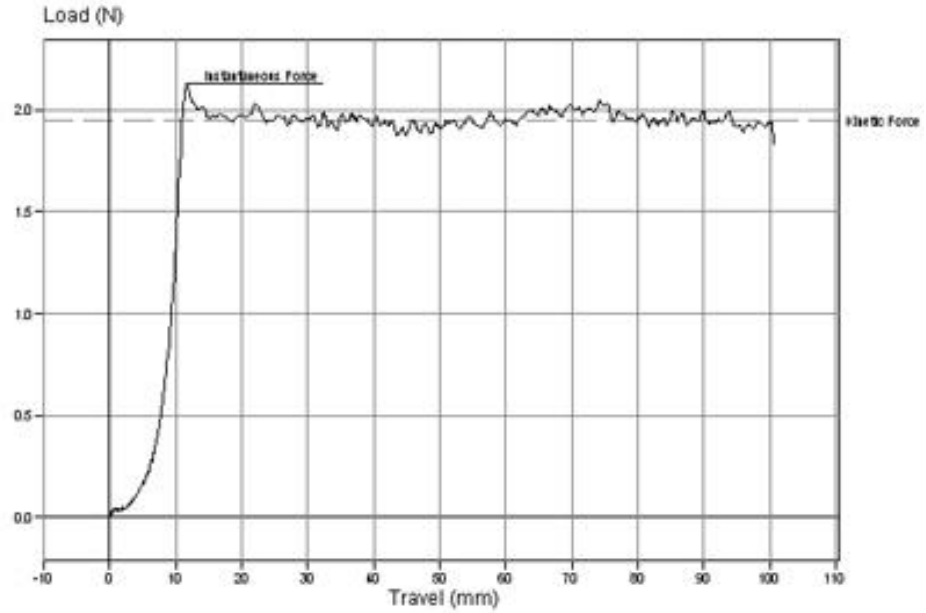


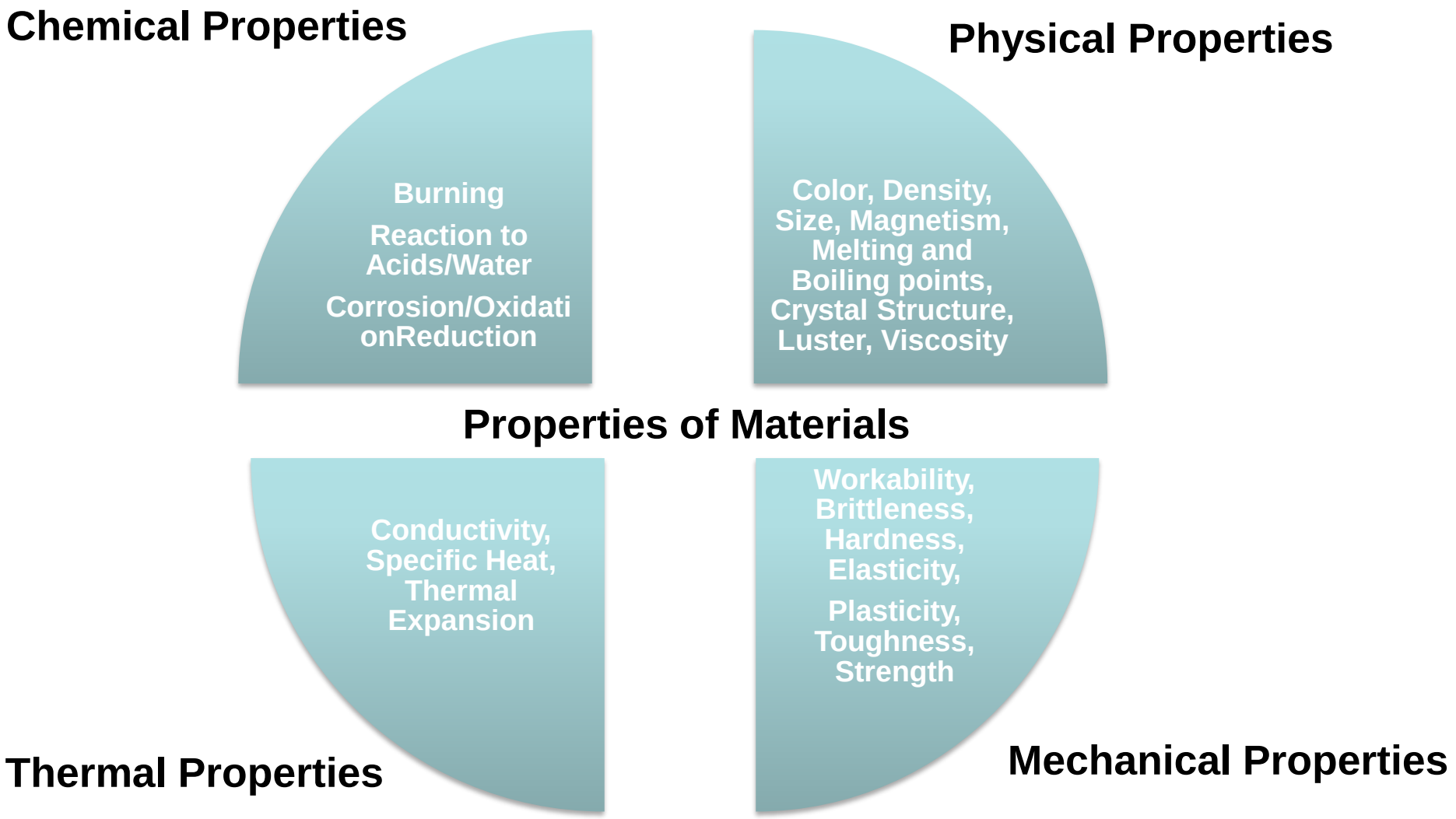
Lab: Sliding Friction

Data Chart

Surface ***Table Top***	***F(gravity) (N)***	***F(friction) (N)***	***Coefficient of Sliding Friction***
Wood			
Sandpaper			
Cardboard			
Plastic			

Friction Tester




Chemical Properties
Burning
Reaction to Acids/Water
Corrosion/OxidationReduction
Physical Properties
Color, Density, Size, Magnetism, Melting and Boiling points, Crystal Structure, Luster, Viscosity
Properties of Materials
Conductivity, Specific Heat, Thermal Expansion
Thermal Properties
Workability, Brittleness, Hardness, Elasticity,
Plasticity, Toughness, Strength
Mechanical Properties

Material Science Bowling

Object of the Game

In this activity,
you will be bowling with
words.

Each of the ten pins shown is a letter.

I F I C

A R T

A L

I

I F I C

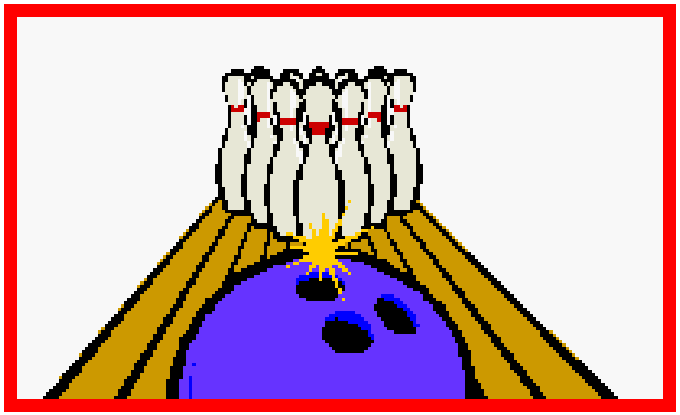
A R T

A L

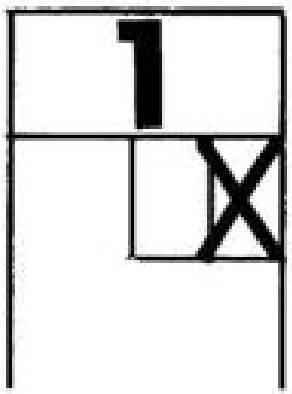
I

If You Make a 10 Letter Word

A R T I F I C I A L



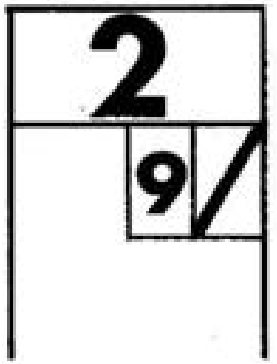
You have a STRIKE!



A Strike

I F I C
A R T
A L
I

If You Make 2 Words Using All 10 Letters..



A Spare

You may use
SCIENCE & NONSCIENCE
words!

Frame 1

S E I T

R E P

O R

P

Frame 1

P R O P E R T I E S

Frame 2

N O I T

N O C

D U

N

Frame 2

C O N D U C T I O N

Frame 3

C Y I T

S A L

T I

E

Frame 3

E L A S T I C I T Y

Frame 4

B O I N

U M C

S O

T

Frame 4

C O M B U S T I O N

Frame 5

S O I T

R A N

O B

P

Frame 5

A B S O R P T I O N

Frame 6

M I E A

T V U

O T

O

Frame 6

A U T O M O T I V E

Frame 7

S A K T

B E A

L L

B

Frame 7

B A S K E T B A L L

Frame 8

C Y I T

N L N

D A

A

Frame 8

D I L A N T A N C Y

Frame 9

R C I T

L E E

A L

C

Frame 9

E L E C T R I C A L

Frame 10

H E C M

I N A

A C

L

Frame 10

M E C H A N I C A L

Frame 10

O R I T

S U L

A N

S

Frame 10

I N S U L A T O R S

Frame 10

M E A T

R Y G

L L

U

Frame 10

M E T A L L U R G Y