LECTURE #18 :
3.11 MECHANICS OF MATERIALS F03

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• REVIEW :
MOHR'S CIRCLE I
• MOHR'S CIRCLE SAMPLE PROBLEMS
• INTRODUCTION :
MOLECULAR ORIGINS OF MECHANICAL PROPERTIES
ASHBY and JONES, Chapters 3/4

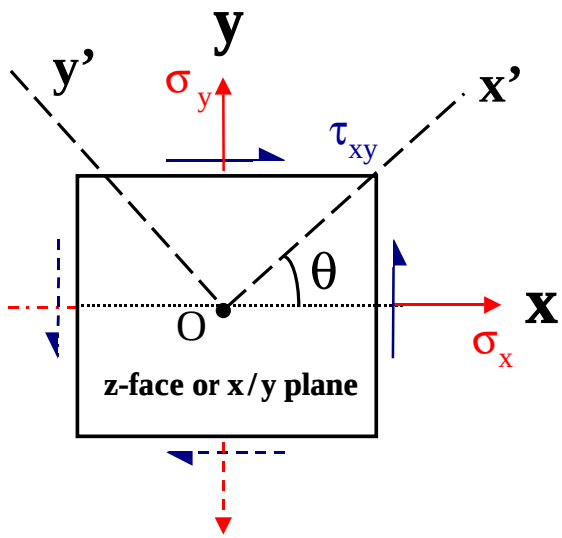
REVIEW LECTURE #17 : MOHR'S CIRCLE

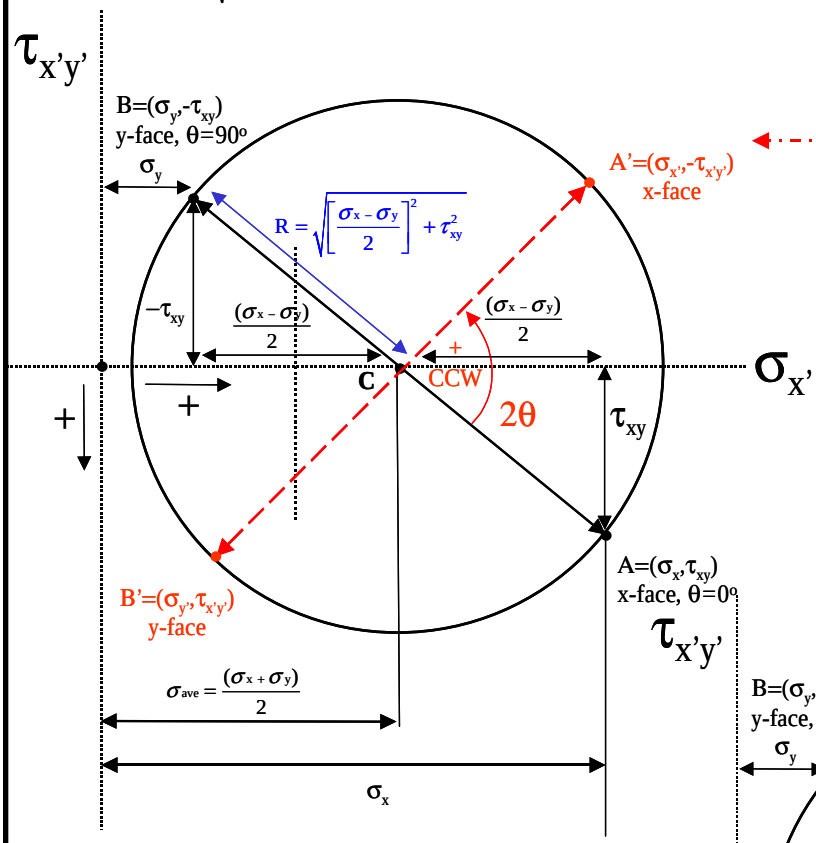
$$(\sigma_{x'} - \sigma_{ave})^2 + \tau_{x'y'}^2 = R^2$$ → *graphical representation of stress transformation equations*

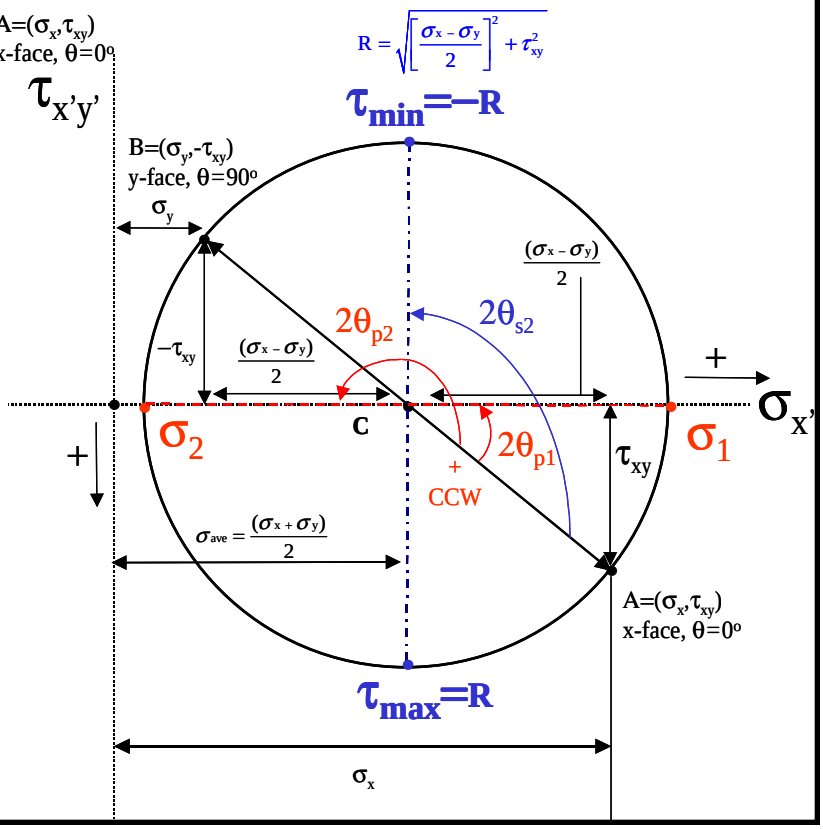
$$\sigma_{ave} = \frac{(\sigma_x + \sigma_y)}{2}$$

$$R = \sqrt{\left[\frac{\sigma_x - \sigma_y}{2}\right]^2 + \tau_{xy}^2}$$

Given stress state :

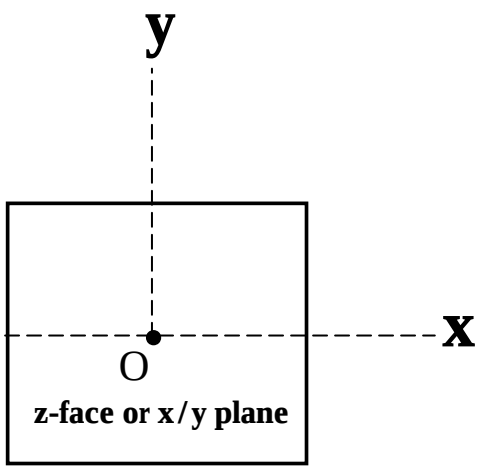


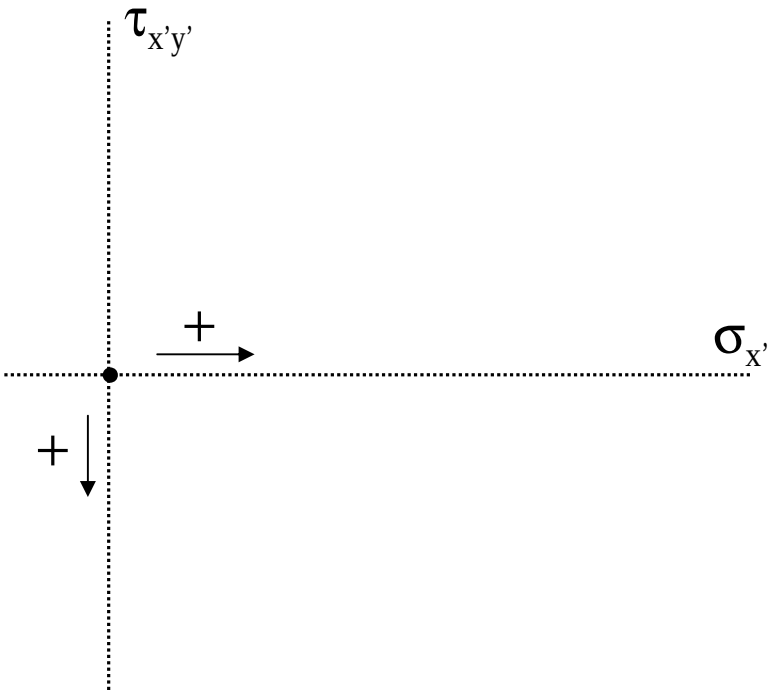




A SIMPLE EXAMPLE OF MOHRS CIRCLE

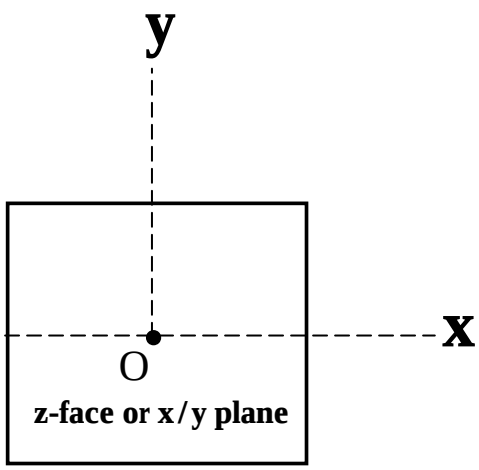
I. Uniaxial Tensile Stress State : $\sigma_x=0$, $\sigma_y=\sigma_o$, $\tau_{xy}=0$

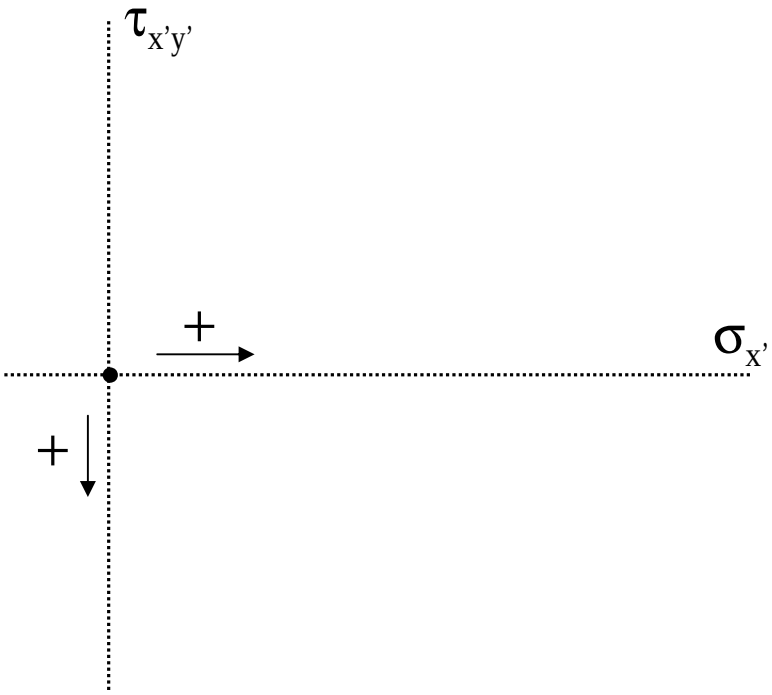




A SIMPLE EXAMPLE OF MOHRS CIRCLE

II. Biaxial Stress State : $\sigma_x=0$, $\sigma_y=\sigma_o$, $\tau_{xy}=0$



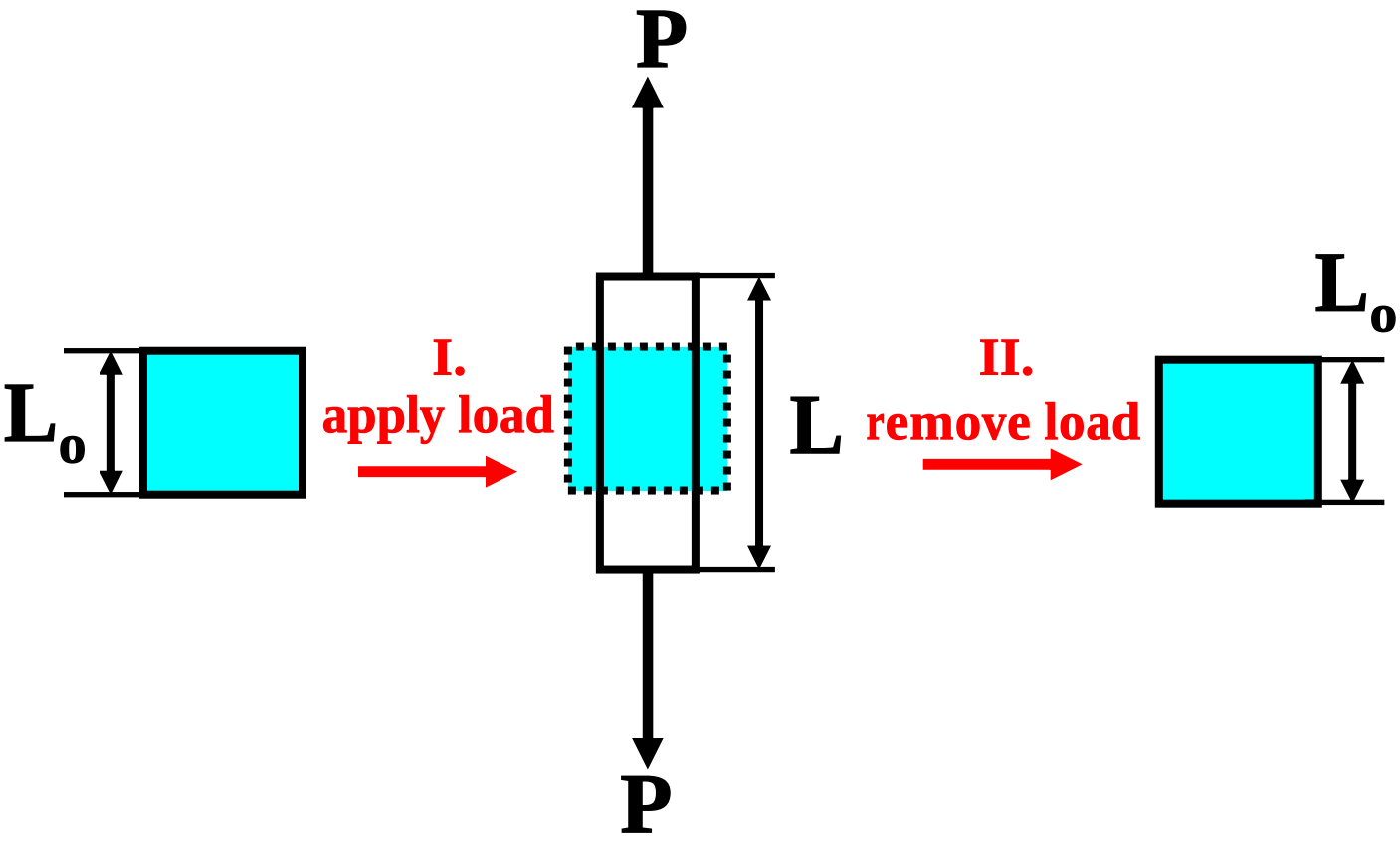


MOHRS CIRCLE JAVA APPLET

http://web.mit.edu/course/3/3.11/www/java/mohr.html

Review Basic Definitions : Elasticity

recoverable or reversible deformation of a material :
if a load is applied, the material instantaneously returns
to its original shape and dimensions



Elastic Moduli : fundamental macroscopic material property of a solid that is a measure of a material's resistance to deformation (stiffness)

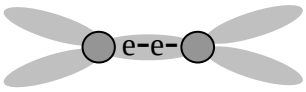
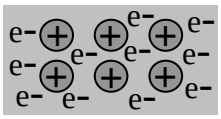
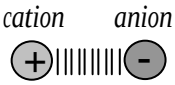
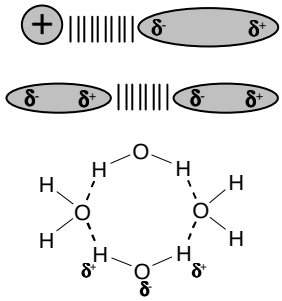
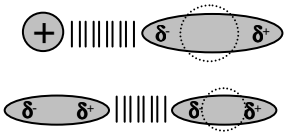
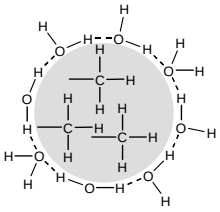
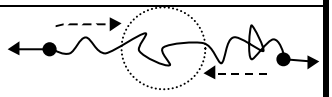
Questions

Answers

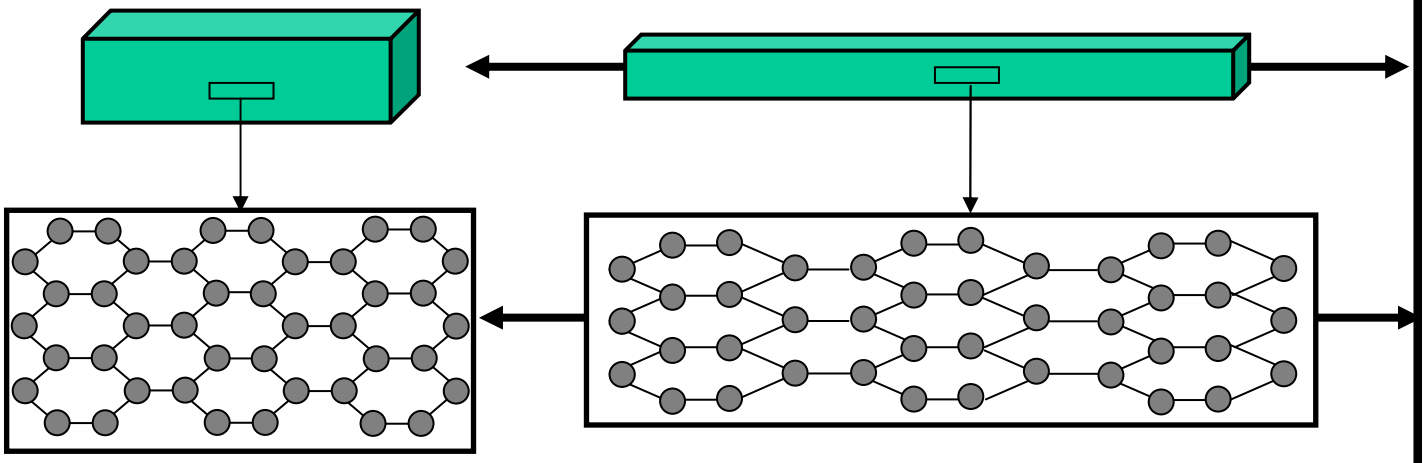
Enthalpic Origin of Elastic Moduli

Thermodynamics…?

Summary of Types of Bonding

Type of Interaction	Classification	Characteristics	Schematic
Covalent :	**Primary or Chemical Bonds :** • usually characterized as individually "strong" • outer orbital e- cooperatively shared between two or more atoms so that discrete nature of atoms is lost • quantum mechanical in origin	• e- are localized • directional (i.e. oriented at well-defined angles to each other)	
Metallic :		• only metals atoms are involved • e- are completely delocalized and mobile throughout entire material • non-directional	
Ionic : • ion-ion		• coulombic in origin, occurs between oppositely charged species • electron transfer from one atom to another	
Polar Interactions : • charge-dipole • dipole-dipole • hydrogen bonding	**Secondary or Physical Interactions :** • usually characterized as individually "weak" • no e- sharing, more subtle attraction between (+) and (-) charges, discrete nature of atoms preserved • typically exhibits : • lack of specificity • lack of directionality • lack of stoichiometry	• force between an ion and a dipole or two dipoles where the (+) charge attracts the (-) charge (purely electrostatic) • *H-bonding* : a special type of dipole-dipole interaction that results from the bonding between a H atom which is partially (+) charged and a highly electronegative atom such as O, F, N, Cl, (directional)	
Polarization Interactions : • charge-nonpolar (induced or instantaneous dipole) • dipole-nonpolar (induced dipole)		• an ion or dipole in the vicinity of a nonpolar atom or molecule causes instantaneous polarization and electrostatic attraction	
Dispersion or London Interactions : (*also called charge-fluctuation, electrodynamic, induced-dipole-induced dipole forces) • nonpolar-nonpolar		• the (+) nucleus of a nonpolar atom attracts the (-) charged electrons of another nonpolar atom resulting in instantaneous, induced, dipoles and fluctuating electron clouds • quantum mechanical in origin	
Hydrophobic :	**Special Interactions :** • not really true "bonds" • non-directional	• attraction between nonpolar molecules in aqueous solution caused by their inability to form H-bonds with HOH so as to minimize the disruption of H-bonds in HOH • entropy-driven	
Entropic Elasticity :		• attractive, recoiling force produced via extensional deformation macromolecules	

Atomistic Basis for Elasticity: One Example : Crystalline Materials



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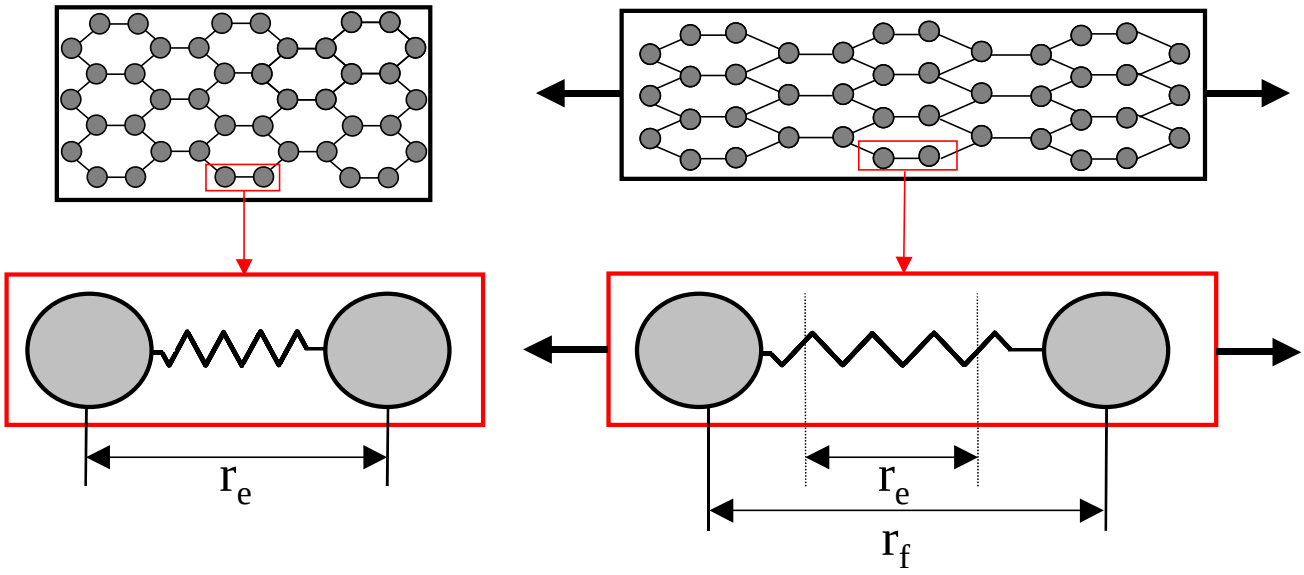
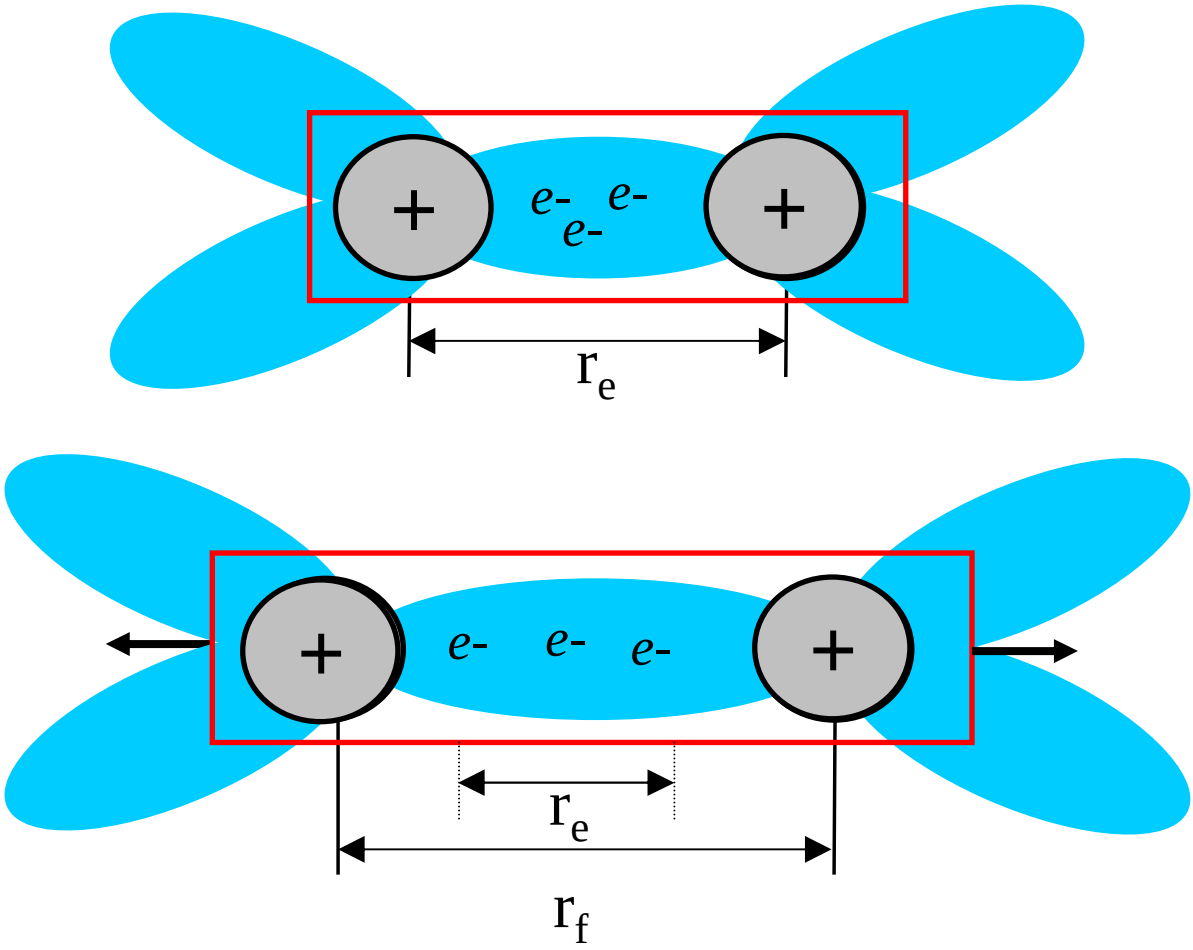


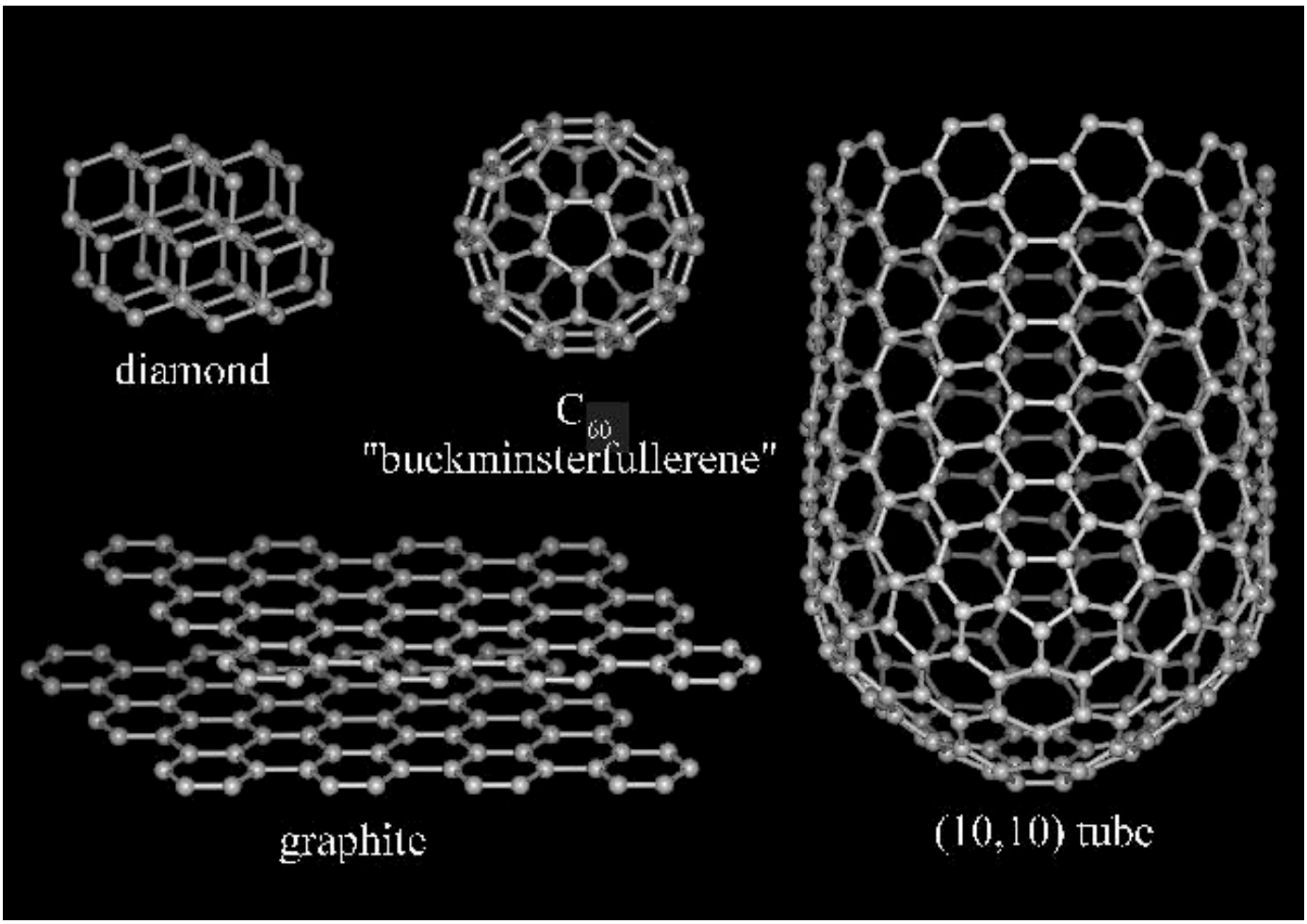
Atomistic Basis for Elasticity:

covalent bond : outer orbitals cooperatively shared



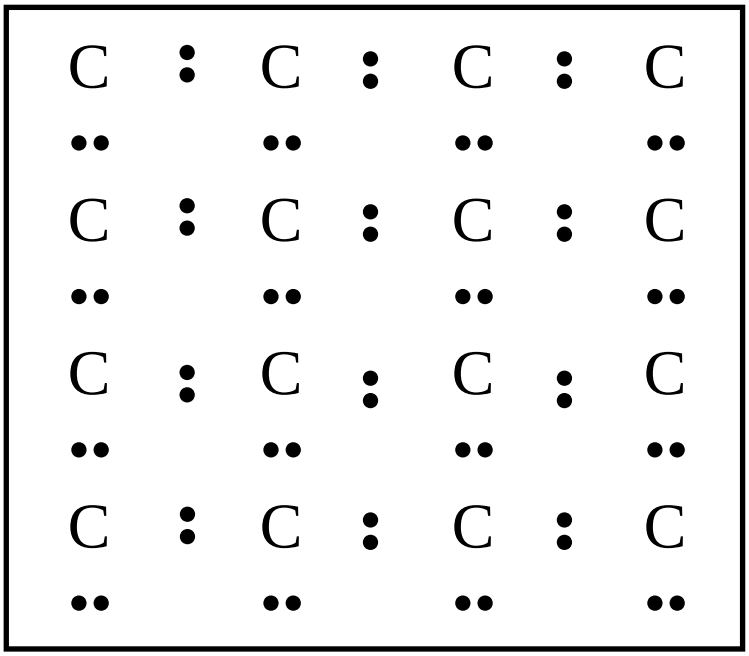
lattice strain disturbs electronic configuration

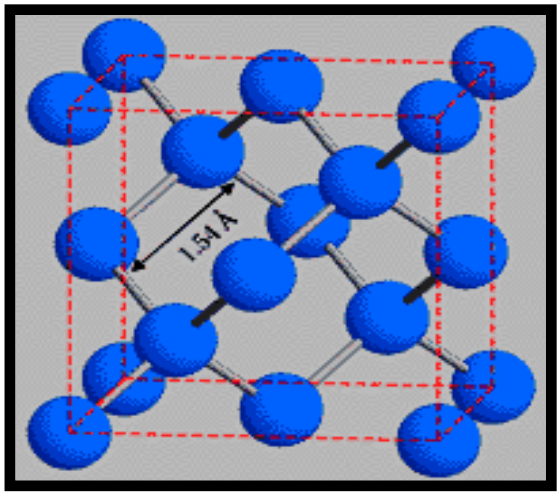
Example : Allotropes of Carbon



*(*http://cnst.rice.edu/images/allotropes.jpg)*

Structure of Diamond



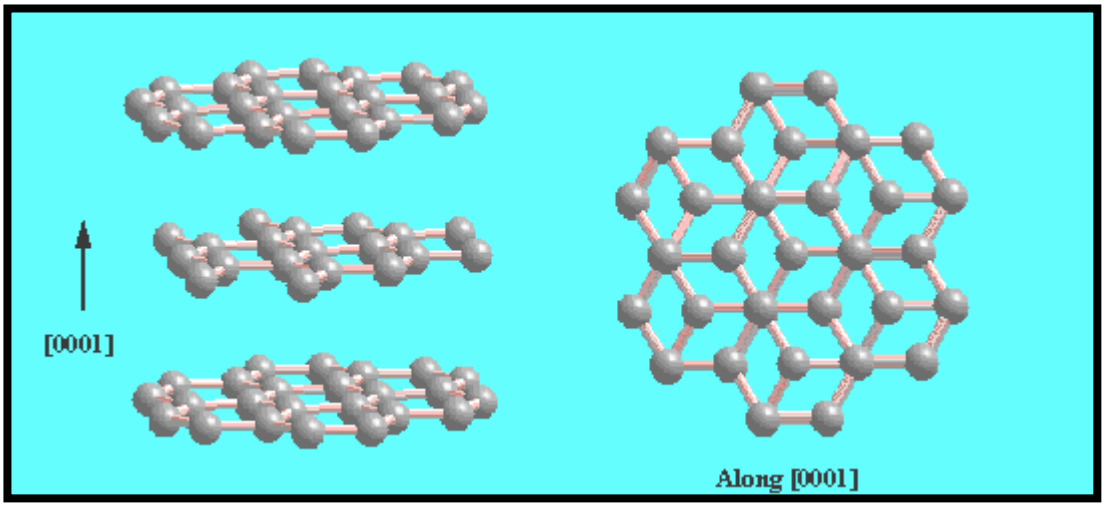


• ***Young's Modulus E=1000 GPa?*** *: each carbon atom has four valence e- and can make four covalent bonds with 4 nearest neighbor atoms*

→ tetrahedral configuration, face-centered cubic (FCC) unit cell

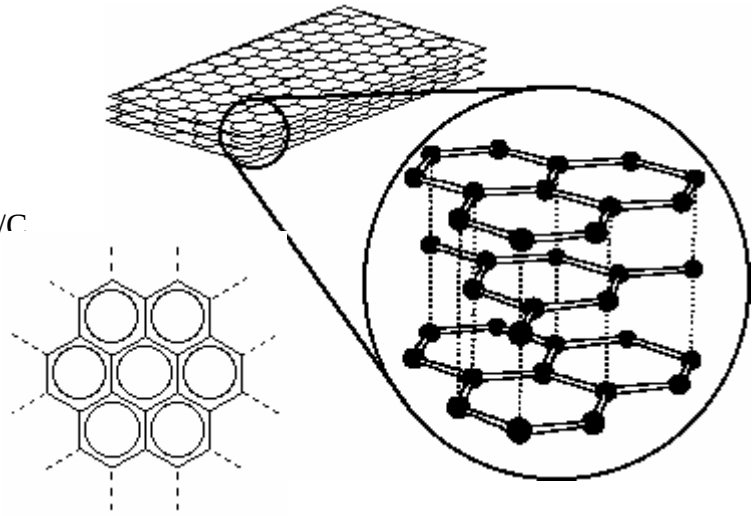
→ rigid crystalline stable 3-D network structure

Structure of Graphite



http://www.phy.mtu.edu/faculty/info/jaszczak/structure.html

http://www.chem.wisc.edu/~newtrad/CurrRef/BDGTopic/lab/Crystlab.html



• ***Young's Modulus E=20 GPa?*** *: each carbon atom is bonded to 3 others valence forming a crystalline layered structure of parallel hexagonal sheets*

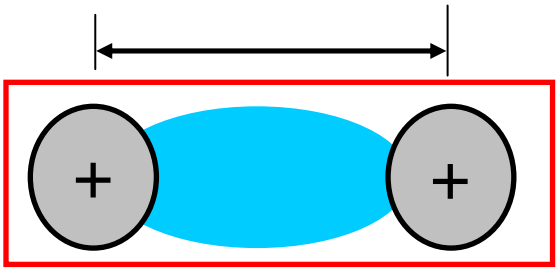
→ In the plane of the sheet : metallic bonding

→ Between sheets : weak van der Waals force

→ Layers can slip past each other (cleavage planes)

Consider an Individual Bond

interatomic distance, r (nm)

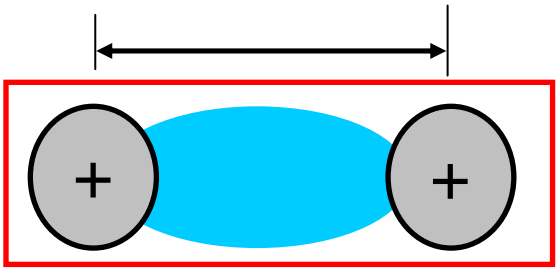


interatomic (bond) energy, *W* (kJ/mol)

interatomic force, F (nN)

Interaction Parameters

interatomic distance, r (nm)



interatomic (bond) energy, *W* (kJ/mol)

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