Introduction to Mechanical Engineering and the Mechanical Properties of Materials

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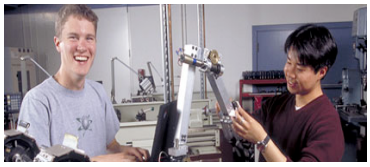
SANTA CLARA UNIVERSITY 1912-2012 100 ENGINEERING

SEEDs Workshop
April 15, 2017

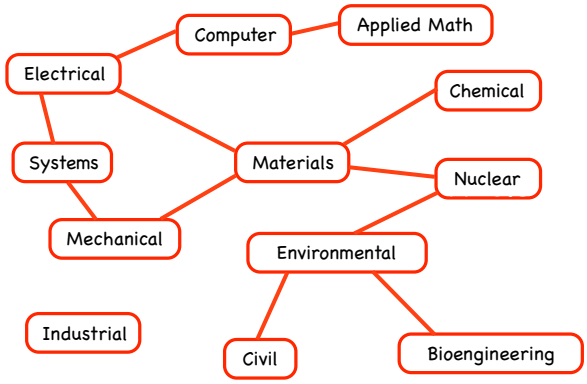
What do we do
Mechanical Engineering: Mission Statement

To develop successful Mechanical Engineers who:

- have broad grounding in engineering fundamentals;
- have strong communication skills;
- have the ability to adapt to changing work environments;



Engineering = Facebook™



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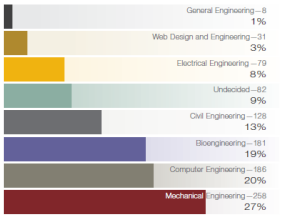
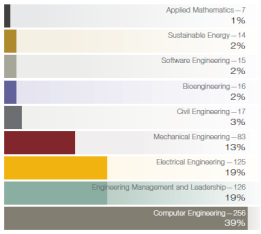
Mechanical Engineering at SCU

Undergraduate Enrollment 2014



Total* – 953, 100%
**Female – 218, 23%*

Graduate Enrollment 2014



Total* – 659, 100%
**Excludes certificate and open university; reflects currently enrolled students only*

Summer 2014 School of Engineering e-news

SANTA CLARA UNIVERSITY

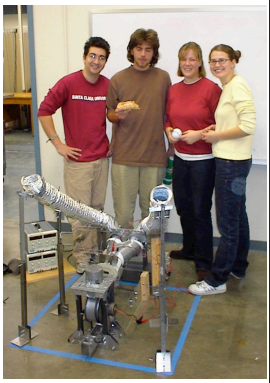
2014 Freshman Admission Profile

- **Acceptance rate 49.3%, 1319 enrollment**
  - 50% male, 50% female
- **Admitted students for the Fall 2011 had the following average scores:**
  - ACT Composite (25th to 75th percentile) 27-32
  - SAT Critical Reading 590-680
  - SAT Math 620-710
  - GPA 3.67
- **Expenses**
  - Tuition $43,812
  - Room and board $12,921

SANTA CLARA UNIVERSITY

2014 Freshman Engineering Admission Profile

- **Demographic data for students enrolled for**
  - Admission rate 51.2%
  - Female (2011) 28.0%
  - Male (2011) 72.0%
- **Admitted students for the 2014 had the following average scores:**
  - ACT Composite 30-34
  - SAT Critical Reading 620-690
  - SAT Math 670-750
  - SAT Composite 1,300-1430
  - GPA (2011) 3.75



ASEE Profiles 2014, institutional research

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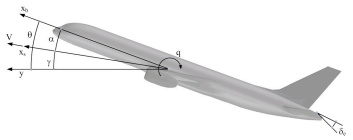
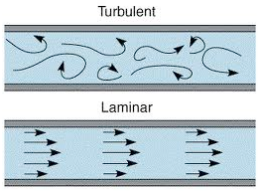
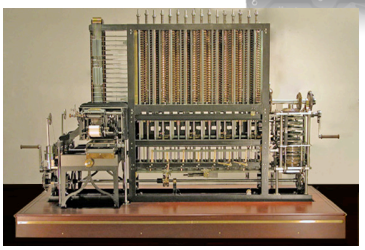
Mechanical Engineering at SCU

KEY TOPICS

- Dynamics & Vibrations
- Fluid Flow & Heat Transport
- Controls, Robotics, & Mechatronics
- Design & Manufacturing







Babbage's Difference Engine (designed in 1849, first built in 2002)

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Mechanical Engineering at SCU

UNDERGRADUATE

- Senior Design Projects
  - *Human Power Vehicle*
  - *Omoverhi: low-cost incubator*
  - *NanoSat*
  - *Solar Tracker*
  - *Solar Water Distiller*
- Solar Decathlon (DoE)
  - SCU: 3rd Place (2007 & 2009)

GRADUATE

- Thermofluids
- Dynamic Systems
- Robotics/Mechatronics
- Mechanical Design
- Materials Engineering

www.scu.edu
SCHOOL OF ENGINEERING
Santa Clara University

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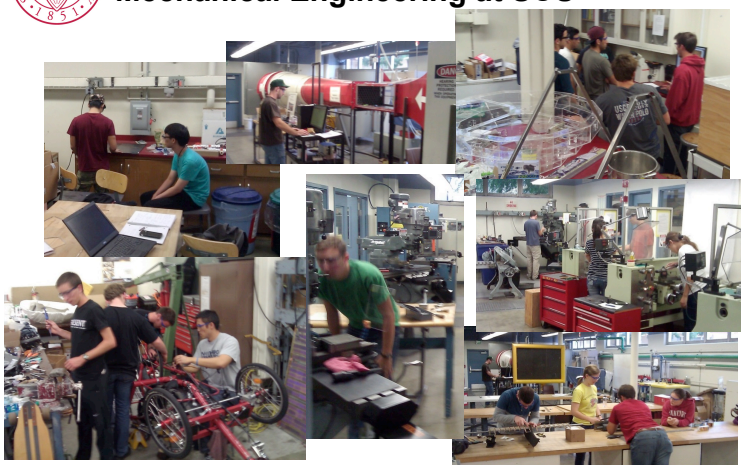
Mechanical Engineering at SCU



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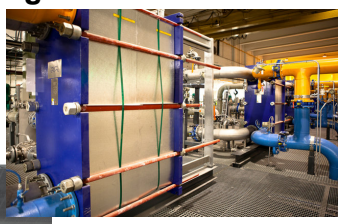
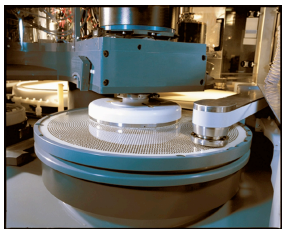
Jobs for Mechanical Engineers

- Aerospace/Defense
- Automotive
- Silicon Valley
  - Chemical Mechanical Planarization
  - Robots in semiconductor manufacturing equipment
- Thermal Management of Computing Systems
  - Google™ uses enough power to continuously power 200,000 homes (NY Times 9/8/11)





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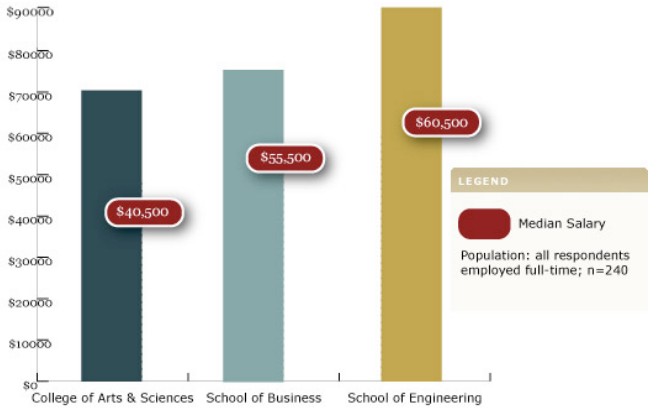
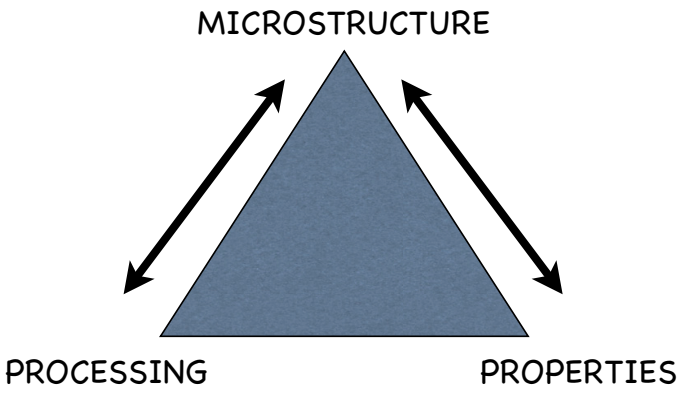
Life after Santa Clara
Survey of 2013 Graduates



Materials Science

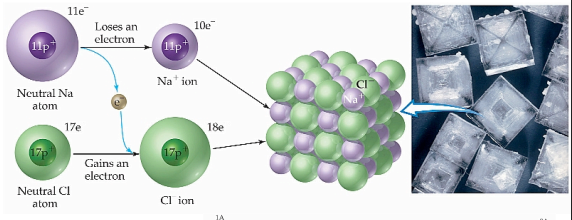
- Bridge between "Science" and "Engineering"
- May be called any of the following:
  - -Materials Science
  - -Materials Science and Engineering
  - -Materials Engineering
- Often combined with Chemical or Mechanical Engineering departments
- Most Engineering students are required to take at least one introductory course in materials

Materials Science

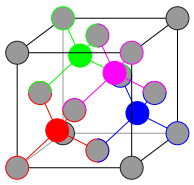


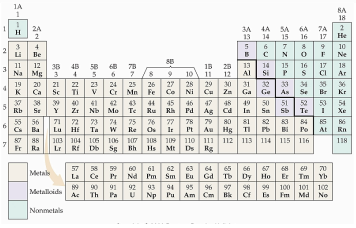
ATOMIC BONDING IN SOLIDS:

Ionic: electrostatic attraction of opposite charges



Covalent: electron sharing (e.g., diamond and silicon)

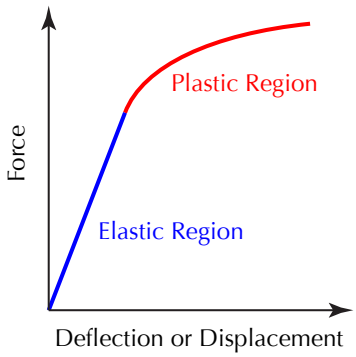


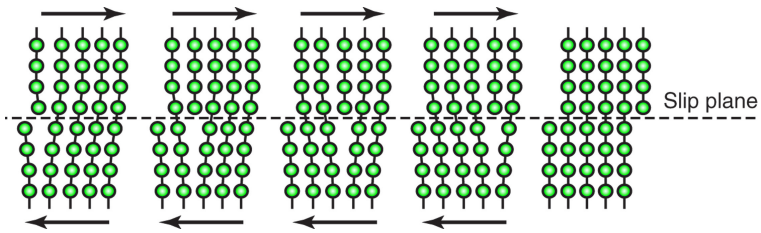


Metallic: free electron model a.k.a. "sea of electrons"

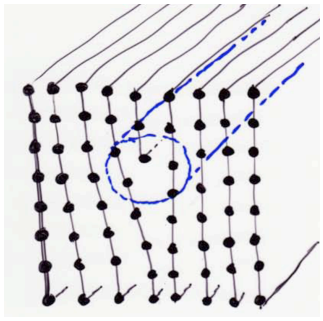
DEFORMATION OF METALS:

- Elastic Region: stretching of atomic bonds (similar to springs)
- Plastic Region: permanent deformation...WHY???
  - -Dislocations





Strain Hardening in Metals:



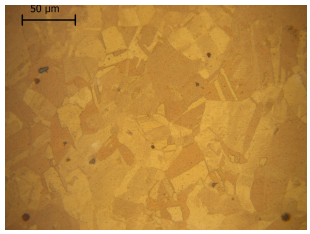
- Higher force needed for continued plastic deformation
- Dislocation movement becomes more difficult as deformation proceeds
- Dislocations get "tangled" up with one another and it becomes harder for them to move, so more force is required to continue deforming the metal.

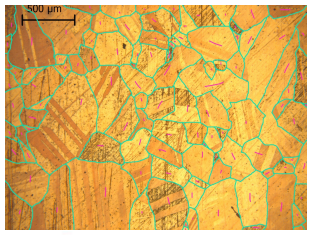
In a heavily deformed metal, there can be as much as ≈10^{12} cm of dislocation line per cm^3 of material.

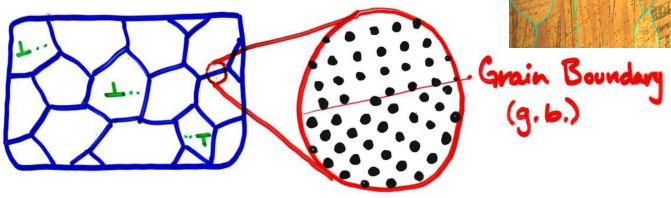
10^{12} cm = 10^7 km ≈ 25× distance to the moon

Microstructure in Solids:

- Solids formed from solidification; this leads to many micro-crystals called grains.
- Difficult for dislocations to cross a grain boundary
- By cooling faster, smaller grains are formed
- When a solid is heated, large grains grow at the expense of smaller grains.







Summary:

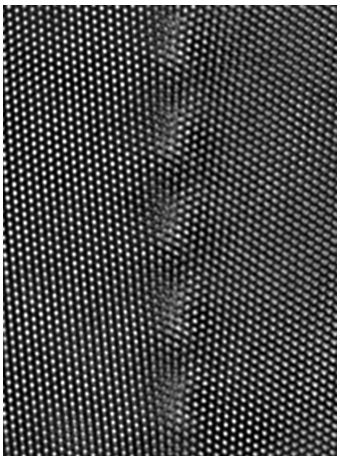


Image by: Seth T. Taylor, *Nature Materials*, **3** 682 (2004).

- Stretching of atomic bonds is reversible and occurs during elastic deformation.
- Dislocation motion is irreversible and leads to permanent or plastic deformation.
- Solids are usually composed of several microscopic crystals known as grains.
- The size of grains increases (grain growth) when a solid material is exposed to higher temperatures.
- Dislocation motion is impeded by grain boundaries; hence, smaller grained metals tend to be more difficult to deform plastically.

LAB WORKSHEET

1) Write the names of your group members below.

_____ _____

_____ _____

_____ _____

2) Write the letter of your brass sample here _____.

3) Write the hardness values you measured for your sample below.

_____ _____ _____

4) After consulting with the other members in your group, write the temperature at which each sample was annealed (500°C, 600°C, 700°C, or 800°C) below.

_____	_____	_____	_____
Sample A	Sample B	Sample C	Sample D

5) Which sample do you expect to have the smallest grain size, and which sample do you expect to have the largest grain size?

_____	_____
smallest grains (A, B, C, or D)	largest grains (A, B, C, or D)

6) On the back of this page, briefly explain how you came to your conclusions for 4) and 5).