

2016 fall

<Freshman Seminar>

“New materials to open the future”

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What are Materials?

- **That's easy! Look around.**
- Our clothes are made of materials, our homes are made of materials - mostly manufactured. Glass windows, vinyl siding, metal silverware, ceramic dishes...
- **Most things are made from many different kinds of materials.**

Periodic Table of the Elements

Period Group

Current ACS and IUPAC preferred.

^aMass number of most stable or best-known isotope
^bMass of the isotope of longest half-life

Symbol **O** Atomic number 8 Atomic weight 15.9994 Electron arrangement 2S²2P⁴

Atomic weights are based on carbon-12. Atomic weights in parentheses indicate the most stable or best-known isotope.

← Transition elements →

1 (IA)																	18 (VIIIA)							
1	H Hydrogen 1.00794 1s ¹																	He Helium 4.002602 1s ²						
2	Li Lithium 6.941 2s ¹	Be Beryllium 9.01218 2s ²																	B Boron 10.81 2s ² 2p ¹	C Carbon 12.011 2s ² 2p ²	N Nitrogen 14.0067 2s ² 2p ³	O Oxygen 15.9994 2s ² 2p ⁴	F Fluorine 18.9984 2s ² 2p ⁵	Ne Neon 21.1797 2s ² 2p ⁶
3	Na Sodium 22.98977 3s ¹	Mg Magnesium 24.305 3s ²																	Al Aluminum 26.98154 3s ² 3p ¹	Si Silicon 28.086 3s ² 3p ²	P Phosphorus 30.97376 3s ² 3p ³	S Sulfur 32.06 3s ² 3p ⁴	Cl Chlorine 35.453 3s ² 3p ⁵	Ar Argon 39.948 3s ² 3p ⁶
4	K Potassium 39.098 4s ¹	Ca Calcium 40.08 4s ²	Sc Scandium 44.9559 3d ¹ 4s ²	Ti Titanium 47.90 3d ² 4s ²	V Vanadium 50.9415 3d ³ 4s ²	Cr Chromium 51.996 3d ⁵ 4s ¹	Mn Manganese 54.9380 3d ⁵ 4s ²	Fe Iron 55.845 3d ⁶ 4s ²	Co Cobalt 58.9332 3d ⁷ 4s ²	Ni Nickel 58.69 3d ⁸ 4s ²	Cu Copper 63.546 3d ¹⁰ 4s ¹	Zn Zinc 65.409 3d ¹⁰ 4s ²	Ga Gallium 69.72 3d ¹⁰ 4s ² 4p ¹	Ge Germanium 72.61 3d ¹⁰ 4s ² 4p ²	As Arsenic 74.9216 3d ¹⁰ 4s ² 4p ³	Se Selenium 78.96 3d ¹⁰ 4s ² 4p ⁴	Br Bromine 79.904 3d ¹⁰ 4s ² 4p ⁵	Kr Krypton 83.80 3d ¹⁰ 4s ² 4p ⁶						
5	Rb Rubidium 85.4678 5s ¹	Sr Strontium 87.62 5s ²	Y Yttrium 88.9059 4d ¹ 5s ²	Zr Zirconium 91.22 4d ² 5s ²	Nb Niobium 92.9064 4d ⁴ 5s ¹	Mo Molybdenum 95.94 4d ⁵ 5s ¹	Tc Technetium 98.9062 ^b 4d ⁵ 5s ²	Ru Ruthenium 101.07 4d ⁷ 5s ¹	Rh Rhodium 102.9055 4d ⁸ 5s ¹	Pd Palladium 106.4 4d ¹⁰	Ag Silver 107.868 4d ¹⁰ 5s ¹	Cd Cadmium 112.411 4d ¹⁰ 5s ²	In Indium 114.82 4d ¹⁰ 5s ² 5p ¹	Sn Tin 118.71 4d ¹⁰ 5s ² 5p ²	Sb Antimony 121.760 4d ¹⁰ 5s ² 5p ³	Te Tellurium 127.60 4d ¹⁰ 5s ² 5p ⁴	I Iodine 126.9045 4d ¹⁰ 5s ² 5p ⁵	Xe Xenon 131.293 4d ¹⁰ 5s ² 5p ⁶						
6	Cs Cesium 132.9054 6s ¹	Ba Barium 137.327 6s ²	La* Lanthanum 138.9055 5d ¹ 6s ²	Hf Hafnium 178.49 4f ¹⁴ 5d ² 6s ²	Ta Tantalum 180.9479 4f ¹⁴ 5d ³ 6s ²	W Tungsten 183.84 4f ¹⁴ 5d ⁴ 6s ²	Re Rhenium 186.2 4f ¹⁴ 5d ⁵ 6s ²	Os Osmium 190.2 4f ¹⁴ 5d ⁶ 6s ²	Ir Iridium 192.22 4f ¹⁴ 5d ⁷ 6s ²	Pt Platinum 195.078 4f ¹⁴ 5d ⁹ 6s ¹	Au Gold 196.9665 4f ¹⁴ 5d ¹⁰ 6s ¹	Hg Mercury 200.59 4f ¹⁴ 5d ¹⁰ 6s ²	Tl Thallium 204.3833 4f ¹⁴ 5d ¹⁰ 6s ² 6p ¹	Pb Lead 207.2 4f ¹⁴ 5d ¹⁰ 6s ² 6p ²	Bi Bismuth 208.9804 4f ¹⁴ 5d ¹⁰ 6s ² 6p ³	Po Polonium (210) ^a 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁴	At Astatine (210) ^a 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁵	Rn Radon (222) ^a 4f ¹⁴ 5d ¹⁰ 6s ² 6p ⁶						
7	Fr Francium (223) ^a 7s ¹	Ra Radium 226.0254 ^b 7s ²	Ac** Actinium (227) ^a 6d ¹ 7s ²	Rf Rutherfordium (261) ^a 5f ¹⁴ 6d ² 7s ²	Db Dubnium (262) ^a 5f ¹⁴ 6d ³ 7s ²	Sg Seaborgium (266) ^a 5f ¹⁴ 6d ⁴ 7s ²	Bh Bohrium (264) ^a 5f ¹⁴ 6d ⁵ 7s ²	Hs Hassium (269) ^a 5f ¹⁴ 6d ⁶ 7s ²	Mt Meitnerium (268) ^a 5f ¹⁴ 6d ⁷ 7s ²	- 110 -	- 111 -													

Legend: Metal (blue), Semimetal (orange), Nonmetal (yellow)

Inner transition elements

Lanthanide series * 6

Actinide series ** 7

Ce Cerium 140.116 4f ¹ 5d ¹ 6s ²	Pr Praseodymium 140.90765 4f ³ 6s ²	Nd Neodymium 144.24 4f ⁴ 6s ²	Pm Promethium (145) ^a 4f ⁵ 6s ²	Sm Samarium 150.4 4f ⁶ 6s ²	Eu Europium 151.964 4f ⁷ 6s ²	Gd Gadolinium 157.25 4f ⁷ 5d ¹ 6s ²	Tb Terbium 158.92534 4f ⁹ 6s ²	Dy Dysprosium 162.50 4f ¹⁰ 6s ²	Ho Holmium 164.93032 4f ¹¹ 6s ²	Er Erbium 167.26 4f ¹² 6s ²	Tm Thulium 168.9342 4f ¹³ 6s ²	Yb Ytterbium 173.04 4f ¹⁴ 6s ²	Lu Lutetium 174.97 4f ¹⁴ 5d ¹ 6s ²
Th Thorium 232.0381 ^b 6d ² 7s ²	Pa Protactinium 231.03688 5f ² 6d ¹ 7s ²	U Uranium 238.02891 5f ³ 6d ¹ 7s ²	Np Neptunium (237) 5f ⁴ 6d ¹ 7s ²	Pu Plutonium (244) 5f ⁶ 7s ²	Am Americium (243) 5f ⁷ 7s ²	Cm Curium (247) ^a 5f ⁷ 6d ¹ 7s ²	Bk Berkelium (247) 5f ⁹ 7s ²	Cf Californium (251) ^a 5f ¹⁰ 7s ²	Es Einsteinium (251) 5f ¹¹ 7s ²	Fm Fermium (257) 5f ¹² 7s ²	Md Mendelevium (258) 5f ¹³ 7s ²	No Nobelium (259) 5f ¹⁴ 7s ²	Lr Lawrencium (262) 5f ¹⁴ 6d ¹ 7s ²

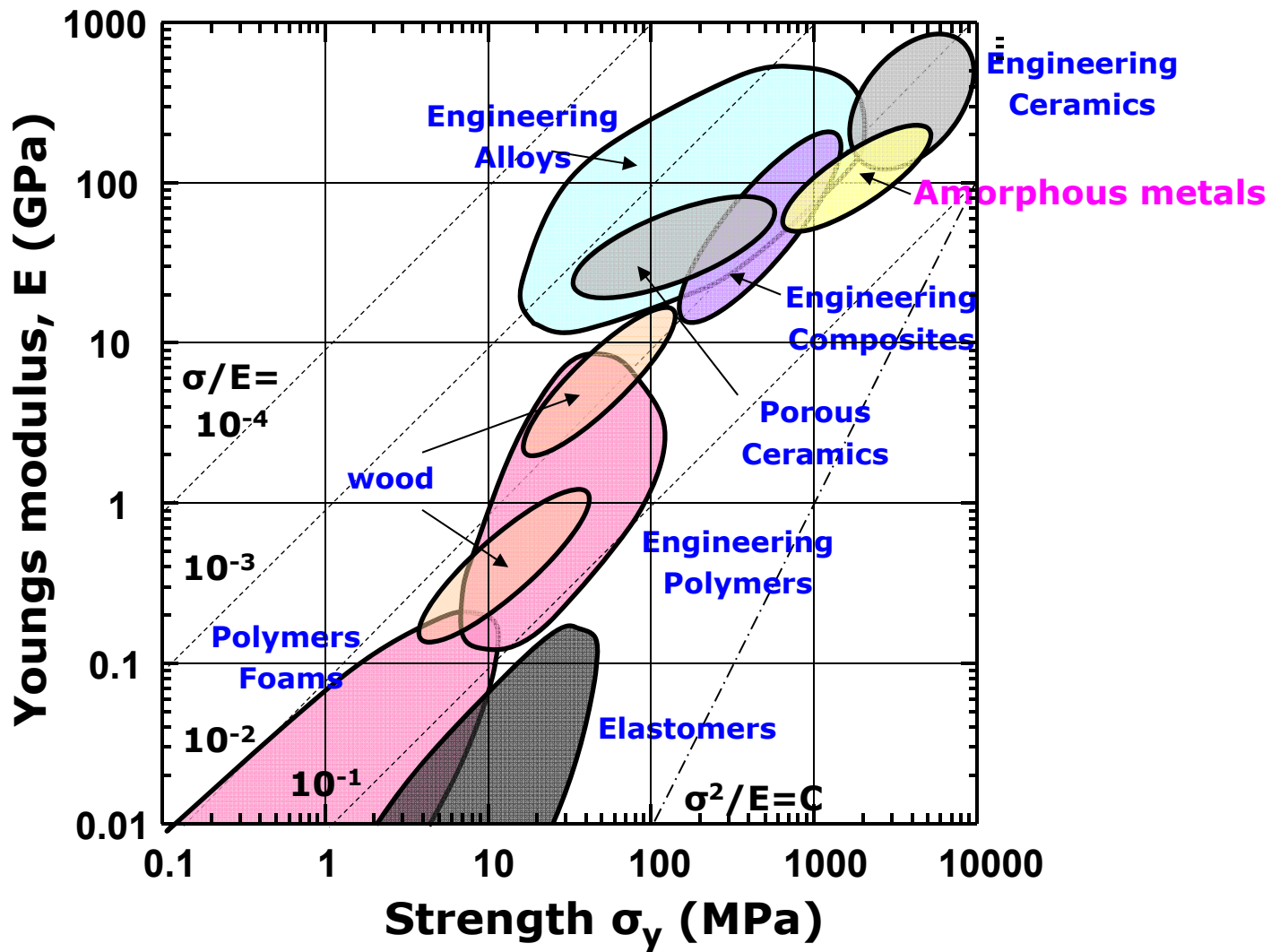
Kinds of Materials

- **Metals:** are materials that are normally combinations of "metallic elements". Metals usually are good conductors of heat and electricity. Also, they are quite strong but malleable and tend to have a lustrous look when polished.
- **Ceramics:** are generally compounds between metallic and nonmetallic elements. Typically they are insulating and resistant to high temperatures and harsh environments.

Kinds of Materials

- **Plastics:** (or polymers) are generally organic compounds based upon carbon and hydrogen. They are very large molecular structures. Usually they are low density and are not stable at high temperatures.
- **Semiconductors:** have electrical properties intermediate between metallic conductors and ceramic insulators. Also, the electrical properties are strongly dependent upon small amounts of impurities.

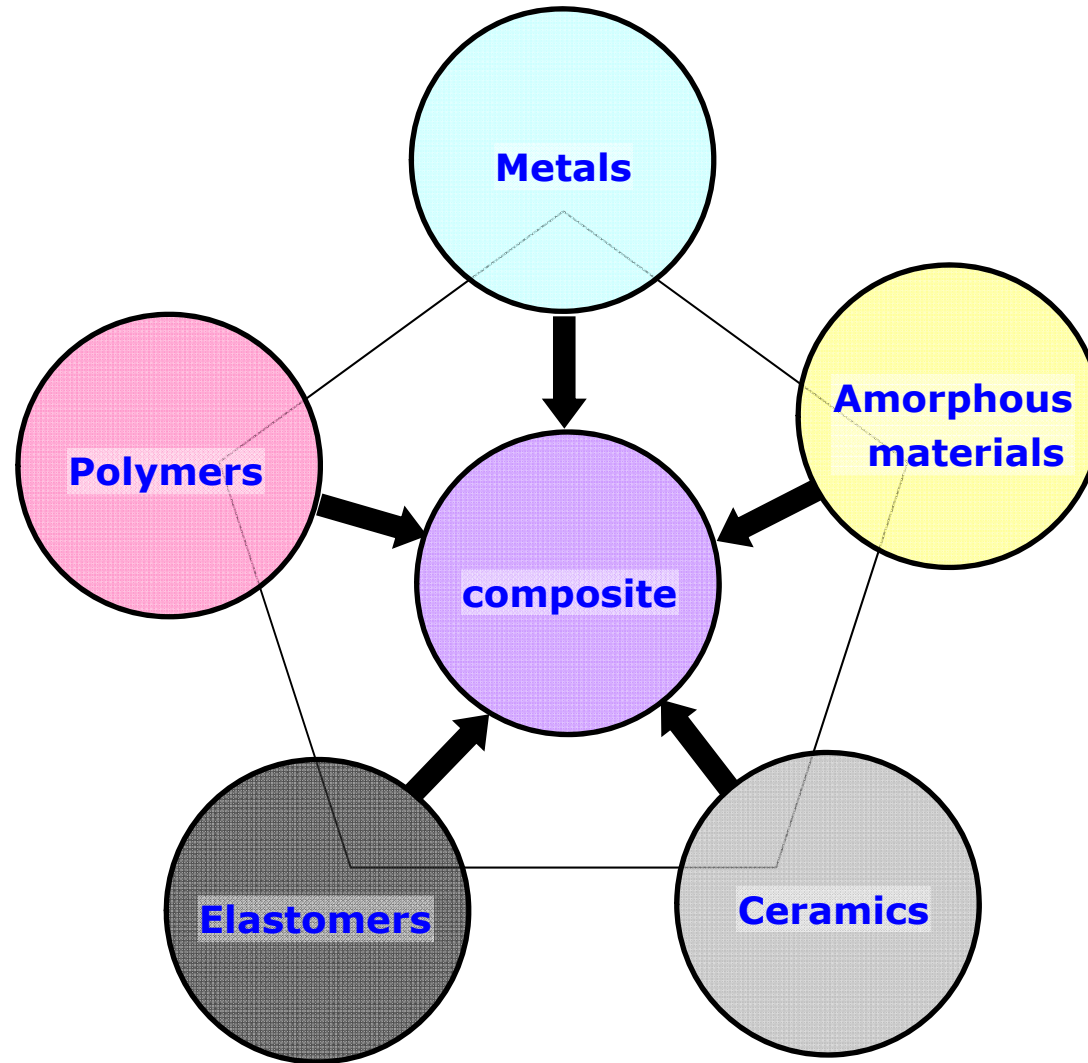
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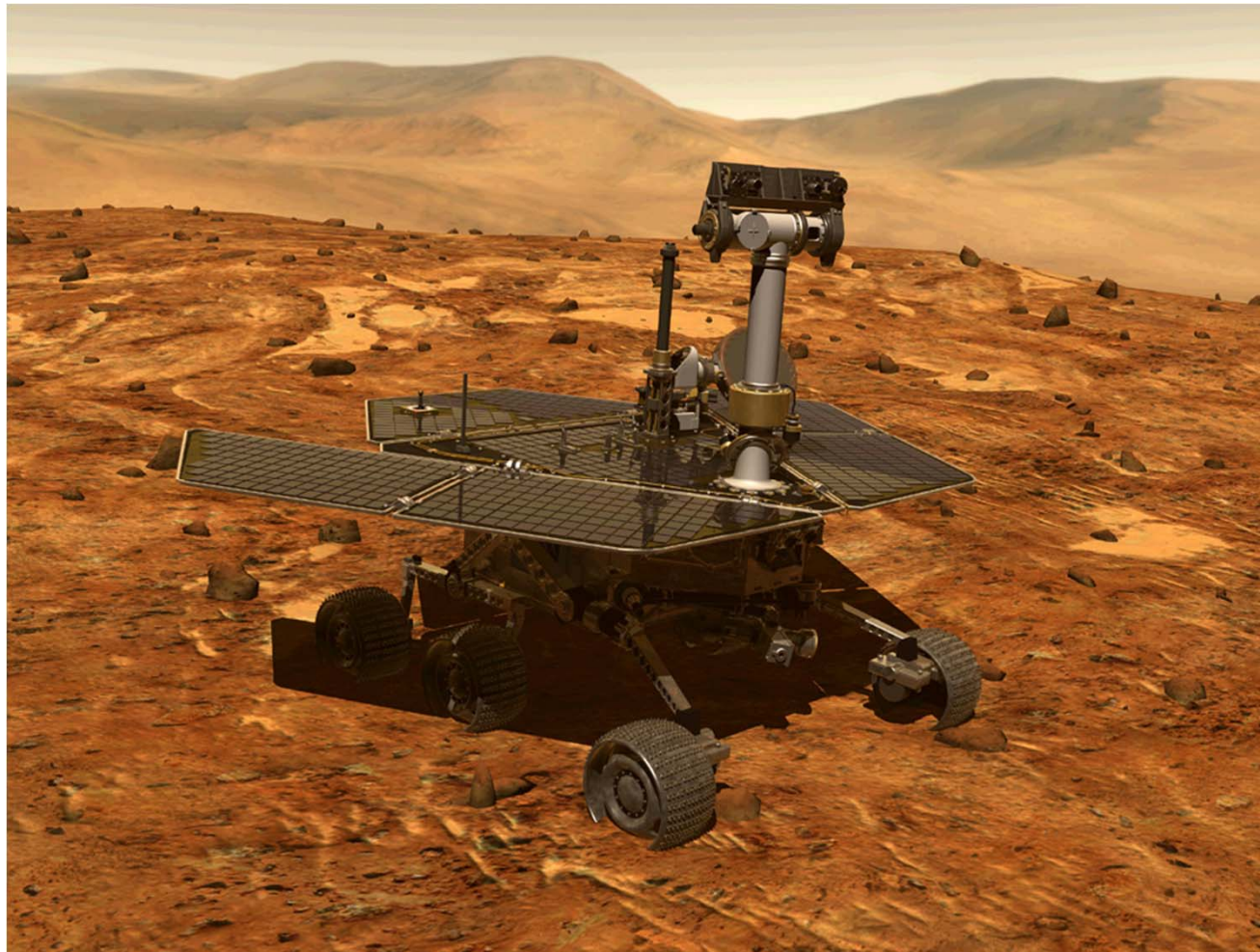
Kinds of Materials

- **Composites:** consist of more than one material type. Fiberglass, a combination of glass and a polymer, is an example. Concrete and plywood are other familiar composites. Many new combinations include ceramic fibers in metal or polymer matrix.

Menu of engineering materials



The Mars Rovers - Spirit and Opportunity



Spirit and Opportunity are made up of materials such as
*** Metals * Ceramics * Polymers * Semiconductors * Composites**