Donald P. Shiley School of Engineering
EGR 221 Materials Science
Assignment 5, Fall 2015

1) a) Compute the diffusion coefficient (D) of nitrogen in iron at 950°C. Note, iron is FCC above 912°C and BCC below that temperature. Having more than one crystal structure is referred to as "allotropic" or "polymorphic." Iron is *allotropic* - aka *polymorphic*.
   b) Compute the diffusion coefficient (D) of nitrogen in iron at 900°C.
   c) Why is the diffusion coefficient greater at 900C? In other words, why, for the same concentration gradient, would the diffusion rate be greater at 900°C than at 950°C?

2) A plain carbon steel initially containing 0.4 % carbon (0.4wt%) is heat treated in a carbon-free oxygen environment. As such, the carbon will diffuse to the surface and react with the oxygen in the atmosphere. This results in a carbon poor surface – this is referred to as *decarburization*. This is almost never a desired situation – although depending upon the application, it may not detrimentally affect performance of the steel. How long will it take at 1100°C for the carbon content to decrease to 0.2wt% at a depth of 0.1mm from the surface? Assume the diffusion coefficient, D, is $6.9 X 10^{-7} cm^2/sec$.

3) Answer the following:
   a) When did Thomas Young live? Besides studying elasticity and having "Young's modulus" named after him, briefly describe one other contribution to science that he made.
   b) When did Robert Hooke live? Besides studying elasticity and having "Hooke's law" named after him, briefly describe one other contribution to science that he made. Briefly describe the experiment he conducted to develop Hooke's law.
   c) Briefly describe "Young's modulus" and briefly describe "Hooke's Law." Are they the same thing? (Hint, no, they are not the same thing).

4) Fill in the table for the material properties. Include ***both*** SI and English units where requested. **Be sure to cite your references (URL's, books, etc.). Hint:** Few things need to be memorized, but Young's modulus (aka modulus of elasticity) of steel and aluminum should be memorized by all mechanical engineers.

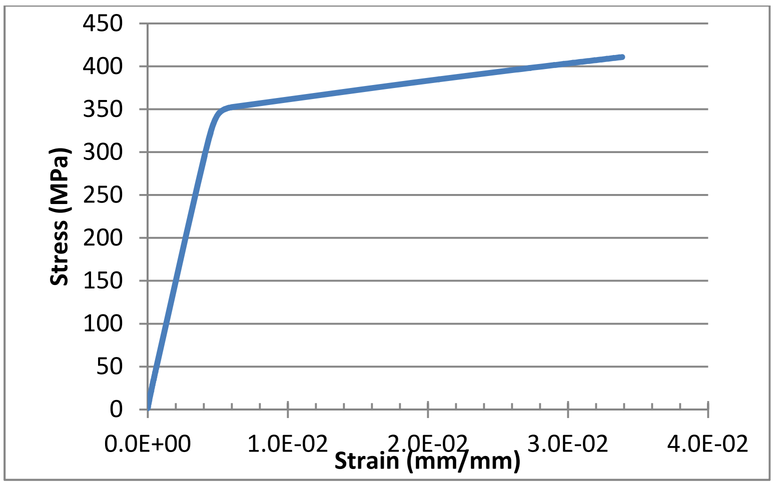
Material	Modulus of elasticity, E		Poisson's ratio, ν	Shear Modulus, G (GPa)*	Density (g/cm^3)
	10^6 psi	GPa			
Aluminum alloys					
Titanium					
Structural steel					

*Hint: the elastic constants of shear modulus (G), Poisson's ratio (ν) and modulus of elasticity (E) are related: $E = 2G (1 + \nu)$.

5) Given a round bar of an aluminum alloy with a diameter of 0.505 inch, a load of 5000 pounds is applied axially (that's the weight of about two Honda Civics!). **Include a sketch** of the bar with force applied. Assuming that the material remains elastic, determine:
   a) Axial stress (hint: calculate from given information)
   b) Axial strain (hint: need to employ at least one material property – an elastic constant)

c) Transverse strain (hint: need to solve (b) first and you need to employ at least one additional material property – another elastic constant)
d) What is the diameter of the bar with the 5000 pound load applied?
e) If the bar is 2 inches long before loading, how long will it be with the 5000 pound load applied?

6) Repeat the above problem, but for a steel bar.
7) Determine from the stress-strain curve shown here.
   a) Yield strength using the 0.2% offset method
   b) Modulus of elasticity
   c) If this is the entire stress-strain curve (up to and including fracture) what is the ductility (%EL)?
   d) What is the ductility (%EL) of 2024-T351 aluminum alloy? (cite your source)
   e) Is this likely an aluminum alloy or steel?



8) From the stress-strain diagram below, determine:
   a) Yield strength
   b) Modulus of elasticity
   c) Is this likely an aluminum alloy or steel?