the STUFF of history

W E E K L Y   A S S I G N M E N T S   D O C U M E N T   (W A D)   1

Hello, and welcome to the Weekly Assignments Document, or WAD. The WAD will become a useful and possibly even cherished tool to those who aim to hone their history skills, master their materials knowledge, and become generally cooler people. Yes, the WAD is huge. Yes, the WAD is detailed. But don't these qualities make the WAD endearing? Try to think of the WAD as your friend – a big, sometimes-awkward, but always-likable friend. The WAD will appreciate this, and so will your instructors.

At the start of each week we will distribute a single WAD to the class. The WAD will provide a comprehensive breakdown of each assignment for the week, including history readings, materials science readings, presentation guidelines, exam problems, materials science homework problems, Rob and Jon perspectives, and reminders about your ongoing project work. We'll also post links to the WAD components on the web-based course schedule. And with that, we're off to Week 1…

PROJECT WORK

DUE DATE: Ongoing

This week, you will begin your historical and materials research, and your laboratory experimentation. You'll select your ancient counterpart, explore this counterpart in the context of your ancient civilization, and start to think about the ways in which the materials and properties of your modern artifact compare and contrast to those of your ancient counterpart.

The big goals for the first week of the project are to establish some goals for yourself and your team, develop some strategies for your historical research and materials testing that are aligned with your goals and feasible in scope, and identify some high quality information sources to support your work. You'll also need to get to know your partners on both the civilization team and your project team, and begin to figure out how you all will communicate with each other, plan schedules, use meeting times, etc.

HISTORY READINGS

DUE DATE: Wednesday, January 19, start of class

Napoleon's Buttons Introduction (pages 1-8 ONLY) and chapter 8: ISOPRENE (pages 141-161)

Welcome to the Napoleon's Buttons readings! We will discuss these at the start of class on Tuesday, so make sure you are ready to discuss them. To prepare for this discussion please do the following:

Look over the brief "Martello's Take on the Napoleon's Buttons Readings" on page 5 of this document.

Listen to the song "Africa" by Toto. Yes, this has nothing to do with anything, but I kind of like that song.

Underline or write down the main themes from the Introduction excerpt – what are the main goals of this book?

Apply the Introduction's goals to Chapter 8. Do the authors achieve their goals here?

Underline or write down at least two interesting pieces of narrative evidence in chapter 8. Do the authors make effective use of evidence?

Underline or write down at least two analytical points that the authors make in chapter 8. Do you agree with these conclusions? What else would you like to learn about these topics?
Be ready to discuss the strengths and weaknesses of this chapter.

SET YOUR OWN GOALS ASSIGNMENT (S-YOGA)

DUE DATE: Wednesday, January 19, end of class

Our course strives to attain the highest pinnacle of student (self) direction. We want you help you to motivate yourself on each activity, and we accomplish this by giving you a major role in structuring your assignments and setting your own goals. In this assignment you take the concept of student self-direction one whoppingly huge step further, by setting your own goals for the entire course. Better yet, you assess your progress at different points of the semester! Pinch yourself my friend, because you are not dreaming.

We will discuss and work on this assignment in class on Wednesday. But you can think about it earlier, since the concept is not very difficult.

Send an email to both instructors with "personal goals" as the subject line. In the body of the email (please, do not send a separate attachment!) list three personal goals that you wish to achieve in our course by the end of the semester. You will have a chance to modify these goals in a month, but give it your best shot now. What do you want to learn? What do you want to improve about yourself? This can be skill mastery, content mastery, or anything else. In the past, students have set goals such as…

> I want to improve my writing ability/ability to participate in class discussions/ability to design a poster.
> I want to create one high-quality deliverable that I can include in my personal portfolio.
> I want to learn about alternative energy technologies and determine if I want to major in this field in grad school.
> I want to use this course to figure out what interests me most at Olin, by the end of the semester I want to decide upon an AHS Concentration and finalize my choice of major.
> I want to learn about educational theory and figure out how to optimize my learning process.
> I want to work on my project planning and management.

Next, outline some strategies that you make take to achieve your goals. What specific things will you do? For example, if you want to develop better teaming skills, what actions can you take, or how may you adjust the ways you interact with your teammates? For this assignment you should write at least a couple sentences for each of your three goals. Please take this seriously, give it some thought, and help us make the class work for you!

MATERIALS SCIENCE READINGS

DUE DATE: Friday, January 21, start of class

- Introduction. Askeland or Callister Chapter 1. This is just an introduction, so make it quick.
- Mechanical properties. These readings cover the basic stress-strain behavior and temperature-dependence of mechanical properties of materials. Pick one (depending on your textbook choice):
  - Callister 6th edition: Chapter 6, Sections 8.2-8.4, 12.8, 15.1-15.8
  - Callister 7th edition: Chapter 6, Sections 8.2-8.4, 12.8, 15.1-15.8
  - Askeland 4th edition: Sections 6.1-6.10, 6.12-6.14, Sections 15.6-15.9
  - Askeland 5th edition: Chapter 6, Sections 7.3-7.5, 16.6-16.9
- Look over the brief "Stolk's Take on the MatSci Readings" on page 6 of this document

EXAM 1

DUE DATE: Friday, January 21, midnight

Instructions: We'll assess the Exam 1 questions and count the scores toward your grade as shown in the "Grade Breakdown" table in your syllabus. You may work on this as much as you like but you must do all work on your own. Submit an electronic copy of your work via **email to both instructors** no later than **midnight on Friday, January 22**. For Question One, submit your responses in **Word format**. For Question Two, submit your solutions in Word or pdf format (if you write your solutions by hand, scan and submit them in pdf format).

Question One: Context Surrounding Your Modern Artifact

Perform a brief historical study of your modern artifact by doing some online research. Answer the following questions with an approximately one paragraph (four sentences or so) response to each. **List your sources for everything!**

a. (one sentence only) How do you specifically define your item? Let us know how broadly or narrowly you define it (i.e., is it an entire racing bicycle, an entire touring bicycle, a bicycle tire, the air intake valve on a bicycle tire, etc.). (No sources needed for this question.)
b. Define your object in terms of its specific design goals. What tasks is it intended to facilitate, or what problems is it intended to solve? When you answer this question you must refer to specific evidence (e.g., an excerpt from an advertisement for your product or one like it; operating instructions; manufacturer's specifications; a dictionary or encyclopedia entry; etc.).
c. What other items belong to your artifact's "family?" (For example, if you are studying a racing bicycle, related "family" items could include children's bicycles, mountain bicycles, touring bicycles, etc.) In what ways do the "family" items physically differ from your own item? In what ways do the "family" items' goals differ from your item's goals? (Use at least one source!)
d. What is the approximate price range of your item or one similar to it? (Do not forget to include your source(s) for this info.) What is the approximate price range of the items comprising your item's "family" (use your answer to question c above)? Which factors might account for the variation in price? Cite and quote your evidence!
e. Speculate on the typical purchasers/users of your item by interpreting the specific evidence from your answers to questions b and d above. Justify your reasoning: what do the pricing and design goals imply about the manufacturer's marketing strategy? Cite and quote your evidence!
f. Speculate on the "cultural values" associated with your specific object by interpreting the specific evidence from your answers to questions b and d above. In this context, "cultural values" refers to the imagery, symbolism, or other associations related to your item. For example, an automobile might express the values of macho recklessness, personal freedom, or technical prowess depending upon the design and/or price of the car. Cite and quote your evidence!
g. Look up your modern item in Wikipedia or any online encyclopedia. In four sentences, recap some of the most salient points about your item's history. Some questions that you might answer include: When did it first appear in its modern form? Who invented it, and how? When were the most units sold – did its popularity peak and subside, or is it more popular now than ever? Did the item take on a different cultural meaning in different time periods (for example, do we associate it with a specific decade, celebrity, or cultural value)? How and why did its form change over the years? List your sources.

Question Two: Mechanical Properties of Your Artifact

For this question, you will estimate the mechanical response of **one** of the material components of your modern artifact (pitchfork, shoe, cultivator, hydration pack, canteen, skateboard, hunting vest). Choose a component that is made from a single material and that is subjected to relatively simple loading during service, if possible. Since you may not yet know exactly what materials are used in your artifact, you will need to guess a material and research properties for your guess. **Please cite your sources for everything.**

a. Identify your modern artifact and specify the particular part of the artifact that you will explore for this question. A photo or sketch may be helpful.
b. What specific material do you think is used in your component (your best guess)? How would you classify this material – metal/alloy, ceramic/inorganic glass, polymer, composite, or metalloid?
c. What are some of the mechanical properties of your component? Please do a bit of research and list values for hardness (with scale), Young's modulus, yield strength, tensile strength, and percent elongation.

Mechanical Property	Units/Scale	Value
Hardness		
Young's Modulus	GPa	
Yield Strength (if appropriate)	MPa	
Tensile Strength, Compressive Strength, or Flexural Strength (whichever is appropriate)	MPa	
Percent Elongation	%	

Having trouble finding properties for your material? Random web sites are not always the best place to go for reliable property data. Check out the CES EduPack software installed on some of the materials science lab computers (e.g., the FTIR computer). Take a look at the appendices of the Callister textbook, check out matweb.com, or delve into the ASM Handbooks or ASM Engineered Materials Handbooks.

d. Given the properties you specified in part (c) and what you know about the stress-strain behavior of materials like the one you selected, sketch a schematic engineering stress-engineering strain curve for a tensile test of your component. Be sure to label your axes.

Okay, now we're going to try estimating forces and stresses in your component for a particular loading configuration. Consider how your component may be loaded during service, or during assembly of the project. Is it tension, compression, flexure, shear, or some other type of loading? If your component is subjected to torsion or a more complex or combined loading (e.g., tension plus flexure), let's simplify the situation and assume flexure, axial tension, or axial compression.

e. Select a loading orientation for your component. Your loading orientation may represent the manner in which the part is loading while it is being used (e.g., a rope in tension, a hammer in flexure), or you may assume a simplified loading state to enable easier calculations (e.g., apply pure compressive force along the length of a part). Sketch your component with the direction of the applied load indicated on the drawing. Is this a tensile, compressive, or flexural load?
f. Estimate the maximum load on your object during service or assembly of your artifact.
g. What cross-sectional area of your component is bearing the maximum applied load?
h. Based on your load and load-bearing area, calculate the maximum stress on your component.
i. Given the stress you calculated in part (h), describe the type of deformation that occurs in the component. Is it linear elastic, nonlinear elastic, plastic, or viscoelastic?

MARTELLO'S TAKE ON THE NAPOLEON'S BUTTONS READINGS:

Hi! Welcome to the world of *Napoleon's Buttons*, a world that shares many characteristics with the "Stuff" of History world that Jon and I have created. This book shares the primary goal of our course: we can learn more about history if we appreciate the materials science concepts that underlie so many human actions, and we can learn more about materials science if we appreciate them in the proper historical and social context. So this should be a win-win – let's sit back, read the book, and let it teach us about the world! Right?

Well, not exactly. Make no mistake, this is a great book and it has much to teach us. But in this course we will learn to be active readers who question and challenge what we read, appreciating the strongest aspects of the book while identifying its weaknesses and thinking about how we might do better. So the book is a starting point, and we'll provide the intellectual muscle needed to take things to the next level. You know, this analytical process is kind of like 80s music – always pushing the envelope, always rocking your socks off, and never the same thing twice.

The Introduction excerpt offers a nice little story explaining the book's title and then lays out some of the goals of the book. I hate writing Introductions but I love reading them because the author has to step out from behind the curtain a bit, wave at the audience, and show us some of their bag of tricks. Have a pencil or laptop handy when you read the Introduction, and make a note of the author's goals. Once they put their money on the table, so to speak, we can apply these goals to every chapter that we read. I think the authors raise some great-sounding objectives here (what are they?) and we should remember them throughout our course. So the next question is… do they live up to these lofty goals? (cue spotlight and portentous music) Do they? (fade to black) Do they? (OK, I took this too far. Next time I'll only repeat a rhetorical question once.)

We will also read chapter eight for Wednesday's class… and chapter five is on deck for next week! Obviously, the first question is to use the roadmap of the Introduction as a lens, to help us assess these two chapters, much in the same manner that I will soon apply the roadmap in your thesis paragraphs to the masterful papers you will write! But I also like to use these chapters as a way to think about our course, still in its infant stages and still trying to find its voice and identity… just like Madonna when she released the song "Borderline!" What do you like most about these chapters? Is it the great **narratives**, the many stories told by the authors? Or is it the intellectual **arguments** that they raise as they use the narratives to appreciate and understand larger themes? We will spend a lot of time discussing evidence and analysis throughout the year, and it helps to think about how the authors attempt to use both, how they may have succeeded or failed in different ways. As I state in the reading questions above (page two of this document) try to make note of the most important pieces of evidence (i.e., the best stories from each chapter) as well as the biggest analytical "themes" – things like serendipity, the importance of entrepreneurship in scientific development, or ethical dimensions of technological implementation. Always think about ways to relate narratives and readings to bigger issues, because this opens the door to larger synthesis, to engaging thesis topics, and to delicious ice cream sundaes at Cabots. Oh yes. (pause) Oh yes indeed.

STOLK'S TAKE ON THE MATSCI READINGS:

Chapter 1 - Introduction. This reading simply provided your textbook author's introduction to the field of materials science, so I'm not going to spend time providing my perspective on their perspective of materials science. I hope you feel properly introduced.

Chapter 6 – Mechanical Properties. Why, you may ask, did I assign a chapter that's a third of the way into the textbook as your first reading assignment? The answer is simple, but twofold. First, I wanted to avoid Chapter 2 like the plague, as it is primarily review of some topics that you've probably seen in your chemistry or physics courses. Can you think of a more boring way to start a new class than review? I can't. Second, I wanted to give you access to some concepts that you could immediately sink your teeth into. Most of you are starting to run some mechanical tests on your modern artifact, or you will be starting these soon, and the topics presented in Chapter 6 will provide you with the terminology and definitions that will enable you to describe the mechanical behaviors and responses of your materials in a formal, scientific manner. For example, instead of using words like "durable" to describe your components, you'll be able to define what we mean by "durable" in terms of hardness, toughness, strength, and other real material properties. But wait, that's not all. You'll also be able to explain how each of these is quantitatively measured, e.g., "**toughness** is the area under the stress-strain curve, which indicates the energy required to fracture a material." You can lose the everyday language and start talking like a scientist (or engineer, if you prefer). As you read and consider the concepts in Chapter 6, push yourself to start using the formal materials science terminology when you think about and discuss the properties of your modern and ancient artifacts.

Okay, so what's important in Chapter 6? First off, we have the tensile test, and a long list of properties that we can measure based on a simple tensile test. Tensile tests provide graphs of **engineering stress** vs. **engineering strain**. As we apply a load or displacement to a material (it doesn't matter which one, really, but the Instron applies displacement and measures the load response), we initially get **elastic**, or recoverable deformation. Note that this is a property that may be directly connected to the **atomic level –** it tells us about the strength of bonds between atoms (more on this in our next reading assignment). The measure of how much stress is required to strain a sample by a certain amount is called the **Young's modulus, or modulus of elasticity**. Note that it's also called the elastic modulus. Why does it have so many names? I don't know, but I like it regardless. You can think of the Young's modulus as the same thing as the spring constant you learned about in physics (remember Hooke's law…$k = F/x$?), except that we materials folks are very clever in their handling of this spring-like response. We like to normalize other people's measurements by sample geometry, give a new name, call it a "material property", and claim it as our own. This seems trivial, but normalizing the spring constant (k) gives us a material property measurement that makes it easy to compare materials, regardless of geometry. This means that a 6 mm bar of copper will have the same Young's modulus as a 6000 mm bar of copper. It also means that we can easily compare the "stiffness" of different materials. I forgot to mention this earlier, but we do the same thing with engineering stress (load over original cross-sectional area) and strain (displacement over original length). Loads and deflections can't be easily compared across different geometries, but stresses and strains travel well from geometry to geometry and from material to material. Are you feeling the power of materials science? If not, take a moment to stand up, take a deep breadth, and flex your muscles (not your cognitive muscles, the other ones). Also take a moment to consider how the Young's moduli of different materials compare. For example, how does steel compare to titanium? How does titanium compare to nylon? How do the Thompson Twins compare to Modern English?

Now let's get back to our tensile test. If we release the load on our specimen while it is undergoing elastic deformation, it snaps back like a rubber band (**elastic recovery).** After we've pushed a material beyond its elastic limit, it begins to plastically (permanently) deform, or **yield**. We use the term **yield strength** to define the point that sorta kinda indicates the transition from elastic deformation to plastic deformation – "sorta kinda" because this transition isn't always easy to identify, so we use the **0.2% strain offset** as a standard method to find the yield strength value. Here's a question for you: does this 0.2% strain offset method work for determining the yield strength of polymers? Why or why not? By the way, have I mentioned that when I use the word "strength," I'm talking about a stress, not a load? Yield strength = yield stress, tensile strength = tensile stress, etc. Not to change the subject, but do you happen to be looking for a material that's going to absorb a lot of energy during loading, but then give it all back upon unloading, i.e., a very "springy" material? If so, you want a material with a high **modulus of resilience**, This property is a measure of the area under the elastic portion of the stress-strain curve. Like resilient people, resilient materials can take a lot of applied stress or strain, but then return to their original, unstressed state. Stretch Armstrong – now that's one resilient dude, as evidenced by this YouTube video.

After the yield point comes **uniform plastic deformation**, during which the entire reduced section of the test specimen deforms in the same way. This continues up to the highest point on the stress-strain curve, the **tensile strength** or **ultimate tensile strength (UTS).** It just so happens that the tensile strength correlates very well to material **hardness**, which is defined as a measure of the resistance to surface indentation or abrasion. I hear that Stephen Sass' biceps are exceptionally hard, but I don't have any evidence to support this. When materials are pushed beyond the tensile strength, **nonuniform plastic deformation**, or "necking" begins. Necking occurs in a localized region of the specimen, and this region will continue to get smaller and smaller until the **true stress** gets too high for the material to bear, at which point it will POP! Fracture. At the end of the test, we can glean one more important material property from our specimen: **ductility**. This is usually accomplished by measuring the **percent elongation** in the test specimen, which is simply the total engineering strain multiplied by 100%.

During plastic deformation, we observe a fascinating property in metallic materials: **strain hardening**. Why is it so fascinating? It means that we can make a metal stronger simply by beating on it. Some Oliners think the same holds true for our first-year students (I'm thinking about the "suck it up, you're at Olin" t-shirts), but I'm not so sure. Why does this happen (the metal strain hardening, not the first-year student strain hardening)? It turns out that beating on (or rolling, drawing, extruding, etc.) a metal introduces a particular type of defect that makes it more resistant to further deformation. That's right – we can make some materials stronger by creating defects in them! Different materials have different strain hardening responses: some only show a small increase in strength, while some can double, triple, even quadruple their yield strength as a result of this effect. Think you can harness this power to manipulate materials to suit your needs? I think you can. We'll see more on this topic in later readings.

Another topic of note in Chapter 6 (or Chapter 7 or 8, depending on your textbook) is that different types of failure produce different looking fracture features. **Brittle failures** tend to be relatively flat and show very little sign of plastic deformation, while **ductile failures** are described by obvious stretching, bending, twisting, etc. in the fractured part. We see these differences in features both at the macroscopic level (e.g., visual examination) and microscopic level (e.g., scanning electron microscopy). Have you fractured any of your artifacts as part of your project experiments? If so, how would you characterize the mode of failure? Can you provide evidence to support your conclusion? Could Wang Chung offer any advice in this situation?

Polymers sections. Everything I just told you is a lie. Well, actually, it's only partially true. All that Hooke's law and elastic deformation stuff would be completely true if we lived in a world made entirely of metals. And though this may seem a utopia to some, including your textbook authors, I'm not sure I could live in a world devoid of Kenneth Cole boots, Alain Mikli eyeglasses, and hair gel. Besides being noteworthy form a personal style perspective, these items are also fascinating from a materials science perspective. They are all composed primarily of polymers, and polymers do not play by the same rules that the metallurgists of old have come to know and love. Polymers are **viscoelastic**, which means that their mechanical response combines aspects of viscous behavior (like a jar of honey) and elastic behavior (like a spring). Viscoelastic materials can provide some interesting and very different responses to load depending on the rate of loading or strain, and depending on the temperature of testing. Generally, high strain rates or lower temperatures provide a more brittle, higher stress response in polymers. Of course, the other thing that dramatically affects a polymer's viscoelastic response is the material structure, both at a molecular level (polymer chain composition, polarity, "bulkiness" of the functional groups in the chain), and at a microscopic level, where things like crystallinity, interchain bonding (crosslinking), molecular weight, and chain branching can make huge differences in the mechanical behavior of the polymer. Which of these factors play into determining the properties of the polymers you're examining in your project work?

Ceramics and inorganic glasses. Crystalline ceramic materials act pretty much like metals, but without all that plastic deformation. Stress-strain curves for ceramics are incredibly boring. Their mechanical response tends to be primarily elastic, unless we heat them to an elevated temperature. Inorganic glasses like window glass or Pyrex behave similarly, except that their viscosity gradually decreases with increasing temperature, which is an incredibly useful effect as it enables us to shape glasses while they are in a semi-solid state (glassblowing!). Perhaps the most important thing to remember with ceramics and glasses is that **defects** play a huge role in determining the material strength. Although ceramics and inorganic glasses are theoretically extremely strong, defects in these materials can cause them to catastrophically fail at stresses that are much, much lower than we expect, especially if we're loading in tension. So be careful when you're designing mechanically loaded ceramic or glass components!

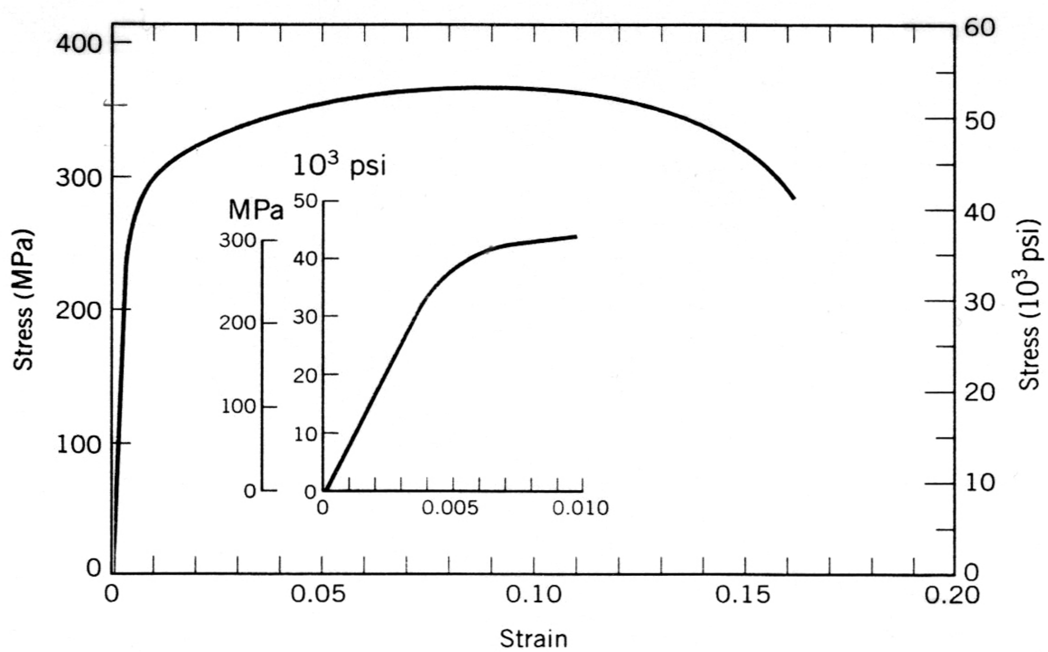
In thinking about applying all of these terms, it may be helpful for you to create some graphs or tables that show the expected stress-strain behaviors of different types of solids – polymers (brittle, semicrystalline, and elastomeric), metals (ductile, brittle, stiff, strong, weak, etc.), ceramics, etc – that were used for the components of your modern artifact. To add to the fun, try doing this for your ancient counterpart!

MAT SCI PRACTICE PROBLEMS

As noted in the syllabus, the homework assignments will include two types of problems: textbook-style practice problems aimed at comprehension and application of concepts, and open-ended problems aimed at development of more advanced abilities in synthesis, analysis, design, and evaluation. When you work through the practice problems, consider how the concepts may apply to your project topic, and think about the significance of the key concepts in ancient society technological development.

Textbook Problems

1. Given the engineering stress-engineering strain diagram for an aluminum alloy initially 11 mm in diameter and 50 mm in length (see next page), calculate the following:
   a. Percent elongation at the moment the aluminum part fractures
   b. Percent elongation after fracture (hint: think about the strain recovery after the break)
   c. True stress at an engineering strain of 0.04
   d. True strain at an engineering strain of 0.04
   e. Elongation (Δl) when a load of 25 kN is applied.



Tensile stress–strain behavior for an aluminum alloy.

2. Askeland (4th ed.) 6-9. Why does silly putty break when you stretch it very quickly?

3. Askeland (4th ed.) 6-25. A force of 100,000 N is applied to a 10 mm x 20 mm iron bar having a yield strength of 400 MPa and a tensile strength of 480 MPa. Determine (a) whether the bar will plastically deform and (b) whether the bar will experience necking.

4. Askeland (4th ed.) 6-25 (yes, there are two 6-25 problems). Calculate the maximum force that a 0.2 in. diameter rod of Al_2O_3, having a yield strength of 35,000 psi, can withstand with no plastic deformation. Express your answer in pounds and Newtons.

5. Askeland (4th ed.) 6-42. A three point bend test is performed on a block of silicon carbide that is 10 cm long, 1.5 cm wide, and 0.6 cm thick and is resting on two supports 7.5 cm apart. The sample breaks when a deflection of 0.09 mm is recorded. Calculate (a) the force that caused the fracture and (b) the flexural strength. The flexural modulus for silicon carbide is 480 GPa. Assume that no plastic deformation occurs.

6. Askeland (4th ed.) 6-47. What determines or controls the strength of ceramics and glasses?

Open-Ended Problems

1. **Liquidmetal.** Go to www.liquidmetal.com, click on the "The Technology" tab, and view the video comparing Liquidmetal to titanium. Alternatively, check out the physical Liquidmetal demo in the materials science lab. Based on your observations of the behavior of the Liquidmetal and stainless steel cylinders in response to the bearing ball loading, sketch stress-strain curve for both materials (on one set of axes).