the STUFF of history

WEEKLY ASSIGNMENTS DOCUMENT (WAD) 3

Hello, and welcome back to the Weekly Assignments Document, or WAD. This is your third big WAD in three weeks – hopefully not enough to cause WAD fatigue disorder (WADFaD). Let us know if your left elbow starts to feel tingly, or if you hear a scratching sound when you close one eye and tilt your head to the side. We have treatments, or we can just hug it out. By the way, did last week's WAD fill the gaping hole in your heart? If not, perhaps the third WAD will do the trick. Our WAD beta testers have only positive things to say about WAD 3.

The WAD provides 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. Prepare yourselves…we're off to Week 3.

PROJECT WORK

DUE DATE: Ongoing

This week, you will continue your historical and materials research, and your laboratory experimentation. Your history reading now opens up the topic of culture, which will be both fun and pragmatic. You will gather a lot of relevant information for use in your part one report: your ancient civilization's culture is relevant for the background section of your paper, and will also tell us about how your ancient artifact was used and modified. We'll also learn about paradigm theory and scientific revolutions, a valuable framework that explains much about the elusive search for truth, normal and extraordinary science, and the power of inertia. When you do your reading you have three objectives in mind. What are the most important components of this reading for use in your presentation on Wednesday? Which citations (especially specific information such as quotes and statistics) from this reading can be inserted into your report? (On this point, don't just make a mental note, but *type all potential citations into a document with page numbers* before you forget them!) And finally, think about the exam at the end of this WAD. It will also help your project preparation, and you might as well get a head start while you're finishing the readings.

On the materials side, this is the week to hit the testing equipment hard and begin synthesizing the information you've been gathering in the lab and through the readings. By now you have a good sense of what properties are important for effective performance of your modern and ancient objects, and you probably have a stack of laboratory data that tells you something about what your modern materials are, and how they respond to temperature, load, etc. You've also finished some textbook readings of materials theory, and you've likely done some additional research on your ancient and modern materials. Try building some connections among all these bits of information. One approach is to start with the desired performance of your object, and work your way down to the atomic-level characteristics of your material. For example, if your object needs to be resistant to wear, you could link the concept of "wear" to a set of material properties that you measured in the lab, supplement this lab data with researched property data for your modern and ancient materials, explain how the structure/bonding/composition of your materials gives them their particular properties, and then highlight the significance of your connections by explaining how well your materials are likely to perform in a real world environment, or by comparing the performance of your ancient and modern materials. Don't forget to support your explanations and conclusions with evidence, and keep track of all your information sources.

HISTORY READINGS

DUE DATE: Tuesday, February 1, start of class

1. Read chapters of your Ancient Civilization text as follows:

Feb. 1 Reading Assignment for Civilization Presentation

Mesopotamia	Mayans	Greece	Japan
Chapters 4, 5, 7, 11	Chapters 6, 7, 8, 9	Chapters 8 and 9	Chapters 6, 7, 8, 9

Hi! This is week two, and you are now reading about some of the cultural aspects of your civilization. Remember the advice from last time: you are responsible for the main points of these chapters but read intelligently, skim (or skip) portions that go into excessive detail for your purposes, feel free to divide and conquer, and seek additional sources online or in the library to augment or replace these. Read the above chapters by Tuesday, and prepare a presentation for your colleagues on Wednesday.

Your Wednesday presentations must address the question "What cultural and intellectual paradigms characterize your society?" This question has many components…

- Which religion and mythologies were practiced or construed by your civilization? What do these religions and myths say about your society? How did religion and myth impact your society in return?
- What was the extent of science and/or philosophy in your civilization? How did science and philosophy impact the rise and fall of your civilization? How did they affect people's daily lives?
- Teach us about your civilization's proficiency in writing, scholarship, literature, and art.
- Think about how you would define your civilization's "culture" – i.e., which principles, belief systems, and practices exerted a defining influence upon your society?
- Relate all of the above factors to some of the technologies and materials used in your society.

Read the assigned chapters with the above questions in mind. Take notes as you read, and refer to exam question one below, since it too relates to these readings.

2. Locate and read some additional readings related to your civilization

We expect you to do some web searching and consult the relevant library reserve books in order to augment your understanding of your ancient civilization. Choose sources that contribute to your presentation and that help you gather key quotes and statistics for your upcoming research project (see exam question one below).

3. Scientific revolutions and paradigms handout

We also have a small handout about the paradigm theory, borrowed from the readings in Rob's History of Technology Foundation. For a few thoughts about this handout, refer to "Rob's thoughts" later in this document.

PRESENTATION TWO

DUE DATE: Wednesday, February 2, start of class

You do not have additional readings due on Wednesday. However your presentation is due at the start of class. Presentations must meet all of the following guidelines:

1. Speak for no more than 15 minutes per group, then take questions.
2. WATCH THE TIME! PRACTICE YOUR TALK! We will time you and mark you down if you run too long.
3. Use images, charts, or visual materials to make this more engaging.
4. Clearly situate your presentation at the start. Offer us an overview and some guiding questions so we know what to expect.
5. Focus your presentation: this cannot be a random mishmash of information, but instead should aim at several common issues or questions, including interesting conclusions.
6. Make sure you include some analysis in this talk. You are not only here to tell a story (though good narrative technique is essential) … make sure you have a goal and a take-home message.
7. Everyone needs to participate, though you may not all have an equal amount of speaking time. If some of you speak more than others in some weeks we will expect the quieter people to have a larger speaking role next time. Also, people with reduced speaking roles should definitely play a large part in designing the presentation and in answering questions.
8. Feel free to suggest discussion questions at the end of your talk.

MATERIALS SCIENCE READINGS

DUE DATE: Wednesday, February 2, midnight

- **Imperfections in Solids**. Callister Chapter 4 or Askeland Chapter 4
- **Thermal properties**. These readings cover the basic thermal behavior of materials. It is fine to give this chapter a quick read, especially if you are not conducting thermal analyses of your modern artifact in the project. While you are reading about thermal properties, consider how the thermal behavior connects to interatomic bond type and strength –there are great links to be made between these concepts!
    - Callister 6th edition: Chapter 19
    - Callister 7th edition: Chapter 19 (I believe this chapter is on the web site: http://bcs.wiley.com/he-bcs/Books?action=resource&bcsId=2971&itemId=0471736961&resourceId=7554. Check the instructions that came with your book)
    - Askeland 4th edition: Chapter 21
    - Askeland 5th edition: Chapter 22
- Look over the brief "Stolk's Take on the MatSci Readings" later in this document
- Please note the concepts that seem to be particularly unclear or difficult, and bring your questions to class.

EXAM 3

DUE DATE: Friday, February 4, midnight

Instructions: Examination questions are graded and count towards your course grade as shown in the "Grade Breakdown" table in your syllabus. You may work on this as much as you like. Submit an electronic copy of your work via **email to both instructors** no later than **midnight on Friday, February 4**. Please use **Word format** for Question One, and either **Word or pdf format** for Question Two. You may write your solutions to Question Two by hand, but please scan and submit these in pdf format. DON'T FORGET TO INCLUDE YOUR NAME IN THE FILENAME.

Question One: Outlines and Evidence

Estimated time for this problem: 2.0-3.0 hours

1. Read the description for the "Historical Research" component of Project One on pages 5-6 of the Project One Overview (points 5-9). Look back over the readings in your "Handbook to Life…" text and all other sources (online, library, paradigm theory, Sass, you name it) that you completed for Wednesday's presentation. Find at least six citations (more would be better) that you can insert into your paper. Include all citation information discussed in last week's exam:
    a. Bibliographic information about the book (author, title, publication date, publisher) or website (URL, author, date accessed), to help you when you write your report later.
    b. The page number or numbers where you found this reference (if taken from a book).
    c. One of the following:
        i. A paraphrasing (i.e., a summary in your words) of the relevant information.
        ii. A specific quotation if the author's words are particularly valuable. Consider using direct quotations if the author is quoting an original source. In this case you should also list the original source, as in "Shakespeare said 'Brevity is the soul of wit' (quoted in Stephen Sass, p. 643)"

2. Read our "Thesis Workshop Handout" on the website. Now look over the two thesis paragraphs below. For each of these thesis paragraphs answer the following:
    a. Identify the first, second, and third story thesis component in each paper (if they exist).
    b. For each paragraph, which stories are strong and which are weak? Why? Which thesis is stronger overall?
    c. What additional detail or specificity would you add to each thesis (or what other alterations would you make) to correct the weaknesses?

The thesis paragraphs are:

> Open the tool shed of any modern-day landowner, push away the cobwebs, blow off the dust, and in the far back corner you will likely find a pile of rusted lawn and garden tools, neglected and slowly rusting back into the form from which they originally came. This wasn't always the life for the humble hoe, a simple yet effective earth-moving tool consisting of a long, straight handle with a perpendicular blade for moving dirt attached at the far end. In millennia past, the

hoe enjoyed a position at the forefront of technology, receiving major upgrades each time a society perfected a better material in order to keep up with the growing demands of early civilizations. A few centuries ago, however, hoe technology peaked and became stagnant; causing it to eventually lose its perch at the forefront of technology in favor of entirely new agricultural inventions, marking the beginning of the decline that led to where the humble hoe rests today.

From its humble beginnings as a conglomerate of isolated hunter gatherers to a militarily ruled international powerhouse, Japan has always thrived on one basic social rule. This basic tenet was the concept that social order and strict moral standards are the backbone of being civilized. This basic mindset led to many traditions of ritual and honor, none less important than the appearance of the individual as a part of the whole. It is from these strict social standards that specific personal grooming and shaving norms appeared, and became an integral part of life. While today the razor is a disposable piece of metal and plastic that is discarded on a whim, it was once a symbol of much more. In Medieval and Early Modern Japan one's shaving habits were defined by who one was or was not in society and was not simply based on aesthetic appeal as they are today. Even though its materials and basic purpose have changed very little over the past half millennia, the razor has been affected drastically by our modern mass produced and disposable society. Yet, buried deep inside, the razor still symbolizes social acceptance and stance, all embodied in a deceptively simple package.

3. Craft a tentative (or "working," if you prefer) three story thesis statement for your part one paper. Follow the guidelines in the "Thesis Workshop Handout." Go ahead, give it your best shot. You will not be forced to stick with this thesis statement if your paper evolves in the days to come, but it helps to have a starting point.

Question Two. The Biggest Thing Since Radio.

Estimated time for this problem: 2 hours

For this question, we're talking **plastics**. Let's pretend for a moment that nothing in life interests you more than exploring the structure and properties of a polymeric component of your Part One modern artifact. Some of you may have already examined a polymeric component as part of the project work. If this is the case, these questions will probably help you with your analyses. For those of you who haven't yet started analyzing a polymeric component, this may help you think about what aspects of the polymer you'd like to explore before the end of Part One. And for those of you who do not plan to explore a polymer as part of your project, this exam will push you into a new realm of learning. In any case, it's good!

TASK 0: Remember to keep track of your sources.

Some of the work you do for this exam may find its way into your Part One paper, so be sure to keep track of your sources as you work through these problems. If you find a good source for material structure or properties, take a moment to record a formal citation that you can use as an endnote in your paper.

TASK 1: Identify Your Polymer.

a. [5] Choose a polymeric component of your modern artifact. This could be the outer shell of a thermos, the handle of a screwdriver, etc. Take a photo of your artifact that shows the polymeric component of interest. Make it a good photo (think about the color, lighting, background, focus, composition, etc.) Present your photo with a descriptive figure caption and appropriate annotations to indicate the polymeric component of interest.

b. [5] Assuming you have full access to Olin's materials science laboratories, specify which laboratory instrument(s) you could use to determine the following:
   i. the molecular structure of the polymer,
   ii. the degradation temperature of the polymer,
   iii. whether or not the polymer contains toxic or hazardous substances such as Pb, Cd, and Hg.

c. [5] What particular polymer (e.g., polycarbonate, polypropylene, epoxy, natural rubber, etc.) is your component? If you've already identified your polymer via lab experimentation, simply indicate your findings here. If you haven't, then take a guess at what polymer was used in your component. Sketch the repeat unit (mer) for your polymer.

d. [5] Create a sketch that shows several chains of your polymer in their expected morphology (e.g., amorphous or crystalline or semicrystalline, linear or branched or crosslinked, etc.

TASK 2: Characterize the Thermal Properties of Your Polymer.

e. [5] Is your polymer a thermoplastic, a thermoset, an elastomer, or a special combination of two of these (e.g., a thermoplastic elastomer (TPE))? Explain your answer based on how the polymer structure responds to temperature.

f. [5] What is the glass transition temperature (T_g) of your polymer? What changes in properties occur as your polymer is cooled below its T_g (if $T_g < 25$ ºC) or heated above its T_g (if $T_g > 25$ ºC)?

g. [5] Would you expect your polymer to be recyclable? Explain your answer.

h. [5] Sketch a schematic differential scanning calorimetry (DSC) curve for your polymer, from -196 °C (liquid nitrogen temperature) to a point beyond its melting or degradation temperature. Label all the important features of your curve, and briefly explain what's happening in the polymer to produce the features.

TASK 3: Characterize the Mechanical Properties of Your Polymer.

i. [5] Plot a schematic engineering stress-engineering strain curve for your polymer. For this plot, imagine an ambient-temperature (~25 ºC) tension test of your polymer that goes all the way to the point of fracture.

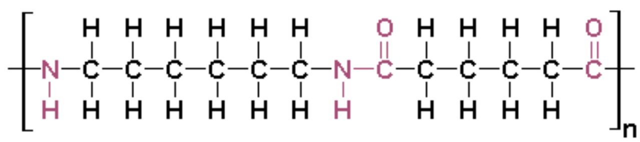
j. [5] Explain the shape of your stress-strain curve based on the expected atomic- or molecular-scale deformation phenomena occurring as your polymer deforms.

k. [5] On the same stress-strain plot, overlay another curve that shows the stress-strain behavior of your polymer at an elevated temperature – let's say 100 ºC. Briefly explain any differences between the elevated and ambient temperature curves.

TASK 4: Compare Your Polymer to Nylon 6,6.

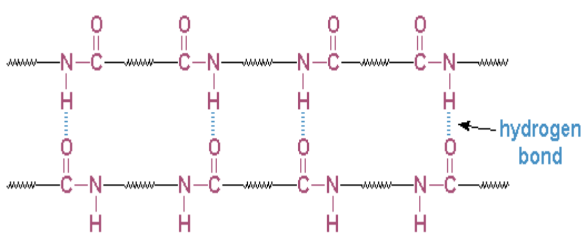
For the last few questions, I'm going to ask you to compare the properties and behaviors of your polymer to those of Nylon. And yes, I am desperately hoping that you did not guess that the polymer in your modern artifact is Nylon.

Nylon belongs to a group of polymers known as polyamides, which are characterized by the presence of an amide group. One of the more common types of Nylon is Nylon 6,6, which has a repeat unit shown below. Note the amide group highlighted in red.[1]



the repeat unit of nylon 6-6

Nylon's attractive mechanical and thermal properties result from excellent bonding between the amide groups of adjacent polymer chains, as indicated in the figure below.[1] Note that the figure only shows the amide groups, not the entire repeat unit of the polymer. Those zigzag lines between the amide groups are the CH_2 parts of the structure.



l. [5] In comparing your polymer to Nylon 6,6, which would you expect to have the highest crystallinity? Provide some supporting rationale for your answer.

m. [5] Which polymer – Nylon 6,6 or yours – would have the highest melting temperature? Provide some supporting rationale for your answer.

[1] http://www.chemheritage.org/EducationalServices/nylon/chem/chem.html

MARTELLO'S TAKE ON THE SCIENTIFIC REVOLUTION READING:

Thomas Kuhn wrote about scientific revolutions and paradigm theory in the 1960s, and this book shook the world. Fans of Kuhn have applied his conception of the scientific process to most aspects of human knowledge, and it is now a challenge to think about objective truth without including mention of his views. So yeah, this is big.

You have several objectives this week. First and foremost I want you to be able to explain this theory to others, which of course means you will need to fully understand it. Paradigm theory and scientific revolutions are not complicated concepts, but make sure you take the time to familiarize yourself with all of the key terms and ideas. Drop them into conversation at least four times prior to class, and tell us about how people respond. Did your roommate think you suddenly became a philosophical powerhouse? Did your significant other start to wonder if you are really a secret snob? Oh, the fun!

Second, think about how you might apply this reading to your project. Did the leaders, artisans, philosophers, clerics, or (most importantly) overall population of your civilization follow any paradigms? Can you relate a paradigm to the development, use, or modification of your object? Can you use paradigm theory to describe the modern development or usage of your item? This will not be possible for all civilizations and for all projects, but it could offer you some interesting food for thought that might strengthen your thesis statement and connect the modern and ancient sections of your report. Always remember the wise words of Edie Brickell and the New Bohemians: "I'm not aware of too many things, I know what I know if you know what I mean."

And finally, what do you think about the applicability of paradigm theory to your career as an engineer (or to whatever career you select)? This theory is not perfect and it is possible to critique it. What are your thoughts about it? Do any of the questions at the end of the document resonate with you? What parts of it strike you as the most or least accurate, the most or least useful? Make it work for you, even if you disagree with it. Be ready to discuss. I know I will.

STOLK'S TAKE ON THE MATSCI READINGS:

Chapter 4 – Imperfections in Solids. I don't have too much to say on this topic, except that defects matter. Small or large, the number and type of imperfections in solid materials can have enormous effects on properties and performance. Sometimes these changes are highly desirable (e.g., increases in strength or ductility, reduction in melting temperature to facilitate processing, increases in electrical conductivity), and sometimes they are not (e.g., increased brittleness, decreased electrical conductivity, increased corrosion rates). I'll give you some examples. First, let's consider **point defects (1D)** in, say, copper. Copper is my favorite metal, by the way. Why, you ask? I like the smell of the oxide, and I consider Cu an underdog in the ultra-competitive, high-stakes world of engineering materials…and I always root for the underdog. If you measure the electrical conductivity of pure copper, you get a very high value – third best among materials. But if you add even minuscule amounts of iron to your pure copper, the conductivity drops like a rock. I'm talking orders of magnitude decreases in Cu conductivity resulting from a little dissolved iron. This dramatic effect was the bane of my existence for three years of my graduate school career (it's a long and very sad story that left me crumpled in the corner of a dark lab, reciting the Cars' "You Might Think" lyrics to my small collection of worthless nanoscale ternary alloys… *oh I think that you're wild…and so-o uniquely styled…you might think I'm crazy, but all I want is you…*). Emotional distress and mild delirium aside, the fact that tiny amounts of dissolved impurities have such enormous effects on properties is a pretty interesting materials phenomenon. Speaking of dissolved impurities, let's talk **solid-state solubility** for a moment**.** I love the way this topic connects back to atomic scale characteristics and to information from the periodic table. Did you think you could look at a periodic table, read off things like electronegativity, atomic radius, crystal structure and valence, and then predict how well elements will get along with each other in the solid state? Very cool.

Line defects (2D), or **dislocations,** are discussed next in the reading. As imperfections go, these are definitely my favorite. Give me a chunk of copper loaded with dislocations, and I'm in heaven. You can't see these defects by eye, or even with optical microscopes, but they are present in large amounts in commercial materials. Hey, here's a riddle for you to share with your friends and family: I am easy to create but difficult to destroy. I form while my surroundings deform. I make metals both weaker and stronger. What am I? A dislocation! Okay, that was perhaps the worst riddle ever. My apologies. Anyway, the thing to remember about dislocations is that (1) they are created when we "cold work", or strain harden, metals, (2) their movement is responsible for the plastic deformation, or "slip", that occurs in metals when we apply a stress, and (3) they interact with each other, and with other types of defects. If you can get a handle on how dislocations interact with point defects (e.g., solute atoms such as Zn in Cu alloys), other dislocations, grain boundaries, and volume defects (e.g., precipitates in a metal), you will be able to control the properties of alloys in amazing ways. You'll be able to strengthen or weaken metals at will. Yes, indeed. More on this later.

Surface (planar, 2D). Grain boundaries are surface defects separate different crystal orientations in a polycrystalline solid, and they can affect properties by interacting with dislocations and messing with diffusion rates in the solid. I make the distinction between grain boundaries and phase boundaries. Phase boundaries act similarly to grain boundaries in terms of their interaction with dislocations, but sometimes we can have two phases (with boundaries in between) that stack up to create a single grain. Does grain size matter? Why yes it does! What happens to strength when we decrease the grain size? Why?

Volume defects (3D). Volume imperfections include things like pores, voids, cracks, precipitates, and inclusions. It probably seems obvious that things like cracks and pores can affect material properties, but the extent to which a given size of volume defect such as a pore depends on the fracture toughness of the material. Metals can deal with pores and cracks much more effectively than ceramics. If you'd like to know more about this, check out the topics in fracture mechanics in your textbook.

Thermal Properties. My goal in having you jump ahead to the thermal properties sections is for you to see some connections between last week's atomic level readings and the various thermal properties we can measure in the mat sci lab. For example, can we predict melting temperature based on atomic-scale characteristics of materials? How about thermal expansion?

MAT SCI PRACTICE PROBLEMS

Textbook Problems

1. Askeland 4-67. Why is most "gold" or "silver" jewelry made out of gold or silver alloyed with copper, i.e, what advantages does copper offer?

2. Solid state solubility. Of the elements in the chart below, name those that would form each of the following relationships with copper (non-metals only have atomic radii listed):

   a. Substitutional solid solution with complete solubility
   b. Substitutional solid solution of incomplete solubility
   c. An interstitial solid solution

Element	Atomic Radius (nm)	Crystal Structure	Electronegativity	Valence
Cu	0.1278	FCC	1.9	+2
C	0.071			
H	0.046			
O	0.060			
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Ni	0.1246	FCC	1.8	+2
Pd	0.1376	FCC	2.2	+2
Pt	0.1387	FCC	2.2	+2
Zn	0.1332	HCP	1.6	+2

3. Vacancies. Calculate the fraction of atom sites that are vacant for pure lead at room temperature (25 °C) and at 310 °C (just below its melting temperature). The activation energy for vacancy formation is about 53 kJ/mole. How do you think the difference in the fraction of vacant sites will affect self-diffusion (diffusion of the atoms within their own crystal)?

4. Strain fields around dislocations. Sketch the distortion of a crystal lattice around an edge dislocation, and show the preferred regions for (i) large substitutional atoms, (ii) small substitutional atoms, and (iii) interstitial atoms. HINT: Determine the type of distortion (tension or compression) that the large and small substitutional atoms will have on a perfect lattice, then think of how the distortion around a dislocation could best be balanced or relieved by the distortion caused by the substitutional atoms.

Open-Ended Problems

1. Askeland Problems 2-38 and 21-31. *NOTE: Only one answer is required, as they are very similar problems.*
   (2-38) Turbine blades used in jet engines can be made from such materials as nickel-based superalloys. We can, in principle, even use ceramic materials such as zirconia or other alloys based on steels. In some cases, the blades also may have to be coated with a thermal barrier coating (TBC) to minimize exposure of the blade material to high temperatures. What design parameters would you consider in selecting a material for the turbine blade and for the coating that would work successfully in a turbine engine? Note that different parts of the engine are exposed to different temperatures, and not all blades are exposed to relatively high temperatures. What problems might occur? Consider the factors such as temperature and humidity in the environment that the turbine blades must function.

   (21-31) What design constraints exist in selecting materials for a turbine blade for a jet engine that is capable of operating at high temperatures?

2. Below is a graph of Heat Flow vs. Temperature for High Density Polyethylene (HDPE) through its melting point. On top of this graph, sketch the expected graph for Low Density Polyethylene, and explain why your curve looks the way it does. Be sure to consider the relative position of the graph as well as the slope of the curve at the melting point onset.