2006-260: TAKING MATERIALS LECTURES BEYOND POWERPOINT

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Taking Materials Lectures Beyond PowerPoint

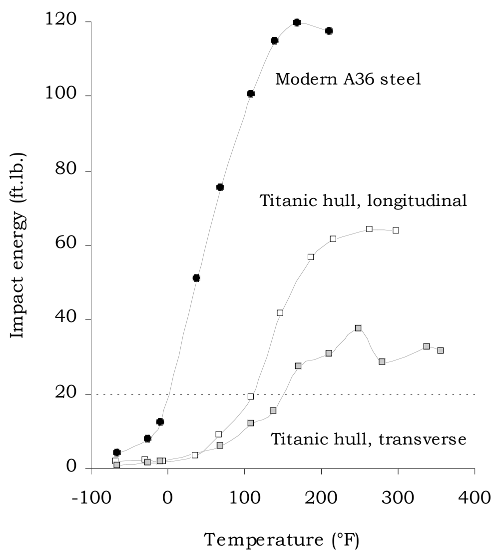
Abstract

Before the days of successful powered flight, aircraft were designed to fit the capabilities of available engines. Orville and Wilbur Wright succeeded in part because they designed the engine to fit the needs of the aircraft. When it comes to presentation software and hardware, most instructors find themselves in the position of the Wright brothers' unsuccessful competitors – designing the classroom lecture and handouts to fit the default capabilities of available presentation technology, rather than designing the presentation technology to fit the needs of the classroom lecture. Most instructors who deliver Materials classes and other survey classes with presentation software use the market leader, Microsoft PowerPoint, not because of its suitability for technical presentations, but because it is widely available. While it is impractical for an instructor to write presentation software, it is certainly practical to improve the selection and use of existing software and hardware to fit the needs of the classroom. For example, the standard handout formats available in PowerPoint lack the flexibility to change individual image sizes, font sizes, line thicknesses, and strategic placement of white spaces for notetaking. However, these capabilities exist in word processors. Today, there is a wider choice of hardware: for example, an iPod is smaller, lighter, and faster to boot than a laptop. This paper documents the evolution of two Materials courses and two other survey courses, from chalkboard lectures, to PowerPoint lectures with standard PowerPoint handouts, to the next step "Beyond PowerPoint".

First Year of Teaching

When I attended college in the 1980s, all of my professors taught by writing on a chalkboard. Students spent nearly the entire class period transcribing notes from the board. There was very little time available for interactive discussion with the instructor; the traditional lecture occupied the entire scheduled class time. In-class experimental demonstrations were a rare treat, because they took too much time. Twenty years later, when I started teaching at a university, I used the same approach as my former instructors: create a set of notes on paper, then deliver the lectures with a chalkboard. To supplement the lecture material, handouts contained pictures, graphs, and tables that could not be replicated well on the chalkboard. Some handouts were mini-lessons that covered additional material not in the lecture or textbook,[1] such as the impact test data in Figure 1. In addition, homework assignments were listed on separate handouts as shown in Figure 2.

MET 180, Class #7
Charpy impact testing of the Titanic's hull



One popular explanation for the sinking of the Titanic is that the hull became brittle in the cold North Atlantic. Charpy impact testing of hull steel shows that the hull would have been brittle in tropical oceans too. Specimens were broken along the grain of the hull plates (longitudinal), and across the grain (transverse). Modern A36 steel, which is comparable in composition to the Titanic hull material, has fewer contaminants and has a higher ductile-to-brittle transition temperature (defined at 20 ft.lb. impact energy)

Data source: Tim Foecke, Metallurgy of the RMS Titanic, NIST internal report NIST-IR 6118.

Figure 1: This supplemental handout from my first year of teaching is printed as a half-sheet.

MET 180
Homework Assignment #7

Reading
Read Chapters 7 & 8.

Textbook Problems
[1] Solve Problem 7-6.

[2] Solve Problem 7-11.

[3] What is the degree of polymerization of polystyrene having a molecular weight of 70,000 g/mole?

[4] Solve Problem 8-20.

[5] Use a spreadsheet (such as Excel) to plot the thermal conductivity of a ceramic vs. porosity, over the range 0 to 40% porosity. For this ceramic, k_o = 0.75 W/mK.

Figure 2: A typical first year homework assignment handout printed as a half-sheet has plenty of space for wordy problem statements, as well as reminders about upcoming exams and laboratory experiments.

Second Year of Teaching

In my second year of teaching, I transformed two Materials courses, a Fluid Power course, and an Instrumentation and Controls course from chalkboard to PowerPoint (PP). Initially, the purpose of the slideshows was legibility; these four survey courses are image-intensive, and chalkboard sketches are inadequate for transmitting complex graphics to students' notes. Each of the 76 lectures took five to ten hours to convert, including preparation of PP handouts. These handouts consisted of most, but not all, of the PP slides, printed six to a page, to assist note-taking. Slides selected for the handout included complex graphs, lengthy equations, large tables, micrographs, and photographs. Slides which were not included in the handout contained solutions to homework problems, and material that was easy to transcribe by hand…such as key words and short equations. The slide handouts were printed in standard PP format, six slides to a page, as in Figure 3. In addition, students received the handouts created for the previous year's chalkboard lectures.

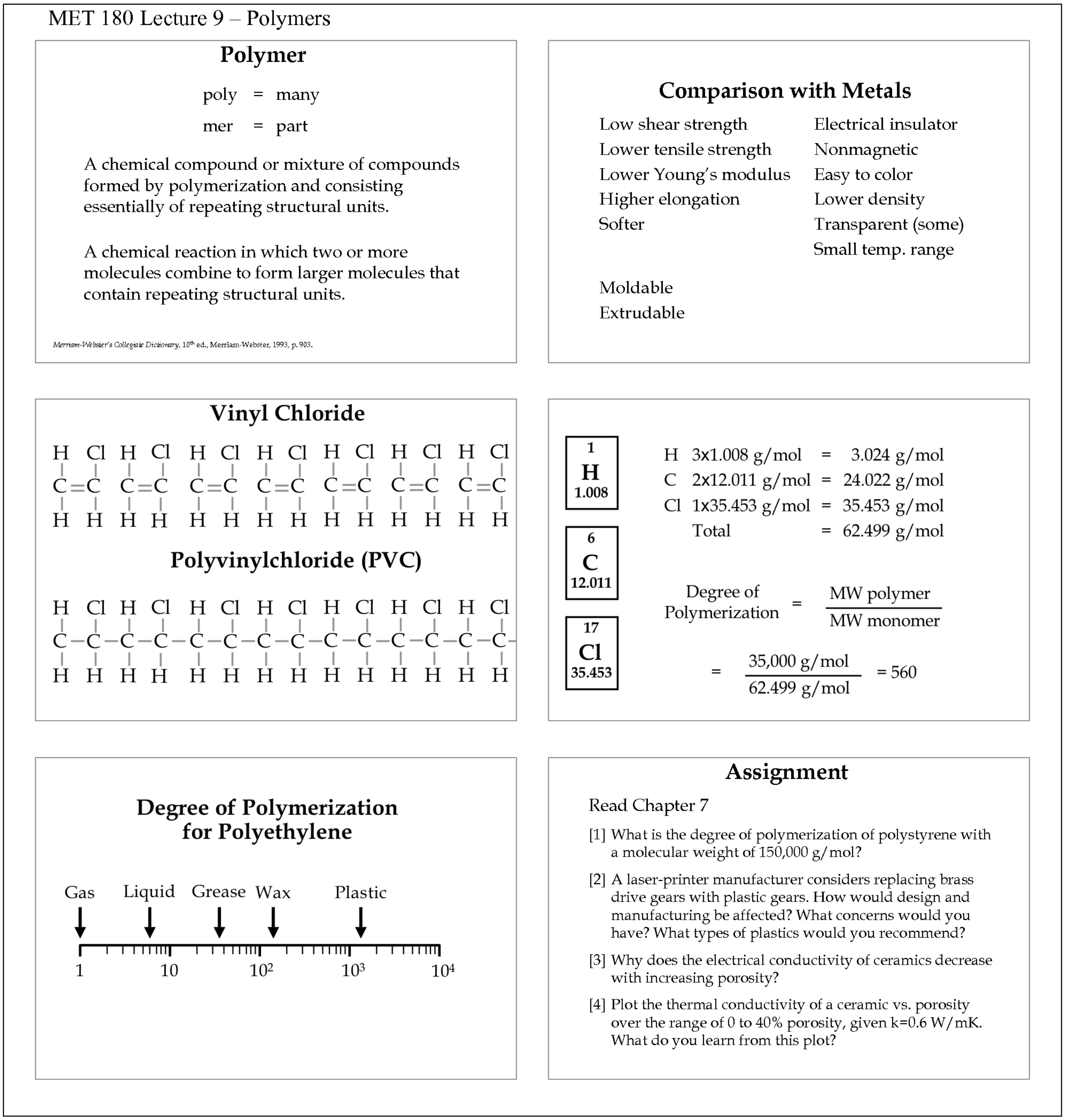


Figure 3: Six slides are printed on each PP slide handout from the second year. This format limits the whitespace available to write notes, and limits the length of the homework assignment to what will fit legibly in a small box.

During this second year, students appeared to take very few notes in the first half of the semester of the freshman Materials course. However, they asked more questions during the lecture, and appeared to be more engaged in thinking about the material than their predecessors in the chalkboard class the year before. For example, they would respond more readily to questions from the instructor, perhaps because they did not have to change from "scribe mode" to "thinking mode". After the midterm exam, notetaking appeared to increase. Lecturing with slideshows instead of chalk reduced the lecture time by 50-60%. This time savings allowed for more interaction with the students, through question-and-answer, or side discussions. It also allowed more time for in-class demonstrations and experiments, such as softening a polystyrene spoon in boiling water to demonstrate glass transition temperature, or heat-treating bobby pins with a propane torch and a bucket of ice brine to demonstrate the martensitic transformation.

Third Year of Teaching

In my third year of teaching, the challenge was to take the PP slideshows and handouts to the next level. There were three driving forces for change: first, the annoyance of lugging a 4 kg laptop from classroom to classroom; second, the frustration of waiting 4½ minutes for the laptop to boot (a consequence of university network software); and third, the conviction that handouts could be designed better for notetaking than standard PP handouts.

The first two issues were initially addressed with an Apple iPod, remote control, and video cable. The iPod fits in a shirt pocket, has a mass of 180 g (just 5% of the mass of the laptop), and it boots instantly. However, an iPod does not play PP slideshows. Instead, PP files are read into Keynote, Apple's presentation software. From there, every slide and build is saved as a png picture file in a dedicated folder for each lecture. Next, the folder is saved to the iPod. This conversion process takes less than five minutes per lecture. Opening the folder with the iPod takes four clicks on the clickwheel control panel, taking less than ten seconds. This approach eliminates a common problem with large, image-intensive PP slideshows. A multi-megabyte PP slideshow can overwhelm the memory on a computer, resulting in missing images or slides, or even a crash. The iPod displays each slide as an individual image, so it will not crash during a slideshow.

Figure 4: The iPod screen shows a PP slide from a polymers lecture. The remote control unit fits comfortably in a palm, and is handy for changing slides while standing away from the iPod.

Unfortunately, while the iPod is light and fast, image quality is not good enough for micrographs and other detailed graphics. The composite video and S-video outputs deliver analog television resolution. The solution to the boot speed and weight issues was to purchase a small 2 kg laptop which boots in 45 seconds, and is independent of the university's network software.

The third issue was more time-consuming: creating better handouts. As the second year progressed, several shortcomings of the 6-slides-to-a-page format became obvious:

1. Line thicknesses appropriate for a projection screen are too thick on a printed page, so graphs and engineering diagrams look like cartoons. These lines should be thinner, because 600 or 1200 dpi laser printing shows detail not visible with the current generation of low resolution projectors, and a reader can adjust the position of the page relative to the eye more easily than an audience member can move closer to a screen in a crowded lecture hall. Slides are designed to be legible by the student at the back of the classroom, not just the student in the front row.

2. There is little space around the slides for taking good notes, especially if the slides are printed with borders (the default in PP). Students must either write very small, write notes on a separate page, or take fewer notes.

3. With all the text from the PP show on the handout, there was little incentive for students to annotate the diagrams. Some students sat through classes without taking any notes at all.

4. Some detailed figures were too small to be useful (or legible) on the printed page. There is no flexibility in PP (or its competitors) for printing some of the slides larger than the rest.

5. Multiple sequential slides in a PP show cannot be displayed in a row or column. There is no flexibility in PP for printing five slides on one page, two on the second page, three across the width of a third, with strategically planned whitespace.

6. Homework assignments were limited to what would fit easily on a slide, which made it difficult to assign wordy problems, or problems using graphs or pictures.

7. Supplemental handouts, such as Figure 1, were stapled to the end of the PP handout, not in the order of discussion during the class. The only way to insert this material within a PP printout is to create a new slide within the PP show.

The solution to all of these problems was to import figures, tables, graphs, and text into a word processor. Images were rescaled, and line thicknesses were reduced to make them less cartoonish. Graphs, pictures, and tables were resized for legibility and to enable better notetaking, with extra white space where needed. Some figures were significantly expanded compared with the standard 6-to-a-page PP handout format used in the previous year. Some labels and lines were deleted to encourage students to mark up graphs and pictures. Homework assignments were given at the bottom of the last page of each handout. The assignments were as detailed as they had been in the first year of teaching, because questions could fill the width of the page.

The chalkboard at the front of my classroom has an aspect ratio of 10:3, but the LCD projector has an aspect ratio of only 4:3. Sequential diagrams that can be drawn across a wide field of view on a chalkboard must either be displayed in quadrants of a screen, or on separate screens. For example, Figure 5 shows a slide for crystal structures. In the new handout format, the crystal structures are shown in a column, with whitespace at the right for notes, as in Figure 6. There is less text on the handout, so students can annotate the figures with labels, and they have room to take notes of the class discussion of calculating the number of atoms per unit cell. Another option is to place sequential diagrams across the page.

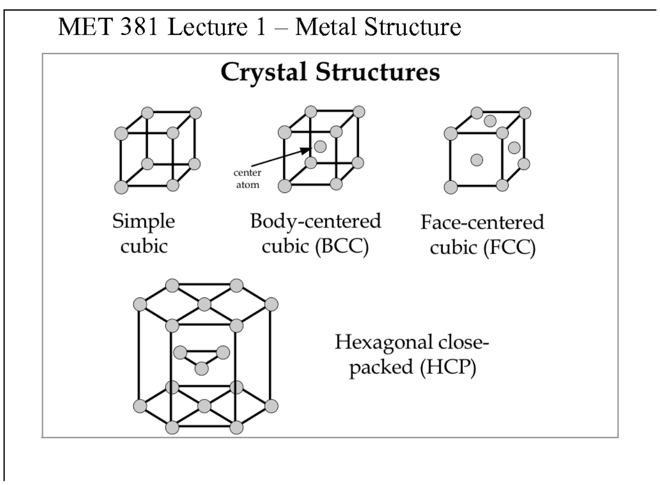


Figure 5: Portion of a handout from the second year of teaching, showing one of six slides on the page. The handout includes the entire content of the slide, but there is little room for annotation by the student.

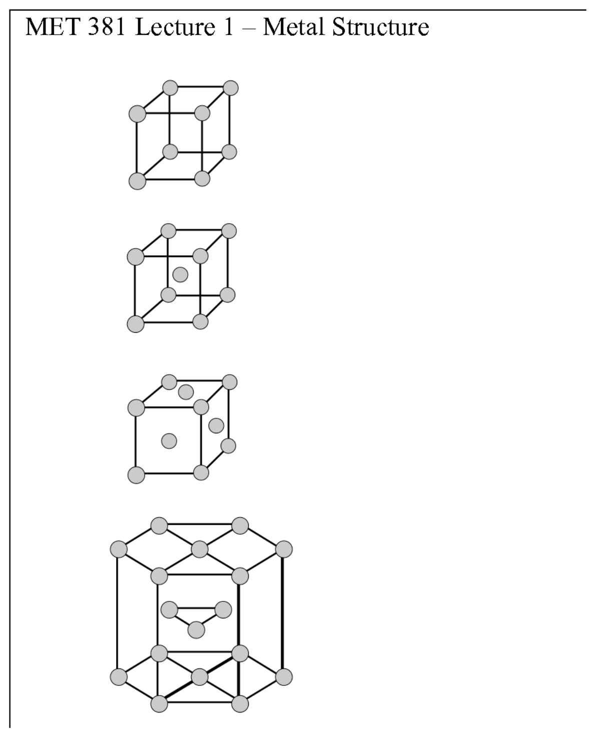
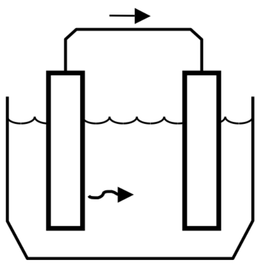


Figure 6: Portion of a handout from the third year of teaching, showing crystal structures in a column, with whitespace at the right for annotation.

Converting the handouts from the old to new format took 1-2 hours per lecture, but it was less time-consuming than creating the original PP slideshow.

MET 381 Lecture 3 – Physical properties

Galvanic Corrosion

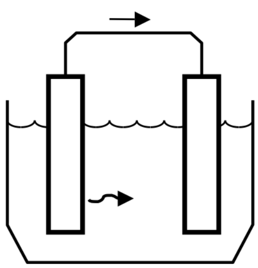


Anode

Cathode

Physical contact

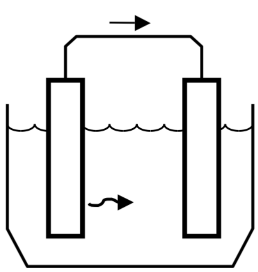
Electrolyte



$M \rightarrow M^{n+} + n\,e^-$

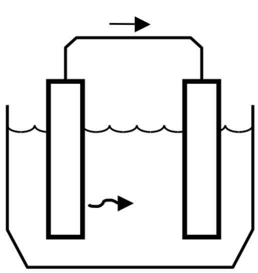
$M^{n+} + n\,e^- \rightarrow M$

$2H^+ + 2e^- \rightarrow H_2$
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$



$Cu \rightarrow Cu^{2+} + 2\,e^-$

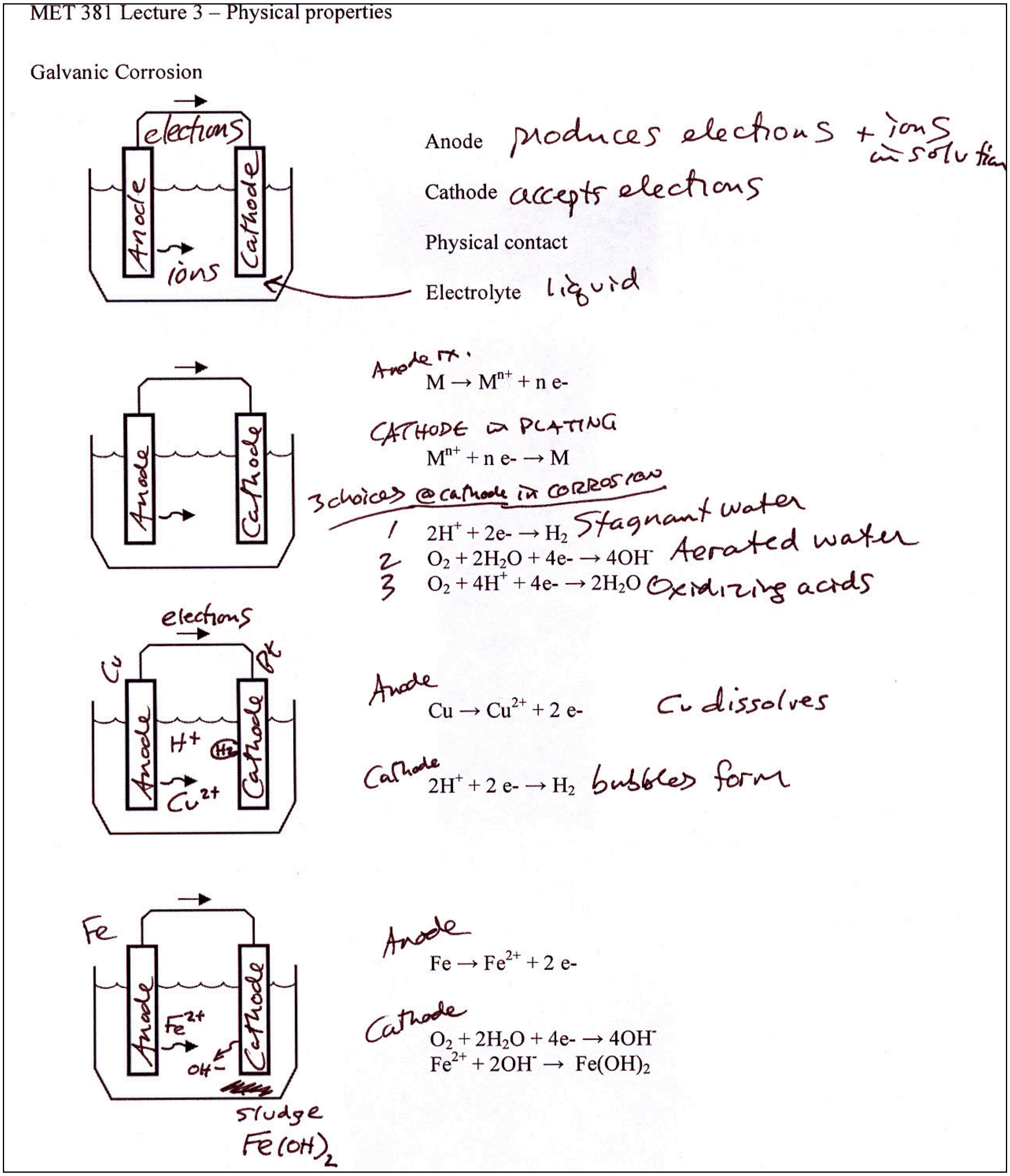
$2H^+ + 2\,e^- \rightarrow H_2$



$Fe \rightarrow Fe^{2+} + 2\,e^-$

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$

Figure 7: Full page from a 5-page handout from the third year of teaching. Diagrams of galvanic cells are provided, along with chemical equations. Students can label the anode, cathode, ions, precipitates, etc. as they take notes. Each diagram is a separate PP slide in the slideshow.


MET 381 Lecture 3 – Physical properties

Galvanic Corrosion

Anode produces elections + ions in solution

Cathode accepts elections

Physical contact

Electrolyte liquid

Anode rx.
$M \rightarrow M^{n+} + n\ e-$

CATHODE ⇒ PLATING
$M^{n+} + n\ e- \rightarrow M$

3 choices @ cathode in CORROSION

1 $2H^+ + 2e- \rightarrow H_2$ Stagnant water

2 $O_2 + 2H_2O + 4e- \rightarrow 4OH^-$ Aerated water

3 $O_2 + 4H^+ + 4e- \rightarrow 2H_2O$ Oxidizing acids

Anode
$Cu \rightarrow Cu^{2+} + 2\ e-$ Cu dissolves

Cathode
$2H^+ + 2\ e- \rightarrow H_2$ bubbles form

Anode
$Fe \rightarrow Fe^{2+} + 2\ e-$

Cathode
$O_2 + 2H_2O + 4e- \rightarrow 4OH^-$
$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$

Figure 8: The galvanic corrosion handout page from Figure 7 as it might appear after the lecture. The student has annotated the diagrams and chemical equations in the available whitespace.

The Effectiveness of Slideshows

Students were surveyed informally in class, and formally with surveys and an extra credit question on the final exam: "Discuss three ways to make this course better". Informally, students expressed a strong preference for the slideshow format. On rare occasions when the projector did not work, and the lecture had to be delivered with a chalkboard instead, students expressed their disfavor, even though they had the handouts for the slideshow. Most but not all students reported on the extra credit question that they preferred the slideshow; a small minority said they learn better by taking notes in a traditional chalkboard format. In a formal, anonymous, end-of-semester survey, students ranked "film, other aids, and lab facilities, if applicable" on a scale of 1 to 4 (poor, fair, good, excellent). Class averages on this question improved by as much as 45% in four courses when the presentation format changed from chalkboard to slideshow. Other factors may have influenced the scores, such as improvements to lab manuals. Quantitative measures of improvement are weak because there is only one semester of control group data for each course (i.e. the chalkboard lecture from the first year).

Conclusions

Several principles were followed in converting four classes from traditional chalkboard to PP and Beyond:

1 Content is key. Slides should not be prepared with canned software features that detract from the content (borders, titles, backgrounds, etc).

2 Slides are not the lecture; they supplement the lecture, and help to tell the story.

3 Handouts should not be copies of the slides; they should be note-taking aids, with sufficient white space for annotation. Drawings, graphs, and lengthy mathematical formulas should appear on the handout. Labels should be left off, to encourage students to take notes.

4 Handouts should be designed for high-resolution laser printing, with different font sizes and line thicknesses than the slides. Font sizes should be consistent throughout the handout.

5 The time saved with slideshows should be used to improve interactive learning, with Socratic question-and-answer and additional in-class demonstrations.

Slideshow technology does not, by itself, improve the learning process. Instead, it allows for the learning experience to become more interactive, because it frees up time for discussions and demonstrations. Students seemed to ask more questions in the PP classes than in the chalkboard classes, perhaps because asking questions did not result in the class ending late.

Wisely constructed handouts are more time-consuming to create than the default PP handout format, but these improved handouts can serve as a notetaking aid, not a substitute for notetaking. If managed well, PP & Beyond methods have great potential; if not managed well, it leads to passive learning after the model of television. Once students leave the university, they will be expected to make presentations in industry and government. Hopefully, presentation methods they are exposed to in school will carry on into their careers.

References

1. Barry Dupen, “Teaching Problem-Solving by Storyboard”, 2005 ASEE Conference & Exposition, June 2005. Conference proceedings, session 2568, paper #432.