

AC 2010-356: DESIGNING USER-FRIENDLY HANDOUTS FOR A FLUID POWER CLASS

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Designing User-Friendly Handouts for a Fluid Power Class

Abstract

Fluid power, the branch of mechanical engineering focused on compressed air and hydraulic systems, is an inherently image-intensive subject. Teaching fluid power involves cutaway diagrams of valves, cylinders, pumps, and motors, as well as performance curves and other technical graphs. Chalkboard instruction is inadequate: substantial image degradation occurs as pictures and graphs are transferred from original sources to the instructor's notes, then to the chalkboard, and finally into the students' notes. In addition, students often run out of time while copying images, and may miss critical details. One solution is to provide printed handouts with images used in the lecture. However, the standard handout formats available in Microsoft PowerPoint lack the flexibility required for notetaking. The number of slides per page is fixed at either 1, 2, 3, 4, 6, or 9; some combinations include horizontal lines for brief notes, but most formats severely restrict notetaking space. Within these formats, the instructor does not have the freedom to print slides on the same page at different magnifications, to change font sizes, to move images on the page, or to insert white spaces for notetaking. Instead, a new approach is needed, in which images are copied into a word processor, then manipulated to transform user-hostile handouts into user-friendly handouts. Assessment of this approach includes student-generated improvement recommendations. Students photocopy their notes, then mark them with red pen to indicate recommended changes. This approach is not limited to fluid power, or even to engineering; it lends itself to any image-intensive topic, technical or otherwise.

Introduction

One reason students choose to enroll in Mechanical Engineering Technology rather than in Mechanical Engineering is the hands-on, practical nature of an MET curriculum. These students like the blend of engineering science and engineering practice, with an emphasis on applications. A Fluid Power course is a good example: students learn fluid flow science (Bernoulli's equation, pipe size selection methods, etc.) as well as hydraulic and pneumatic circuit symbols and circuits, ladder diagrams for electrical control, and the operation characteristics of pumps, piping, valves, gauges, filters, cylinders, and motors. In a typical course, students learn these concepts through readings, lectures, and laboratory experiments using hydraulic and pneumatic test stands.

The first semester I taught Fluid Power to sophomore and junior Mechanical Engineering Technology students, I used a chalkboard to explain equations, graphs, and the construction and operation of fluid power components. While this 19th century teaching technology worked well for equations, it was insufficient for graphs and pictures, so I converted the lectures to PowerPoint, and I printed the slides for the students. PowerPoint offers several printing options for handouts: 1, 2, 3, 4, 6, or 9 slides to a page. I printed 6 to a page, double-sided, to save paper.

Figure 1 shows a typical handout in a default PowerPoint format. Each slide is framed with a border, and all of the content of each slide appears on the handout, in the same arrangement as the original slide. On a black laser printer, colors appear as gray levels.

As a beginning teacher, I needed a source of specific, actionable ideas for improving my teaching, so I introduced an extra credit question to the final exam: “Describe three ways to improve this course.” In the intervening years, this one question has provided more useful feedback than any other source, including peer review by other professors and end-of term, multiple-choice student evaluation forms. Based on student feedback to this extra credit question, the PowerPoint handouts failed on several counts:

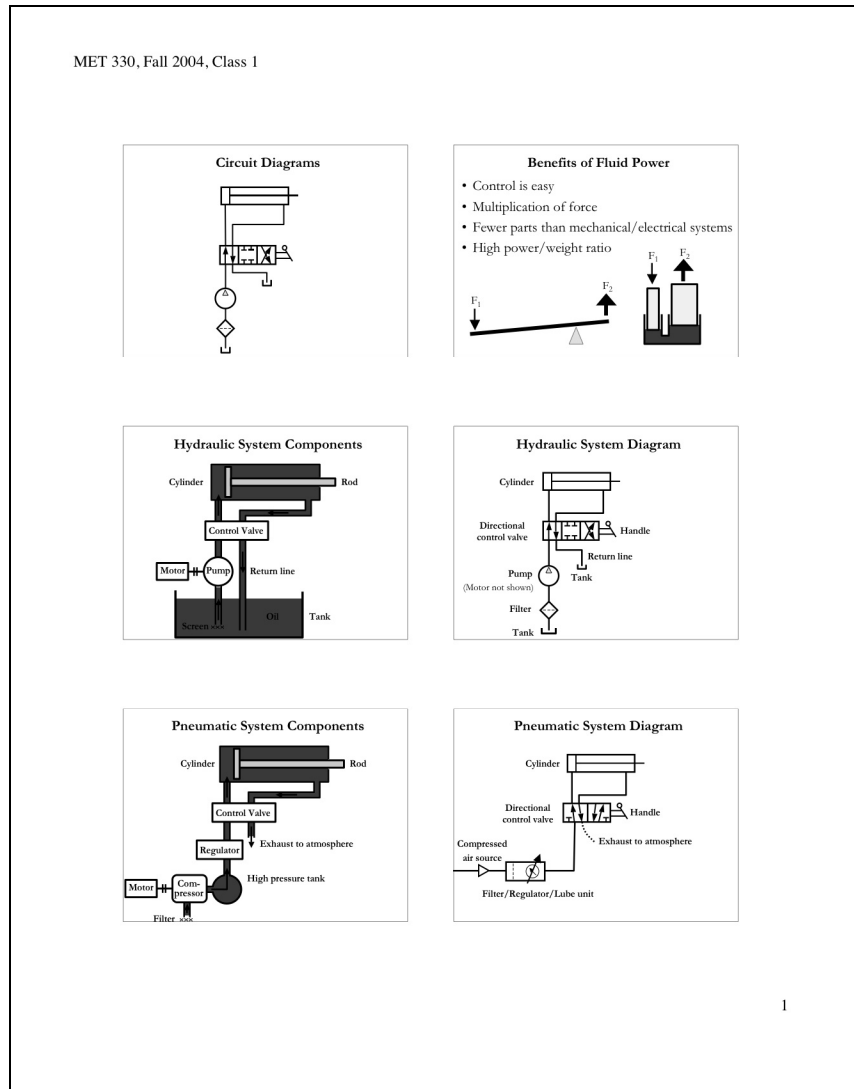


Figure 1: Typical handout page using PowerPoint’s 6-slides-to-a-page format and default borders.

1. The text was too small (especially subscripts and superscripts in equations), and some detailed figures were too small. There is no flexibility in PowerPoint to print some of the slides larger than the rest.
2. Line thicknesses appropriate for a projection screen were too thick on the printed page, so graphs and engineering diagrams looked like cartoons. These lines should be thinner because 1200 dpi laser printing can resolve much finer detail than a standard LCD projector. Slides are designed to be legible from the back of a lecture hall, whereas handouts are designed to be legible from half an arm’s length.
3. Colors did not always translate well into contrasting gray levels. A case in point: the center left slide in Figure 1. In the original slide, yellow “Oil” and “Screen” labels contrast well with the red oil in the tank; in the black-and-white laserprinted handout, these labels are illegible.

4. Content from multiple sequential slides could be not displayed in a row or a column. For example, there is no flexibility in PowerPoint for printing five slides on one page, two on the second page, three across the width of a third, with strategically planned whitespace.
5. 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.
6. Supplemental handouts were stapled to the back of the packet, because PowerPoint will only print slides from the slideshow itself. If the supplemental material was discussed during the lecture, students had to shuffle papers to find the relevant page for notetaking.
7. There was not enough room for notetaking. Students must either write very small, use a separate page, or take fewer notes.

This last observation led to a significant change in the design of the handouts. Clearly, students need better graphics, readable font sizes, and more whitespace for notetaking. While the borders on the handout help to organize slides in frames, they can interfere with students' annotation.

I also noticed that many students stopped taking notes in class, resulting in less understanding and lower grades compared with the previous semester. With all of the slide content in the handout, there was little incentive to take notes. Indeed, some students referred to the handouts as "the notes"...a misconception I was determined to change.

Layout

The solution was to import text, graphics, and tables into Microsoft Word, rearranging the content and spacing to make it easier for students to take notes. Atherton¹ offers the following advice for designing "gapped" handouts to be used as scaffolding for notetaking:

- Use the handout to provide structure to the presentation.
- Provide sufficient space ("gaps") for students to take notes.
- Include complex graphics, tables, etc. without legends or labels, so students can annotate the figures with labels.

In addition to following Atherton's recommendations, I made the following changes:

- Images were enlarged for clarity, in comparison to the small figure size from the 6-to-a-page PowerPoint printing format. Line thicknesses were reduced to make the images less like cartoons. On most sheets, colors were changed to contrasting white, gray, and black which print well on a black laser printer, as illustrated in Figure 2. Where needed, color printing was used on selected handout sheets. Handouts were printed double-sided to save paper.
- Graphs, pictures, and tables were resized for legibility and to enable better notetaking, with extra whitespace where needed.
- Some labels and lines were deleted to encourage students to mark up graphs and pictures. For example, eight labels appear in the left center slide in Figure 1; these labels were deleted to make Figure 2.
- Homework and reading assignments were given at the bottom of the last page of each handout packet. The assignments were more detailed, because questions could fill the width of the page. Announcements of upcoming events were placed immediately before the assignments, because this is one portion of the handout packet that students are guaranteed to revisit.
- Large tables and supplemental diagrams such as Figure 3 were integrated sequentially into the handouts at the appropriate point in the lecture...a feat that is impossible in the standard PowerPoint printed handout format.

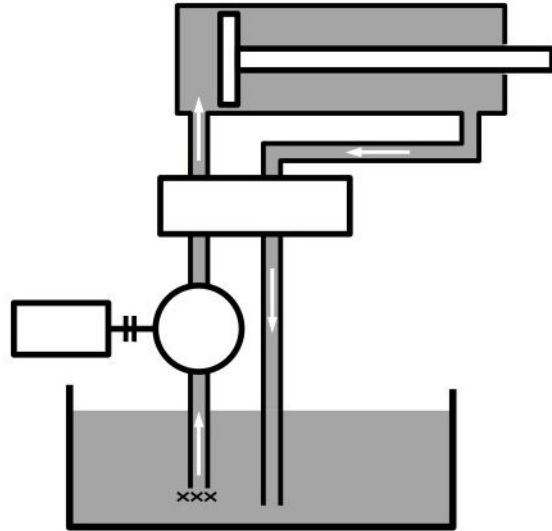


Figure 2: This diagram from Figure 1 was enlarged (shown at actual size), colors were changed to white, gray, and black for contrast. Labels were removed to encourage annotation.

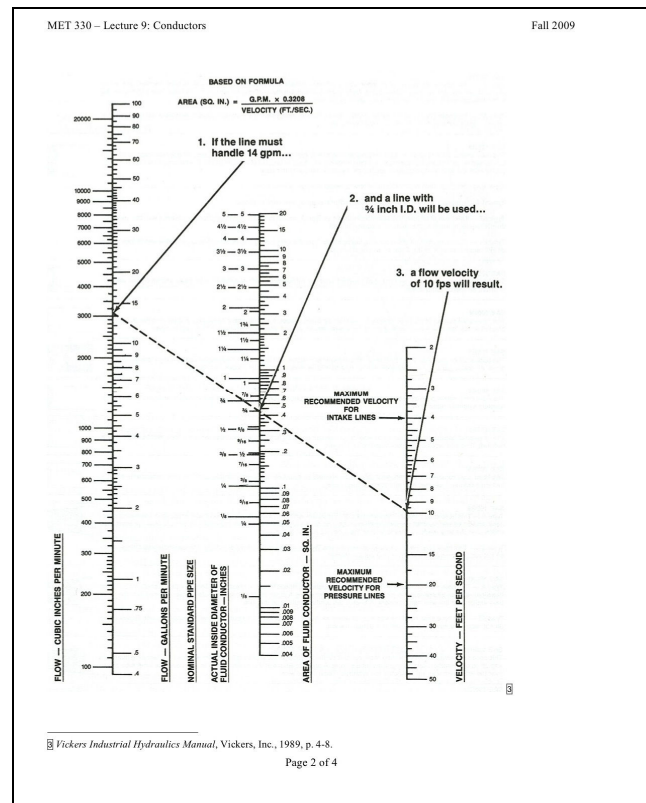


Figure 3: This nomographⁱⁱ was inserted as a page into the handout. The image is not part of the PowerPoint slideshow.

- Images which are discussed sequentially on one or more PowerPoint slides were arranged in rows or columns in the handout. For example, in Figure 4, the ladder diagram symbols for eleven types of switches are presented on two different PowerPoint slides, but they appear in a single column on the handout, with plenty of room for annotation. Also, this format enables students to make comparisons between them. Parallel to the electrical diagrams are fluid power symbols for pressure and limit switches. The electrical relay cartoons at the bottom of the page appear on two separate PowerPoint slides during the lecture; the handout allows for both cartoons to appear side by side, enabling students to make comparisons (and annotations).

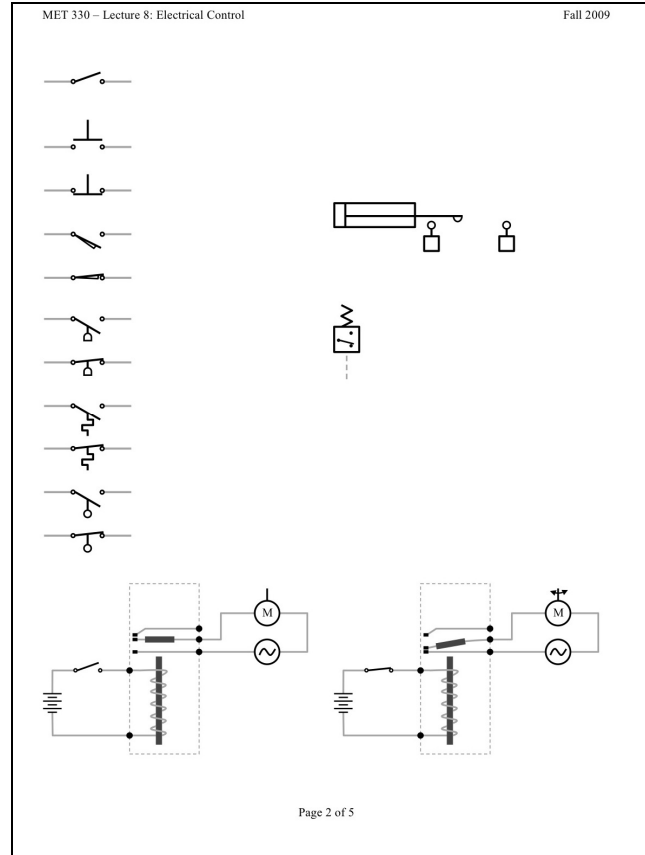


Figure 4: Electrical symbols used in ladder diagrams for electrical control of fluid power systems.

What to Leave Out

The handouts are not “the notes”; instead, they serve as templates for taking notes. McKeachieⁱⁱⁱ cites a number of studies which show that notetaking during a lecture aids memory, but excessive notetaking prevents comprehension during class. The handouts should include items which are difficult to copy (such as graphs, diagrams, and pictures), but not items which are easy to copy or which aid in comprehension (such as diagram labels and equations). For example, the PowerPoint slides which introduce Pascal’s Law (Figure 5) contain equations and labels; the handout for these slides (Figure 6) shows the diagram without the equations and labels.

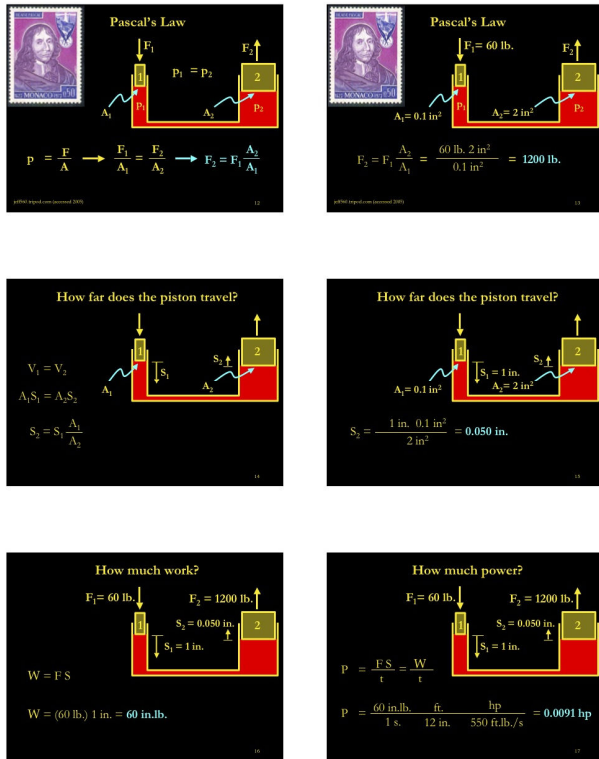


Figure 5: A series of six slides on Pascal's Law presented in class. Slides include equations and labels.

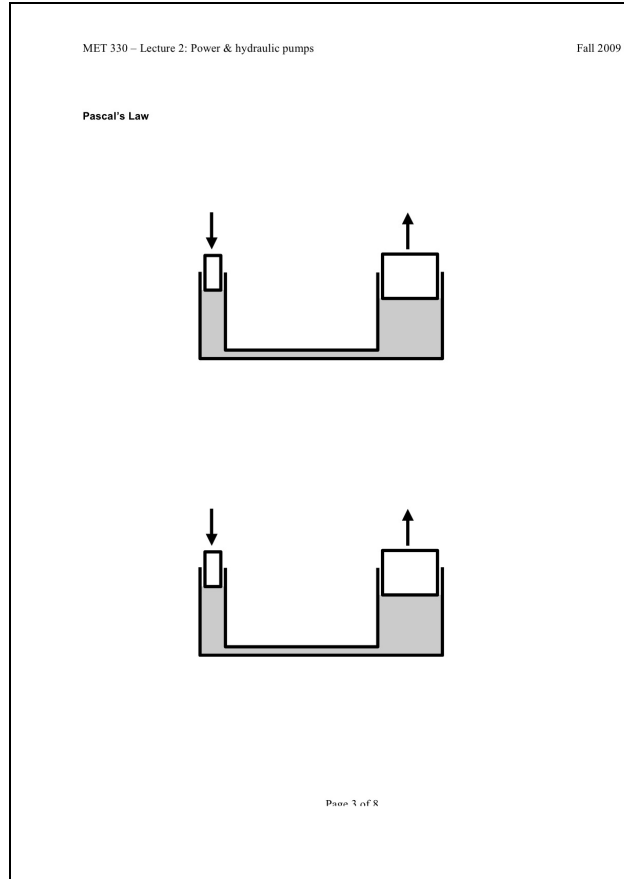


Figure 6: Pascal's Law handout, which leaves whitespace for student notes.

Assessment and Continuous Improvement

If the purpose of designing good handouts is to help students take notes and learn, then assessment should include a review of the notes students take. I award extra credit to students who provide feedback on handout design. These are the instructions for the assignment:

In this course, handouts are used as a template for taking notes in 13 lectures. The handouts contain content that is difficult to copy, such as graphs, pictures, tables, and long equations. The handouts contain whitespace for taking notes on the discussion and for copying content that is easy to copy off the screen. The amount of whitespace and the size of each image is determined by an ancient engineering principle: the Wild Guess. Sometimes the guess is good, but not always.

For extra credit, please critique these handouts, and make suggestions for their improvement. The critique must be specific and actionable. For example, "Add 1 inch of whitespace to the top of p. 7, handout #3 because I ran out of room for notes" is more useful than "I didn't like the October handouts."

Please photocopy or scan the relevant page(s) from your notes, and **mark in red** the changes you would like to see. You can benefit from extra points, and next semester's class will benefit from better handouts.

One third of the students participated in the extra credit assignment, and most of these submissions were thoughtful, detailed, and thorough. Some students submitted recommendations in sentence form. Here are some examples:

The only change I would make is on page 5 under valve actuation: separate the mechanical vs. pilot vs. solenoid better. They run together and look like they are of the same group. It would be easier to keep track of and learn.

Bad PPT – way too much info to write and comprehend while you explain. Add a legend and scale down psia/psig chart.

Lecture 11 the labeling ABC and 123 for diagrams could be written more clearly.

On lecture 2 page 3, I would like to have more room to write, because the diagrams that I had put on this page look too cluttered. If you could move the two diagrams you put on the page to the left or shrink that might help open up more space.

Most of the feedback was in red pen, on photocopies of student notes, as requested in the assignment. For example, Figures 7 and 8 show two students' comments on the Pascal's Law handout from Figure 6. They both want the diagrams to be moved, but to two different positions.

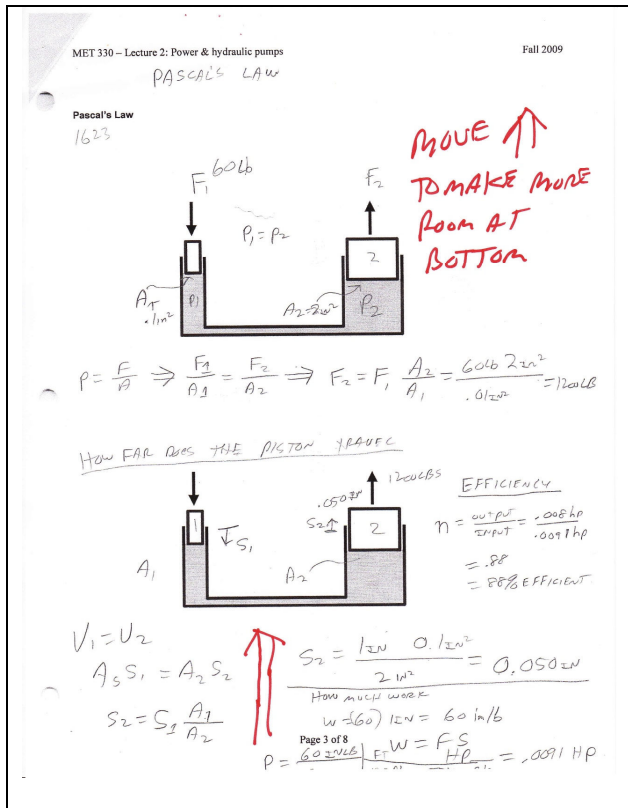


Figure 7: This student recommended moving the diagrams up to provide more whitespace at the bottom of the page.

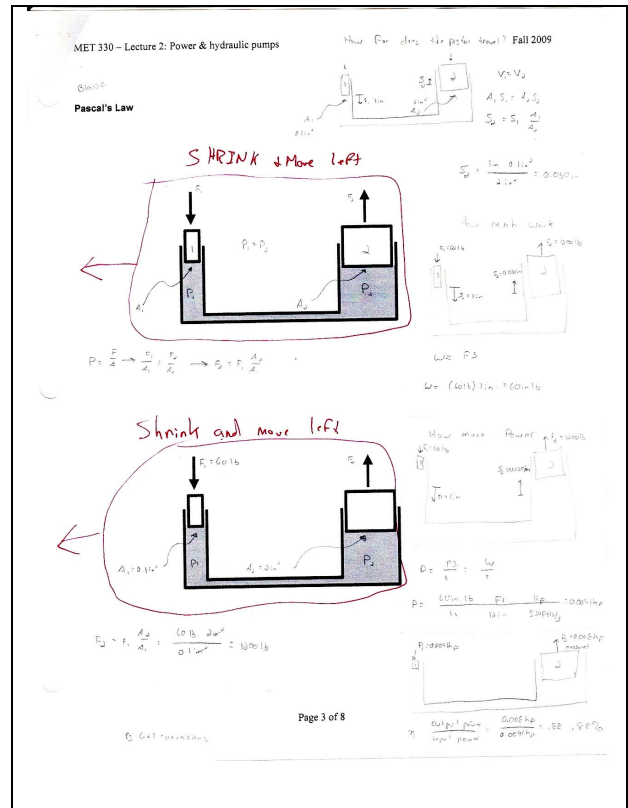


Figure 8: This student recommended moving the diagrams to the left, leaving room on the right to redraw the diagrams for specific cases.

In Figure 9, a student recommended adding more space at the top of a page. This was the first page of the handout packet, and the class began with a discussion of automatic control methods. The discussion was not based on PowerPoint slides, therefore I had failed to include space in the handout packet.

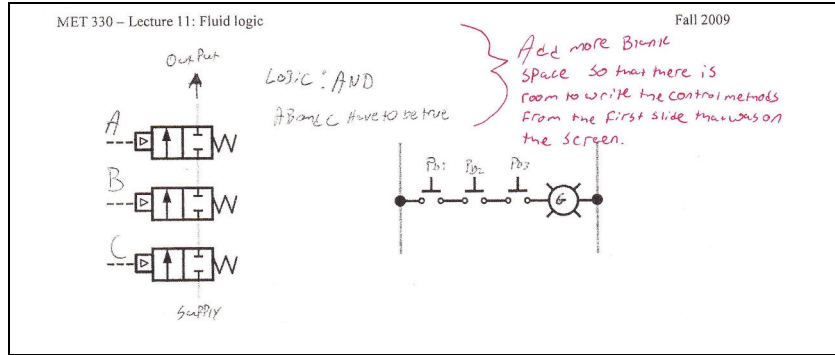


Figure 9: Another request for space.

In Figure 10, a student asked for blank lines next to key items in a diagram. The student remarked:

I think it would be very beneficial to have either boxes or lines for the information that we are supposed to fill out on the diagrams. When there is a lot of info on a slide or handout, it can be very easy to miss something on a picture with a lot of parts.

Perhaps this student has been exposed to Guided Note Taking, or GN, in a previous course. A GN handout typically includes formatting cues such as blank lines and asterisks which prompt students to write particular words or phrases. A significant body of educational research supports the effectiveness of GN, especially among students with learning disabilities. However, it was not my intention to provide this level of cueing. Instead, the handouts are meant to help students develop their annotation skills, which they can carry on to other courses as they annotate drawings, textbooks, and other documents.

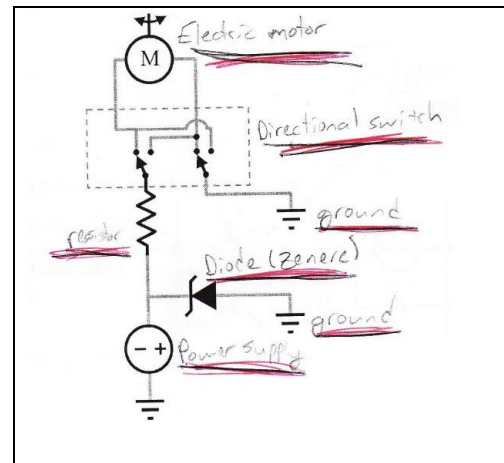


Figure 10: A request to create fill-in-the-blank lines for a diagram.

In end-of-course surveys, students say that they like the handouts, but do the handouts actually improve student learning in this course? This question is difficult to answer because the only comparative data comes from year 1 (no handouts) and year 2 (standard PowerPoint handouts) of a brand-new teaching career. Any measurable improvements in student learning since then could be attributable to the handout design, or they could be attributable to overall improvements in my teaching abilities.

Conclusions

In a highly visual course such as Fluid Power, PowerPoint is an essential instructional tool for teaching engineering graphs, cutaway images, electrical circuits, and fluid power diagrams. However, PowerPoint's printing options are inadequate. This paper discusses a number of

techniques for creating note-friendly handouts by moving PowerPoint images into MS Word, modifying the images, and providing generous whitespace for notetaking. Some of the techniques include:

- Leave out easy-to-copy images, text, and equations to encourage notetaking.
- Adjust font sizes so they appear uniform in the handout.
- Modify line thicknesses and shading as needed.
- Use color printing on selected pages if needed to clarify a diagram (but avoid color combinations such as red and green, or green and blue, which are difficult for colorblind students to discern).
- Provide generous whitespace for notetaking to the right or below images.
- Obtain specific, actionable feedback from students to improve handout design.

Feedback was obtained by asking students to mark up photocopies of their notes in red ink. This method not only provided useful ideas for improving the handouts, it also provided a rare look at how students take notes. This information can help an instructor develop better lectures as well as better handouts.

ⁱ J. S. Atherton, "Learning and Teaching; Handouts." <http://www.learningandteaching.info/teaching/handouts.htm>
Accessed January 2010.

ⁱⁱ *Vickers Industrial Hydraulics Manual*, Vickers Inc., 1989 (out of print) p. 4-8.

ⁱⁱⁱ W. J. McKeachie, *McKeachie's Teaching Tips*, 11th ed., Houghton Mifflin 2002, p. 65-67.