Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #46284

Tips and Tricks on Using LaTeX for Creating Teaching Materials—Perspectives From Two Engineering Faculty

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Tips and Tricks on Using LaTeX for Creating Teaching Materials—Perspectives From Two Engineering Faculty

Abstract

Professors spend significant time creating teaching materials such as lecture notes, handouts, homework/exercises, labs, and exams. Tools that professors use to create teaching materials include Microsoft Word, Google Docs, and LaTeXḂoth Microsoft Word and Google Docs are what-you-see-is-what-you-get (WYSIWYG) document programs whereas LaTeX is a typesetting system that uses a markup language to format plain text.

As compared to Microsoft Word and Google Docs, LaTeX is more modular, easier to create equations, allows programmatic control over typography and formatting, and separates content from the format. In the long term LaTeX can reduce the time and effort required to create teaching materials. For these reasons, the authors chose to use LaTeX to create teaching materials for their courses.

The authors will discuss how they take advantage of LaTeXś modularity, programmability, and typography to prepare their course materials. Some examples will be provided such as how LaTeX is used to create consistent looking syllabi and how it is used to turn on/off solutions in lecture handouts.

1 Introduction

Research indicates that Microsoft Word users rate their experience with Microsoft Word as less efficient than LaTeX users rate their experience with LaTeX. In addition LaTeX users report significantly higher enjoyment and less frustration than Microsoft Word users with their respective softwares. But, LaTeX users do acknowledge that there is a higher learning curve to LaTeX than Microsoft users rate Microsoft Word [1]. Some professors are introducing LaTeX to their freshman to teach students how to make professional materials (papers, resumes and reports). Those professors do recognize that there is a learning curve to LaTeX [2], but hope that if their engineering students are introduced to it early, it will be worth their investment [3].

Certainly LaTeX is not necessarily the correct tool for every project; some journals or grant institutions only accept drafts/submissions in Microsoft Word format. The authors have found LaTeX to be a worthwhile investment in transitioning preparations of their curriculum vitae, tenure documentation, and course materials. Some examples of how the authors use LaTeX to prepare their course materials are presented here.

2 Programs Used by the Authors

- MiKTeX — MiKTeX is an open-source distribution of TeX / LaTeX that includes an integrated package manager [4]. It supports Windows, Mac, and Linux. You must have a TeX / LaTeX distribution installed to compile your LaTeX source.
- TeXstudio — While you can use any text editor to edit LaTeX files, it is much easier to use an integrated writing environment like TeXstudio [5]. It has syntax highlighting, an integrated viewer to view PDF output, code insertion, and wizards for including graphics and creating tables. It is open-source and supports Windows, Mac, and Unix/Linux.
- Overleaf — Overleaf has many of the same capabilities as TeXstudio except that it is online, so you do not have to install anything [6]. In addition, it allows for collaboration between authors.
- Zotero — Zotero is a free program to help manage research information and create bibliographies in various formats, including the BibTeX format [7]. Supports Windows, Mac, iOS, and Linux.

MiKTeX and TeXstudio are installed on all department lab and classroom computers so students have easy access to LaTeX.

3 Modularity

One of the advantages of using LaTeX in your course preparation is that it is easy to make your documents modular. For example, when making syllabi with common sections, such as office hours or University Policies, these sections may be written in one LaTeX file and referenced by multiple files when compiling each syllabus using the include command. This command is also heavily used when making multiple versions of exams.

Another command often used in course preparation is includepdf. This command is used to assemble multiple PDF files into one document. This is useful for assembling problem sets for students or solutions for exams (explained in more detail below).

Finally, input is slightly different than include; include adds a page break between each instance of include. Therefore, if you are creating a multiple choice exam in which multiple questions are used on the same page, input is a better option.

4 Programmability

Below are examples of how LaTeX is used to simplify course documents and development. First, having information stored in one location is critical to removing the potential for errors. For example, having course names or topics reusable in a file can help with naming files, inserting footers, and providing clarity to students.

Even creating student handouts with corresponding faculty solutions in one place (in one file) is critical when developing lectures to minimize errors. Multiple files for student handouts and faculty solutions can be cumbersome and leaves opportunities for errors if/when corrections need to be made. If there is a typo in a problem statement of a lesson handout, the faculty must make sure to make the correction in BOTH the student handout and the faculty solution. When everything is in one LaTeX file, it is easy and straightforward to make the correction.

LaTeX can also be programmed to generate multiple versions of exams. With some thoughtful preparation, folder structure, and defining variables (or "new commands"), one can generate multiple versions of exams with reasonably minimal effort.

4.1 Variables

LaTeX allows you to create variables that can be referenced many times in the document. For example, the course number may show up in the header, in the title of the document, and in meta data of the PDF. By using a variable for the course number, you only have to enter it once in a document.

There is more than one way to create a variable in LaTeX: def, newcommand, and renewcommand.

The def command is a TeXprimitive command for defining a macro. In its simplest usage, we simply wish to replace a reference to the macro (variable) with the text we have defined:

```
\def\course{ENGR 383}
\def\topic{Lab 1}
...
\hypersetup{pdftitle={\course \topic}}
...
\fancyhead[R]{\course\ --- \topic}
```

In the example above, "course" and "topic" have been defined as variables and then are used to set the title of PDF using the hypersetup command and to set the rightmost part of the header using the fancyhead command.

One caution with def is that it does not check if the macro (variable) already exists. Thus, you can inadvertently overwrite a variable without warning.

The newcommand is a LaTeXcommand on top of the def command. One major difference between the two commands is that newcommand does check whether the macro (variable) already exists. For this reason, newcommand is safer to use than def. Here is the example above changed to use newcommand:

```
\newcommand\course{ENGR 383}
\newcommand\topic{Lab 1}
...
\hypersetup{pdftitle={\course \topic}}
...
\fancyhead[R]{\course\ --- \topic}
```

If you have a macro created with newcommand and you need to update it, then you use renewcommand to do that.

4.2 Creating Handouts for Students and Faculty in one place

In this example (Figure 1), a handout for students is shown to the left. A handout with a full solution, shown on the right, is typical of a faculty solution contained in the same LaTeX file but hidden with an ifthenelse statement from the ifthen package. The solution is shown by changing a variable in the LaTeX file and recompiling. The code to generate these two versions is shown in Figure 2 below. A variable showsolutions is set either to 0 (to show the solution) or 1 (to hide the solution) in the header of the LaTeX file, and then recompiled. With the student handout and faculty solution in one file, there is only one place necessary to make corrections should one be identified. Of course you can set these variables however you wish: use the numbers 0 and 1, in whatever order you choose, or the words "on" and "off".

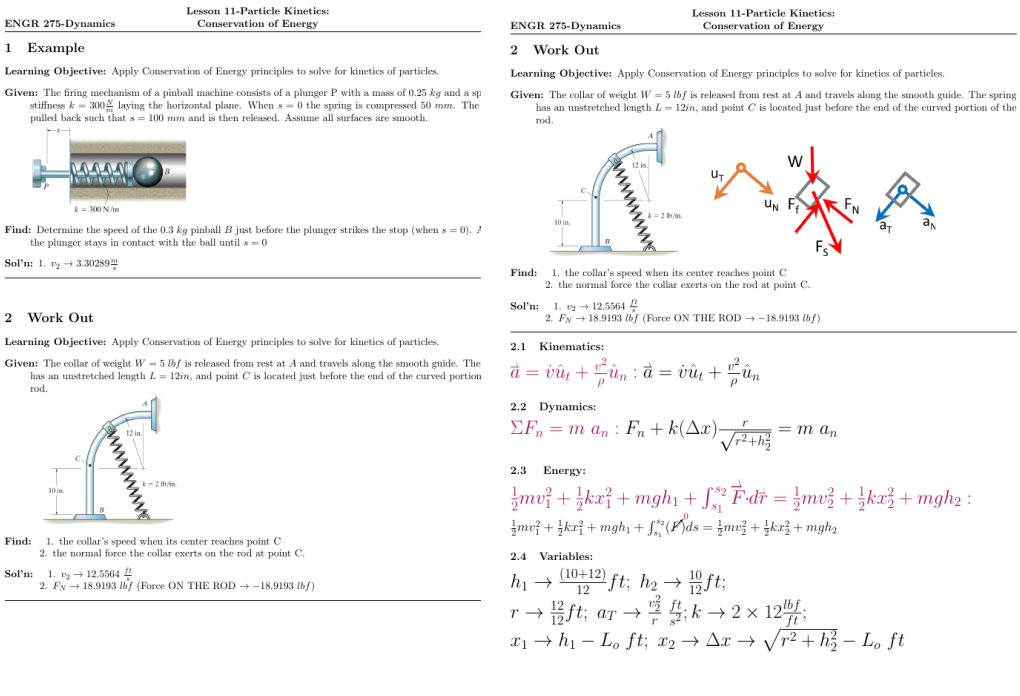


Figure 1: Example of how the ifthen package is used to create student and teacher hand outs.

Notice on the left is a hand out for students that has multiple problems on the page. Students are provided general figures and answers to the problem. However, when the instructor solution is turned on, a full solution including solution figures and equations is presented for the instructor's use. This helps generate consistent solutions between semesters and courses, and also if notes are shared between faculty.

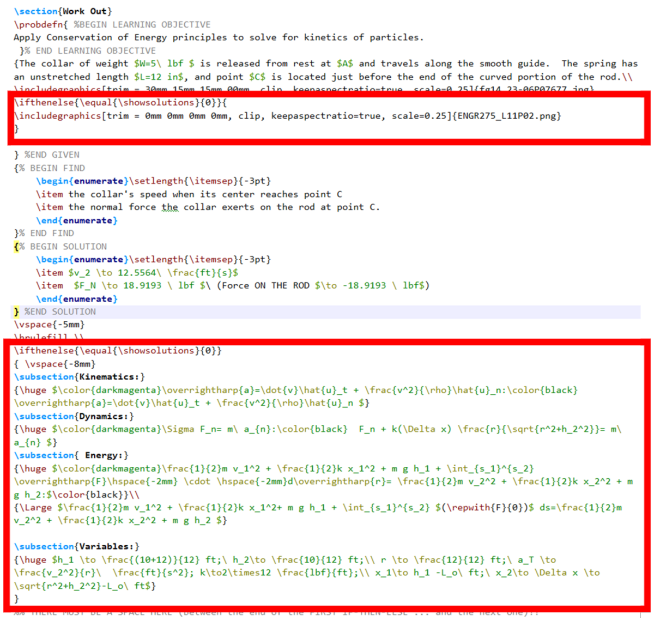


Figure 2: Example of LaTeX code used to generate lecture handouts for students and faculty contained in one file

Shown here is an example of LaTeX code that generates both a handout for students and a faculty solution in one file. The red boxes highlight the code that is "turned on" to show the solution for the faculty reference notes. This includes the coordinate system, free-body, and acceleration diagram in the top box. IN addition, there is a list of equations necessary to solve the problem displayed in the bottom box.

4.3 Creating Test Versions

In order to create a system to help in making different test versions, a directory structure was organized to break down typical test problems into subject matter areas (Figure 3). This example is for a Dynamics class. Here, newcommand is used to take advantage of LaTeX's programmability to create a variable ("version") to allow for selection between problems for different versions of a test (see Figure 4 below).

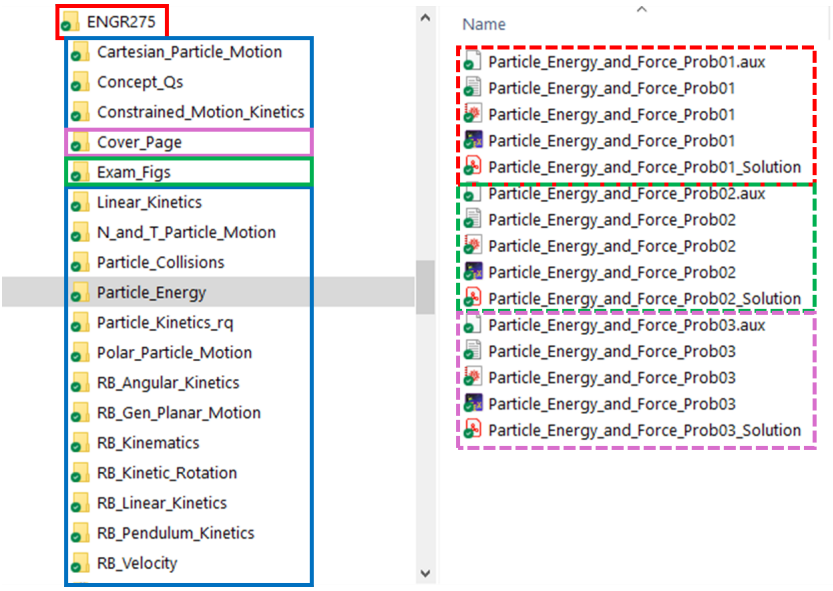


Figure 3: Example Directory Structure for Dynamics Exams

ENGR275 is the course name (solid red box). Each subfolder (solid blue boxes) is named by topic and in each topic folder are problems numbered with similar file name: Particle_Energy_and_Force_ProbXX, where XX is the problem version number (Dashed red/green/magenta). In addition, folders for a common exam cover page (solid magenta box) and all figures (solid green box) are shown.

Next, in the header of the main LaTeX file, variables were created to assist in version control. The variable "version" can change based on how many problem versions you have created. Problem numbers are set at the start but can be reset if the professor wants to change a specific problem within a specific version of a test. In addition, the number of points per problem, or rubric grading scales can be adjusted as needed. All of these variables are shown in Figure 4, below.

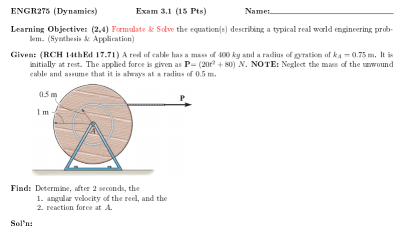
```
%% VERSION CONTROL
%% If you have multiple VERSIONS of an exam you can control version 1, 2 or 3
% by naming your problems and solutions appropriately
\newcommand{\version}{01}% 01 = one, 02 = two or 03 = three

%% COVER SHEET
\newcommand\Course{ENGR275 (Dynamics)}
\newcommand\ExamNum{3}              % Set Default Exam #  - Reads into Cover Sheet
\newcommand\ExamTime{120 minutes}   % Set Default Time  - Reads into Cover Sheet
\newcommand\TotalPts{100}           % Set Default Total Points for exam - Reads into Cover Sheet
\newcommand\Sem{FA}                 % Set Default Semester for exam - Reads into Cover Sheet
\newcommand\Year{2024}              % Set Default Year for exam - Reads into Cover Sheet

%% PROBLEM NUMBER & POINTS DEFAULTS
\newcommand\ProbNum{1}              % Set Default Problem #  - Reads into Problem Statement
\newcommand\ProbPts{25}             % Set Default Problem Points  - Reads into Problem Statement

%% GRADING RUBRIC DEFAULTS
\newcommand\CSFBDPct{42}            % Set Default Rubric Section 01 Value
\newcommand\EQNPct{32}              % Set Default Rubric Section 02 Value
\newcommand\SOLNPct{18}             % Set Default Rubric Section 03 Value
\newcommand\PRESPct{8}              % Set Default Rubric Section 04 Value
```

Figure 4: Example Latex Exam Header

Each LaTeX file contains header information including packages loaded and defined variables. For this example, exam headers also include variables such as the version of the test (solid red box). Next, all of the information that goes into the cover sheet, such as class name, exam number, time, total number of points, semester and year (solid blue box) is declared. The default problem number and points is set up next (solid magenta box), but will be adjusted as new problems are added. Finally, default rubric information is entered (solid green box).

Two ways to reference LaTeX files with problem statements and the corresponding output are shown below. First, with include shown in Figure 5 and also with input shown in Figure 6.

```
\begin{document}
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%% TITLE PAGE

\include{./Cover_Page/Exam_CoverPage}

%%  PROBLEM #1 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    \ifthenelse{\equal{\showsolutions}{0}}{
    \renewcommand\ProbNum{1}
    \renewcommand\ProbPts{15}
        \include{./RB_Kinetic_Rotation/RB_Kinetic_Rotation_Prob\version}}

    \ifthenelse{\equal{\showsolutions}{1}}
    { \includepdf[pages=-]{./RB_Kinetic_Rotation/RB_Rotation_Kinetic_Prob\version_Solution.pdf}
    }


%%% PROBLEM #2 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    \ifthenelse{\equal{\showsolutions}{0}}{
        \renewcommand\ProbNum{2}
        \renewcommand\ProbPts{15}
        \include{./RB_Gen_Planar_Motion/RB_Gen_Planar_Motion_Prob\version} }

    \ifthenelse{\equal{\showsolutions}{1}}
    { \includepdf[pages=-]{./RB_Gen_Planar_Motion/RB_Gen_Planar_Motion_Prob\version_Solution.pdf}
    }
```


ENGR275 (Dynamics) Exam 3.1 (15 Pts) Name:________

Learning Objective: (2,4) Formulate & Solve the equation(s) describing a typical real world engineering problem. (Synthesis & Application)

Given: (RCH 14thEd 17.71) A reel of cable has a mass of 400 kg and a radius of gyration of $k_A = 0.75$ m. It is initially at rest. The applied force is given as $\mathbf{P} = (20t^2 + 80)$ N. **NOTE:** Neglect the mass of the unwound cable and assume that it is always at a radius of 0.5 m.

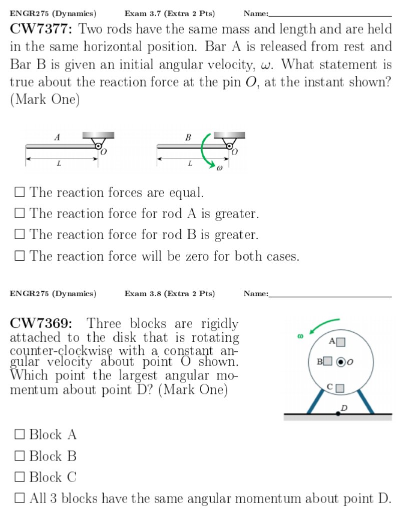
Find: Determine, after 2 seconds, the
1. angular velocity of the reel, and the
2. reaction force at A.

Sol'n:

Figure 5: Example Problem using include, includepdf, and ifthenelse

An example of using include to add questions to exams is shown here. Notice that the solution can be referenced by changing the showsolutions variable. Also notice that variables in the problem figure [8] are similar to the problem text — by default.

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%
%%                          CONCEPT QUESTIONS
%%
%%  CONCEPT QUESTION 1 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    \ifthenelse{\equal{\showsolutions}{0}}{
        \renewcommand\ProbNum{7}
        \renewcommand\ProbPts{2}
        \input{./Concept_Qs/RB_Force/CW7377}}
\
\vspace{10mm}
%%% CONCEPT QUESTION 2 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    \ifthenelse{\equal{\showsolutions}{0}}{
        \renewcommand\ProbNum{8}
        \renewcommand\ProbPts{2}
        \input{./Concept_Qs/Angular_Momentum/CW7369}}
\
\newpage
%%% CONCEPT QUESTION 3 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    \ifthenelse{\equal{\showsolutions}{0}}{
    \renewcommand\ProbNum{9}
    \renewcommand\ProbPts{2}
    \input{./Concept_Qs/RB_Force/CW7376}}
\
\vspace{10mm}
%%%%    CONCEPT QUESTION 3 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    \ifthenelse{\equal{\showsolutions}{0}}{
    \renewcommand\ProbNum{10}
    \renewcommand\ProbPts{2}
    \input{./Concept_Qs/RB_Force/CW7367}}
    \
\end{document}
```


ENGR275 (Dynamics) Exam 3.7 (Extra 2 Pts) Name:________

CW7377: Two rods have the same mass and length and are held in the same horizontal position. Bar A is released from rest and Bar B is given an initial angular velocity, ω. What statement is true about the reaction force at the pin O, at the instant shown? (Mark One)

☐ The reaction forces are equal.
☐ The reaction force for rod A is greater.
☐ The reaction force for rod B is greater.
☐ The reaction force will be zero for both cases.

ENGR275 (Dynamics) Exam 3.8 (Extra 2 Pts) Name:________

CW7369: Three blocks are rigidly attached to the disk that is rotating counter-clockwise with a constant angular velocity about point O shown. Which point the largest angular momentum about point D? (Mark One)

☐ Block A
☐ Block B
☐ Block C
☐ All 3 blocks have the same angular momentum about point D.

Figure 6: Example Problem using input

An example of using input to add concept questions to exams is shown above. Notice that there are four concept questions called, but only two could fit on a page. As many problems that fit on a page will be included using this command.

Finally, if sharing solutions with other faculty, the ifthenelse command can be used to reference the solution to each problem to compile an exam solution to share with others. Similar to how solutions are turned on or off for a lecture handout, this can all be contained in the same exam file. Notice that there is a file name: Particle_Energy_and_Force_ProbXX_Solution.pdf, where XX is the problem version number.

5 Typography

Providing clarity to students is another advantage of using LaTeX in the classroom. Many textbooks are written using LaTeX. Therefore, when referencing variables between notes and a textbook, it is easy to make your notes look like the textbook using LaTeX. This is especially true for exams. If problems are borrowed from textbooks, less time is spent on figure preparation and more time on getting the right question for

the exam. In addition, many textbooks use CircuitTikZ (a program for drawing circuits), to draw circuit diagrams. Adding this package to your LaTeX file, will provide clarity to students. However, there is a considerable learning curve to drawing circuits in LaTeX.

6 Conclusions

There are many reasons to invest the time in learning to use LaTeX in preparing course materials. These include taking advantage of LaTeX's Modularity, Programmability, and Typography. With just a little experience and some thought in how to setup your course directory structure, one can easily prepare a course that allows for adaptability, clarity in communication with students, and ease of progression as the course continues to grow.

Admittedly, there is a little bit of a learning curve to some aspects of LaTeX, however, there is a rich community of resources to help overcome problems. For example, the LaTeX Stack Exchange [9] is a great resource for general information. Tables, which can be somewhat notoriously difficult to create in LaTeX can now be generated online [10], and then pasted into your source file. And of course, having other faculty at your university or in your department can be the most useful community to helping you solve any issues you may come across.

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