

# Creating an Online Resource for Actuarial Students at WPI

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## Abstract

Many actuarial sciences students take actuarial exams during their time at WPI. WPI actuarial faculty provide many exam study resources for these students, however they expressed the need for an online exam study tool. The purpose of this project is to begin the process of creating such an online resource in the form of a database of WeBWorK question sets, as well as a Canvas site. I created a pilot resource for the FM exam, one of the first actuarial exams students typically take. The database of WeBWorK questions can also be used to support the WPI Theory of Interest courses (MA 2211 and MA 2212). I also created a guide documenting how to use WeBWorK, in order to ease the process of creating similar resources for other exams.

## Acknowledgements

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I would also like to thank the WPI Mathematical Sciences Department for sponsoring the FM Exam info session, as well as Rhonda Podell for her support.

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## 1 Introduction

According to Bloomberg, Actuarial Science is one of the most valuable degrees (Griffin, 2018). The average annual salary for actuaries is \$108,000 according to the same study, and the field does not require advanced degrees.

The costs associated with the actuarial field are considerable. Candidates are expected to acquire a bachelor's degree, and take exams and seminars in order to become a certified actuary (Society of Actuaries, 2019). Many companies that hire actuaries offer financial assistance for exams, such as paid study time off, study materials, and exam payment. Similarly, many universities including WPI offer resources for students that can help offset the costs of taking actuarial exams, including exam reimbursements and access to study manuals. However, WPI actuarial faculty are continually looking to expand their resources, particularly with an online study tool.

Online study options for actuarial exams exist, and claim to have very high success rates. One of these online study resources, Coaching Actuaries, claims a 90% passing rate after reaching a certain level in their program. Coaching Actuaries provides thousands of exam level problems, video tutorials, and forums. However, subscriptions like this one can be costly. In order to give WPI students even more options for studying for actuarial exams, WPI actuarial faculty asked me create an online resource containing past actuarial exam problems.

WPI mathematics professors sometimes use an online homework website called WeBWorK in their courses. So, the WPI community's familiarity with the WeBWorK system may make it a good location for the resource to be housed.

In this paper, first I will discuss background information regarding WeBWorK and the actuarial field in Section 2. I will then provide a methodology for how I created an online actuarial exam resource in Section 3. In Section 4 I will discuss the resulting online resource, and conclude in Section 5.

## 2 Background

I will first provide an overview of WeBWorK in Section 2.1. I will then discuss how WeBWorK is used at WPI in Section 2.2. In sections 2.3 and 2.4 I will talk about the Society of Actuaries and Actuarial Resources at WPI respectively. I will then discuss existing online resources in Section 2.5, and finally discuss the need for an Online Resource for WPI Actuarial Students in Section 2.6.

### 2.1 Online Math Homework using WeBWorK

WeBWorK is an online resource where professors can create and assign homework sets and students can complete those homework sets. The system can help professors organize and manage their courses, as well as save them time since the problems are graded automatically. Additionally, WeBWorK is open source, so it serves as a space where professors and other contributors can share problems. Hundreds of universities and institutions use WeBWorK, and can therefore contribute their questions (WeBWorK Sites, 2016).

WeBWorK was created specifically for math courses. So, WeBWorK makes it easy to assign the same math questions with different numbers or even different equations to different students. The types of questions that produce varying numbers are called "dynamic questions." One of the benefits of using WeBWorK is that you do not need to know how to write WeBWorK problems to use the system as an instructor. This is because thousands of questions are publically available. The public problems can be found in the Open Problem Library (OPL) in WeBWorK,

and can be used in any course. Once professors find the problems they like in the OPL, they can easily add the problems to their own homework sets and assign them to students.

## 2.2 WeBWorK at WPI

WeBWorK is commonly used in calculus and other lower level math courses at WPI. In these courses, the professors typically will assign graded homework sets on WeBWorK each week, then release the answers to the assignments after they are due. However, some professors do not grade their WeBWorK assignments, and encourage students to complete the assignments as a study method.

The WPI Mathematical Sciences department also uses WeBWorK as a platform to administer a math placement test for incoming first year students. The placement test is meant to be taken without notes. However, the students can take as much time as they want to complete the placement test, and do so without supervision, so students can easily be misplaced. This may lead to students choosing math courses that they do not have a sufficient background for (Abraham, 2019).

Very few WPI professors write their own WeBWorK problems, instead they pull problems from the Open Problem Library. However, actuarial professors want to incorporate their own WeBWorK problems into their courses. There are currently some WeBWorK questions used in Theory of Interest I (MA 2211) and Theory of Interest II (MA 2212) as study material, however there are not many exam level questions.

## 2.3 Society of Actuaries and Actuarial Exams

The Society of Actuaries and the Casualty Actuarial Society are two major actuarial professional organizations. The SOA and the CAS award advanced certifications for actuaries that have completed all of their requirements (Society of Actuaries, 2019). Along with seminars and courses, the requirements for actuarial certifications involve taking actuarial exams, which test candidates on topics important to the actuarial field. These exams are typically taken throughout the candidate's career, and can result in career advancement as you pass.

WPI students in particular take and pass an average of two actuarial exams during their college career (Abraham, 2019). The first few exams that actuarial students typically take are 3-hour multiple choice exams that require about 300 hours of studying, which is why being prepared is so important. Passing these exams in college can also help students obtain internships and full time positions in the actuarial field (Abraham, 2019).

## 2.4 Actuarial Resources at WPI

There are many actuarial resources for students at WPI, the first being the Actuarial Mathematics major, which is a specialized program in the Mathematical Sciences Department. Within the major there are seven courses listed in Table 1.

Course Number	Course Name
MA 2211	Theory of Interest I
MA2212	Theory of Interest II
MA 3212	Actuarial Mathematics I
MA 3213	Actuarial Mathematics II
MA 4213	Loss Models I – Risk Theory
MA 4214	Loss Models II – Survival Models
MA 4892	Topics in Actuarial Mathematics

*Table 1 describes the actuarial courses offered at WPI as of April 25, 2019.*

Currently, WeBWorK problem sets are used as a study method in MA 2211 and MA 2212. These two courses cover Financial Mathematics topics from the FM Exam. The WPI Mathematical Sciences Department also offers many probability, statistics, and calculus courses that are imperative to the actuarial studies.

Additional resources for WPI students include exam study materials, the Actuarial Club, and exam reimbursements. The Mathematical Sciences Department also houses an “Actuarial Library.” This library consists of study manuals for actuarial exams, which are large sets of past exam questions. Study manuals can be bought online, however WPI students have the ability to borrow them from the Actuarial Library at no cost. The WPI Actuarial Club puts on actuarial events throughout the year including Excel workshops, resume and interview help sessions, and social events. They also facilitate networking between WPI actuarial students and various insurance companies. Additionally, the Actuarial Program Coordinator reimburses students for the cost of their exam if they pass.

### 2.5 Existing Online Exam Study Tools

There are also student discounts on certain exam study services including coachingactuaries.com (Coachingactuaries, 2019). Websites like Coaching Actuaries provide an online alternative to traditional studying. A Coaching Actuaries subscription allows you to access: video tutorials of specific exam problems, timed practice exams, and forums (What are the Benefits of Adapt?, 2018). They also implement progress tracking, which can give students an idea of how prepared they are for the exam (What are the Benefits of Adapt?, 2018).

There are many benefits to using online exam study tools that make them popular study methods. Since some actuarial exams (including exams P and FM) are typically taken on computers, the online study tools can replicate a similar environment to a real exam. One of the drawbacks of these subscriptions is that they can be costly, sometimes hundreds of dollars for an adequate amount of access time. The costs associated with taking actuarial exams can be a barrier for actuarial students, especially for African American and Hispanic students (Casualty Actuarial Society, 2018). So, WPI actuarial faculty approached me to create an online exam study tool using WeBWorK for WPI student.

### 2.6 Online Actuarial Exam Resource using WeBWorK

There are many benefits and drawbacks to using WeBWorK for the vessel of the online study tool. Some of these benefits and drawbacks are presented in Table 2.

Potential <b>Benefits</b> of WeBWorK Study Tool	Potential <b>Drawbacks</b> of WeBWorK Study Tool
Accessible - No cost for WPI students	WeBWorK is not intended for self-driven studying, but for courses
The WPI community is familiar with WeBWorK	No progress tracking ability
Anyone can find resources on WeBWorK if they are having usability problems	Being online can lead to distractions
Convenient - Students and Professors can access WeBWorK on any device	WeBWorK immediately tells you if your answer is wrong or right, which is not true in actuarial exams

*Table 2 depicts the benefits and drawbacks of WeBWorK*

The main reason why I choose to use WeBWorK (as well as Canvas) is that the WPI community already has access, and is already familiar with the system. Each problem set can be

reached from Canvas, because that is the most intuitive way for students to find the sets. The canvas site can also be used to upload relevant documentation, such a study notes, that cannot be uploaded to WeBWorK. Using the Canvas site in addition to the WeBWorK site will add versatility to the functions that the resource can provide.

One of the first exams that aspiring actuaries take is Exam FM: Financial Mathematics. It is likely that students will sit for the FM exam during their time at WPI, which is why I chose FM as the first exam to include in the resource. FM is a 3-hour, 30 multiple-choice question exam (Exam FM: Financial Mathematics, 2019). The main topics of the exam include: time value of money, annuities/cash flows, loans, bonds, asset/liability management, general cash flows and portfolios, immunization, interest rate swaps, and determinants. The Society of Actuaries recommends that you study for 300 hours for the exam, and the exam has about a 50% passing rate (Exam FM: Financial Mathematics, 2019). It is my goal that once the FM exam resource is complete, this concept and methodology can be applied to create other actuarial exams in the future.

### 3 Methodology

I will now discuss my methodology for creating the online actuarial resource. I will describe how I decided what problems to write in Section 3.1. Then in Section 3.2 I will discuss how I familiarized myself with the WeBWorK system from an instructor's perspective. In Sections 3.3 and 3.4 I will describe how I learned how to write WeBWorK problems, then how I created problem templates for each type of question. Once I designed a labeling convention and file organization system as described in Section 3.5, I compiled all of the information I learned and began writing the WeBWorK problems in Section 3.6. Finally, in Section 3.7, I will discuss how I created the Actuarial Resource WeBWorK Guide.

#### 3.1 Decide What Problems to Write

There are two types of problems that I wrote for the FM Exam WeBWorK course: past exam questions and drill questions. The Society of Actuaries has release the questions and solutions of 7 past FM exams, and they can be found online (Past Exams and Solutions, 2019). It was important to include the problems from the past exams because they are the most relevant study materials. This way, students will be exposed to exam-level questions, and can get used to entering their answers on a computer. On the same note, the Society of Actuaries also provides a sample FM exam on their website, and all of those questions were incorporated for the same reason the past exam questions were included (SOA Exam FM Sample Exam, 2019).

It is clear that including the past exam questions are important, however the syllabus for exam FM has changed since those exams were given. Since these questions are no longer relevant, I did not include any questions with topics no longer on the syllabus.

The second type of questions I included in the resource are called "drill questions" these questions are intended to help with memorization, understanding, calculator skills and speed. Drill questions can take anywhere from 10-60 seconds to complete, and are therefore not exam-level questions.

#### 3.2 WeBWorK Familiarization

Once I decided what problems to write, I began familiarizing myself with the WeBWorK system, including: the interface, common question types, user support, and programing language. This allowed me to see what functionality WeBWorK has, as well as its limits.

It was important to learn how to use the WeBWorK Interface from the perspective of an instructor, so I learned how to create homework sets, assign problems, upload files locally, and



search for problems in the Open Problem Library (OPL) through online research. After learning about the structure of WeBWorK courses, I was able to decide on the structure of the FM Exam course. I decided to create homework sets that are open for 30 years, so that students may complete them at any time.

I also familiarized myself with the common question types of WeBWorK problems, two of which being multiple choice and dynamic short answer questions. I chose to use multiple choice questions for the exam-level questions in order to simulate the FM Exam, and I chose to write the drill questions as dynamic short answer questions for versatility.

Next, I researched what user support is available for WeBWorK problem authors, and the programming language used to write problems. As for user support, there is a WeBWorK wiki that contains many helpful webpages about both using WeBWorK and problem writing. It was through the wiki that I was able to find information on the programming language and syntax of WeBWorK problems. From the wiki, I discovered that WeBWorK problems are written in text files in the programming language Perl. The syntax for problems is PG which stands for “problem generating”, and the text files must be saved as .pg files (Problem Authoring Background Information, 2015). There is also a WeBWorK forum, which includes many problems that have already been solved, and the option to ask your own question (Using WeBWorK, 2019).

### 3.3 Learn How to Write WeBWorK Problems

Once I learned about the WeBWorK system, I then focused on how to write problems. I was able to find documentation depicting the basic problem structure of WeBWorK problems (A First WeBWorK Sample Problem, 2011). In general, a WeBWorK problem includes the following sections: tagging and description, initialization, problem set up, problem text, and answer and solution section.

I found browsing the OPL to be the most helpful resource for writing problems, since I was able to view the code associated with each problem. For example, when I was learning how to write a multiple choice problem, I searched for multiple choice problems on the OPL, and was able to apply the code to my own problems.

### 3.4 Design Question Formats and Templates

Once I had a basic understanding of WeBWorK questions, I had to find a way to make all of the problems I was about to write cohesive and easy to understand. This involved making formatting and syntax decisions, so I created templates of each problem type: multiple choice and dynamic. In order to do this, I researched how problem writers typically format their code, and got ideas from existing WeBWorK problems.

### 3.5 Design Organization and Labeling System of Problems

Before I could start writing all of the WeBWorK problems, I had to create a file naming and sorting system. This was necessary because the large number of problems could lead to difficulty finding problems of certain topics. I also needed to decide on naming convention for individual problem files so that they can be easily traced back to their origin, in case something is wrong with the problem. This file organization system and naming convention must also be easily applied to other exams in the future.

### 3.6 Write WeBWorK Problems

Once steps 3.1-3.5 were complete, I was able to get started creating problem files for the past FM exam questions. My general process for writing the WeBWorK problems was to draft them in bulk, then edit them in bulk. For example, I would code one problem at a time, then upload about 50 problems to WeBWorK at once in order to proof-read them. Then I would edit

the problems with errors, then re-upload them to WeBWorK. I followed the same process with the drill questions, however they take longer to write.

### 3.7 Ensure Application of Resource to Other Exams

Once all of the problems were written and uploaded to the WeBWorK course, I focused my efforts into documenting the process so that it can be re-created for other exams in the future. I also added most of the materials I used to write the problems on a flash drive for future use including: all exam problem files, pdf copies of the past FM exams, a problem inventory spreadsheet, my PowerPoint presentation file, and the WeBWorK Guide.

I also presented my work to the WPI actuarial faculty and students, so that they may begin using the resource as soon as possible. I also worked with the WPI actuarial faculty throughout the project so that they have an in-depth understanding of how to use the resource.

## 4 Results and Discussion

In Section 4, I will discuss the results of the methodology, starting with the resulting FM Exam WeBWorK and Canvas sites in Section 4.1. I will then describe how I educated my target audience about the resource in Section 4.2. In Section 4.3 I will describe the Actuarial Resource WeBWorK Guide.

### 4.1 The FM Exam WeBWorK Site

The completed FM Exam WeBWorK Site contains 474 exam questions, and 45 drill questions, totaling 519 questions. I created an inventory spreadsheet containing: problem file names, what exam they were pulled from, and what topics they cover. I decided to sort the problems by the exam they came from, as well as by topic, so that the actuarial professors can easily find what types of problems they are looking for. This means that each problem shows up in multiple local folders, and in multiple homework sets. The list of folders is shown in the Table 3.

	Folder Name	Count of Problems
1	annuities	41
2	determinants	30
3	duration convexity	23
4	immunization	11
5	IRR NPV	8
6	loans bonds	106
7	past topics	138
8	present future acc value	81
9	rates of return	14
10	spots forwards	8
11	swaps	12
12	yield curves	2
13	May 2000 Exam	52
14	November 2000 Exam	49
15	May 2001 Exam	46
16	November 2001 Exam	48
17	May 2003 Exam	48

18	May 2005 Exam	22
19	November 2005 Exam	23
20	Practice Exam 2017	186
21	Annuity drill questions	15
22	Rate conversion drill questions	30

Table 3 folder organization

Each exam problem file name includes the exam they are from, and the number problem that they were on the exam. This is so they can be easily traced back to their origin, in case something is wrong with the problem. An example of the problem naming system of .pg files is shown in Figure 5, and the naming system for images is shown in Figure 6.

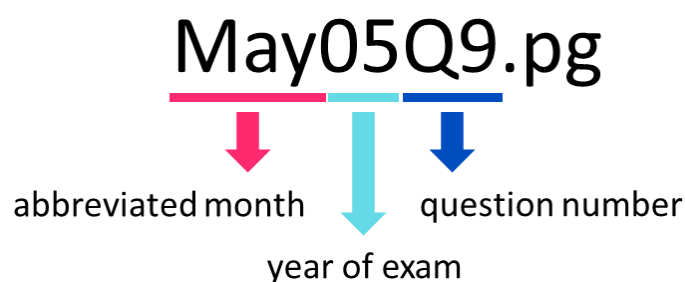


Figure 2 File naming convention example: PG file

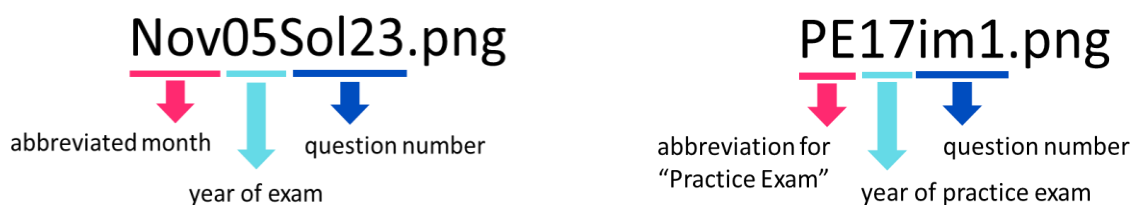


Figure 1 File naming convention example: solution image (left), other image (right)

From the student's perspective, there are 34 sets to complete. This includes six drill sets, and 28 exam level sets. The list of sets available to students is shown in Table 6.

Set Name	
1	Annuities Set 1
2	Determinants Set 1
3	Duration and Convexity Set 1
4	Immunization Set 1
5	IRR NPV Set 1
6	Loans and Bonds Set 1
7	Loans and Bonds Set 2
8	Past Topics Set 1

9	Past Topics Set 2
10	Past Topics Set 3
11	Present and Accumulated Value Set 1
12	Rates of Return Set 1
13	Spots and Forwards Set 1
14	Swaps Set 1
15	Yield Curves Set 1
16	May 2000 Exam
17	November 2000 Exam
18	May 2001 Exam
19	November 2001 Exam
20	May 2003 Exam
21	May 2005 Exam
22	November 2005 Exam
23	Practice Exam Set 1
24	Practice Exam Set 2
25	Practice Exam Set 3
26	Practice Exam Set 4
27	Practice Exam Set 5
28	Practice Exam Set 6
29	Annuity Drill Questions Set 1
30	Annuity Drill Questions Set 2
31	Annuity Drill Questions Set 3
32	Rate Conversion Drill Questions Set 1
33	Rate Conversion Drill Questions Set 2
34	Rate Conversion Drill Questions Set 3

*Table 4 Sets available to students*

Figure 3 shows the question format I used to code each exam problem. Each problem provides the answers to the questions in the hints, shown in purple. This is so that each student can elect to see the solutions at any time, as opposed to when the homework assignment is due. Since the resource is meant to be used as a self-study method, I decided that having the solution in the question is appropriate. Additionally, students can enlarge the image in the second purple hint by clicking on it.

(1 point) **FM\_17\_Practice\_Exam/PE17Q13.pg**

Ernie makes deposits of 100 at time 0, and  $X$  at time 3. The fund grows at a force of interest

$$\delta_t = \frac{t^2}{100}, t > 0.$$

The amount of interest earned from time 3 to time 6 is also  $X$ .

Calculate  $X$ .

- A. 485
- B. 385
- C. 785
- D. 685
- E. 585

[Click for the answer](#)

785

[Click for the full solution](#)

The accumulated amount is  $100 + \int_0^3 100t dt + X e^{\int_0^3 \delta_t dt} = 100 + 1500 + X e^{0.09} = 1650 + X e^{0.09}$ .  
 The amount of interest earned from time 3 to time 6 is  $X e^{\int_3^6 \delta_t dt} - X = X e^{0.09} - X = X(e^{0.09} - 1)$ .  
 Setting  $1650 + X e^{0.09} = X e^{0.09} - X$  gives  $1650 = -X$ , so  $X = -1650$ .  
 The correct answer is C.

Figure 3 Student view of an exam-level FM question

Figure 4 depicts an example of an annuity drill question. Drill questions contain the solutions in the hints as well, with the exception that they provide an extra solution type. Since it is important for candidates to hone their calculator skills, the third hint provides the inputs students would need to enter into their calculator to get the correct answer. Rate conversion drill questions have the same general form as annuity drill questions, except they do not include calculator solutions.

(1 point) **Drill\_CH2/sni.pg**  
 Round your answer to **4 decimal places**.

$s_{\overline{52}|0.063} =$

[Click for the numerical solution](#)

364.6573

[Click for the full solution](#)

$364.6573 = (((1+0.063)^{52}-1)/0.063$

[Click for the calculator solution](#)

N= 52  
 I/Y= (0.063)(100)  
 PV= 0  
 PMT= -1  
 CMPT FV

Figure 4 Student view of an annuity drill question

This resource will be available to all WPI students from May 1, 2019 on. Each WPI actuarial student will be invited to join the course on this day, and other WPI students may join by request.

#### 4.2 Student and Faculty Engagement

I educated both WPI actuarial students and faculty about the Canvas and WeBWorK sites in multiple ways. I mainly educated the faculty through weekly project advisory meetings. Since I took their concerns and requests into consideration during the design of the resource, I was able to tailor it to WPI's needs.

I was able to spread the word of the resource to actuarial students with the help of the WPI Actuarial Club. I sent multiple emails detailing how to access the sites, and how they are meant to be used to the club members. I also held an "FM Exam Info Session" for WPI students on April 16, 2019. In this info session, I described multiple aspects of the FM Exam, as well as demoed the Canvas and WeBWorK sites. This info session hopefully gave the students a good idea of how they can use the resource as a study method. The PowerPoint file I used at the info

session is included in Appendix A. With modifications, this PowerPoint can be used for future presentations about the resource.

### 4.3 WeBWorK Guide

As mentioned in section 3.7, I documented my process by creating a guide to making actuarial resources. This guide is included in full in Appendix B. It provides information on how to use the WeBWorK interface and how to write WeBWorK problems. The chapters in the guide are listed below:

1. About WeBWorK
2. Locally Uploading Problems to WeBWorK
3. Assigning Problem Sets to Students
4. Writing WeBWorK problems
5. Relevant Problem Types and Examples

The guide is meant to ease the creation of additional actuarial exam online tools in the future.

## 5 Recommendations and Conclusion

Since the FM Exam WeBWorK and Canvas Sites will be available to students after the end date of this project, it is important that the actuarial faculty ask for feedback on the resource from the students. It is also important that the actuarial faculty continually updates the list of students who have access to the resource, as well as hold frequent information sessions about the resource. My PowerPoint presentation, described in Section 4.2, can be updated and used for future presentations. I recommend these presentations be given once a year, in D-Term, but mentioned in the first Actuarial Club meeting of the year in A-Term.

Alternatively, I recommend adding actuarial club exec members as instructors to the resource. In this scenario, the Actuarial Club would play a larger role in managing the access list and answering student's questions about the resource. Additionally, the Actuarial Club would be responsible for presenting about the resource on a yearly basis. This would limit the administration time of the resource for actuarial faculty, since a student group would be the main contact point. In the end, I leave it up to the actuarial faculty to decide who moderates the resource.

In order to expedite the creation of other actuarial resources, WPI actuarial faculty should consider offering it as an IQP opportunity. I recommend that the next exam resource be made for the Probability exam (P), since P is the other introductory exam. My hope is that the FM Exam WeBWorK course is a valuable resource for Actuarial Students, that increases their preparedness for the FM Exam. The resource has the potential to help decrease the financial barriers for WPI students who are studying to become actuaries.

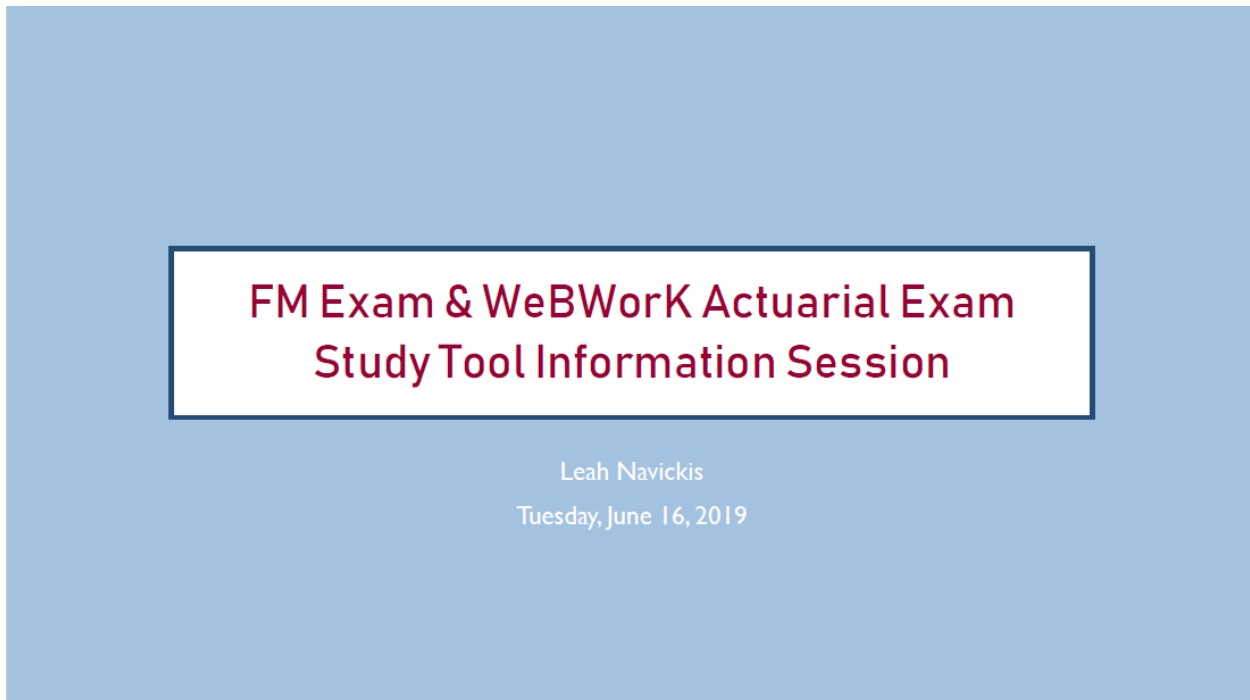
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- Problem Authoring Background Information*. (2015, September 28). Retrieved from [webwork.maa.org: http://webwork.maa.org/wiki:Problem\\_Authoring\\_Background\\_Information#.XLIvvehKg2w](http://webwork.maa.org/wiki:Problem_Authoring_Background_Information#.XLIvvehKg2w)
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- Using WeBWork: General Forums*. (n.d.). Retrieved from [webwork.maa.org: http://webwork.maa.org/moodle/mod/forum/index.php?id=3](http://webwork.maa.org/moodle/mod/forum/index.php?id=3)
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- WeBWork Sites*. (2016, June 22). Retrieved from [WeBWork: http://webwork.maa.org/wiki:WeBWork\\_Sites#.XK-AHOhKg2w](http://webwork.maa.org/wiki:WeBWork_Sites#.XK-AHOhKg2w)
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## Appendix A: FM Info Session PowerPoint

Slide 1:

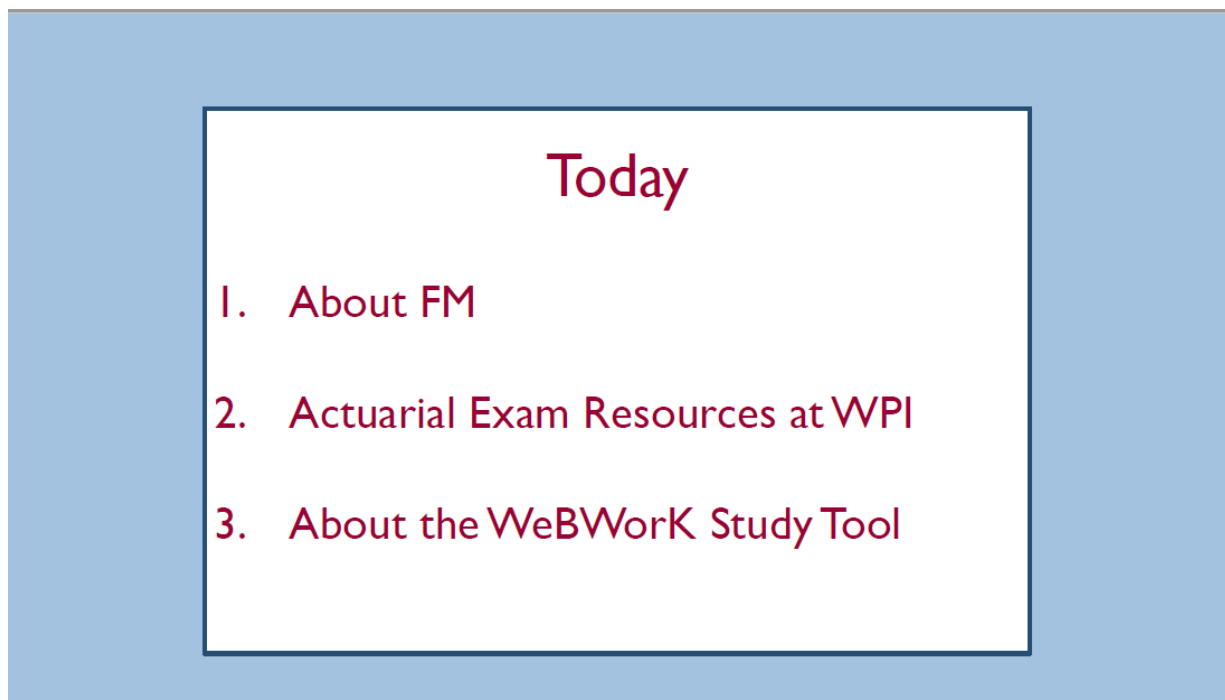


Slide 1 is a blue rectangular slide with a white rectangular box in the center. The box contains the title "FM Exam & WeBWork Actuarial Exam Study Tool Information Session" in a dark red font. Below the box, the presenter's name "Leah Navickis" and the date "Tuesday, June 16, 2019" are written in a smaller, light blue font.

**FM Exam & WeBWork Actuarial Exam  
Study Tool Information Session**

Leah Navickis  
Tuesday, June 16, 2019

Slide 2:



Slide 2 is a blue rectangular slide with a white rectangular box in the center. The box contains the word "Today" in a large, dark red font. Below it is a numbered list of three items in a dark red font: "1. About FM", "2. Actuarial Exam Resources at WPI", and "3. About the WeBWork Study Tool".



**Today**

- 1. About FM**
- 2. Actuarial Exam Resources at WPI**
- 3. About the WeBWork Study Tool**

Slide 3:

I. About FM

# Why Actuarial Exams?

**ASA** Associate of the Society of Actuaries—Requirements    **CERA** Chartered Enterprise Risk Analyst—Requirements    **FSA** Fellow of the Society of Actuaries—Requirements

**ACAS:** Associate of the Casualty Actuarial Society    **FCAS:** Fellow of the Casualty Actuarial Society

<https://www.casact.org/admissions/process/>  
<https://www.soa.org/education/general-info/default.aspx>

Slide 4:

I. About FM

**Exam FM: Financial Mathematics**

“Exam FM is a three-hour multiple-choice examination and is offered via computer-based testing (CBT).”

<https://www.soa.org/education/exam-req/edu-exam-fm-detail.aspx>

- Time Value of Money
  - Annuities/cash flows
  - Loans
  - Bonds
  - asset/liability management
  - General Cash Flows and Portfolios
  - Immunization
  - Interest Rate Swaps
  - Determinants

Slide 5:

2. Actuarial Exam Resources at WPI

Study Manuals      Exam Reimbursements

Theory of Interest Courses

Actuarial Club

Talk to Profs. Abraham and Posterro!!!

Slide 6:

2. Actuarial Exam Resources at WPI

Student Discounts  
(must prove enrollment)

<https://www.coachingactuararies.com/>

@ coachingactuararies

---

Additional Resources: <https://www.soa.org/education/exam-req/resources/edu-sem-workshops.aspx>

Slide 7:

### 3. About the WeBWork Study Tool

- Database of past FM Exam questions
- Full exams
- Sets of exam questions by topic
- Drill questions

\*\*You will have full access to the FMExam WeBWork course starting on May 1, 2019

Slide 8:

### 3. About the WeBWork Study Tool

#### Exam questions:

- Multiple Choice
- Solutions are in the hints!

#### Drill questions:


- Short answer (Type in value)
- Answers:
  - Value
  - Equation Solution
  - Calculator Solution

Slide 9:

### 3. About the WeBWorK Study Tool

Find it through  
canvas:

<https://canvas.wpi.edu/>



# WEBWORK PROBLEM AUTHORING GUIDE FOR WPI ACTUARIAL SCIENCES



Navickis, Leah  
WORCESTER POLYTECHNIC INSTITUTE

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## Context

My name is Leah Navickis and I am an Actuarial Mathematics major and member of the WPI class of 2019. I created this document as part of my Major Qualifying Project. Many actuarial sciences students take actuarial exams during their time at WPI. WPI actuarial faculty provide many exam study resources for these students, however they expressed the need for an online exam study tool.

The purpose of this project is to begin the process of creating such an online resource in the form of a database of WeBWorK question sets, as well as a Canvas site. I created a pilot resource for the FM exam, one of the first actuarial exams students typically take. This pilot resource will also be used in the Theory of Interest courses offered at WPI. Since this is meant to be a study tool, solutions are always available to the students, so some of the techniques used may not apply to graded courses. This document serves as a guide of how to use WeBWorK, in order to ease the process of creating similar resources for other exams.

## 1 About WeBWorK

### 1.1 Purpose of WeBWorK

Simply put, WebWorK is an online resource where professors can create and assign homework sets and students can complete those homework sets. The system can help professors organize and manage their courses, as well as save them time since the problems are graded automatically. Additionally, WeBWorK is open source, so it serves as a space where professors and other contributors can share problems.

### 1.2 Programing Language

The programing language used to write WeBWorK problems is called PG, which stands for “Problem Generating” (Problem Authoring Background Information, 2015). The Problem Generating syntax is written in Perl, and takes some practice. I have found that the easiest way to write problems is to start with an existing problem template, so that you do not have to write problems from scratch. Examples of the PG language can easily be found online, and I will discuss multiple examples in Section 5.

### 1.3 WeBWorK Resources

There are many resources for the WeBWorK community to use. In this section, I will discuss the ways I found useful for both learning how to use WeBWorK and writing new problem types including:

1. The WeBWorK Website
2. The WeBWorK Forum
3. The Open Problem Library (OPL)

#### 1.3.1 The WeBWorK Website

There are multiple web pages on [webwork.maa.org/wiki](http://webwork.maa.org/wiki) that contain valuable information (Main Page: WeBWorK Documentation Wiki, 2019). You should explore the website before writing problems, and start your search for questions there.

#### 1.3.2 The WeBWorK Forum

The WeBWorK forums are excellent for trouble shooting problems in either your code or in the WeBWorK site. You can find questions people have asked, or post your own question (Using WeBWorK: General Forums, n.d.). Some of the questions are answered by regular users or by WeBWorK developers.

#### 1.3.3 The Open Problem Library (OPL)

The most useful way to learn how to write WeBWorK problems is to look at code from similar existing problems. Luckily, thousands of problems are freely available to view and use on

your WeBWorK course website. You can view problems by logging into your WeBWorK course, and navigating to the library browser page. This is shown later on in Figure 14, but you will want to select “Open Problem Library” instead of “Local Problems” next to “Browse”.

#### 1.4 WPI and WeBWorK

WPI is a participating institution in WeBWorK. Many WPI professors use WeBWorK for introductory math and science courses, utilizing freely available homework problems already on WeBWorK. However, not many WPI professors write WeBWorK problems. The purpose of this guide is to serve as a reference for members of the WPI actuarial community in writing WeBWorK problems.

Currently (April 2019), WPI has their own WeBWorK server. You can verify this on the “WeBWorK Sites” page on [webwork.maa.org](http://webwork.maa.org) (WeBWorK Sites, 2016). The system administrator is responsible for managing WPI’s server. The WeBWorK administrator can make new courses and assign instructors to them, which is why it is important to contact them at the beginning of your project. Instructors have the ability to manage their particular courses, including adding students to the course, creating problem sets, assigning problem sets, and uploading their own WeBWorK problems (Instructors, 2016). So, if you are writing problems, you will need to ask the administrator to create a course for you and register you as an instructor. Students have the ability to complete homework sets assigned to them.

#### 2 Locally Uploading a Problem to WeBWorK

There are multiple ways to write and upload your WeBWorK problems to your local problem database, but in this section I will guide you through the method I found most intuitive and useful. Figure 5 shows a flowchart of the process of uploading a problem to WeBWorK.

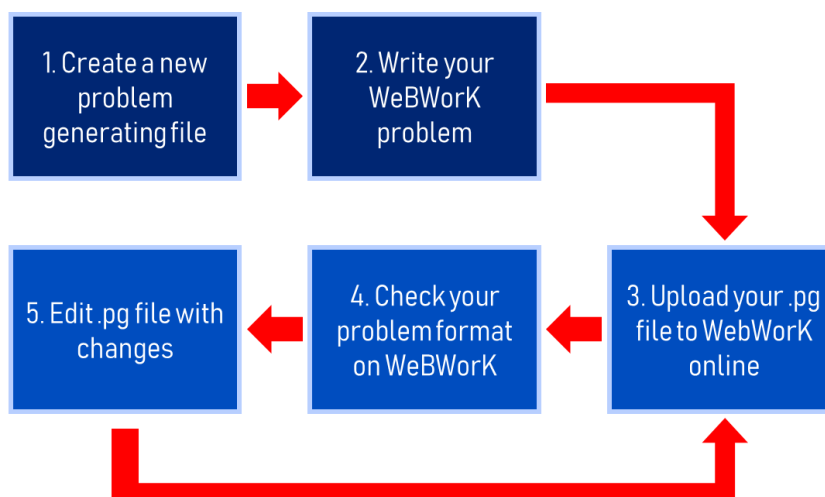


Figure 5 Flow chart depicting the process of uploading a problem to WeBWorK.

##### 2.1 Create a new problem generating file

The first step is to create a text file where you will write your WeBWorK problem. Each WeBWorK problem exists in its own text file, so it is important to use a naming convention and keep your problem files organized. First, open the Notepad application on your computer, or any application that allows you to save a file as a text file. Once you have created a new text file, name and save your file as a .pg file, so that WeBWorK will read it as a problem file. “Pg” stands for “problem generating”. In order to do this, press “file” then “Save as” at the top left of the window. Next to “Save as type”, select “All files”. Then, type your problem name followed by .pg in the “File name” box. The process of saving a file as a problem generation file is shown in Figure 6.

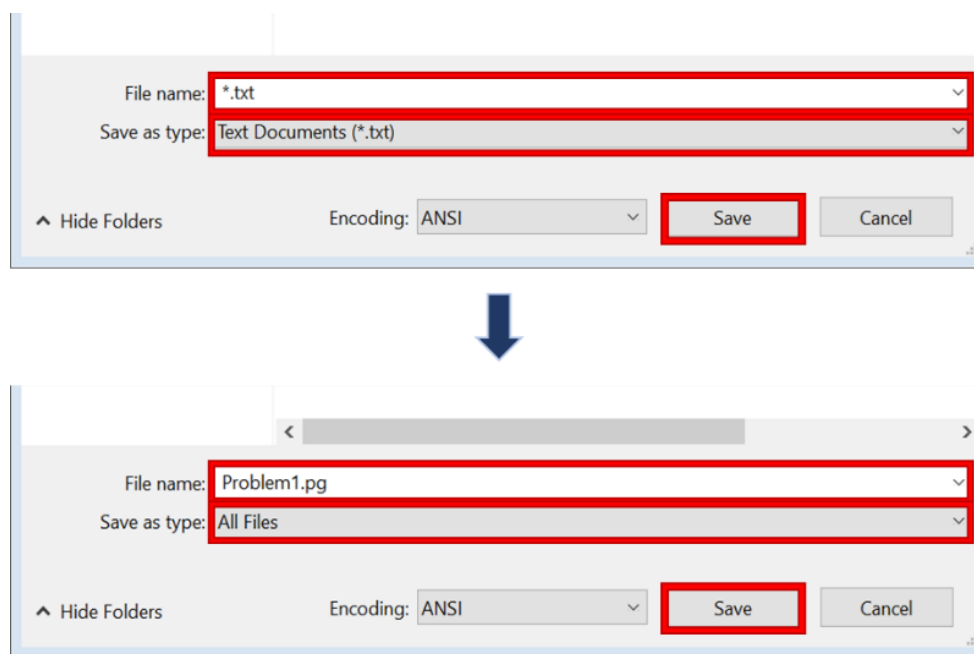


Figure 6 Name your problem generating file.

## 2.2 Write your WeBWorK problem

You can now write your WeBWorK problem by typing directly in your new file, and making sure you save the file afterwards. It is also recommended to format your code in a readable way. I discuss how to author a WeBWorK problem in detail in Section 4 Writing WeBWorK Problems.

## 2.3 Upload your .pg file to WeBWorK online

Now you can upload your new WeBWorK file to the file manager in your WeBWorK course. In order to do this, first open your web browser, and navigate to your WeBWorK course, and login. The left half of Figure 7 shows that I am choosing my “FMExam” course, however you want to choose whatever course you want to upload your problem to. The right side of Figure 7 shows where to find the “file manager” tab in your course. If you do not have a “file manager” tab, check to make sure you are registered as an instructor for the course.

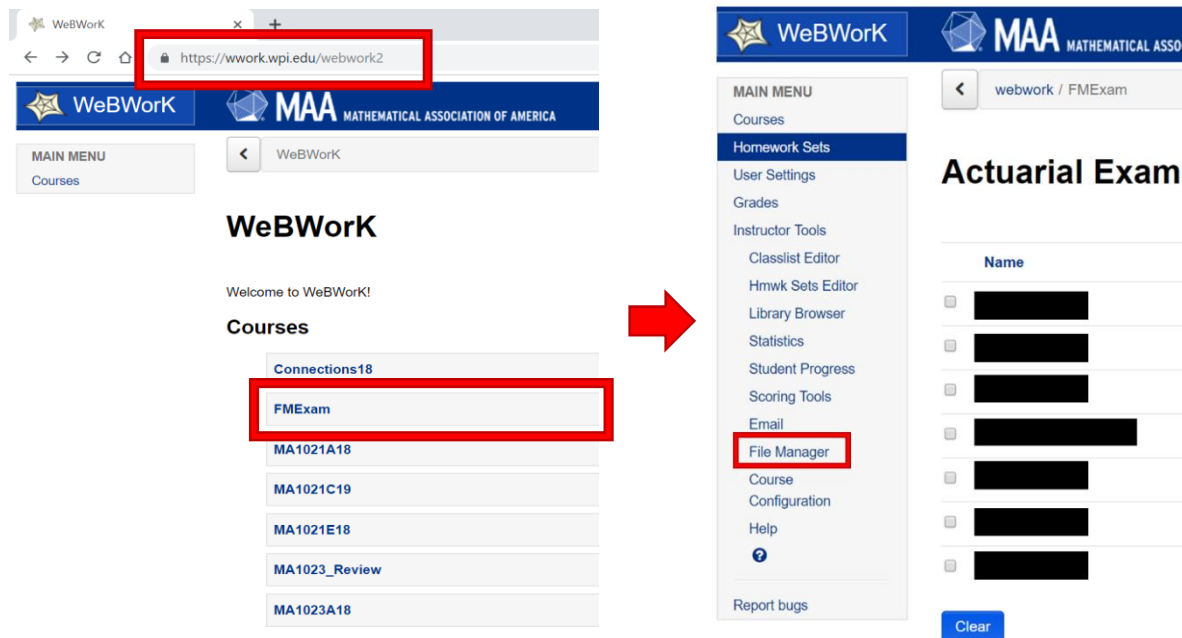


Figure 7 Navigate to file manager.

Next, you must create a new folder to put your file in, so that WeBWork will have a location to retrieve your file from. In order to do this, press the “New Folder” button shown in Figure 9, and name your new folder as shown in Figure 8. Do not forget to press “New Folder” in Figure 8, otherwise your folder will not be created.

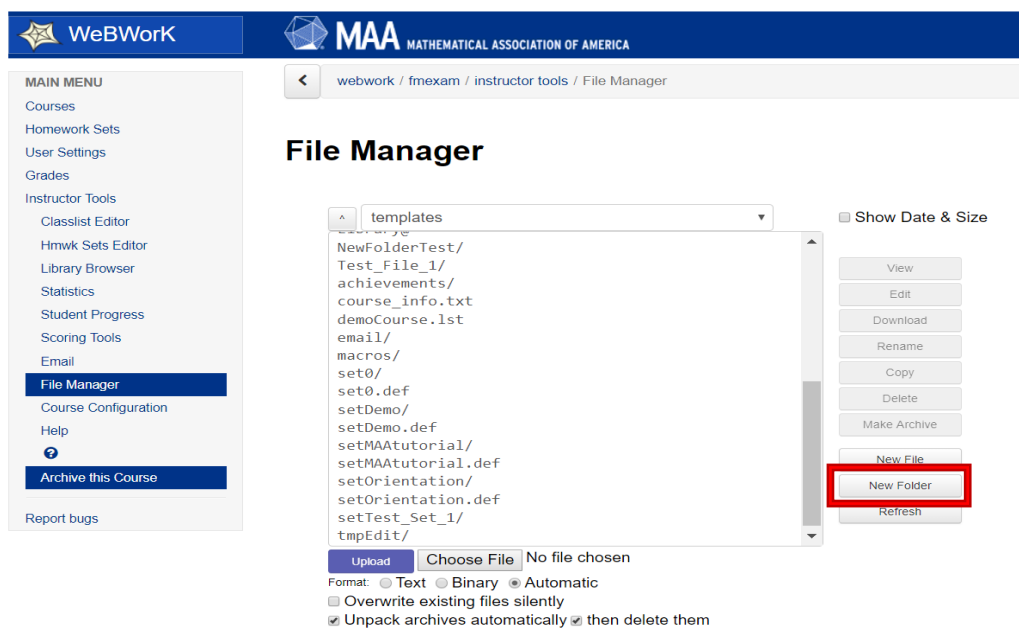


Figure 8 Create a new folder.

## File Manager

Figure 9 Name your new folder.

Now you may begin the process of uploading your problem. Press “Choose File” as shown in Figure 10.

Figure 10 Select “Choose File”.

After pressing this button, a file window will appear, as shown in Figure 11. Now navigate through your files, find your problem, select it, and press “Open”. These actions are also shown in Figure 12Figure 11.

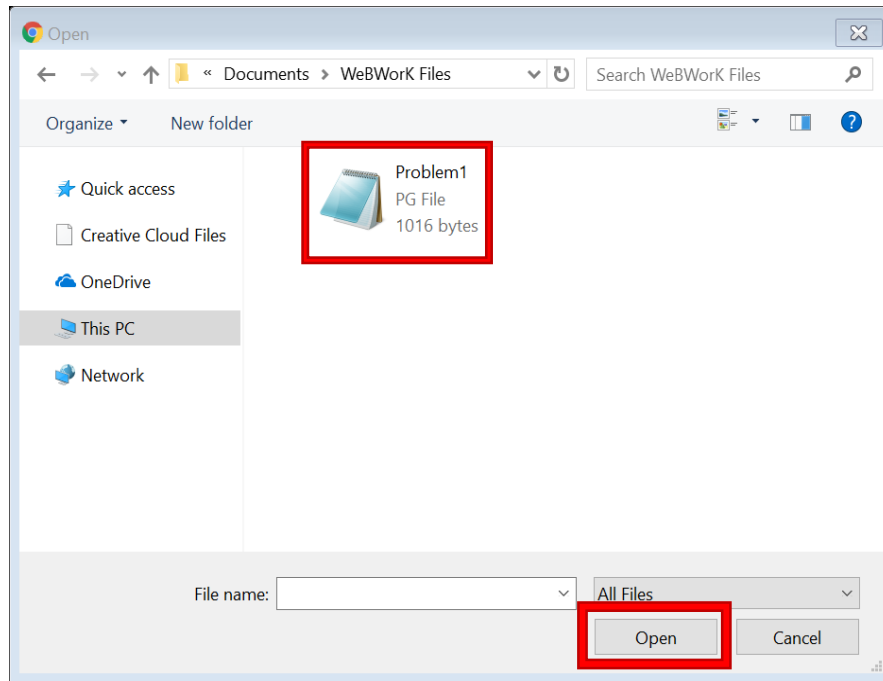


Figure 11 Select your PG file.

After pressing “Open”, the file window should close automatically, bringing you back to the File Manager screen shown in Figure 12. Make sure your problem file name now appears next to the “Choose File” button, indicated by the arrow in Figure 12, then press “Upload”. The settings at the bottom of the screen should not need to be changed.

## File Manager

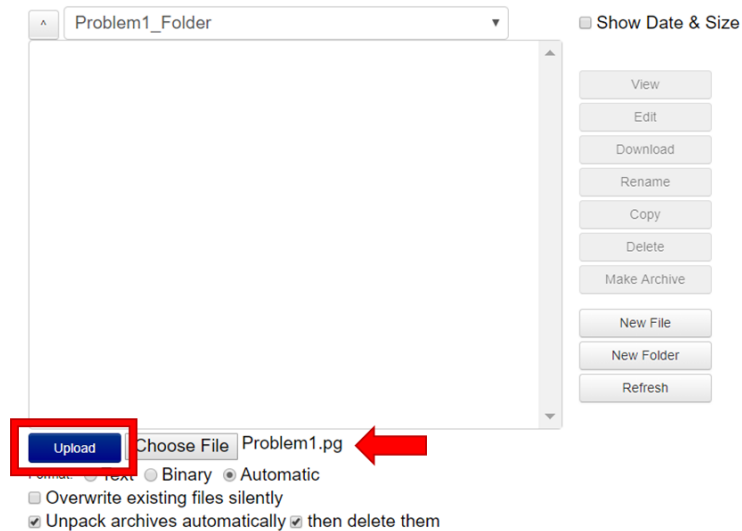


Figure 12 Upload your PG file.

Be sure to check that your problem was uploaded into the correct folder, and that you get a “File uploaded successfully” message such as in Figure 13. Any images incorporated into the question should also be uploaded into the same folder as the question. Once you get the hang of writing questions, you will find it more convenient to upload multiple problems in this step, so that you may proof-read a bunch of problems at once.

## File Manager

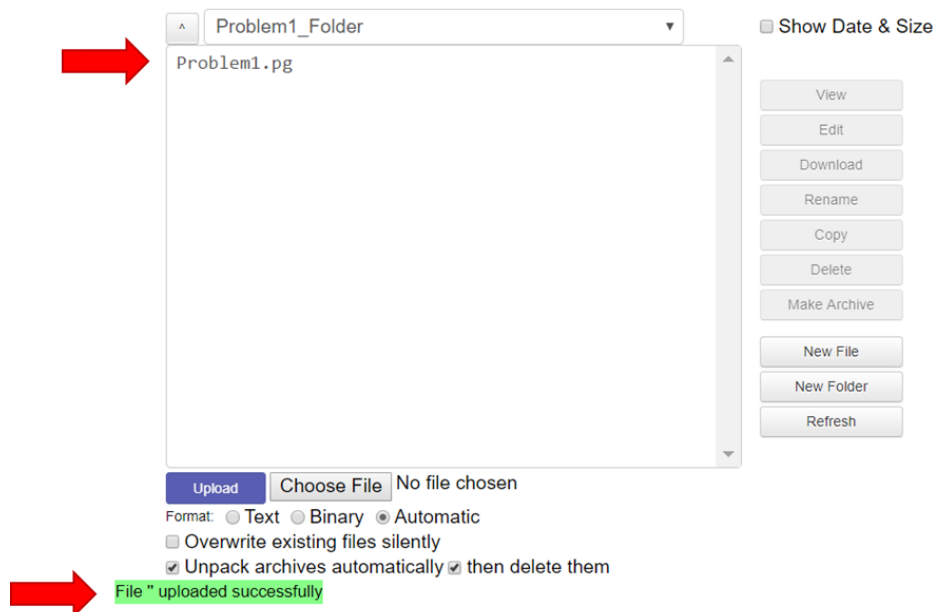


Figure 13 Check that your problem was uploaded.

### 2.4 Check your problem format on WeBWork

Since it is likely that your first few problems will have some mistakes in them, you must now view your problem in WeBWork. To check if you coded your problem correctly, you need to first create a blank problem set. This can be done by navigating to the “Hmwk Sets Editor” Tab on the left of the window, and pressing “Create”. These two buttons are shown in Figure 14.

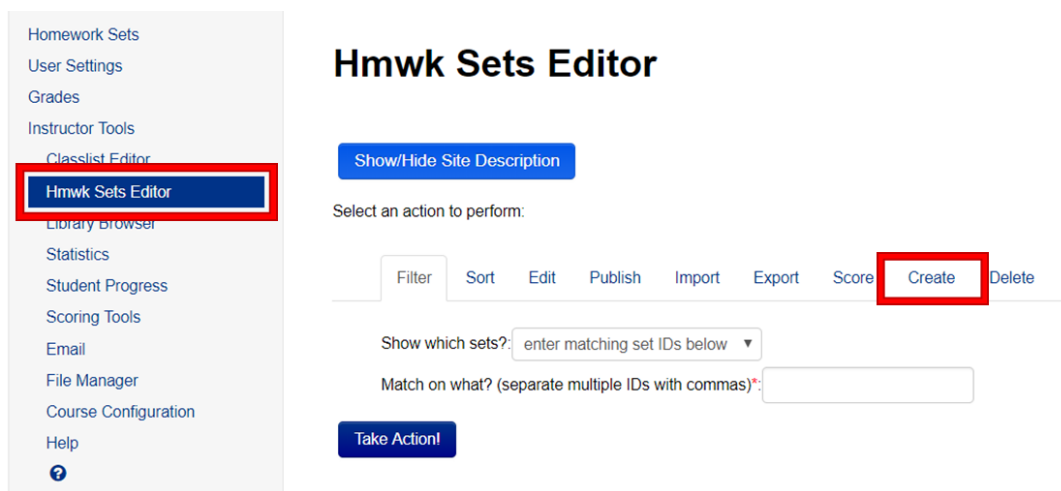


Figure 14 Create a new problem set.

When you press create, the screen should look like Figure 15. You can now select that you want to create a new empty set and the name of the new set. To continue, press “Take Action!”

## Hmwk Sets Editor

Show/Hide Site Description

Select an action to perform:


Filter Sort Edit Publish Import Export Score Create Delete


Name the new set\*

Create as what type of set?


Figure 15 Name your new problem set.

You should then be taken to a different screen with confirmation notifications on the bottom as shown in Figure 16.



<input type="checkbox"/>	<b>Problem1 Set</b> 	0	1/7
--------------------------	---	---	-----

Results of last action performed:

Set Problem1\_Set was assigned to XXXXXXXXXX 

Successfully created new set Problem1\_Set

Figure 16 Check that your problem set was created.

Next, we can finally view the problem by pressing Library browser in the left-hand menu, as shown in Figure 17.



Figure 17 navigate to “Library Browser”.

Now, in order to view your problem, you must pretend that you want to add your new problem to the problem set you created in Figure 15. So, you must select the correct options on the Library Browser page, as shown in Figure 18. Next to “Target Set”, select the new problem set you created. Then, ensure “Local Problems” is selected next to “Browse”, because your problem is stored locally in your course. Next to “Local Problems” select the folder that your problem is in, and finally press “View Problems”. If your problem is written correctly, it should appear on the screen, as shown in Figure 18.

## Library Browser

Figure 18 View your new problem on WeBWorK in the “Library Browser”.

If you have uploaded multiple problems in the folder, all of the problems should appear here as well. If you are satisfied with your problem, you can add it to the problem set by pressing the “Add” button as shown in Figure 19.

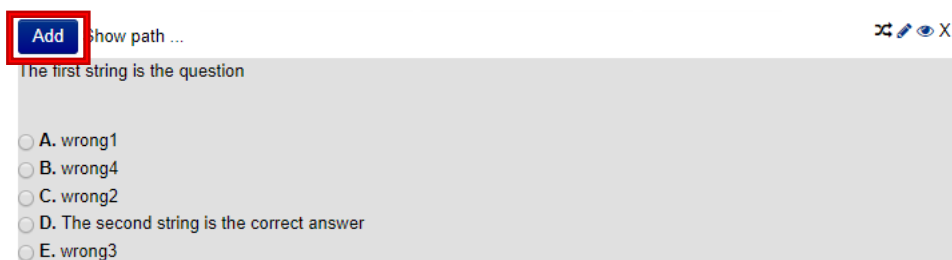


Figure 19 Add your problem to your problem set.

## 2.5 Edit .pg file with changes

Unfortunately, there are a lot of potential mistakes you could have made in your WeBWorK code. This may cause many formatting issues, including code showing up in your problem, images not being displayed properly, or even producing an error message, as shown in Figure 20.



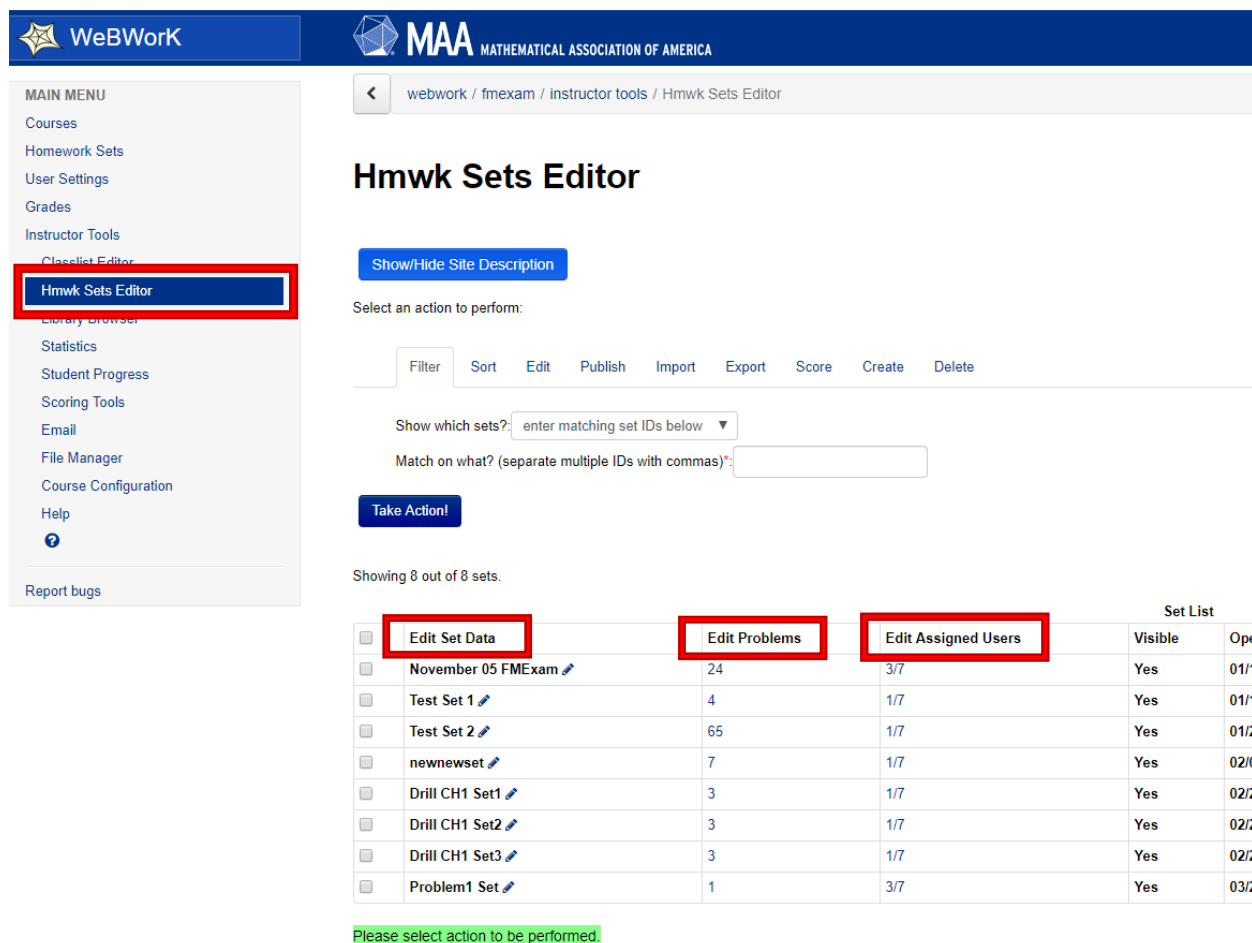
Figure 20 Potential error message

In order to correct your mistakes, you must edit your .pg files directly on your device, then re-upload them to your online folder. In other words, repeat the steps shown in Figure 10 through Figure 18, with the exception that you will not have to create a new problem set this time. Then, proof-read your problems once again, and repeat this process until your problems appear how you want them to. Once you are satisfied with your problems, you can then add them to homework sets by pressing the “Add” button, as I mentioned in Figure 19.

## 3 Assigning Problem Sets to Students

### 3.1 Viewing Problem Sets

In Figures 10-12, we created a problem set, and added a problem to it in Figures 13-15. You can view the problem set you created by clicking on the name of your problem set under “Hmwk Sets Editor”, as shown in **Error! Reference source not found.** You can also view Homework sets under the “Homework Sets” tab, but you cannot edit. Figure 21 also highlights the three main categories you can edit: Set Dates, Problems, and Assigned Users.



webwork / fmexam / instructor tools / Hmwk Sets Editor

## Hmwk Sets Editor

Show/Hide Site Description

Select an action to perform:

Filter Sort Edit Publish Import Export Score Create Delete

Show which sets?:

Match on what? (separate multiple IDs with commas):

Take Action!

Showing 8 out of 8 sets.

	Edit Set Data	Edit Problems	Edit Assigned Users	Visible	Open
<input type="checkbox"/>	November 05 FMEExam	24	3/7	Yes	01/1
<input type="checkbox"/>	Test Set 1	4	1/7	Yes	01/1
<input type="checkbox"/>	Test Set 2	65	1/7	Yes	01/2
<input type="checkbox"/>	newnewset	7	1/7	Yes	02/0
<input type="checkbox"/>	Drill CH1 Set1	3	1/7	Yes	02/2
<input type="checkbox"/>	Drill CH1 Set2	3	1/7	Yes	02/2
<input type="checkbox"/>	Drill CH1 Set3	3	1/7	Yes	02/2
<input type="checkbox"/>	Problem1 Set	1	3/7	Yes	03/2

Please select action to be performed.

Figure 21 Navigate to “Hmwk Sets Editor”.

### 3.2 Edit Set Dates

To set the due dates corresponding to your set, first press the pencil next to the corresponding set name as indicated in Figure 22.

	Edit Set Data	Edit Problems	Edit Assigned Users
<input type="checkbox"/>	November 05 FMEExam	24	3/7
<input type="checkbox"/>	Test Set 1	4	1/7
<input type="checkbox"/>	Test Set 2	65	1/7
<input type="checkbox"/>	newnewset	7	1/7
<input type="checkbox"/>	Drill CH1 Set1	3	1/7
<input type="checkbox"/>	Drill CH1 Set2	3	1/7
<input type="checkbox"/>	Drill CH1 Set3	3	1/7
<input type="checkbox"/>	Problem1 Set	1	3/7

Please select action to be performed.

Figure 22 Select pencil icon to choose due dates.

The next set of steps are shown in Figure 23. In order to input the dates and times, you can manually type the date and times in the text boxes, or you can press the calendar buttons and choose the date that way. First, choose the “Open Date”, which determines when the students will be able to start working on the problem set. Then choose the “Close Date” which is effectively the due date, and then the “Answer Date” determines when the students will be able to view the solutions. Be sure to press “Done” after choosing dates by using the calendar buttons. Finally, press “Take Action!” in order to save your work.

Save changes

**Take Action!**

Showing 1 out of 8 sets.

Set List				
Edit Set	Visible	Open Date	Close Date	Answer Date
Problem1 Set	<input checked="" type="checkbox"/>	03/24/2019 at 11:59pm	03/31/2019 at 11:59pm	04/02/2019 at 11:59pm

Please select action to be performed.

Figure 23 Choose “Open Date”, “Close Date”, and “Answer Date” for your problem set.

### 3.3 Edit Problems

To edit problems, begin from the “Hmwk Sets Editor” tab again, but this time press the number that appears in the “Edit Problems” column of the corresponding set’s row. This number, shown in **Error! Reference source not found.**, represents the number of problems in the c

<input type="checkbox"/>	Edit Set Data	Edit Problems	Edit Assigned Users
<input type="checkbox"/>	November 05 FMEExam	24	3/7
<input type="checkbox"/>	Test Set 1	4	1/7
<input type="checkbox"/>	Test Set 2	65	1/7
<input type="checkbox"/>	newnewset	7	1/7
<input type="checkbox"/>	Drill CH1 Set1	3	1/7
<input type="checkbox"/>	Drill CH1 Set2	3	1/7
<input type="checkbox"/>	Drill CH1 Set3	3	1/7
<input type="checkbox"/>	Problem1 Set	<b>1</b>	3/7

Please select action to be performed.

Figure 24 Select number icon to edit problems.

corresponding set.

You can also change the dates here as shown in figure 21, as well as other settings such as “Visible to Students”, “Hide Hints”, and “Assignment type”. These settings should be left on their default unless you know otherwise.

## Set Detail 2 for set Problem1\_Set

This set **Problem1\_Set** is assigned to 3 students out of 7. [Edit individual versions of set Problem1\\_Set.](#)

Any changes made below will be reflected in the set for ALL students.

[Save Changes](#) [Reset Form](#)

General Information		
Opens	03/24/2019 at 11:59pm	
Closes	03/31/2019 at 11:59pm	
Answers Available	04/02/2019 at 11:59pm	
Visible to Students	Yes	
Hide Hints from Students	No	
Assignment type	homework	

**Set Description**

Figure 25 Adjust assignment settings.

If you scroll down the page, you will find even more settings such as “Set Description” and “Set Headers” shown in Figure 26. Additionally, you can view each problem in the set by pressing “Render All”. You may also delete or make other edits to problems, such as assign weights and the maximum number of times each student can attempt a problem.

**Set Description**

Headers	Data
Set Header 	defaultHeader Use Default Header File
Hardcopy Header 	defaultHeader Use Default Header File

**Problems**

[Renumber Problems](#) [Render All](#) [Hide All](#) Display Mode: images

1 ↓ 	Weight: 1	Source File: Problem1_Folder/Problem1.pg
<input type="checkbox"/> Delete it? <input type="checkbox"/> Mark Correct?	Max attempts: unlimited	

Automatically render problems on page load  
 Force problems to be numbered consecutively from one  
 Add 1 blank problem template(s) to end of homework set

[Save Changes](#) [Reset Form](#) (Any unsaved changes will be lost.)

Figure 26 More assignment settings.

### 3.4 Edit Assigned Users (Assigning Homework Sets to Students)

Once you have created a homework set on WeBWorK and adjusted all of the other settings, you can assign it to the students in your class. Once, again, start from the “Hmwk Sets Editor” tab, and press the fraction under the “Edit Assigned Users” column. This fraction describes how many students the assignment is assigned to. These buttons are indicated in Figure 27.

<input type="checkbox"/>	Edit Set Data	Edit Problems	Edit Assigned Users
<input type="checkbox"/>	November 05 FMEExam	24	3/7
<input type="checkbox"/>	Test Set 1	4	1/7
<input type="checkbox"/>	Test Set 2	65	1/7
<input type="checkbox"/>	newnewset	7	1/7
<input type="checkbox"/>	Drill CH1 Set1	3	1/7
<input type="checkbox"/>	Drill CH1 Set2	3	1/7
<input type="checkbox"/>	Drill CH1 Set3	3	1/7
<input type="checkbox"/>	Problem1 Set	1	3/7

Please select action to be performed.

Figure 27 Select fraction icon under “Edit Assigned Users”.

This will bring you to the “User Assigned” page shown in Figure 24. You can then either press “Assign to All Current Users” or manually select which students to assign the set to by checking the boxes next to their names. Do not forget to press “Save”.

## Users Assigned to Set Problem1\_Set

Assign to All Current Users

*this action can take a long time if there are many students.*

Do not uncheck students, unless you know what you are doing.  
There is NO undo for unassigning students.

When you unassign by unchecking a student's name, you destroy all of the data for homework set **Problem1\_Set** for this student what you want to do before unchecking students.

Assigned	Login Name	Student Name	Section	Close Date
→ <input checked="" type="checkbox"/>	jabraham	(Abraham, Jon)		
<input type="checkbox"/>	admin	(Administrator, )		
<input type="checkbox"/>	myblais	(Blais, Marcel)		
<input type="checkbox"/>	mmalone	(Malone, Mike)		
→ <input checked="" type="checkbox"/>	Inavickis	(Navickis, Leah)		<a href="#">Edit data for Inavickis</a>
→ <input checked="" type="checkbox"/>	posterro	(Posterro, Barry)		
<input type="checkbox"/>	mtaylor	(Taylor, Mark)		

Save

---

There is NO undo for this function. Do not use it unless you know what you are doing! When you unassign a student using this button:

Unassign from All Users

 Read only
  Allow unassign
 

---

Figure 28 Assign your problem set to students on WeBWorK.

### 3.5 Assigning Problem Sets on Canvas

You can now create an assignment on Canvas to direct the students to the correct WeBWork problem set you created in section 3.4. First, log into canvas and select the canvas course you want to add the assignment to. Then navigate to the “Assignments” tab shown in Figure 29, and press the “+Assignment” button.

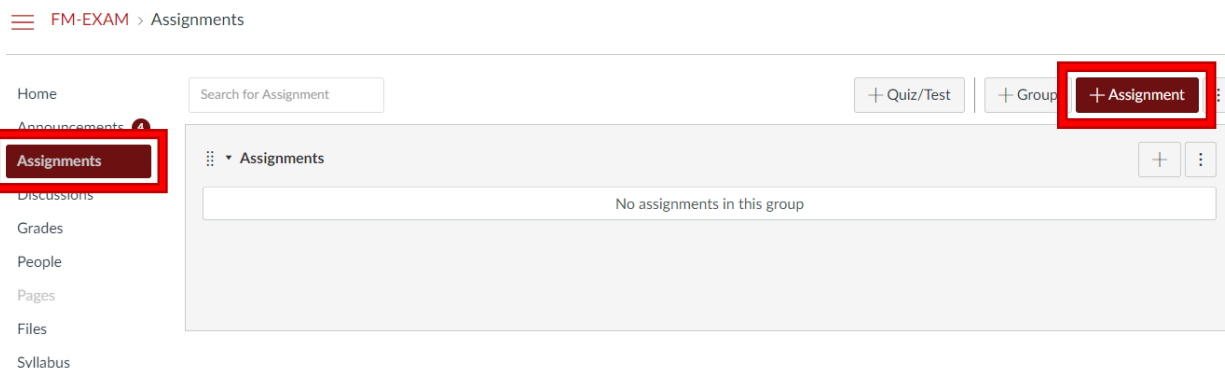


Figure 29 Create a new Canvas assignment.

Now your page will look like Figure 30, and be sure to give your assignment a clear name in the textbox indicated.

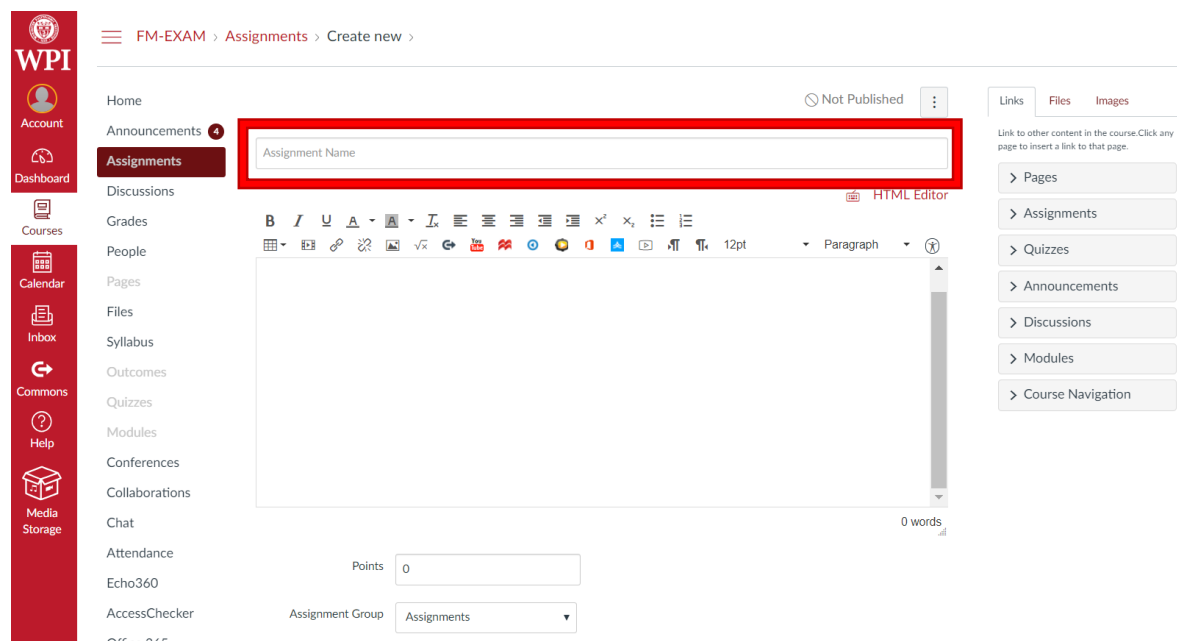


Figure 30 Name Canvas assignment.

Now scroll down the page until the “Submission Type” and “Assign” sections are visible on your screen, as shown in Figure 31. In order to provide a link to the WeBWork assignment for the students, you must first select “External Tool” as the “Submission Type”, and add the link to the WeBWork assignment in the “Enter or find an External Tool URL” field. The URL you need to use is specified in Figure 28. Be sure to select “Load This Tool In A New Tab” so that the students are not exited from canvas. Next, fill out the “Assign to” and Due date settings in the

Assign section. Finally, select “Notify students that is content has changed” so that the students know you have posted an assignment, and press “Save & Publish” to make the assignment available to the students.

The screenshot shows the Canvas assignment settings interface. On the left, there is a sidebar with the following items: Office 365, Class Climate, Arc, and Settings. The main content area is divided into several sections:

- Display Grade as:** A dropdown menu set to "Points".
- Do not count this assignment towards the final grade:** An unchecked checkbox.
- Submission Type:** A dropdown menu set to "External Tool".
- External Tool Options:** A section containing:
  - Enter or find an External Tool URL:** A text input field with a link icon on the left and a "Find" button on the right. The URL entered is "http://www.example.com/launch".
  - Load This Tool In A New Tab:** An unchecked checkbox.
- Assign:** A section with:
  - Assign to:** A dropdown menu set to "Everyone".
  - Due:** A date selection field with a calendar icon.
  - Available from:** A date selection field with a calendar icon.
  - Until:** A date selection field with a calendar icon.
  - + Add:** A button to add more assignees.

At the bottom of the form, there is a checkbox labeled "Notify users that this content has changed" which is checked. To the right of this checkbox are three buttons: "Cancel", "Save & Publish", and "Save".

Red boxes and arrows highlight the following elements:

- The "External Tool" dropdown menu.
- The "Enter or find an External Tool URL" section, including the input field and "Find" button.
- The "Load This Tool In A New Tab" checkbox.
- The "Assign to" dropdown menu.
- The "Due" date field.
- The "Available from" and "Until" date fields.
- The "Notify users that this content has changed" checkbox.
- The "Save & Publish" button.

Figure 31 Adjust Canvas assignment settings.

Figure 32 depicts the exact page of WeBWorK you should take the URL from. For example, the URL I am using is: [https://wwork.wpi.edu/webwork2/FMExam/Problem1\\_Set/](https://wwork.wpi.edu/webwork2/FMExam/Problem1_Set/) because that is where my problem set is actually located (you only need to include up to the problem set name for the URL). You can navigate to this page by going to the “Homework Sets” tab and pressing the corresponding homework set.



The screenshot shows a web browser with the address bar containing the URL: [https://wwork.wpi.edu/webwork2/FMExam/Problem1\\_Set/?effectiveUser=Inavickis&user=Inavickis&key=I36D17fMHqzlvC](https://wwork.wpi.edu/webwork2/FMExam/Problem1_Set/?effectiveUser=Inavickis&user=Inavickis&key=I36D17fMHqzlvC). The page header includes the WeBWorK logo and the MAA (Mathematical Association of America) logo. The left sidebar contains a 'MAIN MENU' with 'Homework Sets' and 'Problem1 Set' highlighted. The main content area is titled 'Problem1 Set' and features a table with the following data:

Homework Sets		Problems		
Name	Attempts	Remaining	Worth	Status
Problem 1	0	unlimited	1	0%

Below the table are buttons for 'Email instructor' and 'Download PDF or TeX Hardcopy for Current Set'. A note at the bottom states: 'This set is visible to students.'

Figure 32 Copy WeBWorK problem set link.

After publishing your assignment in Figure 31, you will now be able to view the assignment you have added in Canvas, shown in Figure 33.

The screenshot shows the Canvas interface with a sidebar on the left containing 'Home', 'Announcements' (with a notification badge), 'Assignments', 'Discussions', 'Grades', and 'People'. The 'Assignments' section is active. A search bar at the top right says 'Search for Assignment'. Below it, a list of assignments is shown, with 'Example Assignment' highlighted. The details for 'Example Assignment' are: 'Available until May 24 | Due Apr 30 at 11:59pm'.

Figure 33 View your new Canvas assignment.

Now, if you press “Load Example Assignment in a new window”, you should be taken to the screen shown in Figure 32, because it is what you liked the assignment to. This button is shown in Figure 34.

The screenshot shows the Canvas interface with a breadcrumb trail: 'FM-EXAM > Assignments > Example Assignment'. The main heading is 'Example Assignment'. Below the heading, there is a message: 'This tool needs to be loaded in a new browser window'. A button labeled 'Load Example Assignment in a new window' is highlighted with a red box.

Figure 34 Check link from Canvas to WeBWorK.

## 4 Writing WeBWorK Problems

### 4.1 Basic Problem Structure

A description of the basic structure of a WeBWorK problem can be found online on WeBWorK's website (SampleProblem1: A First WeBWorK Sample Problem, 2011). I also provide full problem examples later in Section 5.

As you add more problems to your WeBWorK course, it becomes increasingly difficult to find the problems you are looking for. This is why it is important to comment an adequate description at the beginning of each problem code. An example of a descriptive heading is shown in Figure 35. These comments (denoted by #) are not read by WeBWorK, they are intended to provide context for whoever is reading the problem code.

```
DOCUMENT();
# Classification('Type of Problem')

## KEYWORDS('Annuities', 'Interest')
## Exam('FM Exam', 'Date', 'Problem Number')
## Institution('WPI')
## Author('Leah Navickis', 'WPI Actuarial')
## Date('MM-DD-YYYY')
```

Figure 35 Example problem heading.

For the FM Exam, I used 12 different classifications, shown in Figure 32 for the problems. I indicated their category in the “Classification()” section at the top of each problem, as shown in Figure 31. I also created a folder in the FM Exam course for each classification, and added the problems to their corresponding folder, so that the professors will have an easier time finding the problems in the future. I suggest doing the same in any future projects.

### Classifications

1	present_future_acc_value
2	annuities
3	loans_bonds
4	yield_curves
5	IRR_NPV
6	rates_of_return
7	duration_convexity
8	immunization
9	swaps
10	spots_forwards
11	determinants
12	past_topics

Figure 36 FM Exam problem classifications.

## 4.2 Useful WeBWorK Functions

There are many functions used in WeBWorK so that your problem is displayed correctly. Figure 33 contains some useful code.







Description	Code
	<code>\(\ddot s_{\overline{n}\rceil j}\)</code>
	<code>\(\ddot a_{\overline{n}\rceil j}\)</code>
	<code>\(s_{\overline{n}\rceil j}\)</code>
	<code>\(a_{\overline{n}\rceil j}\)</code>
	<code>\(s_{\overline{n}\rceil}\)</code>
	<code>\(a_{\overline{n}\rceil}\)</code>
display image	<code>\{ image( "image.png", width=&gt;500 ) \}</code>
subscript	<code>_ {put expression here}</code>
superscript	<code>^ {put expression here}</code>
exponent	<code>**</code>
fraction	<code>\frac{numerator}{denominator}</code>
new paragraph	<code>\$PAR</code>
add an equation	<code>\(equation\)</code>
multiple choice format	<code>\$mc = new_multiple_choice()</code>
create a variable	<code>\$variable</code>

Figure 37 Useful WeBWorK syntax.

## 5 Relevant Problem Types and Examples

In this section, I will discuss the most relevant problem types to the FM Exam WeBWorK course. All exam questions were written as multiple choice questions, and all drill questions were written as simple dynamic questions. For each type of question, I provide a brief description of the problem type, list the code, and then show an image of how the question appears as to the student.

### 5.1 Multiple Choice

This type of multiple choice question utilizes the `$mc` variable, randomly orders the answer choices, and has only one correct answer. View this type of problem below:

```
DOCUMENT ( ) ;
```

```

# Mutlitple Choice Question Template

# DESCRIPTION
# Add description here.
# ENDDescription

loadMacros("PGbasicmacros.pl",
           "PGchoicemacros.pl",
           "PGanswermacros.pl",

);
TEXT(beginproblem());

$showPartialCorrectAnswers = 0;

# Make a new multiple choice object.
$mc = new_multiple_choice();

# Insert question and answer
$mc -> qa ("The first string is the question",
         "The second string is the correct answer",
);
$mc ->extra(#add the incorrect options here
           "wrong1",
           "wrong2",
           "wrong3",
           "wrong4",
);
# Print the question using $mc->print_q
# Use $mc->print_a to print the list of possible answers.
# This need to be done inside BEGIN_TEXT/END_TEXT.

BEGIN_TEXT

\{$mc -> print_q \}
$PAR
\{$mc -> print_a\}
END_TEXT
# Enter the correct answers to be checked against the answers to the
students.
ANS( str_cmp( $mc->correct_ans )) ;

BEGIN_SOLUTION

Type Solution Here

END_SOLUTION

ENDDOCUMENT();

```

The first string is the question

A. wrong1  
 B. wrong4  
 C. wrong2  
 D. The second string is the correct answer  
 E. wrong3

**Solution:**

( Instructor solution preview: show the student solution after due date. )  
 Type Solution Here

Figure 38 Student View: Multiple Choice Question

## 5.2 Simple Dynamic

In a simple dynamic question, you can create variables that will change depending on who is viewing the problem. For example, in the problem below, each student will get different values of \$a, other than 1600:

```
DOCUMENT ();

# Simple Dynamic Question Template

# DESCRIPTION
# Add description here.
# ENDDescription

loadMacros(
  "PGstandard.pl",
  "PGchoicemacros.pl",
  "PGasu.pl",
  "PGcourse.pl"
);

TEXT(beginproblem());

$a = random(10,20,1)*100;
$ans = $a+100;

TEXT(EV2(<<EOT));
What is \($a+100\)?
```

```

$BR
Answer = \{ans_rule(20)\}
$BR
$BR
EOT

```

```

SOLUTION(EV3(<<'EOT')) ;
$BBOLD SOLUTION: $EBOLD
$BR
\($ans=$a+100\).

```

```
EOT
```

```
ANS(num_cmp($ans));
```

```
ENDDOCUMENT();
```

What is  $1600 + 100$ ?

Answer =

[Solution:](#)

( Instructor solution preview: show the student solution after due date. )

**SOLUTION:**  
 $1700 = 1600 + 100.$

Figure 39 Student View: Simple Dynamic Question

### 5.3 With Image

Knowing how to insert an image in a question will come in handy. You can do this by using the `image()` function in the text of the problem, and by uploading the image directly into your WeBWorK folder with the question. An example of how to add an image in a problem is shown below:

```
DOCUMENT();
```

```
loadMacros(
    "PGstandard.pl",
    "PGbasicmacros.pl",
    "PGchoicemacros.pl",

```

```

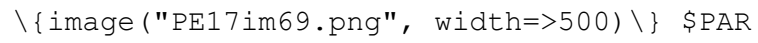
    "PGanswermacros.pl",
    "PGasu.pl",
    "PGcourse.pl",

);
TEXT(beginproblem());

$showPartialCorrectAnswers = 0;

# Make a new multiple choice object.
$mc = new_multiple_choice();

# Insert question and answer
$mc -> qa ("Calculate the number of units of Bond A that must be
purchased to match the liabilities exactly.",
    "0.8807",
);
$mc ->extra(#add the incorrect options here
    "0.8901",
    "0.8975",
    "0.9524",
    "0.9724",
);
# Print the question using $mc->print_q
# Use $mc->print_a to print the list of possible answers.
# This need to be done inside BEGIN_TEXT/END_TEXT.

BEGIN_TEXT
An insurance company must pay liabilities of 99 at the end of one
year,
102 at the end of two years and 100 at the end of three years. The
only
investments available to the company are the following three bonds.
Bond
A and Bond C are annual coupon bonds. Bond B is a zero-coupon bond.
$PAR
 $PAR
All three bonds have a par value of 100 and will be redeemed at par.
$PAR
END_TEXT

BEGIN_TEXT

\{$mc -> print_q \}
$PAR
\{$mc -> print_a\}
END_TEXT

BEGIN_TEXT
$PAR
$PAR
\{

```

```

knowLink("Click for the answer",
value=>'0.8807')
\}
$PAR
END_TEXT

# Enter the correct answers to be checked against the answers to the
students.
ANS( str_cmp( $mc->correct_ans ) ) ;

ENDDOCUMENT();

```

An insurance company must pay liabilities of 99 at the end of one year, 102 at the end of two years and 100 at the end of three years. The only investments available to the company are the following three bonds. Bond A and Bond C are annual coupon bonds. Bond B is a zero-coupon bond.

Bond	Maturity (in years)	Yield-to-Maturity (Annualized)	Coupon Rate
A	1	6%	7%
B	2	7%	0%
C	3	9%	5%

All three bonds have a par value of 100 and will be redeemed at par.

Calculate the number of units of Bond A that must be purchased to match the liabilities exactly.

A. 0.8901  
 B. 0.9724  
 C. 0.8975  
 D. 0.8807  
 E. 0.9524

[Click for the answer](#)

0.8807

Figure 40 Student View: Question with Image

## 5.4 With Hints

This problem is an example of how to add hints. The hint in this problem appears as “Click here for the answer”, however you can name your hint whatever you want. In this project, I elected to use hints to show solutions instead of solutions (as shown in section 5.1), because the students can view hints without the professors setting a due date for the problems. It is okay for the students to have access to the solutions because it is a study tool, so grading is not important. Check out the code below:

```

DOCUMENT();

loadMacros (
  "PGstandard.pl",
  "PGbasicmacros.pl",
  "PGchoicemacros.pl",
  "PGanswermacros.pl",

```



```

    "PGasu.pl",
    "PGcourse.pl",

);
TEXT(beginproblem());

$showPartialCorrectAnswers = 0;

# Make a new multiple choice object.
$mc = new_multiple_choice();

# Insert question and answer
$mc -> qa ("Calculate  $\delta$ .",
          "0.0396",
);
$mc ->extra(#add the incorrect options here
            "0.0388",
            "0.0392",
            "0.0404",
            "0.0414",
);
# Print the question using $mc->print_q
# Use $mc->print_a to print the list of possible answers.
# This need to be done inside BEGIN_TEXT/END_TEXT.

BEGIN_TEXT
Bruce deposits 100 into a bank account. His account is credited
interest at an annual nominal
rate of interest of 4% convertible semiannually. $PAR

At the same time, Peter deposits 100 into a separate account. Peter's
account is credited interest
at an annual force of interest of  $\delta$ . $PAR

After 7.25 years, the value of each account is the same. $PAR
END_TEXT

BEGIN_TEXT

\{$mc -> print_q \}
$PAR
\{$mc -> print_a\}
END_TEXT

BEGIN_TEXT
$PAR
$PAR
\{
knowLink("Click for the answer",
value=>'0.0396')
\}
$PAR

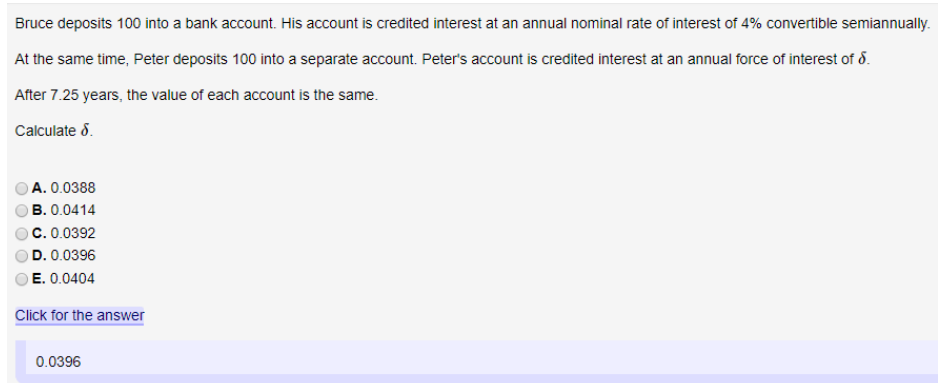
```

```
END_TEXT
```

```
# Enter the correct answers to be checked against the answers to the students.
```

```
ANS( str_cmp( $mc->correct_ans ) ) ;
```

```
ENDDOCUMENT() ;
```



Bruce deposits 100 into a bank account. His account is credited interest at an annual nominal rate of interest of 4% convertible semiannually.

At the same time, Peter deposits 100 into a separate account. Peter's account is credited interest at an annual force of interest of  $\delta$ .

After 7.25 years, the value of each account is the same.

Calculate  $\delta$ .

- A. 0.0388
- B. 0.0414
- C. 0.0392
- D. 0.0396
- E. 0.0404

[Click for the answer](#)

0.0396

Figure 41 Student View: Question with Hint

## References

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<https://www.coachingactuaries.com/>
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<https://www.soa.org/education/exam-req/edu-exam-fm-detail.aspx>
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- Instructors.* (2016, May 2). Retrieved from [webwork.maa.org/wiki](http://webwork.maa.org/wiki):  
<http://webwork.maa.org/wiki/Instructors#.XLJJcuhKg2w>
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[http://webwork.maa.org/wiki/Problem\\_Authoring\\_Background\\_Information#.XLyHbehKg2w](http://webwork.maa.org/wiki/Problem_Authoring_Background_Information#.XLyHbehKg2w)
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[http://webwork.maa.org/wiki/Problem\\_Authoring\\_Background\\_Information#.XLlvvehKg2w](http://webwork.maa.org/wiki/Problem_Authoring_Background_Information#.XLlvvehKg2w)
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<https://www.soa.org/Education/Exam-Req/edu-fsa-req.aspx>
- Using WeBWork.* (2019). Retrieved from [webwork.maa.org](http://webwork.maa.org):  
<http://webwork.maa.org/moodle/mod/forum/index.php?id=3>
- Using WeBWork: General Forums.* (n.d.). Retrieved from [webwork.maa.org](http://webwork.maa.org):  
<http://webwork.maa.org/moodle/mod/forum/index.php?id=3>
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[http://webwork.maa.org/wiki/WeBWork\\_Sites#.XLUcKOhKg2w](http://webwork.maa.org/wiki/WeBWork_Sites#.XLUcKOhKg2w)
- WeBWork Sites.* (2016, June 22). Retrieved from [WeBWork](http://webwork.maa.org):  
[http://webwork.maa.org/wiki/WeBWork\\_Sites#.XK-AHOhKg2w](http://webwork.maa.org/wiki/WeBWork_Sites#.XK-AHOhKg2w)
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<https://support.coachingactuaries.com/article/57/what-are-the-benefits-of-adapt>

