RUTGERS

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# Mortgage Assistant: Navigating the Mortgage Maze

# Final Project Design Report

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# 1. Design Project Overview

The current state of the United States housing market is damaged to say the least. The housing bubble of 2008 banks maliciously persuaded homebuyers to acquire mortgages more expensive than they could handle, leading to a large number of defaults and foreclosures. Housing prices skyrocketed since more and more people were trying to buy and invest in houses. When the craze ended, and there were no more houses to be bought, the market saturated and people were left with a house, or in some cases, multiple houses that they just could not afford. Today housing prices across the country are continuing to drop as a result of people not having the sufficient means to purchase them, and a lot of families have seen their houses been foreclosed on and are in terrible, terrible debt. Although even after all of that, the average American still does not completely understand the intricacies of home buying, nor how to avoid being scammed at a bank.

The purpose of our project was to design a website where the average homebuyer could come to get a detailed, yet comprehensible explanation of the different types of mortgage loans, as well as supply the reader with a list of the current available government programs created to assist them in paying off their mortgage loans. The three main functions of the website are the calculators, the government program list, and the mortgage tutorials. The calculators are used to calculate payment sizes and amortization schedules for the five different types of bank loans. These are the fixed rate mortgage, the adjustable rate mortgage, the balloon mortgage, the interest-only mortgage, and the graduated payment mortgage. All of them have their own terminology and rules which are conveniently explained step by step in the tutorials section of the website. There is also a page designated to show you a side-by-side comparison of all the different mortgage types and their maximum and minimum payments. Using these tools we hope to have generated a location for the common person to come to see their options in home buying as where to go for appropriate help. The website is currently up and running at www.mortgagemaze.net.

## 2. Technical Specifications

In the initial stages of the project the website was running an a standard WAMP stack on a personal computer. The WAMP stack is comprised of the windows operating system, Apache server application, MySQL database software, and the PHP server side scripting language. The Apache server was configured to recognize a custom directory within the host computer to retrieve the necessary files since a domain was not available. For the final product a hosting company was used to allow the website to be live. The purchased domain was mortgagemaze.net and the hosting service provided identical services to the originally used WAMP stack platform.

## 3. Final Project Summary

### 3.1 System Design – Final Version

The final version of the website incorporates three main subsections; government housing programs, mortgage calculators, and mortgage tutorials. All three sections are presented on the homepage in separate columns which contain short descriptive blurbs and an identifying picture for each subsection.  These three main sections are also available on every webpage from the menu on the top-right within the website for instant access at any time. The described final homepage layout is depicted in Figure 3.1.
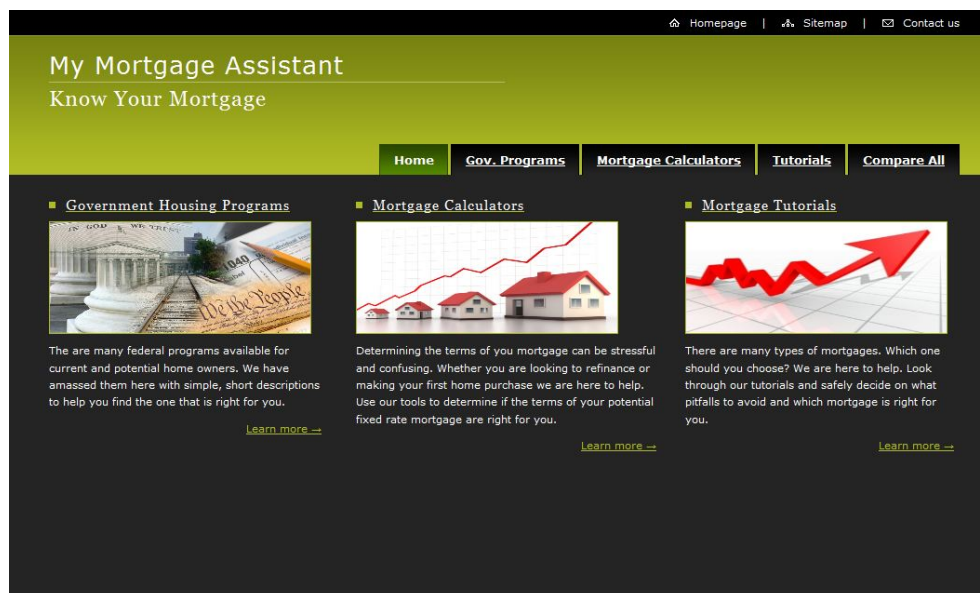


Figure 3.1: The homepage which displays the three main subsections of the website.

The green upper portion of the homepage is a common theme throughout the website to add continuity to the user experience. The aesthetic design of the webpage is a modified version of an open source template provided by Free Website Templates designed by Mantis-a.

The government programs section of the website is aimed to provide help to a medley of different individuals.  Due to the paradox of choice the myriad of government programs presented has been cut down to no more than four per page. Following along these lines the government programs have also been divided into four distinct subgroups as seen is Figure 3.2.



Figure 3.2: Main menu page for the government housing programs section of the website.

This section of the website serves a unique purpose on the website as it connects troubled home owners with government subsidized programs more than it serves to teach a home

owner about mortgages as the other sections do. This is why this section has its own menu and layout. The menu at the top allows for easy navigation through any of the four subsections of government programs from anywhere within this section of the website. The subgroups are broken down into Section 203, Veterans and Low Income, Insurance Plans, and Other. Section 203 contains the programs that are most commonly used and heard about such as the FHA Loan, Section 203b. Within the others section are programs that help very specific groups of people that many be less popular as a consequence or their specifications.

       The mortgage calculator division of the website contains the brunt of the processing power contained in the webpage. This portion of the site first brings the visitor to a menu where they have a choice of the five main mortgages covered by this project; they are fixed rate, adjustable rate, interest only, balloon, and graduated payment mortgages. Each mortgage has its own calculator as each has its own set of parameters necessary for amortization. However, in terms of the visual presentation of information the calculators share a common theme. Figure 3.3 shows an example of a mortgage calculator on the webpage.
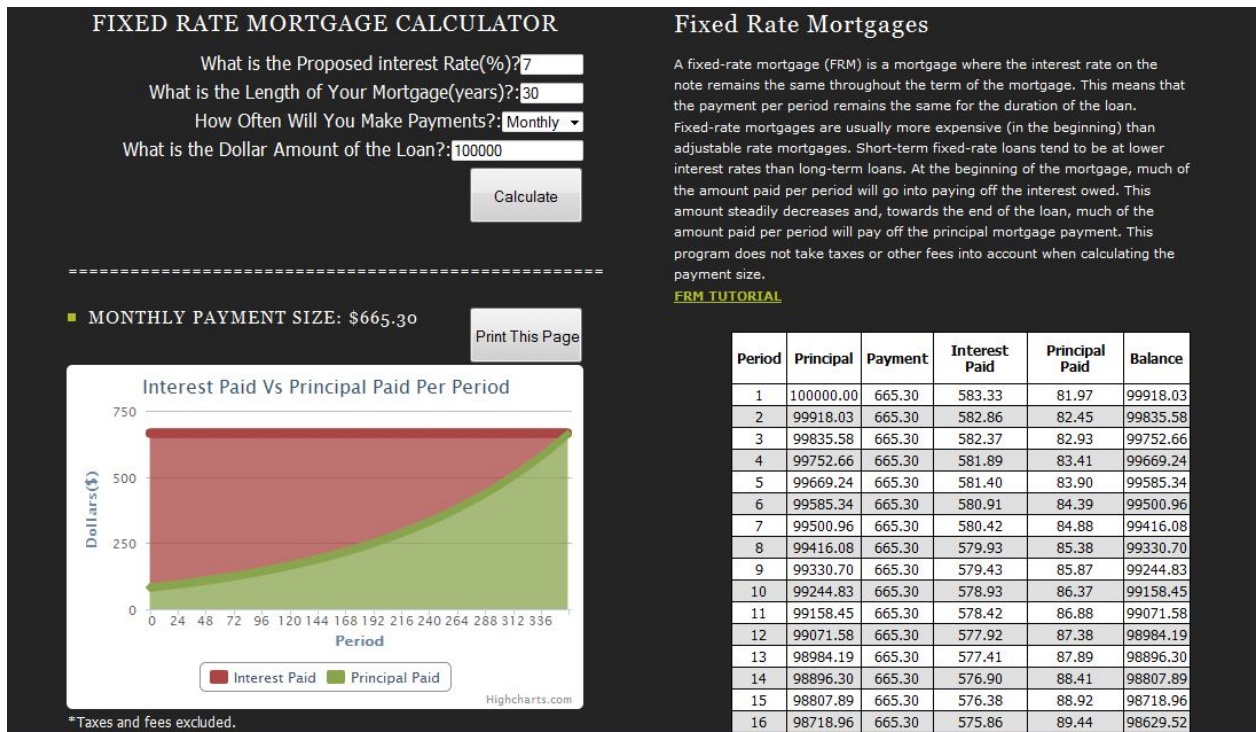


Figure 3.3: One of the five mortgage calculators with input and output data displayed.

The input form for each of the mortgage calculators is found on the top left, which is the first place that a visitor would observe. Next to the calculator is a description of the mortgage type they are about to calculate. Once all of the inputs are submitted in the form and the calculate button is hit all of the output data is displayed for the user. The payment size and visual graphs are shown on the left hand side, while the- at times lengthy- amortization table is available on the right side. The left side provide all of the most common, easily recognizable information such as payment distribution and balance. The right side is for more in depth review on a period by period basis. The print page button allows the user to easily receive a hard copy of the amortization schedule. Every calculator on this website has this format and analytic data.

To accompany the aforementioned calculators are the mortgage tutorials. Each mortgage tutorial is an example walk through of the associated mortgage calculator. The essentials of the graphed information are presented and the pitfalls of the different mortgages are explained. For certain mortgages the variation of payments over time is explicitly analyzed and highlighted. The design of these tutorials is split into the three divisions shown in Figure 3.4 which shows the tutorial of a fixed rate mortgage.

## FIXED RATE MORTGAGE TUTORIAL

A **Fixed Rate Mortgage (FRM)** is a mortgage where the interest rate on the note remains the same throughout the term of the mortgage. This means that the payment per period remains the same for the duration of the loan. Fixed rate mortgages are usually more expensive (in the beginning) than adjustable rate mortgages (ARMs). Short-term fixed rate loans tend to be at lower interest rates than long-term loans. At the beginning of the mortgage, much of the amount paid per period will go into paying off the interest owed. This amount steadily decreases and, towards the end of the loan, much of the amount paid per period will pay off the principal mortgage payment. This program does not take taxes or other fees into account when calculating the payment size.

Our FRM Calculator also provides you with a way to view the amortization schedule of your specific FRM mortgage along with helpful graphs to analyze how the remaining balance and payment distribution will change over time. The following example, on the right, will provide an in-depth look at a standard FRM.

■ THE BOTTOM LINE

Fixed rate mortgages (FRMs) are the industry standard. With one simple payment throughout the life of the mortgage there is no guessing about what next month's payment will be. It is easy to build a responsible budget around such a stable systematic expense. This is a great choice for the average potential home owner. The ability to qualify for a FRM should be a potential home owner's top priority.

FOR EXAMPLE:

Assume you have taken a 7 year, $100,000 FRM at a 7% annual interest rate.

The monthly payments are calculated in such a way that we can pay off the FRM by making a set of equal monthly payments over the life of the loan. In this case the monthly payment is $665.30. Initially- and for quite a while after that- most of that payment will go towards the interest on the mortgage that the bank asks for. In this problem it is not until the 242nd month (over 20 years!) of the 30 year mortgage that the total payment starts to go more towards principal rather than interest.



Figure 1.1

Figure 1.1 shows the slow change from paying mostly interest to principal. As described above at the start the payments go mostly toward interest (red), while at the end the payments rapidly become mostly principal (green). It is
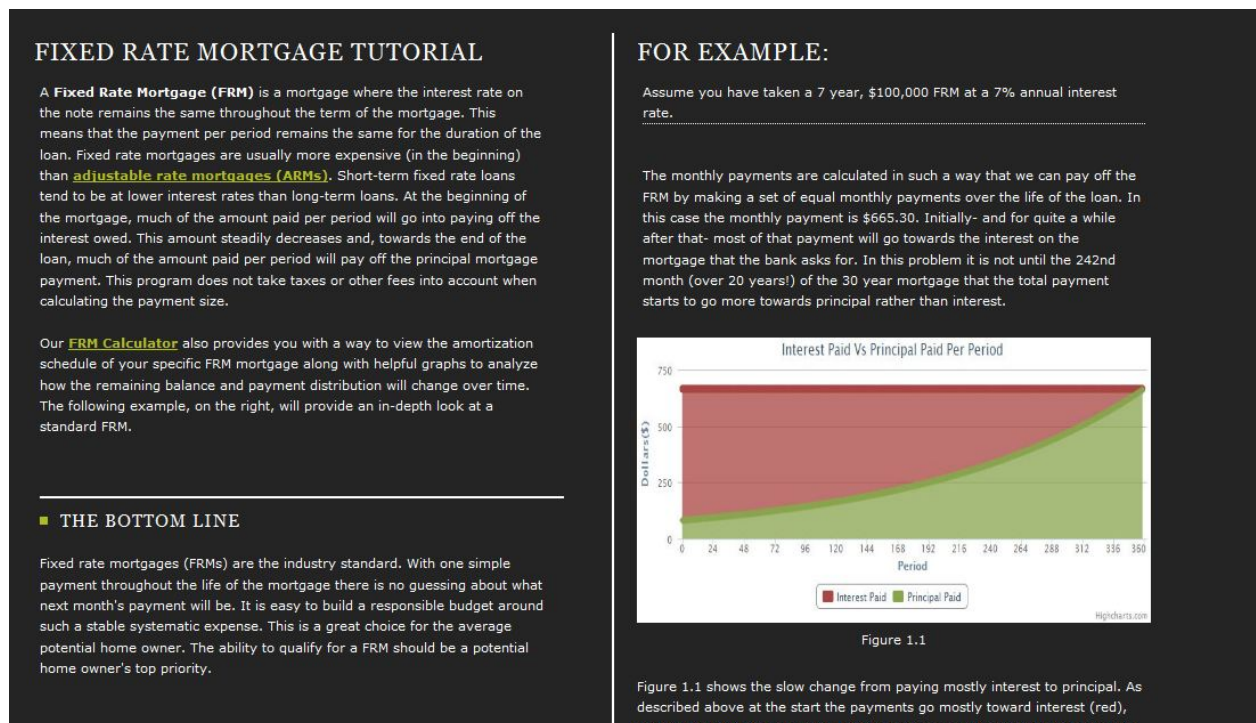
Figure 3.4: The design of the five mortgage tutorials that accompany each calculator.

Each mortgage tutorial begins on the left hand side with a short description of the mortgage itself and includes an embedded link to the actual mortgage calculator. Below the description is a concise blurb usually a few sentences long. This is for a visitor who does not have the time or energy to follow the entire tutorial, but wants to know if the mortgage is still right for them. The right side of the tutorial page is left for the example. The example walks the user through the important months to analyze on a amortization schedule such as the adjustment month in an adjustable rate mortgage, or early termination time on a balloon mortgage for example. The changes and shapes of all the payment and remaining balance graphs are also analyzed in depth so that every user understand the output graphs of his or her specific mortgage. Every example is compared to a fixed rate mortgage at 7% annual interest and an initial principal amount of $100,000. This allows there to be a sense of continuity between the examples and makes comparison of different types of mortgages easier for an average home buyer or owner. The entire process trains an uninformed user home how to operate the available calculators and teaches him or her about the mortgage itself.

# 5. Design Project Details

## 5.1 Fixed Rate Mortgages

Name of team member who **designed** the sub-system: Mark Rusinski

Name of team member who **wrote** this subsection: Mark Rusinski

### 5.1.1 Theoretical Considerations

A fixed rate mortgage is a type of annuity. An annuity is a stream of money over several equally spaced periods of time. In the case of a fixed rate mortgage this stream of money is the set of equal periodic payments the debtor makes over the entire term of the mortgage. The payment size calculated so that this set of equal payments over the life of the annuity will lead to a balance of zero at termination. For this to be true the present value of the annuity stream must be equal to the initial principal borrowed. This means a present value calculation can determine the fixed rate $\sum_{t=1}^{n} \dfrac{1}{(r+1)^t}$ e.

$$PV = C \cdot \sum_{t=0}^{n} \frac{1}{(r+1)^t}$$

(5.1.1.1)

The initial formula is given in equation 5.1.1.1. The variable 'PV' stands for present value, or principal in this case, 'C' is the monthly payment, 'r' is the interest rate, and 't' is the time period that the payment was paid in. Equation 5.1.1 is the mathematical definition of the annuity described above. It is a summation of all the future monthly payments, C, discounted by the interest rate and time value of money to equal the initial present value of the principal borrowed.

The summation term in equation 5.1.1.1 is commonly known as the present value factor and can be simplified further. This term is a geometric series and can be solved in this case by adding the following term that is equivalent to zero.

$$\frac{1}{(1+r)^{n+1}} - \frac{1}{(1+r)^{n+1}} = 0$$

(5.1.1.2)

This term is added the present value factor, S, and common terms are grouped together to form equation 5.1.1.3.

$$S = \frac{1}{1+r} + \frac{1}{1+r}S - \frac{1}{(1+r)^{n+1}}$$

(5.1.1.3)

This leads to the result in equation 5.1.1.4 for the present value factor formula of a fixed rate annuity.

$$S = \frac{1-(1+r)^{-n}}{r}$$

(5.1.1.4)

Finally, the simplified present value annuity equation can be calculated as in equation 5.1.1.5.

$$PV = C \cdot \frac{1-(1+r)^{-n}}{r}$$

(5.1.1.5)

Once the payment size of a mortgage is calculated according to equation 5.1.1.5 all the information regarding the amortization schedule is can be analyzed. The necessary parameters of to complete this calculation are the initial principal borrowed, the interest rate, and the number of periods over the life of the mortgage.

Despite the derivation shown above fixed rate mortgages are the simplest of all the mortgage instruments. A fixed rate mortgage is a mortgage where the interest rate on the note remains the same throughout the term of the mortgage. This means that the payment per period remains the same for the duration of the loan. Fixed rate mortgages are usually more expensive (in the beginning) than adjustable rate mortgages. Short-term fixed rate loans tend to be at lower interest rates than long-term loans. At the beginning of the mortgage, much of the amount paid per period will go into paying off the interest owed. This amount steadily decreases and, towards the end of the loan, much of the amount paid per period will pay off the principal mortgage payment. This program does not take taxes or other fees into account when calculating the payment size.

### 5.1.2 Design Procedure

The fixed rate amortization code was first written in the C++ programming language for testing. It was them translated into PHP so that the algorithm could be

executed by a server when a website user provided the proper inputs to the calculator. Three separate languages were used to fully display the output data specific to the fixed rate mortgage calculator. The amortization table was displayed with html and css to provide the proper formatting and aesthetics. The graphs that display upon submission are all programmed in JavaScript, while the functions for the calculators themselves are written in PHP. All of these languages had to be integrated in order for the fixed rate mortgage calculator to present a user with an enjoyable, intuitive experience.

**5.1.3 Simulation Results**

As an example simulation the case of a 30 year, $100,000 fixed rate mortgage at a 7% interest rate was analyzed. The monthly payments are calculated according to equation 5.1.1.5 where PV is $100,000, the variable n is 360 (years times months), and r, the interest rate, is .07. In this case the monthly payment is $665.30. Initially- and for quite a while after that- most of that payment will go towards the interest on the mortgage that the bank asks for. In this problem it is not until the 242nd month (over 20 years) of the 30 year mortgage that the total payment starts to go more towards principal rather than interest.

Figure 5.1.4.1 shows the slow change from paying mostly interest to principal. As described above at the start the payments go mostly toward interest (red), while at the end the payments rapidly become mostly principal (green). It is not until month 242 (2nd month of the 20th year) that about half the payment goes toward principal. Though this sounds unappealing a fixed rate mortgage is actually the safest and least variable choice out of all the mortgage instruments analyzed. Figure 5.1.4.2 depicts the balance decreasing over the life of the mortgage. Here it can be seen that the balance does not decrease in a straight line. Not until later in the life of the mortgage does the balance start to rapidly decrease. One must wait until the 260th month (nearly 22 years) for half of the mortgage to be paid off. In Table 5.1.4.1 below an important part of the amortization schedule can be seen. This shows that at month 242 finally half the payment is going towards actually paying off the principal of the FRM. From then on the principal begins to decrease at a rapid rate relative to the beginning of the mortgage.

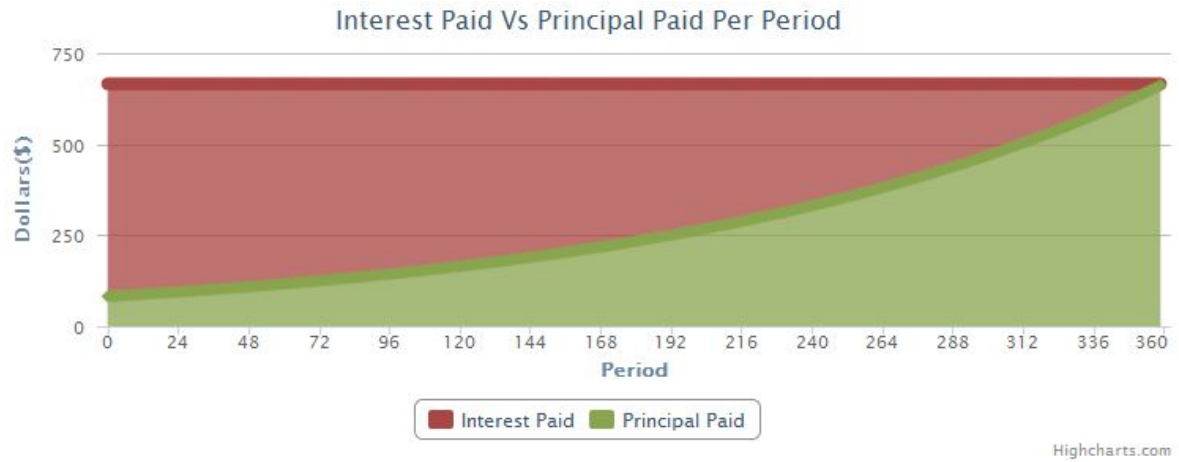### 5.1.4 Observed and Measured Results



Figure 5.1.4.1: The interest paid as compared to the principal paid per period over time.
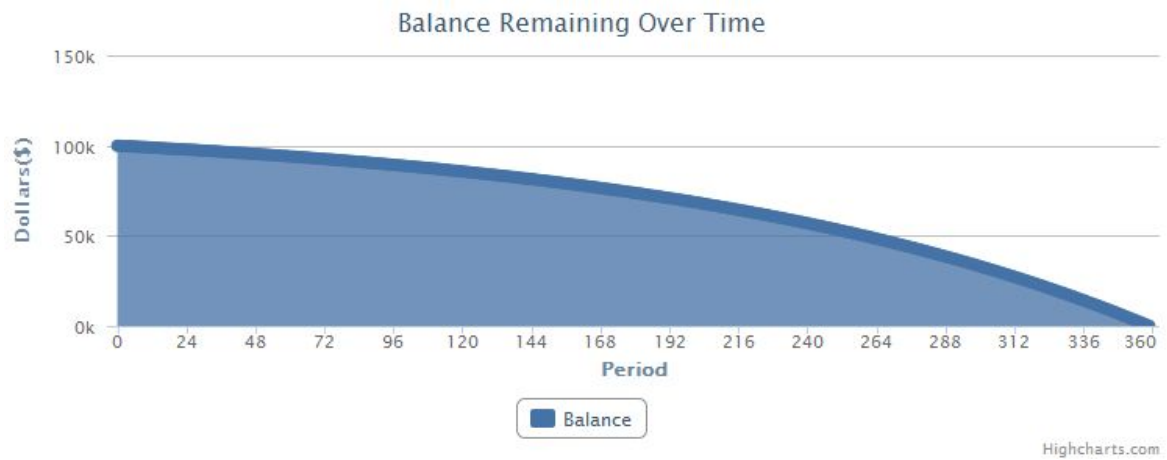


Figure 5.1.4.2: The balance remaining on the fixed rate mortgage on a per period basis.

Table 5.1.4.1: The section of the amortization table where more than half of the mortgage payments start to pay off the principal as compared to interest.

| Period | Principal | Payment | Interest Paid | Principal Paid | Balance |
|--------|-----------|---------|---------------|----------------|---------|
| 238 | 58281.76 | 665.3 | 339.98 | 325.33 | 57956.43 |
| 239 | 57956.43 | 665.3 | 338.08 | 327.22 | 57629.21 |
| 240 | 57629.21 | 665.3 | 336.17 | 329.13 | 57300.08 |
| 241 | 57300.08 | 665.3 | 334.25 | 331.05 | 56969.03 |
| 242 | 56969.03 | 665.3 | 332.32 | 332.98 | 56636.04 |
| 243 | 56636.04 | 665.3 | 330.38 | 334.93 | 56301.12 |
| 244 | 56301.12 | 665.3 | 328.42 | 336.88 | 55964.24 |
| 245 | 55964.24 | 665.3 | 326.46 | 338.84 | 55625.39 |
| 246 | 55625.39 | 665.3 | 324.48 | 340.82 | 55284.57 |

## 5.2 Adjustable Rate Mortgage

Name of team member who **designed** this sub-system:  Neil Supnekar

Name of team member who **wrote** this subsection:  Neil Supnekar

### 5.2.1  Theoretical Considerations

In an adjustable-rate mortgage (ARM), an index rate is the basis for the adjustments of the interest rates on which the loan is based. This means that the homeowner's payments change after every "adjustment period." The most common indices include the London Interbank Offered Rate (LIBOR), the Cost of Funds Index (COFI), and the rates on 1-year Treasury securities. A few lenders use their own costs of funds as indices. There are many variables that go into calculating an amortization schedule for an ARM, which make doing so quite difficult. The aim of this project is to provide homebuyers with the worst-case scenario, in order to dissuade them from purchasing ARMs. Because ARMs adjust with index rates, they can be quite volatile, and payments could increase sharply on any given adjustment period.

**Variables used for the project**:

**Proposed interest rate (rate)**: The initial interest rate at which the payments in the loan are paid. Some ARMs start at a "teaser rate" which is lower than this rate. Buyers should note that this rate is not meant to be the "teaser rate.

**Length of Mortgage (years)**: The length of the loan term in years.

**Frequency of payments (interval)**: Monthly, quarterly, or yearly

**Fixed time (fixedtime)**: For how long is the mortgage payment size fixed?

**Index/margin**: Not used in the actual calculations, because worst-case scenario analysis is being done and it is impossible to find future values of indices.

**Single-period Interest Rate Cap (cap)**: What is the most that the interest rate can adjust every adjustment period (and since this is a worst-case scenario, this is an increase)

**Maximum Possible Interest Rate (maxrate)**: The maximum possible interest rate that can be paid

(adapted from *Financial Engineering Capstone: The Mortgage Maze*, by S. McAfee)

## 5.2.2 Design Procedure

The adjustable-rate calculator was programmed in C++, using many of the same variables and arrays as the fixed-rate mortgage (FRM) as well as the new variables described above. For the length of time that the mortgage was fixed, the code from the FRM case was used. However, the valuation of the payments changed after this period. The amount of times the loop ran was until tf, which was the variable "fixedtime" multiplied by the variable "interval." For the rest of the mortgage term, another loop was ran from tf to t (years*interval). An if statement in the loop would check if modulus of the iterator i and the variable adjint was zero. If that was true, then the interest rate on the payment would adjust. The present value would also adjust, since the payments would be calculated off of that value (every time the rate adjusts, it is akin to starting another FRM

with a reduced principal and term.) Another embedded if statement would check to see that the interest rate was not over the global cap.

A problem was encountered where the rate would seem to "jump" over the global cap. This was problematic in the case of large single-period caps. This is because the cap would be added to the rate before the rate was checked against the global cap. To mitigate this problem, another if statement check was added. If the current rate plus the single-period cap was greater than the global max interest rate, the new interest rate would become the global max interest rate.

After the C++ program was completed, it was then integrated into a php file. All of the other types of mortgages were coded in php.

## 5.2.3 Observed and Measured Results
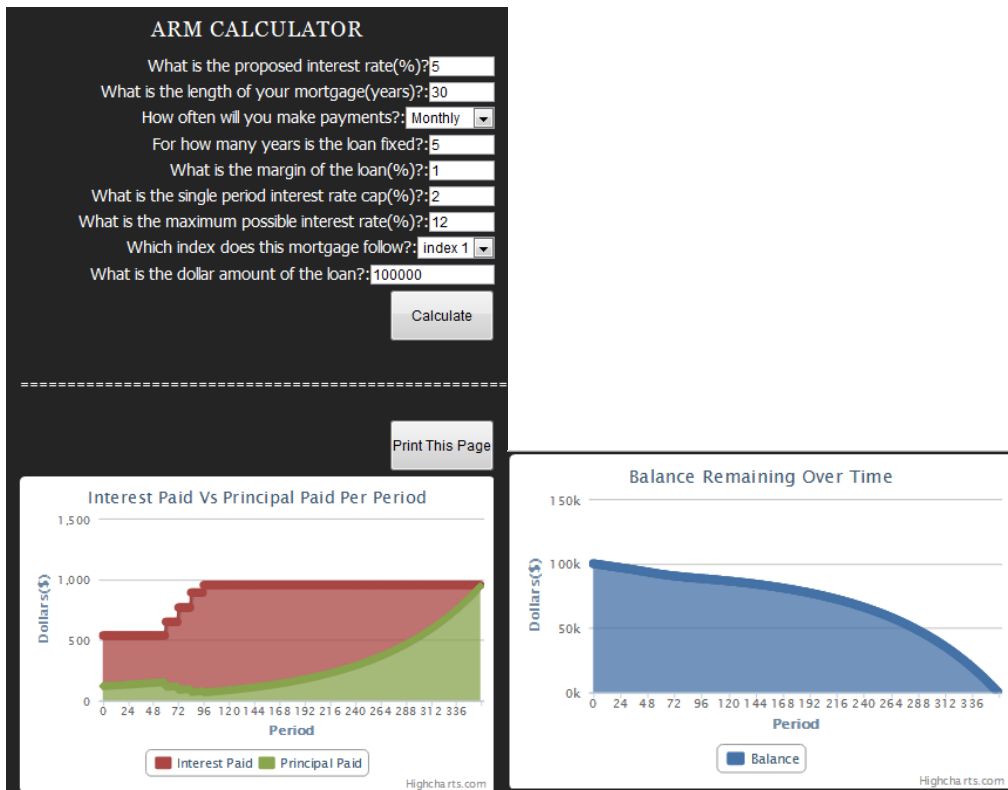
## 5.3 Graduated Payment Mortgage

Name of team member who **designed** this sub-system:  Mark Rusinski

Name of team member who **wrote** this subsection:  Neil Supnekar

### 5.3.1 Theoretical Considerations

A Graduated Payment Mortgage (GPM) is a loan in which payments start at a low level and increase over time. The rate at which the payments rise is called the graduation rate, and the period of time over which the payments raise is called the graduation period. A GPM is a special case of the fixed-rate mortgage (FRM), where the payments start at a lower level than those of a comparable FRM, and eventually rise to a higher level than those of the FRM. After the graduation period ends, the payments remain fixed for the remaining term of the loan. GPMs are available in 30-year and 15-year amortization. Graduation periods typically run from five to fifteen years.

Four parameters are needed to calculate the amortization schedule for this particular type of mortgage. They are the **overall interest rate**, the **term of the loan**, the **graduation period**, and the **graduation rate**. The monthly payments are calculated using the following formula:

$$PMT_1 = \frac{PV}{B \cdot C + (1 + G)^T \cdot D}$$

$where$

- $B = \dfrac{1 - (1 + \frac{i}{12})^{-12}}{\frac{i}{12}}$

- $C = \dfrac{(1 + k)^T - 1)}{k}$

- $D = \dfrac{[1 - (1 + \frac{i}{12})^{-12(N-T)}]}{(1 + \frac{i}{12})^{12T} \cdot (\frac{i}{12})}$

- $k = [(1 + g)(1 + \frac{i}{12})^{-12}] - 1$

PV is the amount of the loan

$PMT_1$ is the monthly payment for the first year

i is the overall interest rate

12 is the number of months in a year

T is the graduation period in years

g is the graduation rate of the monthly payments

N is the term of the loan in years

After the first year, the monthly payment for subsequent years is calculated using the following formula.

$$PMT_t = PMT_1(1 + G)^{i-1} \qquad i = 2, 3, ..., T + 1$$

## 5.3.2  Design Procedure

The GPM was programmed in php using the formulae described above. The variables were all defined, as were k, A, B, C, and D. They were then used to calculate PMT1 (in the program, this is PMT[0], the first entry in the payment array). For the remaining payments, a for loop was implemented to adjust the rate accordingly. The variable "interval" was used to denote the adjustment period. An if statement within the loop checked whether the modulus of i (the number of iterations) and the adjustment period ("interval) was zero. Only then did it change the payment size. The if statement also checked if the iterator i was less than interval*Gperiod, so that the payment size would stop changing after the graduation period was over.

Next, the amortization schedule was calculated in a similar manner to the schedules for the other types of mortgages. The Rpay, PrinPay, Prin, and End arrays are initialized at zero for the first entry of each array. Then, a for loop calculates the interest payment,

the principal payment (PMT – interest paid), and the remaining loan balance. The loop stops when the remaining balance is zero.

### 5.3.3 Observed and Measured Results

*Taxes and fees excluded.



*Taxes and fees excluded.
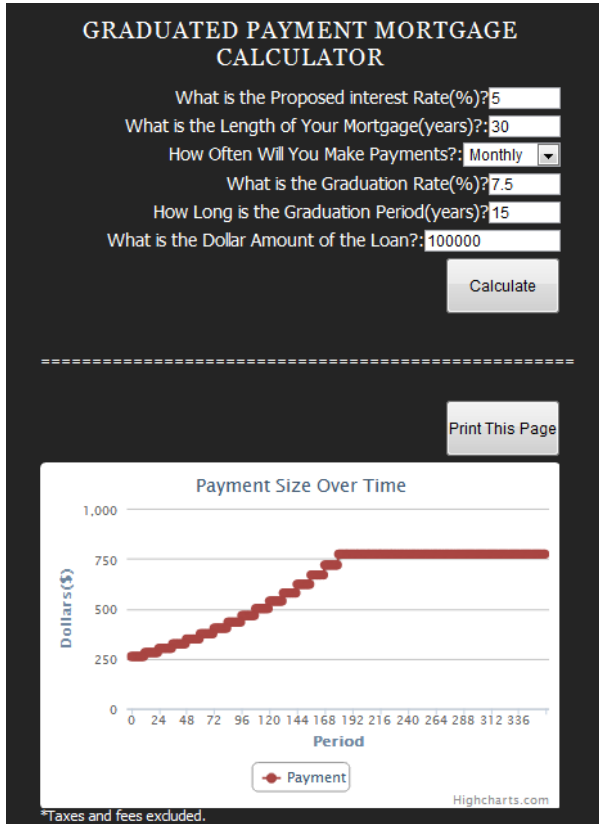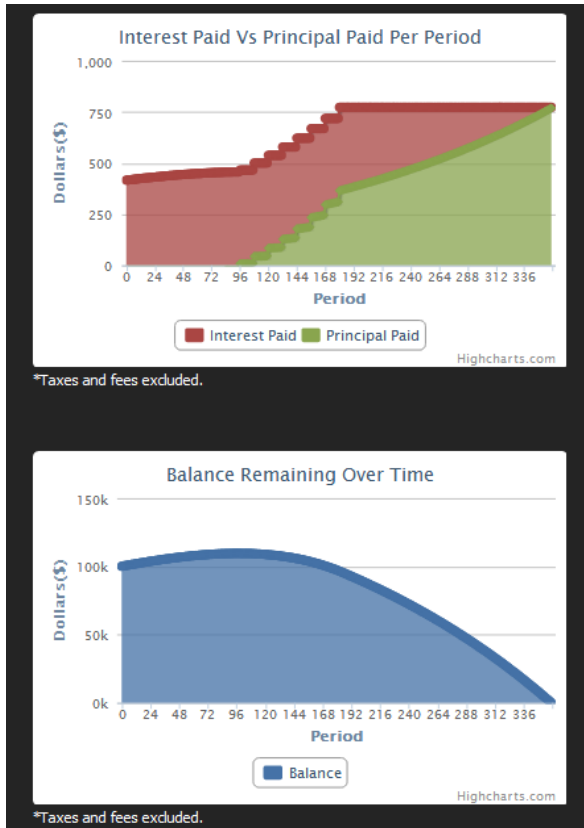
# 5.4 Interest Only Mortgage

Name of team member who **designed** this sub-system:  Mark Rusinski

Name of team member who **wrote** this subsection:  Matt Rodriguez

## 5.4.1 Theoretical Considerations

An interest only mortgage (IOM) functions exactly the way the name implies. The payments made on the mortgage only cover interest paid towards the bank for a predetermined length of time set by the bank. Once the interest only period is over, the mortgage behaves the same way as a fixed rate mortgage. The payment size at the beginning of the payment plan is substantially smaller than the payment size once the interest only period is over. It is sometimes considered a type of balloon mortgage in the sense that the payment size has a dramatic increase at a designated point in time. If a mortgage candidate were to apply for an interest only mortgage without knowing the

risks or increase in payment size, he or she could be stuck with payments much larger than they were ready for, an in turn lose their house.

Interest only mortgages are dependent on the length of time allotted for the interest only period, the interest rate on the mortgage, and the original size of the mortgage. They may seem straightforward but if a homebuyer was to acquire one unknowingly, he or she could be in a lot of trouble once that interest only period was over with.

Overall, interest only mortgages are not typically for the average homeowner in any way, shape, or form. The sudden increase in payment size at the termination of the interest only period could become a large burden on unsuspecting homeowners. One reason to apply for an interest only mortgage is if the buyer is certain that he or she will not be in the house, or paying off the house for a period of time longer than the interest only period, or if someone is expecting to turn a profit from flipping the house in a short period of time. The safest way to purchase a house is to use the fixed rate mortgage where this is little to no surprise involved with respect to monthly payment size.  In the event one is acquired, be sure to understand the risks and policies associated before making a terrible decision.

## 5.4.2 Design Procedures

The Interest only mortgage was coded into php and placed on the website. The majority of the coding was of the same nature as the other mortgage calculations.

### 5.4.3 Observed and Measured Results
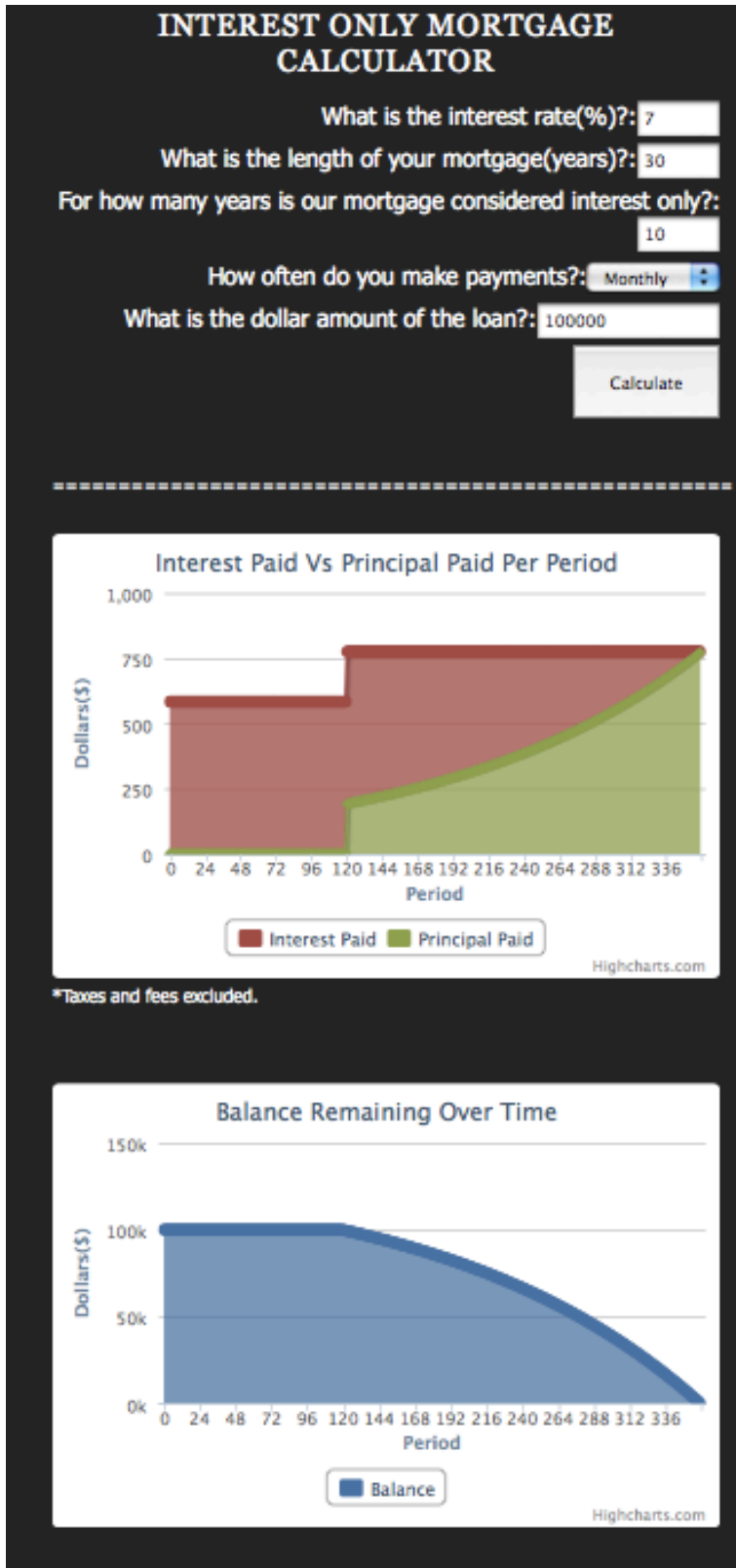
## 5.5 Balloon Mortgage

Name of team member who **designed** this sub-system:  Mark Rusinski

Name of team member who **wrote** this subsection:  Matt Rodriguez

### 5.5.1 Theoretical Considerations

Balloon mortgages are one of the riskiest and most dangerous types of mortgage loans for the uninformed homebuyer. A balloon mortgage has payment sizes calculated by that of a 30 year fixed rate mortgage of equivalent size, with the same interest rate as the balloon mortgage itself. The large difference if that the balloon mortgage expires much quicker than the 30 year fixed mortgage. The typical balloon mortgage payment period is less than 10 years typically. This means that the owner of the balloon mortgage is left with a large lump sum payment at the end of the balloon period and must pay off the house immediately. This sum of money is generally so large that the homeowner needs to either sell the house to pay it off, or renegotiate an extension on the loan.

The balloon mortgage is dictated by a number of variables. The first one is the interest rate, the determining factor in how much money goes back to the bank, and solely to the bank. The next one is the balloon payment length. This is the period of which the homeowner is making small fixed rate calculated payments until he or she reaches a point where they need to pay the lump sum of the house off. The final variable is a function of the other two and it is the balloon payment size itself. This number is the scariest one of all of the different types of mortgage loans as it is the most costly, and least feasible for most people. This is the payment size, generally a six-figure number, which represents how much money you must pay to end your loan and acquire the house.

These mortgages are for those individuals who plan on only owning property for a short term. The main selling points to these mortgages are their low payment size with their short termination times. Both of these numbers are deceiving at first glance to the homebuyer since small payments over the life of a balloon mortgage translates into an even larger lump sum payment at termination. The average homeowner would want

nothing to do with a balloon mortgage due to an inability to pay without selling the house or winning the lottery. A fixed rate mortgage will be a better idea to go with 99% of the time.

## 5.5.2 Design Procedures

The Balloon mortgage was coded into php and placed on the website. The majority of the coding was of the same nature as the other mortgage calculations.

## 5.5.3 Observed and Measured Results
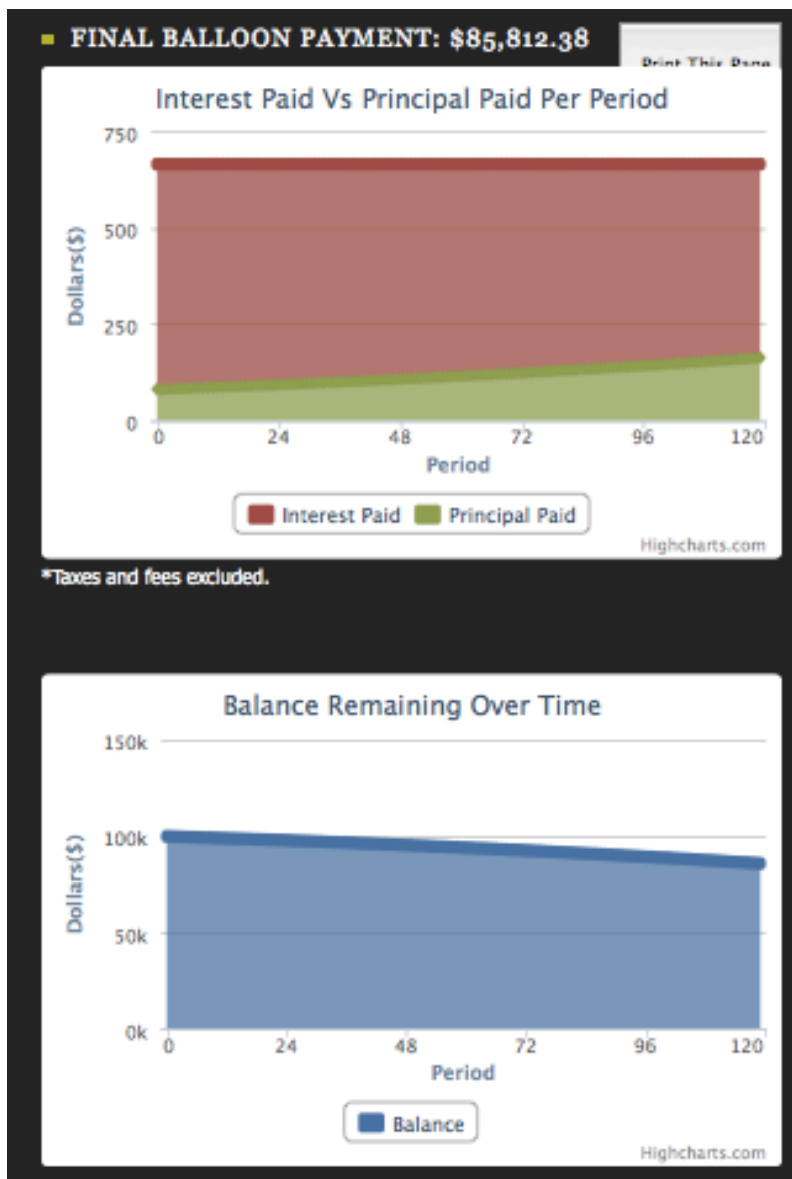
# 6. Integration Considerations

To solve the issue of integration between languages every output and function was called through the PHP language. This required the use of the common 'echo' command in PHP. The html code necessary for the table display was wrapped within every function and displayed using 'echo' in order to display this table with custom input values. The charts were also called using the PHP 'echo' command. This procedure was necessary because PHP is server side while JavaScript is a client side language. As the PHP commanded the output of the specific JavaScript function call to the client the client recognized this and read it as JavaScript. This allowed the proper display of all the graphs with case specific input values to be presented to the user.

# 7. Economic Considerations

## 7.1 Cost Analysis - Prototype

There were no real costs involved in coding the website. All coding was done in php and C++. The templates used to design the website were free. They were provided by mantisatemplates.com and freetemplates.com. The charts were provided for free by Highcharts.com.

## 7.2 Cost Analysis - Final Version

The only real cost involved paying for the domain, which cost $22.

# 8. Manufacturability

The web site, as designed can be viewed on any PC. None of the viewgraphs run using Flash, so the website can also be viewed on Macs. Although the output page of each of the calculators can be printed, it would be useful for consumers to be able to download the amortization schedule as a separate file, perhaps as a spreadsheet. There are free online tools (such as ZohoSheets) that can perform this task.

The website can be viewed on smartphones. All text and graphs are displayed. However, the display does seem cluttered at times and can be difficult to read due to smartphones' smaller screens. A mobile version of this website could be created. Instead of showing all the graphs in the same window, the calculator could just output a page that provides links to the three different graphs and the amortization schedule separately.

There are many free tools that create mobile versions of websites. An Android application was being designed concurrently with the website, but was unable to be completed. However, this is another possible way to expand this web tool to a wider range of consumers.

The web site should also be able to be adapted to future software developments. HTML5 is currently being developed. When completed, it will have improved multimedia support compared to prior versions of HTML. The web site could take advantage of this support by having more ergonomic and interactive viewgraphs and tables.

# 9.    Marketability

Since the domain has already been bought, the task that has to be done now is to popularize the website and generate ad revenue. Google is the most popular search engine, and it has advertisement programs in place. One method is AdWords, where users create their own ads and pay each time the ad is clicked. This method may popularize the website, but it will not generate the revenue needed if the site is to be kept free. The other method is Google AdSense. To generate revenue, Google advertisements can be placed on the website. The javascript code for AdSense would be inserted into the website. Google searches through keywords in order to place relevant ads on the website. These ads are served from websites using the AdWords bidding program.

The main competitors of this website are other mortgage calculators such as bankrate.com and informational sites such as Mortgage Professor. Bankrate's functionality is similar to this website's. However, Bankrate is cluttered with intrusive ads. Sometimes, these ads come in the way of viewing useful content. Also, since Bankrate provides many different kinds of services other than mortgage calculators, it can be difficult to navigate at time. Bankrate also aggregates news articles, blog posts, and mortgage quotes on the homepage. Although this information can be useful, Bankrate's interface can be overwhelming and confusing due to the sheer amount of items that are on the screen at any given time. One area where Bankrate does have an advantage is the amount of mortgage calculators they have. However, many of these

calculators are redundant, such as the fixed-rate vs. adjustable-rate calculator and the interest-only vs. fixed rate calculator. In addition to this problem, the index of calculators is difficult to find without using the site's own search tool. To stay competitive, mortgagemaze.net should offer more types of calculators. For example, Bankrate.com has a points calculator, which would be useful for many consumers. However, mortgagemaze.net is much easier to navigate than Bankrate.com and therefore delivers information to consumers more effectively. The other mortgage calculators on the internet seem even less effective than Bankrate's calculators. Many of them do not even offer ARM calculations. Many of them are cluttered with ads and do not explain how their services work.

The informational competitor to mortgagemaze.net is Mortgage Professor. Although Mortgage Professor also offers a fixed-rate calculator, it does not offer calculators for any of the other types of mortgages. However, what Mortgage Professor does provide is a comprehensive amount of information related to many questions that prospective homebuyers ask. Mortgagemaze.net provides information that is helpful to homebuyers, but it does not provide the vast array of information that Mortgage Professor does. One area where mortgagemaze.net does have an advantage is that it offers links to government programs that may be useful to prospective homebuyers. If people visiting the site follow these links, they can be sure obtain accurate information from the office of Housing and Urban Development. Also, Mortgage Professor may provide more information than is useful for many people. For example, the section describing adjustable-rate mortgages is very informative. However, it does not directly advise homeowners not to take out ARMs, even though it presents evidence against them. Homeowners may not understand this information and may not realize the risks involved in taking out ARMs.

# 10. Individual Discussions

## Overview Discussion of the Project – Matt Rodriguez

This project taught me a great deal about the current state of the country's housing market as well as how to make educated decisions with mortgage loaning. Coming into the semester I had very little background in economics or finance and took the capstone course as more of a last resort, than a priority. Within weeks I found myself taking a lot of pride in what I was learning and creating and started to feel passionate about the problem at hand. People being taken advantage of by the banks in an attempt to generate revenue instead of provide reliable service is a huge issue. The biggest design constraint was making things easy to read, access, and understand. The color scheme of the website was decided to be green solely because green is a very inviting color to most people as it symbolizes a mental connection with the word "go." Developing a lot of the tutorials came down to choosing the right wording as well as placing objects in good relative positions.

The marketability of such a resource is actually relatively high. Even if no money is generated with this tool, that will not stop people from wanting to learn about the ins and outs of their mortgage payments. The economic impact of this site is something totally dependent on those who decide to use it as a valid resource. Hopefully people using the site will no longer be tricked into buying things they could not afford. Education could be a driving force for the economy's growth over the next ten or twenty years as a lot of the new potential homebuyers are children who watched their parents struggle through the financial crisis of 2008. A lot of pressure is being put on banks and the stock market to attract the current college graduates over the next 10 or so years and get them away from the fear of failure they watched their parents struggle so terribly with.  Giving people the tools to make mortgages more readily understandable is a good start in developing a stronger housing market for years to come. People need to realize there is a problem with their level of understanding before they start attempting solutions or jumping into assets they can't afford. Our website accomplished all of these things in one easy to access place.

## Detailed Discussion of Pertinent Subsystems – Matt Rodriguez

Most of the development for this project I did was focused toward an Android platform. Toward the end of the project however, the timeframe got smaller and smaller and the end product of the android application was abandoned in conjunction with the making the website android accessible. I worked on the government programs webpage where all of the programs are separated and detailed with their appropriate requirements. The layout of the page was simple, yet attractive since it bullet pointed every single one of the programs and their requirements. The goal was to create a location where the programs were listed out not only with their names, but also the associated benefits and criteria.

A lot of the android development was learning how to code for android. My initial reason for agreeing to do the financial engineering capstone was to have an excuse to code an android app for the first time from scratch. Throughout the development process it became increasingly hard to put all of the necessary information on such a tiny screen, easily. The end android product was missing the ARM as well as the interest only graphing ability. In the end it didn't seem like a good investment to put it up for display so incomplete, and since I was the only one working on it, giving the code to the rest of the members already working on the website, with no prior knowledge of android development seemed like a bad idea.

Most of the layout decisions, font selection, and photoshop work was also done by myself. A big reason why I spent so much money on the android platform was my desire to create art and design layouts effectively, as it has become somewhat of a hobby of mine to learn how to make random pieces of art in photoshop and apply them to appeal to people's senses to generate laughter, or just a good flow in layout designing. It was kind of heartbreaking to have to abandon the android application so late in the development process, but being able to focus my efforts on successfully enhancing the main webpages seemed like a better investment of time and group strategy. All in all I think I did my part to the best of my abilities, despite seeing a lot of room for improvement in the future as well as having a lot of new ideas that could have been realities.

## Discussion (Mark Rusinski)

This financial engineering project incorporates the concepts of mathematics, finance, and website programming. Concepts of mathematics such as geometric series for annuity calculation were used. Finance in the realm of mortgages was covered in depth for the five main types of mortgages; which are fixed rate, adjustable rate, interest only, balloon, and graduate payment mortgages. The website programming became involved as not only did the algorithms have to be implemented in PHP, but aesthetics had to be scripted in HTML and CSS in to all an enjoyable and easy to use user experience. These three pillars of financial engineering are all present in the Mortgage Assistant financial engineering Capstone project.

Fixed rate mortgages are the standard of the mortgage industry. Before all of the other four mortgages analyzed existed the fixed rate mortgage was the main method of paying for a home. This is because fixed rate mortgages follow a relatively simple model as shown in equation 5.1.1.5. The payments are held constant over the life of the loan. This makes it a fixed debt instrument that offers no surprises to its owner. The only drawback of these mortgages is that they typically have higher interest rates than the other contrived mortgage plans such as an adjustable rate mortgage. Typical terms of a fixed rate mortgage are 10, 15, and 30 years. In each case most of the monthly payments are spent on paying interest which is the bank's main mode of making money off of the investment. It is not until the latter years that does the balance on the mortgage start to decrease exponentially.

Adjustable rate mortgages (ARMs) are the most advertised types of mortgages, but also the most unpredictable. The adjustable rate mortgage is also the main instrument of predatory lenders as marginal candidates for fixed rate mortgages can often qualify for an ARM at a lower interest rate. After a short initial period of most commonly 1, 3, 5, or 7 years this mortgage adjusts its interest rate every year. The rate by which it adjusts is determined by a combination of the margin of the loan and its underlining index. The margin is simply a predetermined amount of percentage points the bank tacks on to the underlying index value at the time. The index value is based on an one of a variety of commonly used assets such as U.S. Treasuries, National Average Contract Mortgage (NACR) Interest Rate Index, Eleventh District Cost of Funds Index, and London

Interbank Offered Rate (LIBOR). Each index has its own characteristics. For example the LIBOR is known to be one of the most volatile indices used. The volatility of these index assets causes the interest rate associated with the mortgage to go up or down accordingly. In the current climate of low interest rate- with fixed rate mortgages below 4%- the chances of these index values driving the interest rate lower are low. It is more likely interest rates will rise, since historically they have been known to go higher that 12%.. This could leave current ARM owners in tight fiscal situations, and the 2008 mortgage crisis is an example of just how bad the situation can get.

Graduated payment mortgages and Interest only mortgages are similar to adjustable rate mortgages, but the payments increase by a predetermined amount. Graduated payment mortgages increase the payment size usually of a period of 5 years, while interest only mortgages have a one-time jump in payment size at the end of the interest only period. These mortgages are dangerous for uninformed home buyers in similar way to adjustable rate mortgages. The initial interest rates are smaller than that of a fixed rate mortgage, but the final payments are much larger. This poses another danger to long term home buyers, who could not afford the fixed rate payments, but are later expected to pay even higher charges in the future.

The final type of mortgage is a balloon. These mortgage payments are calculated as 30 year fixed, but balloon mortgages terminate much soon than that (usually 7 or 10 years). This poses great danger of the home owner who will undoubtedly be unable to pay the final sum if he or she desires to continue living in the home. This mortgage instrument is definatly not for long term home buyers looking to live in a house, but it is rather for a short term investor who believes the property could be flipped for profit.

Each of these mortgages was implemented in PHP for website use. Since the fixed rate mortgage was the simplest instrument it provided for the most compact code, and was the frame work for the other four mortgage calculators. The more complicated mortgages appropriately contained more conditional statements and appended loops in order to perform properly. It is no coincidence that the ARM code contained the most such special case conditional statements. The general observed trend was that the more volatile and dangerous a mortgage instrument was the more complicated it was to code.

Each of the mortgage calculators employed the same table generating function which was developed from the ground up for this website and n augmented graphing function form Highcharts.com. CSS was added for aesthetics which allowed an alternating shading pattern in the table to allow for easy reading between payment periods. The graphing function was augmented to all for select columns of the HTML amortization table to be used in its display. This proved a bit of a challenge as the Highcharts function was written in JavaScript, while the original calculator was in PHP. Buy employing some clever wrapping techniques this issue was overcome.

An understated portion of the project was the amount of time devoted to website aesthetics and usability. Aside from the heading banner used on every webpage on the domain the layout was designed uniquely for this project. The concept of division allocation within the confines of a home screen and the responsibilities between HTML and CSS were all learned because of this task. No software aid was used to produce an overwhelming majority of this website and thus the code is not bulky taking up less than 12 MB of space.

From an economic perspective the potential for this project is high. Since all of the coding and information of this website was developed in house our expenses were minimal. The only purchased item was the domain which costs $22 a year. If profit was to be made off of the website a Highcharts license would also have to be purchased for $50. For profit generation this project would still offer all information for free, which is the goal of this project. However, banner advertisements would be placed around the borders of each webpage. Using an affiliate program, such as Google Adsense, profit could be generated for every time a visitor of the webpage would click the advertisements. The marketability of this project is only limited by the amount of users that visit the domain.

The project as a whole covered many critical topics mathematics, finance, and computer programming. Geometric series calculations were necessary to derive the essentials of annuities, which are the backbone of mortgages. Five financial instruments were studied and analyzed all with unique characteristics but ultimately based off the fixed rate model. Finally, web development and coding was used to present all this

analytic data in a simple, intuitive package that was the Mortgage Assistant website. This was a truly comprehensive financial engineering project.

## Discussion - Neil Supnekar

Main duties:

- Programming the ARM calculator
- Procuring the list of government programs

Programming the ARM calculator was a more difficult task than programming any of the other calculators. All of the calculators modified the code that was used for the fixed-rate calculator, but the ARM calculator required the most modifications. The ARM was coded so that the calculations matched that of a handout distributed by Dr. McAfee. An adjustable-rate mortgage behaves like a fixed-rate mortgage for a certain period of time. For example, a 5/1 ARM remains fixed for five years, and then adjusts every year following the first five years. For the initial five-year period, the code used was the same as the code used for the fixed-rate mortgage. However, the for loop only ran from the first payment to a payment at time tf, which was the last period at which the mortgage stayed fixed. Within the loop, as was the case with the FRM calculator, the interest payment was calculated and subtracted from the payment to yield the principal payment. This principal payment was subtracted from the present value to yield a new present value. All of these values were then displayed line-by-line in a table (since it was programmed in C++, all of this ran in the command prompt.)

Each time the rate adjusted, the calculation was akin to performing another fixed-rate mortgage, but with a different principal loan balance. In Dr. McAfee's example, the first adjustment on a 30-year, $150,000 loan occurred after three months. After three months, there was a "balloon" payment of $149.343.68 to pay off. In order to calculate the payments between this adjustment period and the next, the mortgage was treated as a 357-month (or 360 months minus t, the current amount of months elapsed), $149.343.68 loan FRM. This pay scheme continued until the next adjustment period. At the next adjustment period, the principal loan value was again adjusted to that of the new "balloon" payment and the term was adjusted again to 360-t. In Dr. McAfee's example,

since the adjustment period was once a month, the term was adjusted to 356 months. It is worthwhile to note that Dr. McAfee's example used index and margin values. The website, since it did the worst-case scenario evaluation, did not do that. During the worst-case evaluation, the interest rate keeps increasing by the single-period cap until it hits the global cap. That is what the calculator reflects.

To do these calculations, a second for loop was implemented. This for loop extended from tf to t, which was the time that the loan matured. Inside the loop were three nested if statements. The first statement made sure that the interest rate would only change during each adjustment period. It did this by checking the modulus of the variable adjint (the adjustment period, in months) and i, the iterator variable that counted how many times the loop ran. If this modulus was zero (i.e. that particular iteration signaled that the adjustment period had elapsed), the program would then check if the current interest rate was less than the global max rate. If the rate was not less than the maximum rate, the program went to an else statement that set the rate at the maximum rate. If the rate was less than the maximum interest rate, the value PV (the outstanding principal balance) was set to Prin[i] (the "balloon" amount described earlier.) The third if statement checked to see if adding the single-period cap increased it to a number higher than the maximum rate. If this would happen, the rate was simply set to the maximum interest rate. This fix was added later, after it was discovered that the interest rate "jumped" beyond the maximum rate. If this if statement did not apply, the rate was increased by the single-period cap. A new variable "tmature" was also introduced. This reduced the term of the mortgage from the original (say, t = 360 months for a 30-year loan to t = 360 – i.) This ensured that the calculations matched those detailed above. At first, this was not done, and the payments actually lowered, despite the interest rate increasing. This was because at each adjustment period, the mortgage was still being calculated for a 360-month term. This actually made the mortgage go on infinitely, which could not be the case.

The rest of the code is similar to the code used for the FRM. The variables r, PVF, and c are initialized again. One difference is that PVF now uses tmature instead of t in its calculation. The interest payment is calculated by multiplying the principal loan balance by r (the interest rate as a percentage, divided by 100, and then divided again by the

payment interval.) Then, the principal payment is calculated by subtracting the interest payment from the total payment c. Finally, the principal paid is subtracted by the loan balance and placed in the End[] array. These numbers are then output into the command prompt as before. When End[] reaches zero at the end of the term, the total amount paid is output.

The informational component of the website was done mainly by picking a diverse mix of programs that were mostly available through the Office of Housing and Urban Development. There was a very large array of programs from which to choose, and it was important to find a balance between explaining common programs which apply to average homeowners and more obscure programs.

Four of the programs listed are based off of FHA Loan 203(b), which is one of the more common programs of which people take advantage. The 203(b) program allows lenders to provide 96.5% financing to homeowners purchasing one-to-four-family homes, condos, or townhouses in both urban and rural areas. The homeowners need enough money to close the loan, a satisfactory credit card, and sufficient cash to make the monthly mortgage payments to qualify. Other sections of 203 apply to people who require financial assistance for rehabilitating homes (203(k)), disaster victims (203(h)), and people who are interested in cooperative mortgages (203(n)). There are also insurance programs for those who are interested in purchasing homes on Indian Reservations and those who have manufactured homes. Other programs for low-income citizens fall under the MHA (Making Home Affordable) project. These include the Home Affordable Mortgage Program and the Home Affordable Unemployment Program.

Veterans' Affairs also has programs that help veterans stay in their homes. Any veteran meeting service requirements and who has filled out the necessary paperwork is eligible for a VA loan. The Veteran's Affairs Supportive Housing (VASH) gives veterans who are in need case management the clinical care they need as well as housing rental vouchers.

Finally, there were some programs that were included that did not fall into any of the categories described above. These include Graduated Mortgage payment plans, a

program for people who have second mortgages, a program for people wishing to make energy efficient modifications to their houses, and people who have suffered income losses of at least 15%.

# References

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