Board 12: Work in Progress: Enhancing Student Engagement and Interest in STEM Education through Game-Based Learning Techniques in Bioengineering and Electrical Engineering Core Curricula and How to Create Them

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Introduction:

Engineering education has evolved greatly over the last decade [1, 2]. Implementations of active learning techniques, student centered learning, and effort-based grading were traditionally not typical in the STEM fields, but due in no small part to their ability to increase engagement and interest, these applications have become mainstays within engineering disciplines and have helped to keep students interested in their respective fields [3, 4, 5, 6, 1].

In addition to attrition due to disinterest in our curriculum [7, 8, 2], engineering educators also contend with attrition in bioengineering due to students feeling a lack of belonging [9, 10, 7], a lack of support, or feeling othered due to many factors including discrimination [11, 7]. Others have extensively reviewed the techniques used to combat these systemic issues [12, 13, 14, 15]. These efforts aid in creating a more accessible method for teaching students and building both confidence and belonging in these students such that they can best achieve what it is that they would like to.

To that end, this paper will further those efforts by discussing different game-based learning methodologies and techniques that can increase course accessibility. There are numerous factors that must be considered when adapting lessons into games, and this paper intends to present a diverse subset of these factors so that readers and engineering educators are able to integrate them into their own curricula.

Topic 1: What is game based learning and why is it useful?

Game based learning [16] is a variation of gamification [17] in which instead of using an existing structure of game-like elements to model the entire course and assess outside of the game, it is more focused on using games as lessons to model scenarios and applications for the learning objectives. In this space, it becomes much easier to adapt lesson plans and lower the barrier of entry for students who may feel scared by the material. Furthermore, there are many advantages to implementing application-based learning within concepts in Electrical Engineering and Bioengineering curricula [18, 2]. Creatively implementing these strategies allows students to “play within the sandbox” and test limits in a controlled environment that is safe to fail in, in a manner that will build greater engagement within the course material. These games may also assist with retention as they reinforce and supplement material that is already covered in the lectures, while giving students the opportunity to fortify those foundations [19, 20, 21]. It is also much more accessible as the instructor can use multiple parallel methodologies of conveying information beyond simple lecture and slides.

Topic 2: How do we build games?

Building games is very similar to building the lesson plans that most instructors already prepare for each course [1]. The first step is to decide on a topic on which you would like to focus or prioritize as a learning objective. Considerations include the following:

- What are the aspects of the learning objective that are necessary for students to learn or develop? What skills do you want them to practice, and in which do you want mastery?

Secondly, the instructor should decide on the medium in which they would like to craft the game within. Questions which may be asked to distill these details include:

- What kinds of games would you like to use for this?
- Do you want it to be digital? Online? A specific software?
- Do you want it to be physical? Examples include a Rube Goldberg, physical puzzle, Escape Room, Drawing, etc.
- Do you want students to perform? Sing? Draw? Dance?

Once this is decided, the instructor should consider which methods of visualization would allow their students to get feedback on their results or efforts. Are there methods such that you can implement things that the students would be excited about or interested in to build better alignment with the students' own values and motivations? Lastly, how is learning or effort assessed? Is there a simple way to grade the effort or visualize how well a student performed? Is there a way to get instant feedback to reinforce and associate the correct answers? What about rewards? Are there any motivations to complete it first, last, or correctly?

At the end of this document, I have included several examples of some of my own attempts at creating these labs. Using one such example, Harmonics Lab, the Fourier series is interrogated through the use of auditory, visual, and mathematic examples. We used music to hear the importance of the FFT, as well as to visualize what is happening within.

Topic 3: What are some weaknesses to consider?

While game based learning affords much needed flexibility and engagement to the bioengineering curriculum, it is not a perfect solution for everything in our field. The instructor must reflect on whether all course assignments should be turned into games, or if there can be alternatives that could be considered instead.

Design Weaknesses:
First, building these games requires a substantial amount of effort. Attempting to figure out how best to convey a topic in a novel manner is a very difficult task when you have never done anything like this before. Making sure each game is unique and also does not detract from the lesson is a difficult balancing act. In addition, many classes are limited in the amount of time that can be spent on instructing how best to play the game at the expense of the time that can be allotted to playing said games.

In addition, games have a habit of "running away" from the creator. It can be difficult to prevent

the game from taking the spotlight too much from the material. From experience, sometimes simpler is better, especially for retention of concepts. Additionally, large classes can inhibit game based learning in certain ways. Large classes make games more difficult, as designing an activity for 5-15 people requires different skills and resources than designing for a class of 60+. It may not be feasible to even try to implement a game when no one could play reasonably well in a class time period due to the scale of a large class. Some ways to mitigate this issue involve creating teams such that the overall number of "players" are reduced and more manageable, but it is still a definite concern that must be considered when designing the games.

Audience Considerations:
Games need to take into account the diversity of the population for whom they are built. That is to say, there is no one size fit all game. For example, one semester I built many different word-based puzzles for my MATLAB course, which were popular among students and faculty in the Bioengineering department. The next semester I tried to implement the same manner of puzzles in a higher level Probability course in the Electrical and Computer Engineering (ECEG) department, and was addressed by some of my students asking if the word puzzles were mandatory because they were tedious. Confused, I realized that my word puzzles were not accessible for international students or those with English as a second language. As the demographics of my course changed, I did not consider that the games themselves should have changed as well. The same can be said for color-based elements for color blind students as well. If the games are intended to increase engagement and accessibility, they cannot be a detriment to either. To remedy this, I designed games more focused on the course material and used those topics as the main crux of the puzzle rather than word puzzles or math problems necessarily.

Lastly, games require a certain amount of "buy in" from the students. They don't necessarily have to fully commit to the game, but if you give them something largely unknown (like *Twilight Imperium: Fourth Edition)* and then expect them to learn that game as well as the learning objective in 30 minutes, they're going to give up before they even start. Again, considering your audience here will help focus this down; it's critical to know what the expectations are for each of your games in terms of complexity.

One aspect that still remains to be completed in this work is to assess the impact of these games in some sort of longitudinal or interest based assessment. Current assessments are survey based and assess interest, fear, mastery, and comfort with the material. Investigating if students remain in the program, or if they improve their scores over the course of their tenure, or if they remain in academia afterwards is a multi-variable problem and may be difficult to assess. That being said, there are some aspects that we can do including an exit survey, a graduation exit survey, and entry surveys at the beginning of the semester to investigate snapshots of their state.

Conclusion:
The integration of game-based learning techniques in Bioengineering and Electrical Engineering core courses has a promising potential to foster student engagement and interest in STEM education. This in turn, will help with retention of students as well as retention of material.

IRB Statement: As the data used in this paper was survey and Program Evaluation information, there is not a need for IRB approval at this stage.

Appendix A:

Testimonials

Included here below are a few of the student's responses to the game based learning techniques when applied to a typical MATLAB course in the bioengineering course.

"I personally really enjoyed doing the puzzle style labs! I find coding very very overwhelming so I think a much more rigid or regimented coding lab would make me feel really tense and stressed in comparison to the puzzles. The puzzles helped break down coding concepts into smaller parts, made it much more enjoyable, and was a super unique experience in a lab."

"I do think the puzzles were very helpful while I was learning matlab. It made the process a lot more enjoyable and many times I forgot I was learning along the way. The puzzles helped me cemen[t] the lecture material and really put everything together. Also, I just enjoyed doing them and it made the labs a lot of fun to come to. The atmosphere was also one that we were all able to work together and learn but still joke and have a good time. I do not think a structured computer science approach would have helped me as much. I believe I would have quickly gotten the work done so that I could leave. Whereas there were times I stayed and did the optional part of the puzzle or I did multiple peoples puzzles when it was not necessary. It kept me engaged and eager to learn."

"I think the puzzles were a fun way to learn that kept me engaged. I was able to execute the functions and concepts from the lecture while having a good time. The puzzles made it easier for me to see what was happening without getting bored or overwhelmed at huge portions of code. I am not totally sure what a structured computer science approach would have looked like since I have not taken a computer science course, but I did like the engagement on these activities in lab, so I think for other kids like me who do not have a structured computer science background, it would be fun and helpful to continue learning in this way."

"I do believe the puzzles were extremely helpful in learning how Matlab functions. They were a fun way of engaging us in applying what we learned in class. It led into a different way of thinking about how the commands and functions worked, which is much better than muscle memory coding."

Appendix B:
Example Labs for your perusal.

There are countless examples in literature of different games that can be used to inspire and educate [22, 16, 4, 6, 15, 17]. In this paper, I will list the ones that I have personally completed and tested. I have taught using these game based learning techniques in the following courses: Introduction to Engineering Computing, Fundamentals of Biomedical Signals and Systems, Signals and Systems Theory, Electronic Circuits II, Probabilistic System and Data Analysis and Communication and Information Systems.

In my computational class, I experimented with using MATLAB-based puzzle labs. These served the purpose of making MATLAB less intimidating to students and making the rote portions of coding much more bearable. Using these puzzle labs allowed students to see direct applications for the code that they were running, and how it was built. These labs also added a complicated Murder Mystery lab, which forced students to denoise images, solve MATLAB riddles, and apply different course elements. This lab asked the students to implement all the current course knowledge to solve the puzzles. One of the final labs was the Uno Reverse Card lab, which asked students to create their own puzzles from the course materials and have at least one student in their lab section successfully complete the lab. After the class, I collected exit surveys on a 1-5 scale with 1 being low and 5 being high confidence to quantify the confidence that they felt in their MATLAB coding. All students greatly increased their comfort, with a 1.4 fold change from their initial average of 1.4, which means it more than doubled to 3.5.

In my Probability course, I took what I learned from the previous iterations and introduced a number games and puzzle labs as well. I was able to implement a lab where the students were asked to create code using cross-correlation. However, they needed to use images of their own design to be able to customize it and allow the game to run. Next, I implemented a lab wherein the students were able to test the color distributions of M&M's to explain the chi squared error and how distributions may differ from the models that they have learned thus far.

In my Signals and Systems course, I made as many of my labs game based learning exercises as was possible and found that the students responded positively. For example, I was able to implement many labs where students were required to experience the science or math in an orthogonal method other than what they had before, whether it was auditory, or visually, having to sketch it, or even having to break it. We were able to witness them play and record their favorite songs to analyze them in MATLAB, or have them draw pictures based on their answers from a number of Laplace Transforms.

I have below pasted directly both the MATLAB code as well as the documents here for you to peruse and be inspired by. I am trying to constantly improve these, so any feedback would be helpful.

I have stored these files at the website for your perusal:
https://drive.google.com/drive/folders/1JhrCQpUs4jiirDacOi5oApgrWAVn9RVJ?usp=sharing

Lab 5: Fourier and Find Out!

Due 02/28/2023 at 5 pm

This is a personal experience, but you can chat with your friends. And enemies.

Introduction

This took longer than expected to make, so please excuse any small errors. The big ones, please call me out on. ;)
HI HELLO! TODAY I WANT US TO BREAK FOURIER MATH. I have created a set of puzzles and mysteries using the FFT function that you will be using for your Midterm Project. In order to make it unique and different I want to focus on different aspects, but this may help you a little bit if you wanted to try to figure out how best to represent your signals there!
But, to begin, I want you to download the files that I have uploaded into the Moodle folder!

Procedures

The main premise of today's lab is that Fourier Series and Transforms serve to give us a way to represent signals in a universal format- sinusoids. This is incredibly useful and practical, but also allows us to use it as a tool to understand and deconstruct signals. Naturally, we will use it for games today, but in real life this is WILD math.

Task 1: Fill out Table and Graph these functions:

In class, we mentioned that our Fourier Transforms encode two important pieces of information among other things. The coefficients, which give us the "amount of each ingredient" and the frequency, which gives us the "type of ingredient." Using these pieces we can construct a rough idea of the contents of a signal, excluding of course the harmonics of each of those systems, which we can account for with our summation and our variable n.

SO: Let's graph these and see if we can see anything cool about why these coefficients matter. I have put in front of you, an FFT, which has a bunch of peaks. I would like you to write down in this table what the different coefficients are, as well as the different frequencies. *Note that because of noise, the values will probably be slightly off, so you can round to the nearest number*.

Here you are!

Amplitude (Coefficient)	Frequency (Omega)

Now that we have this fancy table, I would like you to use them to reconstruct the sinusoids that made this! Please write the formulas below, assuming sines:
Recall that they will be in the form:
Data= coefficient(1)*sin (2*pi*f(1)*Time) + coefficient(2)*sin(2*pi*f(2)*Time)+……

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Can you graph the coefficients, and the frequencies across and compare to the FFT. A stem plot with 1:length(f), f will work, as well as stem(1:length(coefficient), coefficient)
What insights do we get by looking at these graphs?

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Task 2: Find the combinations of sines to create this signal!

I have made a smoothie with the following "ingredients". I need you to find out which ingredients I used to make it. It should be on Moodle! (Note that the rounding may be SLIGHTLY off, but that's because of all the schenanigans I am doing in the background.)

```
strawberries=1.5*sin(40*2*pi*Time);
cherries=7*sin(22*2*pi*Time);
bananas=3*sin(75*2*pi*Time);
pomegranate=5*sin(67*2*pi*Time);
peach=4*sin(100*2*pi*Time);
grapefruit=25*sin(27*2*pi*Time);
plum=70*sin(40*2*pi*Time);
watermelon=0.75*sin(18*2*pi*Time);
pineapple=0.5*sin(16*2*pi*Time);
orange=23*sin(50*2*pi*Time);
grapes=20*sin(85*2*pi*Time);
apples=10*sin(125*2*pi*Time);
dragonfruit=5*sin(45*2*pi*Time);
```

What are the ingredients that I used? Why do you think so?

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<u>Which ingredients would you use to make your own smoothie, and please show us the FFT of it if you can! :)</u>

Task 3: SOLVE THE MURDER MYSTERY!!!

Okay, this is why this took me like literally forever to make. I hope that this works!

THERE HAS BEEN A CRIME!!!1!
Our beloved bison mascot Bucky, has been attacked by some vandal which has left his clothes in severe disrepair! The <u>only clue that we have is a recording of the criminal as they were singing while they were committing the crime.</u> Fortunately for us, you are all the best of the best. Using your prodigious detective skills, you have narrowed it down to the following suspects:

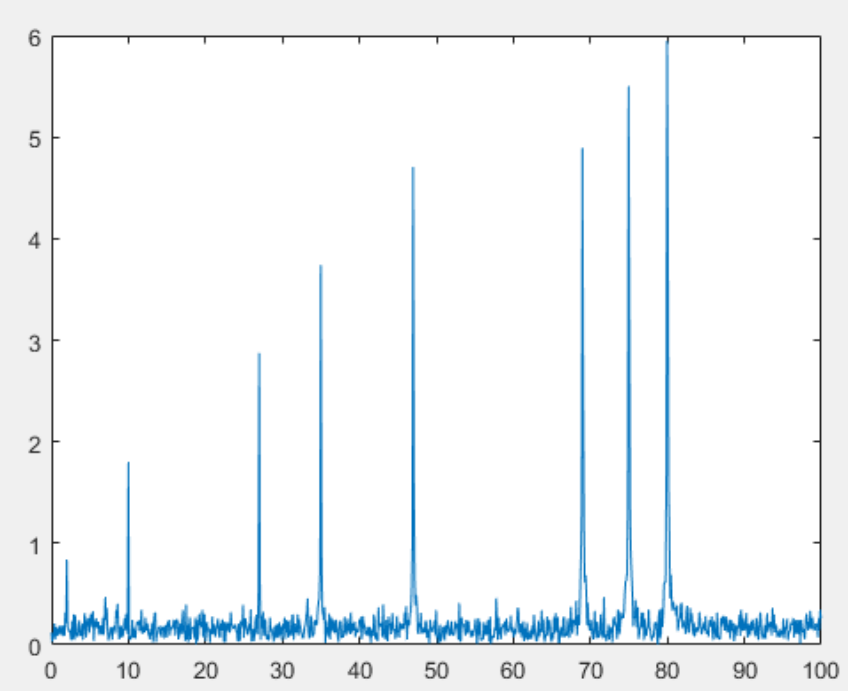
Nittany Lion, from Penn State.

Peruna the Pony, from Southern Methodist University.
Brutus Buckeye, from Ohio State University

The butler, Johnathan Noncoupable

Suspicious Astronaut looking humanoid in red with a visor, from space? Maybe?

We have coaxed them to sing and have gotten the recordings checked and uploaded to Moodle for you. We have also labeled them from A-E from top to bottom on the above list. Please identify which one of these is matches this criminal! (plot(FA,CriminalProfileA) etc. and compare to this picture)
I have uploaded this data onto Moodle for you to peruse!



Now that you have done that, I have provided the coefficient and frequency vectors for each criminal. Please tell me how many of the "weapons" they used. (Put together the coefficients Ca, etc or whatever it may be for the criminal) with the following weapons(Wa etc or whatever it may be for the criminal))

Frequency	Associated Weapon of Choice
2	Red Paint Barrell
10	Scissors
11	Silly Putty
13	Wine Stains
15	Glue residue
17	Let pet rat chew on it
19	Run over by bicycle

20	Cut by pocket spork
21	Dropped into lake
23	Footprints from jumps
25	Blue Paint Barrell
27	Fire burn marks
30	Sharpie attack
33	Bolt related destruction
35	Laminated the uniform
36	Footprints from skips
40	Ice related damage
42	Run over by car
47	Dropped into mud and puddles
50	Footprints from stomps
53	Dropped into pond
57	Hammer related destruction
59	Cut by pocket spoon
60	Electrical Burn marks
61	Expo Marker Graffiti
63	Shark attack
65	Screwdriver related destruction
69	Yellow Paint Barrell
70	Hourglass Related Destruction
75	Acid staining
77	Run over by golf cart multiple times
80	Various strong noxious smelling elements
81	Cut by pocket knife
85	Grease stains from food spillage
90	Green Paint Barrell
100	Footprints from hops

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Lab 6: Writing Music with Harmonies!

Due 03/21/2023 at 5 pm

This is a personal experience, but you can chat with your friends. And enemies.

Introduction

So my dream for this was to have y'all write your own music with the harmonies that you'd solve for using these programs, but unfortunately I don't enough MATLAB magic to create such majesty. Future me will level up and hopefully be able to do it one day.

Procedures

Today's lab is focused on teaching you all what a harmonic is other than just a fancy part of the Fouirer Transform. In this, I want you to **hear** what a harmonic sounds like and how we can play with them and make our own bits of music along with identifying pieces of our favorite pieces and seeing if the code we cobbled together works or not. ;)

Task 1: Please listen to this sine wave and tell me what harmonics it could have:

Just like for your midterm project, I want you to take the sine wave that I have put below and I want you to give me a harmonic and play it for me. Please recall that we first have to take the fundamental frequency- in this case 220 Hz, and then to find a harmonic, multiply by a whole number multiple (n) which will give us a new frequency for the harmonic. Using this information please play a harmonic using the soundsc command of a sine wave that is a harmonic of the frequency above. Then play them both together. :)
{A small hint is that you can set up a sampling frequency and then make a time vector that goes from 0 to some arbritary number like 10 or so, but you want the step size to be the sampling period, which you know is 1/fs. Thus, we could get t=0: sampling period: maximum minus one sampling period (since we start at zero)}

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Task 2: Given the music that I have provided please find the fundamental frequencies that I am playing on an online keyboard.

I have recorded a 20 second thing which represents me playing some notes on the keyboard. I would like you to be detectives again and use the following code to be able to find out what the frequencies that I am using are. I think I called it Bucknell4? Then match those frequencies to the table that I have here to tell me what the notes are that you are seeing. The graph may be ugly but if it gives you the frequencies, that's good enough!

CODE:

```
clc; clear all; close all;

[X,Fs]=audioread("Bucknell University 4.m4a");

x=X;

fs=Fs;

t = (0:size(x,1)-1)/fs;


winLength = round(0.05*fs);

overlapLength = round(0.045*fs);

[f0,idx] = pitch(x,fs,Method="SRH",WindowLength=winLength,OverlapLength=overlapLength);

tf0 = idx/fs;

figure

tiledlayout(2,1)


nexttile

plot(t,x)

ylabel("Amplitude")

title("Audio Signal")

axis tight


nexttile

pitch(x,fs,Method="SRH",WindowLength=winLength,OverlapLength=overlapLength)

title("Pitch Estimations")

hr = harmonicRatio(x,fs,Window=hamming(winLength,"periodic"),OverlapLength=overlapLength);


figure

tiledlayout(3,1)


nexttile
```

```
plot(t,x)
ylabel("Amplitude")
title("Audio Signal")
axis tight

nexttile
pitch(x,fs,Method="SRH",WindowLength=winLength,OverlapLength=overlapLength)
title("Pitch Estimations")
xlabel("")

nexttile
harmonicRatio(x,fs,Window=hamming(winLength,"periodic"),OverlapLength=overlapLength)
title("Harmonic Ratio")
threshold = 0.9;
f0(hr < threshold) = nan;

figure
plot(tf0,f0)
xlabel("Time (s)")
ylabel("Pitch (Hz)")
title("Pitch Estimations")
grid on
```

Note	Frequency (Hz)	Note	Frequency (Hz)	Note	Frequency (Hz)
C_0	16.35	A_2	110.00		
$C^{\#}_0/D^{b}_0$	17.32	$A^{\#}_2/B^{b}_2$	116.54	$F^{\#}_5/G^{b}_5$	739.99
D_0	18.35	B_2	123.47	G_5	783.99
$D^{\#}_0/E^{b}_0$	19.45	C_3	130.81	$G^{\#}_5/A^{b}_5$	830.61
E_0	20.60	$C^{\#}_3/D^{b}_3$	138.59	A_5	880.00
F_0	21.83	D_3	146.83	$A^{\#}_5/B^{b}_5$	932.33
$F^{\#}_0/G^{b}_0$	23.12	$D^{\#}_3/E^{b}_3$	155.56	B_5	987.77
G_0	24.50	E_3	164.81	C_6	1046.50
$G^{\#}_0/A^{b}_0$	25.96	F_3	174.61	$C^{\#}_6/D^{b}_6$	1108.73
A_0	27.50	$F^{\#}_3/G^{b}_3$	185.00	D_6	1174.66
$A^{\#}_0/B^{b}_0$	29.14	G_3	196.00	$D^{\#}_6/E^{b}_6$	1244.51
B_0	30.87	$G^{\#}_3/A^{b}_3$	207.65	E_6	1318.51
C_1	32.70	A_3	220.00	F_6	1396.91
$C^{\#}_1/D^{b}_1$	34.65	$A^{\#}_3/B^{b}_3$	233.08	$F^{\#}_6/G^{b}_6$	1479.98
D_1	36.71	B_3	246.94	G_6	1567.98
$D^{\#}_1/E^{b}_1$	38.89	C_4	261.63	$G^{\#}_6/A^{b}_6$	1661.22
E_1	41.20	$C^{\#}_4/D^{b}_4$	277.18	A_6	1760.00
F_1	43.65	D_4	293.66	$A^{\#}_6/B^{b}_6$	1864.66
$F^{\#}_1/G^{b}_1$	46.25	$D^{\#}_4/E^{b}_4$	311.13	B_6	1975.53
G_1	49.00	E_4	329.63	C_7	2093.00
$G^{\#}_1/A^{b}_1$	51.91	F_4	349.23	$C^{\#}_7/D^{b}_7$	2217.46

A_1	55.00	$F^{\#}_4/G^{b}_4$	369.99	D_7	2349.32
$A^{\#}_1/B^{b}_1$	58.27	G_4	392.00	$D^{\#}_7/E^{b}_7$	2489.02
B_1	61.74	$G^{\#}_4/A^{b}_4$	415.30	E_7	2637.02
C_2	65.41	A_4	440.00	F_7	2793.83
$C^{\#}_2/D^{b}_2$	69.30	$A^{\#}_4/B^{b}_4$	466.16	$F^{\#}_7/G^{b}_7$	2959.96
D_2	73.42	B_4	493.88	G_7	3135.96
$D^{\#}_2/E^{b}_2$	77.78	C_5	523.25	$G^{\#}_7/A^{b}_7$	3322.44
E_2	82.41	$C^{\#}_5/D^{b}_5$	554.37	A_7	3520.00
F_2	87.31	D_5	587.33	$A^{\#}_7/B^{b}_7$	3729.31
$F^{\#}_2/G^{b}_2$	92.50	$D^{\#}_5/E^{b}_5$	622.25	B_7	3951.07
G_2	98.00	E_5	659.25	C_8	4186.01
$G^{\#}_2/A^{b}_2$	103.83	F_5	698.46	$C^{\#}_8/D^{b}_8$	4434.92
D_8	4698.63				
$D^{\#}_8/E^{b}_8$	4978.03				
E_8	5274.04				
F_8	5587.65				
$F^{\#}_8/G^{b}_8$	5919.91				
G_8	6271.93				
$G^{\#}_8/A^{b}_8$	6644.88				
A_8	7040.00				
$A^{\#}_8/B^{b}_8$	7458.62				
B_8	7902.13				

Table Sourced from: https://pages.mtu.edu/~suits/notefreqs.html
There are many online keyboards and Idk which are safe, here is one I used but maybe its dangerous idk:

https://virtualpiano.net/

Let's try it again with an actual song! See if you can find the three or so main notes in this! :) Import the Bucknell5 file into your MATLAB and run it again! Can you reconstruct the song using those notes? :D

Task 3: Pick your favorite song and identify some fundamental frequencies in it!

Again, this is what has taken me the longest time to make and I hope that it works. Here, I want you to record between 5-10 seconds of one of your favorite songs via the Voice Recording app on your phone (I only tried it on apple, but try it on your windows phone and we shall see) and then share it with your email.

Once you have it, import it into Matlab with the function audioread('INSERTNAME') and then run our program that we wrote for part two above. Find me some of the frequencies, and then using that please tell me what other frequencies you know are in the song. Please feel free to use the table to listen to the different notes that are in your song from the fundamental frequencies that you are finding. Do some sound better when you play them at the same time and are they related somehow mathematically?

Just as a proof of concept because I don't have the code for this- can you use the keyboard to play a little bit of your song? Perhaps some of the harmonics that you know you heard in there? ;)

Lab 7: Sudoku Lab!!

Due 03/22/2022 at 5 pm

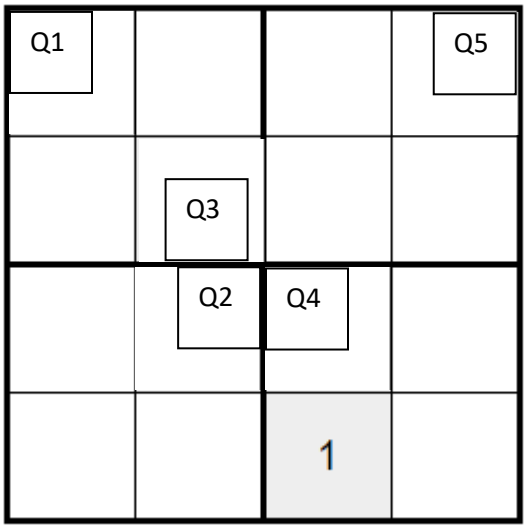
This is a single person exercise. Mostly.

Introduction

I want to preface this by saying that you are all so smart and clever that I have exhausted my expertise in word based games and must now move to games that I am NOT so well versed in, which is these math puzzles. :)

I have created the following 4x4 sudoku puzzle for you to try to solve. To do this, I am going to ask you to do something VERY different than normal. Today, I am going to make you generate code to solve the question or need that I want, and if you do so, your answer will (hopefully) fit within the sudoku square. I want you to realize how much you already know and feel more comfortable using MATLAB as a tool to reach whatever goals that you want. You definitely have got this. 😊 I also acknowledge that there are a million ways to code the same thing, so this could POSSIBLY GO SUPER SIDEWAYS BUT LETS SEE. MAYBE IT WILL WORK. We shall start with a relatively easy one. I have also added a more difficult one for fun, but it isn't for points or anything.

Procedures



If you are unaware, Sudoku Puzzles work by having each different number in each row and column but also in each box. We are doing 1-4 to start. I have written on the left the pseudocode/summary of what I would like you to do. Once you have written the code in MATLAB, please write on the right what the answer you got was. Then you can try to solve the Sudoku Puzzle! I have made only one of these, but slightly more difficult as I don't want to underestimate your brilliance, and give you one that you can solve in about 10 minutes!

Question!	Answers
1) Please write the code in MATLAB and have it run and write it on the right: I have 2 models, and Ben has 4 models. If I was to combine both our models, then evenly divide them, how many would I have? <u>Put your answer from here in the table.</u>	1.
2) **A= 15;** **B= 20;** **C=25;** C is the square root of A squared plus B squared. I want to be able to take this answer and across a loop, set this C as the new B and loop until becomes greater than 50. <u>The square root of this number of Cs is your answer.</u>	2.
3) Could you write a code that will take the equation y=2x+5 with initial conditions 5 and 10, updating the new y as the new x, and populate a 1x 5 vector (U) with those values? <u>(U(1,2)-U(1,1)) divided by 5 is your answer</u>	3.
4) Can you write a code which will take a vector W=[1,2,3,4,5]; and will fill up a matrix (V) with it 5 times? <u>Your answer will be the trace of V minus 11.</u>	4.
5) Using a matrix Q=[10, 20, 15, 30, 20, 40; 50, 100, 75, 150, 100, 200; 5, 10, 15, 30, 20, 40; 25, 50, 35,70, 50, 100; 10, 20, 20, 40, 20, 40;]; I would like you to make a new matrix R, where you would take these values in the matrix, double them all, then add 10 to each value, finishing by	5.

dividing each value by 5. Please output this R. R(1,3) divided by 2 is your answer. :)	

1	4	5		6	
		6	1		
4					
3				1	6
5		2	6	3	4
		3	4	5	1

BONUS ONE FOR FUNZIES IF YOU LOVED THIS STUFF. (This isn't part of the puzzle or lab, but I just wanted to give you a more challenging one.

EXTRA ONE BECAUSE IDK IF YOU WANT THE 9 ONE OR NOT. LIVE YOUR BEST LIFE.

					6			5
9			4	8	3	6		7
	7		2		1			9
3	9	5	6	4		8	7	1
	2	7		3		5		
1		4	8	7	5	9		
5	1		3		8	7		
7	8			2	4	1		3
			9				5	

Lab 7: Stabilitysweeper

Due 03/28/2023 at 5 pm

This is a personal experience, but you can chat with your friends. And enemies.

Introduction

I DID IT. I MADE IT WORK. HAHAHA. IT IS 800 PLUS LINES BUT IT WORKS. PLEASE INDULGE YOURSELF IN THE MONSTROSITY I HAVE CONCOCTED.
This lab will involve a little bit of math, but I hope that I have made it a little more pleasant at least. ;)

Procedures

We will be focusing on using feedback loops to stabilize initially unstable functions. However, that in and of itself isn't always the most fun, like the homework that I accidentally made v difficult, so in apology, I have created this to be a better version of what I wanted to achieve in there. I hope that this makes the concept more clear and also make evident that you are all extremely intelligent and capable engineers already. :)

Task 1: Please look at this map below!

You are a famous adventurer trying to find the mystical treasure held deep within this temple. Your specialty is finding traps and using feedback loops to try to disarm the unstable nature of them and making them stable. Now our goal is to reach the north half of this map, but the ancient builders of this temple have placed many traps throughout the map. It is only through your skills and magic that you can try to figure out which squares are stable and which are not. **Using the program that I have provided, please find which of these are stable, and which are not, by writing down the roots, and circling the letters in the grid that are stable. Once you do so, please draw out a safe path from the south side of the grid to the north side.**

Length of the path to safety(in squares):_____

A	B	C	D	E
F	G	H	I	J
K	L	M	N	O
P	Q	R	S	T
U	V	W	X	Y

Once we do that, we realize that we only have enough rope to traverse a maximum of 5 squares. Is this long enough to try to go across and mark our path? _____

If it isn't we will have to do use our special feedback magic to stabilize the unstable squares. **Please find a shorter path using any of the squares. <u>You may use any value for your feedback loop to change the roots- (it can be a constant, a polynomial, a partial fraction, whatever makes the overall function stable.)</u>**

What is the length of your new path:_____

Which squares did you make safe and what were your feedback values?

Not for a grade, but which of these themes, failure and success were your favorite?
Or explosion I guess. Sounds. ;)

Another question that I wanted to know is, what else could you do with this lab technology? This question isn't for a grade, I am just curious about what would you do with this monstrosity?

Code for you all:

```
% Lab 6

%% Constructing the different matrices
%you don't need to read any of this, you just need to click play and run
%through it! :)
%Best of luck, adventurers!


clear all, clc, clf, close all



AA=[3,4,6,7,-1; 1,2,3,-5,-2; 1,3,-2,-3,3; 5,-2,-3,2,2; 5,-1,3,4,5;];
BB=[-2,2,2,-2,-3;-4,3,8,-2,-1;-6,1,-2,-3,2;-8,-1,-1,-4,3;-2,-1,-3,4,-5];
% prompt1="What Row do you want to check?";
% row=input(prompt1);
% if row==1
prompt="What square do you want to check?";
Location=menu(prompt,'A','B', 'C','D','E','F', 'G','H', 'I', 'J','K', 'L','M','N','O','P','Q', 'R','S','T','U','V','W', 'X','Y');
% elseif row==2
%     prompt="What square do you want to check?";
%     Location=menu(prompt,'F', 'G','H', 'I', 'J');
%
% elseif  row==3
%     prompt="What square do you want to check?";
%     Location=menu(prompt,'K', 'L','M','N','O');
%
```

```
% elseif row==4
%     prompt="What square do you want to check?";
%     Location=menu(prompt,'P','Q', 'R','S','T');
%
% else
%     prompt="What square do you want to check?";
%     Location=menu(prompt,'U','V','W', 'X','Y');
%
% end

if Location==1
    A1=AA(1,1);
    B1=BB(1,1);
    root=-10:1:10;
    y=-0*root;
    plot(root,y)
    xline(0);
    yline(0);
    hold on
    plot(A1,0,'x')
    hold on
    plot (B1,0,'x')
    prompt3="Is this stable?";
    stability=questdlg(prompt3,mfilename,'Yes','No','yes');
    if strcmpi(stability,'yes')
        display('Game Over. Please try again');
        [x1,fs1]=audioread("gameover2.mp3");
        [x2,fs2]=audioread("carexplosion.wav");
        i=imread('boom.jpg');
        figure
        imshow(i);
        soundsc(x2,fs2)
        pause(3)
        soundsc(x1,fs1)


    else
        display('You did it!! :D');
        [x3,fs3]=audioread("victory2.mp3");
        soundsc(x3(1:180000),fs3)
    end
elseif Location==2
    A1=AA(1,2);
    B1=BB(1,2);
    root=-10:1:10;
    y=-0*root;
    plot(root,y)
    xline(0);
    yline(0);
    hold on
    plot(A1,0,'x')
    hold on
    plot (B1,0,'x')
    prompt3="Is this stable?";
    stability=questdlg(prompt3,mfilename,'Yes','No','yes');
    if strcmpi(stability,'yes')
```

```
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover3.mp3");
    [x5,fs5]=audioread("explosionwithpeople.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory3.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==3
A1=AA(1,3);
B1=BB(1,3);
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x7,fs7]=audioread("gameover4.mp3");
    [x8,fs8]=audioread("explosionwithglass.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x8,fs8)
    pause(3)
    soundsc(x7,fs7)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory4.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==4
A1=AA(1,4);
B1=BB(1,4);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
```

```
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x11,fs11]=audioread("gameover5.mp3");
    [x10,fs10]=audioread("explosionwithrocks.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x10,fs10)
    pause(3)
    soundsc(x11,fs11)


else
    display('You did it!! :D');
    [x8,fs8]=audioread("victory5.mp3");
    soundsc(x8(1:200000,:),fs8)
end

elseif Location==5
A1=AA(1,5);
B1=BB(1,5);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'no')
    display('Game over. Please try again');
    [x9,fs9]=audioread("gameover6.mp3");
    [x5,fs5]=audioread("explosionwithpeople.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x9,fs9)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory6.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==6
A1=AA(2,1);
```

```
B1=BB(2,1);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x13,fs13]=audioread("gameover6.mp3");
    [x5,fs5]=audioread("explosionwithglass.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x13,fs13)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory7.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==7
A1=AA(2,2);
B1=BB(2,2);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover7.mp3");
    [x5,fs5]=audioread("bitexplosion.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)
```

```
else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory8.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==8
A1=AA(2,3);
B1=BB(2,3);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("playerdietheme.mp3");
    [x5,fs5]=audioread("carexplosion.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory9.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==9
A1=AA(2,4);
B1=BB(2,4);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'no')
    display('Game over. Please try again');
    [x4,fs4]=audioread("playerdietheme2.mp3");
    [x5,fs5]=audioread("explosionwithrocks.wav");
```

```
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory10.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==10
A1=AA(2,5);
B1=BB(2,5);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'no')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover6.mp3");
    [x5,fs5]=audioread("explosionwithpeople.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory11.m4a");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==11
A1=AA(3,1);
B1=BB(3,1);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
```

```
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("playerdowntheme3.mp3");
    [x5,fs5]=audioread("explosionwithpeople.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory13.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==12
A1=AA(3,2);
B1=BB(3,2);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover1.mp3");
    [x5,fs5]=audioread("carexplosion.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory1.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==13
A1=AA(3,3);
```

```
B1=BB(3,3);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'no')
   display('Game over. Please try again');
   [x4,fs4]=audioread("gameover2.mp3");
   [x5,fs5]=audioread("explosionwithglass.wav");
   i=imread('boom.jpg');
   figure
   imshow(i);
   soundsc(x5,fs5)
   pause(3)
   soundsc(x4,fs4)


else
   display('You did it!! :D');
   [x6,fs6]=audioread("victory2.mp3");
   soundsc(x6(1:200000,:),fs6)
end

elseif Location==14
A1=AA(3,4);
B1=BB(3,4);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'no')
   display('Game over. Please try again');
   [x4,fs4]=audioread("gameover5.mp3");
   [x5,fs5]=audioread("explosionwithpeople.wav");
   i=imread('boom.jpg');
   figure
   imshow(i);
   soundsc(x5,fs5)
   pause(3)
   soundsc(x4,fs4)
```

```
else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory7.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==15
A1=AA(3,5);
B1=BB(3,5);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover5.mp3");
    [x5,fs5]=audioread("bitexplosion.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory10.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==16
A1=AA(4,1);
B1=BB(4,1);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover4.mp3");
    [x5,fs5]=audioread("carexplosion.wav");
```

```
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory9.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==17
A1=AA(4,2);
B1=BB(4,2);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'no')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover1.mp3");
    [x5,fs5]=audioread("explosionwithpeople.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory8.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==18
A1=AA(4,3);
B1=BB(4,3);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
```

```
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'no')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover5.mp3");
    [x5,fs5]=audioread("explosionwithrocks.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory7.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==19
A1=AA(4,4);
B1=BB(4,4);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover4.mp3");
    [x5,fs5]=audioread("explosionwithglass.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory6.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==20
A1=AA(4,5);
```

```
B1=BB(4,5);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover1.mp3");
    [x5,fs5]=audioread("explosionwithpeople.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory2.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==21
A1=AA(5,1);
B1=BB(5,1);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover3.mp3");
    [x5,fs5]=audioread("explosionwithrocks.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)
```

```
else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory2.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==22
A1=AA(5,2);
B1=BB(5,2);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'no')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover3.mp3");
    [x5,fs5]=audioread("carexplosion.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory6.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==23
A1=AA(5,3);
B1=BB(5,3);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover3.mp3");
    [x5,fs5]=audioread("explosionwithpeople.wav");
```

```
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory2.mp3");
    soundsc(x6(1:200000,:),fs6)
end

elseif Location==24
A1=AA(5,4);
B1=BB(5,4);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
hold on
plot (B1,0,'x')
prompt3="Is this stable?";
stability=questdlg(prompt3,mfilename,'Yes','No','yes');
if strcmpi(stability,'yes')
    display('Game over. Please try again');
    [x4,fs4]=audioread("gameover6.mp3");
    [x5,fs5]=audioread("explosionwithrocks.wav");
    i=imread('boom.jpg');
    figure
    imshow(i);
    soundsc(x5,fs5)
    pause(3)
    soundsc(x4,fs4)


else
    display('You did it!! :D');
    [x6,fs6]=audioread("victory13.mp3");
    soundsc(x6(1:270000,:),fs6)
end

elseif Location==25
A1=AA(5,5);
B1=BB(5,5);
root=-10:1:10;
y=-0*root;
plot(root,y)
xline(0);
yline(0);
hold on
plot(A1,0,'x')
```

```
    hold on
    plot (B1,0,'x')
    prompt3="Is this stable?";
    stability=questdlg(prompt3,mfilename,'Yes','No','yes');
    if strcmpi(stability,'yes')
        display('Game over. Please try again');
        [x4,fs4]=audioread("gameover1.mp3");
        [x5,fs5]=audioread("bitexplosion.wav");
        i=imread('boom.jpg');
        figure
        imshow(i);
        soundsc(x5,fs5)
        pause(3)
        soundsc(x4,fs4)


    else
        display('You did it!! :D');
        [x6,fs6]=audioread("victory3.mp3");
        soundsc(x6(1:200000,:),fs6)
    end

end
```

Lab 5: MURDER MYSTERY LAB!

Due 03/22/2022 at 5 pm

This is a single person exercise. Mostly.

Introduction

I HAVE PROMISED YOU THIS AND YOU DESERVE IT AND SO MUCH MORE SO HERE IS MY BEST ATTEMPT TO MURDER A FICTIONAL BEING. I really hope you don't insta solve it like right off the bat, I would be DEVASTATED.

Okay so as usual, I will break this up into different portions. Because this is a MATLAB lab, we will be using MATLAB for all the components. If you have questions, please feel free to ask me, but like don't spoiler your neighbors. ;)

As all things begin with a story, I have tried to write one to help you contextualize the story a little more than usual puzzles. I apologize for the length, but I felt skipping it would make this unreasonably difficult. I have underlined portions that I felt were particularly important, and bolded some information. Otherwise bold is reserved for coding script. **Also the one assumption that I have made here is that nothing bad happened to him BEFORE you met him, so like he isn't suffering from a disease or anything.**

Procedures

Background and Context:

It is the dreariest Spring Break in recent memory. The rain keeps pouring down as you drive to your friends' house to accompany them to their grandfather's alleged 176^{th} birthday party. You think it may be some sort of inside joke, but you aren't completely sure. Duoson Bovini is the patriarch of the Bovini family, a distinguished and old money family that owns a great deal of land in your town, and that you have seen throughout your childhood as a constant staple in your friend's life. Your friend seems nervous and stressed, and has invited you because her grandfather suspects something dramatic at this party, and you being well known as a very clever, intelligent, and driven engineer at the prestigious Bucknell University, were specifically requested by him to try to figure out what is happening, and prevent it if possible.

Once you enter the hotel through the front doors, you see that there is short hallway with a set of double doors leading to a large dining hall in front of you. You enter with your friend and immediately pay your respects to Grandfather Duoson. There seems to be guards stationed on the corners here as well to watch over him, and he gives you a kindly smile as he asks how you have been up at Bucknell. He looks remarkably healthy, and invites the two of you to his study on this floor as he has something private he wants your insight on. Your friend and you leave with him out the main doors, and walk the ten minutes down the side hallway past many sets of camera and a laser system with automatic locks that he is particularly proud of which he claims should deter any funny business during the party. After being thoroughly checked by the guards by his room for weapons of any kind, you enter into a multiroomed suite. It isn't luxurious by any means, but it has a kitchen off to the right, a small living room with a sofa and table, and a bathroom as well. You glance around and notice that it has a bit of clutter on the table and, trying to be helpful, try to go and clean up some of the mess for him. You remove all the plates, utensils, and dishes from the table, after which he waves you off, saying that he is very particular about where things are, and that things are in the place for a reason. His smile then drops from his face as he tells you the reason that he has summoned you here- to prevent his own suspected murder.

Grandfather Duoson doesn't have any enemies, but currently, he thinks that some of his own children are plotting to try to threaten him. He pulls some chairs from the kitchen for you two, and sits on the sofa introducing you to each of them.

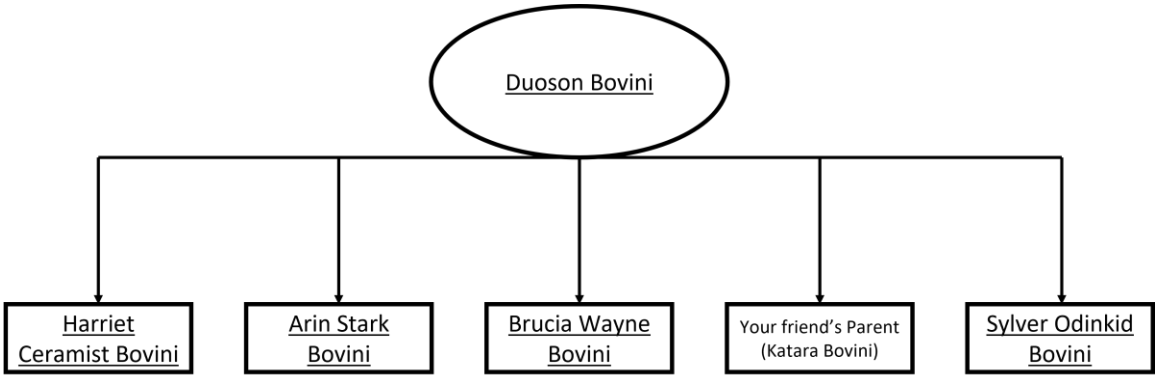


Figure 1: Bovini Family Tree. Grandfather Bovini has 5 children, of which four are present here with various grievances. The underlined are present guests to the birthday party including several local dignitaries and people of note.

Harriet Ceramist Bovini- "Harriet is a very courageous and impetuous sort, you see. She has always had a clever streak in her, but if you cross her, she never forgives, nor does she ever forget. I can't remember the last time that vindictive streak has benefited her, but she will not yield unless she feels she's won. Her fascination with lions and wildlife in general has inspired

her to buy an old castle with a willow tree and rebrand the area as a sanctuary/petting zoo/safari park. If I sound vague here, it's because this lack of direction has resulted in the stalling of the project. The amount of hassle in her shady dealings in trying to push through despite violating regulations and other rules has resulted in no shortage of lawsuits and legal problems for the family which I am still settling as if by magic so that the family name remains untarnished. Her unrepentant attitude has made me question whether she should be the one to inherit the family after I am gone. I plan on talking to her about it tomorrow and if that doesn't resolve it, I have a meeting with my lawyer the day after to change it to give it to a more deserving of my kin. Possibly even you, my dear, " he laughs and smiles to your friend.

Arin Stark Bovini-"Your uncle Arin and your aunt Harriet are more volatile than oil and water. Using his own terms, they are "Francium and Water" in how poorly they interact. As the second eldest of the family, I had hoped his focus would help rein in his sister, but it has done the exact opposite, driving them both to ideological extremes. He wants to go north on an expedition, something to study climate and weather by using chemical analysis of ice cores. Honestly, that may be for the best, as it may be the only place large enough to hold his large ego. His detractors have named him the "King of the North" behind his back and that "he knows nothing but snow", but maybe it would be best for him to be up there if nothing else to remove him from his sister and other toxic relationships around him. It may do him good. His most recent proposal for funding however, was denied allegedly due to lack of good evidence and direction, and he blames me for it. He is extremely frustrated and angry, and has scheduled a meeting with me for this very evening at 8:45! My birthday no less! Well, either way, he is resourceful and clever, despite being overbearing sometimes."

Sylver Odinkid Bovini- "Unlike the rest of his siblings, Sylver has learnt to quietly sit and watch. As the youngest, he learnt early on that speaking out only leads to reprisal so he has become very skilled at getting other people to do what he wants, while doing little to nothing to earn it, as he dislikes immensely getting his own hands, or clothes, dirty. As a proficient user of bladed weapons, he is practically a trickster and charlatan, but is clever enough to never do enough to get caught. Well. Until this time. While he usually can get things to fall into his lap, I now have evidence that he has been spreading the rumors about Harriet's possible disinheritance, as well as who made the critical last vote on the Arctic Expedition, that caused it to fail. Maybe he was jealous and wanted to visit some Nordic country himself. Either way, this is evidence that Sylver would most definitely not want to come to light, and thus, he is meeting, no more like negotiating with me later this evening at approximately 9."

Brucia Wayne Bovini- "This is my adopted daughter who is currently the middle most sibling when we count your own parents, my dear. As you know your aunt Brucia has always been a party goer, and has a penchant for the most expensive and most debauch types of things. Her tastes for the lavish and exorbitant are why I put her in charge of this party, but she has to learn

to rein in her excess. I told her that I would be reducing her allowances for parties and that she no longer could use company funds for these parties, and she was completely flabbergasted. I know that some of this is due to her previous life as an orphan in that Arkham Orphange, but she can't live this way forever. I know that she isn't used to hearing no, as I have spoiled her something rotten, so this may cause her to do something that I can't predict."

After talking, it was roughly 8: 20, and getting up, we put away the chairs. We both noted that there was no food in his study's kitchen. Clearly this was more of a temporary situation than a permanent office. Grandpa Duoson had to stay back for his meetings with Arin and Sylver, so we headed off back to the main room, passing Uncle Arin as he carried a small bag as he went by.

At approximately 9, we saw Uncle Arin come back and Uncle Sylver got up and chatted with him and then headed over to Grandpa Duoson's suite. In the meantime, we chatted with Aunt Brucia and how she was prepping for the 9:30 firework display for Grandfather Duoson. We realized that it was about 9:15, and we about to help her outside, when there was a loud snap, and all of the lights went out. There was a loud scream from someone, and then using our phone lights, we found Brucia in a huddle sobbing. As she has a deep fear of the dark, she was practically inconsolable. We then heard Uncle Arin yelling that they need to find Aunt Harriet because she may be up to no good, and to go check on Grandpa Duoson. We then head outside and find that we can't find Uncle Sylver either. After walking for about 5 minutes, Uncle Sylver is found by someone coming out of the bathroom, and we then find Aunt Harriet locked outside the front door roughly ten minutes later. Once we are all able reconvene approximately 9:50, the lights are clicked back on, and we are able to get to Grandpa Duoson's room too late.

In front of us we see a grisly sight- Grandpa Duoson lays slain on the sofa. After checking to make sure that he is indeed dead, you call the police. We are unsure who got there first to report it, but you instantly take charge and prevent any contamination of the crime scene.

Task 1: Crime Scene Analysis:

Quickly snapping photos of the crime scene, you made sure to have two pictures that contained enough information to be helpful to unraveling the mystery. Unfortunately, the images got corrupted and require some MATLAB modification to become usable.

Download the two blurred images from Moodle. Solve the below clue to figure out the correct code to remove the noise and have denoised images.

Question!	Answers
1) **A= [2 5 8; 3 5 12; 10 4 7;];** **B= [10 5 2; 4 6 5; 3 9 15;];** Please calculate the product of inverse A and B.	Both of these parts will tell you which picture files to move into your MATLAB file to look at and also which code to run. :) 1. If your answer is A, then please save BlurredImage01 and BlurredImage02

a. $\begin{bmatrix} 64 & 112 & 149 \\ 86 & 153 & 211 \\ 137 & 137 & 145 \end{bmatrix}$

b. $\begin{bmatrix} -0.4970 & 0.5879 & 1.5697 \\ 4.4 & 0.60 & -0.8 \\ -1.3758 & 0.1030 & 0.3576 \end{bmatrix}$

c. $\begin{bmatrix} 20 & 25 & 16 \\ 12 & 30 & 60 \\ 30 & 36 & 105 \end{bmatrix}$

d. $\begin{bmatrix} 20 & 25 & 225 \\ 1 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$

into the same directory that you are currently in for MATLAB.

If your answer is B, then please save BlurredImage03 and BlurredImage04 into the same directory that you are currently in for MATLAB.

If your answer is C, then please save BlurredImage05 and BlurredImage06 into the same directory that you are currently in for MATLAB.

If your answer is D, then please save BlurredImage07 and BlurredImage08 into the same directory that you are currently in for MATLAB.

2) What is the difference between A*B and A.*B in terms of the products?

a. $\begin{bmatrix} 20 & 25 & 16 \\ 12 & 30 & 60 \\ 30 & 36 & 105 \end{bmatrix} - \begin{bmatrix} 64 & 112 & 149 \\ 86 & 153 & 211 \\ 137 & 137 & 145 \end{bmatrix}$

$$\begin{bmatrix} -44 & -87 & -133 \\ -74 & -123 & -151 \\ -107 & -101 & -40 \end{bmatrix}$$

b. $\begin{bmatrix} 20 & 25 & 225 \\ 1 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} - \begin{bmatrix} -0.5 & 0.588 & 1.569 \\ 4.4 & 0.60 & -0.8 \\ -1.376 & 0.103 & 0.357 \end{bmatrix}$

$$\begin{bmatrix} 20.4970 & 24.4121 & 223.4303 \\ -3.40 & -0.60 & 0.8 \\ 2.3758 & 0.8970 & 0.6424 \end{bmatrix}$$

2. For this part you will have to make a new script.
In this script you will have to first load in your file as well as declare your initial bit of code for it to be ready to go. First, let's start off with the clearing functions and then do the filter that we would need!

If your answer is A:

```
clf, clc, clear all
figure (1)
I=imread('answerfrom#1');
DN=ordfilt2(I,5,true(5));

J =imread('secondanswerfrom#1');
DN2=ordfilt2(J,5,true(5));

imshowpair(DN,DN2, 'montage')
```

If your answer is B:

```
clf, clc, clear all
figure (1)
I=imread('answerfrom#1');
J=imread('2answerfrom#1');
```

c. $\begin{bmatrix} 64 & 112 & 149 \\ 86 & 153 & 211 \\ 137 & 137 & 145 \end{bmatrix} - \begin{bmatrix} 20 & 25 & 16 \\ 12 & 30 & 60 \\ 30 & 36 & 105 \end{bmatrix}$

$$\begin{bmatrix} 44 & 87 & 133 \\ 74 & 123 & 151 \\ 107 & 101 & 40 \end{bmatrix}$$

d. $\begin{bmatrix} -0.5 & 0.588 & 1.569 \\ 4.4 & 0.60 & -0.8 \\ -1.376 & 0.103 & 0.357 \end{bmatrix} - \begin{bmatrix} 20 & 25 & 225 \\ 1 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$

$$\begin{bmatrix} 20.4970 & -24.42121 & -223.4303 \\ 3.4 & 0.6 & -0.8 \\ -2.3758 & -0.8970 & -0.6424 \end{bmatrix}$$

```
imwrite(J2,'answerfrom#1.jpg')
X3=imread(''answerfrom#1.jpg');
imshow(X3)
figure (2)
imwrite(L3,'2answerfrom#1.jpg');
X4=imread('2answerfrom#1);
imshow(X4)
imshowpair(I,J, ‘montage’)
```

If your answer is C:

```
clf, clc, clear all
figure (1)
J =imread('answerfrom#1’);
DN2=ordfilt2(J,5,true(5));
DN2=imcomplement(DN2);
imshow(DN2)
rectangle('Position',
[3452,724,348,312], 'EdgeColor','r' );
rectangle('Position',
[732,1268,544,584], 'EdgeColor','g' );

figure(2)
I=imread('imagefromnumber#1’);
DN=ordfilt2(I,5,true(5));
DN=imcomplement(DN);
imshow(DN)
rectangle('Position',
[2088,918,880,700], 'EdgeColor','r' );
rectangle('Position',
[2598,840,720,306], 'EdgeColor','g' );
rectangle('Position',
[714,384,1020,756], 'EdgeColor','b' );
rectangle('Position',
[696,1470,870,870], 'EdgeColor','r' );
rectangle('Position',
[2670,132,804,636], 'EdgeColor','g' );
```

If your answer is D:

```
'answerfrom#1’

clf, clc, clear all
figure (1)
I=imread(‘answerfrom#1’);
```

	J =imread('secondanswerfrom#1'); **WM(1:10,1)=[S,O,U,H,J,L,K,M,J,A];** **WM(11:20,1)=[U,E,C,O,B,H,V,X,C,S];** **WM(21:25,1)=[R,G,E,W,C];** **imshowpair(I,J, 'montage')** **rectangle('Position', [3452,724,348,312], 'EdgeColor','r')** **rectangle('Position', [732,1268,544,584], 'EdgeColor','g')**

Now that you have the image, lets make a list of possible suspicious items here.

1) _____
2) _____
3) _____
4) _____
5) _____
6) _____

Murder Mystery Suspicious Items

S	N	L	D	A	P	A	F	O	S	G	T	H	W
T	K	W	L	S	E	S	A	L	N	N	S	O	W
O	U	O	E	I	R	W	A	G	S	S	L	K	A
N	O	B	I	O	O	O	N	U	G	L	E	G	I
E	E	B	H	B	P	R	U	K	I	A	L	R	N
M	I	S	S	L	E	D	L	P	M	D	B	E	F
E	A	L	L	E	R	B	M	U	O	D	A	B	I
S	E	L	K	C	I	P	A	U	I	E	T	A	N
N	A	L	U	T	A	P	S	A	L	R	I	S	I
A	C	A	M	E	R	A	E	N	R	I	N	G	T
R	T	T	E	L	T	N	U	A	G	W	I	T	Y
R	O	O	L	L	A	B	E	K	O	P	C	S	I
O	S	S	S	P	H	O	N	E	L	E	E	G	N
W	A	O	B	A	Z	O	O	K	A	W	L	U	C

Play this puzzle online at : https://thewordsearch.com/puzzle/3442502/

I have placed a small **optional** word find which should have some of the words in it there that should be relevant. HOWEVER, I PUT SOME GARBAJ IN THERE SO PLS DON'T BLINDLY CIRCLE THINGS. THERE IS NOT A BAZOOKA IN THE PICTURES. Also, please note that diagonals are possible for words as well as across and down. A few may even be backwards. ;)

Task 2: Alibi and Murder locations:

Quickly, you grab the four suspects, and isolate them into different rooms for interrogation. You also make sure to prevent them from discarding or hiding anything off their persons, and have the police search to make sure they didn't toss the murder weapon off to try to mislead the detectives and you. Each of them have something different to say about why they were not the murderers.

Harriet: "How dare you accuse, *me*, of being the one to commit this crime! I am the eldest! I am NEXT in command, and the primary inheritor of the family business. What could I POSSIBLY stand to gain by doing this? For your information, I was outside on a phone call that was very important. One of the major investors in my Conservatorium demanded that we talk, and although I am never one to listen to demands, I could not offer a different time. You can check my phone records and verify that I was on the phone both before and during that black out. After the mostly fruitlessly and pointlessly protracted video phone call, I realized I was unable to enter the hotel, and remained outside until discovered by you all. I am OBVIOUSLY not the criminal here! Check some of my less scrupulous siblings. As always, I am perfectly clean of any crime."

Both the detectives and you note that the time for the video phone call was from 9:15-9:40 PM and was later than the estimated time of death for Grandfather Duoson. You also note that the outer doors can be electronically locked and that she was indeed on the phone at the time. It is unclear if she could have murdered him while on the phone, and whether she was indeed locked out at that time, but it is possible.

Arin: "I can't believe that you would suspect me when my sister is CLEARLY far more suspicious than me. Yes, I met with father before the blackout, but he was obviously STILL ALIVE when I left because he still had a few meetings after mine. You can ask Sylver, he met with him at 9, right after me. In fact, I passed him in the hallway after my meeting. During the blackout, I WAS HERE. You all HEARD me yelling for us to find my sister who was NOTICABLY absent in that window. Thus, all of you incompetents are all my witnesses for the blackout. I can't believe that the panel couldn't understand my brilliance in my exploratory venture earlier, and now father can't even vouch on my behalf. Please excuse me, but I am very much not the most suspicious of my siblings. I urge you to better waste your time interrogating them."

Both the detectives and you note that they did indeed have eyewitnesses for Arin during the blackout, with audible and visual confirmation of his presence at the beginning, and various points though not continuously, during the blackout at 9:15.

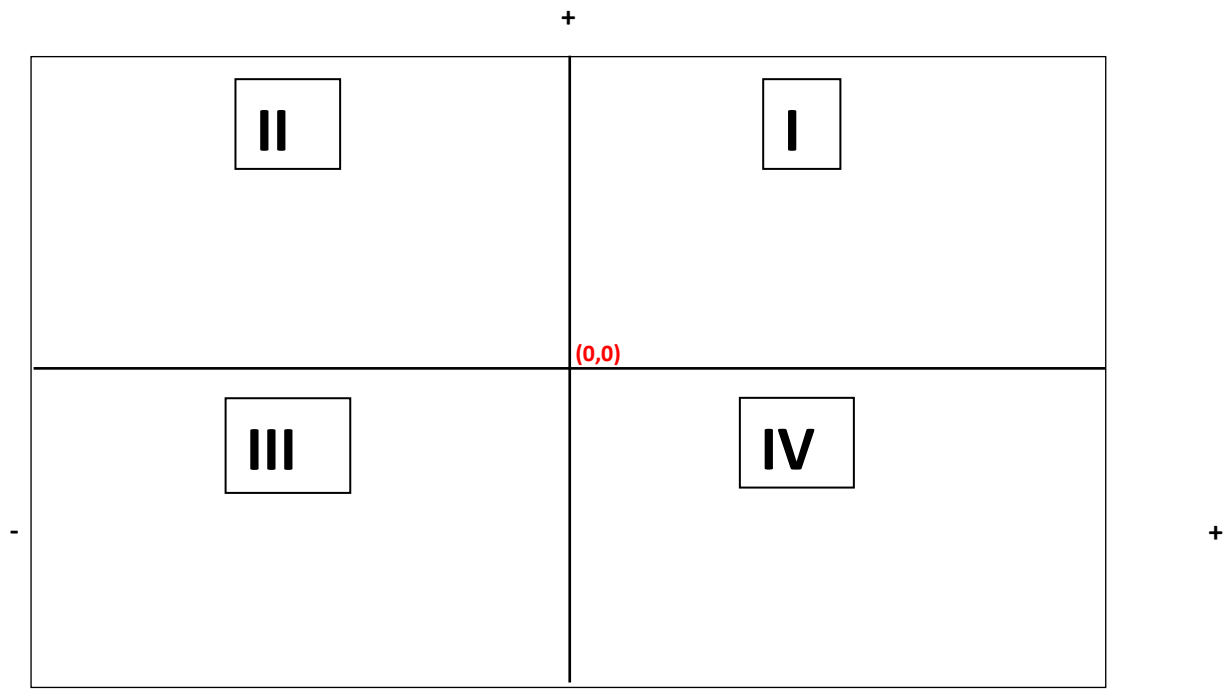
Sylver: "Hello. I am not the murderer. My father has many people who were not pleased with him, but I don't have any such dilemmas. During the blackout, I was trapped in the bathroom as

the doors were jammed or stuck or something. It wasn't until someone let me out that I was able to join you all. I believe this was from after I met with father at 9:15ish, until you all let me out after. I frankly have nothing to validate that. Maybe you could check the locks or something? " **Both the detectives and you note that there are no electronic locks on the bathroom doors. Sylver was let out at 9:30 which is the close to the estimated time of death- however since no one claims to have let him out, it is also possible that he went into the bathroom after the crime and was witnessed coming out.**

Brucia: "He can't be dead. No. Listen. I didn't do this. Listen. He funds me. And yes I have been a little bad. Okay, a lot bad. And yes I was mad. Okay. I said some really terrible things, but if he's DEAD, he can't pay for me okay so I didn't. I DIDN'T. I planned this entire party and I wanted him to see that I could be good, but he didn't even get to see the best parts! Also- OH I was here! You saw me, right? I couldn't do it I was with you! Embarrassingly, I am terrified of the dark and bats, but I couldn't have done whatever it was that happened. Please, you have to believe me. I don't want to be alone again." **Both the detectives and you note that Brucia never left the sight of other people, as she could not be kept in the dark without severe panic. She also seemed the only person to be visibly upset about the death of her adoptive father. She was also indeed the planner of the party so possibly something she could have planned to allow for her alibi to be so iron-clad. Or she's innocent.**

Task 3: Dying Message:

Quickly, you take stock of the situation, and the officers and detectives in the area, who have prevented any funny business with the crime scene stumble upon a small crumpled piece of paper in the fist of Grandfather Duoson. You recognize that it refers to the security system that he was so enamored by, and realize that perhaps you could investigate that for more information. Unfortunately, you will have to solve the code to understand it, as Grandfather Duoson did not want the security system to be so easily cracked. Below is a reconstruction of the note in its entirety:



$x=5;$

$y=10;$

$z=3;$

$w=1;$

```
while w<3
x=-x;
z=z+1;
w=w+2;
end

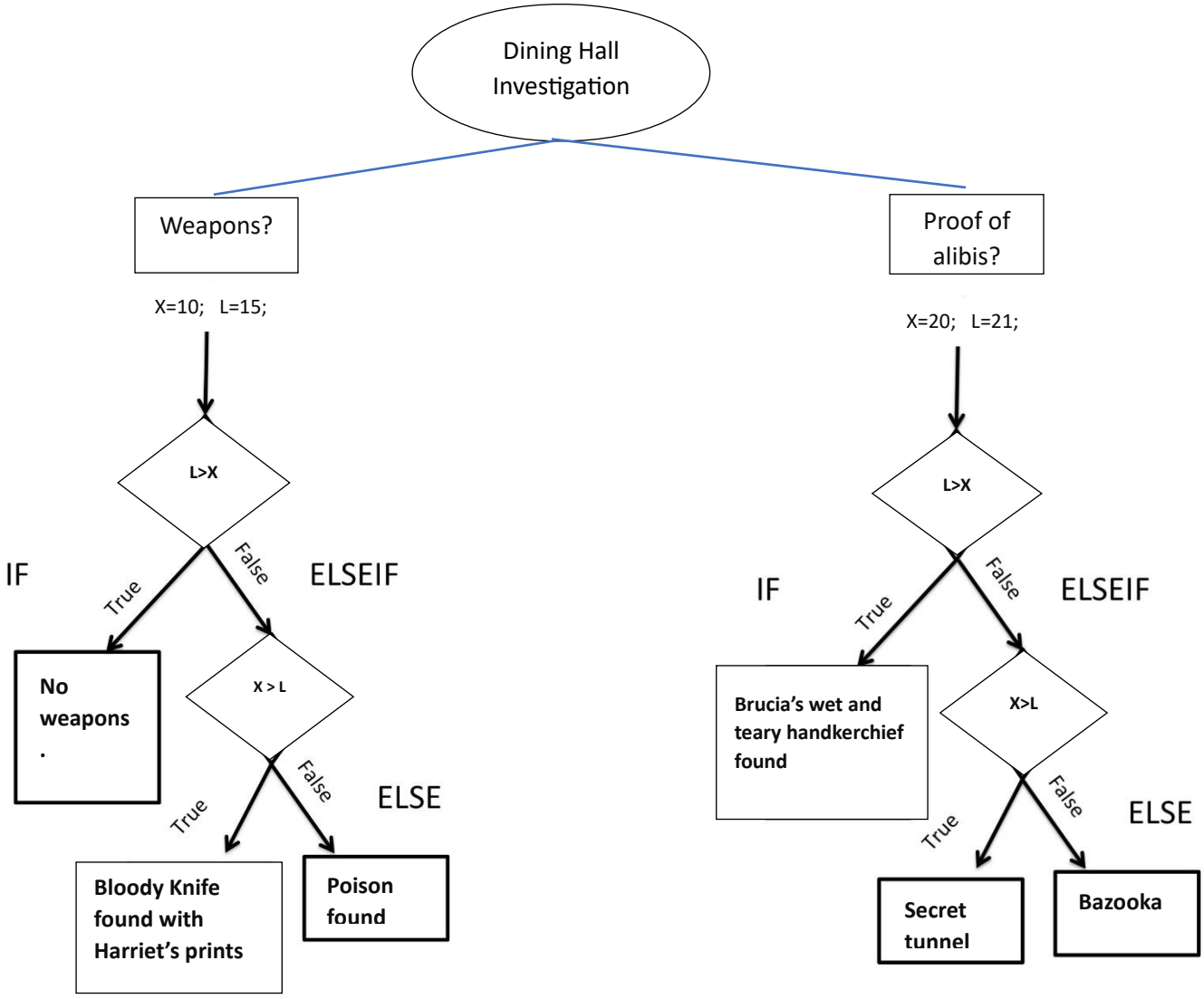
while z<4
y=-y;
z=z+1;
end
(x,y)
```

Once you get the answer, please come and tell, what your answer was. And WHERE it was. Perhaps that will unlock some of the security logs.

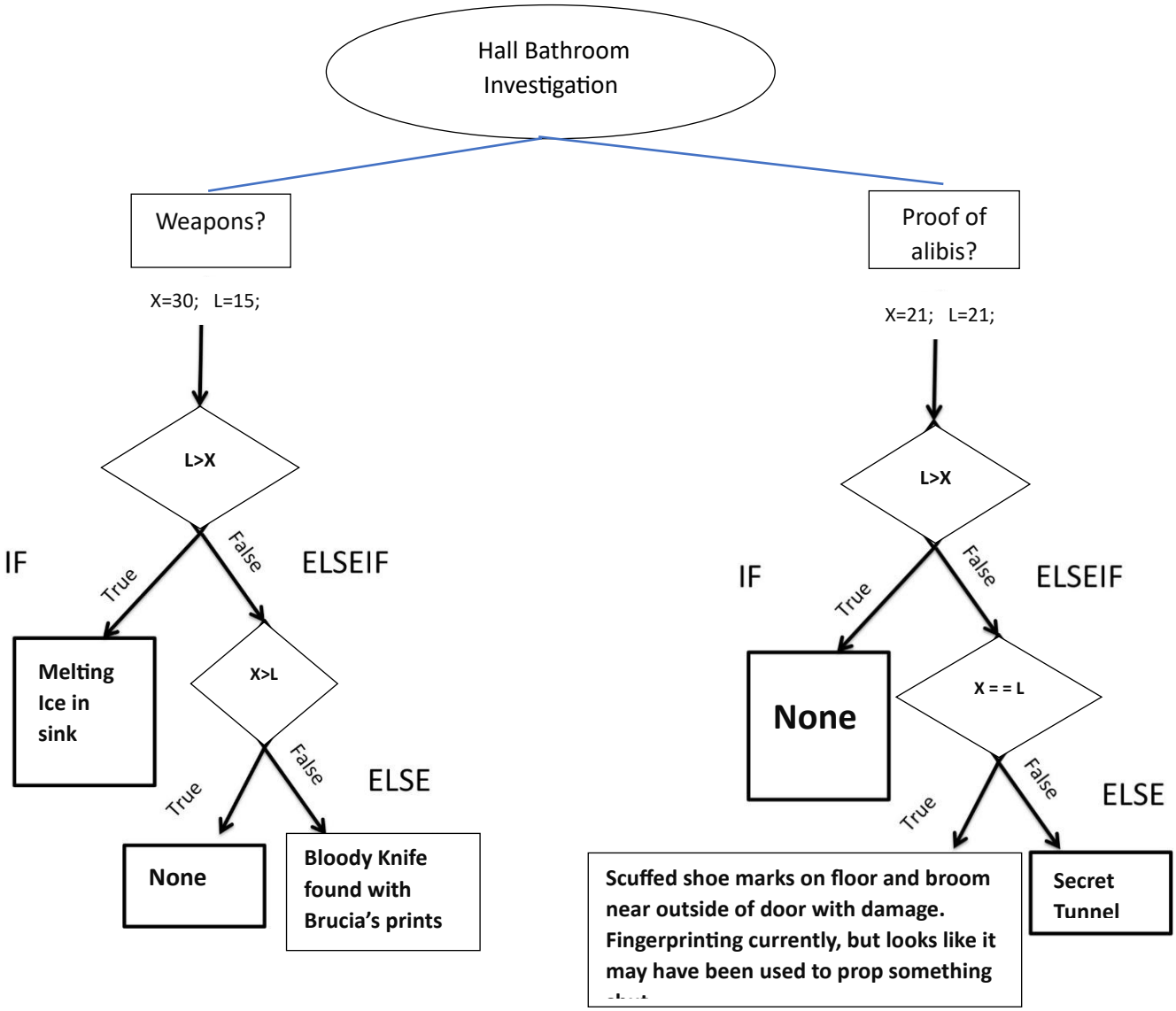
Task 4: Last Clues and then mystery solved:

As you solve this, you have an epiphany and want to try to search some of the other places in the hotel.

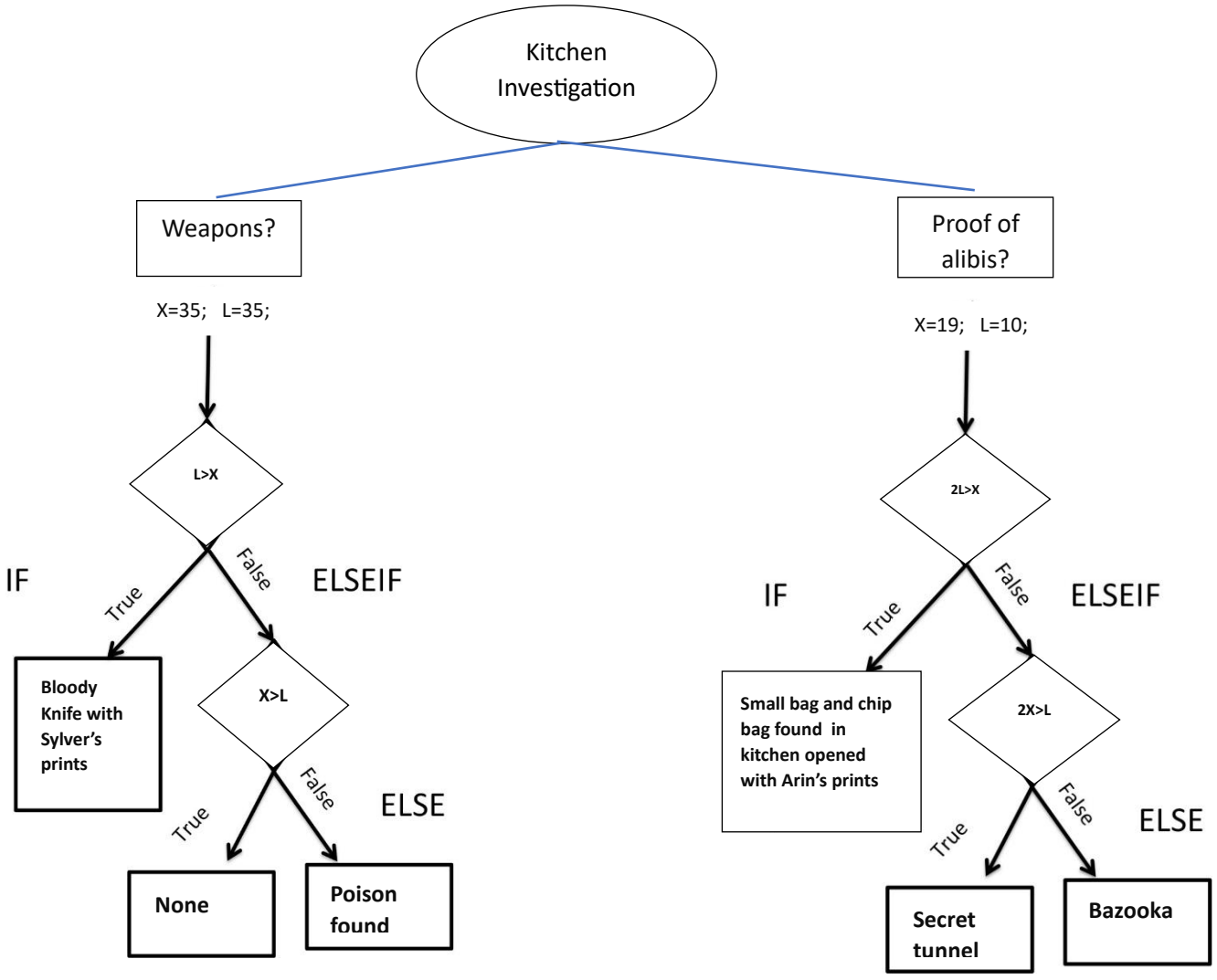
If you want to investigate the dining hall:



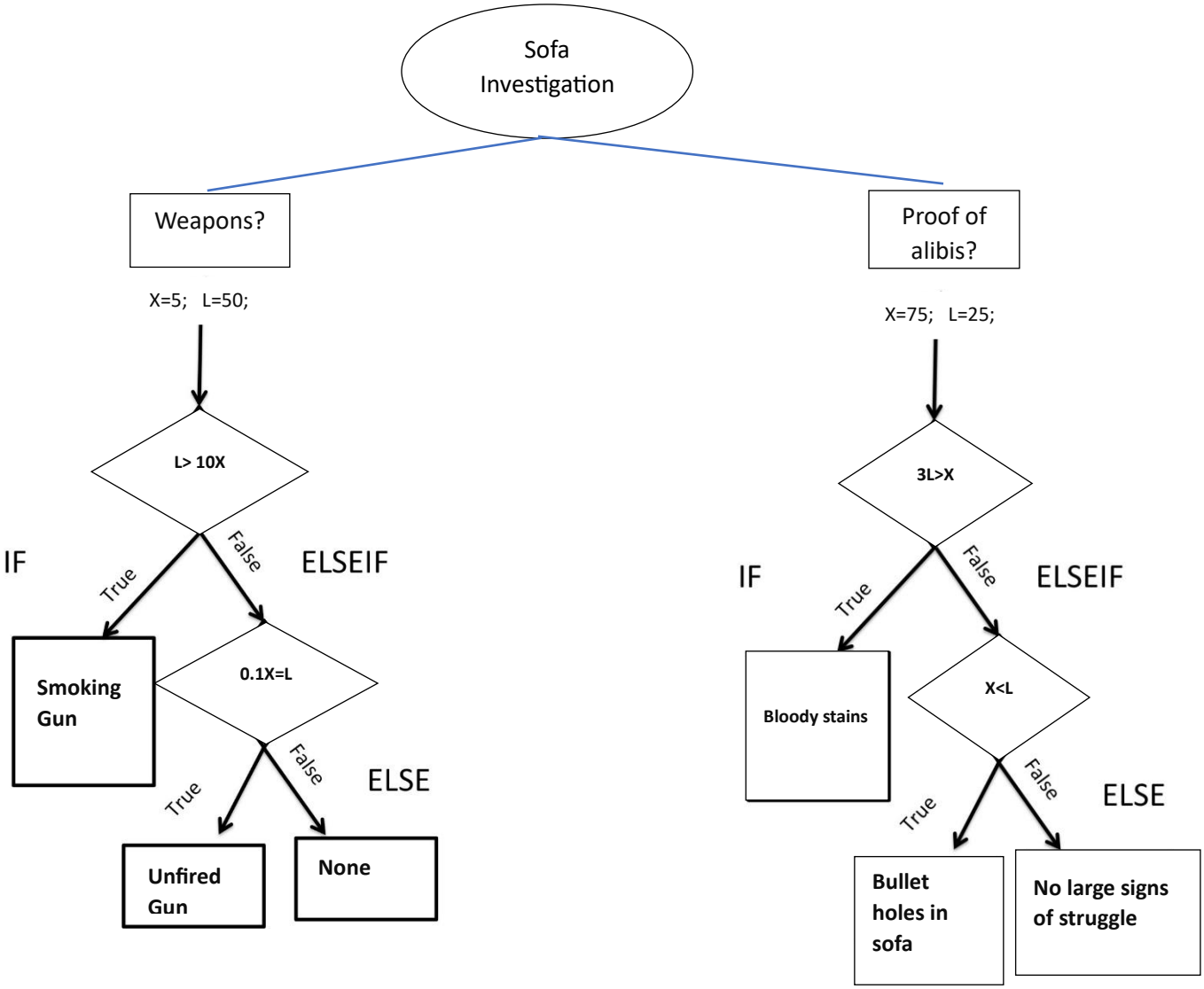
If you want to check the hotel hall bathroom:



If you want to investigate the Study's kitchen:



If you would like to investigate the Study's sofa:



Now it is time to solve for the murderer. Who do you think is the culprit?

_____

How did they do it and how was their alibi misleading?

_____

Bonus file:

*Code for generating a word search in MATLAB which is singlehandedly the most abominable thing I have ever created and attempted. I use it in lectures as a cautionary tale of when you *can* do something, but *should* not do so.*

```
clear all

clc
% int A=1;
% int B=2;
% int C=3;
% int D=4;
% int E=5;
% int F;
% int G;
% int H;
% int I;
% int J;
% int K;
% int L;
% int M;
% int N;
% int O;
% int P;
% int Q;
% int R;
% int S;
% int T;
% int U;
% int V;
% int W;
% int X;
% int Y;
% int Z;
syms A B C D E F G H I J K L M N O P Q R S T U V W X Y Z;
subs A, B, C, D, E, F, G, H ,I ,J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z;

%WordMatrix=rand(100);
%WordMatrix(1:100,1)=[A,V,W,X,T,G,D,Q,Y,H,G,E,C,X,B,H,J,Q,W,F,Y,G,E,W,D,J,C,F,V,K,L,O
,P,D,E,W,S,D,Q,Z,X,D,F,D,E,W,Q,F,G,T,V,C,H,B,D,E,D,S,E,T,F,W,T,G,E,A,Q,E,Q,W,E,R,T,D,
G,H,S,F,A,S,D,E,W,F,T,V,H,C,X,A,Z,G,H,E,J,I,O,B,D];
WordMatrix(1:10,1)=[S,O,U,H,J,L,K,M,J,A];
WordMatrix(11:20,1)=[U,E,C,O,B,H,V,X,C,S];
WordMatrix(21:25,1)=[R,G,E,W,C];

WordMatrix(1:10,2)=[U,E,C,O,B,R,A,N,C,H];
WordMatrix(11:20,2)=[R,W,T,G,E,A,Q,E,Q,W];
WordMatrix(21:25,2)=[I,C,H,B,O];

WordMatrix(1:10,3)=[R,B,K,W,V,S,D,G,A,C];
WordMatrix(11:20,3)=[E,E,G,X,B,D,A,F,Q,R];
WordMatrix(21:25,3)=[U,O,A,F,N];
```

```
WordMatrix(1:10,4)=[P,K,L,M,C,O,O,Y,P,H];
WordMatrix(11:20,4)=[S,E,E,B,L,M,M,A,P,A];
WordMatrix(21:25,4)=[G,H,A,S,D];

WordMatrix(1:10,5)=[R,P,K,A,O,B,D,H,E,E];
WordMatrix(11:20,5)=[G,K,N,M,E,F,G,A,C,V];
WordMatrix(21:25,5)=[B,U,L,B,I];

WordMatrix(1:10,6)=[I,Z,D,N,M,G,R,Z,A,R];
WordMatrix(11:20,6)=[B,C,I,E,A,L,A,S,G,A];
WordMatrix(21:25,6)=[E,L,I,N,T];

WordMatrix(1:10,7)=[S,X,F,Y,P,E,F,A,R,R];
WordMatrix(11:20,7)=[E,O,U,G,C,O,P,P,A,F];
WordMatrix(21:25,7)=[G,R,E,E,I];

WordMatrix(1:10,8)=[E,L,O,T,U,B,C,N,N,Y];
WordMatrix(11:20,8)=[L,N,S,R,H,V,X,C,A,R];
WordMatrix(21:25,8)=[J,O,K,E,O];

WordMatrix(1:10,9)=[A,O,A,I,T,V,E,O,B,C];
WordMatrix(11:20,9)=[I,F,C,O,P,I,Q,E,R,T];
WordMatrix(21:25,9)=[I,O,N,S,N];

WordMatrix(1:10,10)=[A,B,H,M,E,A,D,P,A,A];
WordMatrix(11:20,10)=[E,I,O,C,L,E,R,S,T,A];
WordMatrix(21:25,10)=[S,T,U,F,A];

WordMatrix(1:10,11)=[A,J,K,E,T,T,T,A,N,M];
WordMatrix(11:20,11)=[V,D,C,K,E,Z,A,E,W,Q];
WordMatrix(21:25,11)=[E,N,D,F,L];

WordMatrix(1:10,12)=[S,E,L,S,E,I,F,A,L,H];
WordMatrix(11:20,12)=[E,E,H,S,S,E,A,F,Z,F];
WordMatrix(21:25,12)=[S,T,A,R,S];

WordMatrix(1:10,13)=[M,A,B,R,O,X,G,Z,A,S];
WordMatrix(11:20,13)=[G,N,A,O,B,B,R,E,A,K];
WordMatrix(21:25,13)=[B,I,S,O,N];

WordMatrix(1:10,14)=[S,C,I,D,N,U,M,E,I,B];
WordMatrix(11:20,14)=[A,C,R,U,I,F,S,T,A,T];
WordMatrix(21:25,14)=[E,M,E,N,T];

WordMatrix(1:10,15)=[W,P,I,Q,T,Y,Y,B,P,K];
WordMatrix(11:20,15)=[I,E,O,D,O,O,W,E,C,F];
WordMatrix(21:25,15)=[F,R,U,I,T];

WordMatrix(1:10,16)=[I,O,U,P,T,E,H,C,E,I];
WordMatrix(11:20,16)=[B,E,C,O,N,H,U,F,O,S];
WordMatrix(21:25,16)=[L,O,O,P,S];

WordMatrix(1:10,17)=[T,E,S,I,T,G,E,Q,A,W];
WordMatrix(11:20,17)=[L,E,H,N,E,G,A,M,E,S];
```

```
WordMatrix(21:25,17)=[W,H,I,L,E];

WordMatrix(1:10,18)=[C,H,N,E,T,G,R,Q,C,I];
WordMatrix(11:20,18)=[E,E,A,U,P,S,F,O,R,S];
WordMatrix(21:25,18)=[T,R,W,E,D];

WordMatrix(1:10,19)=[H,U,U,F,T,G,O,Q,H,S];
WordMatrix(11:20,19)=[A,E,I,T,I,C,A,N,D,Y];
WordMatrix(21:25,19)=[R,J,F,S,A];

WordMatrix(1:10,20)=[P,E,N,N,S,Y,L,V,A,N];
WordMatrix(11:20,20)=[N,I,A,O,E,O,J,P,W,F];
WordMatrix(21:25,20)=[Y,C,G,H,A];

WordMatrix(1:10,21)=[O,N,O,E,L,O,W,R,V,A];
WordMatrix(11:20,21)=[G,E,B,S,C,H,J,Q,W,P];
WordMatrix(21:25,21)=[Y,G,E,W,D];

WordMatrix(1:10,22)=[B,O,I,W,T,J,U,I,C,E];
WordMatrix(11:20,22)=[M,E,R,X,E,H,J,Q,W,F];
WordMatrix(21:25,22)=[E,G,E,W,W];

WordMatrix(1:10,23)=[B,H,D,E,W,R,F,A,S,G];
WordMatrix(11:20,23)=[Y,O,U,G,O,T,T,H,I,S];
WordMatrix(21:25,23)=[P,P,W,A,G];

WordMatrix(1:5,24)=[A,D,A,E,E];
WordMatrix(6:15,24)=[B,U,C,K,N,E,L,L,U,N];
WordMatrix(16:25,24)=[I,V,E,R,S,I,T,Y,A,A];


WordMatrix(1:10,25)=[D,F,C,K,L,K,G,U,K,M];
WordMatrix(11:20,25)=[Y,U,I,F,D,G,H,D,S,D];
```

```
WordMatrix(21:25,25)=[V,F,W,E,R];
```

```
WordMatrix =
```

```
[S, U, R, P, R, I, S, E, A, A, A, S, M, S, W, I, T, C, H, P, O, B, B, A, D]
[O, E, B, K, P, Z, X, L, O, B, J, E, A, C, P, O, E, H, U, E, N, O, H, D, F]
[U, C, K, L, K, D, F, O, A, H, K, L, B, I, I, U, S, N, U, N, O, I, D, A, C]
[H, O, W, M, A, N, Y, T, I, M, E, S, R, D, Q, P, I, E, F, N, E, W, E, E, K]
[J, B, V, C, O, M, P, U, T, E, T, E, O, N, T, T, T, T, T, S, L, T, W, E, L]
[L, R, S, O, B, G, E, B, V, A, T, I, X, U, Y, E, G, G, G, Y, O, J, R, B, K]
[K, A, D, O, D, R, F, C, E, D, T, F, G, M, Y, H, E, R, O, L, W, U, F, U, G]
[M, N, G, Y, H, Z, A, N, O, P, A, A, Z, E, B, C, Q, Q, Q, V, R, I, A, C, U]
[J, C, A, P, E, A, R, N, B, A, N, L, A, I, P, E, A, C, H, A, V, C, S, K, K]
[A, H, C, H, E, R, R, Y, C, A, M, H, S, B, K, I, W, I, S, N, A, E, G, N, M]
[U, R, E, S, G, B, E, L, I, E, V, E, G, A, I, B, L, E, A, N, G, M, Y, E, Y]
[E, W, E, E, K, C, O, N, F, I, D, E, N, C, E, E, E, E, E, I, E, E, O, L, U]
[C, T, G, E, N, I, U, S, C, O, C, H, A, R, O, C, H, A, I, A, B, R, U, L, I]
[O, G, X, B, M, E, G, R, O, C, K, S, O, U, D, O, N, U, T, O, S, X, G, U, F]
[B, E, B, L, E, A, C, H, P, L, E, S, B, I, O, N, E, P, I, E, C, E, O, N, D]
[H, A, D, M, F, L, O, V, I, E, Z, E, B, F, O, H, G, S, C, O, H, H, T, I, G]
[V, Q, A, M, G, A, P, X, Q, R, A, A, R, S, W, U, A, F, A, J, J, J, T, V, H]
[X, E, F, A, A, S, P, C, E, S, E, F, E, T, E, F, M, O, N, P, Q, Q, H, E, D]
[C, Q, Q, P, C, G, A, A, R, T, W, Z, A, A, C, O, E, R, D, W, W, W, I, R, S]
[S, W, R, A, V, A, F, R, T, A, Q, F, K, T, F, S, S, S, Y, F, P, F, S, S, D]
[R, I, U, G, B, E, G, J, I, S, E, S, B, E, F, L, W, T, R, Y, Y, E, P, I, V]
[G, C, O, H, U, L, R, O, O, T, N, T, I, M, R, O, H, R, J, C, G, G, P, T, F]
[E, H, A, A, L, I, E, K, N, U, D, A, S, E, U, O, I, W, F, G, E, E, W, Y, W]
[W, B, F, S, B, N, E, E, S, F, F, R, O, N, I, P, L, E, S, H, W, W, A, A, E]
[C, O, N, D, I, T, I, O, N, A, L, S, N, T, T, S, E, D, A, A, D, W, G, A, R]
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