ENGR 231 – Linear Engineering Systems
Answer Template for Lab 5: Spring 2022

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first *last*

Lab 5: The Inverse Matrix and Applications

As a convenience, this **answer template** is provided if you wish to easily submit your work.
Be sure to save it as a PDF before submitting online!

Question 1: Complete the table for the eight magic squares.

Seed Matrix	Magic Square #1	Magic Square #2
$\begin{bmatrix} * & 1 & * \\ * & 5 & * \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} 6 & 1 & 8 \\ 7 & 5 & 3 \\ 2 & 9 & 4 \end{bmatrix}$	$\begin{bmatrix} 8 & 1 & 6 \\ 3 & 5 & 7 \\ 4 & 9 & 2 \end{bmatrix}$
$\begin{bmatrix} * & 3 & * \\ * & 5 & * \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} 4 & 3 & 8 \\ 9 & 5 & 1 \\ 2 & 7 & 6 \end{bmatrix}$	$\begin{bmatrix} 8 & 3 & 4 \\ 1 & 5 & 9 \\ 6 & 7 & 2 \end{bmatrix}$
$\begin{bmatrix} * & 7 & * \\ * & 5 & * \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} 2 & 7 & 6 \\ 9 & 5 & 1 \\ 4 & 3 & 8 \end{bmatrix}$	$\begin{bmatrix} 6 & 7 & 2 \\ 1 & 5 & 9 \\ 8 & 3 & 4 \end{bmatrix}$
$\begin{bmatrix} * & 9 & * \\ * & 5 & * \\ * & * & * \end{bmatrix}$	$\begin{bmatrix} 2 & 9 & 4 \\ 7 & 5 & 3 \\ 6 & 1 & 8 \end{bmatrix}$	$\begin{bmatrix} 4 & 9 & 2 \\ 3 & 5 & 7 \\ 8 & 1 & 6 \end{bmatrix}$

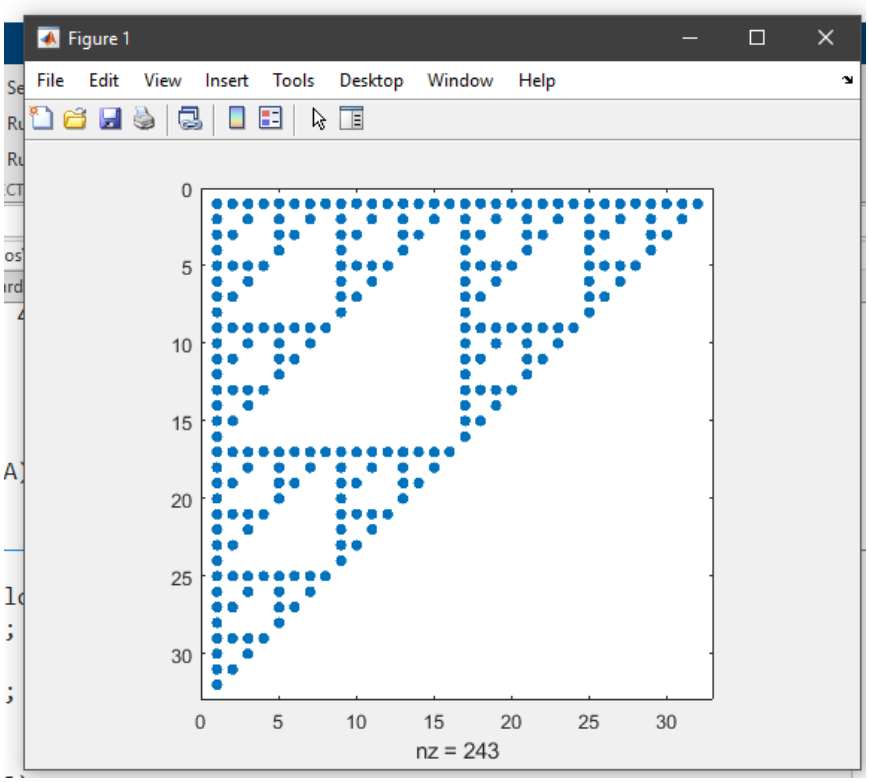
Question 2: Calculate the sum *S* of <u>all</u> the elements in M3 using the formula $S = \vec{\mathbf{r}}^T M3\, \vec{\mathbf{r}}$

S = **45**

Question 3: For each matrix in the table, record its determinant, adjoint and inverse using the commands det(), sym() and adjoint(). DO NOT use MATLAB's inv() command.
Express all coefficients as rational numbers. No decimals allowed!! Code for the first matrix is given for you. In the last column, leave the determinant outside the matrix so all elements are integers.

Matrix A	**Determinant of A**	**Adjoint of A (always exists)**	**Inverse of A** Write **DOES NOT EXIST** if det(A) = 0.
A = sym(magic(3)) Magic Matrix	-360	$\begin{bmatrix} -53 & 52 & -23 \\ 22 & -8 & -38 \\ 7 & -68 & 37 \end{bmatrix}$	$-\frac{1}{360} \cdot \begin{bmatrix} -53 & 52 & -23 \\ 22 & -8 & -38 \\ 7 & -68 & 37 \end{bmatrix}$
A = sym(pascal(4)) Pascal Matrix	1	$\begin{bmatrix} \mathbf{4} & \mathbf{-6} & \mathbf{4} & \mathbf{-1} \\ \mathbf{-6} & \mathbf{14} & \mathbf{-11} & \mathbf{3} \\ \mathbf{4} & \mathbf{-11} & \mathbf{10} & \mathbf{-3} \\ \mathbf{-1} & \mathbf{3} & \mathbf{-3} & \mathbf{1} \end{bmatrix}$	$\begin{bmatrix} \mathbf{4} & \mathbf{-6} & \mathbf{4} & \mathbf{-1} \\ \mathbf{-6} & \mathbf{14} & \mathbf{-11} & \mathbf{3} \\ \mathbf{4} & \mathbf{-11} & \mathbf{10} & \mathbf{-3} \\ \mathbf{-1} & \mathbf{3} & \mathbf{-3} & \mathbf{1} \end{bmatrix}$
A = mod(pascal(4), 2) A = sym(A) Pascal Matrix Mod 2	1	$\begin{bmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{1} \\ \mathbf{0} & \mathbf{0} & \mathbf{1} & \mathbf{-1} \\ \mathbf{0} & \mathbf{1} & \mathbf{0} & \mathbf{-1} \\ \mathbf{1} & \mathbf{-1} & \mathbf{-1} & \mathbf{1} \end{bmatrix}$	$\begin{bmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{1} \\ \mathbf{0} & \mathbf{0} & \mathbf{1} & \mathbf{-1} \\ \mathbf{0} & \mathbf{1} & \mathbf{0} & \mathbf{-1} \\ \mathbf{1} & \mathbf{-1} & \mathbf{-1} & \mathbf{1} \end{bmatrix}$
A = sym(vander(1:4)) Vandermonde Matrix	12	$\begin{bmatrix} \mathbf{-2} & \mathbf{6} & \mathbf{-6} & \mathbf{1} \\ \mathbf{18} & \mathbf{-48} & \mathbf{42} & \mathbf{-12} \\ \mathbf{-52} & \mathbf{114} & \mathbf{-84} & \mathbf{22} \\ \mathbf{48} & \mathbf{-72} & \mathbf{48} & \mathbf{-12} \end{bmatrix}$	$\frac{\mathbf{1}}{\mathbf{12}} * \begin{bmatrix} \mathbf{-2} & \mathbf{6} & \mathbf{-6} & \mathbf{1} \\ \mathbf{18} & \mathbf{-48} & \mathbf{42} & \mathbf{-12} \\ \mathbf{-52} & \mathbf{114} & \mathbf{-84} & \mathbf{22} \\ \mathbf{48} & \mathbf{-72} & \mathbf{48} & \mathbf{-12} \end{bmatrix}$
$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$	0	$\begin{bmatrix} \mathbf{-3} & \mathbf{6} & \mathbf{-3} \\ \mathbf{6} & \mathbf{-12} & \mathbf{6} \\ \mathbf{-3} & \mathbf{6} & \mathbf{-3} \end{bmatrix}$	**DOES NOT EXIST**

Question 4. Paste your 32×32 Sierpinski gasket here.



Question 5: Paste in all your code for this problem here.

```
clear, clc
A = mod(pascal(4), 2); A = sym(A)
I = eye(4);
AI = [A, I];
AIR = rref(AI)
disp(AIR(:,5:end))
```

What inverse did you find? $A^{-1} = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & -1 \\ 0 & 1 & 0 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$

First column is given for free.

Question 6: The adjoint of A is:

$$\text{adjoint}(A) = \begin{bmatrix} 5 & 4 & 3 & 2 & 1 \\ 4 & 8 & 6 & 4 & 2 \\ 3 & 6 & 9 & 6 & 3 \\ 2 & 4 & 6 & 8 & 4 \\ 1 & 2 & 3 & 4 & 5 \end{bmatrix}$$

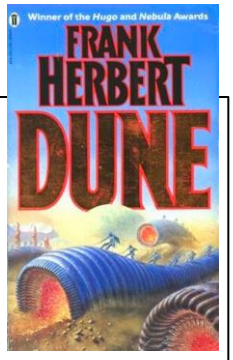
Question 7: Write out the solution. Hint: Every element is an integer.

The unique solution is: $\vec{\mathbf{x}} = A^{-1}\vec{\mathbf{b}} = \begin{bmatrix} \mathbf{1} \\ \mathbf{2} \\ \mathbf{3} \\ \mathbf{4} \\ \mathbf{5} \end{bmatrix}$

A few of the components are given so you can check your work.

Question 8: Put these all together and write A^{-1} in terms of its smaller blocks and their inverses.

Answer: $A^{-1} = \begin{bmatrix} inv(A11) & -inv(A11) * A12 * inv(A22) \\ 0 & inv(A22) \end{bmatrix}$



Questions 9-10: Cryptographic Example:
Decode the secret message and paste in what it says!
You should be able to just copy and paste the matrix.
Then decode it using A^{-1} and print it nicely using fprintf().

The secret message says:
Line 1:
Deep in the human unconscious is a pervasive need for a logical universe that makes sense.

Line 2:
But the real universe is always one step beyond logic. - Frank Herbert, Dune

Grader: One point for each of the two lines.

Ready to Submit?
Be sure all ten questions are answered. When your lab is complete, be sure to submit three files:

1. Your **completed Answer Template** as a PDF file
2. A copy of your **MATLAB Live Script**
3. A **PDF** copy of your **MATLAB Live Script** (Save-Export to PDF…)

The due date is the day after your lab section by **11:59pm** to receive full credit. You have one more day, to submit the lab (but with a small penalty), and then the window closes for good and your grade will be zero.