ENGR 231 – Linear Engineering Systems
MATLAB Exam – Version 1

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First *Last*

Answer Template #1: Spring 2022

This Answer Template is provided for your convenience. Be sure all your answers are recorded inside, then upload your answers as a PDF before the submission window closes. Remember to also submit your Live Script and a PDF copy of your Live Script!

Part A: Circle or check each answer below. (10 points)

Question 1: Find the vector whose 2-norm is 50.

A. $\begin{bmatrix} 10 \\ -20 \\ 10 \\ 20 \\ -40 \\ 20 \end{bmatrix}$ **B.** $\begin{bmatrix} 50 \\ 40 \\ 30 \\ 20 \\ 10 \\ -150 \end{bmatrix}$ **C.** $\begin{bmatrix} 10 \\ 10 \\ 10 \\ 20 \\ 30 \\ 30 \end{bmatrix}$ **D.** $\begin{bmatrix} 10 \\ 10 \\ 10 \\ 10 \\ 6 \\ 4 \end{bmatrix}$

Question 2: My 1-norm, 2-norm and ∞-norm are **all** 12. Find me!

A. $\begin{bmatrix} 6 \\ 0 \\ 6 \\ 0 \end{bmatrix}$ **B.** $\begin{bmatrix} 12 \\ 0 \\ 0 \\ 0 \end{bmatrix}$ **C.** $\begin{bmatrix} 6 \\ 6 \\ 6 \\ 6 \end{bmatrix}$ **D.** $\begin{bmatrix} -12 \\ +12 \\ -12 \\ +12 \end{bmatrix}$

Question 3: Find the matrix M whose cube, is the identity matrix. That is, $M^3 = I$.

$\boldsymbol{A} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 2 & 3 & 4 & 5 \\ 1 & 3 & 6 & 10 & 15 \\ 1 & 4 & 10 & 20 & 35 \\ 1 & 5 & 15 & 35 & 70 \end{bmatrix}$ $\boldsymbol{B} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 & 0 \\ 1 & -2 & 1 & 0 & 0 \\ 1 & -3 & 3 & -1 & 0 \\ 1 & -4 & 6 & -4 & 1 \end{bmatrix}$ $\boldsymbol{C} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ -4 & -3 & -2 & -1 & 0 \\ 6 & 3 & 1 & 0 & 0 \\ -4 & -1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{bmatrix}$ **D.** **None** of these.

Question 4: Record the 2×2 matrix R that you found in the box. $R =$ $\begin{bmatrix} 4 & -3 \\ -5 & 4 \end{bmatrix}$

Question 5: One of these vectors is **orthogonal** to all three columns of the matrix A. **Find it!**

A. $\begin{bmatrix}1\\1\\1\\1\\1\\1\end{bmatrix}$ **B.** $\begin{bmatrix}1\\2\\3\\1\\2\\3\end{bmatrix}$ **C.** $\begin{bmatrix}6\\6\\6\\0\\0\\0\end{bmatrix}$ **D.** $\begin{bmatrix}1\\2\\3\\-1\\-2\\-3\end{bmatrix}$

Question 6: What is the missing element ***k*** in the RAM?

A. 0 **B.** 1 **C.** 2 **D.** 3 **E.** 5

Question 7: The solution for $\vec{\mathbf{x}}$ is:

A. $\begin{bmatrix}5\\-1\\-2\end{bmatrix}$ **B.** $\begin{bmatrix}2\\3\\5\end{bmatrix}$ **C.** $\begin{bmatrix}-2\\3\\5\end{bmatrix}$ **D.** $\begin{bmatrix}6\\6\\6\end{bmatrix}$ **E.** $\begin{bmatrix}0\\3\\5\end{bmatrix}$

Question 8: The sum of all 25 elements is:

A. $V^T A^T A\, V = 351$ **B.** $V^T A^T A\, V = 361$ **C.** $V^T A^T A\, V = 371$ **D.** $V^T A^T A\, V = 381$

Questions 9-10: Paste in your code here. We do not need the resulting inverse – just the code for all steps. Assume A has been entered.

```
AI = [A, eye(5)]
AIR = rref(AI)
Ainv = AIR(:,6:end)
```

Part B: Cramer's Rule! **(5 points)**

Question 1: The determinant of *A* is: **4096**

Question 2: Complete this code so the matrix A8 is correctly defined.

```
A8 = A; % Add one more line below using a colon.
A8(:,8) = b;
```

3. Solve for the last unknown x_8 using Cramer's rule. Show **both** your code and the result for x_8.

Question 3: Paste your code here.

```
x8 = det(A8)/det(A)

After running the code, the value for x8 is: 4
```

4-5: Complete this for loop, to find all the unknowns at once. Add code inside the blue boxes.

```
for i = 1:N
    Ai = A;          % <- Makes a copy of A and names it Ai.
    % Next, replace column i of Ai with b

    Ai(:,i) = b;

    % Find the ith unknown x(i) using Cramer's formula.

    x(i) =   det(Ai)/det(A);
end
x  % Prints out the solution as a column vector.
```

Part C: Row Space, Null Space **(5 points)**

Question 1: The missing element in the **last** column is.

A. 12 **B.** 13 **C.** 14 **D.** 15 **E.** 16

Question 2: The 2 × 8 matrix R consisting of the first two rows of Ared is: (*just give code*)

```
R = Ared(1:2,:)
```

Question 3: The missing element in the second row is:

A. 3 **B.** 4 **C.** 6 **D.** 12

Question 4: The matrix product *RN* is: →

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Question 5: All of these combinations have the same **null** space as *A* **except** one whose null space is just 2D! Find it!

A. $A^T A$ **B.** $A A^T$ **C.** $A A^T A$ **D.** $A^T A A^T A$

Part D: Curve Fitting and Olympic Records **(5 points)**

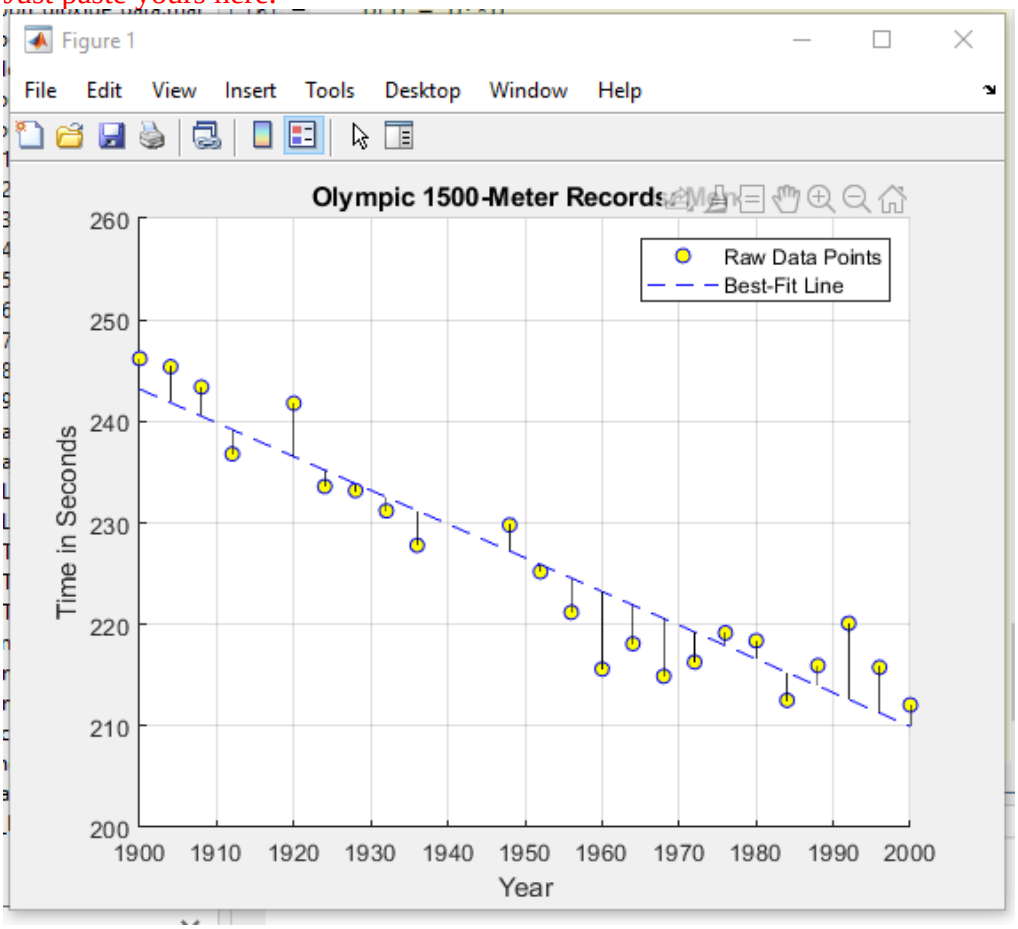
Question 1: The 2×2 matrix $D^T D$ is: $D^T D = \begin{bmatrix} 23 & 44900 \\ 44900 & 87674608 \end{bmatrix}$

Question 2: The best-fit parameter vector is: $\vec{\boldsymbol{\beta}} = \begin{bmatrix} \beta_0 \\ \beta_1 \end{bmatrix} = \begin{bmatrix} 874.4631 \\ -0.3323 \end{bmatrix}$

Question 3: The RMSE (root mean square error) is: **3.6711**

Questions 4-5: Replace the sample plot with your finished graph. **(2 points)**

Just paste yours here.



Ready to Submit?

Be sure all questions are answered. When your MATLAB Exam 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…)