國立中山大學 NATIONAL SUN YAT-SEN UNIVERSITY

線性代數（一） MATH 103 / GEAI 1215: Linear Algebra I

第二次期中考 December 6, 2021 **Midterm 2**

姓名 Name : ____________________

學號 Student ID # : ____________________

Lecturer:	Jephian Lin 林晉宏
Contents:	cover page,
	5 pages of questions,
	score page at the end
To be answered:	on the test paper
Duration:	**110 minutes**
Total points:	**20 points** + 2 extra points

Do not open this packet until instructed to do so.

Instructions:

– Enter your **Name** and **Student ID #** before you start.

– Using the calculator is not allowed (and not necessary) for this exam.

– Any work necessary to arrive at an answer must be shown on the examination paper. Marks will not be given for final answers that are not supported by appropriate work.

– Clearly indicate your final answer to each question either by **underlining it or circling it**. If multiple answers are shown then no marks will be awarded.

– 可用中文或英文作答

1. Let

$$A = \begin{bmatrix} 1 & 3 & -5 & -5 & 9 \\ -5 & -15 & 26 & 25 & -47 \\ 20 & 60 & -105 & -100 & 190 \\ -24 & -72 & 125 & 120 & -226 \end{bmatrix} \text{ and } R = \begin{bmatrix} 1 & 3 & 0 & -5 & -1 \\ 0 & 0 & 1 & 0 & -2 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}.$$

It is known that R is the reduced echelon form of A.

(a) [1pt] Find a basis for Row(A).

(b) [1pt] Find a basis for Col(A).

(c) [1pt] Find a basis for ker(A).

(d) [1pt] Find the rank of A.

(e) [1pt] Find the nullity of A.

2. Let

$$V = \left\{ \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} : x_1 + 3x_2 + 3x_3 + 3x_4 = 0 \right\} \text{ and } \mathbf{a} = \begin{bmatrix} -6 \\ 0 \\ 1 \\ 1 \end{bmatrix}.$$

(a) [2pt] Find a basis of V.

(b) [1pt] Find a basis of V that contains $\mathbf{a}$.

(c) [2pt] Let

$$U = \left\{ \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} : x_1 + x_2 + x_3 + x_4 = 0 \right\}.$$

Find a basis of $U \cap V$.

3. Let $\mathcal{M}_{2,2}$ be the vector space of all 2×2 matrices over $\mathbb{R}$. Let

$$A_1 = \begin{bmatrix} 1 & 1 \\ 0 & 0 \end{bmatrix}, \ A_2 = \begin{bmatrix} 1 & 0 \\ 1 & 0 \end{bmatrix}, \ A_3 = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}, \text{ and } A_4 = \begin{bmatrix} 0 & 1 \\ 0 & 1 \end{bmatrix}.$$

(a) [1pt] Find a basis of $\mathcal{M}_{2,2}$.

(b) [1pt] Find a matrix $A \in \operatorname{span}(\{A_1, A_2, A_3\})$ such that A is nowhere zero （每一項都不是零）.

(c) [1pt] Find a matrix $A \notin \operatorname{span}(\{A_1, A_2, A_3\})$ such that A is nowhere zero （每一項都不是零）.

(d) [2pt] Is $\beta = \{A_1, A_2, A_3, A_4\}$ linearly independent? Explain your reasons.

4. [5pt] 數學作文：請寫一篇短文來向沒修過線性代數的朋友介紹什麼是線性獨立（linearly independent）。

   請寫下線性獨立的定義，並以自己的方式、盡量白話的敘述、或是比喻來說明這個爲什麼要這樣定義？還有爲什麼要考慮這樣的概念？請給一些能幫助他人理解的例子（正面的、反面的），並提出一些這個概念的相關性質；有必要的話可以加上一些圖來輔助說明。格式沒有限制，篇幅大約半面到一面。

   (If Chinese is not your native language, you may use English or the language that you prefer.)

5. [extra 2pt] Consider the vector space $\mathcal{P}_2$ of all polynomials with degree at most 2 and with real coefficients. Recall that if $p = c_0 + c_1 x + c_2 x^2$, then we define

$$\operatorname{ptov}(p) = \begin{bmatrix} c_0 \\ c_1 \\ c_2 \end{bmatrix}.$$

Let p' and p'' be the first and the second derivative of p, respectively. Find a matrix D such that

$$\operatorname{ptov}(p + p' + p'') = D \operatorname{ptov}(p)$$

for any $p \in \mathcal{P}_2$.

[END]

Page	Points	Score
1	5	
2	5	
3	5	
4	5	
5	2	
Total	20 (+2)	