King Fahd University of Petroleum and Minerals
Department of Mathematics

Math 208
Major Exam II
Term 252
13 April 2026

EXAM COVER

Number of versions: 4
Number of questions: 15

King Fahd University of Petroleum and Minerals
Department of Mathematics

Math 208

Major Exam II

Term 252

13 April 2026

Net Time Allowed: 90 Minutes

MASTER VERSION

1. Given that $y = \cos(2x)$ is a solution of the differential equation $y^{(4)} + 4y''' + 8y'' + 16y' + 16y = 0$. The general solution of the differential equation is

   (a) $y = (c_1 + c_2\,x)e^{-2x} + c_3\cos(2x) + c_4\sin(2x)$ ________________ (correct)

   (b) $y = (c_1 + c_2\,x)e^{-2x} + c_3 x\cos(2x) + c_4\sin(2x)$

   (c) $y = (c_1 + c_2\,x)\cos(2x) + (c_3 + c_4 x)\sin(2x)$

   (d) $y = c_1\,e^{-2x} + c_2\,e^{2x} + c_3\cos(2x) + c_4\sin(2x)$

   (e) $y = c_1\,e^{-2x} + c_2\,e^{-x} + c_3\cos(2x) + c_4\sin(2x)$

2. Which pair of vectors in $\mathbb{R}^3$ are linearly independent?

   (a) $v_1 = (2,1,4),\ v_2 = (4,2,5)$ ________________ (correct)

   (b) $v_1 = (0,0,0),\ v_2 = (1,1,1)$

   (c) $v_1 = (3,5,2),\ v_2 = \left(\frac{3}{4},\frac{5}{4},\frac{1}{2}\right)$

   (d) $v_1 = \left(\frac{1}{2},\frac{1}{4},\frac{1}{3}\right),\ v_2 = \left(\frac{1}{4},\frac{1}{8},\frac{1}{6}\right)$

   (e) $v_1 = (1,0,5),\ v_2 = \left(\frac{1}{3},0,\frac{5}{3}\right)$

3. The general solution of the differential equation

$$y^{(4)} - 4y''' + 3y'' + 4y' - 4y = 0$$

is

(a) $y = c_1 e^{x} + c_2 e^{-x} + (c_3 + c_4 x)\, e^{2x}$ ________________ (correct)
(b) $y = c_1 e^{x} + c_2 e^{-x} + c_3 e^{2x} + c_4 e^{4x}$
(c) $y = c_1 e^{x} + c_2 e^{-2x} + (c_3 + c_4 x)\, e^{2x}$
(d) $y = c_1 e^{x} + c_2 e^{2x} + (c_3 + c_4 x)\, e^{-x}$
(e) $y = c_1 e^{-x} + c_2 e^{2x} + (c_3 + c_4 x)\, e^{x}$

4. A linear homogeneous differential equation with real coefficients, having the solutions:
$2,\ 3x\, e^{x} \cos(3x)$ is

(a) $D(D^2 - 2D + 10)^2\, y = 0$ ________________ (correct)
(b) $D(D^2 - 2D + 10)\, y = 0$
(c) $D(D^2 + 2D + 10)^2\, y = 0$
(d) $D(D^2 + 2D + 10)\, y = 0$
(e) $D(D^2 - D + 8)^2\, y = 0$

5. The rank of the matrix $A = \begin{bmatrix} 1 & 2 & -1 & 3 \\ -1 & 1 & 2 & 0 \\ 2 & 1 & -3 & 1 \\ 1 & 5 & 0 & 6 \end{bmatrix}$ is

(a) 3 ____(correct)

(b) 4

(c) 2

(d) 1

(e) 0

6. If the solution

$$\begin{cases} x_1 + 3x_2 - 2x_3 + x_4 = 0 \\ 2x_1 + 6x_2 - x_3 - 7x_4 = 0 \\ x_1 + 3x_2 + x_3 - 8x_4 = 0 \end{cases}$$

Consists of all linear combinations of the vectors:
$v_1 = (a, b, 0, 0)$ and $v_2 = (c, 0, 3, d)$, then $\dfrac{a}{b} + \dfrac{c}{d} =$

(a) 2 ____(correct)

(b) -2

(c) 3

(d) -3

(e) 0

7. If $W(x)$ is the Wronskian of the functions

$$f_1(x) = e^x,\ f_2(x) = \cos(2x),\ \text{and}\ f_3(x) = \sin(2x),\ \text{then}\ W(0) =$$

(a) 10 ____ (correct)

(b) 8

(c) -10

(d) -8

(e) 0

8. The solution of the initial value problem $y'' + y = 0$, $y(0) = 3$, $y'(0) = 0$ is given by

(a) $y = 3\ \cos x$ ____ (correct)

(b) $y = 3\ \cos x - \sin x$

(c) $y = 3\ \cos x + \sin x$

(d) $y = 3\ \sin x + 3$

(e) $y = 3\ \cos x + 2\sin x$

9. If $y_p = A + Bx + Cx^2 + De^x$ is a particular solution of the differential equation $y'' - 6y' + 9y = 27x^2 + 4e^x$, then $A + B + C + D =$

   (a) 10 ________________ (correct)

   (b) 8

   (c) 12

   (d) 11

   (e) 0

10. An appropriate form of a particular solution y_p for the non-homogeneous differential equation

$$(D+2)^3(D^2+4)y = e^{-2x} - \sin(2x) \text{ is given by } y_p(x) =$$

   (a) $Ax^3e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$ ________________ (correct)

   (b) $Ax^2e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

   (c) $Axe^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

   (d) $Ax^3e^{-2x} + B\sin(2x) + Cx\cos(2x)$

   (e) $Ax^3e^{-2x} + Bx\sin(4x) + Cx\sin(4x)$

11. The characteristic equation of the matrix $\begin{bmatrix} 0 & -2 & -1 \\ -3 & -1 & -3 \\ 2 & 2 & -3 \end{bmatrix}$ is

(a) $\lambda^3 + 4\lambda^2 + 5\lambda - 34 = 0$ ______ (correct)

(b) $\lambda^3 - 4\lambda^2 + 5\lambda - 34 = 0$

(c) $\lambda^3 + 4\lambda^2 - 5\lambda + 34 = 0$

(d) $\lambda^3 - 2\lambda^2 - \lambda - 2 = 0$

(e) $\lambda^3 + 3\lambda^2 - \lambda - 2 = 0$

12. A particular solution of the differential equation $y'' - 4y' + 4y = x^{-1}e^{2x}$ is given by $y_p(x) =$

(a) $xe^{2x} \ln|x|$ ______ (correct)

(b) $x^2e^{2x} \ln|x|$

(c) $xe^{3x} \ln|x|$

(d) $x^2e^{-2x} \ln|x|$

(e) $xe^{-2x} \ln|x|$

13. If the matrix $A = \begin{bmatrix} 1 & 2 \\ 2 & -2 \end{bmatrix}$ is diagonalizable with a diagonalizing matrix P and a diagonal matrix $D = \begin{bmatrix} 2 & 0 \\ 0 & -3 \end{bmatrix}$ such that $P^{-1}AP = D$, then

(a) $P = \begin{bmatrix} 2 & 1 \\ 1 & -2 \end{bmatrix}$ ________________________________(correct)

(b) $P = \begin{bmatrix} 2 & 1 \\ -1 & -2 \end{bmatrix}$

(c) $P = \begin{bmatrix} 2 & 1 \\ 2 & -2 \end{bmatrix}$

(d) $P = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$

(e) $P = \begin{bmatrix} 2 & -1 \\ 1 & -2 \end{bmatrix}$

14. A particular solution of the differential equation

$y'' - 3y' + 2y = \cos(e^{-x})$ is given by $y_p(x) =$

(a) $-e^{2x} \cos(e^{-x})$ ________________________________(correct)

(b) $e^{x} \cos(e^{-x})$

(c) $-e^{x} \cos(e^{-x})$

(d) $e^{2x} \cos(e^{x})$

(e) $e^{-2x} \cos(e^{-x})$

15. Given the matrix $A = \begin{bmatrix} 2 & 1 & -1 \\ 0 & 1 & 1 \\ 0 & 0 & 2 \end{bmatrix}$. A basis for the eigenspace that corresponds to the eigenvalue $\lambda = 2$ is $v_1 = \begin{bmatrix} 0 \\ \alpha \\ 1 \end{bmatrix}$, $v_2 = \begin{bmatrix} 1 \\ \beta \\ 0 \end{bmatrix}$, where $2\alpha + \beta =$

(a) 2 ____(correct)

(b) 1

(c) -2

(d) 4

(e) 3

King Fahd University of Petroleum and Minerals
Department of Mathematics

CODE 1 **CODE 1**

Math 208
Major Exam II
Term 252
13 April 2026
Net Time Allowed: 90 Minutes

Name	

ID		**Sec**	

Check that this exam has 15 questions.

Important Instructions:

1. All types of calculators, smart watches or mobile phones are NOT allowed during the examination.
2. Use HB 2.5 pencils only.
3. Use a good eraser. DO NOT use the erasers attached to the pencil.
4. Write your name, ID number and Section number on the examination paper and in the upper left corner of the answer sheet.
5. When bubbling your ID number and Section number, be sure that the bubbles match with the numbers that you write.
6. The Test Code Number is already bubbled in your answer sheet. Make sure that it is the same as that printed on your question paper.
7. When bubbling, make sure that the bubbled space is fully covered.
8. When erasing a bubble, make sure that you do not leave any trace of penciling.

1. The solution of the initial value problem $y'' + y = 0$, $y(0) = 3$, $y'(0) = 0$ is given by

   (a) $y = 3\,\cos x + 2\sin x$
   (b) $y = 3\,\cos x$
   (c) $y = 3\,\cos x - \sin x$
   (d) $y = 3\,\cos x + \sin x$
   (e) $y = 3\,\sin x + 3$

2. The general solution of the differential equation

$$y^{(4)} - 4y''' + 3y'' + 4y' - 4y = 0$$

   is

   (a) $y = c_1e^{-x} + c_2e^{2x} + (c_3 + c_4x)\,e^{x}$
   (b) $y = c_1e^{x} + c_2e^{-x} + c_3e^{2x} + c_4e^{4x}$
   (c) $y = c_1e^{x} + c_2e^{2x} + (c_3 + c_4x)\,e^{-x}$
   (d) $y = c_1e^{x} + c_2e^{-x} + (c_3 + c_4x)\,e^{2x}$
   (e) $y = c_1e^{x} + c_2e^{-2x} + (c_3 + c_4x)\,e^{2x}$

3. An appropriate form of a particular solution y_p for the non-homogeneous differential equation

$$(D+2)^3(D^2+4)y = e^{-2x} - \sin(2x) \text{ is given by } y_p(x) =$$

(a) $Ax^3e^{-2x} + Bx\sin(4x) + Cx\sin(4x)$

(b) $Ax^3e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

(c) $Ax^2e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

(d) $Ax^3e^{-2x} + B\sin(2x) + Cx\cos(2x)$

(e) $Axe^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

4. A particular solution of the differential equation

$$y'' - 3y' + 2y = \cos(e^{-x}) \text{ is given by } y_p(x) =$$

(a) $e^{-2x}\,\cos(e^{-x})$

(b) $e^{x}\,\cos(e^{-x})$

(c) $-e^{2x}\,\cos(e^{-x})$

(d) $-e^{x}\,\cos(e^{-x})$

(e) $e^{2x}\,\cos(e^{x})$

5. If $W(x)$ is the Wronskian of the functions

$$f_1(x) = e^x,\ f_2(x) = \cos(2x),\ \text{and}\ f_3(x) = \sin(2x),\ \text{then}\ W(0) =$$

(a) -10
(b) -8
(c) 0
(d) 8
(e) 10

6. The rank of the matrix $A = \begin{bmatrix} 1 & 2 & -1 & 3 \\ -1 & 1 & 2 & 0 \\ 2 & 1 & -3 & 1 \\ 1 & 5 & 0 & 6 \end{bmatrix}$ is

(a) 0
(b) 2
(c) 3
(d) 4
(e) 1

7. If the matrix $A = \begin{bmatrix} 1 & 2 \\ 2 & -2 \end{bmatrix}$ is diagonalizable with a diagonalizing matrix P and a diagonal matrix $D = \begin{bmatrix} 2 & 0 \\ 0 & -3 \end{bmatrix}$ such that $P^{-1}AP = D$, then

(a) $P = \begin{bmatrix} 2 & -1 \\ 1 & -2 \end{bmatrix}$

(b) $P = \begin{bmatrix} 2 & 1 \\ -1 & -2 \end{bmatrix}$

(c) $P = \begin{bmatrix} 2 & 1 \\ 2 & -2 \end{bmatrix}$

(d) $P = \begin{bmatrix} 2 & 1 \\ 1 & -2 \end{bmatrix}$

(e) $P = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$

8. If $y_p = A + Bx + Cx^2 + De^x$ is a particular solution of the differential equation $y'' - 6y' + 9y = 27x^2 + 4e^x$, then $A + B + C + D =$

(a) 12

(b) 10

(c) 0

(d) 8

(e) 11

9. Which pair of vectors in $\mathbb{R}^3$ are linearly independent?

   (a) $v_1 = (2, 1, 4)$, $v_2 = (4, 2, 5)$
   (b) $v_1 = (3, 5, 2)$, $v_2 = \left(\frac{3}{4}, \frac{5}{4}, \frac{1}{2}\right)$
   (c) $v_1 = (1, 0, 5)$, $v_2 = \left(\frac{1}{3}, 0, \frac{5}{3}\right)$
   (d) $v_1 = (0, 0, 0)$, $v_2 = (1, 1, 1)$
   (e) $v_1 = \left(\frac{1}{2}, \frac{1}{4}, \frac{1}{3}\right)$, $v_2 = \left(\frac{1}{4}, \frac{1}{8}, \frac{1}{6}\right)$

10. If the solution

$$\begin{cases} x_1 + 3x_2 - 2x_3 + x_4 = 0 \\ 2x_1 + 6x_2 - x_3 - 7x_4 = 0 \\ x_1 + 3x_2 + x_3 - 8x_4 = 0 \end{cases}$$

Consists of all linear combinations of the vectors:
$v_1 = (a, b, 0, 0)$ and $v_2 = (c, 0, 3, d)$, then $\frac{a}{b} + \frac{c}{d} =$

   (a) 2
   (b) 0
   (c) 3
   (d) -3
   (e) -2

11. A particular solution of the differential equation $y'' - 4y' + 4y = x^{-1}e^{2x}$ is given by $y_p(x) =$

(a) $xe^{-2x}\ \ln|x|$
(b) $x^2e^{2x}\ \ln|x|$
(c) $x^2e^{-2x}\ \ln|x|$
(d) $xe^{3x}\ \ln|x|$
(e) $xe^{2x}\ \ln|x|$

12. Given that $y = \cos(2x)$ is a solution of the differential equation $y^{(4)} + 4y''' + 8y'' + 16y' + 16y = 0$. The general solution of the differential equation is

(a) $y = c_1\, e^{-2x} + c_2\, e^{-x} + c_3 \cos(2x) + c_4 \sin(2x)$
(b) $y = (c_1 + c_2\, x)e^{-2x} + c_3 x \cos(2x) + c_4 \sin(2x)$
(c) $y = (c_1 + c_2\, x)e^{-2x} + c_3 \cos(2x) + c_4 \sin(2x)$
(d) $y = c_1\, e^{-2x} + c_2\, e^{2x} + c_3 \cos(2x) + c_4 \sin(2x)$
(e) $y = (c_1 + c_2\, x) \cos(2x) + (c_3 + c_4 x) \sin(2x)$

13. The characteristic equation of the matrix $\begin{bmatrix} 0 & -2 & -1 \\ -3 & -1 & -3 \\ 2 & 2 & -3 \end{bmatrix}$ is

(a) $\lambda^3 - 2\lambda^2 - \lambda - 2 = 0$
(b) $\lambda^3 + 4\lambda^2 + 5\lambda - 34 = 0$
(c) $\lambda^3 + 4\lambda^2 - 5\lambda + 34 = 0$
(d) $\lambda^3 + 3\lambda^2 - \lambda - 2 = 0$
(e) $\lambda^3 - 4\lambda^2 + 5\lambda - 34 = 0$

14. A linear homogeneous differential equation with real coefficients, having the solutions:
$2,\ 3x\, e^{x} \cos(3x)$ is

(a) $D(D^2 - 2D + 10)\, y = 0$
(b) $D(D^2 - 2D + 10)^2\, y = 0$
(c) $D(D^2 + 2D + 10)^2\, y = 0$
(d) $D(D^2 - D + 8)^2\, y = 0$
(e) $D(D^2 + 2D + 10)\, y = 0$

15. Given the matrix $A = \begin{bmatrix} 2 & 1 & -1 \\ 0 & 1 & 1 \\ 0 & 0 & 2 \end{bmatrix}$. A basis for the eigenspace that corresponds to the eigenvalue $\lambda = 2$ is $v_1 = \begin{bmatrix} 0 \\ \alpha \\ 1 \end{bmatrix}$, $v_2 = \begin{bmatrix} 1 \\ \beta \\ 0 \end{bmatrix}$, where $2\alpha + \beta =$

(a) 1
(b) 3
(c) -2
(d) 4
(e) 2

King Fahd University of Petroleum and Minerals
Department of Mathematics

CODE 2 **CODE 2**

Math 208
Major Exam II
Term 252
13 April 2026
Net Time Allowed: 90 Minutes

Name	
ID		**Sec**	

Check that this exam has 15 questions.

Important Instructions:

1. All types of calculators, smart watches or mobile phones are NOT allowed during the examination.
2. Use HB 2.5 pencils only.
3. Use a good eraser. DO NOT use the erasers attached to the pencil.
4. Write your name, ID number and Section number on the examination paper and in the upper left corner of the answer sheet.
5. When bubbling your ID number and Section number, be sure that the bubbles match with the numbers that you write.
6. The Test Code Number is already bubbled in your answer sheet. Make sure that it is the same as that printed on your question paper.
7. When bubbling, make sure that the bubbled space is fully covered.
8. When erasing a bubble, make sure that you do not leave any trace of penciling.

1. Which pair of vectors in $\mathbb{R}^3$ are linearly independent?

(a) $v_1 = (3,5,2)$, $v_2 = \left(\frac{3}{4}, \frac{5}{4}, \frac{1}{2}\right)$

(b) $v_1 = (2,1,4)$, $v_2 = (4,2,5)$

(c) $v_1 = (0,0,0)$, $v_2 = (1,1,1)$

(d) $v_1 = \left(\frac{1}{2}, \frac{1}{4}, \frac{1}{3}\right)$, $v_2 = \left(\frac{1}{4}, \frac{1}{8}, \frac{1}{6}\right)$

(e) $v_1 = (1,0,5)$, $v_2 = \left(\frac{1}{3}, 0, \frac{5}{3}\right)$

2. If $y_p = A + Bx + Cx^2 + De^x$ is a particular solution of the differential equation $y'' - 6y' + 9y = 27x^2 + 4e^x$, then $A + B + C + D =$

(a) 8

(b) 0

(c) 12

(d) 10

(e) 11

3. The characteristic equation of the matrix $\begin{bmatrix} 0 & -2 & -1 \\ -3 & -1 & -3 \\ 2 & 2 & -3 \end{bmatrix}$ is

(a) $\lambda^3 + 4\lambda^2 + 5\lambda - 34 = 0$
(b) $\lambda^3 + 3\lambda^2 - \lambda - 2 = 0$
(c) $\lambda^3 + 4\lambda^2 - 5\lambda + 34 = 0$
(d) $\lambda^3 - 2\lambda^2 - \lambda - 2 = 0$
(e) $\lambda^3 - 4\lambda^2 + 5\lambda - 34 = 0$

4. The general solution of the differential equation

$$y^{(4)} - 4y''' + 3y'' + 4y' - 4y = 0$$

is

(a) $y = c_1e^x + c_2e^{-2x} + (c_3 + c_4x)\,e^{2x}$
(b) $y = c_1e^x + c_2e^{2x} + (c_3 + c_4x)\,e^{-x}$
(c) $y = c_1e^x + c_2e^{-x} + (c_3 + c_4x)\,e^{2x}$
(d) $y = c_1e^{-x} + c_2e^{2x} + (c_3 + c_4x)\,e^x$
(e) $y = c_1e^x + c_2e^{-x} + c_3e^{2x} + c_4e^{4x}$

5. An appropriate form of a particular solution y_p for the non-homogeneous differential equation

$$(D+2)^3(D^2+4)y = e^{-2x} - \sin(2x) \text{ is given by } y_p(x) =$$

(a) $Ax^2e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

(b) $Ax^3e^{-2x} + Bx\sin(4x) + Cx\sin(4x)$

(c) $Ax^3e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

(d) $Axe^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

(e) $Ax^3e^{-2x} + B\sin(2x) + Cx\cos(2x)$

6. If the matrix $A = \begin{bmatrix} 1 & 2 \\ 2 & -2 \end{bmatrix}$ is diagonalizable with a diagonalizing matrix P and a diagonal matrix $D = \begin{bmatrix} 2 & 0 \\ 0 & -3 \end{bmatrix}$ such that $P^{-1}AP = D$, then

(a) $P = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$

(b) $P = \begin{bmatrix} 2 & 1 \\ 2 & -2 \end{bmatrix}$

(c) $P = \begin{bmatrix} 2 & -1 \\ 1 & -2 \end{bmatrix}$

(d) $P = \begin{bmatrix} 2 & 1 \\ -1 & -2 \end{bmatrix}$

(e) $P = \begin{bmatrix} 2 & 1 \\ 1 & -2 \end{bmatrix}$

7. A particular solution of the differential equation

$$y'' - 3y' + 2y = \cos(e^{-x}) \text{ is given by } y_p(x) =$$

(a) $e^{2x}\cos(e^{x})$
(b) $e^{-2x}\cos(e^{-x})$
(c) $e^{x}\cos(e^{-x})$
(d) $-e^{2x}\cos(e^{-x})$
(e) $-e^{x}\cos(e^{-x})$

8. A particular solution of the differential equation $y'' - 4y' + 4y = x^{-1}e^{2x}$ is given by $y_p(x) =$

(a) $xe^{-2x}\ln|x|$
(b) $xe^{3x}\ln|x|$
(c) $xe^{2x}\ln|x|$
(d) $x^2e^{-2x}\ln|x|$
(e) $x^2e^{2x}\ln|x|$

9. If the solution

$$\begin{cases} x_1 + 3x_2 - 2x_3 + x_4 = 0 \\ 2x_1 + 6x_2 - x_3 - 7x_4 = 0 \\ x_1 + 3x_2 + x_3 - 8x_4 = 0 \end{cases}$$

Consists of all linear combinations of the vectors:
$v_1 = (a, b, 0, 0)$ and $v_2 = (c, 0, 3, d)$, then $\dfrac{a}{b} + \dfrac{c}{d} =$

(a) -2
(b) -3
(c) 3
(d) 0
(e) 2

10. A linear homogeneous differential equation with real coefficients, having the solutions:
$2,\ 3x\, e^{x} \cos(3x)$ is

(a) $D(D^2 - 2D + 10)^2\, y = 0$
(b) $D(D^2 - 2D + 10)\, y = 0$
(c) $D(D^2 - D + 8)^2\, y = 0$
(d) $D(D^2 + 2D + 10)\, y = 0$
(e) $D(D^2 + 2D + 10)^2\, y = 0$

11. The solution of the initial value problem $y'' + y = 0$, $y(0) = 3$, $y'(0) = 0$ is given by

    (a) $y = 3\,\cos x - \sin x$
    (b) $y = 3\,\cos x$
    (c) $y = 3\,\cos x + \sin x$
    (d) $y = 3\,\sin x + 3$
    (e) $y = 3\,\cos x + 2\sin x$

12. Given that $y = \cos(2x)$ is a solution of the differential equation $y^{(4)} + 4y''' + 8y'' + 16y' + 16y = 0$. The general solution of the differential equation is

    (a) $y = (c_1 + c_2\,x)e^{-2x} + c_3 x\cos(2x) + c_4\sin(2x)$
    (b) $y = (c_1 + c_2\,x)e^{-2x} + c_3\cos(2x) + c_4\sin(2x)$
    (c) $y = c_1\,e^{-2x} + c_2\,e^{2x} + c_3\cos(2x) + c_4\sin(2x)$
    (d) $y = (c_1 + c_2\,x)\cos(2x) + (c_3 + c_4 x)\sin(2x)$
    (e) $y = c_1\,e^{-2x} + c_2\,e^{-x} + c_3\cos(2x) + c_4\sin(2x)$

13. If $W(x)$ is the Wronskian of the functions

$$f_1(x) = e^x,\ f_2(x) = \cos(2x),\ \text{and}\ f_3(x) = \sin(2x),\ \text{then}\ W(0) =$$

(a) -8
(b) 0
(c) 10
(d) -10
(e) 8

14. The rank of the matrix $A = \begin{bmatrix} 1 & 2 & -1 & 3 \\ -1 & 1 & 2 & 0 \\ 2 & 1 & -3 & 1 \\ 1 & 5 & 0 & 6 \end{bmatrix}$ is

(a) 1
(b) 0
(c) 4
(d) 3
(e) 2

15. Given the matrix $A = \begin{bmatrix} 2 & 1 & -1 \\ 0 & 1 & 1 \\ 0 & 0 & 2 \end{bmatrix}$. A basis for the eigenspace that corresponds to the eigenvalue $\lambda = 2$ is $v_1 = \begin{bmatrix} 0 \\ \alpha \\ 1 \end{bmatrix}$, $v_2 = \begin{bmatrix} 1 \\ \beta \\ 0 \end{bmatrix}$, where $2\alpha + \beta =$

(a) 3

(b) -2

(c) 2

(d) 1

(e) 4

King Fahd University of Petroleum and Minerals
Department of Mathematics

CODE 3 **CODE 3**

Math 208
Major Exam II
Term 252
13 April 2026
Net Time Allowed: 90 Minutes

Name			
ID		**Sec**	

Check that this exam has 15 questions.

Important Instructions:

1. All types of calculators, smart watches or mobile phones are NOT allowed during the examination.
2. Use HB 2.5 pencils only.
3. Use a good eraser. DO NOT use the erasers attached to the pencil.
4. Write your name, ID number and Section number on the examination paper and in the upper left corner of the answer sheet.
5. When bubbling your ID number and Section number, be sure that the bubbles match with the numbers that you write.
6. The Test Code Number is already bubbled in your answer sheet. Make sure that it is the same as that printed on your question paper.
7. When bubbling, make sure that the bubbled space is fully covered.
8. When erasing a bubble, make sure that you do not leave any trace of penciling.

1. A linear homogeneous differential equation with real coefficients, having the solutions:
   $2,\ 3x\, e^{x} \cos(3x)$ is

   (a) $D(D^2 + 2D + 10)\, y = 0$
   (b) $D(D^2 - D + 8)^2\, y = 0$
   (c) $D(D^2 + 2D + 10)^2\, y = 0$
   (d) $D(D^2 - 2D + 10)\, y = 0$
   (e) $D(D^2 - 2D + 10)^2\, y = 0$

2. If the matrix $A = \begin{bmatrix} 1 & 2 \\ 2 & -2 \end{bmatrix}$ is diagonalizable with a diagonalizing matrix P and a diagonal matrix $D = \begin{bmatrix} 2 & 0 \\ 0 & -3 \end{bmatrix}$ such that $P^{-1}AP = D$, then

   (a) $P = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$
   (b) $P = \begin{bmatrix} 2 & 1 \\ 2 & -2 \end{bmatrix}$
   (c) $P = \begin{bmatrix} 2 & 1 \\ -1 & -2 \end{bmatrix}$
   (d) $P = \begin{bmatrix} 2 & -1 \\ 1 & -2 \end{bmatrix}$
   (e) $P = \begin{bmatrix} 2 & 1 \\ 1 & -2 \end{bmatrix}$

3. The characteristic equation of the matrix $\begin{bmatrix} 0 & -2 & -1 \\ -3 & -1 & -3 \\ 2 & 2 & -3 \end{bmatrix}$ is

(a) $\lambda^3 - 4\lambda^2 + 5\lambda - 34 = 0$
(b) $\lambda^3 - 2\lambda^2 - \lambda - 2 = 0$
(c) $\lambda^3 + 4\lambda^2 - 5\lambda + 34 = 0$
(d) $\lambda^3 + 4\lambda^2 + 5\lambda - 34 = 0$
(e) $\lambda^3 + 3\lambda^2 - \lambda - 2 = 0$

4. A particular solution of the differential equation $y'' - 4y' + 4y = x^{-1}e^{2x}$ is given by $y_p(x) =$

(a) $x^2e^{2x} \ln|x|$
(b) $x^2e^{-2x} \ln|x|$
(c) $xe^{3x} \ln|x|$
(d) $xe^{2x} \ln|x|$
(e) $xe^{-2x} \ln|x|$

5. If $W(x)$ is the Wronskian of the functions

$$f_1(x) = e^x,\ f_2(x) = \cos(2x),\ \text{and}\ f_3(x) = \sin(2x),\ \text{then}\ W(0) =$$

(a) -8
(b) 0
(c) 10
(d) -10
(e) 8

6. A particular solution of the differential equation

$$y'' - 3y' + 2y = \cos(e^{-x})\ \text{is given by}\ y_p(x) =$$

(a) $e^{2x}\cos(e^x)$
(b) $e^x\cos(e^{-x})$
(c) $e^{-2x}\cos(e^{-x})$
(d) $-e^{2x}\cos(e^{-x})$
(e) $-e^x\cos(e^{-x})$

7. The solution of the initial value problem $y'' + y = 0$, $y(0) = 3$, $y'(0) = 0$ is given by

(a) $y = 3\cos x + 2\sin x$
(b) $y = 3\sin x + 3$
(c) $y = 3\cos x$
(d) $y = 3\cos x - \sin x$
(e) $y = 3\cos x + \sin x$

8. If $y_p = A + Bx + Cx^2 + De^x$ is a particular solution of the differential equation $y'' - 6y' + 9y = 27x^2 + 4e^x$, then $A + B + C + D =$

(a) 0
(b) 10
(c) 12
(d) 8
(e) 11

9. An appropriate form of a particular solution y_p for the non-homogeneous differential equation

$$(D+2)^3(D^2+4)y = e^{-2x} - \sin(2x) \text{ is given by } y_p(x) =$$

(a) $Ax^2e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$
(b) $Ax^3e^{-2x} + Bx\sin(4x) + Cx\sin(4x)$
(c) $Ax^3e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$
(d) $Ax^3e^{-2x} + B\sin(2x) + Cx\cos(2x)$
(e) $Axe^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

10. Given that $y = \cos(2x)$ is a solution of the differential equation $y^{(4)} + 4y''' + 8y'' + 16y' + 16y = 0$. The general solution of the differential equation is

(a) $y = (c_1 + c_2\,x)e^{-2x} + c_3x\cos(2x) + c_4\sin(2x)$
(b) $y = c_1\,e^{-2x} + c_2\,e^{-x} + c_3\cos(2x) + c_4\sin(2x)$
(c) $y = (c_1 + c_2\,x)e^{-2x} + c_3\cos(2x) + c_4\sin(2x)$
(d) $y = (c_1 + c_2\,x)\cos(2x) + (c_3 + c_4x)\sin(2x)$
(e) $y = c_1\,e^{-2x} + c_2\,e^{2x} + c_3\cos(2x) + c_4\sin(2x)$

11. The rank of the matrix $A = \begin{bmatrix} 1 & 2 & -1 & 3 \\ -1 & 1 & 2 & 0 \\ 2 & 1 & -3 & 1 \\ 1 & 5 & 0 & 6 \end{bmatrix}$ is

(a) 3
(b) 0
(c) 2
(d) 4
(e) 1

12. Which pair of vectors in $\mathbb{R}^3$ are linearly independent?

(a) $v_1 = (1, 0, 5)$, $v_2 = \left(\frac{1}{3}, 0, \frac{5}{3}\right)$
(b) $v_1 = (3, 5, 2)$, $v_2 = \left(\frac{3}{4}, \frac{5}{4}, \frac{1}{2}\right)$
(c) $v_1 = \left(\frac{1}{2}, \frac{1}{4}, \frac{1}{3}\right)$, $v_2 = \left(\frac{1}{4}, \frac{1}{8}, \frac{1}{6}\right)$
(d) $v_1 = (0, 0, 0)$, $v_2 = (1, 1, 1)$
(e) $v_1 = (2, 1, 4)$, $v_2 = (4, 2, 5)$

13. The general solution of the differential equation

$$y^{(4)} - 4y''' + 3y'' + 4y' - 4y = 0$$

is

(a) $y = c_1e^{x} + c_2e^{-2x} + (c_3 + c_4x)\, e^{2x}$
(b) $y = c_1e^{x} + c_2e^{-x} + (c_3 + c_4x)\, e^{2x}$
(c) $y = c_1e^{-x} + c_2e^{2x} + (c_3 + c_4x)\, e^{x}$
(d) $y = c_1e^{x} + c_2e^{2x} + (c_3 + c_4x)\, e^{-x}$
(e) $y = c_1e^{x} + c_2e^{-x} + c_3e^{2x} + c_4e^{4x}$

14. If the solution

$$\begin{cases} x_1 + 3x_2 - 2x_3 + x_4 = 0 \\ 2x_1 + 6x_2 - x_3 - 7x_4 = 0 \\ x_1 + 3x_2 + x_3 - 8x_4 = 0 \end{cases}$$

Consists of all linear combinations of the vectors:
$v_1 = (a, b, 0, 0)$ and $v_2 = (c, 0, 3, d)$, then $\dfrac{a}{b} + \dfrac{c}{d} =$

(a) 0
(b) 3
(c) -3
(d) -2
(e) 2

15. Given the matrix $A = \begin{bmatrix} 2 & 1 & -1 \\ 0 & 1 & 1 \\ 0 & 0 & 2 \end{bmatrix}$. A basis for the eigenspace that corresponds to the eigenvalue $\lambda = 2$ is $v_1 = \begin{bmatrix} 0 \\ \alpha \\ 1 \end{bmatrix}$, $v_2 = \begin{bmatrix} 1 \\ \beta \\ 0 \end{bmatrix}$, where $2\alpha + \beta =$

(a) 2

(b) 3

(c) 1

(d) 4

(e) -2

King Fahd University of Petroleum and Minerals
Department of Mathematics

CODE 4 **CODE 4**

Math 208
Major Exam II
Term 252
13 April 2026
Net Time Allowed: 90 Minutes

Name	

ID		**Sec**	

Check that this exam has 15 questions.

Important Instructions:

1. All types of calculators, smart watches or mobile phones are NOT allowed during the examination.
2. Use HB 2.5 pencils only.
3. Use a good eraser. DO NOT use the erasers attached to the pencil.
4. Write your name, ID number and Section number on the examination paper and in the upper left corner of the answer sheet.
5. When bubbling your ID number and Section number, be sure that the bubbles match with the numbers that you write.
6. The Test Code Number is already bubbled in your answer sheet. Make sure that it is the same as that printed on your question paper.
7. When bubbling, make sure that the bubbled space is fully covered.
8. When erasing a bubble, make sure that you do not leave any trace of penciling.

1. A linear homogeneous differential equation with real coefficients, having the solutions:
   $2,\ 3x\, e^{x} \cos(3x)$ is

   (a) $D(D^2 - D + 8)^2\, y = 0$
   (b) $D(D^2 - 2D + 10)^2\, y = 0$
   (c) $D(D^2 + 2D + 10)^2\, y = 0$
   (d) $D(D^2 + 2D + 10)\, y = 0$
   (e) $D(D^2 - 2D + 10)\, y = 0$

2. If the matrix $A = \begin{bmatrix} 1 & 2 \\ 2 & -2 \end{bmatrix}$ is diagonalizable with a diagonalizing matrix P and a diagonal matrix $D = \begin{bmatrix} 2 & 0 \\ 0 & -3 \end{bmatrix}$ such that $P^{-1}AP = D$, then

   (a) $P = \begin{bmatrix} 2 & 1 \\ 2 & -2 \end{bmatrix}$
   (b) $P = \begin{bmatrix} 2 & -1 \\ 1 & -2 \end{bmatrix}$
   (c) $P = \begin{bmatrix} 2 & 1 \\ 1 & -2 \end{bmatrix}$
   (d) $P = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}$
   (e) $P = \begin{bmatrix} 2 & 1 \\ -1 & -2 \end{bmatrix}$

3. A particular solution of the differential equation

$$y'' - 3y' + 2y = \cos(e^{-x}) \text{ is given by } y_p(x) =$$

(a) $e^{2x}\cos(e^{x})$
(b) $e^{x}\cos(e^{-x})$
(c) $e^{-2x}\cos(e^{-x})$
(d) $-e^{2x}\cos(e^{-x})$
(e) $-e^{x}\cos(e^{-x})$

4. The characteristic equation of the matrix $\begin{bmatrix} 0 & -2 & -1 \\ -3 & -1 & -3 \\ 2 & 2 & -3 \end{bmatrix}$ is

(a) $\lambda^3 + 4\lambda^2 + 5\lambda - 34 = 0$
(b) $\lambda^3 - 4\lambda^2 + 5\lambda - 34 = 0$
(c) $\lambda^3 + 3\lambda^2 - \lambda - 2 = 0$
(d) $\lambda^3 - 2\lambda^2 - \lambda - 2 = 0$
(e) $\lambda^3 + 4\lambda^2 - 5\lambda + 34 = 0$

5. The general solution of the differential equation

$$y^{(4)} - 4y''' + 3y'' + 4y' - 4y = 0$$

is

(a) $y = c_1 e^x + c_2 e^{-2x} + (c_3 + c_4 x)\, e^{2x}$
(b) $y = c_1 e^x + c_2 e^{-x} + c_3 e^{2x} + c_4 e^{4x}$
(c) $y = c_1 e^x + c_2 e^{-x} + (c_3 + c_4 x)\, e^{2x}$
(d) $y = c_1 e^x + c_2 e^{2x} + (c_3 + c_4 x)\, e^{-x}$
(e) $y = c_1 e^{-x} + c_2 e^{2x} + (c_3 + c_4 x)\, e^{x}$

6. If the solution

$$\begin{cases} x_1 + 3x_2 - 2x_3 + x_4 = 0 \\ 2x_1 + 6x_2 - x_3 - 7x_4 = 0 \\ x_1 + 3x_2 + x_3 - 8x_4 = 0 \end{cases}$$

Consists of all linear combinations of the vectors:
$v_1 = (a, b, 0, 0)$ and $v_2 = (c, 0, 3, d)$, then $\dfrac{a}{b} + \dfrac{c}{d} =$

(a) -3
(b) -2
(c) 3
(d) 2
(e) 0

7. An appropriate form of a particular solution y_p for the non-homogeneous differential equation

$$(D+2)^3(D^2+4)y = e^{-2x} - \sin(2x) \text{ is given by } y_p(x) =$$

(a) $Ax^3e^{-2x} + Bx\sin(4x) + Cx\sin(4x)$

(b) $Ax^3e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

(c) $Ax^3e^{-2x} + B\sin(2x) + Cx\cos(2x)$

(d) $Axe^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

(e) $Ax^2e^{-2x} + Bx\sin(2x) + Cx\cos(2x)$

8. The solution of the initial value problem $y'' + y = 0$, $y(0) = 3$, $y'(0) = 0$ is given by

(a) $y = 3\ \cos x + 2\sin x$

(b) $y = 3\ \cos x + \sin x$

(c) $y = 3\ \cos x$

(d) $y = 3\ \sin x + 3$

(e) $y = 3\ \cos x - \sin x$

9. The rank of the matrix $A = \begin{bmatrix} 1 & 2 & -1 & 3 \\ -1 & 1 & 2 & 0 \\ 2 & 1 & -3 & 1 \\ 1 & 5 & 0 & 6 \end{bmatrix}$ is

(a) 3
(b) 1
(c) 4
(d) 2
(e) 0

10. If $y_p = A + Bx + Cx^2 + De^x$ is a particular solution of the differential equation $y'' - 6y' + 9y = 27x^2 + 4e^x$, then $A + B + C + D =$

(a) 0
(b) 12
(c) 10
(d) 8
(e) 11

11. Given that $y = \cos(2x)$ is a solution of the differential equation $y^{(4)} + 4y''' + 8y'' + 16y' + 16y = 0$. The general solution of the differential equation is

(a) $y = (c_1 + c_2\, x)e^{-2x} + c_3 x \cos(2x) + c_4 \sin(2x)$

(b) $y = (c_1 + c_2\, x)e^{-2x} + c_3 \cos(2x) + c_4 \sin(2x)$

(c) $y = c_1\, e^{-2x} + c_2\, e^{2x} + c_3 \cos(2x) + c_4 \sin(2x)$

(d) $y = c_1\, e^{-2x} + c_2\, e^{-x} + c_3 \cos(2x) + c_4 \sin(2x)$

(e) $y = (c_1 + c_2\, x) \cos(2x) + (c_3 + c_4 x) \sin(2x)$

12. Which pair of vectors in $\mathbb{R}^3$ are linearly independent?

(a) $v_1 = (0, 0, 0)$, $v_2 = (1, 1, 1)$

(b) $v_1 = (1, 0, 5)$, $v_2 = \left(\frac{1}{3}, 0, \frac{5}{3}\right)$

(c) $v_1 = (2, 1, 4)$, $v_2 = (4, 2, 5)$

(d) $v_1 = \left(\frac{1}{2}, \frac{1}{4}, \frac{1}{3}\right)$, $v_2 = \left(\frac{1}{4}, \frac{1}{8}, \frac{1}{6}\right)$

(e) $v_1 = (3, 5, 2)$, $v_2 = \left(\frac{3}{4}, \frac{5}{4}, \frac{1}{2}\right)$

13. A particular solution of the differential equation $y'' - 4y' + 4y = x^{-1}e^{2x}$ is given by $y_p(x) =$

(a) $xe^{-2x} \ln |x|$
(b) $xe^{2x} \ln |x|$
(c) $xe^{3x} \ln |x|$
(d) $x^2e^{-2x} \ln |x|$
(e) $x^2e^{2x} \ln |x|$

14. If $W(x)$ is the Wronskian of the functions

$$f_1(x) = e^x,\ f_2(x) = \cos(2x), \text{ and } f_3(x) = \sin(2x), \text{ then } W(0) =$$

(a) 8
(b) -8
(c) 10
(d) -10
(e) 0

15. Given the matrix $A = \begin{bmatrix} 2 & 1 & -1 \\ 0 & 1 & 1 \\ 0 & 0 & 2 \end{bmatrix}$. A basis for the eigenspace that corresponds to the eigenvalue $\lambda = 2$ is $v_1 = \begin{bmatrix} 0 \\ \alpha \\ 1 \end{bmatrix}$, $v_2 = \begin{bmatrix} 1 \\ \beta \\ 0 \end{bmatrix}$, where $2\alpha + \beta =$

(a) 4

(b) 3

(c) -2

(d) 1

(e) 2

Answer KEY

Q	MASTER	1	2	3	4
1	A	B 8	B 2	E 4	B 4
2	A	D 3	D 9	E 13	C 13
3	A	B 10	A 11	D 11	D 14
4	A	C 14	C 3	D 12	A 11
5	A	E 7	C 10	C 7	C 3
6	A	C 5	E 13	D 14	D 6
7	A	D 13	D 14	C 8	B 10
8	A	B 9	C 12	B 9	C 8
9	A	A 2	E 6	C 10	A 5
10	A	A 6	A 4	C 1	C 9
11	A	E 12	B 8	A 5	B 1
12	A	C 1	B 1	E 2	C 2
13	A	B 11	C 7	B 3	B 12
14	A	B 4	D 5	E 6	C 7
15	A	E 15	C 15	A 15	E 15

Answer Counts

V	A	B	C	D	E
1	2	5	3	2	3
2	2	3	5	3	2
3	2	2	4	3	4
4	2	4	6	2	1

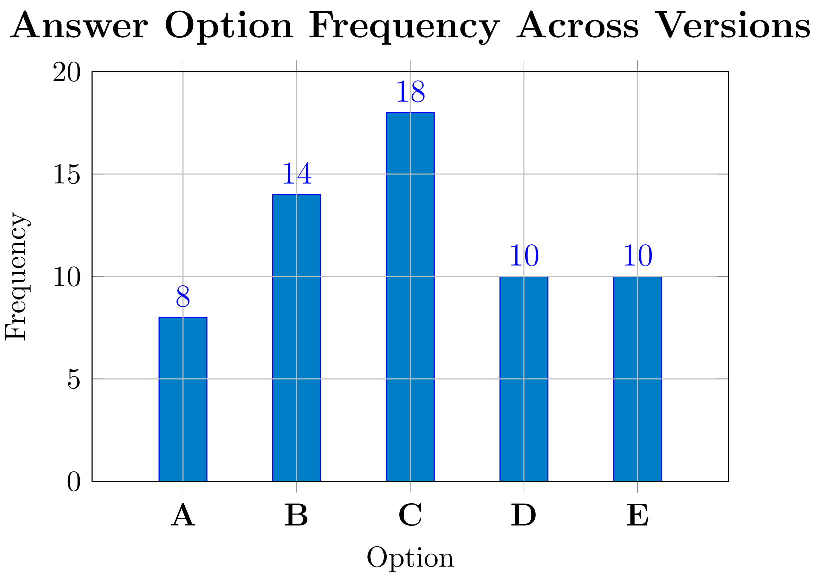

Figure 1: Frequency of Each Answer Option (Excluding MASTER)