

NUST NET practice: mathematics (50 MCQs)

This practice set has 50 original multiple-choice questions for the mathematics section of the NUST Entry Test (NET) Engineering. It follows the NUST NET Engineering mathematics syllabus, which is based on FSc Part 1 and Part 2 mathematics as taught by the Federal and Punjab boards. The NET has no separate syllabus code, so topics are named rather than numbered. The questions cover functions and graphs, quadratic equations, sequences and series, permutations and combinations, the binomial theorem, trigonometry, inverse trigonometric functions, limits, differentiation, integration, analytic geometry, vectors, matrices and determinants, and complex numbers. In each topic the quick recall questions come first and the multi-step questions come last. There is an answer key and a worked solution for every question at the end.

How the paper is marked and how to pace yourself

- Every NET question is a single-best-answer MCQ worth one mark. In the Engineering paper, mathematics is the largest section, at roughly half of all the questions. NUST has said there is no negative marking. Check the current NUST admissions guide before your test, because the format and weightings can change.
- In recent cycles the whole paper has had about 200 MCQs in 3 hours, which is just under a minute per question. That makes one minute per mathematics question a realistic target. Confirm the current numbers in the NUST guide for your year.
- You cannot use a calculator. Every question here can be done by hand.
- Pacing: give this set **50 minutes**, about one minute per question. Recall questions (domains, periods, standard results) should take 20–30 seconds, which leaves 1–2 minutes for the multi-step questions at the end of each topic.
- If a question is taking more than two minutes, make your best guess, mark it and move on. With no negative marking, never leave a question blank.
- Try substituting the options back into the question or testing a simple value. This is often quicker than solving from scratch.

Questions

Functions and graphs

1. The graph of $y = f(x + 1) - 4$ is obtained from the graph of $y = f(x)$ by a shift of:

- A. 1 unit right and 4 units down
- B. 1 unit left and 4 units up
- C. 1 unit left and 4 units down
- D. 4 units left and 1 unit down

2. The domain of $f(x) = \sqrt{4 - x^2}$ is:

- A. $[-2, 2]$
- B. $(-2, 2)$

- C. $x \leq 2$
- D. $[0, 2]$

3. If $f(x) = 2x + 3$ and $g(x) = x^2$, then $(f \circ g)(-2)$ equals:

- A. 1
- B. 11
- C. 7
- D. 19

4. If $f(x) = (3x - 1)/2$, then $f^{-1}(x)$ is:

- A. $(2x - 1)/3$
- B. $(3x + 1)/2$
- C. $2/(3x - 1)$
- D. $(2x + 1)/3$

Quadratic equations and roots

5. The equation $x^2 + mx + 9 = 0$ has equal roots when m equals:

- A. ± 3
- B. ± 9
- C. ± 6
- D. ± 18

6. The quadratic equation whose roots are $2 + \sqrt{3}$ and $2 - \sqrt{3}$ is:

- A. $x^2 + 4x + 1 = 0$
- B. $x^2 - 4x + 1 = 0$
- C. $x^2 - 4x - 1 = 0$
- D. $x^2 - 2x + 1 = 0$

7. The roots of $2x^2 - 5x + k = 0$ are reciprocals of each other. The value of k is:

- A. 2
- B. -2
- C. 5
- D. $1/2$

8. If α and β are the roots of $x^2 - 6x + 4 = 0$, then $\alpha^2 + \beta^2$ equals:

- A. 44
- B. 36
- C. 20
- D. 28

9. If ω is a complex cube root of unity, then $\omega^{29} + \omega^{31}$ equals:

- A. -1

- B. 0
- C. 1
- D. 2ω

Sequences and series

10. The harmonic mean of 3 and 6 is:

- A. 4.5
- B. $\sqrt{18}$
- C. 4
- D. 5

11. The sum to infinity of the geometric series $12 + 4 + \frac{4}{3} + \dots$ is:

- A. 16
- B. 36
- C. 24
- D. 18

12. An arithmetic progression has first term 3 and common difference 2. The sum of its first 15 terms is:

- A. 225
- B. 255
- C. 240
- D. 270

13. In an arithmetic progression the 4th term is 13 and the 9th term is 33. The 20th term is:

- A. 77
- B. 81
- C. 89
- D. 73

Permutations and combinations

14. If ${}^nC_2 = 45$, then n equals:

- A. 9
- B. 10
- C. 45
- D. 15

15. A committee of 3 is chosen from 5 men and 4 women. In how many ways can it be chosen if it must contain exactly 2 women?

- A. 40
- B. 60

- C. 84
- D. 30

16. In how many arrangements of all the letters of the word SETTLE are the two E's next to each other?

- A. 180
- B. 120
- C. 60
- D. 30

Binomial theorem

17. The term independent of x in the expansion of $(x^2 - 2/x)^6$ is:

- A. 240
- B. -160
- C. 60
- D. -240

18. The coefficient of x^2 in the expansion of $(1 + x)(1 - 2x)^5$ is:

- A. 40
- B. 30
- C. 50
- D. -30

Trigonometric identities and equations

19. The period of $y = 3 \sin 4x$ is:

- A. 2π
- B. $\pi/4$
- C. 4π
- D. $\pi/2$

20. The exact value of $\sin 75^\circ$ is:

- A. $(\sqrt{6} - \sqrt{2})/4$
- B. $(\sqrt{3} + 1)/2$
- C. $(\sqrt{6} + \sqrt{2})/4$
- D. $(\sqrt{2} + 1)/4$

21. $(1 - \cos 2\theta)/\sin 2\theta$ simplifies to:

- A. $\tan \theta$
- B. $\cot \theta$
- C. $\sin \theta$
- D. $\sec \theta$

22. A and B are acute angles with $\tan A = 2$ and $\tan B = 3$. Then $A + B$ equals:

- A. $\pi/4$
- B. $3\pi/4$
- C. $2\pi/3$
- D. $5\pi/6$

23. A triangle has sides 5 cm, 7 cm and 8 cm. The angle opposite the 7 cm side is:

- A. 30°
- B. 120°
- C. 60°
- D. 45°

24. How many solutions does $2\cos^2 x - \cos x - 1 = 0$ have in the interval $0 \leq x < 2\pi$?

- A. 2
- B. 4
- C. 1
- D. 3

Inverse trigonometric functions

25. The principal value of $\cos^{-1}(-1/2)$ is:

- A. $-\pi/3$
- B. $\pi/3$
- C. $2\pi/3$
- D. $5\pi/6$

26. $\sin(\cos^{-1}(3/5))$ equals:

- A. $3/4$
- B. $4/5$
- C. $5/4$
- D. $3/5$

Limits

27. $\lim_{x \rightarrow 3} (x^2 - 9)/(x - 3)$ equals:

- A. 0
- B. 3
- C. 9
- D. 6

28. $\lim_{x \rightarrow 0} (\sin 5x)/(\sin 2x)$ equals:

- A. $5/2$
- B. $2/5$

- C. 1
- D. 10

29. $\lim_{x \rightarrow \infty} (1 + 2/x)^x$ equals:

- A. e
- B. e^2
- C. 2e
- D. $e^{1/2}$

Differentiation and its applications

30. $d/dx [\ln(\sin x)]$ equals:

- A. $\cot x$
- B. $\tan x$
- C. $1/\sin x$
- D. $-\cot x$

31. $d/dx [\tan^{-1}(x^2)]$ equals:

- A. $1/(1 + x^4)$
- B. $2x/(1 + x^2)$
- C. $2x/(1 + x^4)$
- D. $x^2/(1 + x^4)$

32. The local maximum value of $y = x^3 - 6x^2 + 9x + 1$ is:

- A. 5
- B. 1
- C. 3
- D. 9

33. The equation of the normal to the curve $y = x^2 - 4x + 7$ at the point (3, 4) is:

- A. $2x - y - 2 = 0$
- B. $x - 2y + 5 = 0$
- C. $x + 2y - 7 = 0$
- D. $x + 2y - 11 = 0$

Integration

34. $\int x e^{x^2} dx$ equals:

- A. $e^{x^2} + C$
- B. $\frac{1}{2} e^{x^2} + C$
- C. $2e^{x^2} + C$
- D. $\frac{1}{2} x^2 e^{x^2} + C$

35. $\int 1/(x \ln x) dx$, for $x > 1$, equals:

- A. $\frac{1}{2}(\ln x)^2 + C$
- B. $1/\ln x + C$
- C. $\ln|x| + C$
- D. $\ln|\ln x| + C$

36. $\int_0^{\pi/2} \cos^2 x \, dx$ equals:

- A. $\pi/2$
- B. $1/2$
- C. $\pi/4$
- D. π

37. $\int_1^e \ln x \, dx$ equals:

- A. e
- B. $e - 1$
- C. 0
- D. 1

38. The area of the region enclosed between the curve $y = x^2$ and the line $y = 2x$ is:

- A. $4/3$ square units
- B. $8/3$ square units
- C. 4 square units
- D. $20/3$ square units

Analytic geometry

39. The focus of the parabola $y^2 = 12x$ is:

- A. $(0, 3)$
- B. $(-3, 0)$
- C. $(12, 0)$
- D. $(3, 0)$

40. The centre and radius of the circle $x^2 + y^2 - 6x + 4y - 12 = 0$ are:

- A. $(-3, 2)$ and 5
- B. $(3, -2)$ and $\sqrt{12}$
- C. $(3, -2)$ and 5
- D. $(3, -2)$ and 25

41. The perpendicular distance from the point $(2, -1)$ to the line $3x + 4y - 12 = 0$ is:

- A. 1
- B. 2
- C. 10
- D. $12/5$

42. The equation of the line through (1, 2) perpendicular to $2x - 3y + 5 = 0$ is:

- A. $3x + 2y - 7 = 0$
- B. $2x - 3y + 4 = 0$
- C. $3x - 2y + 1 = 0$
- D. $3x + 2y + 7 = 0$

Vectors

43. The vectors $2\mathbf{i} + p\mathbf{j} - \mathbf{k}$ and $\mathbf{i} - 3\mathbf{j} + 4\mathbf{k}$ are perpendicular. The value of p is:

- A. $2/3$
- B. $-2/3$
- C. 2
- D. -2

44. The area of the parallelogram with adjacent sides $\mathbf{a} = \mathbf{i} + \mathbf{j}$ and $\mathbf{b} = \mathbf{j} + \mathbf{k}$ is:

- A. $\sqrt{2}$
- B. 1
- C. $\sqrt{3}$
- D. 3

Matrices and determinants

45. The matrix with rows (k, 3) and (4, 6) is singular when k equals:

- A. -2
- B. 8
- C. $1/2$
- D. 2

46. A is a 3×3 matrix with $|A| = 4$. Then $|2A|$ equals:

- A. 8
- B. 16
- C. 32
- D. 64

47. The value of the determinant below (written row by row) is:

2	1	3
0	4	-1
1	0	2

- A. 3
- B. -3
- C. 5

- D. 27

Complex numbers

48. $(2 + i)/(1 - 2i)$ equals:

- A. $-i$
- B. 1
- C. i
- D. -1

49. The principal argument of $z = -1 + \sqrt{3}i$ is:

- A. $\pi/3$
- B. $-\pi/3$
- C. $5\pi/6$
- D. $2\pi/3$

50. $(1 + i)^6$ equals:

- A. $8i$
- B. $-8i$
- C. -8
- D. 8

Answer key

Question	Answer	Question	Answer
1	C	26	B
2	A	27	D
3	B	28	A
4	D	29	B
5	C	30	A
6	B	31	C
7	A	32	A
8	D	33	D
9	A	34	B
10	C	35	D
11	D	36	C
12	B	37	D
13	A	38	A
14	B	39	D

15	D	40	C
16	C	41	B
17	A	42	A
18	B	43	B
19	D	44	C
20	C	45	D
21	A	46	C
22	B	47	A
23	C	48	C
24	D	49	D
25	C	50	B

Answer spread: A = 12, B = 12, C = 13, D = 13.

Worked solutions

1. C Replacing x by $x + 1$ moves the graph 1 unit to the *left*: the value $f(a)$ now appears at $x = a - 1$. Subtracting 4 from the whole function moves the graph 4 units down. A common trap is to read "+1" inside the bracket as a shift to the right (option A).

2. A The expression under the root must not be negative, so $4 - x^2 \geq 0$, which gives $x^2 \leq 4$ and $-2 \leq x \leq 2$. The end points are included because $\sqrt{0} = 0$ is defined.

3. B First find $g(-2) = (-2)^2 = 4$. Then $f(4) = 2(4) + 3 = 11$. Option A, 1, is $(g \circ f)(-2)$. Always apply the inner function first.

4. D Let $y = (3x - 1)/2$. Then $2y = 3x - 1$, so $x = (2y + 1)/3$. Swapping x and y gives $f^{-1}(x) = (2x + 1)/3$. Check: $f(1) = 1$ and $f^{-1}(1) = 3/3 = 1$.

5. C The roots are equal when the discriminant is zero: $b^2 - 4ac = m^2 - 4(1)(9) = 0$. So $m^2 = 36$ and $m = \pm 6$.

6. B The sum of the roots is $(2 + \sqrt{3}) + (2 - \sqrt{3}) = 4$. The product is $2^2 - (\sqrt{3})^2 = 4 - 3 = 1$. The equation is $x^2 - (\text{sum})x + (\text{product}) = 0$, which gives $x^2 - 4x + 1 = 0$.

7. A If the roots are α and $1/\alpha$, their product is 1. For $ax^2 + bx + c = 0$ the product of the roots is $c/a = k/2$. So $k/2 = 1$ and $k = 2$.

8. D $\alpha + \beta = 6$ and $\alpha\beta = 4$. Then $\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta = 36 - 8 = 28$. Option A, 44, comes from adding $2\alpha\beta$ instead of subtracting it.

9. **A** Since $\omega^3 = 1$, reduce each power modulo 3. $29 = 27 + 2$, so $\omega^{29} = \omega^2$. $31 = 30 + 1$, so $\omega^{31} = \omega$. Using $1 + \omega + \omega^2 = 0$, $\omega + \omega^2 = -1$.

10. **C** The harmonic mean of a and b is $2ab/(a + b) = 2(3)(6)/(3 + 6) = 36/9 = 4$. The distractors are the arithmetic mean (4.5) and the geometric mean $G = \sqrt{18} = 3\sqrt{2} \approx 3 \times 1.414 \approx 4.24$. For positive numbers $A \geq G \geq H$, and here $4.5 \geq 4.24 \geq 4$, which confirms the order.

11. **D** $a = 12$ and $r = 4/12 = 1/3$. Since $|r| < 1$, $S_\infty = a/(1 - r) = 12/(2/3) = 18$.

12. **B** $S_n = (n/2)[2a + (n - 1)d]$, so $S_{15} = (15/2)[6 + 14 \times 2] = (15/2)(34) = 15 \times 17 = 255$.

13. **A** Write both terms using $a_n = a + (n - 1)d$: $a + 3d = 13$ and $a + 8d = 33$. Subtracting gives $5d = 20$, so $d = 4$, and then $a = 13 - 12 = 1$. So $a_{20} = 1 + 19 \times 4 = 77$.

Option B, 81, uses $a + 20d$. Option C, 89, wrongly treats 13 as the first term ($13 + 19 \times 4$).

14. **B** ${}^nC_2 = n(n - 1)/2 = 45$, so $n(n - 1) = 90 = 10 \times 9$. So $n = 10$. The other root, $n = -9$, is rejected because n must be a positive integer.

15. **D** Choose 2 of the 4 women: ${}^4C_2 = 6$. Choose the remaining member from the 5 men: ${}^5C_1 = 5$. The total is $6 \times 5 = 30$. Option A, 40, is the count for exactly 2 men, and option C, 84, is 9C_3 with no restriction.

16. **C** SETTLE has the letters S, E, T, T, L, E. Glue the two E's into one block [EE]. That leaves 5 units: [EE], S, T, T, L, with T appearing twice. The number of arrangements is $5!/2! = 120/2 = 60$. The two E's are identical, so swapping them inside the block gives nothing new.

Option A, 180, is $6!/(2! \times 2!)$, the count with no restriction. Option B, 120, forgets to divide by $2!$ for the repeated T.

17. **A** The general term is $T_{r+1} = {}^6C_r (x^2)^{6-r} (-2/x)^r = {}^6C_r (-2)^r x^{12-3r}$. For the term independent of x , $12 - 3r = 0$, so $r = 4$. $T_5 = {}^6C_4 \times (-2)^4 = 15 \times 16 = 240$. The power is even, so the term is positive; option D has the wrong sign.

18. **B** Expand only as far as x^2 : $(1 - 2x)^5 = 1 + 5(-2x) + 10(-2x)^2 + \dots = 1 - 10x + 40x^2 - \dots$

In $(1 + x)(1 - 10x + 40x^2 - \dots)$, the x^2 terms come from $1 \times 40x^2$ and $x \times (-10x)$. The coefficient is $40 - 10 = 30$. Option A, 40, forgets the second product, and option C, 50, gets the sign of the x term wrong.

19. **D** The period of $\sin(kx)$ is $2\pi/k$, so here it is $2\pi/4 = \pi/2$. The amplitude 3 does not change the period.

20. **C** $\sin 75^\circ = \sin(45^\circ + 30^\circ) = \sin 45^\circ \cos 30^\circ + \cos 45^\circ \sin 30^\circ = (1/\sqrt{2})(\sqrt{3}/2) + (1/\sqrt{2})(1/2) = (\sqrt{3} + 1)/(\sqrt{2})$. Multiply the top and bottom by $\sqrt{2}$ to get $(\sqrt{6} + \sqrt{2})/4$. Option A is $\sin 15^\circ$.

21. A Use $1 - \cos 2\theta = 2\sin^2\theta$ and $\sin 2\theta = 2 \sin \theta \cos \theta$. The expression becomes $2\sin^2\theta/(2 \sin \theta \cos \theta) = \sin \theta/\cos \theta = \tan \theta$.

22. B $\tan(A + B) = (\tan A + \tan B)/(1 - \tan A \tan B) = (2 + 3)/(1 - 6) = 5/(-5) = -1$.

A and B are both acute, so $0 < A + B < \pi$. In this interval $\tan = -1$ only at $3\pi/4$. (Also, $\tan A > 1$ and $\tan B > 1$, so each angle is more than $\pi/4$ and their sum is more than $\pi/2$.) Option A, $\pi/4$, comes from ignoring the negative sign.

23. C Let θ be the angle opposite the 7 cm side. By the cosine rule, $\cos \theta = (5^2 + 8^2 - 7^2)/(2 \times 5 \times 8) = (25 + 64 - 49)/80 = 40/80 = 1/2$. So $\theta = 60^\circ$. Option B, 120° , comes from a sign slip that gives $\cos \theta = -1/2$.

24. D Factorise: $2\cos^2x - \cos x - 1 = (2\cos x + 1)(\cos x - 1) = 0$. So $\cos x = 1$ or $\cos x = -1/2$.

- $\cos x = 1$ gives $x = 0$ (2π is not in the interval).
- $\cos x = -1/2$ gives $x = 2\pi/3$ and $x = 4\pi/3$ (second and third quadrants).

That makes 3 solutions in total.

25. C The principal range of $\cos^{-1}$ is $[0, \pi]$. $\cos(\pi/3) = 1/2$, so the angle in $[0, \pi]$ with cosine $-1/2$ is $\pi - \pi/3 = 2\pi/3$. Option A is outside the principal range.

26. B Let $\theta = \cos^{-1}(3/5)$, so $\cos \theta = 3/5$ and θ lies in $[0, \pi]$, where $\sin \theta \geq 0$. $\sin \theta = \sqrt{1 - 9/25} = \sqrt{16/25} = 4/5$. You can also picture a 3-4-5 right-angled triangle.

27. D Substituting directly gives $0/0$, so factorise: $(x^2 - 9)/(x - 3) = (x - 3)(x + 3)/(x - 3) = x + 3$ for $x \neq 3$. The limit is $3 + 3 = 6$.

28. A Write the expression as $[(\sin 5x)/(5x)] \times [(2x)/(\sin 2x)] \times (5x/2x)$. As $x \rightarrow 0$, the first two brackets each tend to 1, which leaves $5/2$.

29. B Use the standard result $\lim_{x \rightarrow \infty} (1 + k/x)^x = e^k$. With $k = 2$, the limit is e^2 . To see why, let $x = 2n$: $(1 + 1/n)^{2n} = [(1 + 1/n)^n]^2 \rightarrow e^2$.

30. A By the chain rule, $d/dx[\ln u] = u'/u$. So $d/dx[\ln(\sin x)] = \cos x/\sin x = \cot x$.

31. C $d/dx[\tan^{-1}u] = u'/(1 + u^2)$. Here $u = x^2$ and $u' = 2x$, so the derivative is $2x/(1 + x^4)$.

32. A $y' = 3x^2 - 12x + 9 = 3(x^2 - 4x + 3) = 3(x - 1)(x - 3)$. The stationary points are at $x = 1$ and $x = 3$.

- $y'' = 6x - 12$. At $x = 1$, $y'' = -6 < 0$, so this is a local maximum.
- At $x = 3$, $y'' = 6 > 0$, so this is a local minimum.

The maximum value is $y(1) = 1 - 6 + 9 + 1 = 5$. Option B, 1, is the minimum value $y(3) = 27 - 54 +$

$$27 + 1 = 1.$$

33. D The point is on the curve because $9 - 12 + 7 = 4$. $dy/dx = 2x - 4$, which is $6 - 4 = 2$ at $x = 3$. So the tangent has gradient 2 and the normal has gradient $-1/2$.

The normal is $y - 4 = -1/2(x - 3)$. Multiply by 2: $2y - 8 = -x + 3$, so $x + 2y - 11 = 0$. Check: $3 + 8 - 11 = 0$. Option A is the tangent, and option B uses gradient $+1/2$ instead of $-1/2$.

34. B Let $u = x^2$. Then $du = 2x dx$, so $x dx = 1/2 du$. The integral becomes $1/2 \int e^u du = 1/2 e^u + C = 1/2 e^{x^2} + C$. Check by differentiating: $d/dx[1/2 e^{x^2}] = 1/2 \times 2x \times e^{x^2} = x e^{x^2}$.

35. D Let $u = \ln x$, so $du = (1/x) dx$. The integral becomes $\int du/u = \ln|u| + C = \ln|\ln x| + C$.

36. C Use $\cos^2 x = (1 + \cos 2x)/2$.

$$\int_0^{\pi/2} (1 + \cos 2x)/2 dx = [x/2 + (\sin 2x)/4] \text{ from } 0 \text{ to } \pi/2 = (\pi/4 + (\sin \pi)/4) - (0 + (\sin 0)/4) = \pi/4 + 0 - 0 = \pi/4.$$

37. D Integrate by parts with $u = \ln x$ and $dv = dx$, so $du = (1/x) dx$ and $v = x$.

$$\int \ln x dx = x \ln x - \int x \times (1/x) dx = x \ln x - x.$$

$$\text{Evaluate: } [x \ln x - x] \text{ from } 1 \text{ to } e = (e \times 1 - e) - (1 \times 0 - 1) = 0 - (-1) = 1.$$

38. A The curves meet where $x^2 = 2x$, that is $x(x - 2) = 0$, so $x = 0$ and $x = 2$. Between these points the line is above the parabola (at $x = 1$, $2x = 2$ and $x^2 = 1$).

$$\text{Area} = \int_0^2 (2x - x^2) dx = [x^2 - x^3/3] \text{ from } 0 \text{ to } 2 = 4 - 8/3 = 4/3 \text{ square units.}$$

Option B, $8/3$, is the area under the parabola alone, and option C, 4, is the area under the line alone. Always subtract the lower curve from the upper one.

39. D Compare with $y^2 = 4ax$: $4a = 12$, so $a = 3$. The focus is $(a, 0) = (3, 0)$ and the directrix is $x = -3$.

40. C Compare with $x^2 + y^2 + 2gx + 2fy + c = 0$: $2g = -6$ so $g = -3$, $2f = 4$ so $f = 2$, and $c = -12$. The centre is $(-g, -f) = (3, -2)$. The radius is $\sqrt{(g^2 + f^2 - c)} = \sqrt{(9 + 4 + 12)} = \sqrt{25} = 5$.

$$\text{41. B The distance is } |ax_1 + by_1 + c|/\sqrt{(a^2 + b^2)} = |3(2) + 4(-1) - 12|/\sqrt{(9 + 16)} = |-10|/5 = 2.$$

42. A Rearranged, the given line is $y = (2/3)x + 5/3$, so its gradient is $2/3$. The perpendicular gradient is $-3/2$. The line through $(1, 2)$ is $y - 2 = -(3/2)(x - 1)$. Multiply by 2: $2y - 4 = -3x + 3$, so $3x + 2y - 7 = 0$. Check: $3(1) + 2(2) - 7 = 0$.

43. B Perpendicular vectors have a dot product of zero: $(2)(1) + (p)(-3) + (-1)(4) = 2 - 3p - 4 = 0$. So $-3p = 2$ and $p = -2/3$.

44. C The area is $|\mathbf{a} \times \mathbf{b}|$, with $\mathbf{a} = (1, 1, 0)$ and $\mathbf{b} = (0, 1, 1)$.

$$\mathbf{a} \times \mathbf{b} = \mathbf{i}(1 \times 1 - 0 \times 1) - \mathbf{j}(1 \times 1 - 0 \times 0) + \mathbf{k}(1 \times 1 - 1 \times 0) = \mathbf{i} - \mathbf{j} + \mathbf{k}.$$

$$|\mathbf{a} \times \mathbf{b}| = \sqrt{1 + 1 + 1} = \sqrt{3}.$$

45. D A matrix is singular when its determinant is zero: $6k - 3 \times 4 = 0$, so $6k = 12$ and $k = 2$.

46. C For an $n \times n$ matrix, $|kA| = k^n|A|$, because each of the n rows is multiplied by k . Here $|2A| = 2^3 \times 4 = 32$. Option A, 8, comes from wrongly using $|2A| = 2|A|$.

47. A Expand along the first row:

$$2 \times (4 \times 2 - (-1) \times 0) - 1 \times (0 \times 2 - (-1) \times 1) + 3 \times (0 \times 0 - 4 \times 1) = 2(8) - 1(1) + 3(-4) = 16 - 1 - 12 = 3.$$

48. C Multiply the top and bottom by the conjugate of the denominator, $1 + 2i$:

$$(2 + i)(1 + 2i)/[(1 - 2i)(1 + 2i)] = (2 + 4i + i + 2i^2)/(1 - 4i^2) = (2 + 5i - 2)/(1 + 4) = 5i/5 = i.$$

49. D $z = -1 + \sqrt{3}i$ has a negative real part and a positive imaginary part, so it is in the second quadrant. The reference angle is $\tan^{-1}(\sqrt{3}/1) = \pi/3$, so the argument is $\pi - \pi/3 = 2\pi/3$. Option A is the reference angle only. Always check the quadrant before you write the argument.

50. B Square first: $(1 + i)^2 = 1 + 2i + i^2 = 2i$. Then $(1 + i)^6 = (2i)^3 = 8i^3 = 8(-i) = -8i$.

Check in polar form: $1 + i$ has modulus $\sqrt{2}$ and argument $\pi/4$. By De Moivre's theorem, $(1 + i)^6$ has modulus $(\sqrt{2})^6 = 8$ and argument $6\pi/4 = 3\pi/2$, which is $8(\cos 3\pi/2 + i \sin 3\pi/2) = -8i$. Option A comes from taking $i^3 = i$.

Scoring guide: 45 or more is excellent, 35–44 is good (go back to the topics you missed), and below 35 means you should revisit the core FSc results before your next timed attempt.