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ENGINEERING MATHEMATICS

CIVIL ENGINEERING

Date of Test : 07/08/2026

ANSWER KEY ➤

- | | | | | |
|--------|---------|---------|---------|---------|
| 1. (c) | 7. (d) | 13. (b) | 19. (b) | 25. (a) |
| 2. (a) | 8. (a) | 14. (b) | 20. (c) | 26. (c) |
| 3. (b) | 9. (d) | 15. (d) | 21. (d) | 27. (c) |
| 4. (a) | 10. (b) | 16. (b) | 22. (d) | 28. (c) |
| 5. (c) | 11. (c) | 17. (d) | 23. (c) | 29. (b) |
| 6. (b) | 12. (c) | 18. (b) | 24. (a) | 30. (a) |

DETAILED EXPLANATIONS

1. (c)

The characteristic equation $[A - \lambda I] = 0$

$$\text{i.e.} \quad \begin{bmatrix} 4-\lambda & 6 \\ 2 & 8-\lambda \end{bmatrix} = 0$$

$$\text{or} \quad (4-\lambda)(8-\lambda) - 12 = 0$$

$$\text{or} \quad 32 - 8\lambda - 4\lambda + \lambda^2 - 12 = 0$$

$$\Rightarrow \quad \lambda^2 - 12\lambda + 20 = 0$$

$$\Rightarrow \quad \lambda^2 - 10\lambda - 2\lambda + 20 = 0$$

$$\Rightarrow \quad (\lambda - 10)(\lambda - 2) = 0$$

$$\Rightarrow \quad \lambda = 10, 2$$

Corresponding to $\lambda = 10$, we have

$$[A - \lambda I]x = \begin{bmatrix} -6 & 6 \\ 2 & -2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$\text{Which gives,} \quad -6x + 6y = 0$$

$$\Rightarrow \quad x = y$$

$$2x - 2y = 0$$

$$\Rightarrow \quad x = y$$

$$\text{i.e. eigen vector} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

Corresponding to $\lambda = 2$, we have

$$[A - \lambda I]x = \begin{bmatrix} 2 & 6 \\ 2 & 6 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$\text{Which gives,} \quad 2x + 6y = 0 \text{ i.e. eigen vector} \begin{bmatrix} -3 \\ 1 \end{bmatrix}$$

2. (a)

The product of eigen values is always equal to the determinant value of the matrix.

$$\lambda_1 = 5,$$

$$\lambda_2 = \text{Unknown}$$

$$|A| = 30$$

$$\lambda_1 \lambda_2 = 30$$

$$5(\lambda_2) = 30$$

$$\Rightarrow \quad \lambda_2 = 6$$

3. (b)

$$\lim_{x \rightarrow 0} \left(\frac{3 \cos^2 x - 2 \sin^2 x}{2 \sin x + 3 \cos x} \right) = \lim_{x \rightarrow 0} \left(\frac{3-0}{0+3} \right) = \frac{3}{3} = 1$$

4. (a)

Probability of atleast one meeting the specification

$$= 1 - (\bar{A} \cap \bar{B} \cap \bar{C} \cap \bar{D})$$

$$= 1 - (0.4 \times 0.3 \times 0.2 \times 0.1)$$

$$= 1 - (0.0024) = 0.9976$$

5. (c)

Case-I: White ball is transferred from urn A to urn B

$$\text{Probability of drawing white ball from B} = \frac{2}{2+4} \times \frac{6}{13} = \frac{2}{13}$$

Case-II: Black ball is transferred from A to B

$$\text{Probability of drawing black ball from B} = \frac{4}{2+4} \times \frac{5}{13} = \frac{10}{39}$$

$$\text{Required probability} = \frac{2}{13} + \frac{10}{39} = \frac{16}{39}$$

6. (b)

$$\frac{\partial M}{\partial y} = \frac{x}{xy} = \frac{1}{y}$$

$$\frac{\partial N}{\partial x} = \frac{m}{y}$$

$$\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$$

$$\Rightarrow m = 1$$

7. (d)

$$\frac{e^x}{(1-e^x)} dx + \frac{\sec^2 y}{\tan y} dy = 0$$

Integrating on both sides, we get,

$$-\ln(1-e^x) + \ln(\tan y) = C_1$$

$$\ln\left(\frac{\tan y}{(1-e^x)}\right) = C_1$$

$$\frac{\tan y}{(1-e^x)} = e^{C_1} = C$$

$$\tan y = C(1-e^x)$$

8. (a)

$$(D^2 + D)y = x^2 + 2x + 8$$

The particular integral is,

$$\begin{aligned} PI &= \frac{x^2 + 2x + 8}{D(1+D)} \\ &= \frac{1}{D}(1+D)^{-1}(x^2 + 2x + 8) = \frac{1}{D}(1-D+D^2-D^3+\dots)(x^2 + 2x + 8) \\ &= \frac{1}{D}(x^2 + 2x + 8 - 2x - 2 + 2) = \frac{1}{D}(x^2 + 8) = \frac{x^3}{3} + 8x \end{aligned}$$

9. (d)

$$\text{Probability of showing even number} = \frac{2}{1+2} = \frac{2}{3}$$

$$\text{Probability of showing odd number} = \frac{1}{1+2} = \frac{1}{3}$$

For sum to be odd = (Even + Even + odd)/(Even + Odd + Even)/(Odd + Even + Even)/(odd + odd + odd)

$$\text{Required probability} = \frac{2}{3} \times \frac{2}{3} \times \frac{1}{3} \times 3 + \frac{1}{3} \times \frac{1}{3} \times \frac{1}{3} = \frac{12+1}{27} = \frac{13}{27}$$

10. (b)

$$y = e^x \cos x$$

In series $e^x \cos x$, coefficient of x^2 is $\frac{1}{2} \left(\frac{d^2 e^x \cos x}{dx^2} \right) \Big|_{x=0}$

$$y' = \frac{de^x \cos x}{dx} = e^x \cos x - e^x \sin x = y - e^x \sin x$$

$$\frac{d^2 e^x \cos x}{dx^2} = y' - e^x \sin x - e^x \cos x = y - e^x \sin x - e^x \sin x - e^x \cos x$$

$$\begin{aligned} \text{At } x = 0, \left(\frac{d^2 e^x \cos x}{dx^2} \right) \Big|_{x=0} &= (e^x \cos x - 2e^x \sin x - e^x \cos x) \Big|_{x=0} \\ &= (-2e^{-x} \sin x) \Big|_{x=0} = 0 \end{aligned}$$

$$\text{So, The coefficient of } x^2 = \frac{1}{2}(0) = 0$$

11. (c)

$$\text{Given matrix is } M = \begin{bmatrix} 12+9i & -i \\ i & 12-9i \end{bmatrix}$$

$$\begin{aligned} \text{Determinant of } M &= \begin{vmatrix} 12+9i & -i \\ i & 12-9i \end{vmatrix} = (12+9i)(12-9i) + i^2 \\ &= (12^2 - 9^2 i^2) + i^2 \\ &= 225 - 1 \\ &= 224 \end{aligned}$$

$$\therefore \text{Inverse of } M = M^{-1} = \frac{1}{|M|} (\text{adj} M) = \frac{1}{224} \begin{bmatrix} 12-9i & i \\ -i & 12+9i \end{bmatrix}$$

12. (c)

$$\begin{vmatrix} 1-\lambda & 2 \\ p & 5-\lambda \end{vmatrix} = 0$$

$$(1-\lambda)(5-\lambda) - 2p = 0$$

$$\lambda^2 - 6\lambda + 5 - 2p = 0$$

Let the roots are λ_1 and λ_2 .

From the characteristic equation,

$$\lambda_1 + \lambda_2 = 6$$

$$\lambda_1 \lambda_2 = 5 - 2p \geq 0 \quad [\text{For roots to be positive}]$$

$$p \leq \frac{5}{2} \quad \dots (i)$$

For roots to be real,

$$6^2 - 4(5 - 2p) \geq 0$$

$$36 - 20 + 8p \geq 0$$

$$p \geq -2$$

... (ii)

From equations (i) and (ii),

$$-2 \leq p \leq \frac{5}{2}$$

13. (b)

For non-trivial solution to exist,

$$\begin{vmatrix} 1 & -2 & 1 \\ k & -1 & 2 \\ 2 & -1 & 1 \end{vmatrix} = 0$$

$$-1 - 8 - k + 2 + 2 + 2k = 0$$

$$k = 5$$

For $k = 5$,

$$x - 2y + z = 0$$

$$5x - y + 2z = 0$$

$$\frac{x}{-4+1} = \frac{y}{5-2} = \frac{z}{-1+10}$$

$$\frac{x}{-3} = \frac{y}{3} = \frac{z}{9}$$

$$x : y : z = -1 : 1 : 3$$

14. (b)

At extremum value $\frac{dy}{dx} = 0$

So,
$$\frac{dy}{dx} = \frac{p}{(x-4)(x-1)} - \frac{(px+q)[(x-4)+(x-1)]}{(x-4)^2(x-1)^2} = 0$$

$$x \neq 4, x \neq 1$$

$$\frac{p(x-4)(x-1) - (px+q)[(x-4)+(x-1)]}{(x-4)^2(x-1)^2} = 0$$

At $x = 2$,

$$p(2-4)(2-1) - (2p+q)[2-4+2-1] = 0$$

$$-2p + 2p + q = 0$$

$$\Rightarrow q = 0$$

$$y(2) = \frac{2p}{(2-4)(2-1)} = -1$$

$$p = 1$$

$\Rightarrow$ The value of p & q are 1 and 0 respectively.

15. (d)

$$f(x) = 2x^3 - 3x^2 - 12x + 5$$

$$f'(x) = 6x^2 - 6x - 12$$

For minima/maxima, $f'(x) = 0$

$$6x^2 - 6x - 12 = 0$$

$$x^2 - x - 2 = 0$$

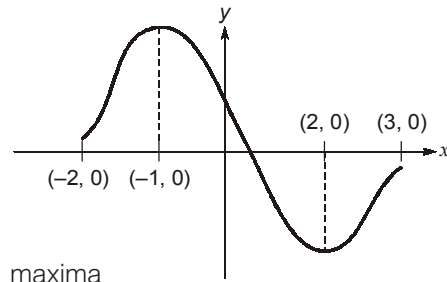
$$(x + 1)(x - 2) = 0$$

$$x = -1, 2$$

$$f''(x) = 12x - 6$$

$$f''(-1) = -12 - 6 = -18 < 0 \Rightarrow \text{maxima}$$

$$f''(2) = 24 - 6 = 18 > 0 \Rightarrow \text{minima}$$

The function has maxima at $x = -1$ and minima at $x = 2$.The function is decreasing between -1 and 2 .

16. (b)

$$f(x) = \frac{\log_e(1+ax) - \log_e(1-bx)}{x}$$

For function to be continuous

$$f(0) = \lim_{x \rightarrow 0} f(x)$$

$$\begin{aligned} &= \lim_{x \rightarrow 0} \frac{\log_e(1+ax) - \log(1-bx)}{x} = \lim_{x \rightarrow 0} \frac{\log_e(1+ax) \times a}{ax} + \frac{\log(1-bx) \times b}{-bx} \\ &= a + b \end{aligned}$$

17. (d)

$$u(x, y) = x^3 - 3xy^2 + 3x^2 - 3y^2$$

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y} = 3x^2 - 3y^2 + 6x$$

$$\frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x} = -6xy - 6y$$

$$dv = \frac{\partial v}{\partial x} \cdot dx + \frac{\partial v}{\partial y} \cdot dy = -\frac{\partial u}{\partial y} dx + \frac{\partial u}{\partial x} dy$$

$$= (6xy + 6y)dx + (3x^2 - 3y^2 + 6x)dy$$

$$v = 3x^2y + 6xy - y^3 + C$$

18. (b)

$$\phi_1 = ax^2 - byz - (a+2)x$$

$$\nabla \phi_1 = [2ax - (a+2)]\hat{i} - bz\hat{j} - by\hat{k}$$

$$\nabla \phi_1(1, -1, 2) = (a-2)\hat{i} - 2b\hat{j} + b\hat{k}$$

$$\phi_2 = 4x^2y + z^3 - 4$$

$$\nabla \phi_2 = 8xy\hat{i} + 4x^2\hat{j} + 3z^2\hat{k}$$

$$\nabla \phi_2(1, -1, 2) = -8\hat{i} + 4\hat{j} + 12\hat{k}$$

Since surfaces are orthogonal to each other at $(1, -1, 2)$

$$\nabla \phi_1 \cdot \nabla \phi_2 = 0$$

$$[(a-2)\hat{i} - 2b\hat{j} + b\hat{k}] \cdot [-8\hat{i} + 4\hat{j} + 12\hat{k}] = 0$$

$$-8(a-2) - 8b + 12b = 0$$

... (i)

Also point (1, -1, 2) lies on the surface.

$$\Rightarrow a \times 1 + 2b = (a+2)1$$

$$b = 1$$

Putting this in equation 1, we get,

$$-8(a-2) - 8 + 12 = 0$$

$$a - 2 = -\frac{1}{8} \times (-4) = 0.5$$

$$a = 2.5$$

19. (b)

z varies from 0 to $\frac{x^2 + y^2}{4}$; y varies from 0 to $\sqrt{16 - x^2}$; x varies from 0 to 4.

$$\begin{aligned} \text{Volume} &= \iiint dx dy dz = \int_0^4 \int_0^{\sqrt{16-x^2}} \int_0^{\frac{x^2+y^2}{4}} dz dy dx \\ &= \frac{1}{4} \int_0^4 \int_0^{\sqrt{16-x^2}} (x^2 + y^2) dy dx = \frac{1}{4} \int_0^4 \left(x^2 y + \frac{y^3}{3} \right) \Big|_0^{\sqrt{16-x^2}} dx \\ &= \frac{1}{4} \int_0^4 \left(x^2 \sqrt{16-x^2} + \frac{(\sqrt{16-x^2})^3}{3} \right) dx \end{aligned}$$

Let,

$$x = 4 \sin \theta \quad x \rightarrow 0 \text{ to } 4$$

$$dx = 4 \cos \theta d\theta \quad \theta \rightarrow 0 \text{ to } \frac{\pi}{2}$$

$$\begin{aligned} \text{Volume} &= \frac{1}{4} \left[4^4 \int_0^{\pi/2} \sin^2 \theta \cos^2 \theta d\theta + \frac{4^4}{3} \int_0^{\pi/2} \cos^4 \theta d\theta \right] \\ &= \frac{1}{4} \left[4^4 \times \frac{\left[\frac{3}{2} \times \frac{3}{2} \right]}{2 \left[\frac{6}{2} \right]} + \frac{4^4}{3} \times \frac{\left[\frac{5}{2} \times \frac{3}{2} \right]}{2 \left[\frac{6}{2} \right]} \right] \\ &= \frac{1}{4} \left[4^4 \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2!} \pi + \frac{4^4}{3} \times \frac{3}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2!} \times \pi \right] \\ &= \frac{1}{4} [16\pi + 16\pi] = 8\pi = 25.13 \text{ unit}^3 \end{aligned}$$

20. (c)

$$\frac{dT}{dt} = k(T-25)$$

T = Temperature of the body in °C and t = time in minutes.

$$\frac{dT}{T-25} = k dt$$

$$\log(T-25) = kt + C_1$$

$$T-25 = Ce^{kt}$$

At t = 0, T = 100°C and at t = 1 minute, T = 75°C.

$$(100-25) = Ce^0$$

$$\Rightarrow C = 75^{\circ}\text{C}$$

$$50 = 75 e^k \Rightarrow e^k = \frac{2}{3}$$

$$\text{At } t = 5 \text{ minutes, } T - 25 = 75 e^{k \times 5}$$

$$T = 25 + 75 \times \left(\frac{2}{3}\right)^5 \approx 34.88^{\circ}\text{C}$$

21. (d)

$$AX = B$$

$$\text{Augmented matrix, } [A : B] = \begin{bmatrix} -2 & 1 & 1 & : & l \\ 1 & -2 & 1 & : & m \\ 1 & 1 & -2 & : & n \end{bmatrix}$$

$$R_3 \rightarrow R_3 + R_2 + R_1;$$

$$[A : B] = \begin{bmatrix} -2 & 1 & 1 & : & l \\ 1 & -2 & 1 & : & m \\ 0 & 0 & 0 & : & l+m+n \end{bmatrix}$$

$$\text{Since, } l + m + n = 0$$

$$\text{Rank of } [A : B] = 2$$

$$\text{Rank of } [A] = \text{Rank of } [A : B] = 2 < 3 \text{ (Number of variables)}$$

$\Rightarrow$ Infinitely many solutions are possible.

22. (d)

$$c(y+c)^2 = x^3 \quad \dots(i)$$

Differentiating, we get

$$2c(y+c) \frac{dy}{dx} = 3x^2$$

$$\Rightarrow \frac{2x^3}{(y+c)^2} (y+c) \frac{dy}{dx} = 3x^2 \quad \left(\because c = \frac{x^3}{(y+c)^2} \right)$$

$$\Rightarrow \frac{2x^2}{y+c} \frac{dy}{dx} = 3x^2$$

$$\Rightarrow \frac{2x}{3} \left(\frac{dy}{dx} \right) = y + c$$

$$\Rightarrow c = \frac{2x}{3} \left(\frac{dy}{dx} \right) - y$$

Putting this value of 'c' in equation (i)

$$\left[\frac{2x}{3} \left(\frac{dy}{dx} \right) - y \right] \left[\frac{2x}{3} \frac{dy}{dx} \right]^2 = x^3$$

23. (c)

Suppose $y = \lim_{x \rightarrow \infty} \left(\frac{x+6}{x+1} \right)^{x+4}$

$$\Rightarrow y = \lim_{x \rightarrow \infty} \left[\left(1 + \frac{5}{x+1} \right)^{\frac{x+1}{5}} \right]^{\left[\frac{5(x+4)}{x+1} \right]}$$

$$\Rightarrow \ln y = \lim_{x \rightarrow \infty} \frac{5(x+4)}{(x+1)} \ln \left(1 + \frac{5}{x+1} \right)^{\frac{x+1}{5}} \quad \dots(i)$$

$\lim_{x \rightarrow \infty} \frac{5(x+4)}{(x+1)}$ is in the form of $\frac{\infty}{\infty}$ and $\lim_{x \rightarrow \infty} \ln \left(1 + \frac{5}{x+1} \right)^{\frac{x+1}{5}}$ is in the form of 0^0 .

Calculating the limits of both terms separately

$$\begin{aligned} \lim_{x \rightarrow \infty} 5 \frac{(x+4)}{(x+1)} &= \lim_{x \rightarrow \infty} 5 \frac{\left(1 + \frac{4}{x} \right)}{\left(1 + \frac{1}{x} \right)} = 5 \frac{(1+0)}{(1+0)} \\ &= 5 \end{aligned}$$

We can use direct result of $\lim_{t \rightarrow 0} (1+t)^{1/t} = e$...(ii)

$$\begin{aligned} \Rightarrow \lim_{x \rightarrow \infty} \ln \left[1 + \frac{5}{x+1} \right]^{\frac{x+1}{5}} &= \ln(e) \\ &= 1 \end{aligned}$$

...(iii)

$$\begin{aligned} \therefore \ln y &= 5(1) \\ \Rightarrow y &= e^5 \end{aligned}$$

24. (a)

Required probability = Chosen a defective bolt from Machine A + Chosen a defective bolt from Machine B + Chosen a defective bolt from Machine C

$$= \frac{1}{2} \times \frac{2}{100} + \frac{1}{4} \times \frac{2}{100} + \frac{1}{4} \times \frac{4}{100} = 0.25 \times 10^{-1} = 0.025$$

25. (a)

$$\begin{aligned} \text{Probability} &= \int_2^{\infty} f(x) dx \\ &= \int_2^{\infty} \left[\frac{1}{2} e^{\frac{-x}{2}} \right] dx \\ &= \left[-e^{\frac{-x}{2}} \right]_2^{\infty} = e^{-1} = 0.368 \end{aligned}$$

26. (c)

$$\sin y \frac{dy}{dx} = \cos y (1 - x \cos y)$$

$$\Rightarrow \sin y \frac{dy}{dx} - \cos y = -x \cos^2 y$$

$$\Rightarrow \frac{\sin y}{\cos^2 y} \frac{dy}{dx} - \frac{\cos y}{\cos^2 y} = -x$$

$$\Rightarrow \tan y \sec y \frac{dy}{dx} - \sec y = -x \quad \dots(i)$$

$$\text{Let} \quad \sec y = t$$

$$\Rightarrow \sec y \tan y \frac{dy}{dx} = \frac{dt}{dx} \quad \dots(ii)$$

From equation (i) and (ii), we get

$$\frac{dt}{dx} - t = -x$$

$$\text{Integrating factor} = e^{\int -dx} = e^{-x}$$

Multiplying the equation by the integrating factor

$$\Rightarrow e^{-x} \frac{dt}{dx} - e^{-x} t = -x e^{-x}$$

$$\Rightarrow t e^{-x} = \int -x e^{-x} dx = x e^{-x} + e^{-x} + c$$

$$\Rightarrow t = (x + 1) + c e^x$$

$$\therefore \sec y = (x + 1) + c e^x$$

27. (c)

$$f(t) = (t + 1)^2$$

$$\Rightarrow \text{Laplace } \{f(t)\} = L(t^2) + L(2t) + L(1)$$

$$= \frac{2}{s^3} + \frac{2}{s^2} + \frac{1}{s}$$

28. (c)

The matrix formed by the coefficients is $\begin{bmatrix} a & 1 & 2 \\ 1 & 2 & 1 \\ 2 & 1 & a \end{bmatrix}$

$$\text{Determinant} = 2a^2 - 2a - 4$$

$$\therefore D = 0 \text{ for } a = 2 \text{ or } a = -1$$

(A) If $D \neq 0$, then the system will have unique solution.

(B) If $a = 2$, the matrix formed by the coefficients is $\begin{bmatrix} 2 & 1 & 2 \\ 1 & 2 & 1 \\ 2 & 1 & 2 \end{bmatrix}$

The rank of matrix is 2.

Considering 'z' as side unknown.

The characteristic determinant will be
$$\begin{vmatrix} 2 & 1 & 0 \\ 1 & 2 & b \\ 2 & 1 & 0 \end{vmatrix}$$

The determinant of this is 0.

The system will have infinite solutions when $a = 2$.

(C) If $a = -1$, the matrix formed by the coefficients is
$$\begin{bmatrix} -1 & 1 & 2 \\ 1 & 2 & 1 \\ 2 & 1 & -1 \end{bmatrix}$$

Its rank is 2.

Considering 'z' as side unknown.

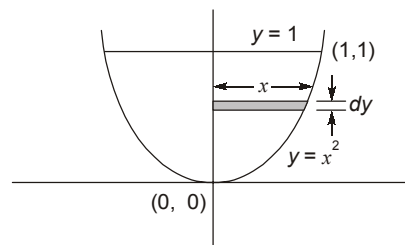
The characteristic matrix is
$$\begin{bmatrix} -1 & 1 & 0 \\ 1 & 2 & b \\ 2 & 1 & 0 \end{bmatrix}$$

The determinant of this matrix is $3b$.

The system will have no solution if $b \neq 0$

$\therefore$ For $a = -1$ and $b \neq 0$, the system will have no solution.

29. (b)



$y = x^2$ and $y = 1$ intersect at $(1, 1)$

Small disk of radius 'x' and depth 'dy' are integrated to compute the volume

$$\begin{aligned} \text{Volume} &= \int_0^1 \pi x^2 dy \\ &= \int_0^1 \pi y dy = \pi \left[\frac{y^2}{2} \right]_0^1 = \frac{\pi}{2} \end{aligned} \quad (\because y = x^2)$$

30. (a)

$$\text{Required probability} = \frac{\text{Favorable outcomes}}{\text{Total possible outcomes}}$$

Favorable outcomes = A false coin is chosen and flipped every time

$$\text{Probability of selecting a false coin} = \frac{1}{4}$$

Probability of getting a tail on every flip of false coin = 1.

$$\therefore \text{Favorable outcomes} = \frac{1}{4} \times 1 = \frac{1}{4}$$

Total possible outcomes = Favourable outcomes + Unfavourable outcomes

Unfavourable outcomes = A fair coin is chosen and flipped everytime to get tail

$$\text{Probability of selecting a fair coin} = \frac{3}{4}$$

Probability of flipping a fair coin 4 times and getting

$$\text{tails every time} = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$$

$$\therefore \text{Unfavourable outcomes} = \frac{3}{4} \times \frac{1}{16} = \frac{3}{64}$$

$$\text{Total possible outcomes} = \frac{1}{4} + \frac{3}{64} = \frac{19}{64}$$

$$\therefore \text{Required probability} = \frac{\frac{1}{4}}{\frac{19}{64}} = \frac{16}{19} \approx 0.84$$

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