

Question 1

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General mathematics (+)

What is the angle, in radian, between the two vectors  $u = (1, 1)$  and  $v = (1 - \sqrt{3}, 1 + \sqrt{3})$ ?

Select one:

- ☐ a.  $\frac{\pi}{6}$
- ☐ b. 0
- ☐ c.  $\frac{\pi}{3}$
- ☐ d.  $\frac{\pi}{2}$
- ☐ e.  $\frac{\pi}{4}$

Question 2

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General mathematics (+)

For  $n \in \mathbb{Z}$ , we consider  $z = (-4\sqrt{3} + 4i)^n$ .

$z$  is a real number if and only if

Select one:

- ☐ a.  $n$  is a multiple of 3
- ☐ b.  $n$  is a multiple of 4
- ☐ c.  $n$  is a multiple of 2
- ☐ d.  $n$  is a multiple of 6
- ☐ e. None of the above

Question 3

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General mathematics (+)

Consider the function  $f : x \mapsto x^4 + 12x^3 + 30x^2 - 100x$ .

What is the minimum value of  $f$  over  $\mathbb{R}$ ?

Select one:

- ☐ a.  $-\infty$
- ☐ b. -53
- ☐ c. 0
- ☐ d. 42
- ☐ e. None of the above

Question 4

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General mathematics (+)

Let  $f : \mathbb{R}^2 \mapsto \mathbb{R}^2$  be defined by  $f(x, y) = (3x - 2y, 4x + 3y)$ .

What is the matrix representation of  $f$  in the canonical basis of  $\mathbb{R}^2$ ?

Select one:

- ☐ a.  $\begin{pmatrix} -3 & 2 \\ 3 & 4 \end{pmatrix}$
- ☐ b.  $\begin{pmatrix} -2 & 3 \\ 3 & 4 \end{pmatrix}$
- ☐ c.  $\begin{pmatrix} 4 & 3 \\ 3 & -2 \end{pmatrix}$
- ☐ d.  $\begin{pmatrix} 3 & -2 \\ 4 & 3 \end{pmatrix}$
- ☐ e. None of the above

Question 5

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General mathematics (++)

Consider the polynomial  $P(X) = X^3 - \frac{3}{2}X^2 + a$ .

For which value of  $a$  does it have three distinct roots?

Select one:

- ☐ a. 1
- ☐ b. 1/4
- ☐ c. -1/2
- ☐ d. 1/2
- ☐ e. 0

Question 6

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General mathematics (++)

Let  $f : \mathbb{R} \mapsto \mathbb{R}$  be a function.

Which of the following assertion is stating exactly that  $f$  is continuous on  $\mathbb{R}$ ?

Select one:

- ☐ a.  $\forall \epsilon > 0, \exists \delta > 0, \forall x \in \mathbb{R}, \forall y \in \mathbb{R}, |x - y| < \delta \Rightarrow |f(x) - f(y)| \leq \epsilon$
- ☐ b.  $\forall x \in \mathbb{R}, \forall \epsilon \geq 0, \exists \delta > 0, \forall y \in \mathbb{R}, |x - y| < \delta \Rightarrow |f(x) - f(y)| \leq \epsilon$
- ☐ c.  $\forall x \in \mathbb{R}, \forall \epsilon > 0, \exists \delta \geq 0, \forall y \in \mathbb{R}, |x - y| < \delta \Rightarrow |f(x) - f(y)| \leq \epsilon$
- ☐ d.  $\forall \epsilon \geq 0, \exists \delta > 0, \forall x \in \mathbb{R}, \forall y \in \mathbb{R}, |x - y| < \delta \Rightarrow |f(x) - f(y)| \leq \epsilon$
- ☐ e.  $\forall x \in \mathbb{R}, \forall \epsilon > 0, \exists \delta > 0, \forall y \in \mathbb{R}, |x - y| < \delta \Rightarrow |f(x) - f(y)| \leq \epsilon$

Question 7

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General mathematics (++)

Consider a pin code with 8 digits, where each digit is a number between 0 and 9. We know that the first digit is 1, there are exactly 3 digits equal to 0, exactly 1 digit equal to 3, and 2 equal to 5.

How many different pin codes are possible?

Select one:

- ☐ a. 420
- ☐ b. 2940
- ☐ c. 4200
- ☐ d. 7840
- ☐ e. 17640

Question 8

Not yet answered

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Analysis (+)

The limit of  $f : x \mapsto \frac{e^x - \sin x - \cos x}{2x^2}$  when  $x \mapsto 0$  is

Select one:

- ☐ a. -1/2
- ☐ b. 1/4
- ☐ c.  $+\infty$
- ☐ d. -1/4
- ☐ e. 1/2

Question 9

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Analysis (+)

We consider the sequence  $S_n = \sum_{k=1}^n \frac{n}{n+k}$ .

What is the limit of  $S_n$  when  $n$  goes to infinity?

Select one:

- ☐ a. 0
- ☐ b. 1
- ☐ c.  $\frac{\pi^2}{6}$
- ☐ d.  $+\infty$
- ☐ e. The limit does not exist.

Question 10

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Analysis (+)

Let  $f$  be the function defined by  $f : (x, y) \mapsto \frac{e^{y\sqrt{x}}}{y^2}$ , for  $x, y > 0$ .

Then, for  $x, y > 0$ , we have

Select one:

- ☐ a.  $\nabla f(x, y) = \frac{1}{2\sqrt{xy}^2} \frac{\sqrt{xy}^2 - 2y}{y^4} e^{2y\sqrt{x}}$
- ☐ b.  $\nabla f(x, y) = \left( \frac{\frac{e^{y\sqrt{x}}}{2\sqrt{xy}}}{\frac{\sqrt{xy}^2 - 2}{y^3} e^{y\sqrt{x}}} \right)$
- ☐ c.  $\nabla f(x, y) = \left( \frac{\frac{e^{y\sqrt{x}}}{\sqrt{xy}}}{\frac{\sqrt{xy}^2 - 2y}{y^4} e^{y\sqrt{x}}} \right)$
- ☐ d.  $\nabla f(x, y) = \left( \frac{\frac{e^{y\sqrt{x}}}{2\sqrt{xy}^2}}{\frac{\sqrt{xy}^2 - 2}{y^3} e^{y\sqrt{x}}} \right)$
- ☐ e.  $\nabla f(x, y) = \left( \frac{\frac{e^{y\sqrt{x}}}{2\sqrt{xy}^2}}{\frac{\sqrt{xy}^2 - 2y}{y^4} e^{y\sqrt{x}}} \right)$

Question 11

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Analysis (++)

Let  $y$  be the solution on  $[0, +\infty[$  of the differential equation  $(1+t)y' + ty = 0$ , with  $y(0) = 1$ .

Then,

Select one:

- ☐ a.  $y(1) = 2e$
- ☐ b.  $y(1) = 1/e$
- ☐ c.  $y(1) = 2/e$
- ☐ d.  $y(1) = e$
- ☐ e.  $y(1) = 1$

Question 12

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Analysis (++)

We consider the following series:

$$S = \sum_{n=1}^{+\infty} n e^{-\sqrt{n}},$$

$$U = \sum_{n=1}^{+\infty} \frac{(3n-1)^3}{(n^2+1)^2},$$

$$V = \sum_{n=1}^{+\infty} 1 - \cos(\sqrt{2}/n).$$

Which of the following statements is true?

Select one:

- ☐ a. All series are convergent.
- ☐ b.  $S$  and  $V$  are convergent,  $U$  is divergent.
- ☐ c.  $S$  and  $U$  are convergent,  $V$  is divergent.
- ☐ d.  $S$  is convergent,  $U$  and  $V$  are divergent.
- ☐ e. None of the above.

Question 13

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Analysis (+++)

We consider the following integrals

$$I = \int_{\pi}^{+\infty} \frac{\sin(x)}{\sqrt{x}} dx,$$

$$J = \int_{\pi}^{+\infty} \frac{\sin^2(x)}{x} dx,$$

$$K = \int_{\pi}^{+\infty} \frac{\sin(x)}{\sqrt{x} + \sin(x)} dx.$$

Which of the following statements is true?

Select one:

- ☐ a.  $I$  is convergent,  $J$  and  $K$  are divergent.
- ☐ b.  $I$  and  $J$  are convergent,  $K$  is divergent.
- ☐ c.  $I$  and  $K$  are convergent,  $J$  is divergent.
- ☐ d. They are all convergent.
- ☐ e. None of the above.

Question 14

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Analysis (+++)

For  $n > 0$ , we define  $I_n = \int_0^1 \frac{dx}{(x^2 + 1)^n}$ .

Select one:

- ☐ a.  $I_{n+1} = I_n + \frac{1}{2n} \left( I_n - \frac{1}{2^n} \right)$
- ☐ b.  $I_n = I_{n+1} + \frac{1}{2n} \left( I_{n+1} - \frac{1}{2^n} \right)$
- ☐ c.  $I_n = I_{n+1} - \frac{1}{2n} \left( I_{n+1} - \frac{1}{2^n} \right)$
- ☐ d.  $I_{n+1} = I_n - \frac{1}{2n} \left( I_n - \frac{1}{2^n} \right)$
- ☐ e. None of the above.

Question 15

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Algebra (+)

Let  $a, b, c$  be real numbers, and let  $D$  be the determinant of the matrix  $\begin{pmatrix} 1+a & a & a \\ b & 1+b & b \\ c & c & 1+c \end{pmatrix}$ .

What is the value of  $D$ ?

Select one:

- ☐ a. 0
- ☐ b. 1
- ☐ c.  $a + b + c$
- ☐ d.  $1 + a + b + c$
- ☐ e.  $1 + 2a + 2b + 2c + ab + bc + ca + abc$

Question 16

Not yet answered

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Algebra (++)

Let  $a, b \in \mathbb{R}$ . The matrix  $M = \begin{pmatrix} 1 & a & 0 \\ 0 & 1 & 0 \\ 0 & 0 & b \end{pmatrix}$  is diagonalizable in  $\mathbb{R}$  if and only if

Select one:

- ☐ a.  $b \neq 1$  and  $a = 0$
- ☐ b.  $b = 0$
- ☐ c.  $b = 1$
- ☐ d.  $b \neq 0$  and  $a = 0$
- ☐ e.  $a = 0$

Question 17

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Algebra (++)

Let  $A$  be a matrix in  $\mathcal{M}_3(\mathbb{R})$ , such that  $A^3 - 3A^2 + 6A - 4I = 0$ .

The determinant of  $A$  is

Select one:

- ☐ a. 4
- ☐ b. 0
- ☐ c.  $\sqrt{3}$
- ☐ d.  $-\sqrt{3}$  or 1
- ☐ e. 4 or 1

Question 18

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Algebra (++)

We consider the vector space  $E$  generated by the functions from  $\mathbb{R} \rightarrow \mathbb{R}$ ,  $x \mapsto 1$ ,  $x \mapsto \cos(2x)$ ,  $x \mapsto \cos^2(x)$ , and  $x \mapsto \sin^2(x)$ . Which of the following statements is true?

Select one:

- ☐ a.  $E$  is a vector space of dimension 2.
- ☐ b.  $E$  is a vector space of dimension 3.
- ☐ c.  $E$  is a vector space of dimension 4.
- ☐ d.  $E$  is a vector space of dimension 1.
- ☐ e.  $E$  is a vector space of infinite dimension.

Question 18

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Algebra (++)

We consider the vector space  $E$  generated by the functions from  $\mathbb{R} \rightarrow \mathbb{R}$ ,  $x \mapsto 1$ ,  $x \mapsto \cos(2x)$ ,  $x \mapsto \cos^2(x)$ , and  $x \mapsto \sin^2(x)$ . Which of the following statements is true?

Select one:

- ☐ a.  $E$  is a vector space of dimension 2.
- ☐ b.  $E$  is a vector space of dimension 3.
- ☐ c.  $E$  is a vector space of dimension 4.
- ☐ d.  $E$  is a vector space of dimension 1.
- ☐ e.  $E$  is a vector space of infinite dimension.

Question 19

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Probability (+)

Let  $X$  and  $Y$  be two independent random variables. Expectation and variance of  $X$  and  $Y$  are  $\mathbb{E}[X] = 2$ ,  $\mathbb{E}[Y] = -1$ ,  $\mathbb{V}[X] = \mathbb{V}[Y] = 1$ .  $\sigma(\cdot)$  is the standard deviation.

Select one:

- ☐ a.  $\mathbb{E}[X + Y] = 0$  and  $\sigma(X + Y) = \sqrt{2}$
- ☐ b.  $\mathbb{E}(X + 2Y) = 0$  and  $\sigma(X + 2Y) = \sqrt{5}$
- ☐ c.  $\mathbb{E}(X - 2Y) = 4$  and  $\sigma(X - 2Y) = 3$
- ☐ d.  $\mathbb{E}[2X] = 4$  and  $\sigma(-X) = -1$
- ☐ e.  $\mathbb{E}[X - Y] = 3$  and  $\sigma(X - Y) = 0$

Question 20

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Probability (+)

The probability that a day of April (30 days) is rainy is  $1/10$ . A bike rental store earns 100 € on non-rainy days, and loses 10 € on rainy days. An insurance against losses due to rain costs 1 € by day, it gives back 10 € to the store if the day is rainy.

What is the expected gain for April month if the insurance is taken out and if not?

Select one:

- ☐ a. 2670 € and 2670 €
- ☐ b. 2340 € and 2670 €
- ☐ c. 2670 € and 2340 €
- ☐ d. 3030 € and 3000 €
- ☐ e. 2530 € and 3300 €

Question 21

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Probability (+)

The weight of a lamb at birth has a Gaussian distribution with mean 3 kg and variance  $0.25 \text{ kg}^2$ . What is the probability that a lamb taken at random has a weight greater than 2.5 kg? Which value the weight should be below with a probability of 0.8?

Select one:

- ☐ a. 0.783 and 2.647 kg
- ☐ b. 0.125 and 3.528 kg
- ☐ c. 0.841 and 3.421 kg
- ☐ d. 0.096 and 3.257 kg
- ☐ e. 0.264 and 2.863 kg

Question 22

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Probability (++)

A padlock has a code of 3 digits randomly chosen among  $(0,1,2,3,4,5,6,7,8,9)$ .

What is the probability that exactly two digits are equal?

Select one:

- ☐ a. 0.1
- ☐ b. 0.27
- ☐ c. 0.5
- ☐ d. 0.66
- ☐ e. 0.33

Question 23

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Probability (++)

An orchard gives apples that may be red or yellow. The apples are attacked by a parasite at random. 50% of the apples are red, the probability of an apple to be attacked is 0.1, and 80 % of the attacked apples are red.

What is the probability that a red apple taken at random is attacked?

Select one:

- ☐ a. 0.25
- ☐ b. 0.08
- ☐ c. 0.16
- ☐ d. 0.8
- ☐ e. 0.9

Question 24

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Probability (++)

Let  $X$  be a positive random variable with expectation 5 and variance 3.

Give bounds on  $\mathbb{P}(3 \leq X \leq 7)$  and  $\mathbb{P}(X \geq 10)$

Select one:

- ☐ a.  $\mathbb{P}(3 \leq X \leq 7) \geq 1/4$  and  $\mathbb{P}(X \geq 10) \leq 1/2$
- ☐ b.  $\mathbb{P}(3 \leq X \leq 7) \geq 1/2$  and  $\mathbb{P}(X \geq 10) \geq 1/4$
- ☐ c.  $\mathbb{P}(3 \leq X \leq 7) \leq 1/2$  and  $\mathbb{P}(X \geq 10) \leq 1/4$
- ☐ d.  $\mathbb{P}(3 \leq X \leq 7) \leq 1/4$  and  $\mathbb{P}(X \geq 10) \geq 1/4$
- ☐ e.  $\mathbb{P}(3 \leq X \leq 7) \leq 1/2$  and  $\mathbb{P}(X \geq 10) \geq 1/2$

Question 25

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Probability (++)

We assume that the yield of a corn plot is a Gaussian random variable with mean 10 kg and standard deviation 1 kg. We measure 25 independent corn plots, and we note  $Y$  the total yield. What is the probability that  $Y$  is greater than 260 kg?

Select one:

- ☐ a. 0.001
- ☐ b. 0.023
- ☐ c. 0.126
- ☐ d. 0.452
- ☐ e. 0.787