

Examples of questions for entrance exam for 2nd cycle studies

study line:

Automatics and Robotics

Exam questions (**multiple choice test**) will be identical or similar to the questions listed below.

Linear algebra

1. We know that structure (G, h) is a group with neutral element e . Select true statements .

2. Consider the system of linear equations
$$\begin{cases} 2x - y + z = 0 \\ x + 2y + 3z = 0. \\ 3x + y + 4z = 0 \end{cases}$$

Mark the correct statements.

3. Let A be a real 3×3 matrix. Finish the statement (mark all correct answers):

„The system of equations $Ax=b$...”

4. Consider the system of linear equations $Ax=b$,
where A is a square $n \times n$ matrix and $b \in \mathbb{R}^n$. Then: (select correct statements)

5. Let g be a real polynomial of degree 5, such that:

$$g(1+i) = g(2-i) = g(1) = 0$$

What can be said about the roots?

6. Consider algebraic equation of degree n :

$$x^n + a_{n-1}x^{n-1} + \dots + a_1x + a_0 = 0.$$

What can be said about solutions?

7. Let A be $n \times n$ real matrix, such that:

$$A^2 + A = 0.$$

What can be said about matrix A ? Mark all correct answers.

8. A square $n \times n$ matrix A has n real eigenvalues

$$\lambda_1 \leq \lambda_2 \leq \dots \leq \lambda_n.$$

Then: ... (select correct statements)

9. Which statements about matrix similarity are true?

10. Polynomial

$$\varphi(\lambda) = a_n\lambda^n + a_{n-1}\lambda^{n-1} + \dots + a_1\lambda + a_0$$

of degree $n \geq 1$ is the characteristic polynomial of a matrix A . Then: ... (select correct statements)

11. Let V be a linear space, whose every element can be expressed as a linear combination of vectors v_1, \dots, v_n . Then: ... (select correct statements)

12. In \mathbb{R}^2 space the following dot product is defined:

$$s((x_1, x_2), (y_1, y_2)) = [x_1 \ x_2] \begin{bmatrix} 2 & 0 \\ 0 & 4 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \end{bmatrix}.$$

Mark the correct answers.

13. Let $A \in \mathbb{R}^{n \times n}$ be a matrix such that

$$\forall x \in \mathbb{R}^n: \quad x^T A x \geq 0.$$

Then: ... (select correct statements)

Numerical methods

1. Which numerical error is associated with necessity of limiting an infinite sequence of computation?
2. How many polynomials of degree up to n can interpolate $n+1$ different nodes?
3. Number -7 in the U2 code is equal to ...
4. What is the name of the method for finding function zeros, which is based on halving the search interval?
5. Analytical formulas for roots of polynomials of degree greater than four are..... (select correct statements)
6. For a system of equations $Ax = b$ with square matrix of dimension 3×3 the singular values of matrix A are $\sigma(A) = \{10^{-2}, 10^2, 1\}$. Compute the conditioning of the system of equations.
7. Which decomposition is used to compute eigenvalues of a square matrix?
8. If in double precision floating point computation the significand (mantissa) has 52 bits, then machine epsilon is approximately ...
9. What does it mean that a Runge-Kutta method has an order of n ?
10. What is the order of Gauss-Legendre quadrature?

Computer science

1. The value of 126 in the binary system is: ...
2. What the code given below in C++ will print on the screen?

```
int Count1 = 1;
int Count2 = 2;
if (Count1 != Count2)
    ++Count2;
else
    ++Count1;
++Count2;
cout << Count1 << '\t' << Count2 << endl;
```

3. Select correct definition of class in C++
4. What the code given below in C++ will print on the screen:

```
using namespace std;
void f(int a, int &b) {
    int t;
    t = b;
    a = b;}
void main(){
    int x = 4, y = 5;
    f(x , y);
    cout << "x is " << x << endl;
    cout << "y is " << y << endl;
```

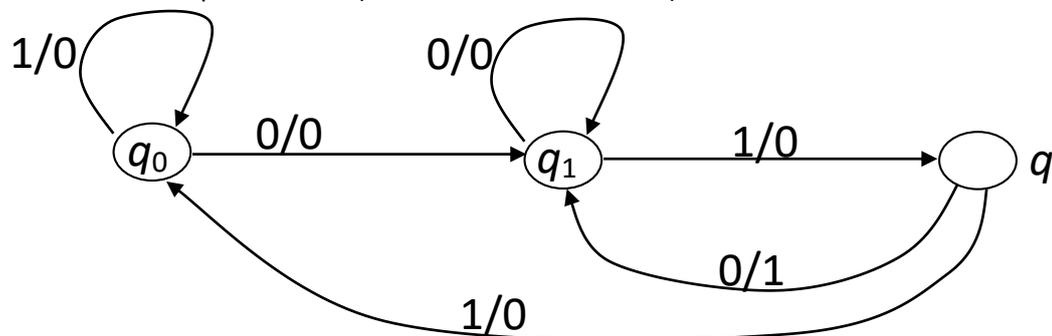
5. What the code given below in C++ will print on the screen:

```
#include < iostream >
using namespace std;
int factorial (int i ) {
    int factorial1 = 1;
    while (i > 1) {
        factorial1 -= i;
        --i;}
    return factorial1;}

void main(){
    int i = 4;
    cout << factorial(i) << endl;}
```

Digital electronics

1. The automaton with one input and one output, shown on the graph above, takes the logical level 1 on the output when: ... (select correct statements)

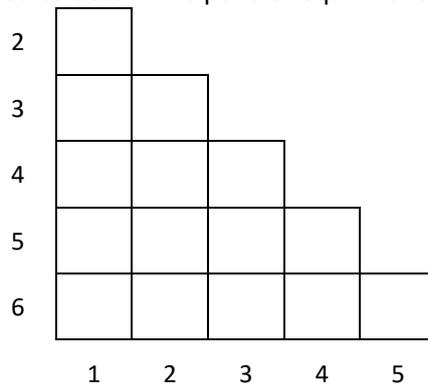


2. Consider the following Boolean function represented by the Sum of the Products: $Y = \overline{x_1} \overline{x_2} \overline{x_3} + \overline{x_1} x_2 \overline{x_3} + x_1 \overline{x_2} x_3 + \overline{x_1} \overline{x_2} x_3$
Which of the functions presented in the form of Product of the Sums (A, B, C and D) gives the same results? (select correct statements)

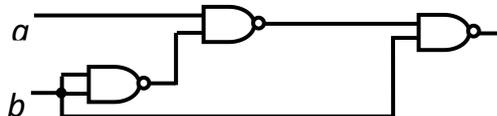
3. The automata's transition/output table is shown below. The automaton has 6 states Q , two inputs X and one output Y . How many states contains an equivalent minimal automaton?

$Q \backslash X$	0	1	Y
1	1	6	0
2	2	6	0
3	3	6	0
4	4	6	0
5	5	6	0
6	6	1	1

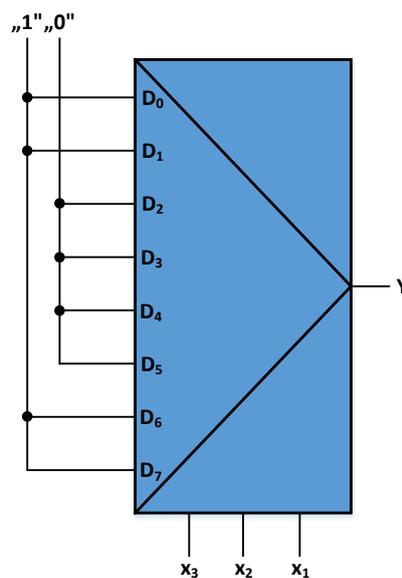
The triangular table can be used to determine pairs of equivalent states:



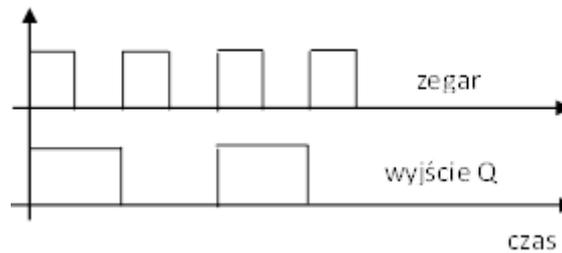
4. What hazards exist in a presented combinational logic circuit with two input signals: a and b ?



5. The figure shows a logical function implemented using the multiplexer. Among the answers presented, indicate the one that shows the correct form of the implemented function



6. We want to receive every second clock pulse at the Q output of the JK flip-flop. Which system does not accomplish this task? The figure shows how the Q signal should look like in relation to the clock signal.



The excitation table of the JK flip-flop is given to facilitate an answer.

$Q^n \rightarrow Q^{n+1}$	J	K
0 → 0	0	x
0 → 1	1	x
1 → 0	x	1
1 → 1	x	0

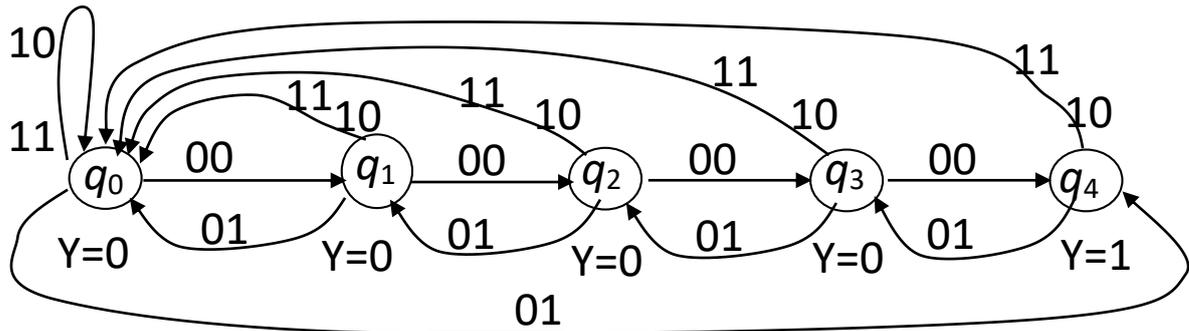
- Only one of the sentences (describing the properties of automata) is true. Indicate this sentence.
- In which function changing the disjunction symbol „+” to the modulo 2 symbol „ \oplus ” will not change the logical value of this function?
- Which Boolean function is linear?
- Only one of the sentences (describing the properties of JK flip-flop) is false. Indicate this sentence.
- How many different Boolean functions of 1 variable and how many different Boolean functions of 3 variables do exist?
- How are combinational and sequential logic implemented in FPGAs?
- What is the XOR polynomial canonical form of the function obtained from the Karnaugh table presented below?

x_1, x_2 x_3	00	01	11	10
0	1	1	0	0
1	1	1	0	0

14. What is the purpose of the finite automata with three coded inputs:

$$a \rightarrow 00 \quad b \rightarrow 01 \quad c \rightarrow 1-$$

and one output with the following graph:



15. Only one of the terms or definitions listed below has nothing to do with logic. Please indicate in which answer

Basics of Automation

1. Static characteristics of control plant allows to estimate ...(select correct answers)
2. The analytical formula of the time response of a plant is as follows: $y(t) = L^{-1}\{U(s) \cdot G(s)\}$. This formula describes ...
3. The spectral transfer function $G(j\omega)$ of the control plant can be calculated analytically as follows: ...
4. Which statements about proportional gain k_r of the PID controller are true?
5. Which statements about integral action (I) of PID controller are true?
6. Which statements about derivative action (D) of PID controller are true?
7. Characteristic polynomials of plants $M(s)$ are given. Mark the asymptotically stable polynomials.
8. Characteristic polynomials of plants $M(s)$ are given. Mark the unstable polynomials
9. The Nyquist plot of an open-loop control system is given. For phase $\varphi(\omega) = -180$ the real part of spectral transfer function is equal: $P(\omega) = -0.75$. The closed-loop control system will be: ...
10. The gain margin (on the Bode diagram) is equal 10 dB. This means that: ...
11. The closed-loop control system containing the 2'nd order plant with delay and linear controller is given. Which controller eliminates the steady-state error in this control system?
12. The settling time in a closed-loop control system (containing controller and control plant) can be estimated using: ...
13. The following performance index of closed-loop control system is given: $I_3 = \int_0^{\infty} \varepsilon^2(t) dt$, where $\varepsilon(t)$ is the error. Which of the following controllers assures finite value of this performance index?
14. The following performance index of closed-loop control system is given: $I_1 = \int_0^{\infty} \varepsilon(t) dt$, where $\varepsilon(t)$ is the error. Which functions $\varepsilon(t)$ can be estimated using it?

Analog electronics

1. The 9.3 k Ω resistor is serially connected to a silicon diode and connected to a 10V voltage in such a way that the diode is polarized in the direction of conduction. Calculate the current's value flowing in the circuit.
2. The 2.2 k Ω resistor is serially connected to a Zener diode (with a $U_z = 5.6$ V) and is connected to a 10V voltage in such a way that the Zener diode is polarized in a barrier direction. Calculate the current value flowing in the circuit.
3. The RC circuit limit frequency in which $R=1\text{k}\Omega$ and $C=1\mu\text{F}$ is equal: ...
4. A bipolar transistor, a type of npn with a gain of $\beta = 100$ works in a state of saturation. Knowing that a current flowing to the base is equal 1mA, the current of the collector is: ...
5. A j-fet field transistor with a channel type n, has got the following parameters: $I_{DSS} = 10\text{mA}$, $U_{off} = -2.5\text{V}$. Knowing that $U_{GS} = 0\text{V}$, the drain current is equal: ...
6. A replacement resistance of a parallel connection of resistors: ...
7. The voltage gain of an amplifier in the common emitter circuit (CE) where the R_E resistor is connected with the CE capacitor in parallel is as follow:

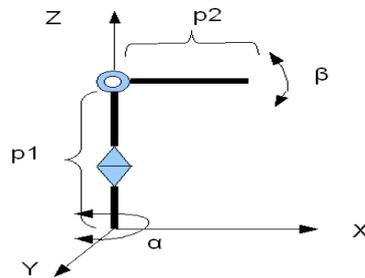
Microprocessor engineering

1. Define the minimum and maximum input and output voltage levels in the TTL standard.
2. Specify the function of a digital multiplexer.
3. Define the principle of the synthesis of logic functions by the "look-up table" method.
4. Define the main components of the JTAG interface.
5. Which digital-to-analog conversion method can filter the dominant sinusoidal disturbance? Explain the answer.
6. List all 8051 processor commands performing stack operations
7. Which VHDL statement allows specific actions to be taken in response to the rising edge of the CLK signal?
8. Determine the role of the process initialization list.

Basics of robotics

1. How many degrees of freedom has a kinematic pair of class V?
2. The number of degrees of freedom of a kinematic chain is ... (select correct statement)

3. Define robot redundancy. Robot is redundant if: ...
4. Jacobian matrix of the manipulator is a matrix which allows ...
5. Solve inverse kinematics for the robot below:



Dynamic system modelling

1. Which of the four types of mathematical models is the easiest for theoretical analysis: ... (select)
2. Static models are described by: ...
3. Transfer function of linear time invariant system $G(s)$ is defined as: ...
4. Which formula describes the solution of state equation?

Automation equipment

1. What is a job of a transducer in an industrial closed-loop control system?
2. Which temperature can be measured using RTD (resistive temperature detector)?
3. Flow rate of which liquids cannot be measured using inductive flow meter?
4. Where we are required to apply intrinsically safe equipment during construction of a control system?
5. Mark features of industrial network: ...
6. Which layers of OSI model are not defined for PROFIBUS network?
7. Which parameters need to be estimated during tuning of PID controller using limit cycle method?
8. Which elements are not parts of a digital controller?
9. Which factors can significantly increase the response time of a PLC?
10. Mark the basic features of the pneumatic cylinder
11. What is a sense of use a positioner in the pneumatic cylinder system?

12. What elementary assumptions need to be met during construction of safety circuits?
13. What is maximum resistance load of 4-20 [mA] current loop?
14. Which layers of OSI model are defined for HART network?
15. In which part of a pipeline the gas pressure sensor/transmitter should be installed?
16. Mark the basic features of the electric actuator

Control theory

1. Consider a dynamical system generated by differential equation:

$$\dot{x}(t) = Ax(t) + Bu(t), \quad A \in R^{n \times n}, B \in R^{n \times r}, \quad 0 \leq t \leq t_k < \infty$$

Let $\text{rank } B = r$. Degree of minimal polynomial of matrix $A \in R^{n \times n}$ is equal to m . Let us fix two arbitrary points in space R^n : $x^0 \in R^n$ and $x^k \in R^n$. When can we determine a control $u \in PC(0, t_k; R^r)$ such that $x(0) = x^0$ and $x(t_k) = x^k$?

2. Consider a dynamical system generated by differential equation:

$$\dot{x}(t) = Ax(t) + Bu(t), \quad A \in R^{n \times n}, B \in R^{n \times r}, \quad 0 \leq t$$

with feedback $u(t) = Kx(t)$, $K \in R^{r \times n}$.

Closed loop system is described by the differential equation $\dot{x}(t) = [A + BK]x(t)$.

Let $s_i(A)$, $i = 1, 2, \dots, n$ be eigenvalues of matrix $A \in R^{n \times n}$.

When can we determine a control $u(t) = Kx(t)$, $K \in R^{r \times n}$ such that the closed loop system is exponentially stable? In other words, when there exists K such that all eigenvalues of matrix $A + BK$ have negative real parts?

3. Consider a dynamical system generated by differential equation:

$$\dot{x}(t) = Ax(t) + Bu(t), \quad A \in R^{n \times n}, B \in R^{n \times r}, \quad 0 \leq t \leq t_k < \infty$$

Let us fix two arbitrary points in space R^n : $x^0 \in R^n$ and $x^k \in R^n$.

Which control $u \in PC(0, t_k; R^r)$ replaces system from point $x(0) = x^0$ into point $x(t_k) = x^k$?

4. Consider a dynamical system generated by differential equation:

$$\dot{x}(t) = Ax(t) + Bu(t), \quad A \in R^{n \times n}, B \in R^{n \times r}, \quad 0 \leq t$$

with feedback $u(t) = Kx(t) + v(t)$, $K \in R^{r \times n}$. Closed loop system is described by the differential equation $\dot{x}(t) = [A + BK]x(t) + Bv(t)$.

Let pair $(A; B)$ be controllable.

For which matrices $K \in R^{r \times n}$ closed loop system is controllable?

5. Consider a dynamical system generated by differential equation:

$$\dot{x}(t) = Ax(t), \quad x(0) \in R^n, \quad A \in R^{n \times n}, \quad 0 \leq t$$

Let us denote as $s_i(A)$ i -th eigenvalue of matrix $A \in R^{n \times n}$. Let $\|v\|$ denotes Euclidean norm of vector $v \in R^n$.

What condition is for the below implication?

For all $x(0) \in R^n$, $\|x(t)\| \rightarrow 0$ where $t \rightarrow \infty$? In other words, when dynamical system is asymptotically stable?

6. Consider a dynamical system generated by differential equation:

$$\dot{x}(t) = Ax(t), \quad x(0) \in R^n, \quad A \in R^{n \times n}, \quad 0 \leq t$$

Let us denote as $s_i(A)$ i -th eigenvalue of matrix $A \in R^{n \times n}$.

Which parameters are called frequencies of own oscillations of the system?

7. Consider a dynamical system described by equations:

$$\dot{x}(t) = Ax(t) + Bu(t), \quad A \in R^{n \times n}, \quad B \in R^{n \times r}, \quad 0 \leq t$$

$$y(t) = Cx(t), \quad C \in R^{m \times n}$$

Which $m \times r$ is called a matrix transfer function of the system?

8. Consider a dynamical system described by equations

$$\dot{x}(t) = Ax(t) + Bu(t), \quad A \in R^{n \times n}, \quad B \in R^{n \times r}, \quad 0 \leq t$$

$$y(t) = Cx(t), \quad C \in R^{m \times n}$$

and its matrix transfer function $G(s) = C[sI - A]^{-1}B$.

All eigenvalues of matrix $s_i(A)$ have negative real part so a dynamical system is asymptotically stable. Let $x(t) = 0$ for $t < 0$.

Let $m = r = 1$ (system is SISO). We denote $G(s) = \int_0^{\infty} g(t)e^{-st} dt$.

What is the output of a system $y(t)$, gdy $u(t) = \delta(t)$?

9. Consider a dynamical system described by equations:

$$\dot{x}(t) = Ax(t) + Bu(t), \quad A \in R^{n \times n}, \quad B \in R^{n \times r}, \quad 0 \leq t$$

$$y(t) = Cx(t), \quad C \in R^{m \times n}$$

and its matrix transfer function $G(s) = C[sI - A]^{-1}B$.

All eigenvalues of matrix $s_i(A)$ have negative real part so a dynamical system is asymptotically stable. The output $y(t)$ tends to $\tilde{y}(t)$ for $t \rightarrow \infty$.

Let $\|v\|$ be an Euclidean norm of vector $v \in R^m$. Convergence is understood as convergence with respect to the norm so for $t \rightarrow \infty$ we have $\|y(t)\| \rightarrow \|\tilde{y}(t)\|$.

Let $m = r = 1$ (SISO system). What is steady state output $\tilde{y}(t)$ for arbitrary $x(0)$ and $u(t) = c1(t)$, $c \in R$?

10. Consider a dynamical system described by equations:

$$\dot{x}(t) = Ax(t) + Bu(t), \quad A \in R^{n \times n}, B \in R^{n \times r}, \quad 0 \leq t$$

$$y(t) = Cx(t), \quad C \in R^{m \times n}$$

and a matrix transfer function $G(s) = C[sI - A]^{-1}B$ and spectral transfer function $G(j\omega)$, $j^2 = -1$, $\omega \geq 0$.

All eigenvalues of matrix A , $s_i(A)$ have negative real part so a dynamical system is asymptotically stable. The output $y(t)$ tends to $\tilde{y}(t)$ for $t \rightarrow \infty$.

Let $\|v\|$ be an Euclidean norm of vector $v \in R^m$. Convergence is understood as convergence with respect to the norm so for $t \rightarrow \infty$ we have $\|y(t)\| \rightarrow \|\tilde{y}(t)\|$.

Let $m = r = 1$ (SISO system). What is steady state output $\tilde{y}(t)$ for arbitrary $x(0)$ and $u(t) = \sin(\omega t)$?

11. Consider a discrete time dynamical system:

$$x[k+1] = Ax[k], \quad A \in R^{n \times n}, \quad k = 0, 1, 2, \dots$$

$z_i(A)$ denotes i -th eigenvalue of matrix $A \in R^{n \times n}$.

A system is asymptotically stable if for every $x[0] \in R^n$ when $k \rightarrow \infty$ the convergence $\|x[k]\| \rightarrow 0$ holds? Discrete time dynamical system is asymptotically stable if: ...

12. Consider second order homogeneous differential equation:

$$\ddot{x}(t) + b\dot{x}(t) + cx(t) = 0, \quad b, c \in R, \quad t \in R$$

Let $\Delta = b^2 - 4c$ and $\lambda^2 + b\lambda + c = (\lambda - \lambda_1)(\lambda - \lambda_2)$.

Which terms are correct?

13. Consider a dynamical system described by equations:

$$\dot{x}(t) = Ax(t) + Bu(t), \quad A \in R^{n \times n}, B \in R^{n \times r}, \quad 0 \leq t$$

$$y(t) = Cx(t), \quad C \in R^{m \times n}$$

and a state observer:

$$\dot{w}(t) = [A - GC]w(t) + Bu(t) + Gy(t), \quad G \in R^{n \times m}, \quad 0 \leq t$$

When a matrix $G \in R^{n \times m}$ exists such that $\|w(t) - x(t)\| \rightarrow 0$ for $t \rightarrow \infty$ and for all $x(0), w(0)$ and for all $u \in PC(0, \infty; R^r)$?

14. Consider a nonlinear system:

$$\dot{x}(t) = Ax(t) + \varphi(x(t)), \quad A \in R^{n \times n}, \quad \|\varphi(z)\|/\|z\| \rightarrow 0 \text{ gdy } \|z\| \rightarrow 0$$

and its linear approximation

$$\dot{w}(t) = Aw(t)$$

When in some small vicinity of zero phase trajectories of nonlinear system are similar to phase trajectories of linear approximation?

15. Consider a dynamical asymptotically stable and detectable system described by equations

$$\dot{x}(t) = Ax(t), \quad x(0) \in R^n, \quad A \in R^{n \times n}, \quad 0 \leq t$$

$$y(t) = Cx(t), \quad C \in R^{m \times n}$$

Let $v(z) = z^T Vz$, $V^T = V \in R^{n \times n}$ be a Lyapunov functional of our system, where V is a solution of a Lyapunov equation $A^T V + VA = -C^T C$. In that case we have

$$\dot{v}(z) = -z^T C^T C z.$$

$$\text{Let } J(x(0)) = \int_0^{\infty} y(t)^T y(t) dt.$$

Knowing Lyapunow functional for our system, what is the value of the performance index $J(x(0))$, which evaluates velocity of vanishing of the function $y(t)$?

Vision systems

1. Median filtration is a ... operation (select correct answer)
2. Which features of an object should not affect the values of shape coefficients?