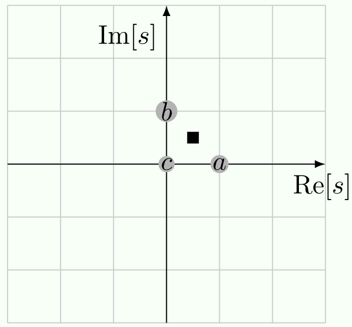
**Question 1**

Where will the sequence of the powers of the complex number ■, i.e., $■^k$ for $k \to +\infty$, converge?




**Potential answers:**

I: $a$

II: $b$

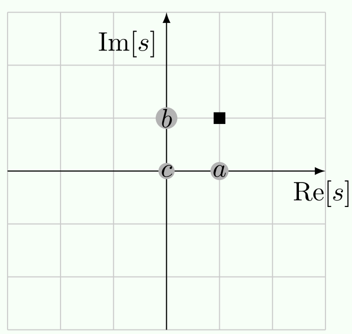
III: $c$

IV: it will diverge

V: I do not know

**Question 2**

Where will the sequence of the powers of the complex number ■, i.e., $■^k$ for $k \to +\infty$, converge?




**Potential answers:**

I: $a$

II: $b$

III: $c$

IV: it will diverge

V: I do not know

**Question 3**

One may use the concept of "impulse response" to describe a nonlinear system.

**Potential answers:**

I: true

II: false

III: it depends on the nonlinear system

IV: I do not know

**Question 4**

One may use the concept of "transfer function" to describe a nonlinear system.

**Potential answers:**

I: true

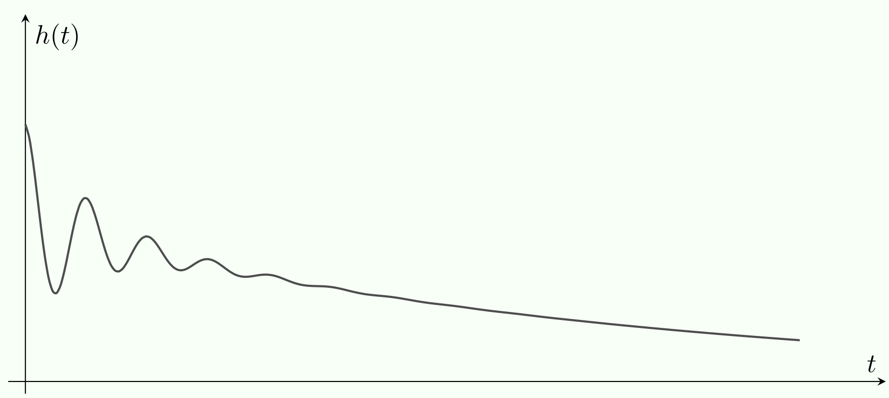
II: false

III: it depends on the nonlinear system

IV: I do not know

**Question 5**

Which type of LTI system may produce the impulse response $h(t)$ represented in the picture?




**Potential answers:**

I: first order

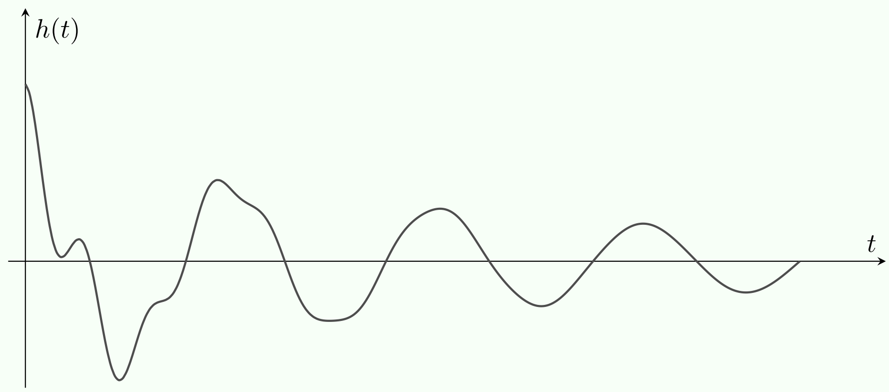
II: second order

III: at least third order

IV: I do not know

**Question 6**

Which type of LTI system may produce the impulse response $h(t)$ represented in the picture?




**Potential answers:**

I: first order

II: second order

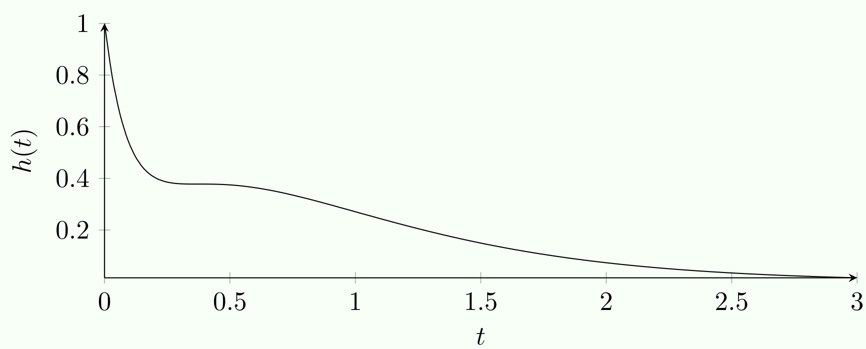
III: third order

IV: at least fourth order

V: I do not know

**Question 7**

Which type of LTI system may produce the impulse response $h(t)$ represented in the picture?




**Potential answers:**

I: first order

II: second order

III: at least third order

IV: I do not know

## Question 8

For which value of $a$ are the equilibria of the continuous-time autonomous LTI system $\dot{y} = ay$ asymptotically stable?

**Potential answers:**

I: $a < 0$

II: $a \leq 0$

III: $a = 0$

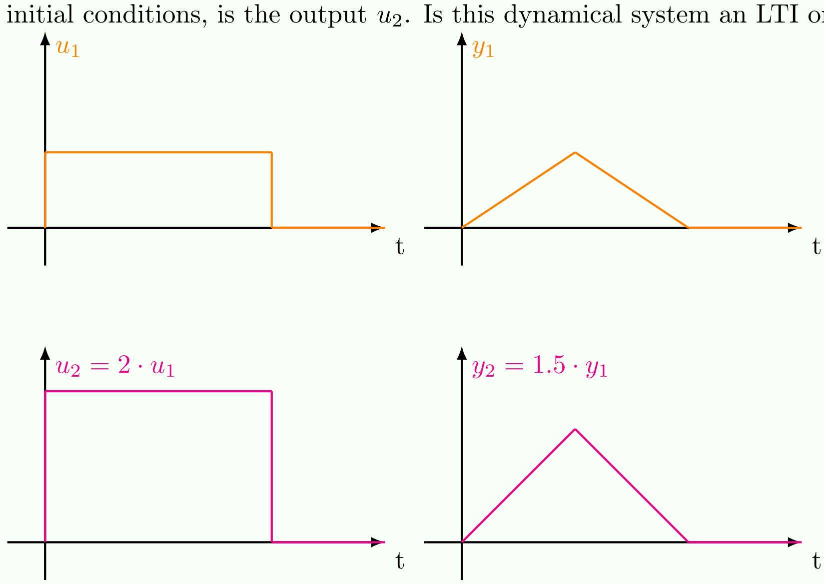
IV: $a \geq 0$

V: $a > 0$

VI: I do not know

## Question 9

Consider a dynamical system whose response to the input $u_1$ below, starting from null initial conditions, is the output $y_1$. Consider also that the response of this system to the input $u_2$ below, again starting from null initial conditions, is the output $u_2$. Is this dynamical system an LTI one?




**Potential answers:**

I: yes

II: no

III: it depends on the actual values of $u_1$ and $y_1$

IV: I do not know

**Question 10**

The impulse response associated to the system $\dot{y} = -0.5y + 3u$ is equal to ...

**Potential answers:**

I: $e^{0.5t}$

II: $e^{-0.5t}$

III: $0.5e^{0.5t}$

IV: $-0.5e^{-0.5t}$

V: $3e^{0.5t}$

VI: $3e^{-0.5t}$

VII: $e^{0.5t}$ for $t \geq 0$, 0 otherwise

VIII: $e^{-0.5t}$ for $t \geq 0$, 0 otherwise

IX: $0.5e^{0.5t}$ for $t \geq 0$, 0 otherwise

X: $-0.5e^{-0.5t}$ for $t \geq 0$, 0 otherwise

XI: $3e^{0.5t}$ for $t \geq 0$, 0 otherwise

XII: $3e^{-0.5t}$ for $t \geq 0$, 0 otherwise

XIII: I do not know

**Question 11**

The impulse response of a LTI system contains all the information that is needed to compute the trajectories of that system for every input $u$ and initial condition $y_0$.

**Potential answers:**

I: true

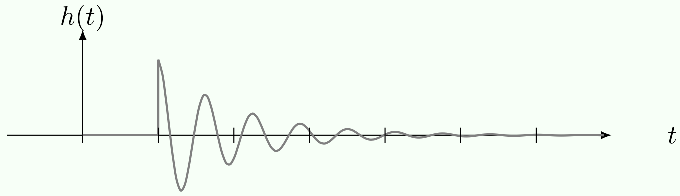
II: false

III: it depends

IV: I do not know

**Question 12**

Consider the impulse response $h(t)$ given by the plot below, where the distance between consecutive marks in the axes indicate one unit.




Assume that for $t < 0$ the LTI system characterized by this impulse response is in equilibrium, i.e., that $y(t) = 0$ for $t < 0$, and that and also $u(t) = 0$ for $t < 0$. Assume then $u(t)$ to be a Dirac delta centered in $t - 10$, i.e., $u(t) = \delta(t - 10)$. Then the output of the system at time 10.0001 is ...

**Potential answers:**

I: $y(10.0001) < 0$

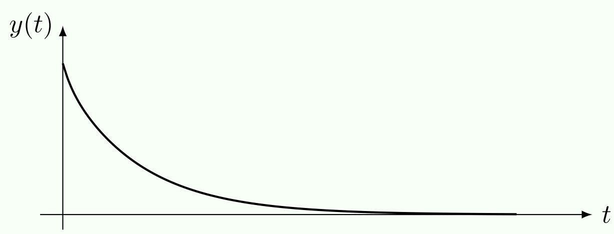
II: $y(10.0001) = 0$

III: $y(10.0001) > 0$

IV: I do not know

**Question 13**

The following response




corresponds to a ... response.

**Potential answers:**

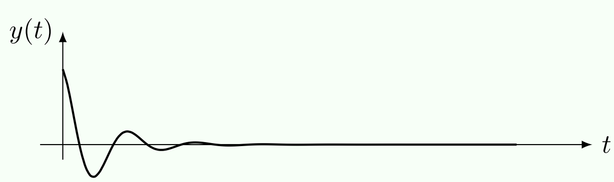
I: underdamped

II: overdamped

III: I do not know

**Question 14**

The following response



corresponds to a . . . response

**Potential answers:**

I: underdamped

II: overdamped

III: I do not know

**Question 15**

The convolution of a rectangular signal with itself leads to . . .

**Potential answers:**

I: another rectangle

II: a triangle

III: a trapezoid

IV: it depends on the length of the rectangle

V: I do not know

**Question 16**

Convolution is a nonlinear operator.

**Potential answers:**

I: true

II: false

III: it depends on the actual signals that are convolved

IV: I do not know

**Question 17**

The equilibria of the system

$$\dot{x} = f(x) = x^2 - 2x - 3$$

are . . .

**Potential answers:**

I: -1

II: 3

III: both -1 and 3

IV: I do not know

**Question 18**

Consider the dynamics $\dot{x} = x^2$, and the trajectory corresponding to $x_0 = c$, given by

$$x(t) = \frac{c}{1-t}.$$

This trajectory ...

**Potential answers:**

I: is bounded

II: diverges to $+\infty$

III: presents a finite escape time

IV: I do not know

**Question 19**

The following definition of simple stability for an equilibrium is correct:

$$\boldsymbol{y}_{eq} \textit{ is simply stable if } \forall\delta > 0 \ \exists\varepsilon > 0 \textit{ s.t. if } \|\boldsymbol{y}_0 - \boldsymbol{y}_{eq}\| \leq \delta \textit{ then } \|\boldsymbol{y}(t) - \boldsymbol{y}_{eq}\| \leq \varepsilon \quad \forall t \geq 0$$

**Potential answers:**

I: true

II: false

III: it depends

IV: I do not know

**Question 20**

The following definition of simple stability is correct:

$$\boldsymbol{y}_{eq} \textit{ is simply stable if } \exists\varepsilon > 0 \ \forall\delta > 0 \textit{ s.t. if } \|\boldsymbol{y}_0 - \boldsymbol{y}_{eq}\| \leq \delta \textit{ then } \|\boldsymbol{y}(t) - \boldsymbol{y}_{eq}\| \leq \varepsilon \quad \forall t \geq 0$$

**Potential answers:**

I: true

II: false

III: it depends

IV: I do not know

## Question 21

The following definition of simple stability is correct:

$$\boldsymbol{y}_{eq} \textit{ is simply stable if } \forall \varepsilon > 0 \; \exists \delta > 0 \textit{ s.t. if } \|\boldsymbol{y}_0 - \boldsymbol{y}_{eq}\| \leq \varepsilon \textit{ then } \|\boldsymbol{y}(t) - \boldsymbol{y}_{eq}\| \leq \delta \quad \forall t \geq 0$$

**Potential answers:**

I: true

II: false

III: it depends

IV: I do not know

## Question 22

The following definition of simple stability is correct:

$$\boldsymbol{y}_{eq} \textit{ is simply stable if } \forall \varepsilon > 0 \; \exists \delta > 0 \textit{ s.t. if } \|\boldsymbol{y}_0 - \boldsymbol{y}_{eq}\| \leq \delta \textit{ then } \|\boldsymbol{y}(t) - \boldsymbol{y}_{eq}\| \leq \varepsilon \quad \forall t \geq 0$$

**Potential answers:**

I: true

II: false

III: it depends

IV: I do not know

## Question 23

The origin $(\boldsymbol{u}, \boldsymbol{y}) = (\boldsymbol{0}, \boldsymbol{0})$ is always an equilibrium for a LTI system of the type $\dot{\boldsymbol{y}} = A\boldsymbol{y} + B\boldsymbol{u}$.

**Potential answers:**

I: true

II: false

III: it depends

IV: I do not know

**Question 24**

The origin is always an equilibrium for a generic system of the type $\dot{\boldsymbol{y}} = \boldsymbol{f}(\boldsymbol{y}, \boldsymbol{u})$.

**Potential answers:**

I: true

II: false

III: it depends

IV: I do not know

**Question 25**

If one says that the matrix $A$ has a trivial kernel, what does this mean?

**Potential answers:**

I: $\mathrm{Ker}(A) = 0$

II: $\mathrm{Ker}(A) = \{0\}$

III: it depends

IV: I do not know

**Question 26**

Can an autonomous LTI system of the type $\dot{\boldsymbol{x}} = A\boldsymbol{x}$ have equilibria of different types? (i.e., have a $\boldsymbol{x}_1$ that is an asymptotically stable equilibrium for the system, another $\boldsymbol{x}_2$ that is instead a marginally stable equilibrium, etc.)

**Potential answers:**

I: yes

II: no

III: it depends

IV: I do not know

## Question 27

Is the continuous time LTI system characterized by the impulse response

$$h(t) = \begin{cases} e^{-2t} & \text{if } t \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

BIBO stable?

**Potential answers:**

I: yes

II: no

III: it depends

IV: I don't know

## Question 28

Is the continuous time LTI system characterized by the impulse response

$$h(t) = \begin{cases} 1 & \text{if } t \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

BIBO stable?

**Potential answers:**

I: yes

II: no

III: it depends

IV: I don't know

**Question 29**

Is the continuous time LTI system characterized by the impulse response

$$h(t) = \begin{cases} \dfrac{1}{t+1} & \text{if } t \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

BIBO stable?

**Potential answers:**

I: yes

II: no

III: it depends

IV: I don't know

**Question 30**

Is the transfer function corresponding to the impulse response

$$h(t) = \begin{cases} \dfrac{1}{t+1} & \text{if } t \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

a rational transfer function?

**Potential answers:**

I: yes

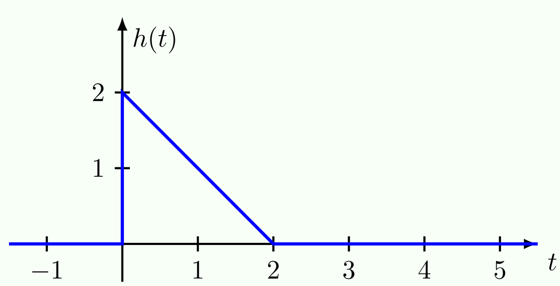
II: no

III: it depends

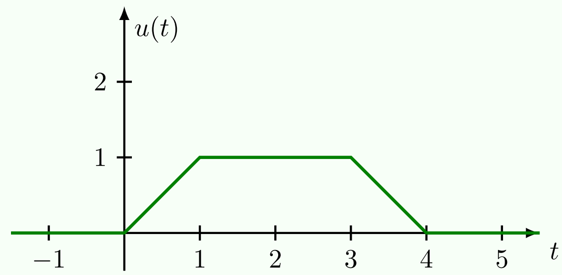
IV: I don't know

**Question 31**

Consider a continuous time LTI system with impulse response $h(t)$ is equal to




and the input signal $u(t)$ equal to




The forced response of the system at $t = 5$ is then equal to ...

**Potential answers:**

I: 1

II: 1/6

III: 6

IV: I don't know

**Question 32**

Can a delayed LTI system (i.e., a LTI system whose impulse response contains a delay) be BIBO stable?

**Potential answers:**

I: yes

II: no

III: it depends

IV: I do not know

**Question 33**

Can a non-causal LTI system be BIBO stable?

**Potential answers:**

I: yes

II: no

III: it depends

IV: I do not know

**Question 34**

Can a LTI system whose transfer function have some poles on the imaginary axis be BIBO stable?

**Potential answers:**

I: yes

II: no

III: it depends

IV: I do not know

**Question 35**

How may one interpret the kernel of a $\mathbb{R}^{n \times m}$ matrix $A$?

**Potential answers:**

I: as the set of equilibria of the system $\dot{\boldsymbol{x}} = A\boldsymbol{x}$

II: as the set of equilibria of the system $\dot{\boldsymbol{x}} = A\boldsymbol{x} + B\boldsymbol{u}$

III: as the set of zeros of the linear map induced by $A$

IV: as the domain of the linear map induced by $A$

V: it depends

VI: I do not know

**Question 36**

How may one interpret the determinant of a $\mathbb{R}^{n \times n}$ matrix $A$?

**Potential answers:**

I: as a measure of the size of the matrix

II: as a measure of the stretching induced by the matrix when transforming the domain into the codomain

III: as a measure of how big the eigenvalues of $A$ are

IV: as a measure of the degree of diagonalizability of the matrix $A$

V: as a measure of the degree of invertibility of the matrix $A$

VI: I do not know

**Question 37**

Which is more correct to say among these two options?

1. a matrix defines a specific linear transformation
2. a matrix defines a specific linear transformation from a specific basis into another

**Potential answers:**

I: the first

II: the second

III: they are equivalent

IV: I don't know

**Question 38**

If a $n \times n$ square matrix has $n$ different eigenvalues then it is diagonalizable

**Potential answers:**

I: true

II: false

III: it depends

IV: I don't know

**Question 39**

A $n \times n$ square matrix needs to have $n$ different eigenvalues to be diagonalizable

**Potential answers:**

I: true

II: false

III: it depends

IV: I don't know

**Question 40**

A $n \times n$ square matrix needs to have its determinant different from zero to be diagonalizable

**Potential answers:**

I: true

II: false

III: it depends

IV: I don't know

**Question 41**

Consider a generic matrix $A \in \mathbb{R}^{n \times n}$, and its characteristic polynomial, i.e., the scalars $\alpha_0, \alpha_1, \ldots, \alpha_{n-1}$ such that

$$A^n = -\alpha_{n-1} A^{n-1} - \ldots - \alpha_1 A - \alpha_0 I$$

and forming the polynomial

$$s^n + \alpha_{n-1} s^{n-1} + \ldots + \alpha_1 s + \alpha_0.$$

Then the characteristic polynomial is the lowest order polynomial that is nullified by $A$. I.e., there are no other scalars $\beta_0, \beta_1, \ldots, \beta_{m-1}$ with $m < n$ such that

$$A^m = -\beta_{m-1} A^{m-1} - \ldots - \beta_1 A - \beta_0 I$$

**Potential answers:**

I: true

II: false

III: it depends

IV: I don't know

**Question 42**

Assume that an autonomous continuous time LTI system $\dot{\boldsymbol{x}} = A\boldsymbol{x}$ is s.t. its state update matrix $A$ is s.t. $A^m = \mathbf{0}$ for some $m \geq 0$. How does this help computing the free evolution of the system?

**Potential answers:**

I: it helps computing the matrix exponential $e^{At}$ associated to the system

II: it helps simplifying the convolution operation one should solve to find the response

III: it helps identifying the stability properties of the system (i.e., it show that the system is marginally stable)

IV: it helps computing the determinant of the system

V: I don't know

**Question 43**

Consider a continuous time input output LTI system of order 4 for which all the poles of its transfer function are distinct. Must the associated impulse response comprise at least one mode of the type $e^{\lambda t}$ with $\lambda \in \mathbb{R}$?

**Potential answers:**

I: yes

II: no

III: it depends

IV: I don't know

**Question 44**

Consider a continuous time input output LTI system of order 3 for which all the poles of its transfer function are distinct. Must the associated impulse response comprise at least one mode of the type $e^{\lambda t}$ with $\lambda \in \mathbb{R}$?

**Potential answers:**

I: yes

II: no

III: it depends

IV: I don't know

**Question 45**

How would one Laplace-transform the ODE $\dddot{y} = \dot{y} + u$, assuming that all the initial conditions are 0?

**Potential answers:**

I: $s^{-3}Y = s^{-1}Y + U$

II: $s^{3}Y = sY + U$

III: I do not know

**Question 46**

To what does $\frac{1}{s}$ correspond, from an intuitive perspective, if we consider Laplace transforms of continuous time signals?

**Potential answers:**

I: a derivative

II: an integrator

III: a multiplication in frequency

IV: I do not know

**Question 47**

What is the region of convergence of the unilateral Laplace transform of the signal $e^{at}$?

**Potential answers:**

I: $\mathrm{Re}\left[s\right] < 0$

II: $\mathrm{Re}\left[s\right] < a$

III: $\mathrm{Re}\left[s\right] > 0$

IV: $\mathrm{Re}\left[s\right] > a$

V: I do not know

**Question 48**

What is the time constant associated to the continuous time LTI system whose transfer function is $\frac{1}{s+3}$?

**Potential answers:**

I: 0.3

II: 3

III: $1/3$

IV: undefined

V: I do not know

**Question 49**

$\mathcal{L}\left(\ddot{x}\right) =?$

**Potential answers:**

I: $s^2X(s) + sx(0) + \dot{x}(0)$

II: $s^2X(s) - sx(0) - \dot{x}(0)$

III: $s^2X(s) + s\dot{x}(0) + x(0)$

IV: $s^2X(s) - s\dot{x}(0) - x(0)$

V: I do not know

**Question 50**

$\mathcal{L}\left(t^n e^{at}\right) =?$

**Potential answers:**

I: $\frac{n!}{(s-a)^n}$

II: $\frac{n!}{(s-a)^{n+1}}$

III: $\frac{n!}{(s+a)^n}$

IV: $\frac{n!}{(s+a)^{n+1}}$

V: I do not know

**Question 51**

In which situation is a second order continuous time LTI system said to be critically damped? When the poles of its transfer function are ...

**Potential answers:**

I: both real and distinct

II: coinciding and real, i.e., the transfer function has a double real pole

III: a complex conjugate pair

IV: I do not know

**Question 52**

In which situation is a second order continuous time LTI system said to be overdamped? When the poles of its transfer function are ...

**Potential answers:**

I: both real and distinct

II: coinciding and real, i.e., the transfer function has a double real pole

III: a complex conjugate pair

IV: I do not know

**Question 53**

In which situation is a second order continuous time LTI system said to be underdamped? When the poles of its transfer function are ...

**Potential answers:**

I: both real and distinct

II: coinciding and real, i.e., the transfer function has a double real pole

III: a complex conjugate pair

IV: I do not know

**Question 54**

Consider writing the free evolution of a continuous time LTI system as a sum of modes, i.e.,

$$y_{\mathrm{fe}}(t) = \sum_i c_i t^{m_i} \exp(\alpha_i t) \cos(\omega_i t + \phi_i).$$

Which of the various parameters above may change with the initial conditions (i.e., $y(0)$, $\dot{y}(0)$, $\ddot{y}(0)$, ...) of the system?

**Potential answers:**

I: only the residuals $c_i$ and the phase shifts $\phi_i$

II: only the orders of the modes $m_i$

III: only the time constants $\left|\frac{1}{\alpha_i}\right|$

IV: only the frequencies $\omega_i$

V: I do not know

**Question 55**

Which measurement unit is associated to $s$ in a Laplace transform of a signal $y(t)$?

**Potential answers:**

I: seconds

II: $\text{seconds}^{-1}$

III: hours

IV: $\text{hours}^{-1}$

V: none of the above

VI: I do not know

**Question 56**

The number of potentially different modes that compose the impulse response of a continuous time LTI system is ...

**Potential answers:**

I: equal to the number of zeros of its transfer function, counted with their multiplicity

II: at most equal to the number of zeros of its transfer function, counted with their multiplicity

III: equal to the number of poles of its transfer function, counted with their multiplicity

IV: at most equal to the number of poles of its transfer function, counted with their multiplicity

V: I do not know

**Question 57**

Every continuous time LTI system admits a rational transfer function.

**Potential answers:**

I: true

II: false

III: it depends on the system

IV: I do not know

**Question 58**

The BIBO stability properties of a continuous time LTI system depend on the position of the zeros of the transfer function of the system, assuming there are no zero poles cancellations.

**Potential answers:**

I: true

II: false

III: it depends on the system

IV: I do not know

**Question 59**

Changing the zeros of a transfer function of an LTI system means changing the transient associated to the step response of that system.

**Potential answers:**

I: true

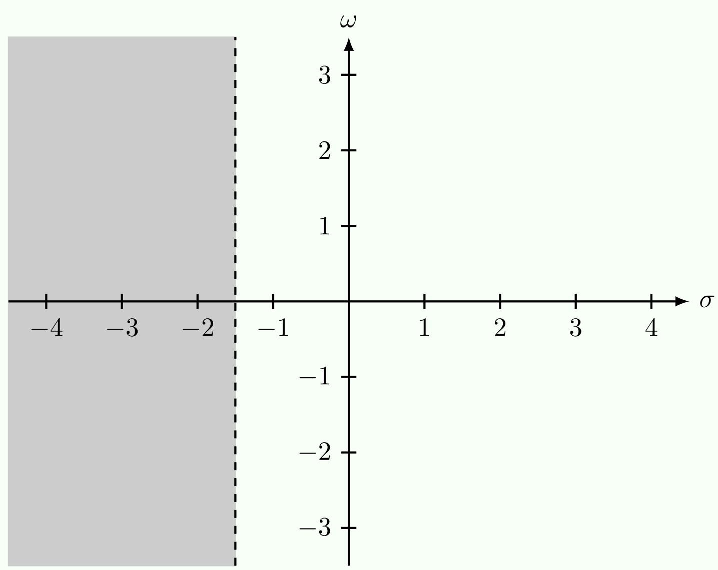
II: false

III: it depends on the system

IV: I do not know

**Question 60**

Assume to know that the region of convergence of the Laplace transform of a time signal $f(t)$ is as in the figure below (i.e., the shaded area is where the Laplace transform does **not** converge). Then ...



**Potential answers:**

I: $\lim_{t \to 0} f(t) = 0$

II: $\lim_{t \to 0} |f(t)| = +\infty$

III: $\lim_{t \to +\infty} f(t) = 0$

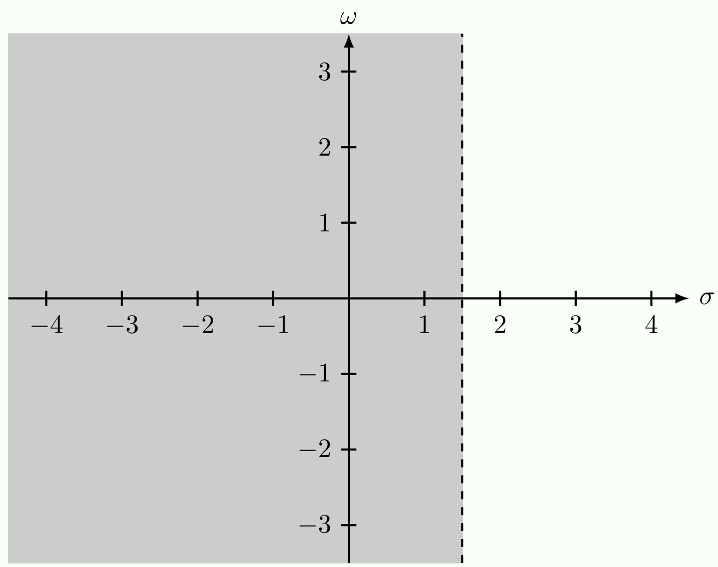
IV: $\lim_{t \to +\infty} |f(t)| = +\infty$

V: it depends on $f(t)$

VI: I do not know

**Question 61**

Assume to know that the region of convergence of the Laplace transform of a time signal $f(t)$ is as in the figure below (i.e., the shaded area is where the Laplace transform does **not** converge). Then ...




**Potential answers:**

I: $\lim_{t \to 0} f(t) = 0$

II: $\lim_{t \to 0} |f(t)| = +\infty$

III: $\lim_{t \to +\infty} f(t) = 0$

IV: $\lim_{t \to +\infty} |f(t)| = +\infty$

V: it depends on $f(t)$

VI: I do not know