Master entrance examination of Beihang, 2019 -2020

Syllabus of Engineering Science

Part I: Linear Time-Invariant systems

Chapter 1: Modeling of automation systems

I – Forward chain control
II – Feedback control

Chapter 2: Hypotheses related to the study of linear time-invariant (LTI) systems

I – Continuity
- 1°) Definition
- 2°) Mathematical consequence

II – Linearity
- 1°) Concept of operating point
- 2°) Local linearization
- 3°) Mathematical consequence
- 4°) Main types of nonlinearities

III – Time invariance
- 1°) Definition
- 2°) Mathematical consequence

Chapter 3: Performances of LTI systems

I – Steady-state performances
- 1°) Stability
- 2°) Precision and robustness

II – Transient-state performances
- 1°) Swiftness
- 2°) Damping

Chapter 4: Mathematical tools for the study of LTI systems

I – Laplace transform of a continuous signal
- 1°) Determination of the time response by convolution
- 2°) Definition of the Laplace transform
- 3°) Convolution product and transfer function
- 4°) Mathematical properties and main theorems
- 5°) Laplace transform of basic signals

II – Modeling by a block diagram

Chapter 5: Time response

I – 1st order systems

- 1°) Differential equation and transfer function
- 2°) Step response
- 3°) Impulse response
- 4°) Response to a ramp

II – 2nd order systems

- 1°) Differential equation and transfer function
- 2°) Step response
- 3°) Impulse response and response to a ramp

III – Other systems

- 1°) Partial fraction decomposition
- 2°) General methodology and implications

Chapter 6: Frequency response

I – Definition and methods

- 1°) Definition
- 2°) Determination of the magnitude and phase shift
- 3°) Magnitude and phase plots

II – Frequency plots

- 1°) Bode plots
- 2°) Nichols plot
- 3°) Nyquist plot

III – Frequency response of some basic systems

- 1°) Integrator system
- 2°) 1st order system
- 3°) 2nd order system
- 4°) Pure delay

IV – Frequency response of other systems

- 1°) General form of a transfer function
- 2°) General methodology and consequences

Chapter 7: Algebraic methods for the determination of the performances of a LTI system

I – Stability

- 1°) Analysis of the transfer function
- 2°) Algebraic determination by means of Routh-Hurwitz's criterion

II – Precision and robustness

- 1°) Different types of closed-loop transfer function
- 2°) Precision conditions
- 3°) Robustness conditions

III – Swiftness and damping

- 1°) Notion of dominant pole
- 2°) Determination of swiftness
- 3°) Determination of damping

Chapter 8: Determination of the performances of a LTI system from the frequency response of its open-loop transfer function

I – General methodology: Nyquist's criterion
II – Stability
  1°) Nyquist's simplified criterion
  2°) Stability margins
III – Damping: Nichols chart
IV – Precision/robustness and swiftness

Chapter 9: Compensation of control systems

I – Constraints, purpose and limits of controllers
  1°) Problem
  2°) Controllers
II – Classical controllers
  1°) Proportional controllers
  2°) Integral controllers
  3°) Derivative controllers
  4°) Complete PID controllers

Part II: Mechanics of systems of rigid solid bodies

I – Fundamental law of equilibrium
II – Fundamental law of dynamics