مواد الامتحان التنافسي لدراسة الدكتوراه في تخصص هندسة السيطرة

للعام الدراسي 2021-2022

ت	اسم المادة	تفاصيل المفردات
1	Mathematics	**1- Ordinary differential equations:** **a)** Solution to linear ordinary differential equation. **b)** Series solution to ODE (power series solution, Legendre polynomial, Frobenius solution and Bessel's function). **c)**Existence and Uniqueness. **2- Complex Analysis:** **a)**Complex plane, Limit and continuity, Analytic function. **b)**Elementary functions. **c)** Complex integration (Line integral using the representation of curve, Cauchy's integral theorem, Cauchy's integral formula). **d)** Infinite series in the complex plane (Convergence and divergence series, Power series, Laurent's expansion). **e)** The theory of residues (Residue integration method, Evaluation of real definite integral). **3-Linear Algebra and Functional Analysis:** **a)** Linear Systems of Equations (Gaussian Elimination). **b)** Matrix Algebra (Matrix Addition and Multiplication, Special Matrices and Transposes, Matrix Inverses, Basic Properties of Determinants). **c)** Vector Spaces and Subspaces (definition of vector spaces and linear transformation, Subspaces, Linear Combinations, Subspaces Associated with Matrices and Operators, Bases and Dimension). **d)**The Eigenvalue Problem(Definitions and Basic Properties, Similarity and Diagonalization, Orthogonal Diagonalization, the Singular Value Decomposition) **e)** Functional Analysis (Normed Linear Spaces and Banach Spaces,Inner Product and Hilbert Spaces) **References:** **1)**Erwin Kreyszig. Advanced Engineering Mathematics. by John Wiley & Sons, 2011. **2)**Thomas S. Shores. Applied Linear Algebra and Matrix Analysis.Springer Science + Business Media, LLC, 2007.
2	Robust Control	**1- Feedback Analysis and Design** a) Sensitivity Functions b) Internal Stability c) Performance Issues of Feedback Design d) Tradeoffs in Feedback Design e) Loop Shaping **2- Model Uncertainty**

a) Additive and Multiplicative Uncertainty **b)** Uncertainty Weighting Function **c)** Robustness Analysis **d)** Robust Stability Analysi **3-Robust Feedback Design** a) Mixed Sensitivity b) Lower Fractional Transformation (LFT) and Upper Fractional Transformation (UTF) c) H2 and H-infinity Optimal Control **References:** 1) Essentials of Robust Control Author: Zhou and Doyle Publisher: Prentice-Hall, 1988 2) Robust Control Design, An Optimal Control Approach Author: Feng Lin Publisher: Wiley, 2007		
1- Knowledge Based Systems: a) Knowledge-Based Systems. b) Expert System. c) Rule-Based Systems. d) Rete algorithm, Conflict resolution, Forward-Chaining ,Backward-Chaining. **2- Artificial Neural Networks:** a) Feed-forward Neural Network, Feedback Neural Network, Neural Processing, Learning and adaptation, Learning rules, Single-Layer and Multi-Layer Perceptron classifiers. b) Nonparametric training concept, Multilayer Feed-Forward Networks. c) Error back-propagation training and learning factors. d) Single Layer Feedback Networks. e) Spiking Neural Network. **3-Fuzzy Logic Control:** a) Foundations of Fuzzy Logic: Sets, Types of Memberships, Logical operations, If-Then Rules. b) Fuzzy Inference Systems. c) Fuzzy Logic Control (Continuous and discrete). d) Type-2 FLC and Interval Type-2 FLC. e) ANFIS. **4- Genetic Algorithm (Binary and Continuous) :** a) Components of a Binary GA, Selecting the Variables and Cost Function b) Variables Coding and Decoding c) Natural Selection methods (mating). d) Types of mating (Cross-Over). e) Mutations f) Next generation. g) Convergence. **References:**	Intelligent Control Systems	3

1)"Introduction to Artificial Neural Systems" By: Jacek M. Zurada, 1999. 2) "Fuzzy Control" By: Kevin M. Passino and Stephen Yurkovich, 1998 3) Practical Genetic Algorithms" By: Randy L. Haupt and Sue Ellen Haupt, 2004		
1-Calculus of Variations and Optimal Control a) Optimum of a Function and a Functional b) The Basic Variational Problem c) The Second Variation d) Extrema of Functions with Conditions e) Extrema of Functionals with Conditions f) Variational Approach to Optimal Control Systems i-Terminal Cost Problem ii- Different Types of Systems iii- Sufficient Condition **2- Linear Quadratic Optimal Control** a) Problem Formulation b) Finite-Time Linear Quadratic Regulator i-Symmetric Property of the Riccati Coefficient Matrix ii-Optimal Control iii- Optimal Performance Index iv-Finite-Time Linear Quadratic Regulator c) Infinite-Time LQR System II i- Meaningful Interpretation of Riccati Coefficient ii- Analytical Solution of the Algebraic Riccati Equation. iii- Infinite-Interval Regulator System: iv- Stability Issues of Time-Invariant Regulator v- Equivalence of Open-Loop and Closed-Loop Optimal Controls **3- Constrained Optimal Control Systems** a) Constrained Optimal Control i- Time-Optimal Control of LTI System ii- Problem Formulation and Statement iii- Solution of the TOC System iv- Structure of Time-Optimal Control System b) TOC of a Double Integral System i- Problem Formulation and Statement. ii- Problem Solution. iii- Engineering Implementation of Control Law. **<u>References:</u>** Desineni Subbaram Naidu, **Optimal Control Systems**, CRC Press LLC, 2003.	Optimal Control	4
1- Second order Systems a) Qualitative Behavior of Linear Systems. b) Multiple Equilibria.	Nonlinear Control System	5

c) Qualitative Behavior Near Equilibrium Points. d) Limit Cycles. **2- Lyapunov Stability** a) Basic Theorems of Lyapunov's Method for Autonomous systems. b) The Invariance Principle. c) Stability of Perturbed Systems 1- Vanishing Perturbation 2- Nonvanishing Perturbation **3- Feedback Control** a) Control Problems b) Stabilization via Linearization c) Integral Control **4- Feedback Linearization** a) Feedback Linearizable System b) Input-Output Linearization **5- Nonlinear Design Tools** a) Lyapunov Redesign b) Backstepping **References:** 1) H. K. Khalil, **Nonlinear Systems,** Prentice Hall, Upper Saddle River, New Jersey, 2002. **2)** J. J. E. Slotine and W. Li. **Applied Nonlinear Control.**Prentice Hall, Englewood Cliffs, NJ, 1991.		
1- Analysis of Control Systems in State Space: (The State Space Approach, Diagonalization, Cayley–Hamilton theorem, State Transition Matrix, Controllability, Observability, Solution of linear time invariant state equations, Solution of linear time varying state equations). 2- **Realization and Stability:** (Stability definitions, internal stability, BIBO stability). 3- **Pole-Placement Design using Full State Feedback:** (Pole-Placement Regulator Design for single input plants, Pole-Placement Regulator design for Plant with Noise, Pole-Placement Design of Tracking systems) 4- **State observers:** (Full order state Observers, Reduced Order State Observer, Ackerman's formula) 5- **Kalman Filter**: (Filtering of Random Signals, White Noise, State Estimation)	Advanced Control Theory	6

References: Burns Ronald S. "Advanced Control Engineering", First Edition 2001.		
1-**Mathematical Modeling of Dynamic Systems** a) Transfer Function and Impulse-Response b) Block Diagrams c) Mechanical Systems d) Electrical Systems e) Liquid-Level Systems f) Thermal Systems **2-Transient and Steady State Response Analysis** a) First-Order Systems b) Second-Order Systems c)Transient-Response Analysis **3-Basic Control Actions and Response of Control System.** a) Basic Control Actions b) Effects of Integral and Derivative Control Actions on System Performance c) Higher-Order Systems d) Routh's Stability Criterion f) Steady-State Errors in Unity-Feedback Control Systems **4-Root Locus Analysis** a) Root-Locus Plots b) Summary of General Rules for Constructing Root Loci c) Root-Locus Plots problems and Solutions d) Root-Locus Analysis of Control Systems e) Root Loci for Systems with Transport Lag **5-Control Systems Design by the Root-Locus Method** a) Preliminary Design Considerations b) Lead Compensation c) Lag Compensation d) Lag-Lead Compensation **6-Frequency Response Analysis** a) Bode Diagrams b) Plotting Bode Diagrams c) Polar Plots d) Drawing Nyquist Plots e) Log-Magnitude versus Phase Plots f)Nyquist Stability Criterion g) Stability Analysis h) Experimental Determination of Transfer Functions **7-Control Systems Design by Frequency Response.** a) Lead Compensation	Classical Control Theory	7

b) Lag Compensation c) Lag-Lead Compensation **References**: Katsuhiko Ogata, **Modern Control Engineering**, 3rd Edition 1997.		
1- State Feedback Direct Model Reference Adaptive Control (Direct MRAC Design for Scalar Systems, Dynamic Inversion MRAC Design for Scalar Systems, MRAC Design for Multi-Input Multi-Output Systems) **2- Robust Adaptive Control** (MRAC Design in the Presence of Bounded Disturbances, MRAC Design Modifications for Robustness (Dead-Zone Modification, σ-Modification, e-Modification) **3- Adaptive Backstepping Control** (Model transformation, Design procedure) **References:** **1)** Eugene Lavretsky, Kevin A. Wise, "**Robust and Adaptive Control**," Springer-Verlag London 2013. **2)** Miroslav Kristic, Ioannis Kanellakopoulos and Petar Kokotavic, "**Nonlinear and Adaptive Control Design,**" New York: Wiley-Interscience, 1995.	Adaptive Control	8