COURSE DESCRIPTION FORM

INSTITUTION FAST - National University of Computers and Emerging Sciences

PROGRAM (S) TO BE EVALUATED BS - Computer Science

A. Course Description

(Fill out the following table for each course in your computer science curriculum. A filled-out form should not be more than 2-3 pages.)

Course Title	Theory of Computation / Automata		
Course Code	CS3005	**Credit Hours**	3 + 0
Prerequisites by Course(s)	Discrete Structures	**Semester**	Spring 2023
Assessment Instruments (With tentative weights)	**Semester Work 20%** (at least 3 assignments and 3 quizzes) **Midterm 30%** (2 Mid semester exam – Week 6 and Week 11) **Final 50%** (Comprehensive end of semester exam)		
Course Coordinator	Muhammad Shahzad		
Office Hours	Details displayed outside my Basement (Old library- CS Block).		
Current Catalog Description	Finite State Models: Language definitions preliminaries, Regular expressions/Regular languages, Finite automata (FAs), Transition graphs (TGs), NFAs, Kleene's theorem, Transducers (automata with output), Pumping lemma and non-regular language Grammars and PDA: CFGs, Derivations, derivation trees and ambiguity, Simplifying CFLs, Normal form grammars and parsing, Decidability, Context sensitive languages, grammars and linear bounded automata (LBA), Chomsky's hierarchy of grammars Turing Machines Theory: Turing machines, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Defining Computers by TMs		
Textbook (or **Laboratory Manual** for Laboratory Courses)	1. John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, Introduction to Automata Theory, Languages, and Computation 2. P. Linz. Introduction to Formal Languages and Automata, 6th edition, 2017 (or 5th or 4th edition), Jones and Barlett 3. Daniel I. A. Cohen, Introduction to Computer Theory		
Reference Material	1. John Martin, Introduction to Languages and the Theory of Computation, Third Edition 2. Michael Sipser, Introduction to Theory of Computation 3. Instructor Notes		
Course Goals	**A. Course Learning Outcomes (CLOs)**		

CLO No.	Course Learning Outcomes	Bloom Taxonomy	Tools
CLO-1	Explain and manipulate the different concepts in automata theory and formal languages such as formal proofs, automata, regular expressions, Turing machines etc	C2 (Understand)	A1, Q1
CLO-2	Prove properties of languages, grammars and automata with rigorously formal mathematical methods	C2 (Understand)	A2, Q2
CLO-3	Design of automata, RE and CFG	C3 (Apply)	Q3, M1, F1
CLO-4	Transform between equivalent NFAs, DFAs and Res	C3 (Apply)	M1, F1
CLO-5	Define Turing machines, PDA machines performing simple tasks	C2 (Understand)	A3, M2, F1 Q3
Tool: A = Assignment, Q = Quiz, M = Midterm, F=Final, CEP = Complex Engineering Problem.			

B. Program Learning Outcomes

PLO 1	Computing Knowledge	Apply knowledge of mathematics, natural sciences, computing fundamentals, and a computing specialization to the solution of complex computing problems.
PLO 2	Problem Analysis	Identify, formulate, research literature, and analyze complex computing problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, and computing sciences.
PLO 3	Design/Develop Solutions	Design solutions for complex computing problems and design systems, components, and processes that meet specifie appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
PLO 4	Investigation & Experimentation	Conduct investigation of complex computing problems using research-based knowledge and research-based methods
PLO 5	Modern Tool Usage	Create, select, and apply appropriate techniques, resources and modern computing tools, including prediction and modeling for complex computing problems.
PLO 6	Society Responsibility	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues relevant to context of complex computing problems.
PLO 7	Environment and Sustainability	Understand and evaluate sustainability and impact of professional computing work in the solution of complex computing problems
PLO 8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of computing practice.
PLO 9	Individual and Team Work	Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
PLO 10	Communication	Communicate effectively on complex computing activities with the computing community and with society at large.
PLO 11	Project Mgmnt and Finance	Demonstrate knowledge and understanding of management principles and economic decision making and app own work as a member or a team.
PLO 12	Life Long Learning	Recognize the need for, and have the preparation and

		ability to engage in independent and life-long learning in the broadest context of technological changes.

C. Relation between CLOs and PLOs
(CLO: Course Learning Outcome, PLOs: Program Learning Outcomes)

		PLOs									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
CLOs	1	✔									
	2		✔								
	3			✔							
	4			✔							
	5			✔							

Topics Covered in the Course (Tentative plan)

Please note:

1. Students are expected to go through the suggested reading topics from at least one reference book and internet, before & after each class.
2. Representative topic of suggested chapters is given week-wise (on right) as Chapter **[Ullman] / [Cohen]**. Please read the full chapter(s).
3. Apart from graded assignments, students are expected to discuss and solve exercises at the end of

Week	Lecture	Topics	CLO	Chapters	Assessments
1.	**1.**	Discussion on Course Outline, Introduction to Finite Automata	CLO-1	[HMU]:1.1 [Linz]: 1	
	2.	What does automata mean? Introduction to Languages, Alphabets, Strings	CLO-1	[HMU]: 1.5 [DC]: 1	
	3.	Kleene Star Closure, Regular Expression (RE)	CLO-3	[DC]: 4 [HMU]: 3 [JM]: 3 [Linz]: 3	
2.	**1.**	Equivalent RE, Finite Automaton (FAs), Equivalent FAs	CLO-3	[HMU]: 2 [JM]: 2 [MS]: 1	
	2.	FA corresponding to finite languages, Transition Graph	CLO-3	[Linz]: 2.1 [DC]: 6	
	3.	Continued			
3.	**1.**	Examples of TGs: accepting all strings, accepting none, starting with b, not ending in b, containing aa, containing aa or bb.	CLO-4	[Linz]: 2 [DC]: 6	***Assignment 1 Friday Release Week 3***
	2.	Generalized Transition Graph	CLO-4	[DC]: 6	

each chapter.			3.	Language accepted by NFA, Recursive definition of NFA	CLO-4	[Linz]: 2.2 [HMU]:2.3	
		4.	1.	Basis Clause and Inductive Clause of NFA	CLO-4, 2	[Instructor Notes]	***Quiz no 1***
			2.	NFA with Λ Transitions, Language accepted by NFA- Λ, Definition of Λ-Closure, Basis Clause and Inductive Clause of NFA- Λ	CLO-4	[Instructor Notes]	
			3.	Conversion of NFA- Λ to equivalent NFA	CLO-4	[Instructor Notes]	
		5.	1.	Conversion of NFA to equivalent DFA	CLO-4	[Instructor Notes]	***Assignment 1 submission Monday Week 5***
			2.	Equivalence of DFAs, NFAs and NFA-Λ	CLO-4	[Instructor Notes]	
			3.	Kleene's Theorem Part-1 & Part-2	CLO-4	[JM]: 3.4, 3.5 [DC]: 7	
		6.	1.				
			2.	**Mid-I Examination**			
			3.				
		7.	1.	Complement of Regular Language and Complement of DFA, Intersection of Regular Languages	CLO-3	[Instructor Notes]	
			2.	Properties of RLs	CLO-2,3	[Linz]: 4 [HMU]: 4	
			3.	Pumping Lemma	CLO-3	[HMU]: 4.1 [JM]: 2.4	
		8.	1.	Minimization of DFA	CLO-4	[Instructor Notes] [HMU]: 4.4	***Quiz no 2 Assignment 2 Friday Release Week 8***
			2.	Mealy & Moore Machines	CLO-4	[DC]: 9	
			3.	Conversion between Mealy & Moore Machines	CLO-4	[Instructor Notes]	
		9.	1.	Regular Grammars, Linear Grammar, Context-free Languages (CFL), Context-free grammars (CFG).	CLO-2,3	[DC]: 13 [MS]: 2	
			2.	Parse Trees, Derivations and ambiguity and Chomsky-normal-form grammars (CNF), Null Production	CLO-3	[DC]: 20 [Linz]: 6.2	
			3.	Trees, Polish Notations, Total Language Tree	CLO-3	[JM]: 4.4	

	10.	**1.**	Push down automata (PDA)	CLO-5	[JM]: 5 [DC]: 17 [MS]: 2.2	***Assignment 2 submission Monday Week 10***
		2.	Deterministic PDA, Pumping Lemma for CFG	CLO-5		
		3.	NPDA and CFG Equivalence	CLO-5		
	11.	**1.**				
		2.	**Mid-II Examination**			
		3.				
	12.	**1.**	Turing Machines (TM) Intro & Formalities	CLO-5	[MS]: 3.1 [Linz]: 9	
		2.	Designing TM as Acceptors/Transducers	CLO-5	[Linz]: 9	
		3.	Turing's Thesis, Turing Machine Variations	CLO-5	[MS]: 3.2 [DC]: 27	
	13.	**1.**	Universal Turing Machine Decidability	CLO-5	[JM]: 7.8 [DC]: 27	***Assignment 3 Friday Release Week 13***
		2.	Recursive vs. recursively enumerable	CLO-5	[JM]: 8 [DC]: 28	
		3.	Continued			
	14.	**1.**	Decidable Problem and Undecidable Problem,	CLO-4	[JM]: 9 [HMU]: 9 [MS]: 4	***Quiz no 3***
		2.	Continued			
		3.	Continued			
	15.	**1.**	Reducibility, Reduction problems	CLO-5	[MS]: 5.1	***Assignment 3 submission Monday Week 15***
		2.	The Chomsky Hierarchy	CLO-1,2,3	[JM]: 8.3	
		3.	Continued			
	16.	**1.**	**Revision**			

Class Time Spent on (in credit hours)	**Theory**	**Problem Analysis**	**Solution Design**	**Social and Ethical Issues**
	5	15	28	0
Oral and Written Communications	Every student is required to submit at least 3 assignments and 3 quizzes with no oral presentations.			

Instructor Name Syed Faisal Ali

Course Coordinator Signature: _____ **Instructor Signature:** _____

Date 10-01-2025