FIRST SEMESTER 2024-25
COURSE HANDOUT

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course

Course No. : **CS / IS F214**
***Course Title*: Logic in Computer Science**

***Instructor-in-Charge*: RAJESH KUMAR (email: rajeshk)**
Instructors:

- **Rajesh Kumar**

Course Website: Check Quanta AWS

1. **Scope and Objective:**

- Indicate the relevance of formal logical methods in computer science.
- Explain the role of and the relationship between formal syntax and semantics of proposition and predicate logic.
- Explain the principles of Binary Decision Diagrams, and manipulate them.
- Explain the principles of SAT solving and apply them to simple examples Apply proof systems (Gentzen, resolution) and prove their equivalence.
- Explain the meaning of soundness and completeness and how these apply to the aforementioned proof systems.
- Understand and be able to work with a computer implementation of one of the topics.

2. **Text Book:**

T1: Michael Huth and Mark Ryan. Logic in Computer Science – Modelling and Reasoning about Systems. Cambridge University Press. 2nd Edition. 2004.

T2: Principles of model checking, C. Baier and J.P. Katoen

T3: M. Ben-Ari, Mathematical Logic for Computer Science (3rd ed.). Springer, 2012, ISBN 978-1-4471-2128-0

3. Course Plan:

3.a. Modules

Module #	Topics
PART A	
I	**Propositional Logic: Natural Deduction, Syntax and Semantics, Soundness and Completeness, Satisfiability.**
II	**Predicate Logic: Syntax and Semantics, Natural Deduction**
PART B	
III	**SAT solving, CNF and DNF form, Horn formulae, Resolution theorem, DPLL**
IV	**Temporal Logic: Regular properties, LTL, CTL and Model Checking, Introduction to model checkers**
V	**Program Verification, Binary decision diagrams**

3. b. Lecture Schedule:

Lecture#	Topics to be covered	Reading
Part A: Propositional and predicate logic		
1	Course Introduction, Informal introduction to logic, Polish notation Propositions, Connectives, Ambiguous statements, Truth tables	T1, Ch. 2
2,3	Propositional Logic: Natural Deduction as a Proof System. Structural induction, BNF grammar for syntax, Structural Induction - Examples T1	T1, Ch. 2
4,5	Natural Deduction, Syntactic rules for conjuction, disjunction, negation, implication	T1, Ch. 2
6,7	Propositional Logic: Natural Deduction: Derived Rules: *Modus Tollens, Law of Excluded Middle (*LEM*), Proof by Contradiction (*PbC*).*	T1, Ch. 2
8,9	Propositional Logic: Semantics, Truth tables, Propositional Logic : Soundness and Completeness statements	T1, Ch. 2

10	Propositional Logic: Soundness Proof	T1, Ch. 2
11, 12	Predicate logic, Predicate Logic: Syntax: Grammar, Predicate Logic: Syntax: Free and Bound Variables	T1, Ch. 2
13, 14	Predicate Logic: Natural Deduction: Rules for Universal Quantification, Predicate Logic: Natural Deduction: Rules for Existential Quantification	T1, Ch. 2
15,16	Predicate Logic: Natural Deduction: Proofs, Syntactic equivalence, semantics and examples	T1, Ch. 2
PART B		
17-18	Propositional Logic: Conjunctive Normal Form (CNF) and Disjunctive Normal Form (DNF) forms, Validity and Satisfiability, Soundness and Completeness	T1, Chapter 1, T3, Chapter 2
19	Propositional Logic: Horn Clauses and Horn Formulas, Algorithm for Satisfiability of Horn Formulas	T1, Chapter 1
20, 21	Proof systems, Gentzen, Resolution Rule, Examples	T3, Chapter 4
22-23	Davis-Putnam Algorithm, An Extended Example of the DPLL Algorithm	T3, Chapter 6
24, 25	Temporal logics, Line time behavior, Safety properties, Liveness properties	T2, Chapter 3
26	Linear Temporal logic, Syntax, Informal semantics, Specifying properties	T2, Chapter 3
27	Computation tree logic, Syntax, Informal semantics, Specifying properties	T2, Chapter 6
28-29	Model checking, Model checking-LTL, Model checking CTL, Introduction to Uppaal Model checker, State-space explosion problem	T2, Chapter 3, 6
30, 31, 32, 34	Binary Decision Diagrams, Reduced Binary Decision Diagrams, Ordered Binary Decision Diagrams, Applying Operators to BDDs	T3, Chapter 5, T1 Chapter 6
34, 35, 36	Verification of sequential programs, Program Verification, Program Synthesis	T2, Chapter 15

36-37	Decidability of different logics, Semantic tableaux, Hilbert system	T3, Chapter 2, 3
38	Presentation by faculty, doctoral students on research problems being addressed using formal verification.	By IC

Evaluation

4. Evaluation Scheme:

Component	Weight	Date	Remarks
Tests (2)	2x10M=20M	TBD	Average of two tests will be reported. To make up for a test, a student can opt for personalized project
Midterm	80M	3-10-2024	Closed Book
Comprehensive Exam (120 minutes)	100M	--	Partly Open book
TOTAL	200M	--	---

Chamber Consultation Hour: IC: Tuesday: 16:00-17:00, Email before is appreciated.

4. Notices: All notices concerning this course will be displayed on the course website only. If there is a need email would be used on short notice (12 hours) – only BITS Pilani mail would be used.

Instructor –In-

Charge CS F214