Birla Institute of Technology & Science, Pilani
Hyderabad Campus

FIRST SEMESTER 2020-2021

Course Handout Part II

Date: 17-08-2020

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 F214*
Course Title	: Logic in Computer Science
Instructor-in-Charge	: Venkatakrishnan Ramaswamy (venkat@hyderabad.bits-pilani.ac.in)
Instructor	: Tathagata Ray (rayt@hyderabad.bits-pilani.ac.in) , Srijanee Mookherji (p20190023@hyderabad.bits-pilani.ac.in)

Scope and Objective of the Course:

Logic – rigorously applied – plays a key role in several areas of Computer Science. The formal study of Logic is therefore an important component in the computer scientist's craft. In this course, we will study propositional logic – syntax, semantics, satisfiability and validity, predicate or first-order logic – syntax, semantics, satisfiability and validity, completeness and compactness. We will briefly outline undecidability and incompleteness. We will cover verification by model checking, linear-time temporal logic (LTL) and computational tree logic (CTL). Additionally, program verification using Hoare logic and proofs of correctness will be discussed. We will briefly introduce modal logic and logic programming.

The objectives of the course are to:

- Understand notions of logic that are used in Computer Science
- Understand proof systems, such as propositional and predicate logic and to master the mechanics of proving statements in them.
- Understand model checking and program verification.

Textbook:

1. Michael Huth, Mark Ryan, *Logic in Computer Science – Modelling and Reasoning about Systems.* Cambridge University Press. 2nd Edition. 2004.
   Errata: https://www.cs.bham.ac.uk/research/projects/lics/second_edition_errata.pdf

Reference books

1. Mordechai Ben-Ari, *Mathematical Logic for Computer Science, 2e*, Springer, 2003.
2. Herbert B. Enderton, *A Mathematical Introduction to Logic, 2e*, Academic Press, 2001.
3. John Kelly, *The Essence of Logic*, Prentice-Hall India, Eastern Economy Edition, 1997.
4. I. M. Copi, *Symbolic Logic*, Prentice-Hall India, reprint of 1979 edition by Macmillan.
5. Kenneth H. Rosen, *Discrete Mathematics & its applications*, 8th Ed, McGraw Hill, 2018.

Course Plan:

Lecture No.	Learning objectives	Topics to be covered	Chapter in the Text Book
1	Course introduction	Course overview, Introduction to Logic. Barber's paradox, Russell's paradox, the historical need for rigour in Mathematics	1
2-4	Learn basic notions of propositional logic and mechanisms of applying proof rules	Propositional Logic: Propositions, logical connectives, natural deduction, rules for natural deduction	1.1, 1.2
5-7	Identify well-formed formulas, state soundness and completeness arguments for propositional logic	Well-formed formulas, parse trees. Semantics of propositional logic, mathematical induction, soundness and completeness of propositional logic	1.3, 1.4
8-10	Recognize/rewrite formulas in CNF & DNF; verify validity/satisfiability of propositions,	Semantic equivalence, satisfiability and validity, conjunctive normal form (CNF), disjunctive normal forms (DNF), Horn clauses and satisfiability	1.5
11	Learn algorithms for solving satisfiability problems	SAT solvers	1.6
12-14	Identify statements not expressible in propositional logic, know basic notions in predicate logic	Predicate logic: Limitations on expressiveness of propositional logic, introduction to predicate logic	2.1, 2.2
15-18	Construct natural deduction proofs in predicate logic	Rules for natural deduction in predicate logic	2.3
19-20	Understand semantic entailment, validity and satisfiability in predicate logic	Semantics of predicate logic	2.4
21	Understand the broad notion of undecidability	Brief overview of undecidability and expressibility of predicate logic	2.5, 2.6
22	Construct state machines for simple problems	State Machines and Graphs	2.7
23-25	Write LTL formulas & design specifications for various scenarios.	Verification by model checking: Introduction & motivation. Linear-time Temporal logic (LTL) – syntax, semantics, equivalences, connectives.	3.1, 3.2
26-27	Familiarity with model checking	Model checking with examples. Overview of the NuSMV model checker	3.3
28-29	Understanding CTL	Branching-time logics. Computation tree logic	3.4

		(CTL) – syntax, semantics, equivalences and connectives	
30	Understand relationship between LTL, CTL and CTL *	CTL* and expressive powers of CTL and LTL	3.5
31	Basic understanding of model-checking algorithms	Brief overview of model-checking algorithms	3.6
32	Understand program verification with example scenarios	Program verification: Introduction & Motivation	4.1
33-34	Recognize program variables and logical variables in verification.	A framework for software verification, Hoare logic	4.2
35-36	Construct partial correctness proofs	Proof calculus for partial correctness	4.3
37-38	Construct total correctness proofs	Proof calculus for total correctness	4.4
39	Basic understanding of the role of modal logic	Brief introduction to modal logic and logic programming	5
40	Big picture view of logic and its role in Computer Science	Summary and review of course	

Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Test 1	30 minutes	10%	September 10 –September 20 (during scheduled class Hour)	Open book
Test 2	30 minutes	15%	October 9-October 20(during scheduled class hour)	Open book
Test 3	30 minutes	15%	November 10-November 20 during scheduled class hour)	Open book
Assignments (3)	Take-home	25%	Submission deadlines to be announced	Open book
Comprehensive exam	120 minutes	35%	As announced in the Time Table	Open book

Chamber Consultation Hour: Thu, 5pm-5:50pm at https://whereby.com/vramaswamy or by prior appointment.

Notices: Will be posted online on a course management system, the details of which will be announced in class. The system will be linked to BITS Pilani email, which students are expected to check several times a day.

Make-up Policy:
No make-ups will be offered, except in case of medical or family emergencies of a severe nature or other unavoidable extenuating circumstances, as judged by the Instructor-in-Charge, for which prior permission must be sought, where feasible. Documented evidence (e.g. a Doctor's note) will be necessary before consideration of such a request. Additionally, a make-up for the comprehensive exam will require approval from the Dean, AUGSD.

Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

INSTRUCTOR-IN-CHARGE
CS F214