Course Code: CIT308
Course Title: Formal Methods, Automata and Software Development
Course Credit: 3 units
Time Allowed: 3 hours
Instruction: Answer **Question One (1)** and any other **Three (3)** Questions

Question 1: 25 marks
1 (a)   List and briefly explain the classification of Formal Methods Semantics. (6 marks)
1 (b)   Describe the process of software verification using formal methods. Include both human-directed and automated proof approaches. (7 marks)
1 (c)   Identify five critical systems where formal methods are particularly applicable. (5 marks)
1 (d)   Explain three limitations of formal methods in software development. (4 marks)
1 (e)   Discuss when and where formal methods should be introduced in software development processes. (3 marks)

Question 2: 15 marks
2 (a)   Identify four relevant areas of research in formal methods. (4 marks)
2 (b)   Explain the concept of formal specification in software development. (3 marks)
2 (c)   Explain the difference between denotational and operational semantics in formal methods. (4 marks)
2 (d)   Describe the process of model checking in automated proof techniques. (4 marks)

Question 3: 15 marks
3 (a)   Describe the following logical connectives and provide their truth tables: AND, OR, NOT, IMPLIES. (8 marks)
3 (b)   Explain the concept of precedence in logical operations and list the order of precedence for the basic logical connectives. (2 marks)
3 (c)   Translate the following English statement into predicate logic: "All airplanes can fly, but some birds cannot fly." (5 marks)

Question 4: 15 Marks
4 (a)   Define a predicate and explain how it differs from a proposition. Provide an example of a predicate. (4 marks)
4 (b)   Explain the concepts of universal and existential quantifiers in predicate logic. Provide an example of each. (6 marks)
4 (c)   Distinguish between bound and free variables in predicate logic. Give an example of each. (5 marks)

Question 5: 15 marks
5 (a)   Explain how predicates and operators can be combined to form more complex logical expressions. Provide an example. (4 marks)
5 (b)   Define a set and explain the concept of cardinality. Provide an example of a finite set and an infinite set. (5 marks)
5 (c)   Explain the following set relationships: subset, superset, and disjoint sets. Provide an example of each. (6 marks)

Question 6: 15 marks
6 (a)   Describe the following set operations: union, intersection, and complement. Illustrate each with a Venn diagram. (9 marks)
6 (b)   Define a sequence and distinguish between arithmetic and geometric sequences. Provide an example of each. (3 marks)
6 (c)   Given the arithmetic sequence 3, 7, 11, 15, ..., find the 10th term and the sum of the first 10 terms. Show your work. (3 marks)