

Discrete Structures (MA5.101)

End Semester Examination (Monsoon 2022)

International Institute of Information Technology, Hyderabad

Time: 180 Minutes (3 Hours)

Total Marks: 180

Instructions: Answer ALL questions.

This is a closed books and notes examination.

Write your answers sequentially as given in the question paper and also all the parts of a question at the same place.

No query is allowed during the examination.

Use of Regular Calculator is allowed.

1. Consider the language of propositional logic (without equality). Consider the ordering \prec between propositional formulas. $A \prec B$ iff formula A is an immediate subformula of formula B .

Apply the principle of induction over the set of propositional formulas ordered according to \prec to show that the valuation of a formula depends only on the assignment of propositional variables occurring in that formula.

[20]

2. (a) Define precisely what is a partial order.

- (b) Identify which of the following are not partial orders and justify why they not.

- ☒ i. The set A along with an arbitrary equivalence relation R .
- ☒ ii. The set students in IIIT along with the binary relation sRt iff the height of student s is not greater than the height of student t .
- ☒ iii. The set P (positive integers) along with the binary relation mRn if m and n are co-prime. (Two numbers are coprime if the only number dividing both of them is 1.)

[10 + 10 = 20]

3. Prove that in an undirected graph (self-loops allowed), the number of vertices whose degree is odd is even.

[20]

4. Let H and K be two product subgroups of a group $\langle G, \cdot \rangle$. The product set of H and K , denoted by $H \cdot K$, is the set of all products of the form $h \cdot k$, for $h \in H$ and $k \in K$. Under what condition the product set $H \cdot K$ is a normal subgroup of G ? Justify your answer.

[20]

5. Let $f : G \rightarrow G'$ be a group epimorphism, and let H be the normal subgroup that is the kernel of the epimorphism. Prove that G' is isomorphic to G/H , where $\langle G/H, \circ \rangle$ is a quotient group.

[20]

6. A non-empty subset S of a ring $(R, +, \cdot)$ will form a sub-ring of R , if and only if, for any two elements x and y of S ,

$$x - y \in S \text{ and } x \cdot y \in S, \forall x, y \in S.$$

The center of a ring R is defined to be

$$\{a \in R \mid ax = xa, \forall x \in R\}.$$

Show that the center of the ring R is a sub-ring of R .

[10]

7. (a) Compute the product of two bytes $\{d3\} \cdot \{8f\}$ in the finite (Galois) field $GF(2^8)$ with respect to an irreducible polynomial $m(x) = x^8 + x^4 + x^3 + x + 1$.

- (b) Under what condition can you compute the multiplicative inverse of a polynomial $b(x)$ modulo a polynomial $m(x)$ in $GF(2^8)$? Explain the algorithm for computing $b(x)^{-1} \pmod{m(x)}$.

[15 + 15 = 30]

8. (a) With respect to the research paper discussed on the hierarchical access control as an application of partial order relation: **Y. F. Chung, H. H. Lee, F. Lai and T. S. Chen, "Access control in user hierarchy based on elliptic curve cryptosystem", Information Sciences (Elsevier), vol. 178, no. 1, pp. 230-243, 2008**, discuss about the key derivation phase where a legal predecessor security class can derive the secret key of its successor security class(s).

- (b) Define syndrome of an n -tuple x with reference of an $r \times n$ parity-check matrix H . Prove that two n -tuples are in the same coset if and only if they have the same syndrome.

[10 + 10 = 20]

9. (a) Define even and odd permutations. Examine whether the following permutation:

$$p = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 2 & 4 & 5 & 6 & 3 & 1 \end{pmatrix}$$

is odd or even.

- (b) Given a set of sixteen natural numbers, none having a prime factor > 7 , show that either some number is a perfect square or, the product of some two distinct numbers is a perfect square.

[Use the fundamental theorem of arithmetic and the canonical representation of a number $n > 1$].

[10 + 10 = 20]

***** End of Question Paper *****