

MATH 271 DISCRETE MATHEMATICS

PRACTICE PROBLEMS 6: RELATIONS – HINTS & SOLUTIONS

Exercise 1. Consider the relation R on \mathbb{Z}^+ defined by: $\forall a, b \in \mathbb{Z}^+, aRb$ if and only if $\gcd(a, b) = 1$. Is R reflexive? symmetric? antisymmetric? transitive?

Solution 1.

- R is not reflexive. Choose $2 \in \mathbb{Z}^+$, and $\gcd(2, 2) = 2 \neq 1$; therefore, 2 is not related to 2.
- R is symmetric. Suppose $a, b \in \mathbb{Z}^+$, then by definition $\gcd(a, b) = \gcd(b, a)$ and so bRa .
- R is not antisymmetric; for instance $\gcd(2, 3) = 1 = \gcd(3, 2)$ so $2R3$ and $3R2$, but $2 \neq 3$.
- R is not transitive; for instance, $2, 3, 4 \in \mathbb{Z}^+$, $2R3$ because $\gcd(2, 3) = 1$ and $3R4$ because $\gcd(3, 4) = 1$, but 2 is not related to 4 because $\gcd(2, 4) = 2 \neq 1$.

Exercise 2. Consider the relation T on \mathbb{Z} defined by: $\forall x, y \in \mathbb{Z}, xTy$ if and only if $3 \mid 2x + y$. Is T reflexive? symmetric? antisymmetric? transitive?

Solution 2.

- T is reflexive. Suppose $a \in \mathbb{Z}$, then $2a + a = 3a$ is divisible by 3 (because $a \in \mathbb{Z}$); therefore, by definition aTa .
- T is symmetric. Suppose $a, b \in \mathbb{Z}$, and suppose aTb . Then by definition of T , 3 divides $2a + b$, so there exists $k \in \mathbb{Z}$ so that $2a + b = 3k$. Now, we see that

$$2b + a = 2b + b - b + a + 2a - 2a = 3b + 3a - (2a + b) = 3b + 3a - 3k = 3(a + b - k),$$

therefore, since $a + b - k \in \mathbb{Z}$, 3 divides $2b + a$ and bTa .

- T is reflexive. Suppose $a, b, c \in \mathbb{Z}$. Suppose that aTb and bTc . Then by definition of T , $3 \mid 2a + b$ and $3 \mid 2b + c$. Then there exists $k, \ell \in \mathbb{Z}$ so that $2a + b = 3k$ and $2b + c = 3\ell$. Now it follows that

$$2a + c = 2a + b - b + 2b - 2b + c = 3k + 3\ell - 3b = 3(k + \ell - b),$$

therefore, since $k + \ell - b \in \mathbb{Z}$, 3 divides $2a + c$ and aTc .

Thus, T is an equivalence relation, i.e., T is reflexive, symmetric and transitive.

Now you show that T is not antisymmetric.

Exercise 3. Recall that for any finite set S , $|S|$ denotes the number of elements in S .

Let $A = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$ and let $B = \{1, 3, 5, 7, 9\}$. Let R be the relation on $\mathcal{P}(A)$ (the power set of A) defined by: for all $X, Y \in \mathcal{P}(A)$, XRY if and only if $|X \cap B| = |Y \cap B|$.

Is R reflexive? symmetric? antisymmetric? transitive?

Solution 3.

Claim: R is reflexive: Suppose that $X \in \mathcal{P}(A)$. Since $|X \cap B| = |X \cap B|$, it follows from the definition of R that $XR X$. Thus, R is reflexive.

Claim: R is symmetric: Suppose that $X, Y \in \mathcal{P}(A)$. Suppose that XRY . By definition of R , $|X \cap B| = |Y \cap B|$. Moreover, $|Y \cap B| = |X \cap B|$ and so YRX , that is R is symmetric.

Claim: R is not antisymmetric: Indeed, $X = \{1\}$ and $Y = \{3\}$ are elements of $\mathcal{P}(A)$ that satisfy XRY and YRX (you can check!), but $X \neq Y$ since $1 \in X$ but $1 \notin Y$.

Claim: R is transitive: Suppose that $X, Y, Z \in \mathcal{P}(A)$. Suppose that XRY and YRZ . Since XRY , we have $|X \cap B| = |Y \cap B|$. Since YRZ , it follows that $|Y \cap B| = |Z \cap B|$. Therefore,

$$|X \cap B| = |Y \cap B| = |Z \cap B|$$

and so XRZ . Thus, R is transitive.

Exercise 4. Let $S = \{1, 2, 3, 4\}$. If possible, define a relation R on S so that:

Practice Problems In Discrete Mathematics

Yu Kiang Leong



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Sapozhenko, 2013-03-09 Many years of practical experience in teaching discrete mathematics form the basis of this text book Part I contains problems on such topics as Boolean algebra k valued logics graphs and networks elements of coding theory automata theory algorithms theory combinatorics Boolean minimization and logical design The exercises are preceded by ample theoretical background material For further study the reader is referred to the extensive bibliography Part II follows the same structure as Part I and gives helpful hints and solutions Audience This book will be of great value to undergraduate students of discrete mathematics whereas the more difficult exercises which comprise about one third of the material will also appeal to postgraduates and researchers *2000 Solved Problems in Discrete Mathematics* Seymour

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Solved and Unsolved Problems of Structural Chemistry Milan Randic, Marjana Novic, Dejan Plavsic, 2016-04-21 Solved and Unsolved Problems of Structural Chemistry introduces new methods and approaches for solving problems related to molecular structure It includes numerous subjects such as aromaticity one of the central themes of chemistry and topics from bioinformatics such as graphical and numerical characterization of DNA proteins and proteomes

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Two Thousand Solved Problems in Discrete Mathematics Seymour Lipschutz, Marc Lipson, 1992

Art And Practice Of Mathematics, The: Interviews At The Institute For Mathematical Sciences, National University Of Singapore, 2010-2020 Yu Kiang Leong, 2021-06-23 This book constitutes the second volume of interviews with prominent mathematicians and mathematical scientists who visited the Institute for Mathematical Sciences National University of Singapore First published in the Institute's newsletter Imprints during the period 2010-2020 they offer glimpses of an

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Math Problems in Water and Wastewater Subhash Verma, 2024-11-29. This book covers the fundamental concepts required to solve typical problems in water and wastewater engineering. Water professionals working in the industry require a license to work in water plants and *Math Problems in Water and Wastewater* aids readers in preparing for the mathematics portion of these exams. It lays a sound foundation that not only helps with the certification examination but also helps water operators in performing their daily activities. The basic concepts and volumes of various unit devices followed by specific problems in water and water treatment are presented through solved example problems. Includes examples both in Imperial and SI units throughout. Covers common and specific topics both for water and wastewater operations. All calculations shown with unit cancellation. All example problems are followed by practice problems. Examples include problems suitable for all level of certification. A brief description of the water and wastewater treatment is given.

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Kaplan MCAT Physics and Math Review
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