

Munkres - Topology - Chapter 3 Solutions

Section 24

Problem 24.3.

Solution: Define $g : X \rightarrow \mathbb{R}$ where $g(x) = f(x) - i_{\mathbb{R}}(x) = f(x) - x$ where $i_{\mathbb{R}}$ is the identity function. Since f and $i_{\mathbb{R}}$ are continuous, g is continuous by Theorems 18.2(e) and 21.5. Since X is connected for all three possibilities given in this problem and \mathbb{R} is ordered, the intermediate-value theorem applies.

For $X = [0, 1]$, observe that $g(0) \geq 0 - 0 = 0$ and $g(1) \leq 1 - 1 = 0$. Clearly if either $g(0)$ or $g(1)$ equals 0, then there is an $x_0 \in X$ where $f(x_0) - x_0 = 0$, so $f(x_0) = x_0$. Otherwise, $g(0) > 0$ and $g(1) < 0$, so by the intermediate-value theorem there is some $x_1 \in X$ where $g(x_1) = 0$, so $f(x_1) = x_1$.

The proposition is not necessarily true if $X = [0, 1)$ or $X = (0, 1]$. Let $f(x) = (1+x)/2$, which is obviously continuous. It follows that $f(x) = x$ if and only if $x = 1$, which not in X .

Problem 24.4.

Solution: If X has only one element, it is trivially a linear continuum, so we will assume X has at least two elements. Let $x, y \in Y$ where $x < y$. Since X is connected, $(-\infty, y)$ and (x, ∞) cannot be a separation of the space. Since the two open sets are clearly non-empty, it must be that they are not disjoint. Therefore there is some $z \in (-\infty, y) \cap (x, \infty)$, from which it follows that $z < y$ and $x < z$. We infer that $x < z < y$.

Next, let Y be a non-empty subset of X that is bounded above, and suppose Y has no supremum. Define $M = \{m \in X : m \geq y \text{ for all } y \in Y\}$ (in other words, the set of upper bounds of Y). Since Y is bounded above, M is non-empty. Then let $A = \bigcup_{y \in Y} (-\infty, y)$ and $B = \bigcup_{m \in M} (m, \infty)$. It follows that A and B are a separation of X , contradicting that X is connected. Given $x_0 \in X$, if $x_0 < y$ for some $y \in Y$, then $x_0 \in (-\infty, y) \subset A$. On the other hand, if $x_0 \geq y$ for all Y , then there is some $m \in M$ such that $m < x_0$, so $x_0 \in (m, \infty) \subset B$. Hence A and B partition X . Further, if $x_1 \in A \cap B$, then $x_1 < y$ for some $y \in Y$ and $x_1 > y'$ for all $y' \in Y$, which is impossible. Therefore A and B are disjoint. Since A and B form an impossible separation of X , we conclude that Y must have a supremum. Accordingly, X is a linear continuum.

Problem 24.4.

Solution: Given $x, y \in X \times [0, 1]$ where $x < y$, we have $x = x_0 \times x_1$ and $y = y_0 \times y_1$. Since $[0, 1]$ is a linear continuum, if $x_0 < y_0$, let $z_1 \in (x_1, 1)$; if $x_0 = y_0$, let $z_1 \in (x_1, y_1)$. Hence if $z = x_0 \times z_1$, then $x < z < y$.

Now let U be a non-empty subset of $X \times [0, 1]$ that is bounded above. Define $M = \{m \in X \times [0, 1] : m \geq a \text{ for all } a \in A\}$, which is the set of all upper bounds of A . Since A is bounded above, we're assured that M is non-empty. Designate $U = \{\pi_1(m) : m \in M\}$, which must be a non-empty subset of X . Since X is well-ordered, there is a least element x' of U . If $x' \notin \pi_1(A)$, then $x' \times 0 > a$ for all $a \in A$. Further, if $x'' < x'$, then any element of $x'' \times [0, 1]$ must be less than some element of A because no upper bound of A has a first coordinate less than x' . Hence $x' \times 0$ is the supremum of A . On the other hand, if $x' \in \pi_1(A)$, the set $V = \{\pi_2(a) : a \in A\}$ is a non-empty subset of $[0, 1]$ that is bounded above by 1, so it has a supremum y' . Accordingly, if $c \in [0, y')$, there is some $d > c$ such that $x' \times d \in A$, which is greater than $x' \times c$. Therefore $x' \times y'$ is the supremum of A , and $X \times [0, 1]$ has the supremum property. We conclude that $X \times [0, 1]$ is a linear continuum.

Problem 24.9.

Solution: Designate $X = \mathbb{R}^2 \setminus A$, and let $x, y \in X$ be given. If there is no element of A on the straight-line path in \mathbb{R}^2 from x to y , then there is obviously a path between the two points by exercise 24.8(a). In the non-trivial case where there is an element of A on the straight-line path between x and y , designate $D_0 = \{\theta \in [0, 2\pi) : \tan^{-1}[(\pi_2(a) - \pi_2(x))/(\pi_1(a) - \pi_1(x))] \neq \theta \text{ for all } a \in A\}$, which are all the angles around x for which there is no element of A on the straight line passing through x at that angle. We will show that D_0 is not empty. Assume the contrary is true and D_0 is empty. It would follow that for every element of the interval $[0, 2\pi)$, there is some element of A on the line at that angle. Consequently, there is an injection from $[0, 2\pi) \rightarrow A$. Because A is countable, there would be an injection from $[0, 2\pi) \rightarrow \mathbb{N}$, establishing that $[0, 2\pi)$ is countable, a contradiction. Therefore D_0 is not empty. Choose an arbitrary θ_0 from D_0 .

Munkres Solutions Chapter 3

M Lipman



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Proceedings of the Fifth Distributed Memory Computing Conference: Applications David W. Walker, Quentin F. Stout, 1990 **Parallel Computing Works!** Geoffrey C. Fox, Roy D. Williams, Guiseppe C. Messina, 2014-06-28 A clear illustration of how parallel computers can be successfully applied to large scale scientific computations This book demonstrates how a variety of applications in physics biology mathematics and other sciences were implemented on real parallel computers to produce new scientific results It investigates issues of fine grained parallelism relevant for future supercomputers with particular emphasis on hypercube architecture The authors describe how they used an experimental approach to configure different massively parallel machines design and implement basic system software and develop algorithms for frequently used mathematical computations They also devise performance models measure the performance characteristics of several computers and create a high performance computing facility based exclusively on parallel computers By addressing all issues involved in scientific problem solving Parallel Computing Works provides valuable insight into computational science for large scale parallel architectures For those in the sciences the findings reveal the usefulness of an important experimental tool Anyone in supercomputing and related computational fields will gain a new perspective on the potential contributions of parallelism Includes over 30 full color illustrations Applied State Estimation and Association Chaw-Bing Chang, Keh-Ping Dunn, 2016-07-08 A rigorous introduction to the theory and applications of state estimation and association an important area in aerospace electronics and defense industries Applied state estimation and association is an important area for practicing engineers in aerospace electronics and defense industries used in such tasks as signal processing tracking and navigation This book offers a rigorous introduction to both theory and application of state estimation and association It takes a unified approach to problem formulation and solution development that helps students and junior engineers build a sound theoretical foundation for their work and develop skills and tools for practical applications Chapters 1 through 6 focus on solving the problem of estimation with a single sensor observing a single object and cover such topics as parameter estimation state estimation for linear and nonlinear systems and multiple model estimation algorithms Chapters 7 through 10 expand the discussion to consider multiple sensors and multiple objects The book can be used in a first year graduate course in control or system engineering or as a reference for professionals Each chapter ends with problems that will help readers to develop derivation skills that can be applied to new problems and to build computer models that offer a useful set of tools for problem solving Readers must be familiar with state variable representation of systems and basic probability theory including random and stochastic processes **Aspects of Combinatorics and Combinatorial Number Theory** Sukumar Das Adhikari, 2002 Metaheuristics for Machine Learning Mansour Eddaly, Bassem Jarboui, Patrick Siarry, 2023-03-13 Using metaheuristics to enhance machine learning techniques has become trendy and has achieved major successes in both supervised classification and regression and unsupervised clustering and

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MATHEMATICAL TECHNIQUES OF OPERATIONAL RESEARCH L. S. GODDARD, 1963

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Mathematics of Computing Parallelism

Elements of Combinatorial Computing Mark B. Wells, 1971 This book is about one aspect of nonnumerical computing the high speed manipulation e g generation covering comparison of combinatorial objects such as permutations partitions and linear graphs There is a close kinship between combinatorial computing and combinatorial mathematics Most of the methods and examples in this book are taken from the study of problems in combinatorial theory but the techniques find application in number theory algebra switching theory biomathematics game theory and operations research The purpose of this book is to cover the basic and important computer methods of solving problems which involve the handling of combinatorial entities and to introduce the pure mathematician to the possibilities of high speed computing while pointing out to computer scientists some of the needs of research mathematicians

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