

## Hatcher Algebraic Topology Solutions

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60SMBR: Intro to Topology Intro to Topology

A Topology Book with Solutions *Introduction to Topology: Made Easy* *The Most Famous Calculus Book in Existence* "Calculus by Michael Spivak" **Introduction to Algebraic Topology : Lecture 1.1 MA 232 (2020) Algebraic Topology 1.1 : Homotopy (Animation Included)** 1. History of Algebraic Topology; Homotopy Equivalence - Pierre Albin SLS-2015-05 - Allen Hatcher **AlgTop0: Introduction to Algebraic Topology** Algebra, Geometry, and Topology: What's The Difference? *Algebraic Topology Urdu Hindi MTH477 LECTURE 02 Algebraic Topology Introduction (Peter May)* *Hatcher Algebraic Topology Solutions*  
HATCHER'S ALGEBRAIC TOPOLOGY SOLUTIONS REID MONROE HARRIS Van Kampen's Theorem Problem 1. Suppose  $G$  and  $H$  are nontrivial groups. Suppose  $x = g_1 h_1 \dots g_n h_n$  lies in the center of  $G \times H$ , where  $g_i \in G$  and  $h_i \in H$ . For any  $g \in G$ , we have  $g x = x g$ . We have  $g g_1 h_1 \dots g_n h_n g^{-1} = g_1 h_1 \dots g_n h_n g^{-1} x$ . The only way for this to be true for all  $g$  is if  $h_i = 1$  for all  $i$ .

**Van Kampen's Theorem**

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Also available are some additional exercises. The Exercises: I have not written up solutions to the exercises. The main reason for this is that the book is used as a textbook at a number of universities where the problem sets count for part of a student's grade.

**Algebraic Topology Book - Cornell University**

We may assume the polynomial is of the form  $p(z) = z^n + a_1 z^{n-1} + \dots + a_n$ . If  $p(z)$  has no roots in  $\mathbb{C}$ , then for each real number  $r > 0$  the formula  $f_r(s) = p(re^{2\pi i s})/p(r)$  defines a loop in the unit circle  $S^1 \subset \mathbb{C}$  based at 1. As  $r$  varies,  $f_r$  is a homotopy of loops based at 1.

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$f_1(x)$  and  $G(x,1) = F(x,0) = f_0(x)$ , i.e. a homotopy between  $f_1$  and  $f_0$ . Thus, the relation of homotopy among maps between two fixed spaces is reflexive, symmetric, and transitive, the latter by lemma 1, i.e. an equivalence relation. (c). Let  $f_0: X \rightarrow Y$  be a homotopy equivalence with homotopy inverse  $g$ .

**Allen Hatcher: Algebraic Topology**

Solutions to Homework # 2 Hatcher, Chap. 0, Problem 16.1 Let  $R_1 = \{x \in \mathbb{R}^n : x_k = 0, 2 \leq k \leq n\}$ ;  $R_n = \{x \in \mathbb{R}^n : x_k = 0, k > n\}$ ; is closed in the Euclidean topology of  $\mathbb{R}^n$ . For each  $x \in R_1$  set  $U_x = \{y \in \mathbb{R}^n : |y_k - x_k| < \epsilon, k=2, \dots, n\}$

**Solutions to Homework # 1 Hatcher, Chap. 0, Problem 4:**

Algebraic Topology. This book, published in 2002, is a beginning graduate-level textbook on algebraic topology from a fairly classical point of view. To find out more or to download it in electronic form, follow this link to the download page.

**Allen Hatcher's Homepage - Cornell University**

Solutions Exam algebraic topology 1, 1-23-2019. Always motivate your answers and state the theorems/results you are using. Unless stated otherwise all homology is taken with integer coefficients. Question 1 a. For a pair of spaces  $(X; Y)$  define  $Z = \{(Y \times \{0,1\}) \times X\}$  where  $(y; 1) \times y$  and  $(y; 0) \times (y; 0)$  for all  $y \in Y$ . Show that for all  $n \in \mathbb{Z}$  we have  $H_n(Z) = H_n(X)$ .

**Solutions Exam algebraic topology 1, 1-23-2019**

By Lemma 1.15 (Hatcher), every loop in  $X$  based at  $x_0$  is homotopic to a product of loops, where each loop is either contained in  $e$  or  $A$ . Since  $n \geq 2$ , a loop contained in  $e$  is nullhomotopic, so every loop in  $X$  is homotopic to a loop in  $A$ . Thus if  $[f] \in \pi_1(X; x_0)$ , there is a loop  $f_0$  in  $A$  such that  $[f] = [f_0]$ . Also that  $[f_0] = [f]$ . We have  $f_0 = f$ , so  $[f_0] = [f] = [f]$ .

**Homework 3 MTH 869 Algebraic Topology**

Let  $f: \mathbb{R}^1 \rightarrow X$ . Let  $E = \text{Int}(e_n)$  and consider  $f|_E$ . This is an open subset of  $(0, 1)$ , so it is the union of a possibly infinite collection of subsets of  $(0, 1)$  of the form  $(a_i, b_i)$ . Let  $x \in E$  and let  $U$  be an open ball around  $x$  in  $E$ .

**Exercise 1.1.18 in Hatcher's Algebraic Topology ...**

Allen Hatcher: Algebraic Topology ALLEN HATCHER: ALGEBRAIC TOPOLOGY MORTEN POULSEN All references are to the 2002 printed edition Chapter 0 Exercise 02 Define  $H: (\mathbb{R}^n \times \{0\}) \times \mathbb{R}^n \rightarrow \{0\}$  by  $H(x,t) = (1-t)x$ . Sketches of solutions to selected exercises Hatcher 2116 a) This could be done directly but let's use the exact sequence First,

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As we shall show in Theorem 2.44, the Euler characteristic of a cell complex depends only on its homotopy type, so the fact that the house with two rooms has the homotopy type of a point implies that its Euler characteristic must be 1, no matter how it is represented as a cell complex. Example 0.3.

**Allen Hatcher - Purdue University**

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Algebraic topology seeks to capture the "essence" of a topological space in terms of various algebraic and combinatorial objects. We will construct three such gadgets: the fundamental group, homology groups, and the cohomology ring. We will apply these to prove various

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For if  $[g(d_1)] = [z_1]$  and  $[g(d_2)] = [z_2]$  then  $[g(d_1 + d_2)] = [z_1 + z_2]$ , so that  $[z_1 + z_2]$  is given by  $a(d_1 + d_2) = a(d_1) + a(d_2)$ , and hence  $a = 0$ . The proof that the sequence of homology groups is exact proceeds in three stages. (a) Certainly since  $\partial^2 = 0$  implies  $\text{Im } \partial^2 \subset \text{Ker } \partial$ . Conversely if  $[z] \in \text{Ker } \partial$  then  $g(z) = a(e)$  for some  $e \in E$ .

**ALGEBRAIC TOPOLOGY - School of Mathematics**

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