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Van Kampen's

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Theorem Problem

1. Suppose G and H are nontrivial groups. Suppose $x = g_1 h_1^{-1} \cdots g_n h_n^{-1}$ lies in the center of $G \times H$, where $g_i \in G$ and $h_i \in H$. For any $g \in G, h \in H$, we have $g x g^{-1} = x$ and $h x h^{-1} = x$. Thus $g g_1 h_1^{-1} \cdots g_n h_n^{-1} g^{-1} = g_1 h_1^{-1} \cdots g_n h_n^{-1}$ and $h g_1 h_1^{-1} \cdots g_n h_n^{-1} h^{-1} = g_1 h_1^{-1} \cdots g_n h_n^{-1}$. This implies $g g_1 = g_1 g$ and $h h_n = h_n h$. The only

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way for this to
be true for all
 g_i if $h_i = 1$ H
for all i .

Van Kampen's Theorem

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are a few
solutions to
some of the

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trickier problems...

Recall: Let X be

a topological

space, $A \subset X$

subspace of X .

Suppose $f, g:$

$X \rightarrow X$ are maps

restricting to

the identity on

A . Then a

homotopy

relative to A (or

just: a homotopy

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rel. A) from f to

gis a map $H: X$

$I \rightarrow X$ satisfying:

(1) $H(a; t) =$

a for all $a \in A$ and

all $t \in I$,

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here. Our course
will primarily
use Chapters 0,
1, 2, and 3.

Prerequisites.

In addition to
formal

prerequisites,

we will use a
number of

notions and

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explanation.

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$n \cdot \dots \cdot h \cdot 1 \cdot g \cdot 1$
 $1 = 1.$

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Exercises

Instructor: W.

D. Gillam Due:

At the

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discretion of
the student
Scholium. Let
 X be a

topological
space, \mathcal{U}_a cover
of X , $X_n =$
 $\text{Hom}(n; X)$ the set
of singular n -
simplices in X ,
 XU_n the subset
of X_n consisting
of those $\sigma \in X_n$
for which there

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is some U with

$\varphi(n) \in U$. Since

the restriction

of any $\varphi \in X_U$ to

any face ...

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Exercises

Although we have

in mind an

audience with

prior exposure

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Topology or differential topology, for the most part a good knowledge of linear algebra, advanced calculus, and point-set topology should suffice. Some acquaintance with manifolds,

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Simplicial
complexes,
singular

homology and
cohomology, and
homotopy groups
is helpful, but
not really ...

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topology on
 X so that f is
continuous, viz,
 $f^{-1}(U)$ is open \iff
 $f(U)$ is open.
The resulting
topological

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Topology is called
the quotient

space. E.g. Let

$I = [0; 1] \subset \mathbb{R}$ and

$X = I \times I$. We put

the weakest

equivalence

relation on

X s.t. $(0; x) \sim$

$(1; x); (x; 0) \sim$

$(x; 1)$ for $x \in I$.

We sometimes sum

up this info in

the following

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set topological
nature that
arise in
algebraic
topology. Since
this is a
textbook on

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algebraic
topology,
details

involving point-
set topology are
often treated
lightly or
skipped entirely
in the body of
the text. Not
included in this
book is the
important but
somewhat more

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homotopy groups

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the groups

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$\pi_n(X, A; x_0)$ 75
10. Suspension
Theorem and
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INTRODUCTION

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more elementary
parts of
algebraic
topology,
although

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Ruiter February

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Proposition 0.1

(Exercise

1.1.10). Let

$(X; x_0)$ and $(Y; y_0)$

be pointed,

path-connected

spaces. Let $f:$

$I \rightarrow X$ and $g:$

$I \rightarrow Y$ both

be loops based

at $(x_0; y_0)$.

Via inclusions,

we can think of

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f, g as loops I
 $\rightarrow X \times Y$ based at (x_0, y_0) . Let $p_X: X \times Y \rightarrow X$ and $p_Y: X \times Y \rightarrow Y$ be the standard projections. Then we have $f'g'$ via the homotopy

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1) Let X be the connected sum of two tori, let a_1 and b_1 be the meridian and longitude of the first torus, and let a_2 and b_2 be the meridian and longitude of the second torus.

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There is a simple closed curve γ that is homotopic to a 1 bla γ 1b γ 1. Let Y be the union of X with a 2 -disk D , where the boundary of

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Exercise 1.34.

Formulate a
universal
property for the
?bre product.

The product of
topological
spaces allows
the introduction
of the notion of
a topological
group. De?nition

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1.35. A topological group is a group equipped with a topology such

**INTRODUCTION TO
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Solutions to
Homework # 2
Hatcher, Chap.
0, Problem 16.1
Let $R := M_{n,1}$

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 $R = \mathbb{R}^n \sim X = \{(x_k)_{k=1}^n : x_n = 0\}$
 $\cong \mathbb{R}^{n-1} \times \{0\}$ We

define a topology on R^1 by

declaring a set $S \subseteq R^1$ closed if

and only if, $\exists n \in \mathbb{N}$, $0 < \epsilon_n < 1/n$, the

intersection $S \cap \mathbb{R}^n$ of S with the

n -th

dimensional

subspace $\mathbb{R}^n = \{(x_1, \dots, x_n) : x_{n+1} = \dots = x_{n+k} = 0\}$

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$(x_k)_{k \geq 1}; x_k = 0;$
 $\delta_k > \epsilon$ is closed
in the Euclidean
topology of
 \mathbb{R}^n . For each $x \in \mathbb{R}^n$
set J_x

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

This book is
designed to
introduce a

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Topology to some
of the important
ideas of

algebraic

topology by

emphasizing the

relations of

these ideas with

other areas of

mathematics.

Rather than

choosing one

point of view of

modern topology

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(homotopy
theory,
simplicial

complexes,

singular theory,

axiomatic

homology,

differential

topology, etc

...

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First Course |

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First and

foremost, this

course is an

excursion into

the realm of

algebraic

topology. Please

take a few hours

to review point-

set topology;

for the most

part, chapters

1-5 of Lee (or

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or 2-3 of

Munkres or 3-6

of Kahn),

contain the

prerequisite

information. Be

sure you

understand

quotient and

adjunction

spaces.

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references are

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Chapter 0 Ex.

0.2. Define H :

$(\mathbb{R}^n \setminus \{0\}) \times I \rightarrow \mathbb{R}^n \setminus \{0\}$ by $H(x, t) = (1-t)x + t \frac{|x|}{|x|} x,$

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$x \in \mathbb{R}^n \setminus \{0\}$, $t \in I$. It is easily verified that H is a homotopy between the identity map and a retraction onto S^{n-1} , i.e. a deformation retraction. Ex. 0.3.

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