Term Information

Spring 2018

General Information

Course Bulletin Listing/Subject Area	Mathematics
Fiscal Unit/Academic Org	Mathematics - D0671
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	4570
Course Title	Applied Algebraic Topology
Transcript Abbreviation	Applied Alg. Top.
Course Description	This course will serve as an introduction to algebraic topology, with a view toward persistent homology of point clouds for applications to data analysis. Homology of simplicial complexes over a field with a focus on building up intuition about homology moving to a specialized notion of persistent homology of persistence modules. Real-world applications to data analysis will be provided.
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week, 8 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus

Prerequisites and Exclusions

Prerequisites/Corequisites	A C- or better in Math 2568 and Math 3345.
Exclusions	
Electronically Enforced	Yes

Cross-Listings

Cross-Listings

Subject/CIP Code

Subject/CIP Code Subsidy Level Intended Rank 27.0101 Baccalaureate Course Junior, Senior

Requirement/Elective Designation

The course is an elective (for this or other units) or is a service course for other units

Course Details	
Course goals or learning	• Understand metric topology
objectives/outcomes	Understand simplicial complexes and their homology
	 Understand persistent holmology
	 Understand structures on spaces of barcodes
Content Topic List	Metric topology
	 Homology of simplicial complexes
	Point clouds and associated spaces
	Persistent holmology
	Persistance diagrams
	 Structures on the space of barcodes
	• Applications
Sought Concurrence	No
Attachments	App_Alg_Top_Syllabus.pdf: Syllabus-Revised
	(Syllabus. Owner: Husen,William J)
	Curriculum_map_math_apllied_phyisics_20170509.pdf: Curriculum map - Applied math-physics
	(Other Supporting Documentation. Owner: Husen, William J)
	Curriculum_map_math_applied_chem_20170509.pdf: Curriculum map - Applied math-chem
	(Other Supporting Documentation. Owner: Husen, William J)
	Curriculum_map_math_education_20170509.pdf: Curriculum map - math ed
	(Other Supporting Documentation. Owner: Husen, William J)
	Curriculum_map_math_financial_20170509.pdf: Curriculum map - financial math
	(Other Supporting Documentation. Owner: Husen, William J)
	Curriculum_map_math_math_bio_20170509.pdf: curriculum map - math bio
	(Other Supporting Documentation. Owner: Husen, William J)
	Curriculum_map_math_theoretical_20170509.pdf: curriculum map - theoretical math
	(Other Supporting Documentation. Owner: Husen, William J)
Comments	1. Revised Syllabus to include course number and meeting times/dates.
	2. Attached curriculum maps for math tracks. (by Husen, William J on 06/09/2017 10:46 AM)
	• See 4-27-17 e-mail to B Husen. (by Vankeerbergen, Bernadette Chantal on 04/27/2017 03:12 PM)

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Husen,William J	04/07/2017 11:44 AM	Submitted for Approval
Approved	Husen,William J	04/07/2017 11:45 AM	Unit Approval
Approved	Haddad,Deborah Moore	04/07/2017 01:06 PM	College Approval
Revision Requested	Vankeerbergen,Bernadet te Chantal	04/27/2017 03:12 PM	ASCCAO Approval
Submitted	Husen,William J	06/09/2017 10:46 AM	Submitted for Approval
Approved	Husen,William J	06/09/2017 10:46 AM	Unit Approval
Approved	Haddad,Deborah Moore	06/12/2017 10:19 AM	College Approval
Pending Approval	Nolen,Dawn Vankeerbergen,Bernadet te Chantal Hanlin,Deborah Kay Jenkins,Mary Ellen Bigler	06/12/2017 10:19 AM	ASCCAO Approval

MATH 4570 - APPLIED ALGEBRAIC TOPOLOGY

Course Description. The course will serve as an introduction to algebraic topology, with a view toward persistent homology of point clouds for applications to data analysis. In order to keep the material accessible to a wide audience, an emphasis will be placed on homology of simplicial complexes over a field. We will focus on building up intuition about what homology measures through concrete examples. We will then move on to the more specialized notion of persistent homology of persistence modules. Real-world applications to data analysis will be provided.

Credit Hours. 3

Class Meetings. 11:30am-12:25pm MWF

Intended Audience The course is designed for junior and senior undergraduate mathematics majors. No prior knowledge of topology or abstract algebra will be assumed. Students with familiarity in these subjects are welcome, as there is not a significant overlap with the standard courses. The course will also be appropriate for computer science and data analytics majors with a strong math background.

Prerequisites. A C- or better in Math 2568 and Math 3345 or equivalent.

Grading. Grades for the course will be determined by weekly homework assignments (60%), a midterm project (15%) and a final project (25%). Students will be given choices of topics for the midterm and final projects. These will range from guided investigations into deeper mathematics than what is covered in lecture to programming projects.

Text. The course will roughly follow the recent survey article [?] by Gunnar Carlsson. Background material which does not appear in the survey paper will be supplemented by additional course notes.

Academic Misconduct Statement. It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/.

Disability Statement. Students with disabilities (including mental health, chronic or temporary medical conditions) that have been certified by the Office of Student Life Disability Services will be appropriately accommodated and should inform the instructor as soon as possible of their needs. The Office of Student Life Disability Services is located in 098 Baker Hall, 113 W. 12th Avenue; telephone 614- 292-3307, slds@osu.edu; slds.osu.edu.

Tentative Schedule

Week 1: Review of Linear Algebra I

- Course overview and motivation
- Vector spaces and subspaces over \mathbb{R} and F_2
- Examples
- Basis and dimension
- Linear transformations and matrix representations
- Homework: Basic properties of vector spaces

Week 2: Review of Linear Algebra II

- Kernel and cokernel of a linear transformation
- Quotient vector spaces
- Inner product spaces
- Normed spaces, leading to first examples of metrics
- Homework: Calculations with linear transformations, properties of norms

Week 3: Metric Topology I

- Definition of a metric space
- Examples of metric spaces
- Open and closed sets
- Continuous maps between metric spaces
- Homework: Working with basic properties of metric spaces

Week 4: Metric Topology II

- Basic topological properties of metric spaces: connectedness, compactness
- Equivalence relations
- Homeomorphism
- How to distinguish metric spaces? Light introduction to the ideas of π_0, π_1
- Example: clustering in finite metric spaces via π_0
- Homework: Basic topological properties

Week 5: Homology of Simplicial Complexes I

- Motivation: distinguishing metric spaces through linear algebra
- Return to linear algebra: free vector spaces generated by a finite set
- Homology of simplicial complexes: develop intuition by working simple examples in detail; start with calculations over F_2
- Homework: Working with free vector spaces and some basic homology calculations over ${\cal F}_2$

Week 6: Homology of Simplicial Complexes II

- Chain complexes of vector spaces and boundary maps
- Abstract definition of homology of a chain complex of vector spaces
- Rigorous definition of homology of a simplicial complex
- Normal forms for matrix pairs as an algorithm for computing homology
- Light introduction to functoriality: inclusion maps induce maps on homology
- Homework: Calculating homology of simple examples of simplicial complexes and proving basic properties of homology

Week 7: Homology of Simplicial Complexes III

- Informal discussion of extending homology to general metric spaces
- Homotopy and homotopy equivalence in metric spaces
- Contractibility
- Contractible simplicial complexes have trivial homology (statement without formal proof)
- Homework: Working with homotopies

Week 8: Point Clouds and Associated Spaces

- Motivation: why study point clouds?
- Examples of point clouds arising from real-world data
- Point clouds as finite metric spaces
- Single-linkage clustering
- Persistent sets
- Vietoris-Rips complex
- Mid term project due

Week 9: Persistent Homology I

- Homology of the Vietoris-Rips complex of a point cloud
- Persistence vector spaces: definitions of persistence vector space, linear transformations, sub-persistence vector space
- Finitely-presented persistence vector spaces
- Basic properties of persistence vector spaces
- Homework: more basic properties of persistence vector spaces

Week 10: Persistent Homology II

- Classification theorem for finitely-presented persistence vector spaces
- Demonstration: Javaplex for topological data analysis
- Homework: filling in details of the proof of the classification theorem

Week 11: Persistence Diagrams

- Barcodes and persistence diagrams
- Persistent homology algorithm
- Computational examples
- Examples and applications of barcodes in the literature

Week 12: Structures on the Space of Barcodes I

- Define bottleneck distance on Barcode space
- Define Gromov-Hausdorff distance on the space of finite metric spaces
- Discuss the stability theorem relating the two distances (without proof)
- Homework: fill in details showing the bottleneck distance and Gromov-Hausdorff distance are metrics

Week 13: Structures on the Space of Barcodes II

- Define interleaving distance
- Work with a variety of simple examples to develop intuition about interleaving distance
- Sketch the proof of the isometry theorem relating interleaving distance to bottleneck distance
- Homework: fill in some details of the proof of the isometry theorem

Week 14: Applications

- The last week will be spent studying specific applications to real-world data. This can be catered to interests of the students.
- Final project

References

[1] Carlsson, G., 2014. Topological pattern recognition for point cloud data. Acta Numerica, 23, p.289.

C	A	A CORE AND A DESCRIPTION OF A	(0) (1)		1	1			1					
Curriculum N	viap - iviatnematics BA/BS -	Аррнеа тгаск ((Physics)											
	Course	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5								
Prerequisits														
	Biology 1113 or 1114			Reginning		Intermediate								
-				Deginning		Intermediate								
	Chem 1210			Beginning		Intermediate								
	CSE 1222 or 1223			Beginning		Intermediate								
	Math 1151	Beginning	Beginning	Beginning										
	Math 1152	Beginning	Beginning	Beginning										
	Math 1295	~ ~	~ ~	~ ~	Intermediate	Reginning								
	Physics 1250			Designing	Internediate	Laterna adiata								
	Physics 1250			Beginning		Intermediate								
	Physics 1251			Beginning		Intermediate								
Core														
00.0	Mash 2152	المغم مسمع مطالعهم	laste anno e alleste a	Designing										
	Math 2153	Intermediate	Intermediate	Beginning										
	Math 2568	Beginning	Beginning	Beginning		Beginning								
	Math 3345	Advanced	Beginning	Intermediate	Intermediate									
	Math 4530 or Stat 4201	Intermediate	Beginning	Intermediate	Intermediate	Intermediate								
	Stat 4202	Intermediate	~ ~	Intermediate	1	Intermediate	l		İ			l		l
		cuidte	1	cuiute	1	cuidte			1					
Required in t	track													
	Math 2255	Beginning	Intermediate	Intermediate	Beginning									
	Math 4557	Intermediate		Intermediate	Intermediate	Intermediate								
	Wath 4557	Internetitute		Internediate	Internediate	Internetitute								
Required app	plied math courses (choose	two)												
	Math 3607			Intermediate	Intermediate	Advanced								
	Math 4552	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4552	Internetitute	Internediate	Internediate	Adversed	Adventered								
	Math 4556			intermediate	Advanced	Advanced								
Required app	plied science courses													
	Physics 2300					Advanced								
	Physics 2301					Advanced								
	PHysics 2301					Auvanceu								
Electives														
	Math 3607 (if not before)			Intermediate	Intermediate	Advanced								
	Math 3007 (In not before)	A.I	A.1	Internediate	Adventer	Auvanceu								
	Math 4547	Advanced	Advanced	Intermediate	Advanced	ведінінд								
	Math 4548	Advanced	Advanced	Intermediate	Advanced	Begining								
	Math 4551	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4552 (if not before)	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4556 (if not before)			Intermediate	Advanced	Advanced								
	Math 5101	Boginning	Advanced	Intermediate		Intermediate								
		Deginning	Auvanceu	merneuiate		intermediate								
	Iviath 5102	вeginning	Advanced	intermediate		Intermediate								
	Math 5451	Beginning	Beginning	Intermediate	Beginning	Advanced								
	Math 5756	1		Beginning	Intermediate	Intermediate								
	Math 5757			Beginning	Intermediate	Intermediate								
		1	1						1					
		l				l								
Expected ma	jor program learning outco	mes												
	Goal 1	Learn concept	tual framework	s needed to st	udv higher ma	thematics, inclu	uding an intro	duction to m	athematical r	easoning and	an understan	ding of how t	o read and w	rite proofs
	Goal 2	Aquire basic n	nastery of core	areas of math	ematics includ	ing calculus an	alveis and alg	ehra						
	Cool 2	Develop a	aful matha		eniace shills	ing calculus, di	arysis ariu dig	c.o.a.						
	GOal 3	Develop powe	eriul matnema	lical problem s	uiving skills.	L								
	Goal 4	Learn to comr	municate math	ematical under	rstanding effec	tively.								
	Goal 5	Become profic	<u>cient in chos</u> en	tracks within t	the major.									

Curriculum N	App Mathematics PA /PS	Applied Track	Chamistry)											· · · · ·
Curriculum	hap - Mathematics BA/BS -	Аррней ттаск (Chemistry)											ļi
	-													
	Course	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5								L
Prerequisits														L
-	Biology 1113 or 1114			Beginning		Intermediate								
	Chem 1210			Beginning		Intermediate								
	Chem 1220			Beginning		Intermediate								
	CSE 1222 or 1223			Beginning		Intermediate								
	Math 1151	Beginning	Beginning	Beginning										
	Math 1152	Beginning	Beginning	Beginning										
	Math 1295				Intermediate	Beginning								
	Physics 1250			Beginning		Intermediate								
	Physics 1251			Beginning		Intermediate								
				88										
Coro														
COLE	Math 2152			Designing										l
	Wath 2153	Intermediate	Intermediate	Beginning										L
	Math 2568	Beginning	Beginning	Beginning		Beginning								
	Math 3345	Advanced	Beginning	Intermediate	Intermediate									L
-	Math 4530 or Stat 4201	Intermediate	Beginning	Intermediate	Intermediate	Intermediate								
	Stat 4202	Intermediate		Intermediate		Intermediate								
Required in t	rack													
	Math 2255	Beginning	Intermediate	Intermediate	Beginning									
	Math 4557	Intermediate		Intermediate	Intermediate	Intermediate								
Required an	alied math courses (choose	two)												
Required ap	Math 2607	(00)		Intermediate	Intermediate	Advanced								
	Math 4552	1		Internetiate	Interneulate	Auvanceu								
	Ivialn 4552	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								l
	Wath 4556			Intermediate	Advanced	Advanced								L
-														
Required app	plied science courses (choos	e two)												
	Chem 2210					Advanced								
	Chem 4300					Advanced								
	Chem 4310					Advanced								
Electives				1										
	Math 3607 (if not before)			Intermediate	Intermediate	Advanced								
	Math 4547	Advanced	Advanced	Intermediate	Advanced	Begining			1					
	Math 4548	Advanced	Advanced	Intermediate	Advanced	Regining								
	Math 4551	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4551	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4552 (If not before)	memediate	memediate	Internediate	Adversed	Advensed								
<u> </u>	Iviaul 4556 (If not before)			intermediate	Auvanced	Auvanced								<u> </u>
	Iviath 5101	Beginning	Advanced	Intermediate		intermediate								l
	Math 5102	Beginning	Advanced	Intermediate		Intermediate								l
L	Math 5451	Beginning	Beginning	Intermediate	Beginning	Advanced			l					ļ
	Math 5756			Beginning	Intermediate	Intermediate								ļ
	Math 5757			Beginning	Intermediate	Intermediate								
														1
Expected ma	jor program learning outco	mes		1										
	Goal 1	Learn concept	ual framework	s needed to st	udv higher mat	thematics, inclu	uding an intro	duction to m	athematical r	easoning and	an understan	ding of how t	o read and w	rite proofs.
	Goal 2	Aquire basic n	nastery of core	areas of math	ematics includ	ing calculus an	alysis and alg	ebra.		2				
	Goal 3	Develop pour	arful mathema	tical problem s	olving skille									
	Goal A	Loarn to come	nunicata math	omatical under	estanding off	tivoly								
	Goal 4	Deserve and		ematical under	stanung enec	uvely.			ł					I
1	C IDUD	become profit	Lient in chosen	LI ACKS WITNIN T	ne major.	1						1		1

Curriculum I	Map - Mathematics BA/BS - Educat	ion Track												
	Course	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5								
Prerequisits														
	Math 1151	Begining	Begining	Begining										
	Math 1152	Begining	Begining	Begining										
	Math 1295				Intermediate	Begining								
	CSE 1222, 1223 or 2221			Begining	Begining									
Core														
	Math 2153	Intermediate	Intermediate	Begining										
	Math 2568	Begining	Begining	Begining		Begining								
	Math 3345	Advanced	Begining	Intermediate	Intermediate									
	Math 4530 or Stat 4201	Intermediate	Begining	Intermediate	Intermediate	Intermediate								
	Stat 4202	Intermediate		Intermediate		Intermediate								
Required in	track													
	Math 4504	Advanced	Intermediate	Intermediate	Advanced	Advanced								
	Math 4507	Advanced	Intermediate	Intermediate	Advanced	Advanced								
	Math 4547	Advanced	Advanced	Intermediate	Advanced	Begining								
	Math 4548	Advanced	Advanced	Intermediate	Advanced	Begining								
	Math 4578	Intermediate	Intermediate	Intermediate	Intermediate	Advanced								
	Math 4580	Advanced	Advanced	Intermediate	Advanced	Begining								
	Math 4581	Advanced	Advanced	Intermediate	Advanced	Begining								
Expected ma	ajor program learning outcomes													
	Goal 1	Learn concept	tual framework	s needed to stu	dy higher math	nematics, incluc	ling an introd	uction to mat	hematical rea	soning and a	n understandi	ng of how to	read and writ	e proofs.
	Goal 2	Aquire basic n	nastery of core	areas of mathe	matics includir	ig calculus, ana	ysis and algel	ora.						
	Goal 3	Develop powe	erful mathemat	ical problem so	lving skills.									
	Goal 4	Learn to comr	nunicate mathe	ematical unders	tanding effecti	vely.								
	Goal 5	Become profig	cient in chosen	tracks within th	ne maior.									

Curriculum N	An - Mathematics BA/BS -	Financial Track												
carricalarit	nap matternatios bry bb													
	Course	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5								
Proroquisits	course	00011	00012	00015	00014	00015								
Trerequisits	AcctMIS 2000			Regining		Intermediate								
	CSE 1222 or 1223			Begining		Intermediate								
	CSE 2111			Begining		Intermediate								
	Econ 2001			Begining		Intermediate								
	Econ 2002			Begining		Intermediate								
	Math 1151	Regining	Begining	Begining		Internetiate								
	Math 1151 Math 1152	Begining	Begining	Begining										
	Math 1295	Degining	Degining	Degining	Intermediate	Begining								
	111255				Internetiate	Degining								
	-													
Core	-													
0010	Math 2153	Intermediate	Intermediate	Regining										
	Math 2568	Begining	Begining	Begining		Begining								
	Math 3345	Advanced	Advanced	Intermediate	Intermediate	Intermediate								
	Math 4530 or Stat 4201	Intermediate	Begining	Intermediate	Intermediate	Intermediate								
	Stat 4202	Intermediate		Intermediate		Intermediate								
Required in t	rack													
	BusFin 3120 or 3220			Intermediate	Intermediate	Advanced								
	Math 2255	Begining	Intermediate	Intermediate	Begining									
	Math 3589			Intermediate	Intermediate	Advanced								
	Math 3607			Intermediate	Intermediate	Advanced								
	Math 3618			Intermediate	Advanced	Advanced								
	Math 5632			Intermediate	Advanced	Advanced								
Required in t	rack - Choose one													
	Math 4512	Intermediate		Intermediate	Intermediate	Intermediate								
	Math 4547	Advanced	Advanced	Intermediate	Advanced	Begining								
	Math 4557	Intermediate		Intermediate	Intermediate	Intermediate								
Expected ma	jor program learning outco	mes												
	Goal 1	Learn conceptual frameworks needed to study higher mathematics, including an introduction to mathematical reasoning and an understanding of how to r											o read and w	rite proofs.
	Goal 2	Aquire basic mastery of core areas of mathematics including calculus, analysis and algebra.												
	Goal 3	Develop powe	erful mathemat	tical problem s	olving skills.									
	Goal 4	Learn to comr	nunicate math	ematical under	rstanding effec	tively.								
	Goal 5	Become profi	cient in chosen	tracks within t	the major.									

Curriculum N	Ian - Mathematics BA/BS - M	1ath Biolomy		1	1									
Curriculum	Tap - Mathematics BAy B3 - W	Iatri Biology												
	Course	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5								
Prerequisits														
	Biology 1112			Reginning		Intermediate								
	Diology 1115			Deginning		lintermediate								
	BIOIOGY 1114			Beginning		Intermediate								
	Chem 1210			Beginning		Intermediate								
	Math 1151	Beginning	Beginning	Beginning										
	Math 1152	Reginning	Beginning	Reginning										
	Math 1152	Deginning	Deginning	Deginning										
	Math 1295				Intermediate	Beginning								
Core														
COIC	March 2452	1	1	D										
	Math 2153	Intermediate	Intermediate	Beginning										
	Math 2568	Beginning	Beginning	Beginning		Beginning								
	Math 3345	Advanced	Beginning	Intermediate	Intermediate									
	Math 4530 or Stat 4201	Intermediate	Beginning	Intermediate	Intermediate	Intermediate								
	Stat 4202	Intermediate	88	Intermediate		Intermediate								
	3181 4202	Interneulate		Interneulate		Interneulate								
				1	1									
Required in t	rack													
	Math 2255	Poging :	Internet - died -	Internet a diada	Poging := -									
	IVIdUI 2200	Беділігіng	muermediate	mermediate	Deginiting									
	Math 3350				Intermediate	Beginning								
				1	1									
Required in t	rack Chaosa ana			<u> </u>	<u> </u>									
nequired in t	I aux - Unouse one													
	Math 5660 or MolGen 5660					Intermediate								
	Biology 3401					Intermediate								
Required app	lied math courses (choose to	wo)												
	Math 3607			Intermediate	Intermediate	Advanced								
	Math 4EEC			Intermediate	Advanced	Advanced								
	Math 4556			Intermediate	Advanced	Advanced								
	Math 4557	Intermediate		Intermediate	Intermediate	Intermediate								
Required apr	lied science courses													
nequired upp	Develop 2200					المعمونية الم								
	Physics 2300					Advanced								
	Physics 2301					Advanced								
El a ativia a														
Electives														
	Biochem 4511					Advanced								
	Chem 2510					Advanced								
	FEOB 3310					Advanced								
	EE08 3430					Advanced								
<u> </u>	LLUD 3420			<u> </u>	<u> </u>	Auvanceu							-	
	EEUB 4520					Advanced								
	Math 3607 (if not before)	L		Intermediate	Intermediate	Advanced	L	L	L			L		
	Math 4530				Intermediate	Advanced								
	Math 4547	Advanced	Advanced	Intermediat-	Advanced	Regining	1	1	1			1		
<u> </u>	iviau(14347	Auvanceu	Auvanceu	memediate	Auvanceu	Degining							-	
	Math 4551	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4552	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4556 (if not before)			Intermediate	Advanced	Advanced								
	Math AFE7 (if not hof)	Intermedict-		Intermediate	Intermediate	Intermedict-								
	wati 4557 (ii not belore)	memeulate		memediate	memeulate	memediate								
	Math 4580	Advanced	Advanced	Intermediate	Advanced	Begining								
	Math 5101	Beginning	Advanced	Intermediate	1	Intermediate								
	Math 5102	Beginning	Advanced	Intermediate		Intermediate								
	Math 5540H	Advanced	Advanced	Advanced	Intermediat-	Regining								
	ivia(1) 3340F	Auvanceu	Auvanceu	Auvanced	memediate	Degining								
	MolGen 4500					Advanced								
	MolGen 5601			1	1	Advanced								
				<u> </u>	<u> </u>									
		I		<u> </u>	<u> </u>								-	
Expected ma	or program learning outcom	nes												
	Goal 1	Learn concept	tual frameworl	<u>ks need</u> ed to st	udy higher mat	hematics, inclu	uding an intro	duction to m	athematical r	easoning and	an understan	ding of how t	o read and wr	rite proofs.
	Goal 2	Aquire basic n	nastery of core	areas of math	ematics includi	ng calculus an	alvsis and alg	ebra.						
	Cool 3	Dovelop provide	orful mothers	tical problem -	olving skills		, 515 arra dig							
L		Develop powe	en ul matriema	ucal problem s	UNING SKIIIS.									
L	Goal 4	Learn to comr	municate math	ematical unde	rstanding effec	tively.								
I	Goal 5	Become profic	cient in chosen	tracks within t	the major.									

				-	-	-								
Curriculum Map - Mathemati	cs BA/BS - Theoretical Trac	:k												
	Course	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5								
Prerequisits														
	Math 1151	Begining	Begining	Begining										
	Math 1152	Begining	Begining	Begining										
	Math 1295				Intermediate	Begining								
														l
														l
Core														l
	Math 2153	Intermediate	Intermediate	Begining										
	Math 2568	Begining	Begining	Begining		Begining								l
	Math 3345	Advanced	Advanced	Intermediate	Intermediate	Intermediate								l
	Math 4530 or Stat 4201	Intermediate	Begining	Intermediate	Intermediate	Intermediate								
	Stat 4202	Intermediate		Intermediate		Intermediate								
Required in track														
	Math 2255	Begining	Intermediate	Intermediate	Begining									
	Math 4547	Advanced	Advanced	Intermediate	Advanced	Begining								1
	Math 4548	Advanced	Advanced	Intermediate	Advanced	Begining								
	Math 4580	Advanced	Advanced	Intermediate	Advanced	Begining								1
	Math 4581	Advanced	Advanced	Intermediate	Advanced	Begining								
Electives														
	Math 3589			Intermediate	Intermediate	Advanced								
	Math 3607			Intermediate	Intermediate	Advanced								
	Math 3618			Intermediate	Advanced	Advanced								
	Math 4350			Intermediate	Advanced	Advanced								
	Math 4504	Advanced	Intermediate	Intermediate	Advanced	Advanced								
	Math 4507	Advanced	Intermediate	Intermediate	Advanced	Advanced								
	Math 4551	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4552	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4556			Intermediate	Advanced	Advanced								
	Math 4557	Intermediate		Intermediate	Intermediate	Intermediate								
	Math 4570	Intermediate	Intermediate	Advanced	Intermediate	Intermediate								
	Math 4573	Advanced	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4575	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate								
	Math 4578	Intermediate	Intermediate	Intermediate	Intermediate	Advanced								
	Math 5632			Intermediate	Advanced	Advanced								
			1											
Expected major program lear	ning outcomes		l											
	y higher mathe	matics, includin	g an introduc	tion to mathe	matical reaso	ning and an u	inderstanding	of how to re	ad and write	proofs.				
	Goal 2	Aquire basic m	astery of core a	reas of mathen	natics including	calculus, analys	is and algebra	a.						
	Goal 3	Develop powe	rful mathematio	al problem solv	ving skills.	,,,	8							
	Goal 4	Learn to comm	nunicate mathe	matical underst	elv.									
	Goal 5	Become profic	ient in chosen t	racks within the	major.									
J		prome												L