College Curriculum Committee, 1420 Lurie Engineering Center Building



Form Number 1112

Action Requested

O New Course
O Modification of Existing Course
O Deletion of Course

Complete the following sections:

New Courses - B & C completely

Modifications - A modified information, B & C completely Deletions - A & C completely

Date 7/14/2003

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	Atmosph	eriç, Oceanic, &	Space Sciences	241		Home De	epartment		Div#	Course Numbe
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	Course Title									
	Space S		n for Space Scien	ces		Course Title	•			
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	VIATION	Transcript Max = 20 Spaces	Desg Space	e Sc		ABBRE- VIATION	Max = 19 Spaces Transcript			
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] F	Curriculum Faculty Rackham Cross listed	- d Unit 1					nitted By: Home Dep Department AOSS Perry Sa	t. Cross-fisted Dept	1	
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SUPPORTING	STATEMENT		
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Are any special reso	ources or facilities required for this course?		
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Detail the Special red	quirements		
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College Curriculum Committee, 1420 Lurie Engineering Center Building



Form Number 1213

Action Requested

New CourseModification of Existing CourseDeletion of Course

Complete the following sections: New Courses - B & C completely Modifications - A modified information, B & C completely

Date 11/18/2003

Deletions - A & C completely Effective Fall 2004

	A. c	URRENT LIST	ING			В. "	350450555			
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	Cross Listed	d Course Information					d Course Information	and Guoines	AOSS	
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[3	1 Occide Time					Course Title				
	Space S	ystems Managem	ent				olicy and Manag	lement		
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_	VIATION	Transcript Max = 20 Spaces	Space Sys	Mang		ABBRE- VIATION	Max = 19 Spaces Transcript	Space Pol &		
Х	Course Desc	ription				Course Door	Max = 20 Spaces			
	The first part of the course will offer a comprehensive introduction to modern management methods used in large projects. The second part will concentrate on successful management example of complex space projects. This course will usually be taught by adjunct faculty with extensive experience in successful management of large space projects.				space po space co missions modem i manager	Fair of the course will Droving detailed information and				
_	PROGR		e	Elective	i	PHC(C): ☑ a □ t	- Termenus O Decume F	e f g	□ h ⊠ i	⊠j⊠k
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	Maximum H Can it be re	epeatable? ○ Yes ⊙ N	lo 11 Times?			Printing Info (O	rmation 图 Print the co ptional) 图 Print the co	ourse in the Bulletin ourse in the Time Sched	dule	
	Class Type(s)	c OSee	m ⊠A-E b □ CR/NC s □ S/U d □ P/E	Loc ⊠ Ar ⊡ Bio	cation n Arbor n Arbor no Davis no Davis ension	Offering Y	Lenn	Even Years 🔲 Odd Y	ears Title Profess	f term 1 1st 2nd
_	Approval					Grad Course: Atta	ch nomination if Cognizar	nt Faculty is not a regula	er graduate faculty	
	Curriculum	Comm.				Subm Name, Signature &	nitted By: 📕 Home Dept Department	. Cross-listed Dept.	1	
	Faculty Rackham Cross listed Cross listed	1 Unit 1				Home Dept. Cross-listed Dept(s	AOSS Perry Sar	THE WE	lum	
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Form Number	er
1213	

SUPPORTING STATEMENT

The class "Space Policy and Management" covers an important part of any space system development. The class covers important management techniques and currently used space systems development. In addition, the class discusses the historical and current space policy. There is no such class in the college of engineering.
the college of engineering
Are any special resources or facilities required for this course?
Detail the Special requirements

AOSS 581

SPACE POLICY AND MANAGEMENT

Objectives: This course is intended to provide detailed information on how space policy is developed in the United States and the international space community, how these policies result in specific space missions, and how space missions are managed. The course will provide the context in which space missions are executed, as well as detailed information on management techniques and processes. Project Managers from NASA centers and industry will lecture on the detailed management techniques and processes.

The course outline, roughly by week during the semester, is:

- 1. The history of space policy in the United States.
- 2. The structure of the US Government, and US programs in space.
- 3. The current processes for approving and selecting US space missions.
- 4. The current state of international space programs.
- 5. The current state of commercial space activities.
- 6. The prospects for and constraints on the future of space.
- 7. How to develop proposals; forming teams; estimation techniques.
- 8. The fundamentals of project management.
- 9. Work breakdown structures.
- 10. PERT/CPM and GANTT project planning, reporting and tracking; variance and earned value tracking.
- 11. Risk management and quality assurance practices.
- 12. Case studies.
- 13. Case studies.
- 14. Case studies.

Grading Policy: Students will be assigned a research project on as aspect of space policy for 50% of their grade, and will participate in a case stud for the remaining 50%.

College Curriculum Committee, 1420 Lurie Engineering Center Building



Form Number 1221

Action Requested

New CourseModification of Existing CourseDeletion of Course

Complete the following sections: New Courses - B & C completely Modifications - A modified information, B & C completely Deletions - A & C completely

Date 11/21/2003

Effective Fall 2004

	A. CURRENT LISTING	B DEGUEOTER AND THE				
_	Home Department Div# Course Number	B. REQUESTED LISTING				
X	Aerospace	Home Department Atmospheric, Oceanic, & Space Sciences AOSS 582				
	Cross Listed Course Information					
	Atmospheric, Oceanic, & Space Sciences AOSS 582	Cross Listed Course Information Aerospace AERO 582				
	Course Title					
		Course Title				
	TITLE Time Sched	Spacecraft Technology				
	ABBRE- Max = 19 Spaces VIATION Transcript Max = 20 Spaces Max = 20 Spaces	TITLE ABBRE- Max = 19 Spaces Spacecraft Tech VIATION Transcript Co-				
х	Course Description	Max = 20 Spaces Spacecraft Tech				
	A systematic and comprehensive review of spacecraft and space mission technology, including trajectory and orbital mechanics, propulsion systems, power and thermal systems, structures, control, and communications.					
	Prerequisites PROGRAM OUTCOMES: a b c d e f g h i j k Degree Requirements	□ PROGRAMIC UNGO SING SING SING SING SING SING SING SING				
	Credit Restrictions	© Enforced ⊙ Advised Credit				
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X	Racktham Grad	Level of Credit Undergrad only Rackham Grad Rockham Grad Ugrad or Rockham Grad Ugrad or Rockham Grad Ugrad or Non-Rickham Grad				
C.	Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable? C Yes ③ No Maximum Hours? Maximum Times?	Printing Information (Optional) Print the course in the Bulletin				
	Can it be repeated in the same term? O Yes O No					
]	Class Class Cype(s)	Terms & D				
1	Other Officer_ Y Camp Davis	Cognizant Faculty Thomas H. Zurbuchen Title Associate Professor				
L						
	pproval	Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty				
	Curriculum Comm	Submitted By: Home Dept. Cross-listed Dept. Home Dept. AERO				
		Cross-listed Dept(s). AOSS Perry Samson				
	Cross listed Unit 1					
	Pross listed Unit 2					
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Form Number	
1221	_

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begins with a through introduction on the space system design process of their integration into a space system, broken down into sub-system requirements. This process is illustrated using recent space missions with a variety of purposes. Key spacecraft technologies are then discussed in this context. The technologies discussed here included purposes, and the properties and top-level systems aspects from each technology. Several of these technologies are analyzed in detail, using modern design tools, analytical and numerical methods.	ie,
The class is given top-level objectives defining a space mission. Based on these objectives, alternative architectures to be developed and formulated in a Phase A study. This practical design study is concluded in a public presentation the next students of AERO 483/583 who will choose their projects based on these presentations. The students of AERO 483/583 who will choose their projects based on these presentations. The students	i.are.
The 582-583 sequence is to be inter-departmental and interdisciplinary. Due to the fact that AERO 583 is co-taught AERO-483, its home department appropriately is Aerospace Engineering. Subsequently, to reflect the key idea of t sequence of design classes, AOSS 582, is moved to the AOSS department.	with his
Are any special resources at the sile.	********
Are any special resources or facilities required for this course?	*****
Computer room with software for orbit design, space environment modeling, CAD and other packages relevant for	•••
	
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Course Objectives:

- 1. Introduce space system design process.
- 2. Familiarize students on how to apply this process for existing space missions.
- 3. Introduce students to key spacecraft technologies, including propulsion, orbit design, space environment, space launcher, and others.
- 4. Familiarize students with technology tradeoffs using analytic, numerical and designated tool-kits.
- 5. Experience the integration of these technologies by performing a design study of a space mission at the Phase A level.

Course Outcomes:

- 1. Have basic understanding of space systems and how they relate to their subsystems and technologies.
- 2. Understand the basic principles of key technologies that are relevant for these systems.
- 3. Know how to apply these design processes for space systems and perform relevant trade studies of key-subsystems.
- 4. Perform top-level space design by working in a group of technology specialists.

Assessment Tools

- 1. Written homework for individuals and small groups.
- 2. Mid-term exam
- 3. Final Exam

College Curriculum Committee, 1420 Lurie Engineering Center Building



Form Number 1222

Action Requested

C.

New Course Modification of Existing Course O Deletion of Course

Complete the following sections:

New Courses - B & C completely Modifications - A modified information, B & C completely Deletions - A & C completely

Date 11/21/2003

Effective Fall 2004 A. CURRENT LISTING B. REQUESTED LISTING Home Department Div# Course Number Home Department Div# Course Number Atmospheric, Oceanic, & Space Sciences Cross Listed Course Information AOSS 584 Cross Listed Course Information Course Title Course Title Space Instrumentation Time Sched TITLE Max = 19 Spaces Time Sched ABBRE Space Instrumenta Transcript Max = 20 Spaces Max = 19 Spaces VIATION ARRRE. Transcript VIATION Space Instrumenta Max = 20 Spaces Course Description Course Description for Official Publication (Max = 50 words) A survey of the physical principles and engineering of instrumentation used throughout the many related fields of space science. Upon completion of the course, students will have a firm grasp of the principles and techniques used to sense and measure photons, neutral gases, charged particles, and cosmic dust. PROGRAM OUTCOMES PROGRAM OUTCOMES □a □b □c □d □e □f □g □h □i □j □k ⊠a □b ⊠c ⊠d ⊠e ⊠f ⊠g ⊠h ⊠i ⊠j ⊠k Degree Requirements O Degree Requirement O Tech Elective O Other Degree Requirements O Degree Requirement O Tech Elective O Core Course O Other Prerequisites O Enforced O Advised Prerequisites Graduate Standing ○ Enforced ⊙ Advised Level of Credit Undergrad only
Rackham Grad
Non-Rickham Grad
Ugrad or Rickham Grad
Ugrad or Non-Rickham Grad Credit Hours Contact Level of Credit ☐ Alf Credit types ☐ Rckhm Grad w/add'l Work Undergrad only
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☐ Ugrad or Rickhm Grad
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Other	Other_	□ ¥.,	☐ Camp Davis ☐ Extension	Cognizant Faculty J.H. Waite Title Professor	
Approval				Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty	
☐ Curriculum Comm. ☐ Faculty ☐ Rackham ☐ Cross listed Unit 1				Submitted By: Home Dept. Cross-fisted Dept. Name, Signature & Department Home Dept. AOSS Perry Samson Cross-listed Dept(s).	
Cross listed Unit 2					

Form	Number
1222	

SUPF	'ORT	ING	STAT	TEMENT	Г
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the design, development, and operations of space instrumentation. Course is necessary to meet the needs of the new.
Are any special resources or facilities required for this course?
Detail the Special requirements
1) the use of an in class computer lab resource — Rm# 2139 2) the use of a vacuum lab facility — Rm# 2114, 3) the use of an optical lab facility — Rm# 2120 4) the use of several pieces of SPRL lab equipment such as an RGA 5) engineering support from SPRL personnel

AOSS 584 Space Instrumentation

Space science instrumentation is a discipline aimed at creating state-of-the-art sensors capable of measuring the environments of the Earth, the planets and their satellites, the Sun, and interplanetary space. AOSS 584 is a recently developed course that surveys the physical principles and engineering of instrumentation used throughout the many related fields of space science. Upon completion of the course students will have a firm grasp of the principles and techniques used to sense and measure photons, neutral gases, charged particles, and cosmic dust. After a review of methods, instrumentation, and vacuum technology, the laboratory section of the course will concentrate on the testing and characterization of prototype instruments for future Mars missions. The laboratory is equipped with a small (clean) high-vacuum facility, clean bench, modern electronic instrumentation, photon and particle sources, and optical benches (photon and charged particle). For further information, please contact Dr. J. Hunter Waite (hunterw@umich.edu).

1. Course Outline (including weekly schedule sample from 2003 winter term)

AOSS		·	Space Science Instrumentation	W
<u>Date</u>	No.		Lecture/lab Descriptions	Winter 200?
	1	LAB		Comment John Eder/Lisa
	2a	LEC	HW: Introduction: Instructors & office hours, purpose and philosophy of course (science <i>and</i> engineering); lab basics prototype development; course structure; reading lists; grading; homework.	Stowe Student bios
	2b	LEC	HW: Mars as a scientific backdrop	
	3	LEC	HW: The space environment: gravitation, vibration, vacuum, thermal, radiation, plasma, debris; Instrument concepts & design	
	4	LEC	HW: Introduction to particle optics	
	5	LAB	TZ: Lab 1a, Particle optics	
	6	LAB	TZ: Lab 1b, Particle optics	
	7	LEC	NR: Introduction to photon optics	
	8	LEC	NR: Photon optics systems	Lab report #1
	9	LAB	NR: Lab 2b, Photon Optics	
	10	LAB	NR: Lab 2b, Photon Optics	
	11	LEC	HW: Introduction to vacuum systems	
	12	Lab	BB: Lab 3a, Measurement of partial pressure	
	13	LAB	BB: Lab 3b, Measurement of partial pressure	
	14	LEC	HW: Mass Spectrometers and Ion Sources	
7	Winter	break		

_AOS	S 584		Space Science Instrumentation	W:4- 2000
Date	No.		Lecture/lab Descriptions	Winter 200?
Mar	15	LEC		Comment Lab report #2
Mar	16	LAB	HW: Matlab simulation of vacuum system	* •
Mar	17	LAB	BB: Prototype lab, session one, Conductance calibration	Lab report #3
Mar	18	LAB	BB, HW: Prototype lab, session two, Zeolite pumping speed	
Mar	19	LEC	HW: Photon and particle detectors	
Mar	20	LAB	BB, HW: Prototype lab, session three, Molecular flow regime	
Mar	21	LAB	BB, HW: Prototype lab, session four, Staged pumping technique	
Mar	22	LAB	BB, HW: Prototype lab, session five, Known mixture characterization	
Apr	23	LAB	BB, HW: Prototype lab, session six, Temperature dependence	
Apr	24	LAB	BB, HW: Prototype lab, session seven, Unknown mixture	
Apr	25	LAB	BB: Prototype lab, session eight, Volcano sample analysis	
Apr	26	LAB	BB: Prototype lab, session nine, Volcano sample analysis	
Apr	27	LEC	BB, HW: Instrument concepts, design, and engineering; Prototype Reviews	Lab report #4

2. Required/recommended text books and/or coursepacks *Reading list (primary text in bold):*

Moore, J. H., C.C. Davis, and M. A. Coplan, "Building Scientific Apparatus, third edition," Advanced Book Program, Perseus Books, Cambridge, MA., ISBN 0-8133-4066-3, 2003.

Cruise, A. M., et al., "Principles of Space Instrument Design," Cambridge Aerospace Series, Vol. 9, Cambridge U. Press, 1998; ISBN 0-521-45164-7.

Lipson, S. G., H. Lipson, and D. S. Tannhauser, "Optical Physics," 3rd Ed., Cambridge U. Press, 1995; ISBN 0 521 43631 1 (pb).

Wertz, J. R., and W. J. Larson, "Space mission analysis and design," 3rd Ed., Microcosm & Kluwer, 1999; ISBN 1-881883-10-8 (pb). (Chapters 1 through 4, 8, 9, 12, 19)

Wollnik, H., "Optics of charged particles," Academic Press, 1987; ISBN 0-12-762130-X.

3. Grading and exam policies

6 lab reports
Oral presentation for the final

88.5% 12.5%

4. Prerequisite courses (if any)

None required, but a thorough knowledge of college level physics and mathematics is highly recommended.

College Curriculum Committee, 1420 Lurie Engineering Center Building



Form Number 1223

Action Requested

New CourseModification of Existing CourseDeletion of Course

Complete the following sections:

New Courses - B & C completely Modifications - A modified information, B & C completely Deletions - A & C completely

Date 11/21/2003

Effective Fall 2004

	A. CURRENT LISTING	D -				· · · · · · · · · · · · · · · · · · ·
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L		. Ione De	partment		Div#	Course Number
	Cross Listed Course Information	Atmospe	eric, Oceanic, & Spac	e Sciences	AOSS	
		Cross Listed	d Course Information			
_						
L	Course Title					
		Course Title				
	TITLE Time Sched	Introduc	tion to Remote Se	ensing and Inv	ersion Theor	у
	ABBRE- Max = 19 Spaces VIATION Transcript	TITLE ABBRE-	Time Sched Max = 19 Spaces	Remote Ser	———— <u> </u>	<u> </u>
_	Max = 20 Spaces	VIATION	Transcript	Remote Sen		
Х	Course Description An introduction to the teach	Course Decor	Max = 20 Spaces		ısıng ————	
	An introduction to the techniques of remote sensing in the optical	Introduct	ription for Official Publication	n (Max = 50 words)		
	spectral region. Atmospheric sounding and spectroscopic study of the atmosphere. Methods of inversion of measurements to yield	of emission	tion to active (rad	ar and lidar) ai	nd passive (t	hermal
	model parameters. Optimal estimation, non-linear inversion, and	Fundame	entals of electrom	and microway	e remote sei	nsing.
	sequential estimation.		a. Opiioui Denor	MANCA Charas	4	
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	PROGRAM OUTCOMES.					
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	Core Course O Other	Degree Requ	whereness O Decree Re	Chimment @ Test	lective	MJ MK
	Prerequisites © Enforced © Advised	Draromiloites e	O Free Flecti	Se 0 0	1000140	
	Credit	· rorequisites (Graduate Standing C Enforced © Advised			
	Restrictions	Credit Restrictions				
	Level of Credit Undergrad only Rachten God Rachten God All Credit types Credit Hours Contact Rachten God	Level of Credi				
	☐ Rackham Grad ☐ Rockham Grad W/add'l Work Min Max Hrs/Wk	Undergrad onl	 V ⊠AliCredi	if types	Credit Hours	Contact
ł	Ugrad or Non-Rockhm Grad Ugrad or Non-Rockhm Grad	☐ Rackham Gra ☐ Non-Rickhm G	arad ⊔ rickonm	Grad w/add'l Work	Min Max	Hrs/Wk 3
Ī	OI TYRS	☐ Ugrad or Rokt ☐ Ugrad or Non-	hm Grad -Rokhm Grad		<u>3</u> 3	Number
C.	Repeatability (Indi Research, Dir. Study, Dissertation: Is this course repeatable?	Printing Infor				of Wks13
ŀ	Maximum Hours? Maximum Times?	(Or	otional) 🖾 Print the cou	rse in the Bulletin rse in the Time Sched	lule	
	Can it be repeated in the same term? O Yes O No					
_	Class Type(s) Lec	T				
	□ Rec □ Sem □ Sem □ A-F Location	7,04.01	□ H □ HIA □ HIb □		Hal	term 1 1st 2nd
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	☐ Ind ☐ ☐ P/F ☐ Exological Station ☐ ☐ Other ☐ V ☐ Camp Davis	Cognizant Faculty		her S. Ruf		
	Extension	Member:		ior S. Nui	Title Profess	or
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Form	Number
1223	

### SUPPORTING STATEMENT

sensing — to better set the context of the section on inversion methods. Some advanced topics in inversion methods previously covered in the course will be deleted to accommodate these additions. The changes are being made in order undergraduates and first year PhD students.
Are any enocial recovery.
Are any special resources or facilities required for this course?
Detail the Special requirements
- 4

### 1. Supporting Documentation:

### 1.1 Course Outline (including weekly schedule of subject matter covered)

Lecture number(s)

- 1 Introduction to remote sensing and the inverse problem
- Review of electromagnetic theory and instrumentation (propagation, radiative transfer, diffraction limited imaging, signal generation and detection.)
- 5 Active surface remote sensing fundamentals (radar and lidar)
- 6-7 Active surface remote sensing applications and examples (land imagery, ocean surface characterization, interferometric SAR)
- Passive surface remote sensing fundamentals (Thermal emission, dielectric boundaries, emissivity)
- 9-10 Passive surface remote sensing applications and examples (IR and microwave land, ocean, cryosphere applications)
- Atmospheric remote sensing fundamentals (atmospheric characteristics)
- 12-13 Passive atmospheric remote sensing applications and examples (limb and nadir sounding)
- 14-16 Active atmospheric remote sensing applications and examples (atmospheric lidar, meteorological radar)
- 17-18 Review of linear algebra and random processes (Vector spaces, linear operators, bases, determinants, eigenvalues and eigenvectors. Descriptions of noise processes and propagation of noise through a linear system. Noise correlation and covariance.)
- 19-21 Regression Analysis (Minimization of quadratic functionals, least squares solutions, constrained least squares solutions. Iterative non-linear minimization)
- 22-24 Other Inversion Methods (Optimal estimation. Statistical inversion. Maximum probability estimation.)
- 25-27 Information Content (Statistical interdependence of measurements, benefits of over sampling, and error magnification due to processing.)

## 1.2 Required/recommended textbooks and/or coursepacks

- Elachi, C., <u>Introduction to the Physics and Techniques of Remote Sensing</u>, John Wiley & Sons, NY, 413 pp, 1987.
- F.T. Ulaby, R.K. Moore and A.K. Fung, Microwave Remote Sensing Active and Passive, Volume III From Theory to Applications, Ch. 17, Artech House, Inc., Norwood, MA, 1986.
- C.D. Rodgers, Inverse Methods for Atmospheric Sounding, World Scientific Publ., Singapore, 2000.
- S. Twomey, Introduction to the Mathematics of Inversion in Remote Sensing and Indirect Measurements, Dover Publ., Mineola, NY, 1996.

#### 1.3 Grading and exam policies:

### **Homework**

- Homework will be assigned approximately every week

### Midterm and Final Exams

- Lecture notes, homework solutions and copies of assigned readings are permitted during the exams.
- No additional books or reference materials are permitted.

**Grading Policy** 

60% Homework

15% Midterm Exam (covering material from lectures, assigned

readings, and homework)

Final Exam (comprehensive but focused on 2nd half of term) 25%

#### Prerequisite courses (if any) 1.4

There are no specific prerequisites, but students are expected to be familiar with electricity and magnetism (at the level of Maxwell's equations), vector calculus, and linear algebra and to have a reasonable facility with scientific computer programming.

College Curriculum Committee, 1420 Lurie Engineering Center Building



Form Number 1316

### Action Requested

New Course
 Modification of Existing Course
 Deletion of Course

### Complete the following sections:

New Courses - B & C completely Modifications - A modified information, B & C completely

Date 2/4/2004

Deletions - A & C completely Effective Fall 2004 A. CURRENT LISTING B. REQUESTED LISTING Home Department Dlv# Course Number Home Department Div# Course Number Atmospheric, Oceanic, & Space Sciences Cross Listed Course Information AOSS 596 Cross Listed Course Information Course Title Course Title Gaskinetic Theory Time Sched TITLE Max = 19 Spaces Time Sched ABBRE-TITLE Gaskinetic Theory Transcript Max = 20 Spaces Max = 19 Spaces VIATION ARBRE-Transcript VIATION Gaskinetic Theory Max = 20 Spaces Course Description Course Description for Official Publication (Max = 50 words) Maxwell-Boltzmann distribution, kinetic determination of equation of state, specific heats of gases. Dynamics of two-particle collisions. Elementary transport theory, molecular effusion, hydrodynamic transport coefficients, mean free path method. Advanced transport theory, the Boltzmann equation, collision terms, Chapman-Enskog transport theory. Aerodynamics of free-molecular flow. Shock waves. PROGRAM ZOUTCOMES PROCERAM COUNCEMES! □a □b □c □d □e □f □g □h □i □j □k □a □b □c □d □e □f □g □h □i □j □k Degree Requirements O Degree Requirement
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This is an old course in AQSS that originated from the Aero 532 (gaskinetic Theory) course. It was cross-listed for some 20 years between AQSS and Aero. However, a few years ago the Aero department made some fundamental changes to the course to reflect their changing needs. Aero 532 is no longer cross-listed in AQSS, and we would like to put Gaskinetic Theory back to our revised graduate curriculum.
Are any special resources or facilities required for this course?
Detail the Special requirements
- Farm requirements

### Textbook:

Gombosi: Gaskinetic Theory, Cambridge University Press, Cambridge, UK, 1994.

#### Outline:

- 1. Introduction
- 1.1. Brief history of gaskinetic theory
- 1.2. The road to gaskinetic theory in science and engineering
- 1.2.1. Hydrostatics
- 1.2.2. Hydrodynamics (fluid mechanics)
- 1.2.3. Gaskinetic theory
- 1.3. Basic assumptions of gaskinetic theory
- 1.3.1. Molecular hypothesis
- 1.3.2. Classical conservation laws
- 1.3.3. Statistical nature of the theory
- 1.4. Solid angles and curvilinear coordinates
- 1.4.1. Spherical coordinates and solid angles
- 1.4.2. Cylindrical coordinates 1.6.
- 2. Equilibrium Kinetic Theory
- 2.1. Distribution functions
- 2.2. Phase-space distributions and macroscopic averages
- 2.2.1. Phase-space
- 2.2.2. Phase-space distribution
- 2.2.3. Macroscopic averages
- 2.3. The Maxwell-Boltzmann distribution
- 2.3.1. Maxwell's assumptions
- 2.3.2. The distribution of molecular velocities under equilibrium conditions
- 2.4. Determination of the Lagrange multiplier
- 2.4.1. Gas pressure on a wall
- 2.4.2. Equation of state
- 2.5. Elementary properties of the Maxwell-Boltzmann distribution
- 2.5.1. Distribution of molecular speeds
- 2.5.2. Mixture of gases
- 2.5.3. Moments of the Maxwell-Boltzmann distribution
- 2.6. Specific heats of gases
- 2.6.1. Equipartition of translational energy
- 2.6.2. Specific heats of monatomic gases
- 2.6.3. Specific heats of diatomic gases
- 2.7. Problems
- 3. Binary Collisions
- 3.1. Kinematics of two particle collisions
- 3.1.1. Center of mass and relative position coordinates
- 3.1.2. Particle motion in a central field of force

- 3.1.3. Angle of deflection
- 3.1.4. Inverse power interactions
- 3.1.5. Particle motion in laboratory and center of mass frames
- 3.2. Statistical description of collisional effects
- 3.2.1. Mean free time
- 3.2.2. Mean free path
- 3.2.3. Collision cross section
- 3.2.4. Collision cross sections for inverse power interactions
- 3.3. Relations between statistical and molecular quantities
- 3.3.1. Collision frequency
- 3.3.2. Collision rate
- 3.3.3. Chemical reactions
- 4. Elementary Transport Theory
- 4.1. Molecular effusion
- 4.1.1. Hydrodynamic escape
- 4.1.2. Kinetic effusion
- 4.1.3. Transport of macroscopic quantities through the orifice
- 4.2. Hydrodynamic transport coefficients
- 4.2.1. Viscosity
- 4.2.2. Heat conductivity
- 4.2.3. Diffusion coefficient
- 4.3. Mean free path method
- 4.3.1. Mean free path treatment of transport phenomena
- 4.3.2. Diffusion
- 4.3.3. Heat conduction
- 4.3.4. Viscosity
- 4.3.5. Some general remarks about the mean free path method
- 4.3.6. The mean free path method in three dimensions
- 4.4. Flow in a tube
- 4.4.1. Poiseuille flow
- 4.4.2. Slip flow
- 4.4.3. Free molecular flow in a tube
- 5. The Boltzmann Equation
- 5.1. Derivation of the Boltzmann equation
- 5.1.1. The evolution of the phase-space distribution function
- 5.1.2. The Boltzmann collision integral
- 5.1.3. Multispecies gases
- 5.2. The H-theorem and equilibrium distributions
- 5.2.1. The H-theorem
- 5.2.2. Equilibrium distribution
- 5.3. Approximate collision terms
- 5.3.1. Relaxation time approximation (BGK approximation)
- 5.3.2. Fokker-Planck approximation
- 5.4. Non-Equilibrium Solutions of the Boltzmann Equation

- 6. Generalized Transport Equations
- 6.1. Moments of the Boltzmann equation
- 6.1.1. Velocity moments of the phase space distribution function
- 6.1.2. Maxwell's equation of change
- 6.2 The Euler equations
- 6.3. The 20 moment equations
- 6.3.1. The Chapman-Enskog distribution function
- 6.3.2. Transport equations for the Chapman-Enskog coefficients
- 6.3.3. Grad's closing relation and the 20 moment approximation
- 6.4 The 13 moment approximation and the Navier-Stokes equations
- 6.4.1. The 13 moment equations
- 6.4.2. Collision terms for a single species gas
- 6.4.3. The Navier-Stokes equation
- 6.5. Collision terms for multispecies gases
- 6.5.1. Collision term for the momentum equation
- 6.5.2. Collision term for the pressure tensor
- 6.5.3. Collision term for the heat flow vector
- 6.6 Simplified sets of transport equations
- 6.6.1. The 10 moment approximation
- 6.6.2 The 8 moment approximation
- 6.6.3. The 5 moment approximation
- 7. Free Molecular Aerodynamics
- 7.1 Transfer of mass, momentum, and translational energy
- 7.1.1. Reflection coefficients
- 7.1.2. Transfer of mass
- 7.1.3. Transfer of perpendicular momentum
- 7.1.4. Transfer of tangential momentum
- 7.1.5. Transfer of translational energy
- 7.1.6. Limiting cases
- 7.2. Free molecular heat transfer
- 7.2.1. Recovery temperature, Stanton number and thermal recovery factor
- 7.2.2. Free molecular heat transfer to specific bodies
- 7.2.3. Heat transfer between two plates
- 7.3. Free molecular aerodynamic forces
- 7.3.1. Pressure and shearing stress
- 7.3.2. Lift and drag forces
- 7.3.3. Free molecular aerodynamic coefficients for specific bodies
- 8. Shock Waves
- 8.1 Hydrodynamic description
- 8.1.1. Normal shock waves in perfect gases
- 8.1.2. The structure of shock waves in viscous gases
- 8.2. Kinetic description of shocks: the Mott-Smith model

College Curriculum Committee, 1420 Lurie Engineering Center Building



Form	Number
1217	7

### **Action Requested**

New CourseModification of Existing CourseDeletion of Course

Complete the following sections:

New Courses - B & C completely

Modifications - A modified information, B & C completely

Deletions - A & C completely

Date 11/19/2003

Effective Winter 2004

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## Form Number

SUPPORTING STATEMENT The terms are being changed from Fall to Winter for staffing reasons. Are any special resources or facilities required for this course? ☐ Yes ☐ No Detail the Special requirements

College Curriculum Committee, 1420 Lurie Engineering Center Building



Form Number

#### Action Requested

O New Course

Modification of Existing Course

O Deletion of Course

Complete the following sections:

New Courses - B & C completely

Modifications - A modified information, B & C completely Deletions - A & C completely

Effective Winter 2004

Date 11/19/2003

A. CURRENT LISTING B. REQUESTED LISTING Home Denartment Div# Course Number Home Department Biomedical Engineering Course Number 242 458 Biomedical Engineering 242 458 Cross Listed Course Information Cross Listed Course Information EECS 280 458 **EECS** 280 458 Course Title Course Title Biomedical Instrumentation and Design Biomedical Instrumentation and Design Time Sched TITLE Max = 19 Spaces Time Sched ABBRE-Max = 19 Spaces Transcript VIATION ABBRE-Max = 20 Spaces Transcript VIATION Max = 20 Spaces Course Description Measurement and analysis of biopotentials and biomedical Course Description for Official Publication (Max = 50 words) Measurement and analysis of biopotentials and biomedical transducer characteristics; electrical safety; applications of FETs; transducer characteristics; electrical safety; applications of FETs; integrated circuits, operational amplifiers for signal processing and integrated circuits, operational amplifiers for signal processing and computer interfacing; signal analysis and display on the laboratory computer interfacing; signal analysis and display on the laboratory minicomputer. Lecture and laboratory. minicomputer. Lecture and laboratory. PROGRAM OUTCOMES: PROGRAM OUTCOMES: ⊠a ⊠b ⊠c ⊠d ⊡e ⊠f ⊠g ⊠h ⊠i ⊠j ⊠k ⊠d 🗆 e ⊠f ⊠g ⊠h ⊠i ⊠j ⊠k O Degree Requirement
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Home Dept. Matthew O'Donnell, Chair Biomedical Engineering ☐ Faculty Cross-listed Dept(s). ☐ Rackham ☐ Cross listed Unit 1☐ Cross listed Unit 2

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