The University of Michigan
College of Engineering
Curriculum Committee

Agenda
March 2, 2004
1:30-3:00 p.m.
GM Room
Fourth Floor Lurie Engineering Center

1. Approval of Minutes from January 27, 2004 Meeting
2. Program Change for Computer Engineering
3. Course Approval Forms
4. Program Change for AOSS

University of Michigan
College of Engineering
Curriculum Committee Meeting
Tuesday January 27, 2004
1:30-3:00 p.m.
Lurie Engineering Center GM Room
Minutes

Greg Hulbert called the meeting to order at 1:45 p.m.

Members Present: G.Hulbert, J. Bartlett , C. Cesnik, E. Chan, J.Fessler, G. Herrin, J. Holloway, J.Patel, R. Robertson, S. Takayama , L.Thompson

Members Absent, W. Hansen (CEE), S. Montgomery (ChE), S. Pang, M. Parsons H.Peng (INTERPRO). P.Samson (AOSS).

Guests: Stephen Pollock, Stacie Edington

EGL Broadening and Modifications to Requirements

Stephen Pollock talked about some proposed changes to the Engineering Global Leadership program. Handouts regarding this were in the meeting packet.
Steve introduced Stacie Edington who has replaced Melissa Eljamal as the administrative person for the EGL program.
The EGL program is an honors program with some of the best students in the College. Students need a 3.6 GPA to apply to this program. At this time it is restricted to IOE and ME for practical reasons. Steve was here to talk about some minor changes he would like approved, and their plans to expand it to the rest of the College. This is an overlay program, not a degree program but sits on top of existing programs, a Bachelor's Degree program, and then a Master's Degree program

The two minor changes that he is requesting are: 1. Right now they are requiring student have 24 (IOE students) 20 (ME student) total Humanities/Social Science courses. All of the students have had more than this number just by satisfying the EGL overlays.
Since the students are satisfying this anyway, they want to remove the requirement from their Bulletin, Website, etc. This will make auditing easier and remove some worry from the students, since some think this is on top of the requirements they already have and it isn't.
2. .Currently, the Cultural Core is 12 hours. They allow up to 3 hours of cultural core satisfaction if study abroad has led to courses counted as grades on the University of Michigan transcript. They would like to add a statement that says up to 3 hours of the cultural core requirement can be satisfied by working abroad for at least eight weeks in an environment which is in the cultural core area of the student.
Greg Hulbert called for a motion to remove the HU/SS credit hour requirement from the EGL Program and to allow three hours of the cultural core requirement to be waived by allowing eight weeks or more of work abroad. Moved and seconded.
Discussion.

In response to a question, Steve Pollock noted that EGL students have to satisfy all undergrad program requirements. Over and above those requirements they are required to take 12 courses in their cultural core and 8 hours of language (not in their native tongue). Just by completing the cultural core, EGL students end up with 28-30 hours of HU/SS.
1 abstention Motion **Carried (approved).**

Additional EGL Program Information
Steve Pollock said that there has been a committee appointed by Stella Pang to oversee this program, and they have been asked to expand this program beyond ME and IOE.
This has been working well for the last two years and now they would like to expand this program as an overlay to the rest of the College.
They would like to work with departments and businesses on this. He would like to work with whoever is necessary to give this a course number.
In response to how many students have gone through this program, the answer was 77 students.

Motion to approve the minutes of the last meeting

The minutes of the last meeting were approved

Course Approvals

Greg Hulbert called for a motion to approve the following courses. This was moved and seconded.
Motion Carried (approved)

This includes the course approval forms from the January 13, 2004 meeting.

AOSS 304 (X-Listed with ENSCEN 304) Deletion
AOSS 320 (X-Listed with GEO SCI 320) New Course
AOSS 321 (X-Listed with GEO SCI 321) New Course
AOSS 408 (X-Listed with ENSCEN 408) Deletion
AOSS 430 (X-Listed with ENSCEN 430) Deletion
AOSS 434 (X-Listed with ENSCEN 434) Deletion
AOSS 458 (X-Listed with ENSCEN 458) Deletion
AOSS 459 (X-Listed with ENSCEN 459) Deletion
AOSS 462 Modification – Changed Prerequisites from AOSS 305 ***to: AOSS 350.***
AOSS 465 (X-Listed with ENSCEN 465) Deletion
AOSS 469 (X-Listed with NAME 469) Deletion
AOSS 480 (X-Listed with GEOSCI 480) Deletion
CHE 530 (X-Listed with BIOINFO 530) Modification – Changed Title; Changed Description
NAME 320 Modification – Changed prerequisites from ME 211 or ME 240 or permission of instructor
to: MATH 215 AND ME 221 OR ME 240, or permission of instructor.
NAME 332 Modification – Changed prerequisites from NA 331 ***to: NA 331 and PHYS 240.***

Program Change for AOSS

Greg Hulbert stated that the Program Change for AOSS has not been approved yet since AOSS doesn't have the Program in place to approve yet. There are 3 new courses and 2 course deletions that have to come before the Committee. These courses need to come to the Committee by the March 2 meeting in order for the Committee to vote on the Program change, since the Program change needs to go before the Faculty Committee for vote.

SGUS AOSS/Space Engineering

The SGUS for AOSS/Space Engineering is deferred to the next meeting, it is still in progress.

CS-LSA Proposed Changes for LSA to Consider

The CS-LSA Proposed Changes to the Computer Science Program are from the last meeting's (1-13-04) packet from Toby Teorey. There are two parts: One that deals with changes in the CS Engineering Program which is for this Committee for discussion and motion for approval and the other for informational purposes – dealing with program changes in LS&A.

Greg Hulbert asked for a motion for approval of the changes in the memo (of January 2, 2004) from Toby Teorey specifically the program changes items 1,2 and 3, on page 4 of the memo, changing the name to "Advanced CS Technical Electives." and changing the number from 10 to 16, eliminating the upper level Flexible Technical Electives, and eliminating the Engineering Breadth Electives, the result of that is adding those 4 credits to the Flexible Technical Electives. Page 7 of the memo shows the original Sample Schedule and page 8 of the memo shows the proposed sample schedule.
Moved and seconded. Discussion
Greg Hulbert amended the motion to include items 1 through 5 from the cover page of the memo.
Vote: 11 in favor, 1 Abstained **Motion Carried (approved)**
This Proposal needs to go to the College of Engineering Faculty Committee for approval

Proposed Agenda for Joint CoE/LS&A Curriculum Committee Meeting

Copies of the proposed agenda for the Joint CoE/LS&A Curriculum Committee Meeting were passed out to the Committee. This meeting is scheduled for Tuesday, February 3, 2004.
Items 1. and 5.are discussion items coming from The College of Engineering, the remaining items (2 through 4) are proposed by LS&A.
Jeanne Murabito had sent a memo to bob Owen regarding question 2. *Proposed Changes to the CS-LSA Program: Item 5 (Items 1-4 Were Approved on 1/13/04)*
She had no response of yet, but if she gets a response she will send it out to the Committee.

Adjournment: Motion to adjourn was made and seconded
Motion carried (approved)

Next Meeting
Tuesday, March 2, 2004
1:30-**3:00** p.m.
GM Room – Fourth Floor LEC

To: CoE Curr. Comm
From: Jeff Fessler, Chair, EECS Curr. Comm. Jeff Fessler
Tue Jan 27 15:19:55 EST 2004

Please find attached a sample schedule that reflects proposed changes in the electives requirements for the Computer Engineering degree. These proposed changes were approved on 2004-1-27 by EECS Faculty. We request approval of these program changes by the CoE curr. comm.

Existing Requirements:

4 "Flex. Tech. Elec."
(this is actually an "EECS elective" requirement that is misnamed)
3 Engin. Breadth Elec.
(we used to think that ABET required this, but now they don't)
16 Free Elec.
(this is more free electives than most, if not all, CoE programs)

Proposed Requirements:

3 EECS Technical Elective
(see list in advising office)
7 Flex. Tech. Elec.
(see list in advising office, maintained by CE Program Committee, includes many Math, Science, and Engineering courses)
13 Free Elec.

MDE requirement change:

We also propose to allow CE majors to satisfy their MDE requirement by taking any MDE course in the CoE, including Engin 450. (This does not reduce the number of CE courses they must take since they still must take 10 upper level CE electives.) This is also a program change, and is reflected in a footnote in the sample schedule.

Supporting Statement:

These changes eliminate the Engin. Breadth Requirement so that CE students can choose to their technical electives more broadly, while also tightening up the free electives to be more consistent with the rest of CoE. It also makes the terminology somewhat more consistent with the EE and CS degrees. We are also increasing flexibility with regard to the MDE requirement.

Effective date:

This will apply automatically to all students who declare as CE majors after the date of the CoE approval of this change. The CE program advisors would also allow existing CE majors to use this set of rules if they prefer. (Such students would be "giving up" a free elective to get the flexibility to "avoid" taking a Engin. Breadth elective or to take a non-EECS MDE course.)

Sample Schedule
B.S.E. Computer Engineering

	Credit Hours	Terms 1	2	3	4	5	6	7	8
Subjects Required by all programs (55 hrs.)									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
ENGR 100	4	4	-	-	-	-	-	-	-
ENGR 101	4	-	4	-	-	-	-	-	-
Chemistry 125/130 or Chemistry 210/211	5	-	5	-	-	-	-	-	-
Physics 140 with Lab 141; 240 with Lab 241	10	5	-	5	-	-	-	-	-
Humanities and Social Science	16	4	4	-	4	4	-	-	-
Program Subjects (32 hrs.)									
EECS 203, Discrete Mathematics	4	-	-	4	-	-	-	-	-
EECS 206, Signals and Systems	4	-	-	-	4	-	-	-	-
EECS 215, Introduction to Circuits	4	-	-	-	-	4	-	-	-
EECS 270, Intro to Logic Design	4	-	-	4	-	-	-	-	-
EECS 280, Programming and Elem. Data Structures	4	-	-	-	4	-	-	-	-
EECS 370, Intro to Computer Organization	4	-	-	-	-	4	-	-	-
EECS 401, Math 425 or Stat 412	3	-	-	-	-	3	-	-	-
[1]TCHNCLCM 215 or 281	1	-	-	-	-	1	-	-	-
[2]TCHNCLCM 496/EECS 496	4	-	-	-	-	-	-	-	4
[3]Technical Electives (28 hrs.)									
[4]Flexible Technical Electives	7	-	-	-	-	-	4	1	2
[5]EECS Elective	3	-	-	-	-	-	-	3	-
[6]Core Electives	8	-	-	-	-	-	8	-	-
[7]Upper Level CE Electives	10	-	-	-	-	-	-	4	6
Free Electives (13 hrs.)	13	-	-	-	-	-	4	6	3
Total	**128**	**17**	**17**	**17**	**16**	**16**	**16**	**14**	**15**

[1] ***TCHNCLCM 215 or 281:*** Must be elected concurrently with EECS 215 or EECS 281 respectively.

[2] ***TCHNCLCM 496/EECS 496:*** Must be elected concurrently with a Major Design Experience course.

3 ***Technical Electives:*** At least one of these classes must be a Major Design Experience course in some ABET accredited program in the College of Engineering.

[4] ***Flexible Technical Elective:*** The flexible technical elective requirement may be fulfilled by taking selected courses in EECS, other engineering departments, biology, chemistry, economics, math, or physics. See the Undergraduate Advising Office for the current list.

[5] ***EECS Elective:*** this requirement may be fulfilled by taking a selected class in EECS. See the Undergraduate Advising office for the current list.

[6] ***Core Electives:*** 8 credits from the following list: EECS 281, 306, 312, 373.

[7] ***Upper Level CE Electives:*** 10 credits from the following list: EECS 427*, 452*, 470*, 478, 482, 483*, 489, 527, 570, 573, 578, 582, 583*, 589, 627 (MDE courses are indicated with a *). Other courses may be acceptable with prior approval of the Chief Program Advisor.

A maximum of 4 credits of EECS 499 may be applied to Technical Elective Requirements and only in the area of EECS Technical Electives or Flexible Technical Electives. Anything beyond 4 credits will be applied toward Free Electives.

COURSE APPROVAL FORMS

For March 3, 2004 CoE CC Meeting

AERO 526 New Course

AOSS 123 (X-Listed with GEO SCI 123 & ENV STUD 123) Deletion

AOSS 464 (X-Listed with AERO 464) Modification – Changing Title; Changing Description; Changing Level of Credit from: Ugrad or Rckham Grad ***to: All Credit Types***; Changing Credit Hours from: 3 ***to: 4***; Changing Contact hours from: 3 **to: 4.**

AOSS 556 Deletion

AOSS 581 Modification – Changing Title; Changing Description.

AOSS 582 (X-Listed with AERO 582) Modification – Switching Home Department from: AERO ***to: AOSS***; Changing Description; Changing Credit Hours from: 3 ***to: 4***. Changing Contact hours from: 3 **to: 4.**

AOSS 584 New Course

AOSS 585 Modification – Changing Description

AOSS 596 New Course

BIOMED 417 (X-Listed with EECS 417) Modification – Changing Term of Offering from: Fall **to: Winter.**

BIOMED 458 (X-Listed with EECS 458) Modification – Changing Term of Offering from: Winter to: ***Winter and Fall***

EECS 385 New Course

EECS 460 Modification – Changing Description; Changing Prerequisites from: EECS 212/316 or EECS 306 or Graduate Standing ***to: EECS 306 or Graduate Standing***; Changing Credit Hours from: 3 ***to: 4***; Changing Contact Hrs Wk from: 3 ***to: 4***; Changing Class Type from: Lecture ***to: Lecture and Discussion***.

EECS 480 New Course

EECS 487 Modification – Changing Prerequisites from: EECS 281 and senior standing or graduate standing ***to: EECS 281 or graduate standing***.

EECS 495 Modification – Changing Level of Credit from: Ugrad or Rkham grad ***to: All Credit Types***.

EECS 551 Modification – Changing Title, Changing Description, Changing Prerequisites from: EECS 451 ***to: Preceded or accompanied by EECS 501.***

EECS 556 Modification – Changing Title Abbreviation for Transcript; Changing Prerequisites from: EECS 451 and EECS 501 ***to: EECS 551 and EECS 501.***

EECS 559 Modification – Changing Prerequisites from: EECS 451 and EECS 501 ***to: EECS 551 and EECS 501.***

EECS 659 Modification – Changing Title Abbreviation for Time Schedule and Transcript; Changing Prerequisites from: EECS 559 ***to: EECS 564 or EECS 559.***

EECS 574 Modification – Changing Title

EECS 586 Modification – Changing Credit Hours from: 3 ***to: 4***, Changing Contact Hours Wk From: 3 ***to 4***, Changing Class Type from: Lecture ***to: Lecture & Discussion.***

EECS 587 Modification – Changing Description, Credit Hours from: 3 ***to: 4***, Changing Contact Hours Wk From: 3 ***to: 4.***

EECS 691 New Course

ENGR 110 New Course

IOE 265 (X-Listed with STATS 265) Modification – Changing Prerequisites from: MATH 116 and ENGR 101 ***to: MATH 116 AND ENGR 101 C- or better (enforced)***; Changing Credit Restrictions from: No credit to those who have completed or are enrolled in Stats 311, 400, 405, 412 or ECON 405 ***to: No credit granted to those who have completed or are enrolled in STATS 350, 400, 405 or 412 or ECON 404, 405 or environ/NRS 438***

IOE 421 Modification – Changing Level of Credit from: Undergrad only, Rackham Grad ***to: Undergrad only, Rackham Grad, non-Rckhm Grad***. Changing Credit Hours from: 4 ***to:3***. Changing Contact Hours from 4 ***to: 3.***

IOE 422 Modification – Changing Credit Hours from: 4 ***to: 3***. Changing Contact Hours from 4 ***to: 3.***

IOE 432 Modification – – Changing Level of credit from: Undergrad only, Rackham Grad ***to: Undergrad only, Rackham Grad, Non-Rckhm Grad***, Changing Credit hours from: 4 ***to: 3.*** Changing Contact Hours from 4 ***to: 3.***

IOE 436 Modification – Changing Level of credit from: Undergrad only, Rackham Grad ***to: Undergrad only, Rackham Grad, Non-Rckhm Grad***, Changing Credit hours from: 4 ***to: 3.*** Changing Contact Hours from 4 ***to: 3.***

IOE 441 (X-Listed with MFG 441) Modification – Changing Credit hours from: 4 ***to: 3***, Changing Contact Hours from 4 ***to: 3.***

IOE 447 (X-Listed with MFG 447) Modification –Changing Level of Credit from: Undergrad only, Rackham Grad ***to: Undergrad only, Rackham Grad, Non-Rckhm Grad***; Changing Credit Hours from: 4 ***to: 3***; Changing Contact Hours from 4 ***to: 3.***

IOE 461(X-Listed with MFG 461 Modification – Changing Level of Credit from: Undergrad only, Rackham Grad ***to: Undergrad only, Rackham Grad, Non-Rckhm Grad,*** Changing Credit Hours from: 3 **to: 4,** Changing Contact Hourse Wk from 3 ***to: 4.***

IOE 465 Modification – Changing Level of Credit from: Undergrad only; Rackham Grad ***to: Undergrad only, Rackham, Non-Rckhm Grad***. Changing Credit Hours from: 4 ***to: 3.*** Changing Contact Hours from: 4 ***to: 3.***

IOE 466 (X-Listed with STATS 466 and MFG 466) Modification -- Changing Level of Credit from: Undergrad only, Rackham Grad ***to: Undergrad only, Rackham Grad, Non-Rckhm Grad.*** Changing Credit Hours from 4 ***to: 3***, Changing Contact hours from 4 ***to: 3.***

IOE 490 Modification -- Changing Title; Changing Description; Changing Prerequisites from: Permission of Department; mandatory pass/fail ***to: Permission of Instructor***; Changing Credit Restrictions from: maximum 4 credit hours per term ***to: Not for Graduate Credit, maximum 4 credit hours per term.*** Changing Level of Credit from: Ugrad or Rckham Grad ***to: undergrad only***.

IOE 590 Modification -- Changing Title; Changing Description; Changing Prerequisites from: Permission of Instructor ***to: Graduate Standing and Permission of Instructor***. Changing Level of Credit from: Rackham Grad ***to: Rackham Grad, Non-Rckhm Grad***; Changing Credit hours from: 1-3 ***to: 2-4***.

IOE 593 Modification – Changing Description; ***Adding Credit Restriction: 2-4 credits per election***.

IOE 690

Deletion

IOE 790

Deletion

IOE 801 Modification – Changing Title; Changing Description; Changing Prerequisites from: IOE 800: Concurrent with IOE 802: mandatory satisfactory/unsatisfactory ***to: IOE Ph.D. Precandidate; Permission of Instructor***.

IOE 916

Deletion

IOE 990 Modification – Changing Title; Changing Description; Changing Prerequisites from: Permission of Department ***to: Completion of IOE Qualifying Exam and Permission of Instructor; Adding Credit Restrictions: I, II, III (2-8 credits) IIIa, IIIb (1-4 credits).***

IOE 995 Modification – Changing Title; Changing Description; Changing Prerequisites from: Graduate School authorization for admission as a doctoral candidate ***to: Graduate School authorization for admission as a doctoral candidate and P.I.***; ***Adding Credit Restrictions: I, II, III -8 credits) IIIa, IIIb (4 credits).***

MFG 503 Modification – Removing X-Listing with OMS; Adding Prerequisite: ***501, TMI, PIM.***

MSE 242 Modification – Changing Prerequisites from: Preceded or accompanied by Physics 240. Math 216 ***to: Physics 240 and preceded or accompanied by Math 216.***

MSE 330 Modification – Changing Prerequisites from: Chem 210. Phys 140/141. Math 215 or Math 285 and prec. or accom. by MSE 350. ***to: Chem 130 or 210. Phys 140/141. Math 215 and MSE 220 or 250.***

MSE 335 Modification – Changing Prerequisites from: Math 216 and MSE 220 or 250 ***to: Math 215 and 216 and MSE 220 or 250.***

MSE 465 Modification – Changing Prerequisites from: MSE 220/250. MSE 242. MSE 360. MSE 365 (concurrent) (advised) ***to: MSE 220 or 250. MSE 242. and MSE 360 (enforced)***

MSE 489 (X-Listed with MFG 489) Modification – Changing Prerequisites from: Preceded or accompanied by MSE 430 and MSE 435 ***to: MSE 330 and MSE 335.***

MSE 493 Modification – Changing Title, Changing Prerequisite from: MSE 350 (advised) ***to: MSE 350 (enforced)***

NAME 280 New Course

NAME 562 (X-listed with MFG 563) Modification – Changing Title, Changing Description, Changing Prerequisites from: B.S. in Engineering (advised) ***to: NA 280 (C-) or Graduate Standing***, Changing Level of Credit from: Rackham Grad Non-Rckhm Grad ***to: All Credit types***, Changing Credit hours from: 3 ***to: 4***, Changing Contact Hours Wk from 3 ***to: 4.***

THE UNIVERSITY OF MICHIGAN – COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

[redacted]

Form Number **1206**

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
Deletions - A & C completely

Date 11/7/2003
Effective Fall 2004

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number	Home Department: Aerospace Engineering / Div #: Aerosp / Course Number: 526
Cross Listed Course Information	Cross Listed Course Information
Course Title	Course Title: Hypersonic Aerothermodynamics
TITLE ABBREVIATION — Time Sched Max = 19 Spaces	Hypersonics
TITLE ABBREVIATION — Transcript Max = 20 Spaces	Hypersonics
Course Description	Course Description for Official Publication (Max = 50 words): Hypersonic vehicles offer rapid air transportation and access to space. This course provides an introduction to the aerothermodynamics of hypersonic vehicles. Topics covered include: vehicle types (missiles, space planes, air-breathers); flight dynamics (trajectory, range, stability); aerothermodynamics (fluid dynamics, thermodynamics, aerodynamics, heating); and propulsion systems (scramjets, combined cycles).
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	**PROGRAM OUTCOMES:** ☒a ☐b ☒c ☐d ☒e ☐f ☐g ☐h ☐i ☒j ☒k
Degree Requirements: ( ) Degree Requirement ( ) Core Course ( ) Free Elective ( ) Tech Elective ( ) Other	Degree Requirements: ( ) Degree Requirement ( ) Core Course ( ) Free Elective (•) Tech Elective ( ) Other
Prerequisites: ( ) Enforced ( ) Advised	Prerequisites: Grad Standing, or Aero 225 and Aero 325 ( ) Enforced (•) Advised
Credit Restrictions	Credit Restrictions
Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad; ☐ All Credit types ☐ Rckhm Grad w/add'l Work	Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad; ☒ All Credit types ☐ Rckhm Grad w/add'l Work
Credit Hours Min ___ Max ___ ; Contact Hrs/Wk ___ ; Number of Wks ___	Credit Hours Min 3 Max 3 ; Contact Hrs/Wk 3 ; Number of Wks term
C. Repeatability (Indi Research, Dir. Study, Dissertation): Is this course repeatable? ( ) Yes (•) No; Maximum Hours? ___ Maximum Times? ___; Can it be repeated in the same term? ( ) Yes (•) No	Printing Information (Optional): ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule
Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___ ; Graded Section: (•) Lec ( ) Rec ( ) Sem ( ) Lab ( ) Dis ( ) Ind ( ) Other ___ ; Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y ; Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension	Terms & Freq. of Offering: ■ I ☐ II ☐ IIIa ☐ IIIb ☐ III; ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years; Half term ☐ 1st ☐ 2nd
	Cognizant Faculty Member: Iain D. Boyd; Title: Professor
	Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm. _____
- ☐ Faculty _____
- ☐ Rackham _____
- ☐ Cross listed Unit 1 _____
- ☐ Cross listed Unit 2 _____

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department:
Home Dept. K.G. Powell, Aerospace Eng
Cross-listed Dept(s). _____

Form Number

1206

SUPPORTING STATEMENT

Hypersonic vehicles fly at speeds that are significantly higher than the speed of sound. There are several important types of hypersonic vehicles including space planes (e.g. the Space Shuttle), re-entry vehicles (e.g. the Apollo Command Module), planetary entry vehicles (e.g. Pathfinder to Mars), and ballistic missiles (e.g. the Patriot Missile). Novel ideas for future hypersonic vehicles employ air-breathing propulsion and include cruise aircraft that would revolutionize long-distance air transportation. For example, it would be possible to fly from New York to Sydney, Australia, in under two hours. In addition, fully reusable launch vehicles would drastically reduce space launch costs.

There are several key technology difficulties to be overcome before these new types of hypersonic aircraft are successfully developed. These include the efficient operation of an air-breathing propulsion system, integration of the propulsion system into the airframe, and development of high-temperature materials. In the US and around the world, there are several current hypersonic technology research and development programs. The centerpiece in the US is NASA's X43 flight demonstration program which aims to demonstrate the propulsion and aerodynamics needed for efficient hypersonic flight. Due to the compelling need for advanced hypersonic technology, this area will be studied for many years to come.

There is also significant investment in hypersonics research at US academia. In NASA's URETI competition of 2001, of the 9 awards made, 2 were in the area of hypersonics and one of these was awarded to a joint University of Michigan and University of Maryland proposal. This project involves 10 Aero faculty and more than 15 of our graduate students.

There have been courses on hypersonics within the Aero curriculum many years ago. With the renewed interest and activity in hypersonics, the present lack of a hypersonics course represents an important void in the curriculum. Both senior undergraduate and first-year graduate Aerospace Engineering students should have an opportunity to learn about this important field. The course builds on introductory gas dynamics theory presented in AERO 225, on basic aerodynamics presented in AERO 325, and on jet propulsion presented in AERO 335. AERO 526 thus provides a technical elective built on fundamental courses, on a subject of topical interest.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

Aero 526: Hypersonic Aerothermodynamics

COURSE #: 526	**COURSE TITLE: HYPERSONIC AEROTHERMODYNAMICS**
TERMS OFFERED: Fall	**PREREQUISITES:** Grad Standing, or Aero 225 and Aero 325
INSTRUCTOR(S): Boyd	**SCIENCE/DESIGN: 3/0**
CATALOG DESCRIPTION: Hypersonic vehicles offer rapid air transportation and access to space. This course provides an introduction to the aerothermodynamics of hypersonic vehicles. Topics covered include: vehicle types (missiles, space planes, air-breathers); flight dynamics (trajectory, range, stability); aerothermodynamics (fluid dynamics, thermodynamics, aerodynamics, heating); and propulsion systems (scramjets, combined cycles).	**COURSE TOPICS:** 1. Hypersonic vehicle types 2. Hypersonic vehicle trajectories 3. Shock wave analysis 4. Real gas effects 5. Stagnation point analysis 6. Pressure distribution 7. Heat transfer and skin friction distribution 8. Hypersonic propulsion systems

COURSE OBJECTIVES*	1. Review the missions of different hypersonic vehicles 2. Introduce students to the trajectories followed by different hypersonic vehicles 3. Study the environment around hypersonic vehicles created by strong shock waves 4. Introduce students to real gas effects caused by high temperature conditions 5. Study pressure and heat transfer phenomena at the stagnation point of a hypersonic vehicle 6. Study the distribution of pressure around a general vehicle shape 7. Study the distribution of heat transfer and skin friction around a general vehicle shape 8. Review hypersonic propulsion options based on rocket, turbine, and ram/scramjet technology.

COURSE OUTCOMES*	**On completion of Aero 526, students can:** 1. Analyze the trajectories of ballistic missiles, space planes, and air-breathing hypersonic vehicles. 2. Perform perfect and real gas analyses of shock waves. 3. Have a basic understanding of real gas effects such as vibrational activation, dissociation, ionization, and molecular transport phenomena. 4. Determine the stagnation properties of a hypersonic vehicle. 5. Determine profiles of pressure, skin friction, and heat transfer around a vehicle. 6. Have a basic understanding of hypersonic propulsion options including combined cycle technologies.
ASSESSMENT TOOLS	1. Written homework assignments 2. Mid-term exam 3. Final exam

Approved by Aero faculty: January 31, 2003

UNIVERSITY OF MICHIGAN

Professor Iain D. Boyd
Department of Aerospace Engineering
Ann Arbor, Michigan, 48109-2140, USA
(734) 615-3281
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18 November 2003

MEMORANDUM RE: AERO 526

Please note that the proposed new course AERO 526: *Hypersonic Aerothermodynamics* is being taught this current Fall term (2003) as a pilot course (AERO 729) and has a very healthy enrollment of 50 students (approximately 50% undergraduates and 50% graduates).

Sincerely,

I. Boyd

Iain D. Boyd
Professor of Aerospace Engineering

AERO 729
Special Topics in Gas Dynamics:
Hypersonic Aerothermodynamics
Fall Term 2003

Course organization

Class:	Tuesday and Thursday, 12:00 - 1:30 pm, Room: FXB 1012
Instructor:	Iain D. Boyd, 3012 FXB
	(734) 615-3281 (tel), (734) 763-0578 (fax), iainboyd@umich.edu
	Office hours: 10am to 11am, every Monday, Tuesday, Wednesday
Text:	*Hypersonic Aerothermodynamics*, JJ Bertin, AIAA, 1994.

Grade:		
	8 projects at 5% each	= 40%
	1 mid-term exam	= 25%
	1 final exam	= 35%
	TOTAL	= 100%

Additional References

Anderson, *Modern Compressible Flow*, McGraw-Hall, 2002
Anderson, *Hypersonic and High Temperature Gas Dynamics*, McGraw-Hill, 1989
Hankey, *Re-entry Aerodynamics*, AIAA, 1988
Heiser & Pratt, *Hypersonic Airbreathing Propulsion*, AIAA, 1994
Rasmussen, *Hypersonic Flow*, Wiley, 1994

Course Web Site

Login using your uniquename at the URL: *coursetools.ummu.umich.edu*
The site will be used for homework assignments and solutions, and announcements.

AERO 729: Hypersonic Aerothermodynamics
Syllabus

1. Introduction [1 lecture]
   - Course outline
   - Broad overview of hypersonics

2. Hypersonic flight mechanics [3 lectures]
   - Trajectory equations
   - Ballistic entry (missile)
   - Equilibrium glide (Space Shuttle)
   - Air-breathing, powered flight

3. Aerothermodynamics phenomena [5 lectures]
   - Review of compressible gas dynamics
   - Real gas effects and air chemistry
   - Fluid conservation equations
   - Transport phenomena
   - Review of aerodynamics

4. Stagnation Region Phenomena [3 lectures]
   - Stagnation streamline and stagnation point
   - Fay-Riddell stagnation point convective heat transfer

5. Surface Pressure [3 lectures]
   - Newtonian models
   - Shock-wave/boundary layer interaction
   - Separation effects

6. Heat Transfer and Skin Friction [3 lectures]
   - Boundary layers
   - Surface temperature
   - Eckert's method
   - Reynolds analogy
   - Laminar and turbulent boundary layers

7. Aerodynamic Forces and Moments [2 lectures]
   - Newtonian aerodynamics
   - Sharp and blunt code

8. Hypersonic propulsion [2 lectures]
   - Rockets
   - Air-breathing systems (turbo-jets, ramjets, scramjets)
   - Rocket based and turbine based combined cycles

THE UNIVERSITY OF MICHIGAN – COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

[redacted]

Form Number **1228**

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
Deletions - A & C completely

Date 12/3/2003
Effective Fall 2004

A. CURRENT LISTING

Home Department: Geological Sciences — Div # 377 — Course Number 123

Cross Listed Course Information:
Atmospheric, Oceanic, & Space Sciences — AOSS 123
Environmental Studies — 366 123

Course Title: Life and the Global Environment

TITLE ABBREVIATION — Time Sched Max = 19 Spaces: Life & Global Env; Transcript Max = 20 Spaces: Global Envir

Course Description:
Life has affected the global environment throughtout Earth history, but the changes brought about by human beings are much more rapid than any the planet has experienced before. This course views the global change of the present from the perspective of planetary history, enphasizing environmental constraints on biological evolution and possible constraints on human activity in the future.

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites: None ○ Enforced ○ Advised

Credit Restrictions:

Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min 2 Max 2

Contact Hrs/Wk 2

Number of Wks 14

C. Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ⊙ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

B. REQUESTED LISTING

Home Department — Div # — Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION — Time Sched Max = 19 Spaces: ____ ; Transcript Max = 20 Spaces: ____

Course Description for Official Publication (Max = 50 words)

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions:

Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min ____ Max ____

Contact Hrs/Wk ____

Number of Wks ____

Printing Information (Optional): ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Terms & Freq. of Offering: ☐ I ■ II ☐ IIIa ☐ IIIb ☐ III — ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: James C.G. Walker — Title Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm. _____
- ☐ Faculty _____
- ☐ Rackham _____
- ☐ Cross listed Unit 1 _____
- ☐ Cross listed Unit 2 _____

Submitted By: ☐ Home Dept. ■ Cross-listed Dept.

Name, Signature & Department

Home Dept. Geol Sci

Cross-listed Dept(s). AOSS Perry Samson

Env. Studies

Form Number
1228

SUPPORTING STATEMENT

Instructor has retired

Are any special resources or facilities required for this course? ☐ Yes ☐ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN – COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

[redacted]

Form Number **1224**

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
Deletions - A & C completely

Date 11/24/2003
Effective Fall 2004

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number	Home Department: Atmospheric, Oceanic, & Space Sciences / Div #: AOSS / Course Number: 464
Cross Listed Course Information	Cross Listed Course Information: Aerospace / AERO 464
X Course Title: Introduction to the Space Environment	Course Title: Introduction to the Space and Spacecraft Environment
TITLE ABBREVIATION — Time Sched Max = 19 Spaces: Intro Space Enviroment	TITLE ABBREVIATION — Time Sched Max = 19 Spaces: Space & S/C Env
Transcript Max = 20 Spaces: Space Intro	Transcript Max = 20 Spaces: Space & S/C Env
X Course Description: An introduction to physical and aeronomical processes in the space environment. Discussion of theoretical tools, the Sun, solar spectrum, solar wind, interplanetary magnetic field, magnetosphere, ionosphere and upper atmospheres. Atmospheric processes, densities, temperatures, and wind.	Course Description for Official Publication (Max = 50 words): An introduction to physical and aeronomical processes in the space environment. Discussion of theoretical tools, the Sun, solar spectrum, solar wind, interplanetary magnetic field, magnetosphere, ionosphere and upper atmospheres. Atmospheric processes, densities, temperatures, and wind. Spacecraft interaction with radiation, spacecraft aerodynamics, spacecraft-plasma interactions.
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	PROGRAM OUTCOMES: ☒a ☐b ☐c ☒d ☐e ☐f ☐g ☐h ☒i ☒j ☒k
Degree Requirements: ◉ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ◉ Tech Elective ○ Other
☐ Prerequisites: ○ Enforced ○ Advised	Prerequisites: Senior or Graduate Standing ○ Enforced ⊙ Advised
☐ Credit Restrictions	Credit Restrictions
X Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☒ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work	Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☒ All Credit types ☐ Rckhm Grad w/add'l Work
Credit Hours Min 3 Max 3 — Contact Hrs/Wk 3 — Number of Wks 13	Credit Hours Min 4 Max 4 — Contact Hrs/Wk 4 — Number of Wks 13
C. Repeatability (Indl Research, Dir. Study, Dissertation): Is this course repeatable? ○ Yes ⊙ No; Maximum Hours?; Maximum Times?; Can it be repeated in the same term? ○ Yes ○ No	Printing Information (Optional): ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule
☐ Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other; Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other; Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y; Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension	Terms & Freq. of Offering: ■ I ☐ II ☐ IIIa ☐ IIIb ☐ III ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years; Half term ☐ 1st ☐ 2nd
	Cognizant Faculty Member: Tamas I. Gombosi; Title: Professor/Chairman
	Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

☐ Curriculum Comm. _____
☐ Faculty _____
☐ Rackham _____
☐ Cross listed Unit 1 _____
☐ Cross listed Unit 2 _____

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. AOSS Perry Samson
Cross-listed Dept(s). AERO

Form Number

1224

SUPPORTING STATEMENT

The course is being extended from 3 credits to 4 credits and discussion about spacecraft-environment interactions is added in order to fit into the new MENG in Space Engineering program. The course will also serve senior undergraduates and first year PhD students.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

2.1 Course Outline (including weekly schedule of subject matter covered)

Week 1

Introduction

1. Theoretical description of Gases and Plasmas
   - 1.1. Particle Orbit Theory
     - 1.1.1. Particles in Constant External Fields
       - 1.1.1.1. Neutral Particles
       - 1.1.1.2. Uniform Electric Field
       - 1.1.1.3. Uniform Magnetic Field
       - 1.1.1.4. Guiding Center Drifts
     - 1.1.2. Non-Uniform Magnetic Fields
       - 1.1.2.1. Magnetic Mirror Force
       - 1.1.2.2. Magnetic Moment
       - 1.1.2.3. Magnetic Mirroring
       - 1.1.2.4. Gradient and Curvature Drifts
     - 1.1.3. Adiabatic Invariants
       - 1.1.3.1. The First Adiabatic Invariant
       - 1.1.3.2. The Second Adiabatic Invariant
       - 1.1.3.3. The Third Adiabatic Invariant

Week 2

   - 1.2. Kinetic Theory
     - 1.2.1. Collisions
       - 1.2.1.1. Mean Free Path
       - 1.2.1.2. Collision Cross Section
       - 1.2.1.3. Collision Frequency, Collision Rate
     - 1.2.2. The Boltzmann Equation
       - 1.2.2.1. Phase-Space Distribution Function
       - 1.2.2.2. Evolution of the Phase-Space Distribution Function
       - 1.2.2.3. Local Equilibrium Distribution
       - 1.2.2.4. Collision Terms
     - 1.2.3. Multispecies Gases
     - 1.2.4. Elastic Binary Collisions
   - 1.3. Basic Plasma Phenomena
     - 1.3.1. Debye Shielding
     - 1.3.2. Plasma Parameter
     - 1.3.3. Plasma Frequency
   - 1.4. Fluid and MHD Theory
     - 1.4.1. Moment Equations
       - 1.4.1.1. Velocity Moments
       - 1.4.1.2. The Euler and Navier-Stokes Equations
     - 1.4.2. Transport Equations for Multispecies Gases

Week 3

1.4.3.MHD Equations for Conducting Fluids
1.4.3.1. Single-Fluid Equations
1.4.3.2. Generalized Ohm's Law
1.4.4.Ideal MHD
1.5. Waves and Oscillations 83
1.5.1.Linearized Fluid Equations
1.5.2.Sound Waves
1.5.3.Alfven Waves
1.5.4.Plane Waves
1.5.5.Internal Gravity Waves
1.5.6.Waves in Field-Free Plasmas
1.5.6.1. Langmuir Waves
1.5.6.2. Electromagnetic Waves

Week 4

1.5.7.MHD Waves
1.5.8.Plasma Waves in a Cold Magnetized Plasma
1.5.9.Parallel Plasma Waves
1.5.9.1. Circularly Polarized Waves
1.5.9.2. Whistler Waves
1.5.9.3. Low Frequency Waves
1.6. Shocks and Discontinuities
1.6.1.Normal Shock Waves in Perfect Gases
1.6.2.MHD Shocks and Discontinuities
1.6.2.1. Contact and Tangential Discontinuities
1.6.2.2. MHD Shocks
1.7. Transport of Superthermal Particles
1.7.1.Transport of Energetic Particles
1.7.2.Guiding Center Transport

Week 5

2. The Upper Atmosphere
2.1. The Terrestrial Upper Atmosphere
2.1.1.Hydrostatic Equilibrium
2.1.2.Stability of the Atmosphere
2.1.3.Winds and Waves
2.1.3.1. Acceleration due to Planetary Rotation
2.1.3.2. Linearized Equations
2.1.3.3. Geostrophic and Thermal Winds
2.1.3.4. Acoustic-Gravity Waves
2.1.4.Diffusion
2.1.4.1. Molecular Diffusion
2.1.4.2. Eddy Diffusion
2.1.4.3. Diffusive Equilibrium
2.1.4.4. Maximum Diffusion Velocities
2.1.5.Thermal Structure

2.1.6.The Exosphere

Week 6

2.1.7.Some Concepts of Atmospheric Chemistry
2.1.7.1. Thermodynamics
2.1.7.2. Chemical Kinetics
2.1.8.Atmospheric Composition and Chemistry
2.1.8.1. Stratosphere and Mesosphere
2.1.8.2. Thermosphere

2.2. Airglow and Aurora
2.2.1.Measuring Atmospheric Emissions: The Rayleigh
2.2.2.Atomic and Molecular Spectra
2.2.2.1. Ground States of Atoms
2.2.2.2. Atomic Excited States
2.2.2.3. Molecular Structure
2.2.3.Airglow
2.2.4.Aurora
2.2.5.Auroral Electrons

Week 7

2.3. The Ionosphere
2.3.1.Ionization Profile
2.3.2.Ion Composition and Chemistry
2.3.2.1. The D Region
2.3.2.2. The E Region
2.3.2.3. The F1 Region
2.3.2.4. The F2 Peak Region
2.3.3.Gyration Dominated Plasma Transport
2.3.4.Ambipolar Electric Field and Diffusion
2.3.5.Diffusive Equilibrium in the F2 Region
2.3.6.The Topside Ionosphere and Plasmasphere
2.3.7.The Polar Wind
2.3.8.Ionospheric Energetics
2.3.9.Ionospheric Conductivities and Currents

Week 8

3. Sun-Earth Connection

3.1. The Sun 221
3.1.1.Thermonuclear Energy Generation in the Core
3.1.2.Internal Structure
3.1.2.1. Pressure Balance
3.1.2.2. Energy Transport in the Solar Interior
3.1.2.3. Radial Structure
3.1.2.4. Solar Oscillations
3.1.3.Generation of Solar Magnetic Fields

3.1.4.11.5 The Sunspot Number and the Solar Cycle
3.1.5.11.6 The Solar Atmosphere
3.1.5.1. 11.6.1 The Photosphere
3.1.5.2. 11.6.2 The Chromosphere
3.1.5.3. 11.6.3 The Transition Region
3.1.5.4. 11.6.4 The Corona
3.1.6.11.7 Radiative Transfer in the Solar Atmosphere
3.1.6.1. 11.7.1 Local Thermodynamic Equilibrium Approximation
3.1.6.2. 11.7.2 The Gray Atmosphere
3.1.7.11.8 Flares and Coronal Mass Ejections

Week 9

3.2. The Solar Wind 249
3.2.1.Hydrostatic Equilibrium: It Does Not Work
3.2.2.Coronal Expansion
3.2.3.Interplanetary Magnetic Field (IMF)
3.2.3.1. Field Lines and Stream Lines
3.2.3.2. Magnetic Field Lines
3.2.4.Coronal Structure and Magnetic Field
3.2.5.Solar Wind Stream Structure
3.2.6.Non-Recurring Disturbances in the Solar Wind
3.2.7.The Heliosphere

Week 10

3.3. Cosmic Rays and Energetic Particles
3.3.1.Galactic Cosmic Rays
3.3.1.1. Solar Cycle Modulation of Galactic Cosmic Rays
3.3.1.2. Diffusion Theory of Cosmic Ray Modulation
3.3.1.3. Modulation due to Diffusion and Cosmic Ray Drift
3.3.2.Solar Energetic Particles
3.3.3.Energetic Particle Acceleration in the Heliosphere
3.3.3.1. Stochastic Acceleration
3.3.3.2. Shock Acceleration

Week 11

3.4. The Terrestrial Magnetosphere
3.4.1.The Intrinsic Magnetic Field
3.4.2.Interaction of the Solar Wind with the Terrestrial Magnetic Field
3.4.2.1. The Chapman-Ferraro Model

3.4.2.2. The Bow Shock and the Magnetopause
3.4.2.3. The Magnetospheric Cavity
3.4.3.Magnetospheric Current Systems
3.4.3.1. The Magnetopause Current
3.4.3.2. The Tail Current
3.4.3.3. The Ring Current
3.4.3.4. Field Aligned Currents
3.4.4.Plasma Convection in the Magnetosphere
3.4.4.1. The Axford-Hines and the Dungey Models
3.4.4.2. Magnetic Diffusion
3.4.4.3. Magnetic Reconnection
3.4.4.4. Convection Electric Field
3.4.5.Radiation Belts
3.4.6.High-Latitude Electrodynamics
3.4.6.1. Polar Cap Convection for Southward IMF
3.4.6.2. Ionospheric Convection Velocities
3.4.7.Magnetic Activity and Substorms
3.4.7.1. Sq Current and the Equatorial Electrojet
3.4.7.2. Magnetic Storms
3.4.7.3. Substorms
3.4.7.4. Geomagnetic Activity Indices

Week 12

4. Spacecraft Interactions
4.1. Spacecraft-Plasma Interactions
4.1.1.Electric Potential on a Wall
4.1.2.Structure of the Plasma Sheet
4.1.3.The Plasma Probe
4.1.4.Plasma Flow around Spacecraft
4.2. Neutral Gas Interactions
4.2.1.Free Molecular Interaction
4.2.1.1. Reflection Coefficients
4.2.1.2. Transfer of Mass, Momentum and Energy
4.2.1.3. Free Molecular Heat Transfer
4.2.1.4. Free Molecular Aerodynamic Forces
4.2.1.4.1. Drag
4.2.1.4.2. Drag Coefficients for Specific Bodies
4.2.2.Satellite Lifetime and Orbit Decay
4.3. Radiation Interactions
4.3.1.Radiation Interactions with Matter
4.3.2.Shielding
4.3.3.Solar Array Degradation

2.2 Required/recommended textbooks and/or coursepacks

Gombosi: Physics of the Space Environment (Cambridge 1998)

Hastings & Garrett: Spacecraft-Environment Interactions (Cambridge 1996)

2.3 Grading and exam policies:

There is one 2-hour midterm (closed book with 1 page of notes) and a 2-hour final (closed book with 2 pages of notes). There will be weekly homework sets and one class project.

Grading: 20% homework, 20% midterm, 20% class project, 40% final

2.4 Prerequisite courses (if any)

There are no specific prerequisites, but students are expected to be familiar with classical mechanics, electricity and magnetism (at the level of Maxwell's equations), vector calculus, differential equations and complex variables.