Course Approval Form

For approval of new courses and deletions or modifications to an existing course.

More information is located on page 2.

Action Requested:
- [ ] Create new course
- [ ] Delete existing course
- [X] Modify existing course (check all that apply)
  - [X] Title
  - [ ] Prereq/coreq
  - [ ] Credits
  - [ ] Schedule Type
  - [ ] Repeat Status
  - [ ] Restrictions
  - [ ] Grade Type

Course Level:
- [ ] Undergraduate
- [X] Graduate

College/School: College of Science
Department: Physics and Astronomy
Submitted by: Merav Opher
Ext: 3-4571
Email: mopher@gmu.edu

Subject Code: ASTR **Number:** 660
(Do not list multiple codes or numbers. Each course proposal must have a separate form.)

Effective Term:
- [X] Fall
- [ ] Spring
- [ ] Summer

Year 2011

Title:
Current: ASTR 760 Space Plasma Physics
Banner (30 characters max including spaces):
New: ASTR 660 Plasma Physics for Space and Astrophysics

Credits: (check one)
- [3] Fixed: or
- [ ] Variable: to

Repeat Status: (check one)
- [X] Not Repeatable (NR)
- [ ] Repeatable within degree (RD)
- [ ] Repeatable within term (RT)

Total repeatable credits allowed:

Grade Mode: (check one)
- [X] Regular (A, B, C, etc.)
- [ ] Satisfactory/No Credit
- [ ] Special (A, B C, etc. +IP)

Schedule Type Code(s): (check all that apply)
- [X] Lecture (LEC)
- [ ] Lab (LAB)
- [ ] Recitation (RCT)
- [ ] Internship (INT)
- [ ] Independent Study (IND)
- [ ] Seminar (SEM)
- [ ] Studio (STU)

Prerequisite(s):	**Corequisite(s):**
PHYS 305	

Special Instructions: (restrictions for major, college, or degree; cross-listed courses; hard-coding; etc.)

Title change to Plasma Physics for Space and Astrophysics to reflect that the content will be generalized to include applications in astrophysics

Catalog Copy for NEW Courses Only (Consult University Catalog for models)

Description (No more than 60 words, use verb phrases and present tense)	**Notes** (List additional information for the course)

Indicate number of contact hours: Hours of Lecture or Seminar per week: 3 Hours of Lab or Studio:

When Offered: (check all that apply) [3] Fall [ ] Summer [ ] Spring

Approval Signatures

Department Approval Date

College/School Approval Date

If this course includes subject matter currently dealt with by any other units, the originating department must circulate this proposal for review by those units and obtain the necessary signatures prior to submission. Failure to do so will delay action on this proposal.

Unit Name	Unit Approval Name	Unit Approver's Signature	Date

For Graduate Courses Only

Graduate Council Member

Provost Office

Graduate Council Approval Date

Course Proposal Submitted to the Curriculum Committee of the College of Science

1. COURSE NUMBER AND TITLE:

ASTR 660 Plasma Physics for Space and Astrophysics (3:3:0)

Course Prerequisites:

PHYS 305

Catalog Description:

This course is intended to provide students with the necessary background to be able to produce groundbreaking research in space physics and astrophysics. Since Space Physics and Astrophysics cover different regimes of plasma, this course will introduce the basic concepts in kinetic, fluid and MHD plasmas and the properties of the waves that can propagate in these media. It will also cover the basics of shocks, discontinuities, transport and acceleration of particles (e.g., cosmic rays), and MHD instabilities. The emphasis will be on an intuitive understanding of the major aspects of plasma physics.

2. COURSE JUSTIFICATION:

Course Objectives:

Introduce basic plasma concepts for students intending to do research in space and astrophysics. It will cover basic magnetohydrodynamic plasma concepts and some kinetic concepts when needed. The major change will be to start from fluid concept and work our way to plasma ones.
Potential book change will be to use The Physics of Fluids and Plasmas, an Introduction for Astrophysicists by Arnab Rai Choudhuri. Topics covered in the course will be:
Plasma orbit theory, shocks, waves, turbulence, reconnection, dynamo process and acceleration of particles.

Course Necessity:

The content of the course will be expanded to include application to astrophysics

Course Relationship to Existing Programs:

No similar course is offered in other departments

Course Relationship to Existing Courses:

There is no similar course being offered

3. APPROVAL HISTORY:

4. SCHEDULING AND PROPOSED INSTRUCTORS:

Semester of Initial Offering:

Offered alternate fall semesters

Proposed Instructors:

Opher, Zhang

5. TENTATIVE SYLLABUS: See below.

Plasma for Space and Astrophysics

Instructor: Prof. Merav Opher
E-mail: mopher@gmu.edu
http://www.physics.gmu.edu/~mopher
Office Hours: Tuesday 4:00-6:00pm or by appointment

Text Book:
"Introduction to Plasma Physics with Space and Laboratory Applications"
by Donald A. Gurnett and Amitava Bhattacharjee

Other readings:
"Space Physics, An introduction to plasmas and particles in the heliosphere and magnetosphere" by May-Britt Kallenrode
"Principles of Magnetohydrodynamics"by Hans Goedbloed and Stefaan Poedts
"Plasma Physics for Astrophysics" by R. M. Kulsrud

Evaluation : HW assignments (40%), Final Exam (35%) Mid Term (15%) and a final project (10%) -

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The final project can be chosen from:
(a) Dynamo Theory
(b) Acceleration of Particles in Shocks
(c) Reconnection
(d) Supernova shocks

Topics:
Definition of plasma properties [Chapter 1 of [1]]
-Debye length
-Plasma frequency
-Cyclotron frequency, etc.
Macroscopic and Microscopic description of plasma
Kinetic Theory -Major Concepts [Chapter 9 of [1]]
Particle Motions in Electromagnetic Fields [Chapter 2 of [1]]
Magnetohydrodynamics [Chapter 3 of [1]]
-Basic equations
-Flux freezing
-Examples/Applications
-Validity of MHD equations
Conservation Relations [Chapter 4 of [1]]
MHD Waves [Chapter 5 of [1]]
Shocks and Non Linear Steepening [Chapter 6 of [1]]
Instabilities [Chapter 7 of [1]]

Transport of Particles-Application to
Supernova remnants
Coronal Heating
Supernovas
Extragalacic jets
Cosmic rays

Class Schedule and Content:

January 29 - 1st class

Definition of plasma properties
Description of Plasma: Kinetic Theory and MHD
Particle Motions in Electromagnetic Fields

February 05 - 2nd class - HW#1

Particle Motions in Electromagnetic Fields: Motion in a Uniform Magnetic Field
Drifts (non homogeneous B; curvature; gradient drifts)
Magnetic Mirrors; Examples in Space Physics

February 12 - 3rd class

Kinetic Description
Magnetohydrodynamics: Basic MHD equations

February 19 - 4th class - HW#2
Magnetohydrodynamics
Frozen Field Theorem
Application of Flux Freezing

February 26 - 5th class
Magnetic diffusion
Energy Equation
Conservation Relations
MHD Waves

March 5 - 6th class - HW#3

Recconection
Shock waves and reconnection
Current sheets
Fast reconnection
Petschek model

March 12 - Modification to Petschek model
Observational tests
Numerical Simualtions
Applications: YSO, AGNs
March 19 - 7th class

Origin of Magnetic Fields
Mechanisms of generation of magnetic fields
Type of dynamo
alpha-effect
Application to diferential rotation of the Sun and stars
Magnetic field of the galaxy

March 26 - 8th class- HW#4

MHD Waves
Waves in Cold Unmagnetized Plasma

April 2 - 9th class
Waves and Instabilities
Magneto-acustic waves
Instability Parker-Rayleigh-Taylor

April 9 - 10th class - HW #5
MID TERM

April 16 - 11th class
Shocks and Nonlinear steepening:
Discontinuities (Contact and Rotational)
Shock waves

April 23 - 12th class - HW#6

Weak and Strong shock limits

Parallel and Perpendicular Shocks

Entropy of Shocks

Observations of MHD shocks

Instabilities: Interchange instability

Parker instability

Magnetorotational instability

April 30 - 13th class - Recconection

Shock waves and reconnection

Current sheets

Fast reconnection

Petschek model

May 07 - 13th class - no class - FINAL EXAM AND FINAL PROJECT DUE