AUBURN UNIVERSITY

Date: 08/01/2014 *(MM/DD/YYYY)*

Proposal Form For Addition And Revision Of Courses

1. Proposing College / School: Samuel Ginn College of Engineering

Department: Aerospace Engineering

2. Course Prefix and Number: AERO/ MATH 6460/6466

3. Effective Term: Fall 2015

4. Course Title: Perturbation Methods

Abbreviated Title (30 characters or less): Perturbation Methods

5. Requested Action:

- ○ Renumber a Course — Current Course Number:
- ◉ Add a Course — Proposed Course Number:
- ○ Revise a Course — Type of Revision:

6. Course Credit:

Contact/Group Hours	Scheduled Type (e.g.: Lab, Lecture, Practicum, Directed Study)	Weekly or Per Term?	Credit Hours	Anticipated Enrollment
3	Lecture	3	3	25

Maximum Hours (Repeatability): 3

Total Credit Hours: 3

7. Grading Type: ◉ Regular (ABCDF) ○ Satisfactory/Unsatisfactory (S/U) ○ Audit

8. Prerequisites/Corequisites:

Use "P:" to indicate a prerequisite, "C:" to indicate a corequisite, and "P/C:" to indicate a prerequisite with concurrency.

P MATH 2660 or departmental approval

9. Restrictions: *List specific restriction in space above.* ☒ College ☐ Major ☐ Standing ☐ Degree

10. Course Description:

(20 Words or Less; exactly as it should appear in the Bulletin)

Analytical solutions of nonlinear problems, ODEs, PDEs, multiple scales, and transcendental equations in engineering, mathematics, and physics using both regular and singular perturbation methods.

11. May Count Either: aero/math 5460 **or** aero/math 6460 *(Indicate if this particular course cannot be counted for credit in addition to another)*

12. Affected Program(s):

(Respond "N/A" if not included in any program; attach memorandum if more space is required)

Program Type (e.g.: minor, major, etc.)	Program Title (e.g.: MS in Chemistry, Performance Option, Minor in Art)	Requirement or Elective? (required or optional?)
Major	Master in Aerospace Engineering	Elective
Major	PhD in Aerospace Engineering	Elective

13. Overlapping or Duplication of Other Units' Offerings:

(If course is included in any other degree program, is used as an elective frequently by other unit(s), or is in an area similar to that covered by another college/school, attach correspondence with relevant unit)

◉ Applicable ○ Not Applicable

14. Justification:

The MATH department has agreed to cross-list this course with AERO. (see attachment)
Many of the problems facing physicists, engineers, and applied mathematicians involve difficulties in solving nonlinear equations, transcendental equations, differential equations with variable coefficients, and nonlinear boundary conditions. Solutions to such problems are usually approximated using numerical techniques, analytical techniques, and combinations thereof. Foremost among analytical techniques are the systematic methods of perturbation theory, where a problem is linearized and solved approximately in terms of a small or a large parameter or coordinate. These mathematical techniques constitute an essential component of a student's "toolbox" for reducing the complexity of mathematical problems before solving them.

(Include a concise, yet adequate rationale for the addition/revision of the course, citing accreditation, assessments (faculty, graduate, and/or external) where applicable)

15. Resources:

No additional resources are required.

(Indicate whether existing resources such as library materials, classroom/laboratory space, and faculty appointments are adequate to support the proposed addition/revision; if additional resources are required, indicate how such needs will be met, referencing the appropriate level of authorization -- i.e.: Dean -- where necessary; if no additional resources or shifting of resources will be necessary, respond "Not Applicable")

16. Student Learning Outcomes:

1. understand when and how perturbation methods can be applied;
2. obtain regular perturbation solutions to algebraic equations involving small or large parameters;
3. construct perturbation solutions to linear and nonlinear boundary value problems for ordinary differential equations (ODEs);
4. identify singular perturbation problems and apply one of the strained-coordinate methods;
5. understand how solutions to initial value problems may depend on slow and fast scales and apply matched asymptotic and multiple scale methods to such problems.

The first four learning outcomes pertain to both undergraduate and graduate students. The last learning outcome is expected of the graduate students and is part of the Graduate Project (see grading info)

(State in measurable terms (reflective of course level) what students should be able to do when they have completed this course)

17. Course Content Outline:

Textbook: Carl M. Bender, and Steven A. Orszag, Advanced Mathematical Methods for Scientists and Engineers I: Asymptotic Methods and Perturbation Theory, Springer. 2010
References:
1. Milton Van Dyke, Perturbation Methods in Fluid Mechanics, Annotated Edition, Parabolic Press, Inc., Stanford, CA, 1975.
2. Bhimsen K. Shivamoggi, Perturbation Methods for Differential Equations, Birkhäuser, Boston, 2002.
3. Carl M. Bender, and Steven A. Orszag, Advanced Mathematical Methods for Scientists and Engineers, McGraw-Hill, Inc., 1978.
4. Shijun Liao, Beyond Perturbation: Introduction to the Homotopy Analysis Method, 1st ed., Chapman & Hall/CRC Press, Boca Raton, FL, 2003.
5. Ali Hassan Nayfeh, Introduction to Perturbation Techniques, Wiley Classics Library Edition, John Wiley & Sons, Inc., 1981.
6. Ali Hassan Nayfeh, Perturbation Methods, John Wiley & Sons, Inc., 1973.
7. James A. Murdock, Perturbation Theory and Methods, John Wiley & Sons, Inc., 1991.
8. Jerry Kevorkian, and Julian D. Cole, Multiple Scale and Singular Perturbation Methods, Springer-Verlag, Inc., 1996.
9. A. Aziz, and T. Y. Na, Perturbation Methods in Heat Transfer, Hemisphere Publishing Corp., 1984.
Objectives: The purpose of this course is to introduce students to asymptotic methods used in the construction of analytical approximations to

transcendental equations and differential equations.
Lecture Topics:
Week 1 : Introduction, examples, High-order polynomial
Week 2: High-order polynomial, Landau Orders –Gauge Functions,
Week 3: Non-dimensionalizing Equations, Regular Perturbations –Von Karman's Eqn., Regular Perturbations –Slab Problem.
Week 4: Regular Perturbations –Method of Ansatz
Week 5: Regular Perturbations –Laplace's Eqn., Regular Perturbations – Flow Past Cylinder
Week 6: Singular Perturbations –Nonlinear Spring
Week 7: Strained Coordinates –Lindstedt
Week 8: EXAM I, Post-Exam/Catching Up
Week 9: Strained Coordinates –PLK BCs
Week 10: Strained Coordinates –Pritulo, Boundary Layer Theory –Prandtl's Matching Principle
Week 11: Inner Approximation –Erdelyi, Van Dyke's Matching Principle
Week 12: EXAM II, Post-Exam/Catching UP
Week 13: Matched-Asymptotic Expansions
Week 14: Matched-Asymptotic Expansions, Multiple Scales
Week 15: Multiple Scales
Wekk 16: FINAL EXAM (undergraduate), Project Due (graduate)

(Provide a comprehensive, week-by-week breakdown of course content, including assignment due dates)

18. Assignments / Projects:

Homework: 20% contributes to all learning objectives
Test I: 25% contributes to learning objectives #1 and #2
Test II: 25% contributes to learning objectives #3 and #4
Undergraduate students –Final Exam: 30% - contributes to all learning objectives
Graduate students –Final Project: 30%- contributes to all learning objectives, but with special emphasis on Learning Outcome #5
The Final Project for the graduate students will involve the solution of a problem related to the individual student's area of interest within engineering, physics or mathematics using the methods developed in the course. This Final Project for the graduate students will replace an in-class final exam. The undergraduate students will not complete a project, but will have to complete an in-class final exam.
The course instructor will work with the Engineering Graduate Outreach Program office to conduct lectures in a video studio classroom. Engineering Outreach will deliver video content to distance learning students. The instructor will use Canvas to communicate with students, provide learning materials, and post assignments and grades. Engineering Outreach will arrange exam proctoring services.

(List all quizzes, projects, reports, activities and other components of the course grade -- including a brief description of each assignment that clarifies its contribution to the course's learning objectives)

19. Rubric and Grading Scale:

Assessment Contribution to Course Grade
Homework: 20%
Exams (2@25%): 50%
Final Exam/Project: 30%
Course Grading Scale:
90-100% - A
80-89% - B
70-79% - C
60-69% - D
Below 60% - F

(List all components of the course grade -- including attendance and/or participation if relevant -- with point totals for each; indicate point totals and ranges or percentages for grading scale; for S/U grading, detail performance expectations for a passing grade)

20. Justification for Graduate Credit:

The course material is taught at the graduate level by our peer institutions. Understanding the course material will require a high degree of critical thinking and a knowledge base that can only be obtained outside of the course lecture material by reading the

suggested reference material. The department has taught this course as a AERO 7970: Special Topics course during the past year and the students found it to be a very challenging course.

(Include a brief statement explaining how the course meets graduate educational standards (i.e.: rigorous standards for evaluation, development of critical thinking and analytical skills, etc.))

(Included below are standard statements regarding course policies. If necessary, a statement may be altered to reflect the academic policies of individual faculty members and/or the academic unit or department, provided that there is no conflict with the Student Policy eHandbook, Faculty Handbook, *or any existing university policy.)*

POLICY STATEMENTS

Attendance: Although attendance is not required, students are expected to attend all classes, and will be held responsible for any content covered in the event of an absence.

Excused Absences: Students are granted excused absences from class for the following reasons: illness of the student or serious illness of a member of the student's immediate family, the death of a member of the student's immediate family, trips for student organizations sponsored by an academic unit, trips for university classes, trips for participation in intercollegiate athletic events, subpoena for a court appearance, and religious holidays. Students who wish to have an excused absence from class for any other reason must contact the instructor in advance of the absence to request permission. The instructor will weigh the merits of the request, and render a decision. When feasible, the student must notify the instructor prior to the occurrence of any excused absences, but in no case shall such notification occur more than one week after the absence. Appropriate documentation for all excused absences is required. Please consult the **Student Policy eHandbook** for more information on excused absences.

Make-Up Policy: Arrangement to make up a missed major examination (e.g.:hour exams, mid-term exams) due to properly authorized excused absences must be initiated by the student within one week of the end of the period of the excused absence(s). Except in unusual circumstances, such as the continued absence of the student or the advent of university holidays, a make-up exam will take place within two weeks of the date that the student initiates arrangements for it. Except in extraordinary circumstances, no make-up exams will be arranged during the last three days before the final exam period begins.

Academic Honesty Policy: All portions of the Auburn University student academic honesty code (Title XII) found in the **Student Policy eHandbook** will apply to university courses. All academic honesty violations or alleged violations of the SGA Code of Laws will be reported to the Office of the Provost, which will then refer the case to the Academic Honesty Committee.

Disability Accommodations: Students who need accommodations are asked to electronically submit their approved accommodations through AU Access and to arrange a meeting during office hours the first week of classes, or as soon as possible if accommodations are needed immediately. If you have a conflict with my office hours, an alternate time can be arranged. To set up this meeting, please contact me by e-mail. If you have not established accommodations through the Office of Accessibility, but need accommodations, make an appointment with the Office of Accessibility, 1228 Haley Center, 844-2096 (V/TT).

Approvals

Department Chair / Head	Date 1/13/15
College / School Curriculum Committee	Date 1/22/15
College / School Dean	Date 1/22/15
Dean of the Graduate School *(for Graduate Courses)*	Date
Assoc. Provost for Undergraduate Studies *(for Undergraduate Courses)*	Date

Contact Person:	Steve Gross	**Telephone:**	4-6846
E-Mail Address:	grossrs@auburn.edu	**Fax:**	