Texas A&M University

Departmental Request for a New Course

Undergraduate • Graduate • Professional

• Submit original form and attach a course syllabus.

1. This request is submitted by the Department of ____________________________
   Aerospace Engineering

2. Course prefix, number and complete title of course: ____________________________
   AERO 640 - Turbulence Processes

3. Course description (not more than 50 words): Fundamentals of conservation, Lagrangian, transformation and variance properties: flow features averaging, realizability; elementary turbulence processes: viscous, advective/inertial processes; role of pressure; models of elementary viscous RDT, RDT for velocity gradients, equipartition of energy, restricted Euler equations; isotropic and homogeneous turbulence.

4. Prerequisite(s) ____________________________ Cross-listed with ____________________________
   Cross-listed courses require the signature of both department heads.

5. Is this a variable credit course? □ Yes □ No If yes, from ______ to ______.

6. Is this a repeatable course? □ Yes □ No If yes, this course may be taken ______ times. Will the course be repeated within the same semester/term? □ Yes □ No

7. Has this course been taught as a 289/489/689? □ Yes □ No If yes, how many times? ______ Indicate the number of students enrolled for each academic period it was taught. 94A-9, 06A-10 & to be taught 06A as 689.

8. This course will be:
   a. required for students enrolled in the following degree program(s) (e.g., B.A. in history)

   b. an elective for students enrolled in the following degree program(s) (e.g., M.S., Ph.D. in geography)
   an elective for students enrolled in MS, PHD graduate programs in aerospace engineering.

9. If other departments are teaching or are responsible for related subject matter, the course must be coordinated with these departments. Attach approval letters.

10. Prefix     Course #   Title (excluding punctuation)
    AERO 640   Turbulence Processes

    Lec.  Lab  SCH  Subject Matter Content Code  Admin. Unit  Acad. Year  FICE Code
    0  3  0  0  0  3  1  4  0  2  0  1  0  0  0  6  0  1  0  0  0  9  1  0  0  0  3  6  3  2

Approval recommended by:

Head of Department Walter E. Haller for Helen L. Ross - AERO

Date 12-3-07

Chair, College Review Committee

Date 12/19/07

Dean of College

Date 6/5/07

Submitted to Coordinating Board by:

Dean of College

Date

Director of Academic Support Services

Date Effective Date

Questions regarding this form should be directed to Sandra Willams at 845-8836.

OAR/AS – 04/07
MEMORANDUM

DATE: December 4, 2007

TO: Dr. N. K. Anand
   Associate Dean for Graduate Programs
   ESSAP - College of Engineering
   204 Zachary

THRU: Dr. Dennis O'Neal
       Professor and Head
       Department of Mechanical Engineering

THRU: Dr. Helen L. Reed
       Professor and Head
       Department of Aerospace Engineering
       719C H. R. Bright

RE: New Course: AERO 640 – Turbulence Processes

The Department of Aerospace Engineering requests that the Department of Mechanical Engineering support our request for a new course, AERO 640-Turbulence Processes.

AERO 640 appears to have some overlap to existing courses taught by Mechanical Engineering, specifically MEEN 636-Turbulence: Theory and Engineering Applications and MEEN 637-Turbulence Measurement and Analysis. However, AERO 640 expands topics specific to aerospace engineering and will not duplicate the mechanical engineering courses.

Your consideration of this request is greatly appreciated.

cc: Attachment: new course form/syllabus file
   Dr. Sai Lau (slau@menor.tamu.edu )
   Dr. Haisler (haisler@tamu.edu )
Department of Aerospace Engineering  
AERO 640 - Turbulence Processes  
Credit 3: (3-0)

**Instructor:** Dr. Sharath S. Girimaji, Professor, Aerospace Engineering Dept. – HRBB 607B, (979)845-1674,  
girimaji@aero.tamu.edu

**Textbook:** None  
**Reference:** 'Turbulent Flows' by S. B. Pope  
**Prerequisites:** None  
**Attendance Policy:** Students are expected to attend class.

**Course Description:** Fundamentals of conservation, Lagrangian, transformation and variance properties; flow features: laminar, transition and turbulence regimes, characteristics, spectrum; statistical (filter/average) description: scales, Reynolds, arbitrary averaging, realizability; elementary turbulence processes: viscous, advective/inertial process, role of pressure; models of elementary processes: RDT, viscous RDT, RDT for velocity gradients, equipartion of energy, restricted Euler equations; isotropic and homogeneous turbulence

**Learning Objectives:** At the end of this course, the students will be able to:
1. To understand the physics underlying various turbulence processes: production, slow and rapid pressure strain correlation and dissipation,  
2. To be able to perform linear analysis with Rapid Distortion Theory  
3. To be able to perform non-linear studies with Homogenized Euler Equation.  
4. To perform direct numerical simulations of isotropic and anisotropic turbulence to examine various features of turbulent cascade, energy transfer and scales of motion.  
5. To comprehend closure modeling issues

**Syllabus:**

<table>
<thead>
<tr>
<th>Topics</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 1. Fundamentals  
a) On the nature of turbulence  
b) Governing equations  
c) Lagrangian description  
d) Transformation and invariance properties | 4 |
| 2. Flow features  
a) Laminar, transition and turbulence regimes  
b) Turbulence characteristics  
c) Turbulence spectrum  
d) Scales of turbulence | 4 |
| 3. Statistical description  
a) Need for statistical description  
b) Reynolds and generalized central moment averaging  
c) Generalized statistics equations  
d) Realizability and other kinematic constraints | 4 |
| 4. Elementary turbulence processes  
a) Advective/inertial process – production and transport  
b) Viscous process – dissipation and transport  
c) Role of pressure – redistribution and transport | 10 |
| 5. Models of elementary processes  
a) Inviscid RDT – linear model of advection and pressure effects  
b) Viscous RDT: RDT + viscous effect  
c) Homogenized Euler equations: Model for non-linear advection and pressure effects | 13 |
| 6. Isotropic and homogeneous turbulence | 6 |

**Total Hours:** 42

**Method of Evaluation:**
- Assignments and projects (3 X 30%) 90%  
- Final 10%
Contributions to Professional Component:

1. Prepares students to understand the physics underlying the various processes that make up turbulence.
2. Introduces students to the basic tool required for examining turbulence.
3. Builds on foundation established by exploring closure modeling ideas.
4. Prepares students for a career in advanced CFD with turbulence modeling

Relationship to Program Outcomes:

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Assessment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand the physics underlying various turbulence processes</td>
<td>Projects and Finals</td>
</tr>
<tr>
<td>Linear analysis using RDT</td>
<td>Projects</td>
</tr>
<tr>
<td>Non-linear analysis using Homogenized Euler Equation</td>
<td>Projects</td>
</tr>
<tr>
<td>Direct numerical simulations of isotropic and anisotropic turbulence</td>
<td>Projects</td>
</tr>
<tr>
<td>To comprehend closure modeling issues</td>
<td>Assignment</td>
</tr>
</tbody>
</table>

Americans with Disabilities Act
The Americans with Disabilities Act (ADA) is a federal antidiscrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities in Room B118 Cain Hall, or call 845-1637.

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