King Fahd University of Petroleum & Minerals
MECHANICAL ENGINEERING DEPARTMENT
ME 425: Compressible Fluid Flow

Catalogue Description: (3-0-3)
Fundamentals of compressible fluid flow (gas dynamics) in relation to effects of area change (nozzles and diffusers), friction and heat interaction (Fanno and Rayleigh lines and isothermal flow), combustion waves (deflagration, explosion and detonation waves), normal and oblique shock waves and their effects on flow properties (extended diffusers and supersonic airfoils). Applications to flow through pipelines, subsonic, sonic and supersonic flights, turbomachinery and combustion.

Status in Curriculum (Required or Elective): Required (offered Fall & Spring)

Prerequisites: ME 311

Co-requisites: None

Prerequisites by Topics:
- Conservation of Mass (ME311)
- Momentum Equations (ME311)
- Energy Balance (ME203&ME311)

Textbook: **Compressible Fluid Flow,** M.A.Saad, 2nd Ed.,Prentice-Hall, 1995.

References:
1) **Gas Dynamics**, M.H.Aksel and O.C.Eralp, , Prentice-Hall, 1993.
2) **Fundamentals Of Compressible Fluid Dynamics**, P. Balachandran PHI Learning Pvt. Ltd., Technology & Engineering, 2006
3) **Gas Dynamics**, E. Rathakrishnan, PHI Learning Pvt. Ltd., Aug 1, 2004

Coordinator: **Dr. Bekir Sami Yilbas,** Professor of Mechanical Engineering

Goals: (general objectives)
This course is intended to cover theory and applications of compressible fluid flow. The course emphasizes the practical application and design considerations of flow systems including flow into variable area ducts with friction and heat transfer, standing shocks, two-dimensional shock waves, and expansion waves.

Course Outline (Lecture Topics):
1. Introduction to Flow and Thermodynamic Properties: *Fundamental analysis for thermodynamic properties of gases, etc* (3 hours)
2. Equations of flow and isontropic flow in variable and constant area ducts: *Subsonic and supersonic flow into convergence and divergent nozzles. Supersonic and subsonic diffusers, Efficiencies analysis* (8 hours)
3. Normal shock waves: *Thermodynamic and Flow analysis of normal shock waves, shock waves in convergent and convergent-divergent nozzles, shock waves in diffusers, etc.* (8 hours)
4. Adiabatic frictional flow in ducts: *Analysis of Fanno-line flows in a constant area ducts, subsonic and supersonic flows in a convergent and divergent nozzle with constant area ducts.* (8 hours)
5. Flow with heat interaction: Analysis of Rayleigh Line Flows, supersonic and subsonic flows with heat interaction in constant and variable area ducts. (7 hours)
6. Two dimensional waves: *Analysis of Oblique Shock waves, Flow passes over two dimensional wedges, Prandtl Meyer Flow over corners, etc.* (7 hours)
7. Introduction to Linearized flow: *Flow passes over undulated surface, introduction to hyperbolic flows.* (4 hours)

Design Activities/Projects:
Design assignments including sonic and supersonic nozzle designs and two-dimensional supersonic airfoil design are assigned.

Computer Usage:
Students are encouraged to solve some assigned homework problems using the available engineering software, such as Excel, EES, MATLAB

Laboratory: None

Assessment Tools:

i- Mid-term Examinations
ii- Homework Assignments
iii- Quizzes
iv- Final Exam

Course Learning Outcomes:

I- Students shall gain clear knowledge about some of the basic mechanisms, thermodynamic analysis and fluid mechanics properties of gases; demonstrate a clear understanding of the use of the properties;

II- Students shall demonstrate the ability to assess the flow characteristics in nozzles and determine geometric configurations of variable area flow passages.

III- Students shall demonstrate the ability to determine flow properties across sanding shock waves in variable area ducts.

IV- Students shall be able to perform design analysis of flow systems involving with friction and heat transfer in constant area ducts.

V- Students shall demonstrate ability to construct two-dimensional waves in internal and external diffusers.

VI- Students shall demonstrate a basic understanding of the expansion waves in sharp edges of two-dimensional airfoils;

Course Learning Outcomes mapped to Student Outcomes:

Student Outcomes	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*
Course-to-Student outcome mapping	I, III, IV		II, V		II, III, IV, V			VI			
Emphasis*	**S**		**M**		**L**			l			

* **L**:: Little/None **M**: Moderate **S**: Strong

Status of Continuous Improvement review of this Course:

Date reviewed: March 05, 2015 **Reviewed by:** Dr. A.Z. Sahin
Prepared by: Dr. Bekir Sami Yilbas **Date prepared:** March 03, 2015