A Course Proposal

Entitled

Physics of Fluid Flow Experiments

(For UG 4th Year, BT-MT Dual Degree)

Submitted
By

Dr. Mrinal Kaushik

(Assistant Professor)

March 12, 2015

Department of Aerospace Engineering

Indian Institute of Technology Kharagpur

Kharagpur - 721302, India

Course Name

Physics of Fluid Flow Experiments

Proposed Course Instructors

1. Dr. Mrinal Kaushik

   Assistant Professor, Department of Aerospace Engineering

   Indian Institute of Technology Kharagpur

   Email: mkaushik@aero.iitkgp.ernet.in

   Website: http://mrinalkaushik.webs.com/

2. Prof. K. P. Sinhamahapatra

   Professor, Department of Aerospace Engineering

   Indian Institute of Technology Kharagpur

   Email: kalyanps@aero.iitkgp.ernet.in

Semester in which course will be offered

Both (autumn and spring) semesters

Justification for Introducing the New Course

In the existing undergraduate curriculum of aerospace engineering, there are two second level aerodynamic laboratory courses which must be credited compulsorily in order to complete the degree requirements. However, these courses are mainly focused in conducting the experiments only, but the flow physics behind them is hardly stressed upon because of their fixed laboratory timings. Although, these courses provide practical exposure to some introductory level experiments in low and high-speed aerodynamics, but more in depth information and theoretical background is highly desired for successful completion of their projects. It has been observed in

the past that many of the students faced difficulty in explaining the flow physics behind their project work in aerodynamics and allied areas. Therefore, there is an urge to have an exhaustive course which is not only dedicated in explaining the flow physics behind the fluid mechanics and/or aerodynamics experiments but also provide complete exposure to various instrumentation in them from existing mechanical ones to modern sophisticated electronic equipment. In the proposed course, these shortcomings are tried to address through its versatile contents covering vast areas in applied aerodynamics. This course should be kept under elective category so that, all the undergraduate students studying in various streams across the institute can credit and get benefited provided they have credited fluid mechanics and gas dynamics courses as a prerequisite. Also, the proposed course should be offered in both autumn and spring semesters, so that the students can be encouraged to credit this ambitious course even in case of timing clash with their regular and/or other elective courses in a particular semester.

Text Books:

- Experimental methods for engineers, J.P. Holman, 8^{th} edition, McGraw-Hill Book Co. (1989).
- Low-Speed Wind Tunnel Testing, Jewel B. Barlow, William H. Rae, Alan Pope, Wiley Publications (1999).
- High-Speed Wind Tunnel Testing, Alan Pope and Kenneth L Goin, Krieger Publishing Company (1978).
- Experiments in Fluid Mechanics, Robert A. Granger, Saunders College Publishing (1995).

Reference Texts:

- Springer Hand Book of Experimental Fluid Mechanics, edited by C. Tropea, A. L. Yarin and J. F. Foss, Springer (2007).
- Hot-wire Anemometry by A. E. Perry Oxford University Press (1982).

Course Content

- Review of Flow Physics (Gas Dynamics and Fluid Mechanics).
- Wind Tunnels and it instrumentations (Low-Speed Wind Tunnels, High-Speed Wind Tunnels, Special Purpose Wind Tunnels, Ludwig Tubes, Shock Tunnels and High Enthalpy Tunnels).
- Flow Visualization (Smoke, Dust, Surface Contours, Optical Methods)
- Hot Wire Anemometry (Constant Current, Constant Temperature and Constant Voltage, Frequency Response, etc.)
- Analogue Methods (Hele-Shaw Apparatus, Shallow Water Analogy, Hydraulic Jumps)
- Pressure Measurement Instruments (Barometer, Manometer, Traverse, Pitot Probe, Pitot-Static Probe, Disk Probe, etc.)
- Factors affecting the Pressure Measurements (Orientation, Vibration, Viscous Effects, etc.)
- Temperature Measurements (Thermocouple, Thermometer, Pyrometer, etc.)
- Uncertainty Analysis (Error, Uncertainty, etc.)

Physics of Fluid Flow Experiments

Prerequisites #

- Introduction to Aerodynamics AND/ OR Fluid Mechanics.
- Gas Dynamics.

Total number of lectures: 40 (Approx.)

- Need and objective (1 lecture),
- Fundamentals of fluid mechanics – Review. (2 lectures)
- Design, calibration and operation of subsonic, supersonic and hypersonic wind tunnels. (12 lectures)
- Incompressible and compressible flow visualization - Smoke, tuft, oil, Shadowgraph, Schlieren and Interferometer. (5 lectures)
- Hot Wire Anemometry - Types, principle, operation and limitations. (5 lectures)
- Wind tunnel balances, pressure and noise measurements - Probes, characteristics of the probes, design and application of probes and transducers. (5 lectures)
- Temperature measurements - Thermometer, thermocouple, construction and measurement with thermocouple. (3 lectures),
- Wall shear stress - direct measurement. (1 lecture),
- Flow measurements - Types of meters, venturimeter, nozzles. (2 lectures)
- Geophysical flows - Spin up and spin down. (2 lectures)
- Data acquisition and processing. (1 lectures)
- Uncertainty analysis. (1 lecture)