

- ☒ INTRODUCTION TO MEASUREMENT TECHNIQUES  
OCTOBER 8-12, 2012
- ☐ INTRODUCTION TO CFD  
JANUARY 21-25, 2013
- ☐ CUBESAT TECHNOLOGY AND APPLICATIONS  
JANUARY 29 - FEBRUARY 1, 2013
- ☐ SMALL AEROPLANE DESIGN  
FEBRUARY 4-8, 2013
- ☐ CFD FOR ATMOSPHERIC FLOW AND WIND ENGINEERING  
MARCH 11-13, 2013
- ☐ ACCURATE AND EFFICIENT AEROACOUSTIC PREDICTION APPROACHES FOR AIRFRAME NOISE  
MARCH 25-28, 2013
- ☐ AEROENGINE DESIGN: FROM STATE OF THE ART TURBOFANS TOWARDS INNOVATIVE ARCHITECTURES  
APRIL 8-12, 2013
- ☐ RADIATION AND GAS-SURFACE INTERACTION PHENOMENA ON HIGH SPEED RE-ENTRY (STO-AVT-VKI)  
MAY 6-8, 2013
- ☐ TURBULENT COMBUSTION  
MAY 13-17, 2013
- ☐ 37<sup>TH</sup> COMPUTATIONAL FLUID DYNAMICS: ADVANCED ALGORITHMS  
MAY 21-24, 2013
- ☐ SOURCE TERM CHARACTERIZATION OF THE CONSEQUENCES OF STORAGE TANK AGGRESSIONS (STO-AVT-VKI)  
JUNE 4-6, 2013
- ☐ TRANSITION AND TURBULENCE IN HIGH-SPEED FLOW  
JUNE 10-14, 2013
- ☐ FLOW CHARACTERISTICS AND PERFORMANCE OF SAFETY VALVES  
SEPTEMBER 9-13, 2013
- ☐ ACCURATE TEMPERATURE MEASUREMENTS  
SEPTEMBER 16-20, 2013



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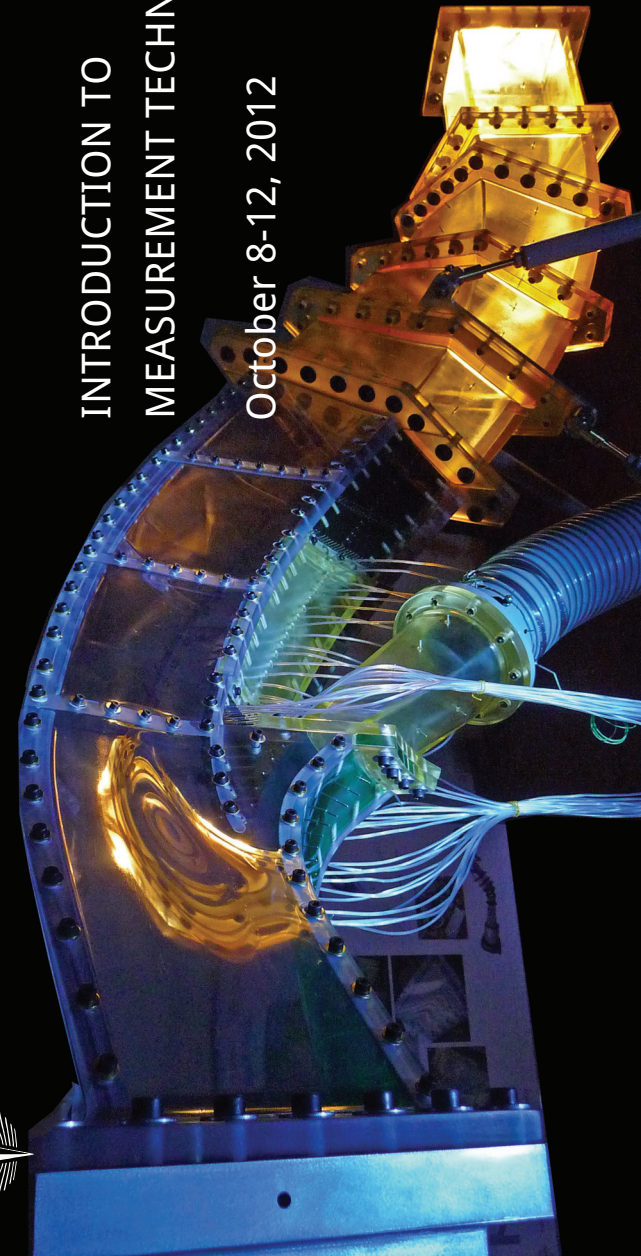
Lecture Series Secretary  
von Karman Institute for Fluid Dynamics  
Waterloosesteenweg 72  
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Belgium

von KARMAN INSTITUTE FOR FLUID DYNAMICS



# INTRODUCTION TO MEASUREMENT TECHNIQUES

October 8-12, 2012



## INTRODUCTION

The objective of this course is to provide young engineers with a broad overview of traditional and advanced measurement techniques applicable to fluid dynamics.

Each measurement technique and its field of application will be described. Limitations and advantages will be discussed and special attention will be given to the subject of error estimation.

A choice of relevant techniques will be demonstrated to groups of six people maximum during lab sessions on Thursday afternoon and Friday in the VKI facilities. This will provide an opportunity to get acquainted with the available hardware and will allow for discussion of individual problems.

This course, prepared and presented by the VKI teaching staff, is based on a long experience with the different techniques for research applications.

Lectures are given by Professors T. Arts, J.-F. Brouckaert, J.-M. Buchlin, M. Carbonaro, O. Chazot, G. Paniagua, R.A. Van den Braembussche, M.R. Vetrano and Dr. Y. Babou of the von Karman Institute. The Director of this course is Professor T. Arts of the von Karman Institute.



VON KARMAN INSTITUTE FOR  
FLUID DYNAMICS

## ONLINE REGISTRATION AVAILABLE

<https://www.vki.ac.be/registration>

It is highly recommended that the registration is sent at the latest 15 days before the beginning of the course. A letter of acceptance and additional information will be sent on receipt of the application form.

## COURSE FEE

The fee for the lecture series is 1350 euro, applicable to citizens of NATO countries contributing to the financing of the VKI (Belgium, Czech Republic, France, Germany, Hungary, Iceland, Italy, Luxembourg, Norway, Portugal, Spain and Turkey). For citizens of other NATO countries and of NATO partner countries, the fee is 1760 euro. For non-NATO citizens the fee is 1920 euro. These prices include 21% VAT. The fee includes printed notes, lunches, beverages, and administrative costs. Lectures will be given in English and printed notes will be distributed during registration.

## FELLOWSHIPS

To encourage greater participation in our Lecture Series programme by university members, the Institute has established a limited number of VKI Lecture Series fellowships for citizens of NATO countries contributing to the financing of the VKI, as well as for citizens of other NATO countries and NATO partner countries coming from a university in a VKI financing country. The recipient of such fellowship is entitled to attend the Lecture Series at a reduced fee, which will be 675 euro (VAT included) for assistants not having a Ph.D. degree and for Ph.D. candidates, and 300 euro (VAT included) for undergraduate students. For non-NATO citizens coming from a university in a VKI financing country, the fee is 960 euro (VAT included) for assistants not having a Ph.D. degree and for Ph.D. candidates, and 400 euro (VAT included) for undergraduate students.

The request to be considered for an award must accompany the application to attend the Lecture Series, and the applicant must provide a recommendation letter from his or her professor; if not done so, the request will not be taken into consideration. All possible alternative sources of funding should be investigated before aid is requested under this scheme, so that those most in need will benefit.

## METHODS OF PAYMENT

Payment 2 weeks prior to the beginning of the course (name and course title clearly indicated) by bank transfer to our account at BNP Paribas Fortis Bank, avenue de la Forêt de Soignes 322, 1640 Rhode-Saint-Genèse, Belgium, IBAN BE57 2100 3153 3035 (strongly recommended). SWIFT BIC GEBABEBB. Late registration can be paid in cash (euro), or by VISA or Eurocard at the beginning of the course. Lectures will be given in English and printed notes will be distributed during registration. Proceedings of lecture series may be purchased at VKI (by e-mail vanhaelen@vki.ac.be or by fax: 32 2 359 96 00).

## GENERAL OUTLINE

### 1. Components of a measurement chain

### 2. Measurement uncertainties and errors

### 3. Transducers

- active and passive transducers
- transducers for different applications
- amplifiers (types and matching)
- frequency response

### 4. Pressure measurements

- static pressure (description and errors)
- total pressure (probes and errors)
- flow direction measurements (2 & 3 dimensional)
- unsteady pressure measurements (frequency response & calibration)

### 5. Temperature measurements

- thermocouples, cold wires
- surface measurement devices (thin films – liquid crystals)
- infrared thermography (principles – spatial resolution – quality factor)

### 6. Hot wire anemometry

- probe construction and calibration
- control circuits & linearisation
- angular response
- turbulence measurements

### 7. Optical measurement techniques

- laser doppler velocimetry (LDV)
- particle image velocimetry (PIV)
- optical density & spectroscopic measurements

### 8. Flow visualisation

- air and water flows
- streamlines and skin friction lines

### 9. Force measurements

### 10. Signal displays, recording & processing

- display, recording
- analog to digital conversion
- Fourier analysis
- numerical systems and their application for data processing

### The following demonstrations are scheduled on Thursday afternoon and Friday :

- LDV, PIV & holographic interferometry
- hot wires
- infrared thermography
- thin films, liquid crystals, thermocouples, and cold wires
- steady and unsteady pressure measurements
- flow visualisation (watertunnel, schlieren, shadowgraph, oil flow, etc.)

*Lunch will be taken from 12h30 to 14h00. Coffee breaks are scheduled each morning and afternoon.*



[twitter.com/vki\\_vonkarman](https://twitter.com/vki_vonkarman)

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