

Exam Physical Measurement Methods (4P580)

Monday November 2, 2009 14:00-17:00

[NOTE: PROBLEMS MAY BE ANSWERED IN BOTH ENGLISH AND DUTCH]

Problem 1 Various topics. Provide to-the-point answers including brief argumentation.

- (a) Why is it not advisable to use an orifice meter directly behind a flow obstruction?
- (b) Does dye injection enable visualisation of unsteady fluid trajectories?
- (c) Can rotameters be employed for unsteady flows?
- (d) Why is the indicator method unreliable in laminar flows?
- (e) Can the flow direction be determined with a standard hot-wire anemometer?

Opgave 2 Velocity measurements using Particle-Image Velocimetry (PIV) and Particle-Tracking Velocimetry (PTV).

- (a) Describe the general laboratory set-up for PIV/PTV measurements. Specify its basic components and briefly discuss their function.
- (b) Describe in a concise way the working principles of PIV and PTV.

Consider an unsteady flow (water: $\nu = 10^{-6} \text{ m}^2/\text{s}$, $\rho = 1000 \text{ kg/m}^3$) driven by an oscillating horizontal wall ($f = 30 \text{ Hz}$, $U = 1 \text{ m/s}$) inducing predominantly horizontal fluid motion. Seeding particles ($d = 0.1 \text{ mm}$, $\rho = 2000 \text{ kg/m}^3$) are added for flow measurements by PIV.

- (c) Estimate by a force balance whether the particles can follow the flow sufficiently fast.
- (d) Estimate by a force balance whether gravity (acting downward in vertical direction) may cause significant departures of particle trajectories from fluid trajectories.
- (e) How must the experiment be modified for data-processing with PTV instead of PIV?

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Opgave 3 Velocity measurements with Laser-Doppler Velocimetry (LDV).

- (a) Describe the general laboratory set-up for LDV measurements. Specify its basic components and briefly discuss their function.
- (b) Derive the relation between velocity and Doppler shift for the LDV set-up.
- (c) Explain the principle of “heterodyning” and why it is necessary for LDV.
- (d) Name 2 important advantages of LDV over velocity measurements with a Pitot tube.
- (e) Name a number of disadvantages of LDV.

Opgave 4 Temperature measurements in non-isothermal flows.

- (a) Describe the physical working principle of thermocouples.
- (b) Describe the physical working principle of resistance-temperature detectors (RTDs).
- (c) Describe the physical working principle of Laser-Induced Fluorescence (LIF).
- (d) What is an essential advantage of LIF over thermocouples and RTDs?
- (e) Briefly discuss a few potential error sources in temperature measurements with LIF.