REF: TECHWEB05

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# Optical Systems

## (part I - course No. 035187,

## part II- course No. 036019)

## (*Obligatory courses for Extended area "Optical Engineering")*

## I. Syllabus of the Courses and the score

1. Optical Systems –part I

A. The Framework

Lectures: 2 hours weekly, Exercises: 1 hour weekly
Total score: 2.5 points

Term examination: 3 hours
Home work: 6 exercises sheets

Grading: 20%-home work exercises, 80% - term exam

B. The Syllabus

1.1. Introduction to Optical Systems Engineering

1.2. Optical systems in paraxial area
- 1.2.1. Ray optics and sign convention. Real and virtual objects and images
- 1.2.2. Thin lenses and optical layout of Microscope and Telescope
- 1.2.3. Diaphragms in Optical systems. Vignetting.
- 1.2.4. Role of Prisms and analysis of unfolded diagrams

1.3. Theory of Imaging
- 1.3.1. Optical aberrations
  - 1.3.1.1. General consideration. Rays fan and aberration plot. Concept of wave aberrations
  - 1.3.1.2. Chromatic aberrations; principles of achromatic lens design
  - 1.3.1.3. Spherical aberration and Coma
  - 1.3.1.4. Aberrations of tilted beams (Field aberrations)
  - 1.3.1.5. Sine condition and Aplanatic points
  - 1.3.1.6. Addition of aberrations
- 1.3.2. Diffraction effects and Resolution.

1.3.3. Image Evaluation.
1.3.4. Two special cases (Telecentric system and Telephoto system)

1.4. Sources of Light and illumination systems
1.4.1. Thermal radiation sources for visible and IR
1.4.2. Lens-based illumination systems
1.4.3. Lasers
1.4.3.1. Main characteristics of a laser beam,
1.4.3.2. Beam expanding and spatial filtering
1.4.3.3. Laser diodes
1.4.4. Light Emitted Diodes (LEDs)

1.5. Detectors of Light
1.5.1. Parameters of radiation detectors. Thermal noise, shot noise and dark current.
1.5.2. Electro-optical detectors (photocell, photomultiplier and semiconductors detectors)
1.5.3. CCD detectors (line arrays and area sensors)

## 2. Optical Systems –part II

### A. The Framework

Lectures: 2 hours weekly, Exercises: 1 hour weekly
Total score: 2.5 points

Term examination: 3 hours
Home work: 6 exercises sheets

Grading: 20%-home work exercises, 80% - term exam

### B. The Syllabus

2.1. Optical Systems for spectral measurements
2.1.1. Spectral properties of materials and spectral instruments
2.1.2. Prism-based systems
2.1.3. Diffractive gratings and grating-based systems
2.1.3.1. Plane diffractive gratings and related configurations
2.1.3.2. Systems with concave diffraction gratings
2.1.4. Interferometry-based spectral instruments
2.1.4.1. Interference filters and interferometer Fabry-Perot
2.1.4.2. Fourier Spectrometer
2.1.5. Spectrophotometry

2.2. Non-contact measurements of Temperature
- 2.2.1. Thermal Radiation laws and Surface properties
- 2.2.2. Color Temperature measurements
- 2.2.3. Brightness Temperature measurements
- 2.2.4. Measurements of Temperature gradients

2.3. Optical Scanners and Acousto-Optics
- 2.3.1. Mirrors scanners
- 2.3..2. Electro-mechanical scanners
- 2.3.3. Acousto-optics and acousto-optical scanners
  - 2.3.3.1. Acousto-optical effect and Acousto-Optical cell (AOM)
  - 2.3.3.2. Two operation modes - AOM as Modulator of light and AOM as Deflector of optical beams
  - 2.3.3.3. AOM architecture for spectral analysis

2.4. Optical systems for Distance measurements
- 2.4.1. Laser Rangefinders
- 2.4.2.. Interferometric configuration
- 2.4.3. Stratified light beam and imaging measurements technique

2.5. Systems for Flow parameters measurement:
- 2.5.1. Principles of Laser Doppler Velocimetry (LDV)
- 2.5.2. Measurement of velocity in 1-D, 2-D and 3-D Flow geometry
- 2.4.1.3. Two phase Flow and principles of particles sizing

2.6. Color imaging and color detection
- 2.6.1. Physiology of color vision
- 2.6.2. Color coordinates and color quantitative presentation
- 2.6.3. Color video signals and color CCDs

## II. Literature

*Main Textbook*:

1. N.Menn. Practical Optics

*Additional sources*:

1. M.Born, E.Wolf . Principles of Optics
2. L.Levi. Applied Optics.
3. W.Smith. Modern Optical Engineering
4. F.Jenkins, H.White. Fundamentals of Optics
5. L.Martin. Technical Optics. Volume II.
6. Applied Optics and Optical Engineering, Volumes I-V
7. J.Goodman. Introduction to Fourier Optics.
8. A.Yariv, P.Yeh. Optical waves in Crystals.
9. F.Durst, A.Melling, J.Whitelaw. Principle and Practice of Laser Doppler Anemometry.
10. E.M.Sparrow, R.D. Cess. Radiation Heat Transfer.
11. J.Verdeyen. Laser Electtronics.
12. M.Young. Optics and Lasers. (v.5 in Spriner Series in Optical Engineering, 1984)

13. Optical and Infrared Detectors. (v.19 in “Topics in Applied Physics”, Edited by R.J.Keyes)
14. Andrew .F.Inglis. Video Engineering.
15. B.S.Rinkevichius. Laser Diagnostics in Fluid Mechanics, 1998
16. R.M.Boynton. Human Color Vision.
17. S. Tolansky. An Introduction to Interferometry. 1954