DAU DAYAL INSTITUTE OF VOCATIONAL EDUCATION, KHANDARI, AGRA
OPTICAL INSTRUMENTATION

Course – I : Geometrical Optics and Optical Components

(There should be refresher up to three lectures on basic principles of geometrical optics, image formation by lenses and mirrors)

Laws of reflection and refraction, Refractive index and optical path, Fermat's principle, sign convention, reflection and refraction at spherical surfaces, virtual and real images, lateral or transverse magnification, refraction through lenses, cardinal points of an optical system, nodal slide, Newton's formula for combination of lenses.

Ideal images and aberrations, chromatic aberration (Abbe number, achromatic Doublet, cemented doublet), mono-chromatic aberration (spherical aberration and its removal), coma, astigmatism and curvature of field, distortion.

Aplanatic points and surfaces, stops, and apertures, entrance and exit pupil, field of view: vignetting, entrance and exit windows, effective aperture of entrance pupil, Dispersion (Primary and Secondary Rainbow).

Optical System Components

Single lenses, plane-parallel plates, plane, spherical and aspheric mirrors, optical lightguides, Fresnel's lenes, various types of prisms (right angle prism, roof prism, porro prism erecting prism system, cube corner prism, achromatic prism, direct vision prism) and their applications, beam splitters, cubes, opthalmic lenses, Polarizing beam splitting prisms (Rochon, Senarmont, Wallaston, Foster, Ferussner).

Reference Books:

1. Optics : Ajoy Ghatak
2. A Text book of Optics : N. Subrahmanyam and Brij Lal
3. Geometrical and Physical Optics : R.S. Longhurst
4. ~~Optical workshop technology: R. Hradaynath~~
5. ~~Geometrical and Physical Optics: R. S. Longhurst~~

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Course – 2: Wave Optics

Basic concepts of wave propagation, superposition principle, Huygen's principle, wavefront, reflection and refraction of plane wave front at plane surface, interference of waves including some examples, coherent sources and its conditions.

Interference of Light

Interference by division of wavefront: Frenel's Biprism, interference frings with white light, lateral shift of fringes, localization of fringes

Interference by division of amplitude: Stoke's treatment, interference from thin films, colours in thin films, extended source, interference in thin films, Newton's Ring and its applications.

Michelson's interferometer and its applications, multiple beam interference: Fabry Perot interferometer, interference filters coherence.

Diffraction of Light

Fresnel's Diffraction: Fresnel's half period zone method, division of plane wave front into half period zones, zone plate, diffraction through circular aperture.

Fraunhofer Diffraction: Single-slit and N- slit Fraunhofer diffraction pattern, limit of resolution, diffraction grating, Resolving power of grating.

Polarization of Light

Production of polarized light, double refraction, circular and elliptical polarization, Retardation plates, (quarter and half-wave), analysis of polarized light, Nicol prism.

Optical rotation, optical activity, specific rotation, Polarimeters (Half-Shade, Bi-quartz)

Reference Books

1. Optics : Ajoy Ghatak
2. A text book of optics : N. Subrahmanyam and Brij Lal
3. Waves, Acoustics and Optics : Dr. J.C. Upadhayaya
4. Geometrical and Physical Optics : R.S. Longhurst

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LABORATORY PROGRAMME

Laboratory I: Basic experiments and measurements in optics

This laboratory should expose the students to various phenomena in optics and to various techniques of measurement in optics. Following is a list as a suggestion however, care should be taken in setting up this laboratory such that the experiments are distinct from (and in addition to) the experiments offered to the students in the physics course).

1. Focal length measurement by Nodal & other methods.
2. Measurement of radius of curvature by Spherometer.
3. Measurement of NA of Microscope objective and magnification of Microscope & Telescope.
4. Measurements of Resolution of Telescope/Micrometer.
5. Measurement of optical coating parameters.
6. Interference by double slit.
7. Interference by using Fresnel Biprism.
8. Measurement of Radius of curvature by Newton's ring method.
9. Measurement of wavelength by Michelson interferometer.
10. Angle measurement by Angle Dekkor.
11. Measurement of Refractive Index using Abbe refractometer.
12. Measurement of wavelength by single slit diffraction pattern of wire, hair and screw.
13. Measurement of wavelength of light using circular aperture diffraction pattern.
14. Measurement of field of view and magnification of Telescope.
15. Detection of strain in optical glass using strain viewer.
16. Measurement of birefringence of crystals by polarizing microscope.
17. Experiments on polarization using half and quarter wave plates.

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Course – 3: Optical Workshop Technology

Optical glass and classification, optical glass composition, properties of optical glass (optical, mechanical, thermal, electrical, chemical), silica and high silica glasses.

Optical crystals, optical plastic, filter glasses, optical materials for Infra-red, ultraviolet, fiber, laser and nuclear applications, ceramics.

Optical Processing Materials: Abrasives, synthetic abrasives, (aluminium oxide, carborundum, diamond powder, Emery or powdered putty powder etc.), Adhesives, cleaning agents, polishing materials, (pitch, wax, plastic, cutting fluids), optical cements and its classification.

Optical machines: Sawing, trepanning, curve generating, aspheric generating, polishing, centering, edging, diamond turning, surface coating.

Fabrication: Single lens and prism, optical contact method, miniature optics, jigs and fixtures centering, edging and cementing, moulding.

Fabrication methods: Blanchard method, conic generators, electro-forming processes, replication method, controlled vacuum coating methods, Schmidt correctors, deposition techniques for thin films.

References Books:

1. Optical workshop technology: R. Hradaynath
2. Applied optics and optical Engineering : Rudolf Kingslake (Vol I)
3. Optical Instrumentation Theory and Design : B.N. Begunav, N.P. Zakaznov

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Course – 4 : Opto-mechanical Design and Tutorials

Optical Design:

Raytracing in an optical system given by its cardinal points, raytracing for tilted object planes, raytracing for a prefect system, multielement optical systems, paraxial optics, optical invariant, numerical raytracing with zero rays.

Simple program computation of aberrations using ray trace data, analysis of singlet, doublet and triplet lenses, spot diagrams and their use in analysis.

Opto-Mechanical Design :

Drawing basics notation and nomenclature: Mechanical, optical and opto-electrical system, optical mechanical subassembly and opto-electrical systems, optical mechanical subassembly and final assembly drawing. Design of opto-mechanical mounts and subassemblies, material consideration. Assembly and alignment techniques for opto-mechanical subassemblies and systems, environmental effects, tolerancing.

Lens design of simple objectives and eyepieces (Maksutov reflecting objective, Huygen eyepiece, Ramsden, Kellner. Orthoscopic, negative etc.) Focusing of an eyepiece, Basic Alogrithms for optical engineering.

Reference Books:

1. Optical Instrumentation Theory and Design : B.N. Begunov, N.P. Zakaznov, S.L. Kiryushin, V.I. Kuzichev.
2. Applied optics and optical engineering : George W. Hopkins

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Laboratory II: Engineering Drawing and Mechanical Basic optical workshop

Part – I: Mechanical Workshop:

1. Engineering Drawing
2. Handling of Lathe machine, Drilling machine, Slitting/cutting machine, Milling machine
3. Fitting shop Optical Workshop

Part – II: Optical Workshop

1. Slitting & Cutting
2. Rounding
3. Curve Generation
4. Grinding & Smoothing
5. Block making/Blocking
6. Polisher making

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Course-5: Light Sources and Illumination Engineering

Visual Optics: Optical performance of human eye, visual acuity, accommodation, defects in eye, instrumental myopia, concept of empty magnification.

Photometry light flux, brightness and illumination units and measurements. C.I.E. standard sources of light: incandescent sources, discharge lamps (Mercury, sodium, fluorescent, etc.) and their characteristics, UV and IR sources, light emitting diodes, hazards related with optical sources.

Detectors for visible, IR and UV radiations.

Color, color mixing and measurements, color vision, application on textile and paint industry.

Illuminator engineering: Basic of illumination engineering illumination calculations lighting and coloring of factories, offices, stadium etc.

Reference Books:

1. Geometrical and Physical Optics : R.S. Longhurst
2. A. text book of optics : N. Subrahmanyam and B. Lal
3. Applied Optics and Optical Engineering : Rudolf Kingslake (Vol. I and II)
4. Optics : Francis Weston Sears.

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Course- 6: Basic Optical Instruments

Illumination systems: Purpose and types of illumination systems, searchlight and collimator systems, Catadioptric systems, condenser systems.

Eyepieces:

Huygen's eyepiece, Gauss eyepiece, Ramsden eyepiece, Kellner eyepiece etc. ad their applications.

Microscopes:

Theory and construction of simple microscopes, design parameters (Magnification, resolving power, objective and eyepiece characteristics, working distance, tuble length, numerical aperture etc.) Biot and trio heads, Different types of microscopes Student, dissecting pathological, metallurgical, long working distance, stereo, zoom, phase contrast, interference, polarizing, scanning, optical, ultraviolet and microscopes, concept of electron microscopy.

Refractometers (Abbe, Hilgerchance), Prism and Grating spectrometer and Spectrograph, Monochromators

Telescopes:

Construction and design parameters, Resolving power useful magnification, objective systems and eyepiece, the function of a field lens, Different types of telescopes (Galileans, Newton telescope, Lens erecting telescopes. Stereoscopic telescopes, survey telescope Herschel's telescope, Gregory's telescope, Cassegrain's telescope, Coude's telescope, Reflection telescope: etc.), Sextant, theodolite, binoculars.

Reference Books

1. A text book of optics : N. Subramanayam and Brij Lal
2. Optics and Lasers : Matt Young
3. Applied Instrumentation Theory and Design: B.N. Begunov.
4. Applied optics and optical Engineering : Rudolf Kingslake (Vol. III and Vol IV)
5. Optical Source Book : Sybil P- Parker

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Laboratory- III: Optical Workshop and Mini Project

1. Production of lenses, mirrors & prisms
2. Centering & edging
3. Testing-Physical Dimensions, Surface accuracy, Surface finish, Testing of centering of lenses.
4. Vacuum coating, thin film deposition
5. Mini Project in Optical Workshop

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Course- 7: Projection and Photographic optics

Projection systems

Constriction and working of various projection systems (overhead projectors, shied projectors, profile projectors, episcopes) TV optics (TV systems characteristics, flying – spot scanners, TV cameras, film projectors and TV film cameras, Display devices).

Photographic optics

Definition, Camera (Types, inter changeable lenses and depth of field, films, light and exposure, filters, flash, accessories). Composition (Outdoor, portrait, nature, night photography), Darkroom (accessories) Developer and its constituents, darkroom chemicals. Negatives (Developing the films, defects), Printing and enlarging (Papers, Grades, Weights, Surfaces, Final Points of Enlarging), Toning of prints, Formulas for toners, colour photography, Digital photography

Reference Books

1. A text book of photography : O.P. Sharma
2. Optical Instrumentation, Theory and Design : B.N. Begunov
3. Applied optics and optical Engineering : Rudolf Kingslake (Vol. II , III, IV)

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Course- 8: Opthalmic Optics and Optical Metrology

Spherical Lenses Astigmatic lenses, Transposition of spherical lenses, axis direction of astigmatic lenses axis setting in ophthalmic lenses, prismatic effect of lenses (Decentration prismatic effect of spectacles in near work, bifocal lenses (Requirements, types fused bifocals), Projective glasses, Optical dispensing lens from and thickness, optical aberrations, spectacle lens design, best from lenses in theory and compromise in present practice measurement of power of lenses using dioptemeter neutralisation method, vertometer Contant lens type and how to prescribe ISI-standards on ophthalmic lenses.

Ophthalmic instruments Ophthalmoscopes, retinoscopes autorefractors, Keratometers slit lamp fundus camera loupes etc.

Length, Angel and surface finish measurements, interferometer, Moire technique and Polariscope Indian standards and calibration.

Reference Books:

1. Handbook of Ophthalmology, S.C. Gupta & A.K. Gupta (JPB, Delhi)
2. Principles and practice of Ophthomology, vol (I), Gholon A. Peymen, sander, Goldberg, (Jaypee Brother, P.B. No. 7193, New Delhi)
3. "Engineering Metrology", Er.R.K. Jain, Khanna Publications.

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Laboratory –IV: Ophthalmic Optics and Photographic Processing

Paper – I: Ophthalmic optics

Ophthalmic workshop : Checking of lenses, optical centring & center marking cutting, edging, glazing & fitting lenses in spectacles drilling in lenses, testing of strain in fitted lenses, measurement of optical centers of fitted lenses in spectacle of + 1 Diopter & + 10 Diopter, fabrication of ophthalmic lenses spherical (low power, high power + 10) toric and bifocal, measurement of parameters of contact lens (power & back radius).

Measurement of curvature of Dummy Eye with Karatometer

Paper — II Photographic processing :

In this laboratory the students should be given practice to process black and white and colour films. They should get a practice for enlargement of photographs and also for taking photographs. Help should be taken from an experienced technical person from an local photographic processing unit/shop.

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Course – 9: Lasers & Advanced Instruments

Lasers : Basic theory (Active medium, pumping, optical resonators), types of pumping, type of lasers and their characteristics mode locking and Q-switching He-Ne, Ruby Nd-YAG carbon dioxide, argon ion, semiconductor etc. lasers application science and industry, laser safety.

Holography: Basic principles recording and reconstruction of different type of holograms, application of holograph in display and non-destructive testing (NDT) Holographic optical elements.

Advanced instruments (Including laser based instruments), laser alignment system laser centering devices bar scanners, laser printer, Rangefinders gung sight night vision equipment, image tubes.

Reference Books:

1. Lasers and Non-linear optics by B.B. Laud, Wiley Eastern Limited, New Delhi, India
2. Optics and Laser by Matt Young, Springer Verlag. New york
3. Laser and Masers by Charles A. Pike, W.Foulshan & co. Ltd, England.
4. LASERS- Principles, Types and Applications by K.R. Nambiar, New age International Publishers, New Delhi.

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Course -10: Fiber Optics and Optoelectronic Instrumentation

Fiber Optics: Basic concept characteristics of various types of fibers, Acceptance angle and cone, numerical aperture, dispersion, V number etc.

Application and Instrumentation: applications in telecommunication and medicine, fiber based sensor, fiber optics components, connectors and splices, OTDR.

Optoelectronic Instrumentation: Basics of electronics, specification and identification of components basic circuits for LEDs laser diodes and photo detectors LCDs, photomilitpliers tubes etc.

Reference Books:

1. Understanding Fiber Optics by Jeff Hecht, Prentice Hall, New Jersey.
2. Fiber Optic by Gred Keiser, Prentice Hall, New Jersey.
3. Optical Fiber & Laser by Anuradha, New Age publisher, New Delhi.
4. Optical Electronics by A..K. Ghatak & Thyagarajan, Foundation Books, New Delhi.
5. Applied Optics and Optical Engineering (Series) Eds. R. Kingelake, Eds. J.C. Wyant & R. Bhannon.
6. Introduction to Applied Optics for Engineer (Academic 1977) K.A. Jones,

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Laboratory –V: Advance Optical Instruments Laboratory

Part — I:

This laboratory would consists of some advance techniques in optical testing and measurements. The following is the list of some of these instruments/experiments as a suggestion.

Twyman green interferometer, lateral shearing interferometer, radial shearing interferometer, point diffraction interferometer, knife edge test, ronchi test, Schlieren test Hartmann screen test, parallelism flatness testing by using autocollimeter, Fizeau interferometer, spectrometers/ spectrographs same of the military/survey instruments covered in the courses.

Part—II:

This laboratory would consist of experiments with lasers some of which are include blow as a suggestion.

Nature of the laser beams, profile, spot, size and beam divergence. different type of laser speckles (objective and subjective), recording and reconstruction of holograms, experiments on spatial filtering, identification of fibers using diffraction measurement of N.A. of a optical fiber, coupling of fibers to different types of sources multiple slit diffraction, annular aperture diffraction, measurement of illuminance, luminance, etc.

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COURSE-11: Major Project

This laboratory would consist of an extended experience with an instruments (military, survey, medical or any other advance instruments such as interferometer, monochromators, spectrometer/spectrograph). The student should be able to appear assemble the instruments and be familiar with its uses. At the end of the project the student should write a report on the works carried out in the laboratory. In some cases the project may also consist of actual fabrication of some simple instrument. The nature of the project offered would depends on the resources available at a given location. Assistance should also be taken, wherever possible from the local optical user industry to set tip the project.

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Course -12: Quality Control, Production –Planning Prospects and Entrepreneurship

National standards for optical components, system and instruments, tolerances and specification in optics importance of quality assurance and stage inspection in production, workshop flowcharting and concepts in production planning layout of optical workshops, safety measures, exposure to national optics industry and R&D organizations.

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