L V Prasad Eye Institute

భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

MTech in Ophthalmic Engineering

A blended Masters' degree program through
the combined expertise of L V Prasad Eye Institute
(in ophthalmic care) and
the Indian Institute of Technology - Hyderabad
(in engineering and technology)

PREAMBLE

The World Health Organization identifies blindness and vision impairment as one of the major determinants of poor quality of life and financial productivity of individuals. According to LANCET, Vision loss causes $410.7 billion in lost productivity annually. While this problem is global in nature, its effects are compounded in mid-to low-resource countries like India. Of the total magnitude of blindness and vision impairment, up to 85% of them are due to avoidable causes like uncorrected refractive errors and cataracts. The vast majority of the remaining can be addressed through appropriate medical and technological interventions. It has been well-recognized that such a global problem can be best addressed through a team of professionals that tackle multiple dimensions of the problem. On the medical side, the team will comprise ophthalmologists, optometrists, ophthalmic technicians, and nurses that will offer optical, rehabilitative, therapeutic, and surgical care to patients. On the technology side, the team should comprise equipment-maintenance technicians and biomedical engineers who will develop novel technology to bridge critical gaps in the medical system. While robust models for eye care delivery have been developed on the medical side of things (e.g., the pyramidal model of eye care by LVPEI), significant gaps still exist in meeting the technology side of the problem. The proposed Master's degree level collaborative training program between LVPEI and IITH is an attempt to successfully bridge this gap.

HOW WILL THIS COLLABORATIVE PROGRAM BRIDGE THE GAP?

As such, in a country like India, there is no dearth of engineers who get trained from qualified programs across the country. Several of them also take up technology innovation as part of their professional career. The gap however lies in the siloed work culture of engineers and health care professional and their limited understanding of each other's capabilities and problems that needs a solution. For instance, a health care professional may be largely unaware of the technology surrounding them that may help solve a medical problem they are currently facing. The engineer, on the other hand, might have the technology know-how to solve this problem but is unaware of the specific nature of the problem that needs to be solved. It is our belief that the aforementioned gap in medicine, in general, and ophthalmic care, in specific, will be effectively solved if these siloes are broken and health care professionals and engineers are empowered in knowledge and skill about each other's field. This may be achieved through a training program that blends essential elements of medical care (ophthalmic care, in this instance) and engineering (optics, biomechanics, and controls engineering, in this instance).

The proposal below is a broad outline for such a blended training program that can be offered to students at a Masters's degree level through the collective expertise of LVPEI in ophthalmic care and IITH in engineering and technology.

Program Objectives

- Prepare professionals with a solid base in engineering and clinical exposure focussed on ophthalmology.
- Provide professionals for technology organizations working in ophthalmology & related fields.
- Inspire cross-functional (engineering & ophthalmology) teams to advance technology-related research in ophthalmology.
- Enable engineers & clinicians to get deeply involved in designing better technology products/services
- Create professionals who can take up technology challenges in ophthalmology as a startup

Expected Graduate Attributes

- Ability to reach the unreached in a clinically valid manner
- Lead in devising precision eye care using engineering technology
- Ability to understand, assimilate & apply every technology in Eyes are.
- Be a bridge between the medical & engineering professionals especially in ophthalmic field
- Ability to refine/ simplify the technology to improve the result or reduce the cost substantially

Learning Outcomes

- Thorough with fundamentals of electrical/electronics/optical/design/software engineering and all sub-divisions of ophthalmology and its technologies
- Have a project completed using one or more of the technologies used in Opthalmology
- Well trained in 3-4 (sensors/control systems/ AI-ML/ optoelectronics) advanced technologies (as per their electives)
- Thorough with clinical research / validation methodologies specifically related to technology
- Well prepared to manage medical technology business / startups

Who can join the program?

- BTech in any Engineering stream
- MBBS or MD/MS in Ophthalmology
- Four-year BS or MS in Optometry
- M.Sc in Physics/Applied Physics

Career post completion of this program:

- Higher education (Ph.D.) in vision science or engineering/technology research
- Employment in Eye Hospital & Research Institutes like LVPEI etc.,
- Employment in multinationals that specialize in R & D of ophthalmic equipment
- Employment in industrial-grade camera manufacturing companies
- Employment in national-level companies that design ophthalmic equipment
- Multinationals that work on digital health

Proposed curriculum:

Given the blended nature of this program, both LVPEI and IITH will be actively involved in the training of these students. There will be a Bridging course to help students from different streams. In general, the program will contain 4 semesters of training, with 2 semesters worth of coursework and 2 semesters worth of research projects. In the coursework, training related to ophthalmic care and vision science will be taught by LVPEI and those related to engineering and technology will be taught by IITH.

Course Structure

Institute	Dept.	Title	Instructor	Type	Credit
Semester I					
LVPEI /IITH	AECE/ IITH	Introduction to Ophthalmology and Optometry /Introduction to Engineering principles	AECE/PHY	Bridging Core	1
LVPEI + IITH	AECE/ IITH	The Cornea & Crystalline lens	AECE	Core	3
LVPEI + IITH	AECE/ IITH	Applied Optics (Theory + Lab)	SSR,VS,BR, NK	Core	2
IITH	PHY	Intraocular pressure control	AECE	Core	2
IITH	BM	Multidisciplinary Ophthalmic Imaging	RJ	Core	2
IITH	LA	Communications	Mandatory	Mandatory	1
IITH	IITH	Electives - I	Electives	Electives	3
Total Credits					**14**
Semester II					
LVPEI +IITH	AECE	Eye and Brain Part 1: Retina and Pupils	AECE	Core	3
LVPEI + IITH	AECE	Eye and Brain Part 2: Visual perception and Oculomotor control	AECE	Core	2
IITH +LVPEI	IITH	Innovation & Technology in Ophthalmic Engineering	RJ	Core	1
IITH +LVPEI	ALL	Industrial lecture (Research Methodology and Journal Reading)	Mandatory	Mandatory	1
IITH	IITH	Electives – 2	Electives	Electives	7
Total Credits					**14**
Semester III					
IITH +LVPEI	ALL	Major Project Phase – I	Mandatory	Mandatory	12
		Total Credits			12
		Semester IV			
IITH +LVPEI	ALL	Major Project Phase – II	Mandatory	Mandatory	12
Semester IV					
IITH +LVPEI	ALL	Major Project Phase – II	Mandatory	Mandatory	12
Total Credits					**14**

Course Credits Break-up

Semester	Type	Credits	Total Credits
I	Core (Theory + Lab)	11	14
	Electives	3	
II	Core (Theory + Lab)	7	14
	Electives	7	
III	Major Project Phase – I	12	12
IV	Major Project Phase – II	12	14
Total Course Credit			**52**

Course curriculum from LVPEI

S No	Instructor	Course title	Type	Credits	Course lead
Semester I					
1.1	**AECE**	**Introduction to Ophthalmology and Optometry** • Anatomy and physiology of ocular structures and visual pathways • Optics and image formation in the retina • Scene re-creation in the visual cortex • Pressure control mechanism of the eye • Ocular blood supply • Nervous control of the eye • Oculomotor control • Common pathologies of the eye and visual system • The challenge of eye care globally and in India	**Bridging Course**	**1**	**LVPEI**
1.2	**PHY**	**Introduction to Engineering principles (Bridging Course)** • Mathematical methods for Engineers • Basics of Computations/ Programming • Data Analysis/Statistics/ Visualization • Engineering Physics and applications • Other Engineering Department specific modules	**Bridging Course**	**1**	**IITH**

2.0	**AECE**	**The Cornea and Crystalline lens** • ***Clinical component*** ○ Applied anatomy and physiology and clinical assessment ○ Common corneal diseases – pathophysiology, optical, pharmaceutical and surgical management ○ Eye banking ○ Presbyopia and Cataract – pathophysiology and optical and surgical management • ***Vision Science component*** ○ Optics properties related to image formation ○ Tissue biomechanics • ***Instrumentation component*** ○ Instrumentation to evaluate health, biometry and biomechanics of cornea and crystalline lens ○ Instrumentation for surgical management of corneal and keratorefractive surgery and cataract ○ Optical design of intraocular lenses and contact lenses for presbyopia and cataract correction	**Core**	**3**	**LVPEI**
3.0	**PHY (Optics Group)**	**Applied Optics** • Adaptive Optics • Lens Design and Technology (Design & Lab) • Laser experiments, Interferometer • Fiber Optics and Experiments	**Core (Theory & Lab)**	**2**	**IITH**
4.0	**RJ**	**Multidisciplinary Ophthalmic Imaging** • Optical Coherence Tomography (OCT) • Microscopy Techniques - Confocal, Two photon microscopy, Electron Microscopy etc., • Magnetic Resonance Imaging • Ultrasound Techniques	**Core**	**2**	**IITH**

5.0	**AECE**	**Intraocular pressure control** • ***Clinical component*** ○ Applied anatomy and physiology of the aqueous humor drainage and clinical assessment ○ Common forms of glaucoma and its management • ***Vision Science component*** ○ Impact of intraocular pressure on retinal health ○ Principles underlying the assessment of retinal sensitivity • ***Instrumentation component*** ○ Instrumentation to evaluate health of the aqueous drainage channel, optic nerve head and retinal nerve fiber	**Core**	**2**	**LVPEI**

Semester 2					
S No	**Instructor**	**Course title**	**Type**	**Credits**	**Course lead**
1.0	**AECE**	**Eye and Brain Part 1: The Retina and Pupils** • ***Clinical component*** ○ Applied anatomy, physiology, blood supply, neural control and clinical assessment ○ Common pathologies and their management ○ Instrumentation for surgical management of retinal pathology • ***Vision Science component*** ○ Image formation in the retina ○ Conversion of light to electrical signals in the retina ○ Light and optical regulation of the pupils • ***Instrumentation component*** ○ Instrumentation to evaluate health of the retina ○ Instrumentation for electrophysiological assessment of retina ○ Instrumentation for surgical management of retinal pathology ○ Instrumentation for objective assessment of pupillary health	**Core**	**3**	**LVPEI + IITH**

2.0	**AECE**	**Eye and Brain Part 2: Visual perception and oculomotor controls** • Four fundamental aspects of visual perception: Spatial, Color, Binocular and Motion visual perception • Psychophysical assessment techniques for low-level visual perception • Impact of common eye diseases on visual perception • Neural control of eye movements • Controls engineering models for eye movement control • Eye movement measurement techniques and instrumentation • Applied anatomy and physiology of extraocular muscles and clinical assessment • Common forms of strabismus and non-strabismic binocular vision disorders and their optical and surgical management	**Core**	**3**	**LVPEI + IITH**
3.0	**LA**	**Innovation, Technology & Entrepreneurship (Core)** • Innovations in corneal optics and biomechanics assessments • Innovations in intraocular pressure assessment • Innovations in retinal imaging & pupillary assessment • Innovations in refractive error assessment • Innovations in visual fields assessment • Innovations in assessment of patients with special needs	**Core**	**1**	**IITH**

LVPEI -Electives				
S No	**Instructor**	**Course title**	**Credits**	**Department**
1.0	**AECE**	**Eye and Brain Part 5: Visual cognition** • Anatomy and physiology of Area V2, V3 and higher-level cortex • Dorsal and ventral streams of processing • High-level perception of complex scenes (faces, etc) • Introduction to measurement of cortical activity (single-unit recordings, fMRI, etc) • Common dysfunctions associated with visual cognition (prosopagnosia, Charles-Bonnet syndrome, etc)	**2**	**AECE**
2.0	**AECE**	**Orbit and ocular plastics** • ***Clinical component*** ○ Applied anatomy and physiology of the orbit, lacrimal drainage channel and tear film and their clinical assessment ○ Common diseases of the orbit, lacrimal drainage channel and eye cancer ○ Ocular and orbital prosthesis for cosmetic repair of the eye and orbit • ***Instrumentation component*** ○ Instrumentation for the assessment of the orbit and lacrimal drainage ○ Fundamental techniques in ocular prosthesis	**2**	**AECE**

IITH-Electives				
S No	**Instructor**	**Course title**	**Credits**	**Department**
1.0	**BR/VS**	**Lasers in Ophthalmic Engineering** • Fundamentals of Lasers • Types of Lasers • Lasers for Ophthalmic Surgery • Lasers in ophthalmic measurement instrumentation	**2**	**PHY**
2.0	**NK/SSK**	**Optoelectronics** • Fundamentals of Optoelectronics • Optical fiber and Optoelectronic Technology for Ophthalmic practices • Imaging Detectors and sensors • Laser diodes, LEDs, Photodetectors	**2**	**PHY**
3.0	**NK/VC**	**Computational and Numerical Method** • Introduction to Programming (MATLAB/ PYTHON) • Advanced Computational Techniques • Finite Element Method • Simulink Modelling and other Toolboxes related to Ophthalmology	**2**	**PHY+MAE**
4.0	**VC/RM**	**Stress Analysis & Biomechanics** • Kinematics: Deformation and Strain • Constitutive Behaviour • Stress-Strain relationship • Visco-elastic behaviour of eye structures • Non-commutativity of eye rotations	**2**	**MAE**
5.0	**NK**	**Image and Signal Processing** • Sampling Techniques • Fourier Analysis, Convolution, Transform Techniques • Wavelet Analysis, Filters, patterns • Applications of image and signal processing in vision - optical and neural filtering of retinal image • Eye as a Fourier analyzer	**2**	**PHY+EE**
6.0	**FP**	**Biofabrication** • Basics and mechanisms of 3D bioprinting • 3D tissue/organ printing • Development of biomaterial formulation (bioinks) • Modulating properties of biomaterials • State-of-the-art examples of translation of biofabricated products from the bench towards the bedside	**2**	**BM**

	JG	**Biomaterials for Ophthalmic Applications** • Introduction of different generations of biomaterials • Different class of materials used for Eye Care • Understanding the general properties of different classes of materials to be used as biomaterials Familiarity with biological response to biomaterials, biocompatibility and hemocompatibility	**2**	**BM**
7.0	**FP+SNR**	**Tissue Engineering** • Fundamentals and current status • Stem cells: embryonic and mesenchymal stem cells; cell differentiation; • Extracellular matrix components and their regulation of cell behavior; • In vitro and in vivo testing of biomaterials. • Bioreactor; Cell migration; Growth factors; • Different approaches for angiogenesis and its importance.	**2**	**BM**
8.0	**AKR + JG**	**Nanomedicine** • Nanoscience and nanotechnology and its application in biology and medicine. • Fundamentals of nanoscience and Nano-scale engineering, and their potential application in the human health care system.	**2**	**BM**
9.0	**NK**	**Fluid Mechanics** • Fundamentals of Fluid Dynamics • Modelling blood flow through retinal capillaries • Modelling aqueous humour dynamics to control intraocular pressure • Modelling tear film dynamics	**2**	**PHY+MAE**
10.0	**NG**	**AI & ML Ocular specific** • AI for Ophthalmic practices • Neural Network and Deep learning • Optimization Techniques • Disease Forecasting/prediction	**1**	**PHY+BM**
11.0	**DE**	**Entrepreneurship/ IP + Patent Filing** • Intellectual right/Copyright • Patent Filing - Patent application, Procedure, Legal requirements etc.,	**1**	**DE**
12.0	**All**	**Industrial Lecture** • Webinars/Workshops/Lectures • Industry/Clinical Lab visits • Research Methodology + Journal Club readings	**1**	**All**

Project work:

Collaborative project between LVPEI and IITH 2nd year leading to an independent Masters's level thesis. All projects will also be encouraged to be published in international peer-review journals or in the proceedings of reputed conferences.

Partnering Departments from IITH :

- Three departments would play a major role
  - Department of Physics
  - Biomedical Engineering
  - Mechanical Engineering
  - Department of Design
  - Department of Entrepreneurship and Management
  - Department of Liberal Arts

IITH Faculty Members agreed to involve in the Program

S.No.	Initial	Name	Department
1	BR	Dr. Bhuvanesh Ramakrishna	PHY
2	VS	Dr.Vandana Sharma	
3	SSK	Dr. Sai Santhosh Kumar Raavi	
4	NK	Dr. Nithyanandan Kanagaraj	
5	RJ	Prof.Renu John	BM
6	FP	Dr.Falguni Pati	
7	AKR	Dr.Arvind Kumar Rengan	
8	JG	Dr. Jyotsnendu Giri	
9	NG	Dr. Nagaraj Ganapathy	
10	RM	Prof. Ramji Manoharan	MAE
11	RM	Dr. Viswanath Cinthapenta	

LVPEI Teaching Faculty Members associated with the Program

S.No.	Initial	Name	Department
1	SB	Shrikant Bharadwaj	AECE
2	RT	Rathinam Thyagarajan	
3	PS	Prem Nandhini Satgunam	
4	PV	Pavan Verkicharla	
5	CR	Charanya Ramachandran	
6	HC	Harsha Chintoju	
7	VJ	Vineet Joshi	
8	PR	Pravin Krishna	

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