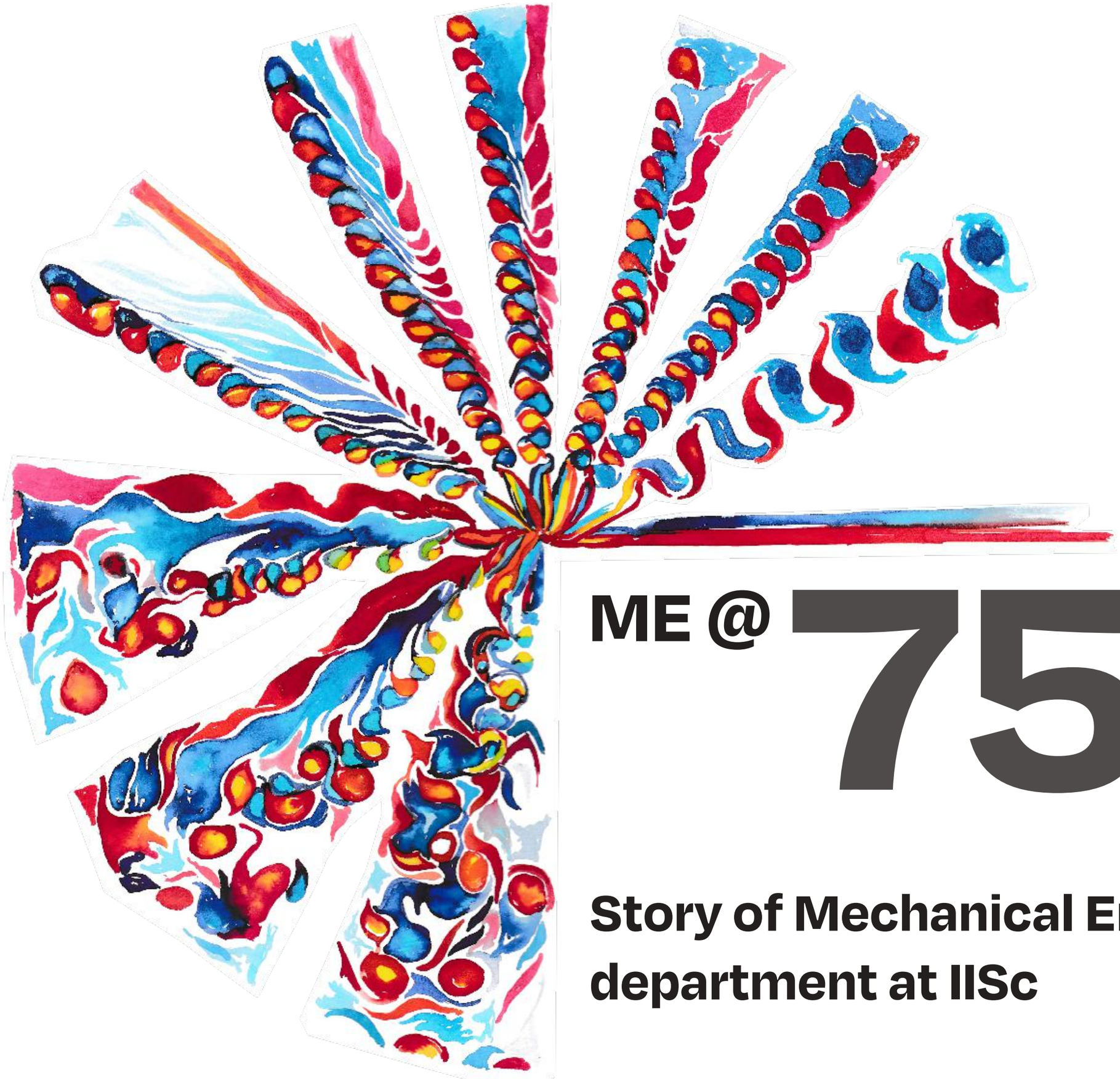

ME @ 75

Story of Mechanical Engineering department at IISc

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ME @ 75

Story of Mechanical Engineering Department at IISc

Design and Illustrations by Megha Ramachandra

Preface

The story of the Mechanical Engineering department at IISc begins perhaps with the words of Sir M Visveswaraya when he said, "the war that is going on [World War II] is a mechanical engineer's war," and urged the Institute to start working in applied areas in addition to fundamental ones. Mechanical Engineering activities subsequently commenced in 1945 in the Internal Combustion Engineering (ICE) department. This book brings out the story of the Mechanical Engineering department from that period until today, with bifurcations and mergers in between, with the final emergence of a single Department of Mechanical Engineering, now referred to as ME, in 1972.

On the 75th anniversary of the department, this book, ME@75, brings out the story of the department, a snapshot of the present research activities, the people of the department, and pictures and memories that bring to life, the "Life at ME". The vision for such a book that captures the history of the department on our 75th anniversary was clearly felt, and activities in this direction were initiated by our former Chair and present Dean of Mechanical Sciences, Prof Ananthasuresh. He and the heritage committee that he set-up, worked through a very difficult COVID-19 period collecting information from the Institute archives and past students and faculty.

I must add here a very deep thanks to the Office of Communications (OoC) for their help in getting the material together for this book, and in particular, Deepika S., who has been a constant and invaluable help in obtaining information from the Institute archives. Over the past few months my colleague, Prof Namrata Gundiah, who brought in a huge amount of energy and with the help of a team of students, postdocs, staff, colleagues, writers, designers, and an artist, put together this book with stories, facts, and pictures. I am immensely grateful to her for readily accepting this enormous task and for taking huge interest in getting this book completed and ready in time for the inauguration of the "ME@75: Research frontiers" conference on 29 June 2022, where this book will be released by the past and present faculty of the department.

I will end by stating that seeing this book develop and getting acquainted with all the historical information from the archives and former colleagues and staff, has personally been an exhilarating experience. Just a couple of days back, as we were having a final look at the book, Prof Mruthyunjaya, who helped proofread and give his feedback, mentioned that the day that Dr Rajendra Prasad, the first President of India, inaugurated the Power Engineering building in 1951, he was a school student standing on the road outside waving as Dr Rajendra Prasad went by. This is not a story that is in the book, but one that adds to the stories of the department within this book.

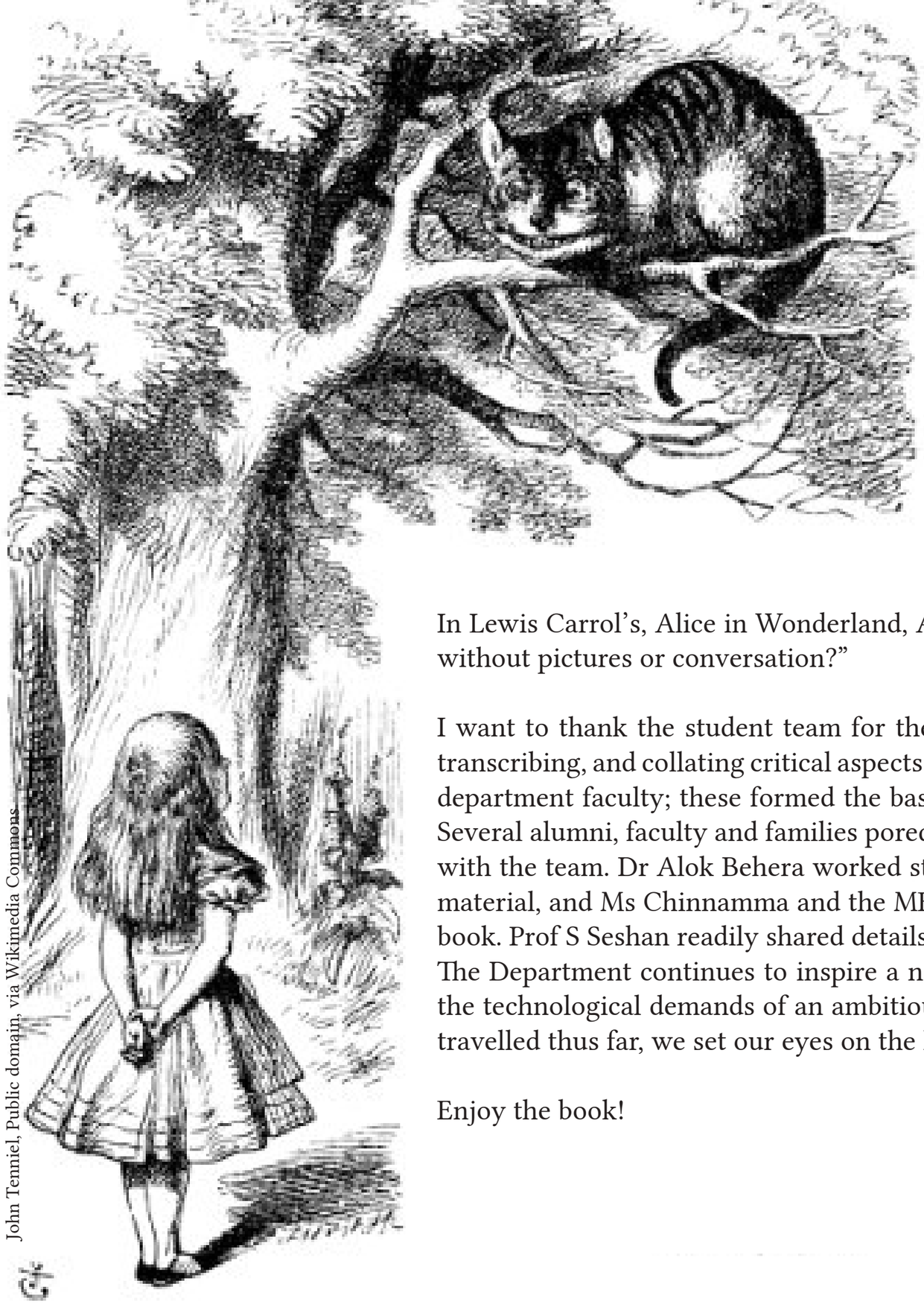
Raghuraman N Govardhan
Professor and Chair
Department of Mechanical Engineering
27 June, 2022

Foreword

It is my privilege and delight to present this book in celebration of the 75th year of the Department of Mechanical Engineering at the Indian Institute of Science. We started out as the Department of Internal Combustion Engine (ICE) in pre-independence India. To support the aspirations of a growing and industrializing nation, the department initially emphasized on Electrical and Mechanical Sciences within the Power Engineering department. Merger of the Department of ICE with Mechanical Sciences resulted in the Department of Mechanical Engineering as we know it today. In the words of the well-known historian, Will Durant, "The present is the past rolled up for action, and the past is the present unrolled for understanding".

This book was put together in an attempt to outline the genesis and history of the department and its growth along with independent India. The efforts of many enthusiastic volunteers made this enormous task possible. Thanks to Prof Raghuraman Govardhan, Chair, Mechanical Engineering department, for entrusting me with this activity. Ms Deepika S from the Office of Communications (OoC), equipped with deep archival knowledge of the department, greatly helped locate information, link people and several disparate snippets from our research into a cohesive description. Deepika, with her colleagues from OoC, also shared many documents from the ICE years which were a treat to read.

I am deeply grateful to the artist, Ms Aarti Gurjar, who brought to life the book cover which is inspired from vortex shedding patterns arranged to span three quarter of a circle. Ms Megha Ramachandra, an energetic and creative designer, spun magic with her illustrations and book design. Ms Pavitra Srivatsan, with timely help from Mr Joel P Joseph, understood the academic demands, and weaved diverse aspects into an enjoyable narrative. Mr Mithun Nair, Assistant Registrar (HR), gleaned details of the department faculty over the years. I will cherish the enthusiastic support and diligent eye-for-detail which Prof Yogendra Simha brought into this book. Thanks also to Prof Jaywant Arakeri who discussed the material at great depth, including the placement of colons and semi-colons, where appropriate. Departmental colleagues, Drs Balachandra Suri, Susmita Dash, Himabindu, Jishnu Keshavan, contributed help at a moment's notice.



John Tenniel, Public domain, via Wikimedia Commons

In Lewis Carrol's, Alice in Wonderland, Alice thinks, "And what is the use of a book without pictures or conversation?"

I want to thank the student team for their energetic contributions in interviewing, transcribing, and collating critical aspects from several conversations with alumni and department faculty; these formed the basis for much of the storytelling in the book. Several alumni, faculty and families pored through old photographs and shared these with the team. Dr Alok Behera worked steadily in the background to crosscheck the material, and Ms Chinnamma and the ME office collated several photographs for the book. Prof S Seshan readily shared details and helped link people and historical facts. The Department continues to inspire a new generation of engineers as they address the technological demands of an ambitious nation. Even as we look back at the road travelled thus far, we set our eyes on the horizon ahead that shows great promise.

Enjoy the book!

Namrata Gundiah
Professor
Department of Mechanical Engineering

Contents

The Council at their meeting held on 30th March, 1942 appointed a Committee consisting of:

Sir Vithal N. Chandavarkar, Kt., M.A., Bar-at-Law, M.L.A. Mr. M Venkatanaranappa, B.A., and The Director to prepare plans and estimates and suggest ways and means for raising funds for implementing the following two resolutions passed by the Court at their meeting held on 28th March 1942:—
"That in view of the fact that it is almost impossible to import from abroad ready-made industrial plants for various manufacturing processes which are now being developed in India, it is desirable that a first-class research workshop of Mechanical Engineering should be established in the Indian Institute of Science, Bangalore, with a suitable staff, attached to it, of Fuel Engineers, Chemical Engineers, Mechanical Engineers and Metallography experts, who, by close co-operation and intimate team work, would be able to solve the problems of design and construction necessary for the erection of such plants."[3]

1 | Our Story
Mechanical Engineering at IISc

The Mechanical Engineering (ME) department at the Indian Institute of Science (IISc) began as a response to India's industrial requirements in the 20th century. This response sought to equip people with the knowledge of working processes and machinery, help nurture and develop their technological skills, and become independent from importing industrial plants required for various manufacturing processes. Even as the young nation navigated the turbulent changes brought about by World War II, seeds of academic discontent brewed steadily inside the very walls of the Institute.

In this spirit of change, Sir M Visvesvaraya, the President of IISc's Court from 1938 to 1946, drew attention to the Irvine Committee's report (1936)[1]. The report highlighted the Institute's preference for fundamental research and neglect of applied research. Calling the Institute to recalibrate its academic focus, Sir Visvesvaraya exhorted, "The war that is going on is a mechanical engineer's war."[2]

Five years later, in 1945, the Department of Internal Combustion Engineering (ICE) was established.

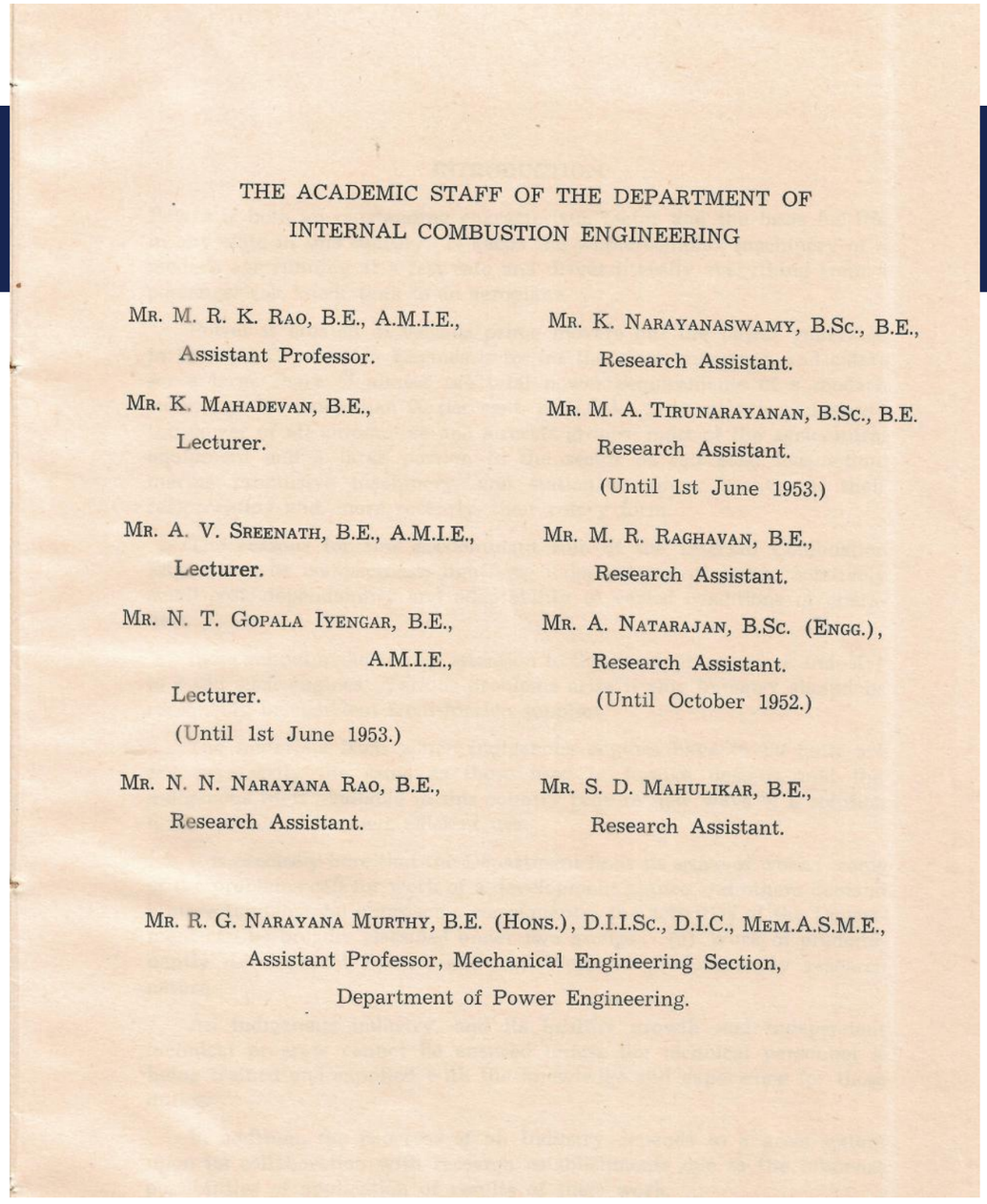
[1] *From the address at the Inauguration Ceremony of the new Department of Metallurgy, Page 1-2.*
[2] *From the 75 years of the Department of Mechanical Engineering, published by the Office of Communications.*
[3] *From the IISc Council minutes of the meeting, 1942.*

1.1 | Early years

The Annual Report (1944-45) records two developments, which played significant roles in the establishment of the ICE Department.

First, Sir Jnan Chandra Ghosh's visit to England as a member of the Indian Scientific Mission. Sir Ghosh, the then Director of IISc, discussed with experts the need for new areas of research at the Institute. Based on their recommendations, he appointed Major BC Carter to teach "the working of Internal Combustion Engines"[4] to the students at the Department of Aeronautical Engineering.

Second, the Institute decided to start postgraduate programmes in Heavy Engineering, Power Engineering (PE), Designing of Machinery, and Chemical Engineering, "in view of the post-war plans for the proper development of the resources of the country."[5] The newly established ICE department was housed in a large building, presently occupied by the Society for Innovation and Development (SID). Major Carter headed this department and the Central Workshop. The workshop, presently a part of the Centre for Product Design and Manufacturing (CPDM), also ran a liquid air-plant and maintained cold



THE ACADEMIC STAFF OF THE DEPARTMENT OF
INTERNAL COMBUSTION ENGINEERING

MR. M. R. K. RAO, B.E., A.M.I.E.,
Assistant Professor.

MR. K. MAHADEVAN, B.E.,
Lecturer.

MR. A. V. SREENATH, B.E., A.M.I.E.,
Lecturer.

MR. N. T. GOPALA IYENGAR, B.E., A.M.I.E.,
Lecturer.
(Until 1st June 1953.)

MR. N. N. NARAYANA RAO, B.E.,
Research Assistant.

MR. K. NARAYANASWAMY, B.Sc., B.E.,
Research Assistant.

MR. M. A. TIRUNARAYANAN, B.Sc., B.E.
Research Assistant.
(Until 1st June 1953.)

MR. M. R. RAGHAVAN, B.E.,
Research Assistant.

MR. A. NATARAJAN, B.Sc. (ENGG.),
Research Assistant.
(Until October 1952.)

MR. S. D. MAHULIKAR, B.E.,
Research Assistant.

MR. R. G. NARAYANA MURTHY, B.E. (HONS.), D.I.I.Sc., D.I.C., MEM.A.S.M.E.,
Assistant Professor, Mechanical Engineering Section,
Department of Power Engineering.

Faculty list: *The names of the academic staff of the ICE and PE departments in July, 1953*[6]

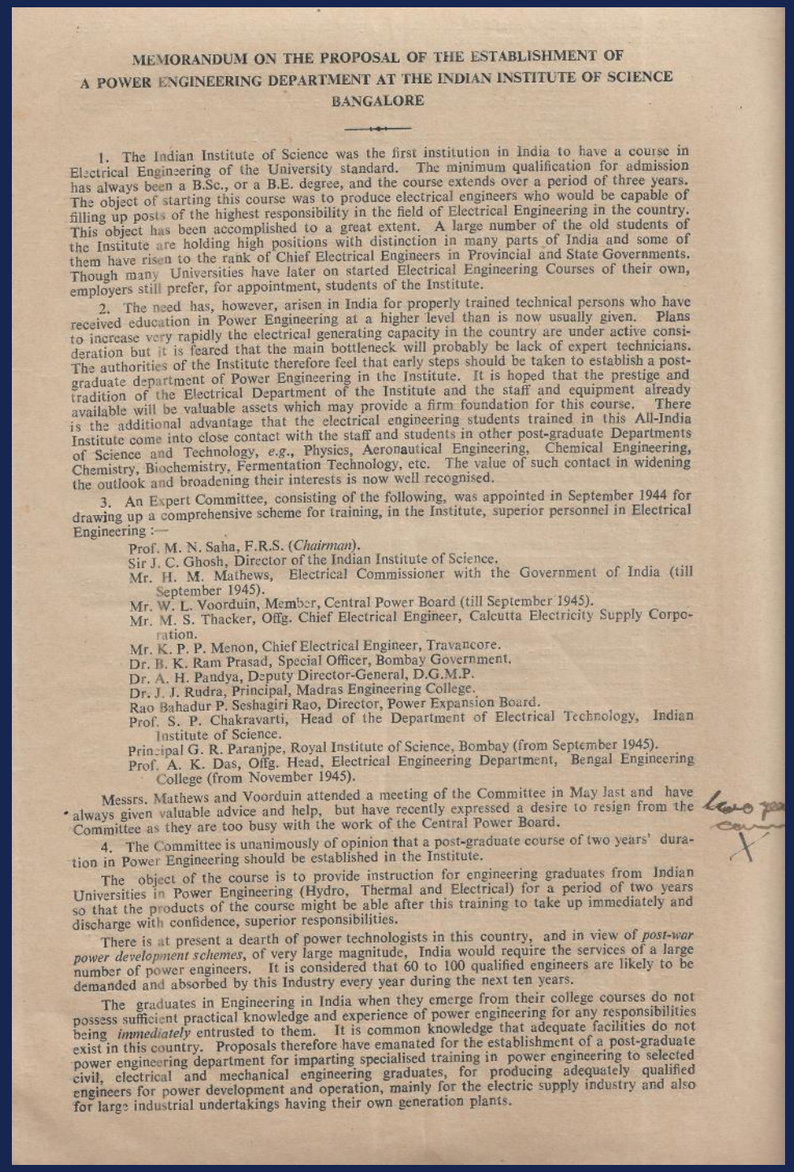
[4] *From the 75 years of the Department of Mechanical Engineering, published by the Office of Communications, IISc.*
[5] *From the Annual Reports 1944-45.*
[6] *From the brochure issued on the occasion of the official opening of the ICE department.*

A new home: *The newly constructed ICE building*

Following Major Carter, Prof Hans A Havemann headed the department from 1949 to 1957. Prof Havemann was also subsequently involved in establishing the Indian Institute of Technology (IIT) Madras, when he was listed as a "German expert with valuable India experience and a potential recruit for 'the German IIT'" to be established by the West German Rucker mission in 1956.[7]

[7] *From 'The Establishment of IIT Madras, German Cold War Development Assistance and Engineering Education in India' by Roland Wittje.*

The ICE formed just one part of what would later become the Department of Mechanical Engineering. The second part was the soon-to-be established PE department, tasked with supporting the electrical power projects that had mushroomed across the country after World War II. The foundation stone for the PE building was laid in 1947 by former Cabinet Minister Syama Prasad Mukherjee, and the building was inaugurated by Dr Rajendra Prasad, the then President of India, in 1951. Prof MS Thacker, who later became the Institute's Director and subsequently the Director-General of the Council of Scientific and Industrial Research (CSIR) in 1955, was appointed as the first head of this newly created department.



MEMORANDUM ON THE PROPOSAL OF THE ESTABLISHMENT OF A POWER ENGINEERING DEPARTMENT AT THE INDIAN INSTITUTE OF SCIENCE BANGALORE

1. The Indian Institute of Science was the first institution in India to have a course in Electrical Engineering of the University standard. The minimum qualification for admission has always been a B.Sc., or a B.E. degree, and the course extends over a period of three years. The object of starting this course was to produce electrical engineers who would be capable of filling up posts of the highest responsibility in the field of Electrical Engineering in the country. This object has been accomplished to a great extent. A large number of the old students of the Institute are holding high positions with distinction in many parts of India and some of them have risen to the rank of Chief Electrical Engineers in Provincial and State Governments. Though many Universities have later on started Electrical Engineering Courses of their own, employers still prefer, for appointment, students of the Institute.

2. The need has, however, arisen in India for properly trained technical persons who have received education in Power Engineering at a higher level than is now usually given. Plans to increase very rapidly the electrical generating capacity in the country are under active consideration but it is feared that the main bottleneck will probably be lack of expert technicians. The authorities of the Institute therefore feel that early steps should be taken to establish a post-graduate department of Power Engineering in the Institute. It is hoped that the prestige and tradition of the Electrical Department of the Institute and the staff and equipment already available will be valuable assets which may provide a firm foundation for this course. There is the additional advantage that the electrical engineering students trained in this All-India Institute come into close contact with the staff and students in other post-graduate Departments of Science and Technology, *e.g.*, Physics, Aeronautical Engineering, Chemical Engineering, Chemistry, Biochemistry, Fermentation Technology, etc. The value of such contact in widening the outlook and broadening their interests is now well recognised.

3. An Expert Committee, consisting of the following, was appointed in September 1944 for drawing up a comprehensive scheme for training, in the Institute, superior personnel in Electrical Engineering :—

Prof. M. N. Saha, F.R.S. (*Chairman*).
Sir J. C. Ghosh, Director of the Indian Institute of Science.
Mr. H. M. Mathews, Electrical Commissioner with the Government of India (till September 1945).
Mr. W. L. Voorduin, Member, Central Power Board (till September 1945).
Mr. M. S. Thacker, Offg. Chief Electrical Engineer, Calcutta Electricity Supply Corporation.
Mr. K. P. P. Menon, Chief Electrical Engineer, Travancore.
Dr. B. K. Ram Prasad, Special Officer, Bombay Government.
Dr. A. H. Pandya, Deputy Director-General, D.G.M.P.
Dr. J. J. Rudra, Principal, Madras Engineering College.
Rao Bahadur P. Seshagiri Rao, Director, Power Expansion Board.
Prof. S. P. Chakravarti, Head of the Department of Electrical Technology, Indian Institute of Science.
Principal G. R. Paranjpe, Royal Institute of Science, Bombay (from September 1945).
Prof. A. K. Das, Offg. Head, Electrical Engineering Department, Bengal Engineering College (from November 1945).

Messrs. Mathews and Voorduin attended a meeting of the Committee in May last and have always given valuable advice and help, but have recently expressed a desire to resign from the Committee as they are too busy with the work of the Central Power Board.

4. The Committee is unanimously of opinion that a post-graduate course of two years' duration in Power Engineering should be established in the Institute.

The object of the course is to provide instruction for engineering graduates from Indian Universities in Power Engineering (Hydro, Thermal and Electrical) for a period of two years so that the products of the course might be able after this training to take up immediately and discharge with confidence, superior responsibilities.

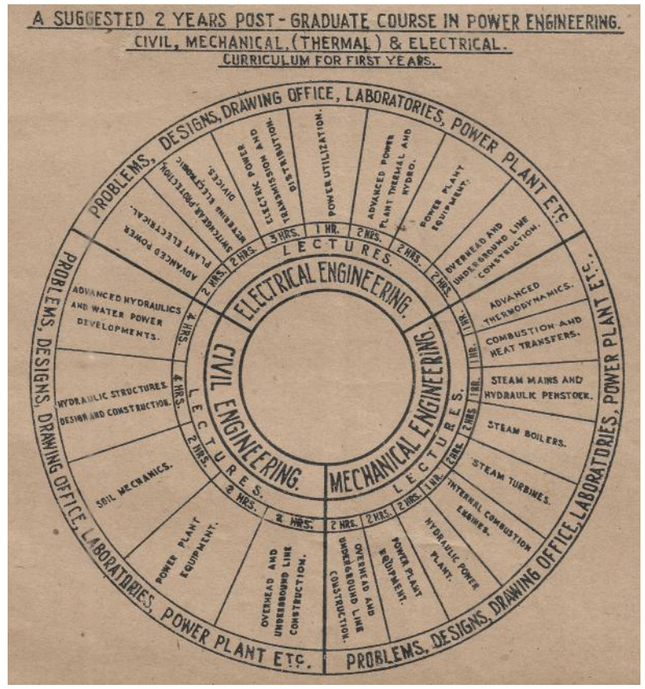
There is at present a dearth of power technologists in this country, and in view of *post-war power development schemes*, of very large magnitude, India would require the services of a large number of power engineers. It is considered that 60 to 100 qualified engineers are likely to be demanded and absorbed by this Industry every year during the next ten years.

The graduates in Engineering in India when they emerge from their college courses do not possess sufficient practical knowledge and experience of power engineering for any responsibilities being *immediately* entrusted to them. It is common knowledge that adequate facilities do not exist in this country. Proposals therefore have emanated for the establishment of a post-graduate power engineering department for imparting specialised training in power engineering to selected civil, electrical and mechanical engineering graduates, for producing adequately qualified engineers for power development and operation, mainly for the electric supply industry and also for large industrial undertakings having their own generation plants.

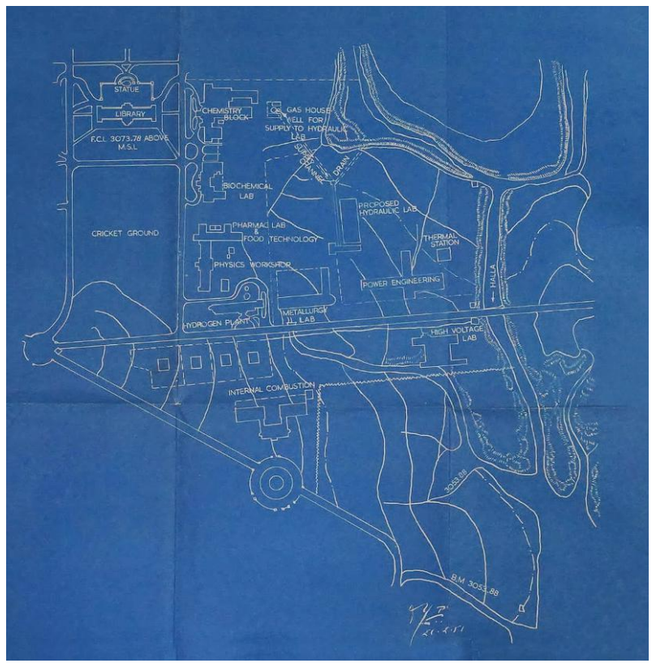
Thinking ahead: *Memorandum of the proposal to set up the PE department*

A momentous occasion: *Rajendra Prasad, former President of India, at the inauguration of the PE department, 1951*

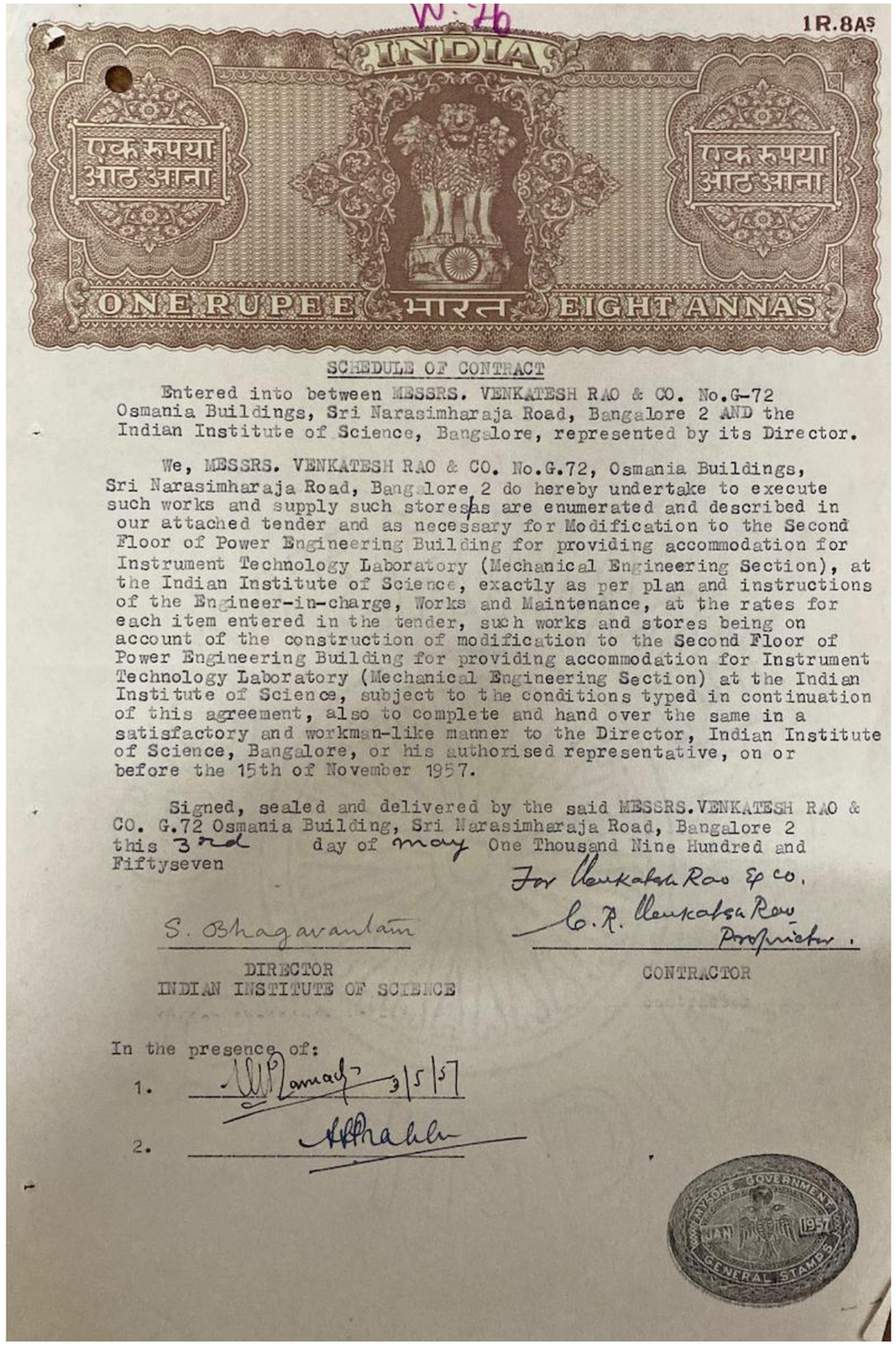
A memento from the foundation-laying ceremony for the Hydraulics Research Laboratory of the PE department



Proposed curriculum: *From a 1945 memorandum on a proposal to establish PE*

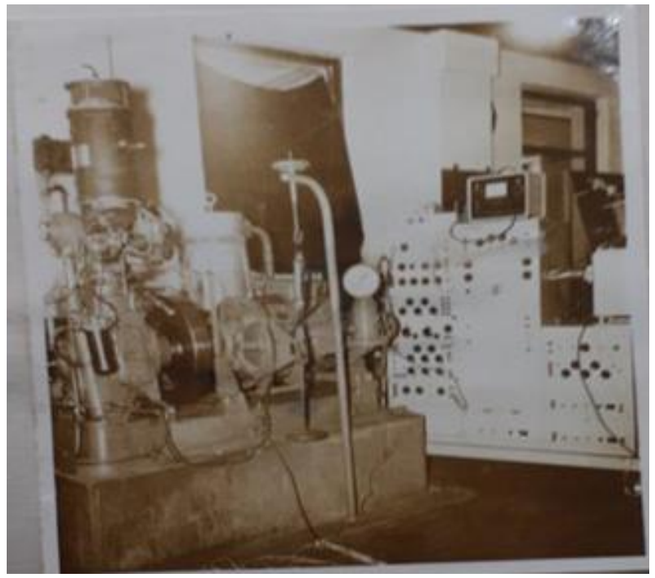


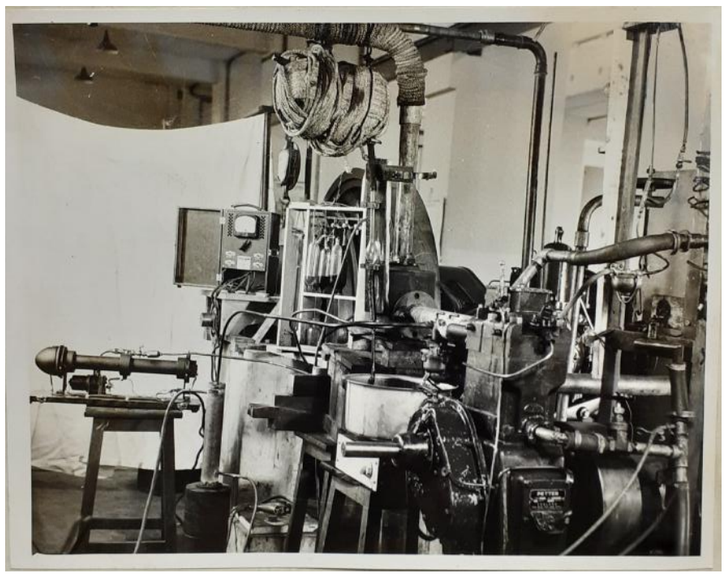
The blueprint: *Plan showing different wings, including the PE and ICE departments, 1951*



Indian industry at the time was rudimentary at best. India imported fuel and engines, which proved to be very expensive. The 1953 brochure issued on the opening of ICE department captures the scenario of the time clearly, "Power is created in various prime movers but the power generated in Internal Combustion Engines is by far the most important, and caters for a large share of almost the total power requirements of a modern state… India cannot avoid to pay attention to the development of an Industry to build such engines. Various problems arise if the industry should be reasonably independent from foreign supplies."

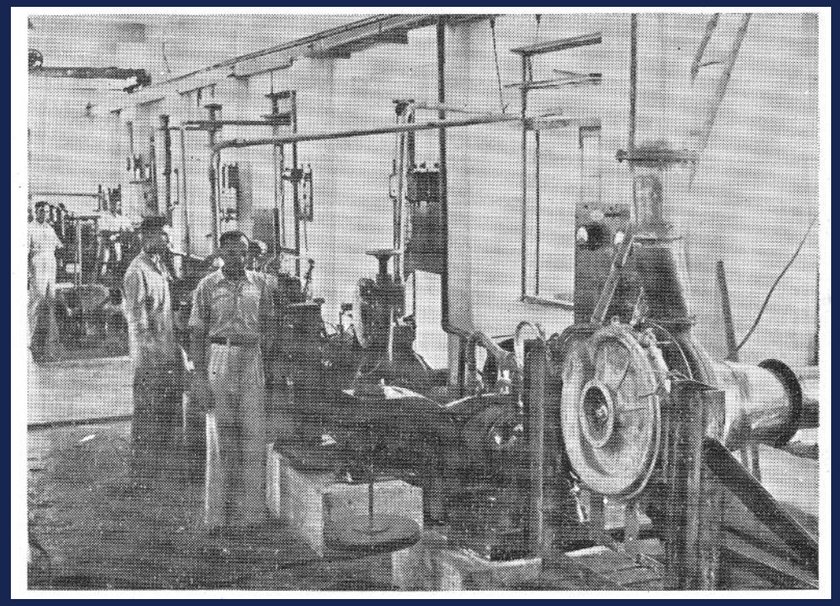
The Annual Reports of the Institute describe how the stands on which engines were hoisted for testing often required significant realignment to accommodate foreign-made engines. In the shadow of these restrictions, many collaborative projects were carried out by ICE under the aegis of the fledgling CSIR. One of these — led by Prof Havemann and Mr VM Ghatage, Chief Engineer of Hindustan Aeronautics Limited (HAL) — focused on developing a fully indigenous six-cylinder engine for the HT2, India's first aircraft used to train the Indian Air Force pilots. Under Prof Havemann's stewardship, the department worked on several types of engines such as Ricardo engines with variable compression ratios, and experimented with different types of fuels, including dual fuels such as cetane and octane.

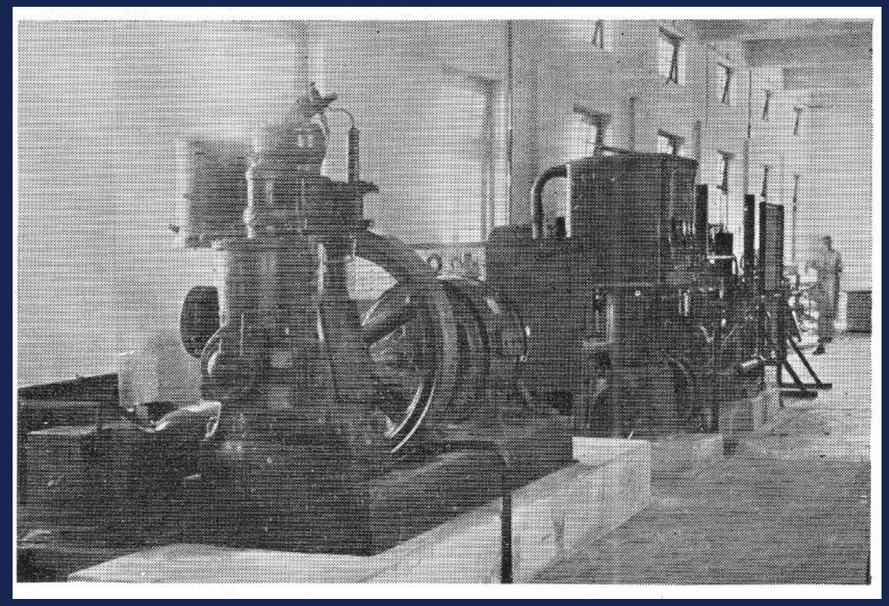




Engine power: *(Left): A Ricardo engine[8]; (Right): A Petter engine[9]*

[8] A picture from the PhD thesis of SLV Chary, 1965.
[9] A picture from A Natarajan's Associateship thesis 'Some studies on the utilisation of heavy fuels in high-speed diesel engines,' 1955.





***Engines at work**: Engineers at the ICE laboratory, 1953*

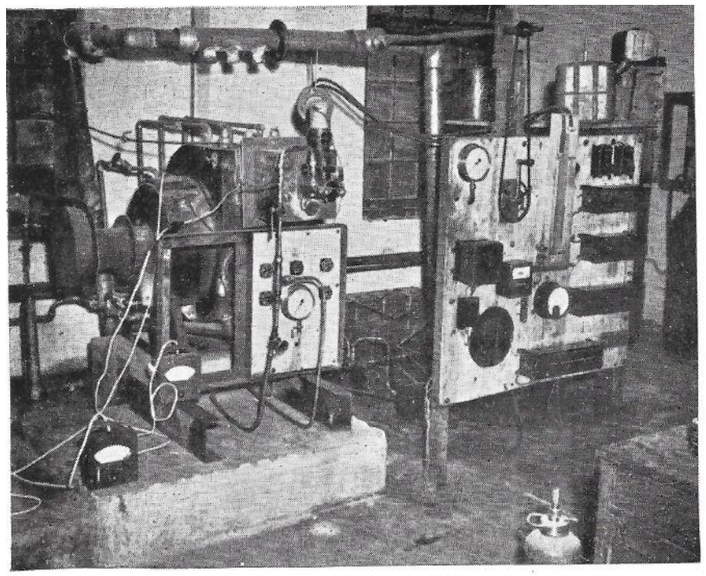
Researchers at the department collaborated actively with their counterparts in the industry to design various types of engines and components. These were housed and tested in a large hangar in the west wing, according to a former faculty member, Prof V Kuppu Rao.

The researchers collaborated with many engine companies like Kirloskar Oil Engine Company (Pune), The Cooper Diesel Engine Company (Pune) in Satara Road, Bosch-MICO Fuel Injectors (Bangalore), The Premier Automobiles (Bombay), and Ashok Leyland Trucks (Madras). Dr N Raman, who retired from the department as a Principal Research Scientist in 2003, attributes the flourishing industry-academia collaboration to the excellent R&D at ICE.

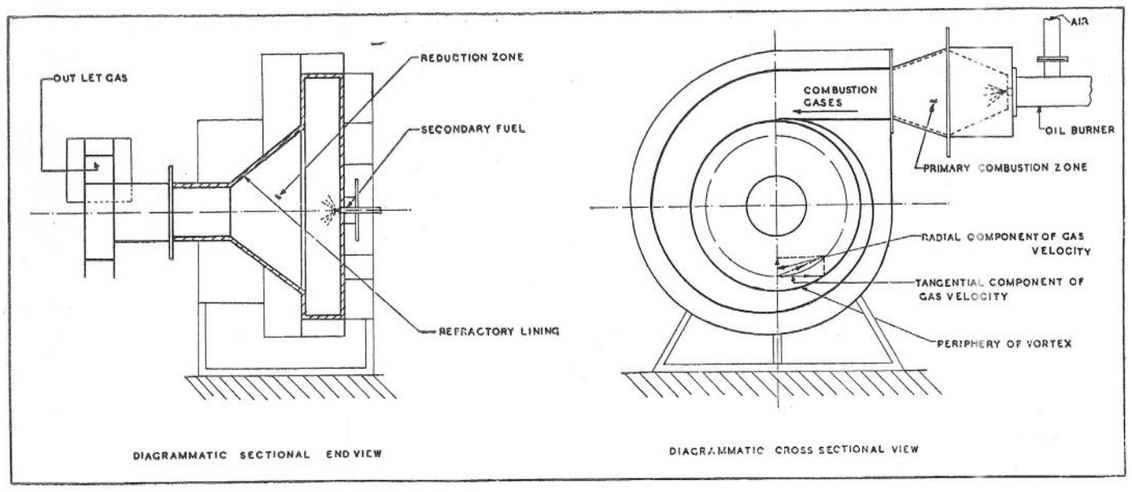
"MICO, which later became Robert Bosch Co., moved to Bangalore because of their collaboration with ICE at IISc," he recalls.

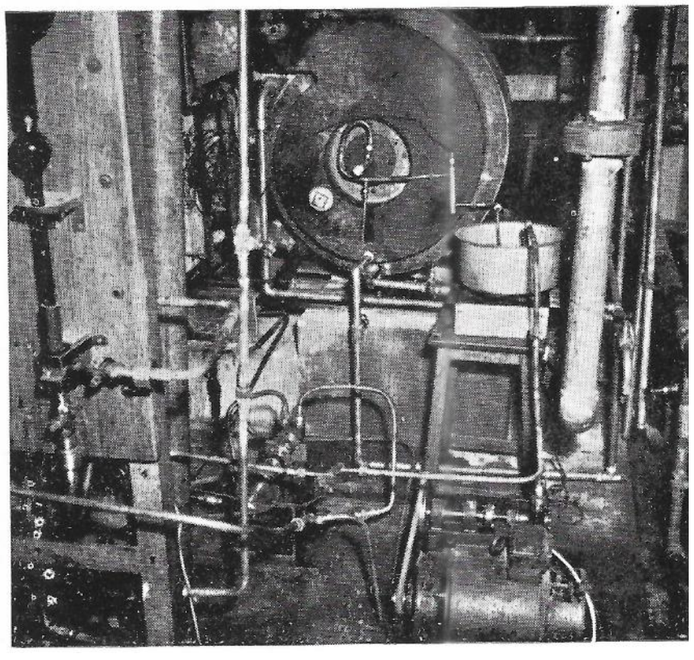
Another of Prof Havemann's projects centred on an engine using hot air as the working medium, which could prove useful in rural areas where organic fuels like firewood or charcoal were more abundant than gasoline or diesel. Prof BVA Rao, who pursued his DIISc — which later became the Master of Engineering (ME) degree — at the Department from 1956 to 1958, served as faculty at IIT Bombay and IIT Madras, and went on to become the Chairman of the National Design Research Foundation (NDRF) of the Institution of Engineers (India), recalls working on a project titled 'Torsional Vibrations of IC Engines Crank Shafts' under the guidance of Prof MRK Rao.

He also recollected conducting research blending alcohol in petrol or diesel engines to boost their energy or power. “This would be useful for vehicles moving on rough terrains and hilly areas, especially in military operations. Nearly 30% of excess power was possible by this technique and everyone, including the German Professor [Prof Havemann] and my guide Prof Rao, was happy.”



Show and tell: *(Below): A diagram to show the development of a Cyclone Gas Producer and Combustion for Low Grade Fuels; (Right) and the machine*[10]





[10] *From the brochure issued on the occasion of the official opening of the ICE department.*

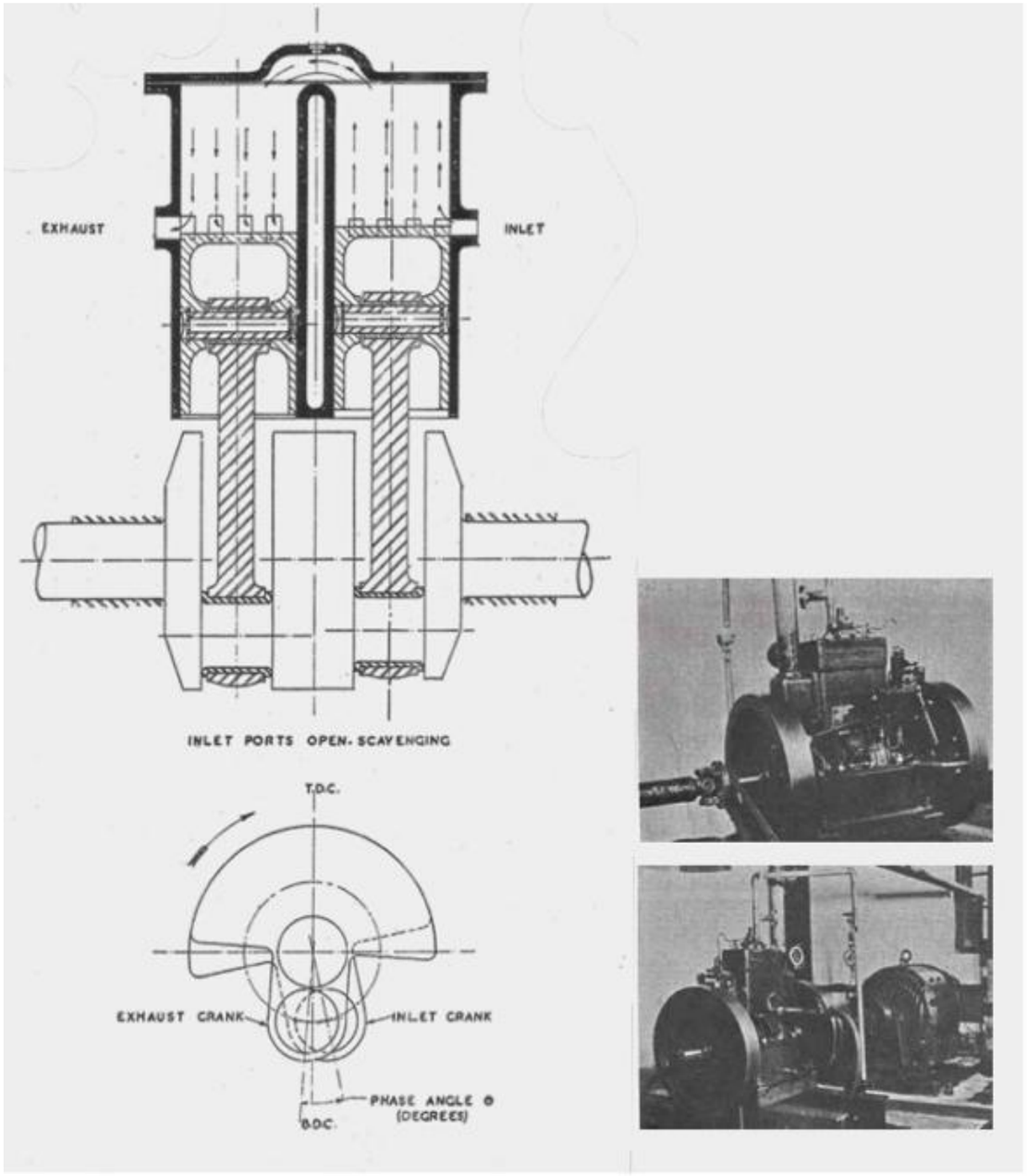
There was a strong emphasis on hands-on learning "to avoid unnecessary duplication of staff and equipment."[11] Students built equipment and machines for their projects in the Central Workshop, which would become indispensable to the students of the department in subsequent years. A Thermal Power Station (TPS) was also set up to train students in understanding the operation and maintenance of such equipment.

On the floor: *The Central Workshop*

Mr RA Rao, who pursued his Master's degree from the department in 1958, under the supervision of Prof AV Sreenath, says, "Engine lubricants are the most complex of all petroleum products. They were imported under various oil company brand names; little was known or understood about their field performance capabilities." Mr Rao was subsequently involved in evolving national standards for petroleum products by the Bureau of Indian Standards. He also worked with the armed forces in Ladakh during the Indo-China war in 1961, for a month, ensuring that the trucks and other vehicles running on IC engines ran smoothly. His son, RV Ravikrishna, is currently a Professor at the ME department, and continues to work on combustion and biofuels.

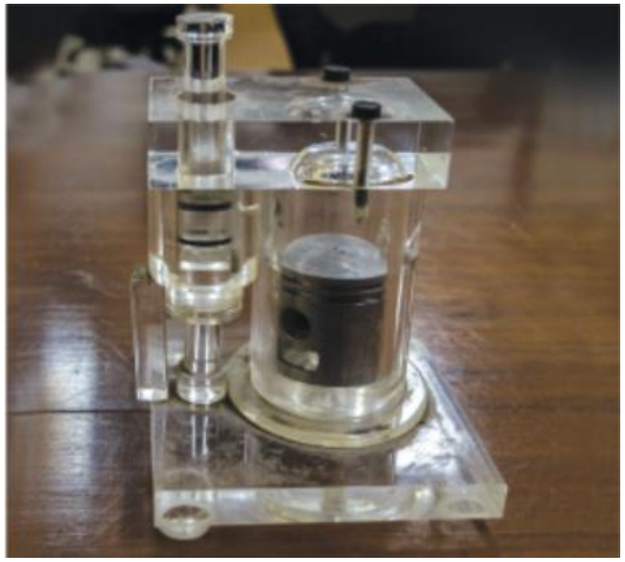
A powerful connection: *Mr RA Rao (left) with his son Prof RV Ravikrishna*

[11] *From the 75 years of the Department of Mechanical Engineering, published by the Office of Communications, IISc.*



From idea to reality: *The design (left) and development of a U-type two-stroke diesel engine*

In the later years, Prof MV Narasimhan and Dr Raman worked on a two-stroke engine to reduce pollution and increase fuel efficiency. Prof Ravikrishna also contributed to these efforts. The concept, which was handed over to TVS Motors, was one of the many successful technology transfers from IISc to the industry. More recently, there has been significant work on alternate fuels for such IC engines by Prof Ravikrishna, Dr Himabindu M and Dr R Thirumaleswara Naik.



A model of the two-stroke engine whose technology was transferred to TVS India

Noise reduction in vehicle exhaust became another focus area of study for the researchers at the ICE department. The study of industrial acoustics, particularly mufflers and silencers, was pioneered by Prof ML Munjal, Emeritus Professor at the ME department. Currently the AICTE Distinguished Chair Professor and INSA Honorary Scientist, Prof Munjal started as a student in the department in 1966 and joined as a lecturer upon graduating in 1968. He and others in the department worked on several industry projects related to noise control and vibration; even stealth technologies for Indian Navy submarines and silencers to limit cockpit noise in a fighter aircraft. Prof Munjal proposed the general design criteria for silencers, which led to the establishment of the Facility for Research in Technical Acoustics (FRITA) in 1998. Prof Venkata Sonti, Professor at the ME department, is a prominent present member of FRITA and conducts research on the fluid structure interactions of acoustic panels.

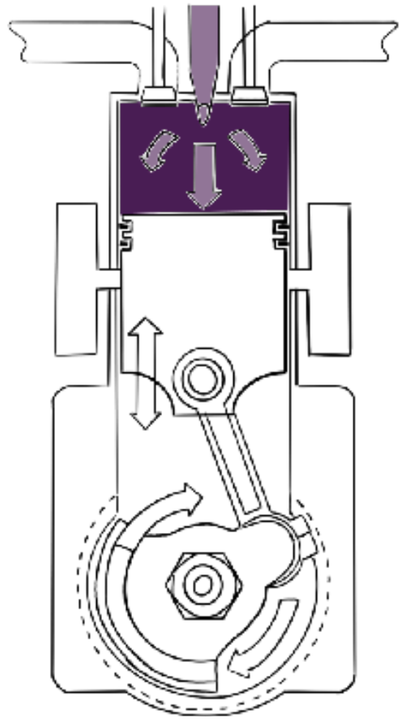
A research trip: *(L to R): Prof ML Munjal, Mr Jasjit Ahluvalia of IAC Acoustics and Mr DN Raju during the US leg of the study tour for setting up FRITA, 1996*[12]

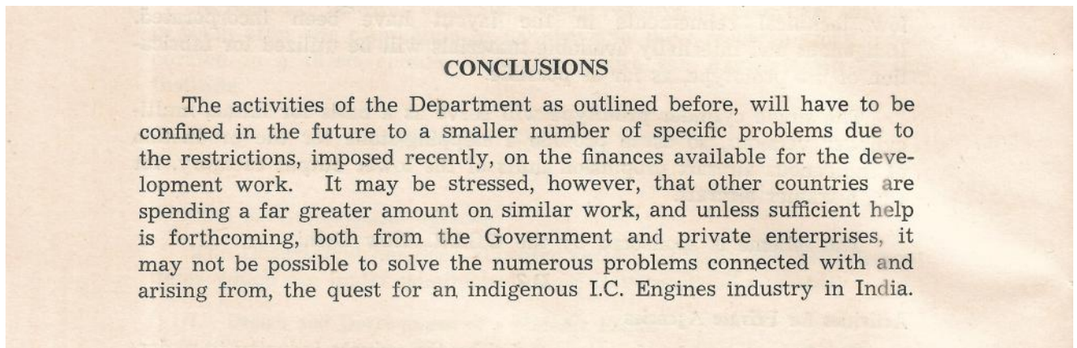
[12] *Photo courtesy: Mr DN Raju.*

1.2 | Expansion into heat engines

The PE department bifurcated into Electrical and Mechanical Engineering sections. Prof Carter appointed Dr Arcot Ramachandran as an Assistant Professor in 1950 to begin research on heat transfer and thermal sciences. Prof Havemann saw Ramachandran as a representative of the new generation of Indian science administrators — those who had received training in the United States and inculcated an aspiration for industrial research. Prof Ramachandran later headed the ME section and helped spawn several programs on energy research across the country.

"The ICE was not a very big department", recalls S Seshan, Professor Emeritus and former Chair of the ME department. Its growth — in terms of the number of students, faculty and lab facilities — became somewhat constrained. There was a lot in common between the curricula and courses of the mechanical division of PE and the ICE department. The Indian automobile industry was also developing at a very slow rate and presented inadequate career prospects for IC engineers. These factors led to the merger of the two in the 1970s, forming the ME department as we know it today.



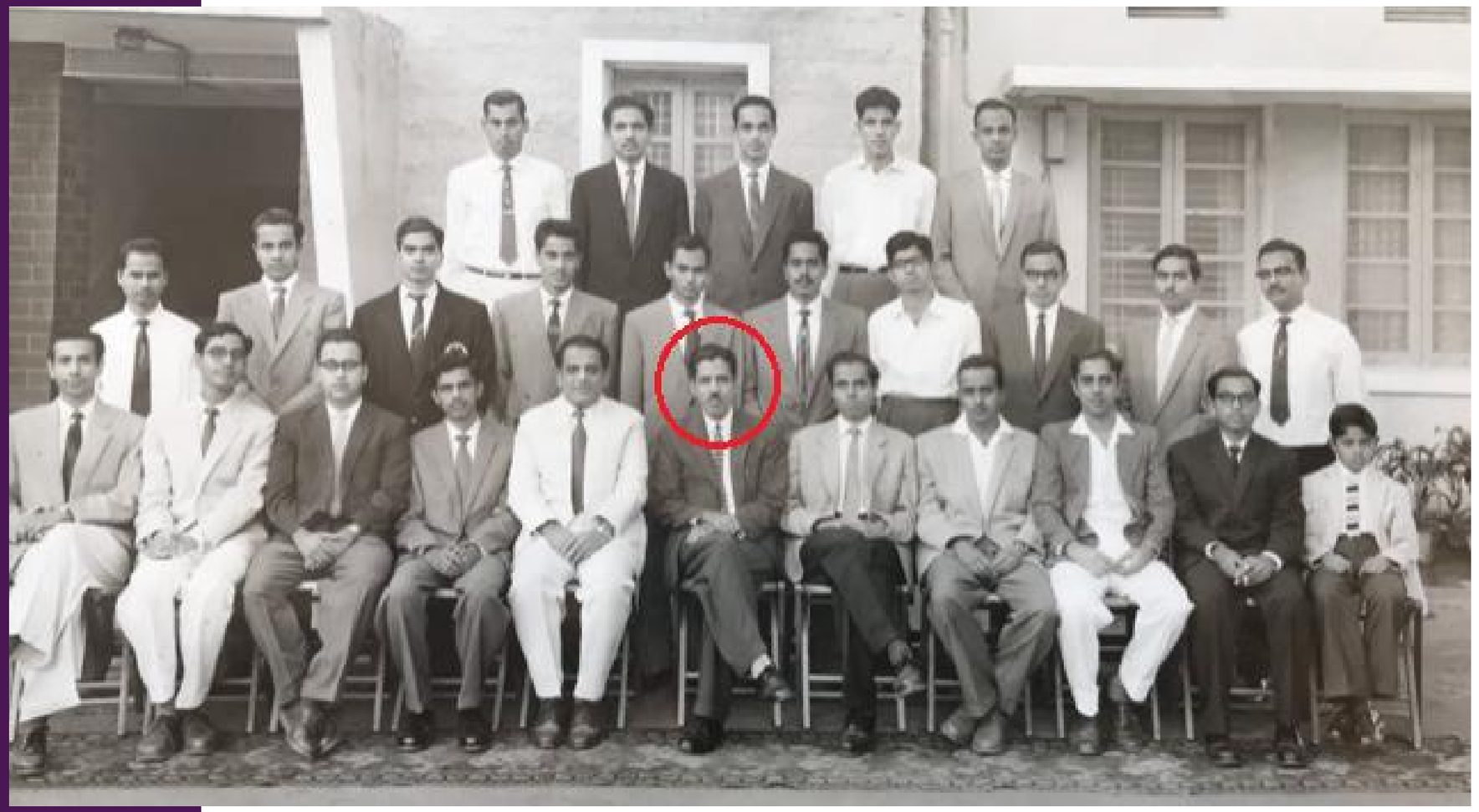


CONCLUSIONS

The activities of the Department as outlined before, will have to be confined in the future to a smaller number of specific problems due to the restrictions, imposed recently, on the finances available for the development work. It may be stressed, however, that other countries are spending a far greater amount on similar work, and unless sufficient help is forthcoming, both from the Government and private enterprises, it may not be possible to solve the numerous problems connected with and arising from, the quest for an indigenous I.C. Engines industry in India.

Changes ahead: *Conclusions from the ICE brochure in1953*[13]

[13] *From the brochure issued to commemorate the official opening of the ICE department.*

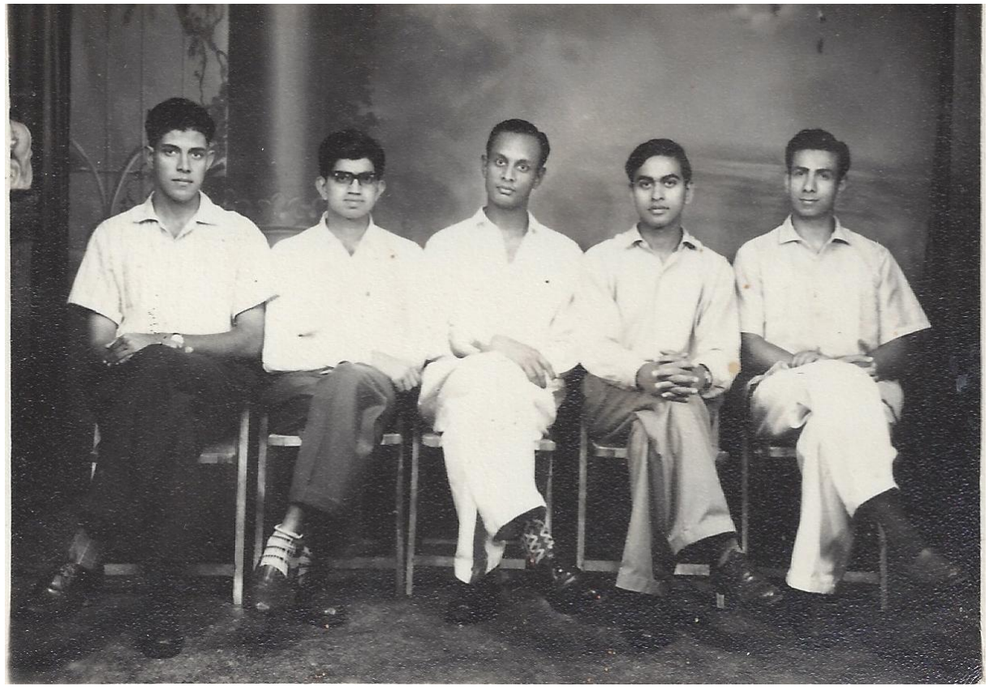


A new direction: *Prof Ramachandran (circled) in a group photo with the ME department, 1961*

Prof J Srinivasan (Prof JS), a former Professor at the ME department, says that the merger was recommended by an international review committee that did not completely appreciate how rudimentary the state of Indian automobile industry was at that time.

Prof Ramachandran, who headed the ME section before its merger with the ICE department, introduced many new programmes and courses like Nuclear Engineering and Machine Design.

These initiatives laid the foundation to the research in the area of heat transfer and thermal sciences in the department. Dr J Gururaja, a former student of Prof Ramachandran, who also worked with him later, says with admiration, “He [Ramachandran] was always looking beyond the current state of affairs at that time: What new branches can there be? What new areas can we start? Who are the competent people available?” Prof Ramachandran was also very influential. Dr Arkal Shenoy recalls how Prof Ramachandran had asked the students in his batch to not worry about jobs, and apply at TATA power. All the students — even those who could not make it to the interview that day — were offered jobs.



Researchers through the years: *Prof Ramachandran's students, including Prof BG Nair (second from left)*

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The ICE batch of 1968-70: *Sitting (L to R): Miss Prabha Krishna Swamy, Mr S Venkatesh, Dr M Narasimhan, Mr K Narayana Swamy, Prof A V Sreenath, Dr V Kuppu Rao, Mr DL Prasanna Rao, Mr ML Munjal and Mr KR Hariharan; Standing First Row (L to R): Messrs Major Harjap Singh, PVK Perumal, S Narayana Das, M Muslim, R Raman, N Raman, MS Chandrasekhar, Dr K Mishra, A Suryanarayanan and PV Subba Rao; Standing II Row (L to R): Messrs K Ramamurthi, K Annamalai, VS Venkatanathan, N Raghu, K Rama Krishna, S Azeez, SS Iyengar, Jagbir Singh, NK Mital, HR Sriranga Rajan and N Satyanarayana*

The ME group gathered on a terrace

Dr Shenoy recalls another incident from his time at Georgia Institute of Technology, as a newly enrolled PhD student following his stint at IISc as a Master's student. "In those days, the degree certificate would reach us by mail about six months after the completion of the degree. The Registrar at Georgia Tech would not allow me to join the course without the degree certificate," he says. "When the Dean got to know that I was a student of Prof Ramachandran, the matter was settled without any further discussion." In 1967, Prof Ramachandran moved to IIT Madras as its Director. Later, he served as the first secretary of the then newly established Department of Science and Technology (DST), Government of India. Prof MV Krishnamurthy recalls how Prof Ramachandran extended support to his work on numerical heat transfer, despite the lack of adequate computational facilities at IISc.

Prof Ramachandran helped him access the computational centres at IIT Kanpur and Tata Institute of Fundamental Research (TIFR), Bombay. Krishnamurthy recalls fondly how he and Prof HR Nagendra, former Professor at the ME department and the present Director and founder of SVYASA[14], would travel to TIFR to use the computational facility, CDC 3600, which was one of the fastest at that time. In another instance, Mr S Kasturi, another former student, needed some stainless steel sheets to manufacture trapezoidal ducts for experiments on laminar and turbulent fluid flow. "They were not available at that time in the whole of India, except at HAL," Kasturi recalls. "Prof Ramachandran was very helpful; he contacted the Director of HAL and procured all the material."

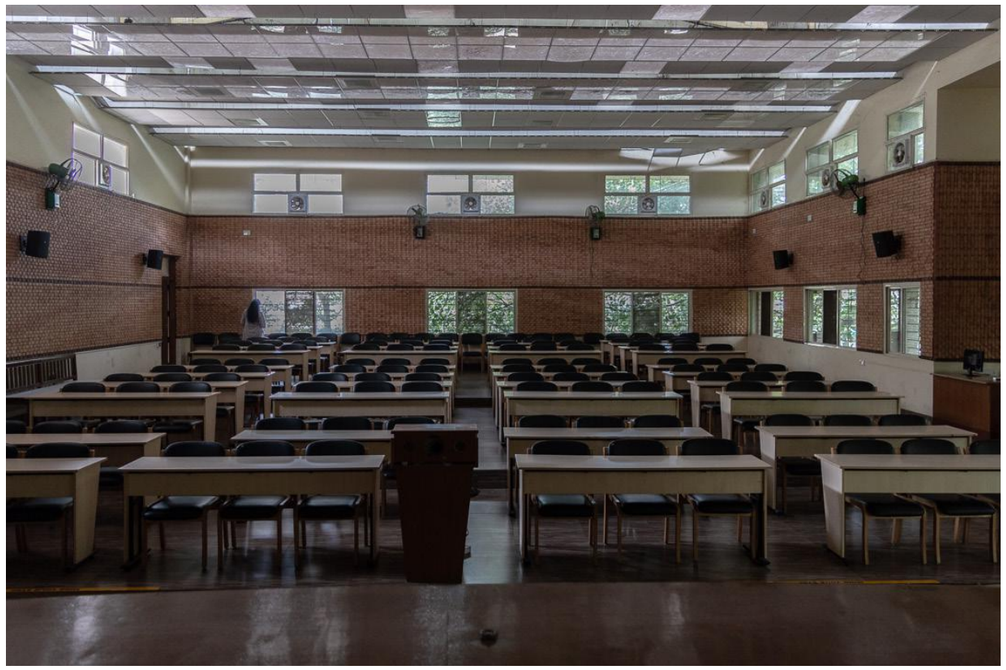
[14] *Swami Vivekananda Yoga Anusandhana Samsthana*

Prof Krishnamurthy and other students of Prof Ramachandran have carried his legacy forward, training and mentoring many more individuals. For instance, Prof Krishnamurthy mentored Dr GSVL Narasimham, Chief Research Scientist at the ME department, who expanded thermal engineering to encompass refrigeration, air conditioning and solar engineering, inspiring engineers from industry and college teachers to embark on green energy initiatives.

Heat transfer and energy research, which Prof Ramachandran pioneered, continues to be an important part of the department's focus to this day. Prof Ramachandran recruited many faculty members with industry experience. This includes Mr BK Subbarao, whose experience in thermal power plants helped build a new focus area in the department. The growth of this beginning can be seen in recent research focusing on thermo-chemical storage, combustion and spray research, refrigeration technologies and thermal management in spacecraft systems. Drs Susmita Dash and Navaneetha K Ravichandran, Assistant Professors at the department, have recently added to the activities of this group with their focus on different aspects of micro and nanoscale heat transfer. Dr Dash's lab focuses on developing strategies to enhance thermal and fluid transport using micro and nanotextured surfaces, whereas Dr Ravichandran's group works on nanoscale heat transfer phenomena that are critical for thermal management of electronics.

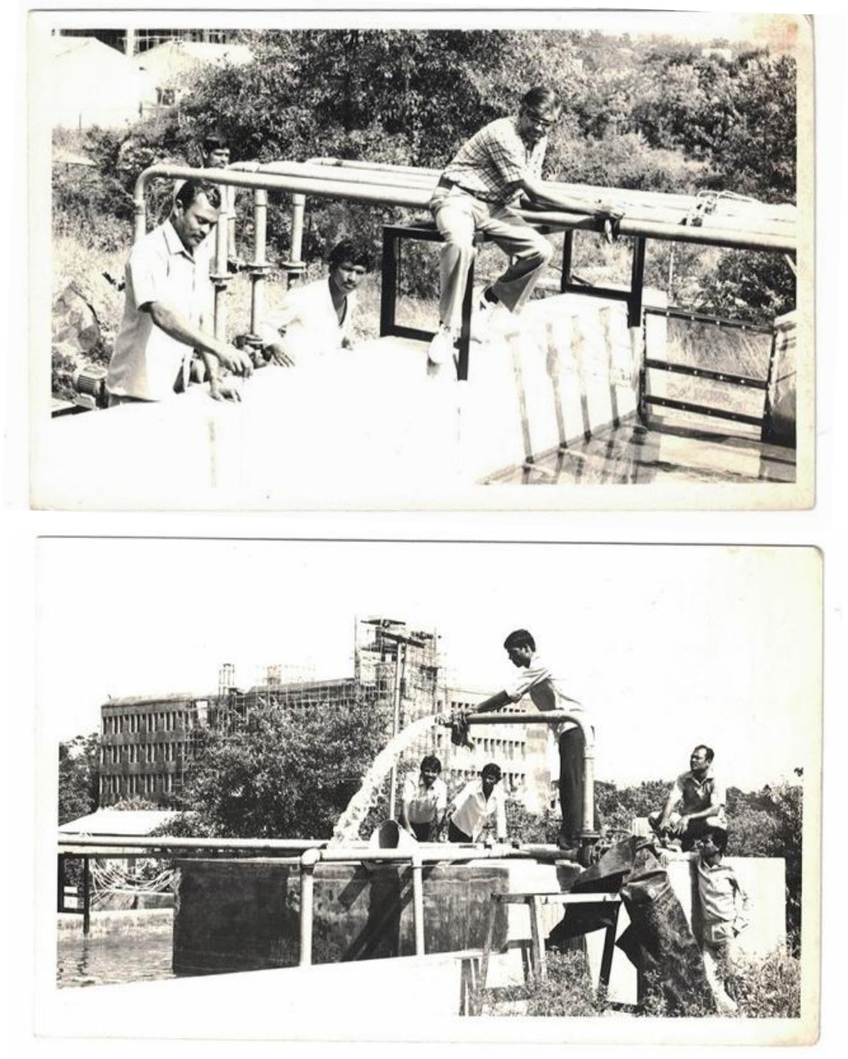
As a befitting tribute to the founder Chair of PE, the faculty of the ME department unanimously approved the naming of a newly constructed auditorium as Prof Arcot Ramachandran or AR auditorium. The AR auditorium, and the construction of an additional floor in the main ME building, stemmed from a need to have a larger space to accommodate students, as well as provide additional office space. The project's vision was primarily conceived by Prof Jaywant H Arakeri (Prof JHA). The construction took several years and was spread over the tenure of two Chairs, Profs JHA and R Narasimhan. The AR auditorium was inaugurated in 2013.

The auditorium is designed for thermal comfort, given the climatic conditions in Bangalore, which has comfortable temperatures all year except for the months of March and April. The thick walls in the auditorium provide the thermal mass to make use of the fluctuations in temperature during the day, and 'stores the cold' from the nights. Acoustic panelling that is usually made of fabric and light boards would not allow this 'cold storage.' A large part of the heat load in the auditorium comes from the occupants: a 100 W of heat per person leads to 10 KW of heat for 100 people in the audience. This hot air then rises and is sucked out through two exhaust systems: the turbo ventilators on the roof, whose turbines rotate by the wind, and a series of low-noise exhaust fans placed high up on the walls. Natural light pours in from the large windows and from the translucent panels fitted in the ceiling, and this lasts for most of the day. Perhaps the most innovative aspect of the auditorium is the acoustic design. The walls are fitted with clay tiles that feature waves of specific wavelength; this pattern limits sound reverberation and echoing. Mr Narasimha Swamy, from Broadcast Engineering Consultants India Ltd, helped design the acoustic elements in the auditorium. With a seating capacity of 120, this auditorium witnesses several classes, meetings and conferences hosted by researchers from various departments on the campus.



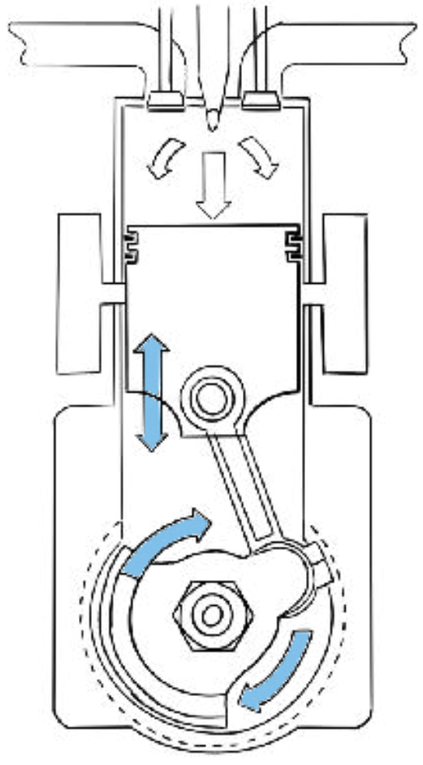
One of a kind: *(Top): The AR auditorium's design is a reflection of the inward-outward balance that the Department has achieved over the years; (Bottom): Prof JHA gestures at the wave-like tiles in the context of the acoustic design in the AR auditorium*

1.3 | Fluids and the Power of turbines



In fluid motion: *(Top): Prof BG Nair steps up to guide Mr Narayanswamy for sump studies to ensure smooth operation; (Below): Another view of the experimental system,1990*

From Heat Transfer to Fluid Mechanics, the wheels of research in the ME department never stop turning. Fluid mechanics involves the study of fluids, gases and plasmas, and the forces that act on them. Both these fields of research have found significant applications in industry and other disciplines of science including biomedical engineering, agriculture, meteorology and biology. Prof S Soundranayagam (Prof SS) pioneered the department's research in fluid mechanics in 1971. Bringing in a strong industry experience, Prof SS built an advanced laboratory with several wind tunnels and turbomachinery rigs. The funds provided by IISc and the Aeronautics Research and Development Board helped the ME department create a strong presence in the areas of Turbomachinery and Fluid Mechanics.



Prof SS's expertise was much sought after by several companies like Voltas, Best & Crompton, NGEF, Jyothi's Ltd and Worthington Pumps, and national laboratories like NAL, NSTL and GTRE, even after his retirement in 1990. He was actively involved in the Kaveri engine project and in the design of several types of propulsors for the Indian Navy.

The man and the machine: *(Top): Prof Punit Singh's father, Jasmail Singh (center), Prof S Soundranayagam (left) and his wife Rosemary (right), outside their home in Kodaikanal, 2014; (Bottom): A small-scale version of Prof Soundranayagam's micro-hydel turbine*

Prof SS pursued research in micro-hydel power with great passion and this became an important and socially relevant initiative for the ME researchers as well. Prof Punit Singh, presently a faculty member of the Centre for Sustainable Technologies (CST), recalls the long treks Prof SS would take in the Himalayas, and his dream of making better turbines for the people. "He [Prof SS] got the design for a crossflow turbine from the German-Swiss firm Banki, and I think that he designed his own Pelton turbine."

Interestingly, the forerunner to CST was the Application of Science and Technology to Rural Areas (ASTRA), which was set up in 1974, and attracted some of the faculty of the ME department. ASTRA developed several rural technologies like biogas plants, low-carbon housing, and small-scale fertiliser industries. Prof SS also designed a Kaplan turbine for a canal drop scheme, which used an ultra-low head of approximately 0.5 to 1 m, in Srirangapatna for the Karnataka Electricity Board. Micro-hydel power generators were also used to power coffee estates in Coorg and small townships in Kedarnath and Arunachal Pradesh. In a DST-funded project in Nagaland, Prof SS developed a low cost technology for a small hydro project, called Cross Flow Turbine, which has been used to meet the energy demands of several villages in Nagaland.[15] Profs JHA and Raghuraman N Govardhan had the benefit of attending his course on turbomachinery, the contents of which is the basis for the course currently taught in the department.

[15] *From https://dst.nagaland.gov.in/activities/engineering-division/microhydel-projects.html*

The ME department also saw its first woman employee and student in Prabha Krishnaswamy (later Prabha Venkatesh), who joined as a Junior Technical Assistant in 1970, and went on to complete her PhD in the department. Her doctoral research was on Laser Doppler Anemometry (LDA), a non-contact method to measure fluid flow velocity, which is now a routine method in most laboratories.

Prof Vijay Arakeri's entry into the department in 1977 as a young fluid mechanician trained from Caltech brought in the expertise in hydrodynamics and cavitation.

Prof Arakeri, who held a joint appointment with the Department of Civil Engineering, revived the Cavitation Water Tunnel. His early years in the department were spent investigating fundamental and applied problems in the cavitation tunnel, which were of interest to the Navy.

*(Top) Use of ultrasonics in control of travelling bubble cavitation[16]; **Picture perfect:** (Bottom): Prof MV Krishnamurthy and Prof Vijay Arakeri with Mr Dharuman (right) showing Prof G Padmanaban, Director of IISc, photos of the water tunnel*

[16] *A picture from the PhD thesis of Dhiman Chatterjee, 2003*

A hot ticket: *The solar pond in front of the TPS building*

He initially focussed mainly on the study of underwater noise from marine propellers and turbulent boundary layer noise in towed-arrays. His focus later shifted to bubble plumes, cavitation control and single-bubble sonoluminescence (SL), which is the phenomenon of light emission from nonlinear motion of a gas bubble. SL technology gained a lot of publicity in the early 2000s because of its possible connection to bubble nuclear fusion.

Prof JS, a specialist in thermal sciences, who joined the department in 1982 from IIT Kanpur, gave further impetus to research in fluids and thermal sciences. He undertook the major task of building a solar pond. A solar pond is a lake with salt water, which collects and stores solar thermal energy. Prof JS built a 240-square metre solar pond in front of the old thermal power station.

Mr C Dharuman, who joined IISc in 1986 as a Scientific Assistant, was involved in the development and running of the solar pond. The solar pond project also triggered fundamental research in double-diffusive convection. Prof JHA, the younger brother of Prof Vijay Arakeri, joined the Department as a faculty member in 1988, collaborated with Prof JS, and had several joint research students. Two of them, Anupam Dewan and KR Sreenivas, are now faculty at IIT Delhi and JNCASR respectively.

The team discovered an interesting phenomenon — the bifurcation of a buoyant jet in a stratified medium which used salt to create convective flows. Meanwhile, Prof JS slowly shifted his attention to atmospheric sciences around 1995. Talking about his interest in atmospheric research, Prof JS says, "What makes it attractive is that fluid dynamics, heat transfer and thermodynamics interact in very complicated ways in the atmosphere. For example, the monsoon is driven by the sun's radiation, which creates a temperature gradient near the ground. This leads to convection which modifies the atmosphere, which in turn affects the way the sun's radiation reaches the ground. And when the clouds form, they too radiate heat. So, the monsoon is a complex interaction between radiation, convection, thermodynamics and a stratified medium which is the atmosphere."

Currently, a range of fluid mechanics phenomena like turbulent convection, drag reduction and boundary layer interactions are being studied in the department. Prof Govardhan, specialising in flow-induced vibration of structures, and Prof JHA have worked on several projects on unsteady flows of relevance to bio-fluid mechanics and fish propulsion. "I've worked in very diverse fields. In some sense, I've covered all non-dimensional numbers," says Prof JHA. Bio-fluid mechanics was further strengthened with Prof Namrata Gundiah joining the department; she collaborated with Prof JHA to study arterial flows.

More recent entrants, Profs Ratnesh K Shukla and Gaurav Tomar, primarily work in computational fluid mechanics, and their groups study many interesting problems including optimal surface actuation for drag reduction, thrust from rigid/flexible flapping foils for 'robotic fish,' multiphase flow simulations and atomisation and sprays. Prof Saptarshi Basu works in experimental fluid mechanics and combustion and addresses a number of difficult fluid dynamics problems in these areas, including a lot of recent work in the area of respiratory droplets and disease transmission spurred by the COVID-19 pandemic. More recently, Prof Aloke Kumar, who works in complex flows, and Dr Balachandra Suri, who works in transition to turbulence, have further added to the strength and diversity of research areas within the fluids group.

The Thermal Sciences and Energy Systems group has contributed significantly in basic and applied research. The Interdisciplinary Centre for Energy Research (ICER), which was founded in 2012, emerged from this group's efforts. ICER handles some of IISc's biggest projects, namely the Indo-US solar consortium (SERIIUS), the National Centre for Combustion Research and Development (NCCRD) and the National Centre for Clean Coal Research and Development (NCCCR&D). Prof Pradip Dutta and his former doctoral student, Prof Pramod Kumar, who is now a faculty at the ME department, work on supercritical carbon dioxide-based solar thermal plants and turbines which gives India an opportunity to become a world leader in this next-generation technology. This aims to fulfil a major objective of the National Solar Mission with its emphasis on indigenous manufacturing.

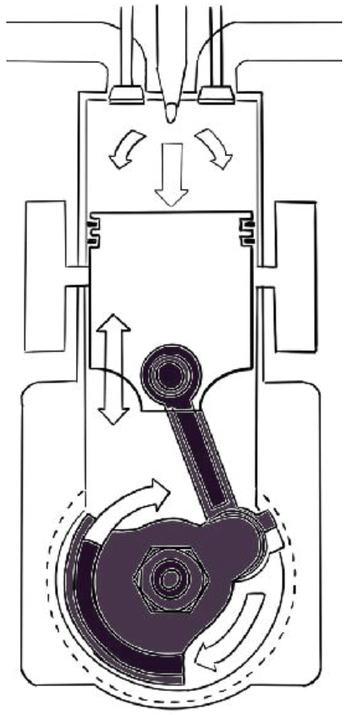
Generations of Arakeris: *(L to R): Jaywant Arakeri, Vijay Arakeri, with sons, Tapas and Navanit*

1.4 | Casting a new generation of engineers

Metal casting, a sophisticated technique to make metallic components directly from liquid metal, remained more of an art for decades.[17] However, the advent of the automobile and machine tool industries also mandated the presence of qualified foundry engineers to manage metal casting plants. The ME department made critical contributions to this industry with the development of Cast-Iron (CI) crankshafts — the rotating parts that form the backbone of an IC engine — to replace forged crankshafts in automobiles, to reduce production cost by up to 40%.

The crankshaft is a critical part of the power-train, which includes a chamber into which a mixture of air and fuel is injected. A reciprocating piston in the chamber transforms high pressure gases, caused by the volatile mixture, into useful work via the crankshaft. There can be hundreds of moving parts in a machine.

Prof S Seshan explains, "The crankshaft is a fairly intricate steel component, and is complicated and expensive to manufacture.



Our department ventured into developing cast crankshafts with the aim of reducing the weight as well as the cost, without compromising on the property standards. The availability of ductile iron and austempered ductile iron served as yet another incentive for such an endeavour." However, these designs were not used for commercial purposes.

The department offered an exclusive Master's degree programme in Foundry Engineering. Prof S Ramamurthy, General Manager, HAL, launched this programme in August, 1958 with the support of Prof Ramachandran.

[17] From the section IISc's Distinctive Master's Programme in Foundry Engineering by S Seshan as part of the 75 years of the Department of Mechanical Engineering, published by the Office of Communications.
[18] From the Council's minutes, 1958.

Name	*Subject*	*Year*	*Term*
Mr. B. K. Subba Rao	Power Plant Design Project	P.E. I	I & II
	Power Plant Operation	P.E. I & II	I & II
	Special Project	P.E. I & II	I & II
Mr. K. Krishna Prasad	Measurement Techniques Lab.	P.E. I	I
	Power Plant Operation	P.E. I & II	I & II
	Special Project	P.E. I & II	
Mr. P. R. Srinivasan	Power Plant Operation	P.E. I & II	I & II

Practical training for Power Engineering (Mechanical) Students 1958–59:

9—Department of Atomic Energy, Bombay.

1—Tata Power Co., Ltd., Bombay.

B–2. Master of Engineering Degree Course in Foundry Engineering

Three students have been awarded the Diploma in Foundry Engineering of the Institute and ten students have been awarded the Master of Engineering degree in Foundry Engineering. Fourteen students are at present undergoing instruction.

The following lectures were given for students in Foundry Engineering:—

Name	*Subject*	*Term*
Dr. A. Ramachandran	Heat Transfer	I
Dr. S. Ramamurthy	Pattern Design	I
	Foundry Metallurgy	I & II
	Casting Design	II
Mr. M. R. Raghavan	Materials and Design	II
Mr. M. R. Seshadri	Furnace Technology	I & II
	Moulding Materials	I
	Casting Inspection	II
Mr. B. Ramaswamy Rao	Foundry Mechanisation	II
	Practical Instruction and Laboratory	
Dr. A. Ramachandran	Special Project	II
Dr. S. Ramamurthy	Foundry Process Laboratory	I
	Foundry Practice	II
	Special Project	II

The foundation: *The foundry engineering curriculum, 1958*[18]

Prof MR Seshadri, who took over this programme in 1961, formed the Bangalore Chapter of the Institute of Indian Foundrymen in 1966. The programme included two semesters of course work, followed by a six-month internship. This was later converted into a four-semester programme. The foundry group was also actively involved in doctoral research activities and sponsored R&D projects. Among the research students who became faculty of the ME department were Profs KS Sreenivasa Murthy, Mandyam N Srinivasan (Prof MNS), Malur N Srinivasan (presently at Lamar University, USA) and S Seshan. Technology development that emerged from their work included cast metal-matrix composites (based on Al, Cu and Mg), gravity die casting of CI, Cast SG Iron crankshafts, high chromium CI, ultra-high-strength austempered ductile iron, software for casting design and metal flow studies, and technology forecasting in the casting industry. These were all unique because they represented newer materials and faster, less expensive and flexible routes of mass production.

Prof B Ravi, currently a faculty at IIT Bombay, who was mentored by Prof MNS, says, “He [Prof MNS] stood out because of his physically imposing personality, but he was a soft-hearted gentleman. He exhorted us to explore new directions as well as deep dive into ‘fundamentals’, which made our research work both exciting and challenging. He had earlier performed as an English theatre artist and used this experience to hone our communication skills.” Prof Raghu V Prakash, currently a faculty at IIT Madras, another graduate of this program says, “Prof MNS also guided Prof Manivannan (IIT Madras) in haptics and biomechanics which exhibits his multi-faceted personality.” Mr KG Haridasan, who joined the department in 1985 and became a permanent employee as a laboratory helper the following year, reminisces those times, “I used to learn a lot of things while working in mechanical department, not only melting or moulding, slowly I learned to analyse the material structures, their different compositions and analysis of mechanical properties like tensile strength and hardness. Mr Sommanna, who was a Scientific Officer at that time, taught me a lot of things, and Prof Seshan and Prof KS Srinivasa Murthy always encouraged me.”

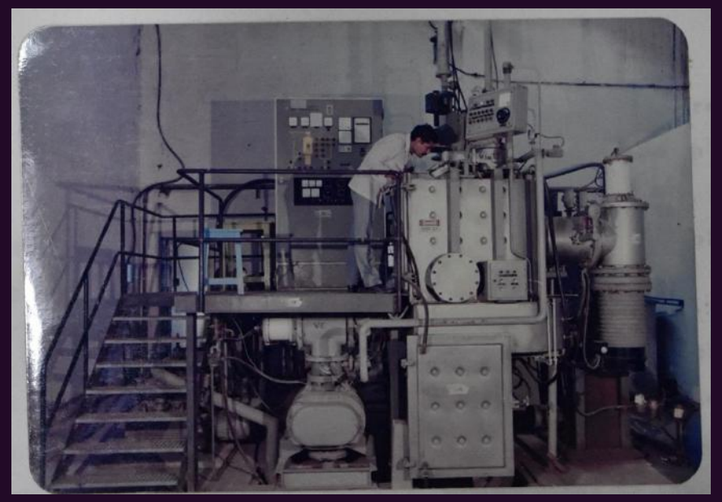
Postgraduate Foundry Engineering group, Batch of 1957-58: *Sitting (L to R): Messrs B Ramaswamy Rao, MR Raghavan, KS Grewal, Mrs Susila Ramachandran, Master Balakrishnan Ramachandran, Prof Ramachandran, Dr S Rama Murthy, Messrs MR Seshadri and B Vijay Mohan Rao, BC Basava Raj; Standing (L to R): Messrs MN Srinivasan, KL Raghupathy, NRK Paramahamsa, TS Venkoba Rao, Hans Raj Seth, YK Subramanya and MC Shanmugam*

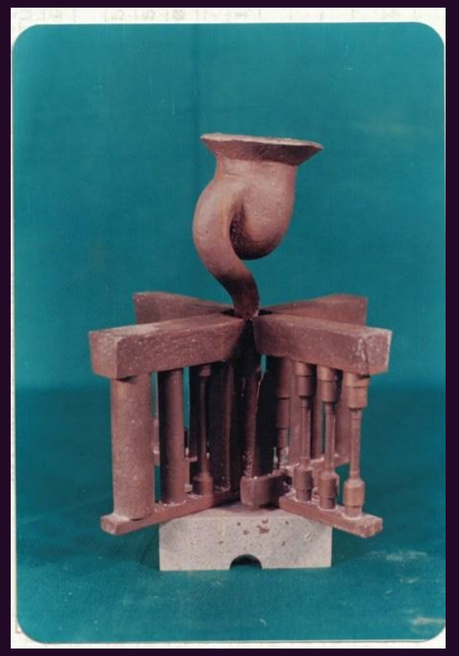
Prof Pradeep Rohatgi, presently at the University of Wisconsin, Milwaukee, along with colleagues like Prof Malur N Srinivasan, initiated work on metal matrix composites at the foundry. Their students included Prof MK Surappa, former Director of IIT Ropar, and Dr S Seetharamu, former Director of CPRI, Bangalore, among others. "Foundry Science and Engineering (FSE) attracted me as it had a good combination of energy, materials engineering, heat transfer, fluid mechanics, resource utilisation, waste management and application technologies," says Dr Seetharamu. Over a hundred highly-trained foundry engineers from this programme powered the metal casting industry as senior executives from the 1970s to 1990.

Coming together: *Scenes from the inauguration of the new ME building, 1994. Prof CNR Rao, Director of IISc, seen with colleagues from the ME department*

According to Dr Seetharamu "The Institute-Industry interaction was excellent at FSE with repeated visits to the industries including BHEL, Kirloskar Electric Co., HMT, Best & Crompton Engineering Ltd. and many other foundries." The programme later merged with mainstream mechanical engineering activities, and an updated foundry was created at the new ME department building which was inaugurated in 1994.

Prof KSS Murthy started the semi-solid facility in the early 2000s along with other researchers such as Profs Dutta, JHA, Seshan, Ramnarayan (from Electrical Engineering) and Kailas. Several industries were also started by students like Mr Babu Sathyan, Dr S Sundaramurthy and Mr Ramadurai.





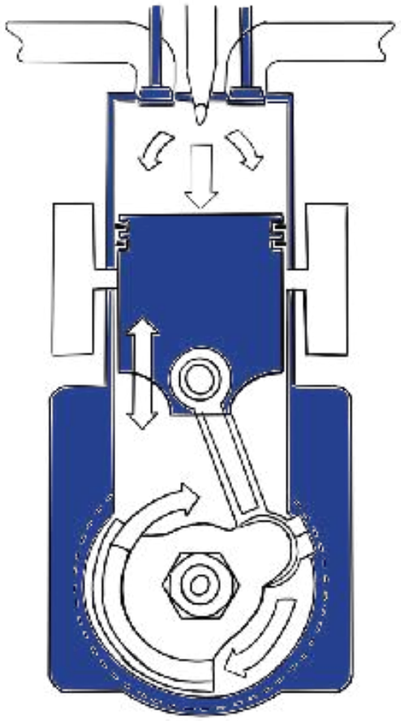
The people and the process: *(Top-left) (L to R): Dr S Seetharamu, Dr BK Muralidhara, Dr Narasimha Murthy and Prof Malur N Srinivasan in 2018; (Bottom-left) an overall view of the vacuum induction melting furnace; (Center): Melt treatment at the foundry[19]; (Far right) a picture of a test casting tree[20]*

[19] File photo by KG Haridasan

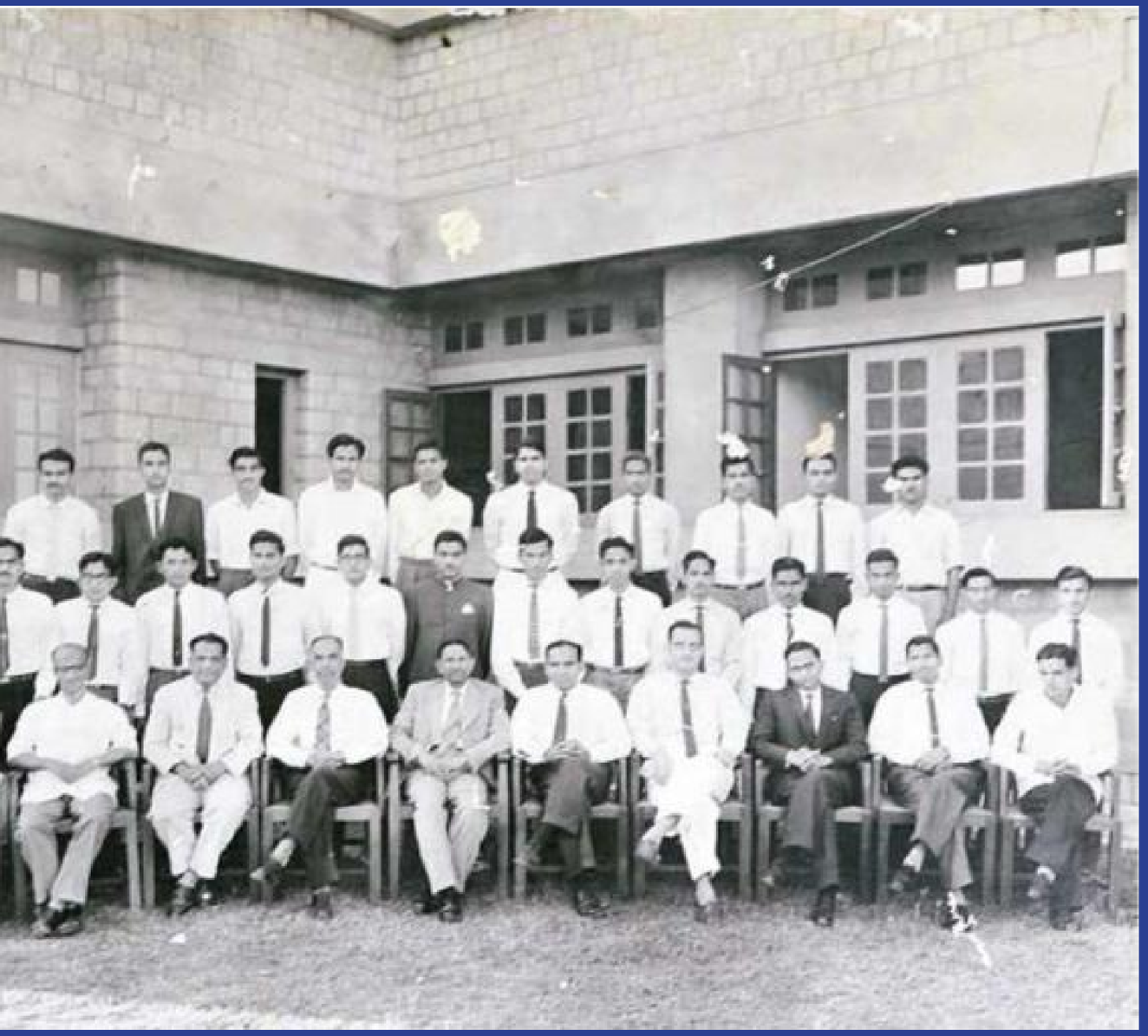
[20] From 'Effect of foundry variables on structure and properties of investment cast nickel base super alloy PK 24(IN100)' by HS Chandrasekhariah, 1989.

1.5 | Designing a new future

The Annual Reports in the 1960s mention several collaborative projects between the ICE department and the ME section of the PE department, hinting at the eventual formation of the ME department as we know it today. The then Director Prof Satish Dhawan invited Prof LS Srinath (Prof LSS) from IIT Kanpur to lead the merger of the two sections in 1972. Dr Gururaja, an alumnus of the first batch of the ME degree from the department recalls, "He [Prof LSS] was interested in creating an integrated approach to mechanical science." He also describes the academic freedom he enjoyed in the department, "My own stay in the Institute has been very rewarding. One thing that struck me was the amount of freedom and informality that existed at that time. I am not sure that the same level of freedom and informality exists now. Informality means there were no real barriers to interacting with professors, and professors were like friends."



IISc was comparatively slow to expand in the field of solid mechanics, but witnessed a flurry of faculty recruitments, and student enrolments in different specialisations of engineering design in the 1970s. According to Prof KRY Simha, Emeritus Professor from the department, "Prof P Srinivasan introduced research and teaching on mechanical vibration, beginning in 1951, along with Prof MR Raghavan, who dealt with the dynamics of machinery and mechanical design. These pioneers taught all the students of Power Engineering from both Electrical and Mechanical sections."



The power batch: *The ME faculty along with the final year PE (Electrical) students, 1963-64. At the time, the PE department had two divisions, Electrical and Mechanical*

Prof LSS's expertise in the optical methods of stress analysis helped advance research in experimental solid mechanics in the newly merged ME department. Dr KSS Aradhya reminisces about Prof LSS as a disciplined, deadline-driven person and an excellent teacher who loved to be around his lab. "Prof Srinath's courses on Solid Mechanics, Experimental Mechanics, and Theory of Elasticity were so popular in those days that they used to attract lots of students from other departments, and a few professors as well."

Kaleidoscopic vision: *Scattered fringes as seen in the polariscope designed by Prof Srinath*

"The subtle power of scattered light stress analysis, which Prof LSS developed with Prof Max Frocht, an illustrious student of Prof SP Timoshenko, greatly enhanced the scope of 3D experimentation," says Prof Simha. It was during this time that the faculty across departments and disciplines interacted actively and offered several basic courses and electives that covered the entire gamut of solid mechanics. Other participating faculty of the ME department included Profs N Srinivasa Murthy, DL Prasanna Rao, TS Mruthyunjaya, PR Arora, NS Bapat and Udipi Shrinivasa. The surge of talent during this period was countered by uneven Solid Mechanics requirements across departments. This led to the inevitable production of books and course materials, which were suited to universities and institutes in India. Prof LSS's technical books inspired generations of students pursuing higher education. He trained his doctoral students to prepare course syllabi and design training courses for industries, and set up the Centre for Continuing Education at IISc. He also delivered faculty training programs for the teachers in technical institutions at the time while serving as the President of the Indian Society for Technical Education.

In the early 1970s, the ME department also initiated R&D in social engineering, focusing on rural problems in addition to meeting urban challenges. Prof Udipi Shrinivasa quotes Prof Roddam Narasimha, former Director of NAL and NIAS, who said right after the 1971 oil crisis:"Our villagers would not be able to stand another crisis of this kind. We won't be able to pump water for food production."

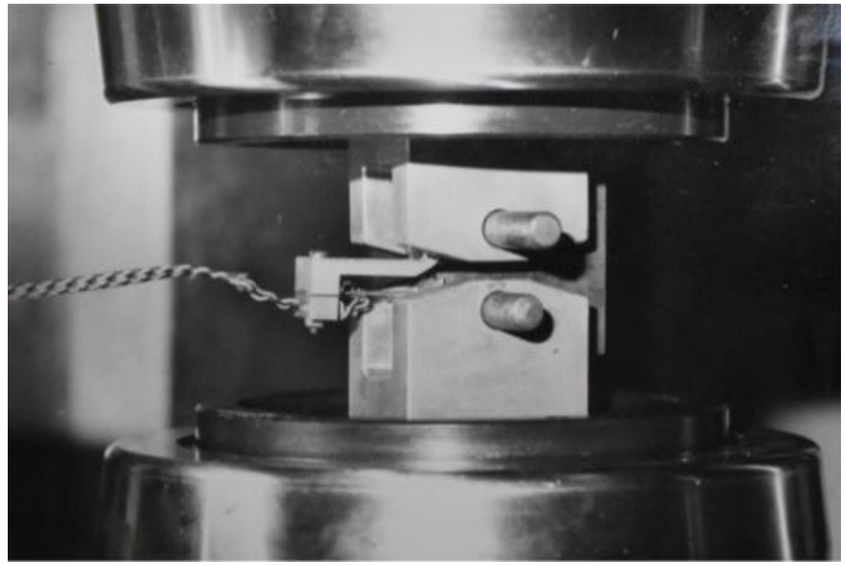
In privileged company: *(L to R): Prof A Ramachandran, Prof LS Srinath, Prof P Balaram, Director of IISc, Prof MV Krishnamurthy at the Institute's Centenary celebrations, 2008*

Prof Shrinivasa collaborated with Prof HS Mukunda, former Chair of the Department of Aerospace Engineering at IISc, to build gasifiers. He also headed the first Advanced Product Designing and Prototyping (APDAP) group, where rapid prototyping, die-making for industries, and R&D for the defence sector were carried out. "The Mahindra Scorpio rear-end mirror casing comes out of our design," he says. Prof Shrinivasa designed and developed helmets for fighter pilots. He also contributed to the development and exploration of alternative biofuels, such as *Pongamia pinnata* ['Honge' in Kannada].

Carrying the ME story forward: *The ME department, 1985*

One of the longest running courses in design, called the Design of Engineering Systems, was initiated in 1963 by Prof MR Raghavan. The course, which has since been renamed as Creative Engineering Design, is currently taught by Amaresh Chakrabarti, Professor and Chair of CPDM, who is also an alumnus of the ME department. Prof Mruthyunjaya, a former faculty of the department and Raghavan's student, joined the Master's programme at the ME department when only two faculty members, Profs Raghavan and P Srinivasan, worked on design research. Prof Mruthyunjaya says, "[The] ME department in IISc became a centre of research activity in India in the field of Mechanisms." He recounts how he became deeply interested in creative engineering design through the lectures of Bernard Roth, a Visiting Professor from Stanford University, in 1984. He studied design methodology during his sabbatical as a Visiting Professor at Ohio State University and took over the engineering design course in 1988 following his return to the department.

A two-year Master's program in Design, which started with inputs from colleagues at the Centre for Electronics Design and Technology (CEDT), now known as the Department of Electronic Systems Engineering, led to the transformation of the Central Workshop into the CPDM in 1996-97. Prof Mruthyunjaya was the first Chair of the new CPDM department, which also had a Master's programme in product design. Around the same time, the faculty of the ME department joined hands with Tata Consultancy Services (TCS) to start APDAP to provide design services for a slew of industry clients including BHEL, TVS, GM India and DRDO.



Compact tension sample testing of fatigue threshold[21]

The goal of this venture was to take a product from the drawing board all the way up to prototyping and work with industry partners for large-scale manufacture.

Work in Solid Mechanics flourished with the induction of professors, such as Prof Simha, who applied experimental, theoretical and computational solid mechanics to study fracture phenomena in the 1980s, and initiated the first graduate-level course on fracture mechanics in India. "Encouraged by the enthusiastic response from students and engineers enrolled from within and outside IISc, a book on fracture mechanics for engineering design was published, besides a couple of books on fracture of solids and structures for impact and blast loading scenarios," Simha says. "Just like hydrodynamic turbulence, fracture and fragmentation of solids obey power law cascades under intense loading, which is immensely significant to powder technology and pharmaceuticals."

[21] *From Raghu V. Prakash's thesis Fatigue threshold ductile iron, 1988.*

The current trend to explore exciting new avenues of experimental, theoretical and computational solid mechanics in the ME department is being overseen by Prof CS Jog, R Narasimhan, and Ramsharan Rangarajan. Manufacturing and Design, including Finite Element Analysis (FEA), continue to remain an important part of the department. Prof Mruthyunjaya's student, Dibakar Sen, who is now a Professor at CPDM and ME, along with Prof GK Ananthasuresh, Professor and Dean of Division of Mechanical Sciences, are advancing the frontiers through their work on Compliant Mechanisms and their applications into diverse areas of science, engineering and medicine.

The ME faculty, led by Prof K Srinivasa Murthy and Pradip Dutta, set up the National Facility for Semisolid Forming (NFSSF) in 2004 with funding from DST, DRDO and the Ministry of Mines. NFSSF researchers developed an indigenous version of thixocasting which has proved tremendously useful in the manufacture of light-weight vehicle components, including parts for two-wheelers manufactured by TVS Motors. At the turn of the century, newer research areas were developed by Profs Ashitava Ghosal, B Gurumoorthy, Rudra Pratap, who is currently the Vice Chancellor of Plaksha University, Mohali, and served as the Dean of Planning and Infrastructure at IISc, and Anindya Chatterjee, presently at IIT Kanpur. They established groups specialising in Computer Aided Design (CAD), MEMS and nanotechnology, multibody dynamics and control, and robotics.

These are the core strengths of design research anywhere in the world. Prof Rudra Pratap played an instrumental role in establishing the Centre for Nano Science and Engineering (CeNSE) in 2010 and served as the founding Chair. ME faculty, Profs Ghosal, Ananthasuresh and Jayanth GR, helped to establish the Robert Bosch Centre for Cyber-physical Systems (RBCCPS). Later Dr Jishnu Keshavan joined the department to study problems in robotics. As Prof Gurumoorthy says, "The best products of the department are the students themselves."

During the early years of the ICE department, Dr Raman studied the lubrication aspects of IC engines and taught a course on Tribology, extending the pioneering work of Prof Raghavan. Prof Sanjay K Biswas later expanded work in tribology, specialising in contact mechanics, dry friction and wear. Prof MS Bobji, Professor at the ME department, recalls Prof Biswas' conversation with Prof Satish Dhawan, "Dhawan encouraged me [Biswas] to join IISc." Biswas designed and developed the 'pin-on-disc' instrument for simultaneous measurement of friction and wear in materials shortly after joining the department. The primary innovation of his design was to measure the wear rate in real-time which translated into a commercial success. Several engineering colleges today have one such instrument as a part of their research training.

Biswas brothers in arms: *Sanjay (left) with brother Siddharth (right) and a student*

Mr Shyam Sundar recalls how the Tribology lab had no equipment when he started working in the department. The group soon acquired an adhesion rig, journal bearing rig, thrust bearing rig, scratch tester, indentation tester and nanoindenter thanks to generous funding from public and private agencies. Prof Biswas also acquired a Scanning Electron Microscope (SEM) and Image Analyser in 1988. Collaborations with major Indian oil companies resulted in the development of new instruments to measure forces between engineering surfaces with specific topographies, atomic force microscopy, and an in situ Raman tribometer to track changes in surfaces in the presence of lubricants.

New technology: *Mr Shyam Sundar seen operating on the first SEM of the ME department, 1988*

Joy of work: *Students in the tribology laboratory in the 1990s*

Prof Biswas served as the Chair of the ME department and later as Dean of Engineering.[22] As an administrator, Prof Biswas ushered the Bioengineering program at IISc, which catalysed collaborations between biologists and engineers. This culminated in the establishment of the Centre for Biosystems Science and Engineering (BSSE) in 2012 with funding from the Department of Biotechnology. Prof Ananthasuresh served as the founding Co-Chair of BSSE. The seed for interdisciplinary work in Bioengineering propelled newer research areas such as biomechanics and mechanobiology, with active participation from the faculty of the ME department, Profs Namrata Gundiah and Aloke Kumar, among others. A decade following Prof Biswas' dream for a vibrant community of interdisciplinary research in bioengineering, IISc is all set to start a postgraduate medical school, with a full-fledged hospital with research and diagnostic facilities.

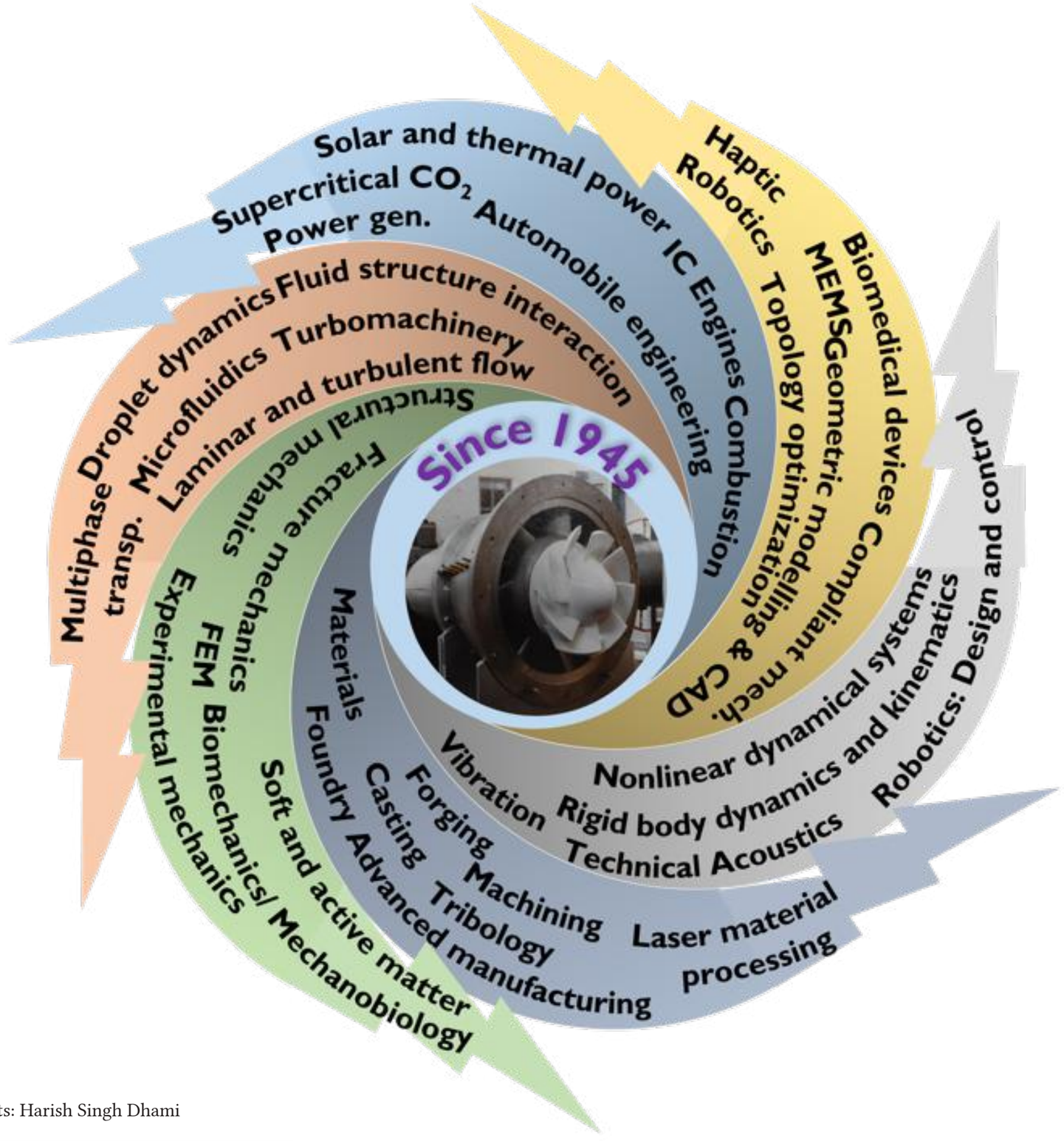
[22] *From http://eprints.iisc.ac.in/47221/1/Cur_Scie_104-12_1718.pdf*


ME Main Building
ME
Labs
PE Building
TPS Building
ME Quadrangle
Sump

2 | Glimpses of ME research and education

From the days of the ICE and PE departments to mechanical engineering activities as it stands today, the ME department has continued to break new ground across different research areas. Over the last 75 years, the ME faculty has contributed to the evolution of a robust curriculum through the publication of books in classical and emerging areas of research, which have been well received both at home and abroad. If the purpose of research is to investigate and create new knowledge, and to enable the transition of this new knowledge to its application for the benefit of larger society, it is indeed a testimony to the fact that the department has kept up with the times to remain relevant in the modern interdisciplinary age.

The department and the sylvan surroundings: *Aerial view of the ME department*



Credits: Harish Singh Dhami

2022

1945

2.1 | Present areas of research

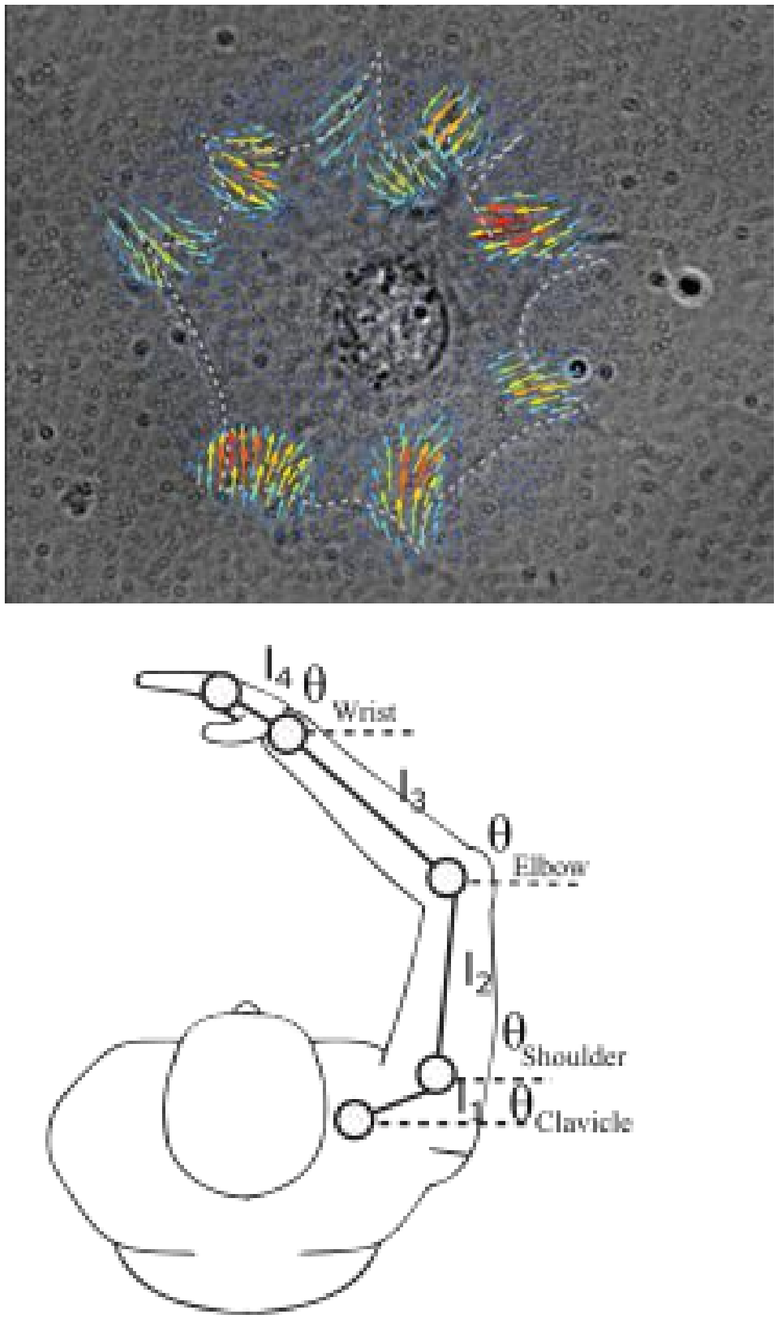
With the intent of extending the frontiers of contemporary research, the ME department has, over time, embraced emerging interdisciplinary topics alongside the traditionally core areas of mechanical engineering. This research journey traverses and knits together relevant themes in materials, structures, mechanisms, manufacturing, fracture, tribology, dynamics, vibration, design, control, computational modelling of solids and fluids, experimental fluid dynamics, multiscale and multiphase physics, biomechanics, robotics, turbomachinery, combustion and fuel technologies, energy transport and storage, power generation, micro and nanoscale phenomena, and soft active matter among others. The rich diversity in faculty backgrounds enables the department to explore a blend of theoretical, experimental and applied studies.

2.1.1 | Biomechanics and Biomedical Devices

Research Areas

- Biofilms
- Cell Mechanics
- Mechanodiagnostics
- Mechanobiology
- Hemodynamics of endothelial cells
- Protein design
- Bio- and Biomedical devices
- Laparoscopic Apparatus

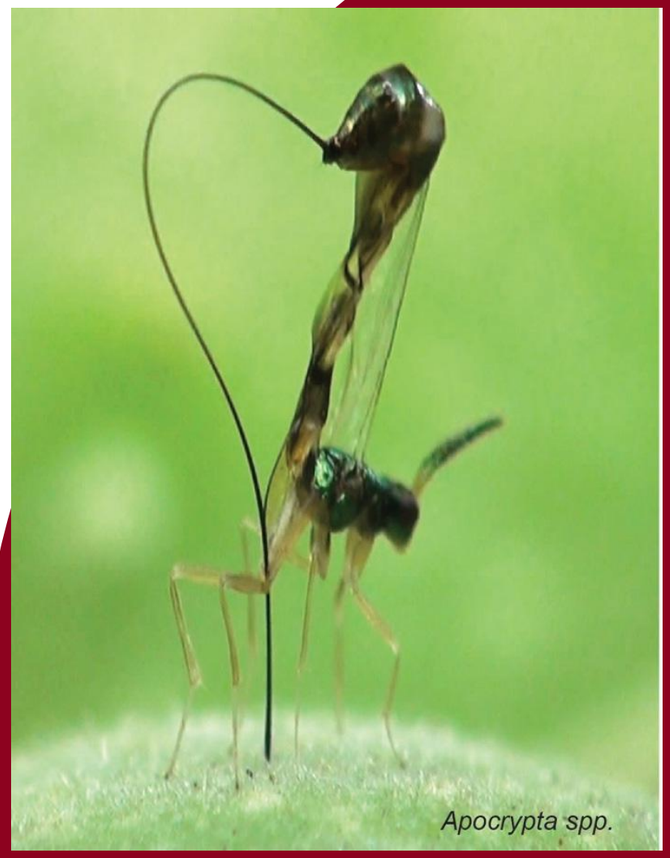
The ME department houses full-fledged laboratories equipped with cell culture rooms, microscopes, instruments and software for mechanical characterisation, protein quantification and software which integrates capabilities in research at the interface of mechanics and biology. Faculty conduct research on cell and tissue mechanics, as well as bacterial biofilms. Additionally, there are design and prototyping facilities to develop biomedical devices. Work in biomechanics was started by Prof GK Ananthasuresh with bio-micromanipulation of single cells to characterize mechanical responses. Prof Namrata Gundiah, with her interest in tissue and cell mechanics, substantially enhanced the scope of research in this area. Her work has resulted in several patents, and novel methods to quantify cancer cell adhesions to substrates.

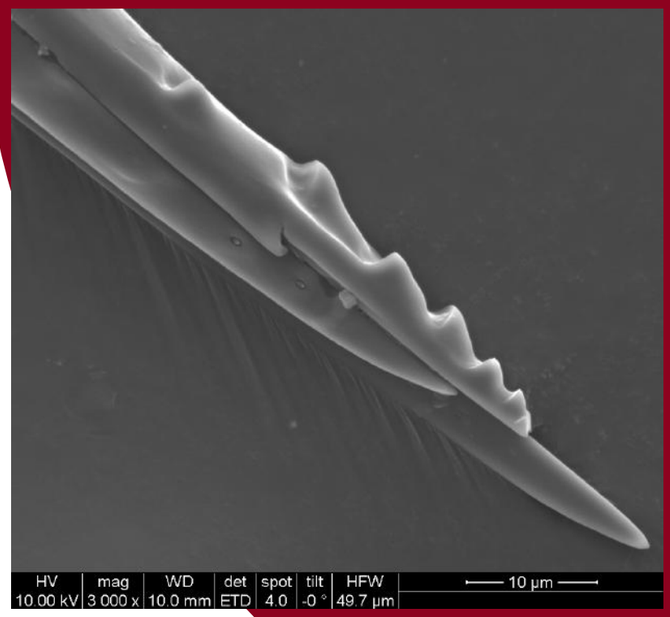


(Top): Cell tractions on polyacrylamide substrates;
(Bottom): Arm model and tracker positions to measure joint rotation angles

More recently, she and Prof Jaywant Arakeri collaborated to elucidate the role of hemodynamics in endothelial mechanobiology. Profs Bobji and Gundiah's groups have quantified insect-based materials using atomic force microscopy. Prof Ashitava Ghosal, in collaboration with Prof Aditya Murthy and researchers at the Centre for Neuroscience, has revisited the issue of redundancy in human arms which is an important problem in robotics. Their studies suggest new insights into the resolution of this redundancy in tasks such as the numerous configurations one can take when touching one's nose.

Prof Aloke Kumar's group presents another line of research with the study of biofilm viscoelasticity. In collaboration with Dr Koushik Viswanathan, Prof Kumar's group uses bacterial cultures to induce calcite precipitations of Martian and Lunar simulant soils as space "bricks." Projects in agriculture were also started by many members of the department that address problems at the interface of plant physiology and engineering.



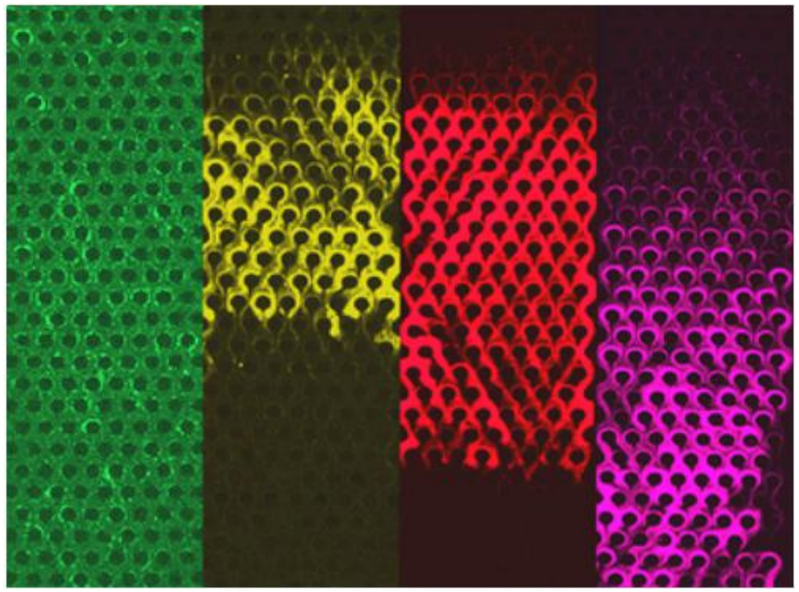


(Right): The insect and the tool for cutting through hard substrates; (Top): An endoscopy simulator developed by Mimyk

The area of research continues to grow in collaboration with other departments and centres, like the BSSE, within and outside IISc. It is worth noting that two start-up companies were successfully spun off from the biological research here in the Department from Prof Ananthasuresh's group. One is BendFlex, which is currently pursuing an *in vitro* fertilization chip using mechanical manipulation and characterization techniques developed in-house. The other is Mimyk, which specialises in medical simulation tools based on an endoscopy simulator developed here.

Faculty

- Prof GK Ananthasuresh
- Prof Jaywant H Arakeri
- Prof MS Bobji
- Prof Ashitava Ghosal
- Prof Namrata Gundiah
- Prof Aloke Kumar



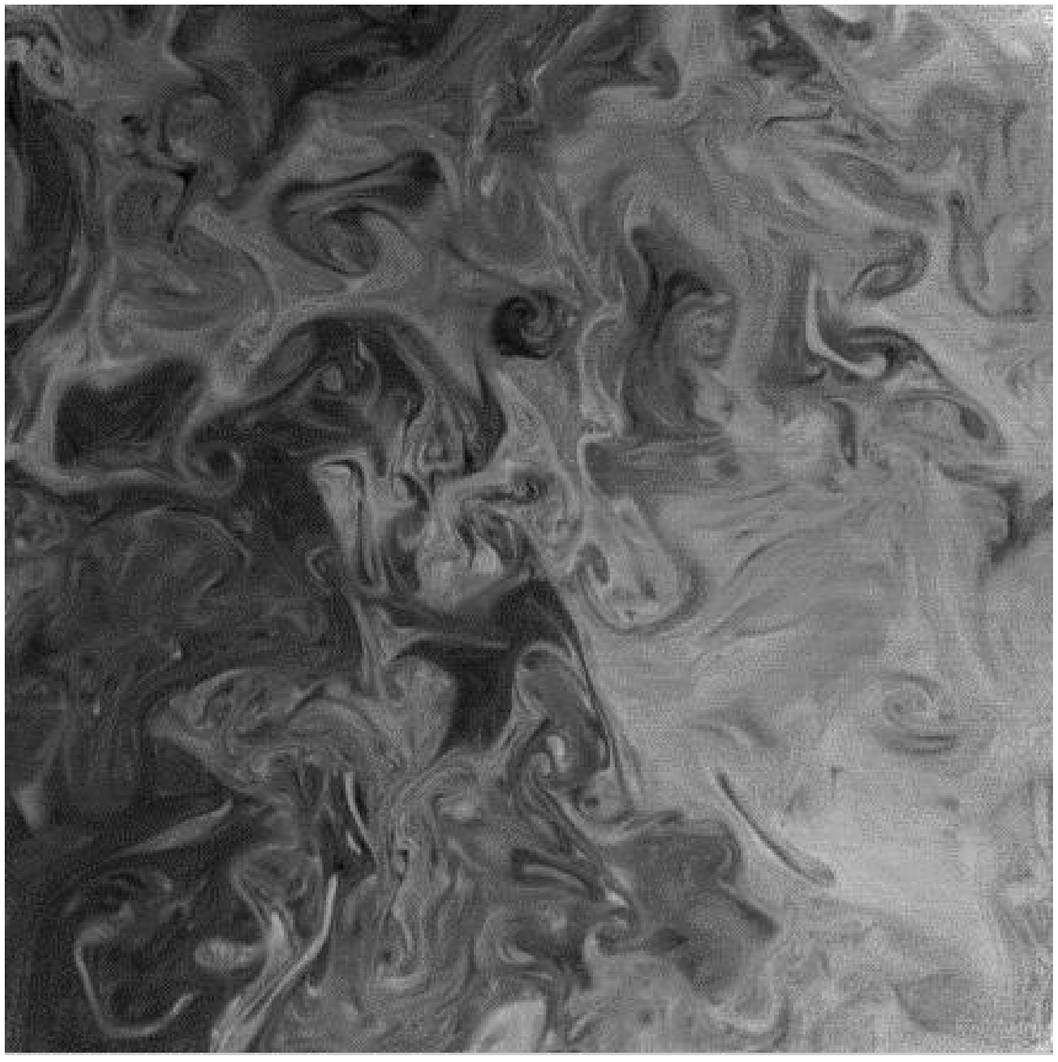
Post clogging behavior of bacterial streamers in a microfluidic device containing a micropillar array

2.1.2 | Fluid mechanics and flow physics

Research Areas

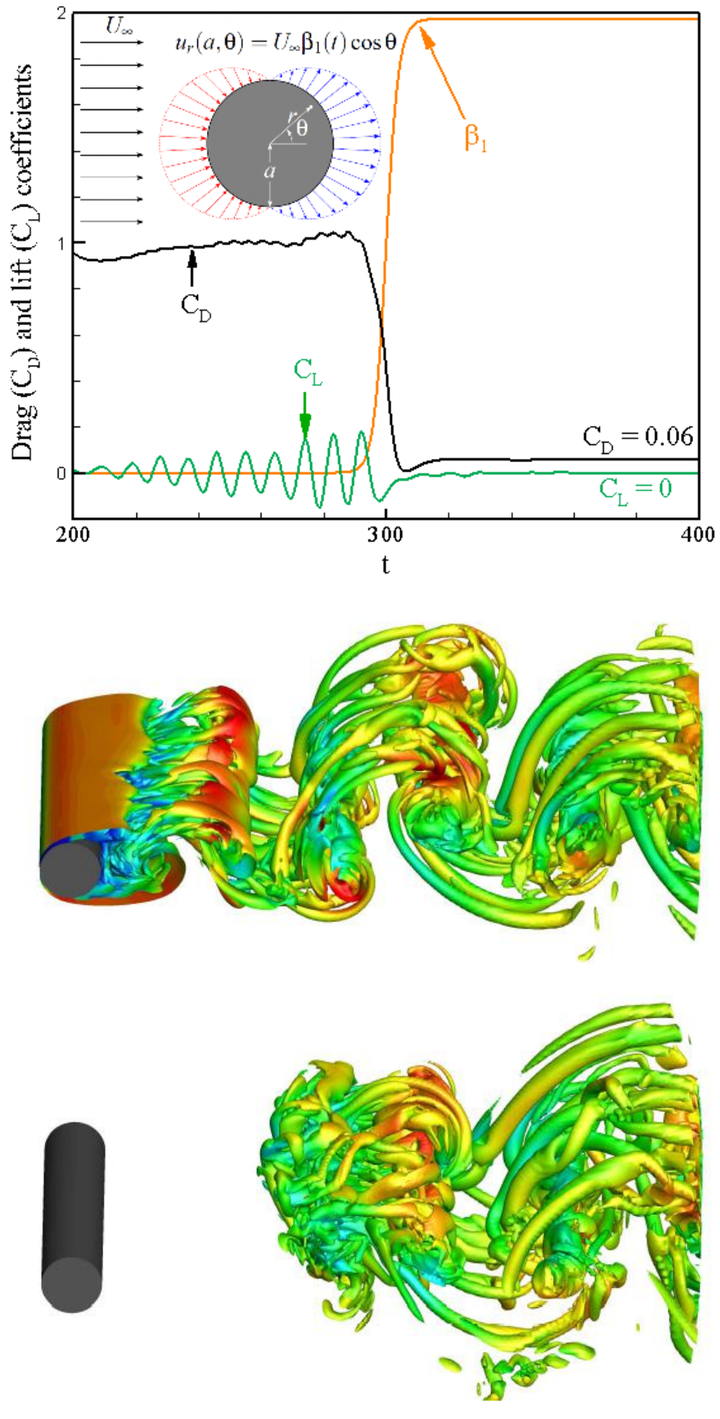
- Turbulence
- Thermal convection
- High-speed multiphase compressible flows
- Shock boundary layer interactions
- Drag reduction using bubbles and surface actuation
- Transonic/Supersonic flows
- Bio-inspired unmanned water vehicles
- Biofluid mechanics
- Drop/Bubbles in Electric Fields
- Liquid jet atomization in a crossflow
- Complex fluids
- Multiscale simulations
- Precision agriculture

The faculty at the department research a range of fluid mechanics phenomena using both experimental and computational methods. Prof Arakeri's group has been actively carrying out experimental research in turbulent natural convection since the late 1980s. His activities have now diversified into applied areas including precision agriculture in protected environments. The experimental capability of the fluid mechanics team was enhanced after Prof Raghuraman N Govardhan joined the department in the early 2000s. His areas of interest include drag reduction, interaction of vortex with bubbles, turbomachinery flutter and shock boundary layer interactions.

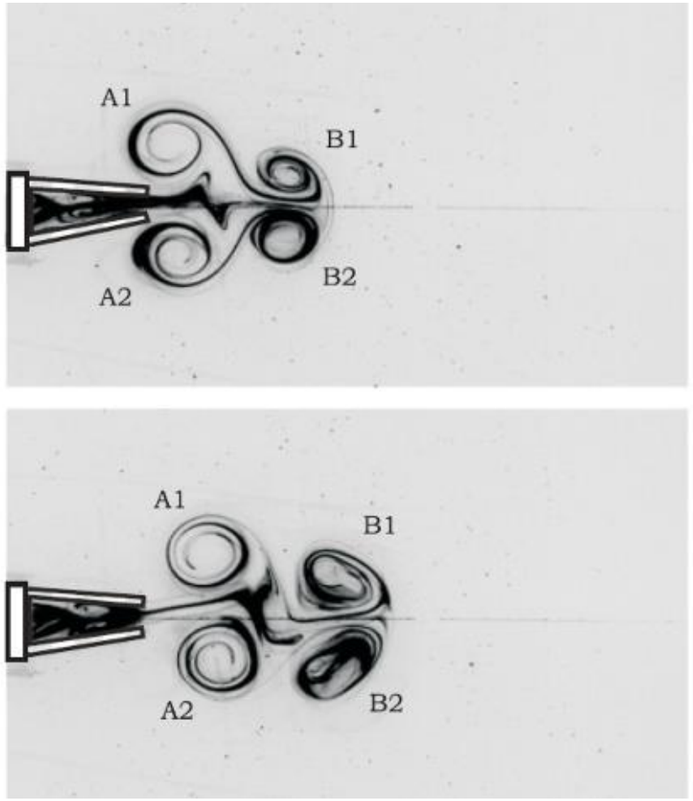


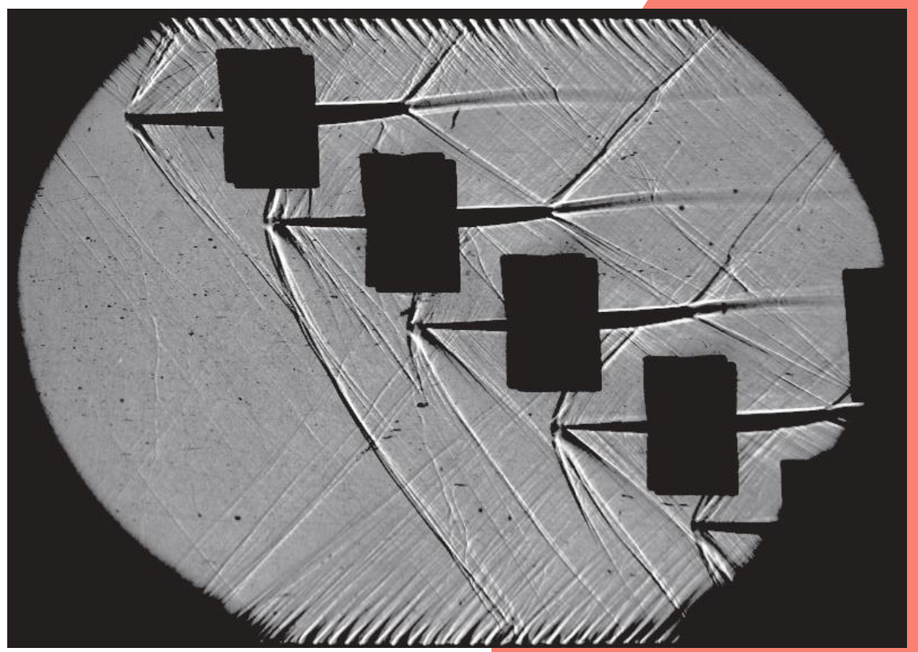
New type of Turbulent flow. *Axially homogeneous convection in a tube*

Profs Ratnesh K Shukla and Gaurav Tomar strengthened the computational aspect of the fluid mechanics group. Together, they cover a wide range of topics in computational fluid dynamics (CFD) involving multiscale, multiphase and complex non-Newtonian flows. Prof Aloke Kumar has also joined this group, introducing the relatively nascent area of complex fluids. The newest addition to the group is Dr Balachandra Suri, who works on dynamical systems approaches to understanding transitional turbulence

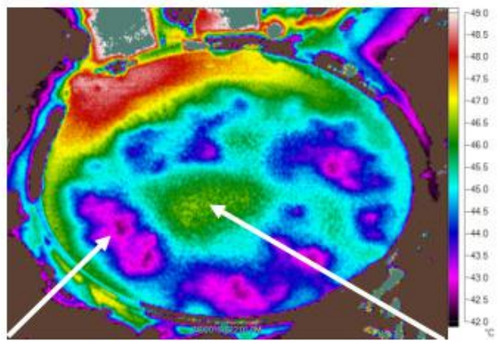


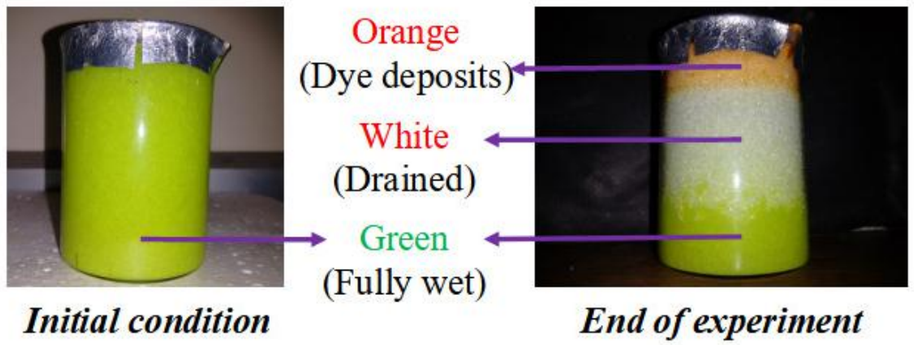
Drag reduction and flow control at Re_D = 1000





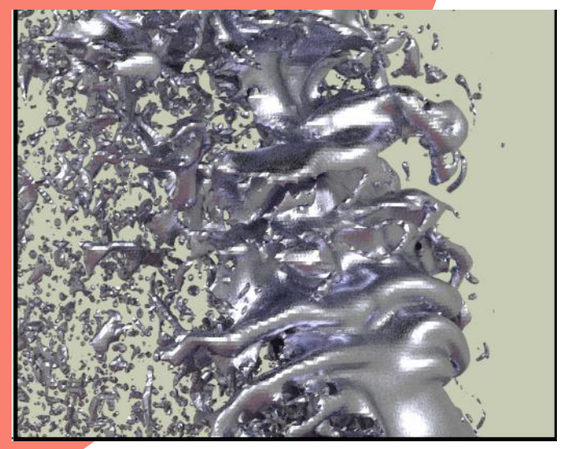
Squid-like propulsion: *(Left): Vortex patterns formed at flexible nozzle exit;* ***Transonic flow:*** *(Right): Shock patterns in a transonic compressor cascade*





Evaporation from conventional porous media: *(Left): Wet film (pink colour) about 40C less than the dry region (dark green colour); (Right): Fluorescein dye showing evaporation sites*

The experimental and computational teams collaborate on a number of challenging and interesting fluid dynamics problems such as optimal surface actuation for drag reduction, thrust from rigid/flexible flapping foils for 'robotic fish', and biofluid mechanics involving flexible surfaces and unsteady boundary layers.



Simulations of liquid jet breakup in crossflow

Faculty

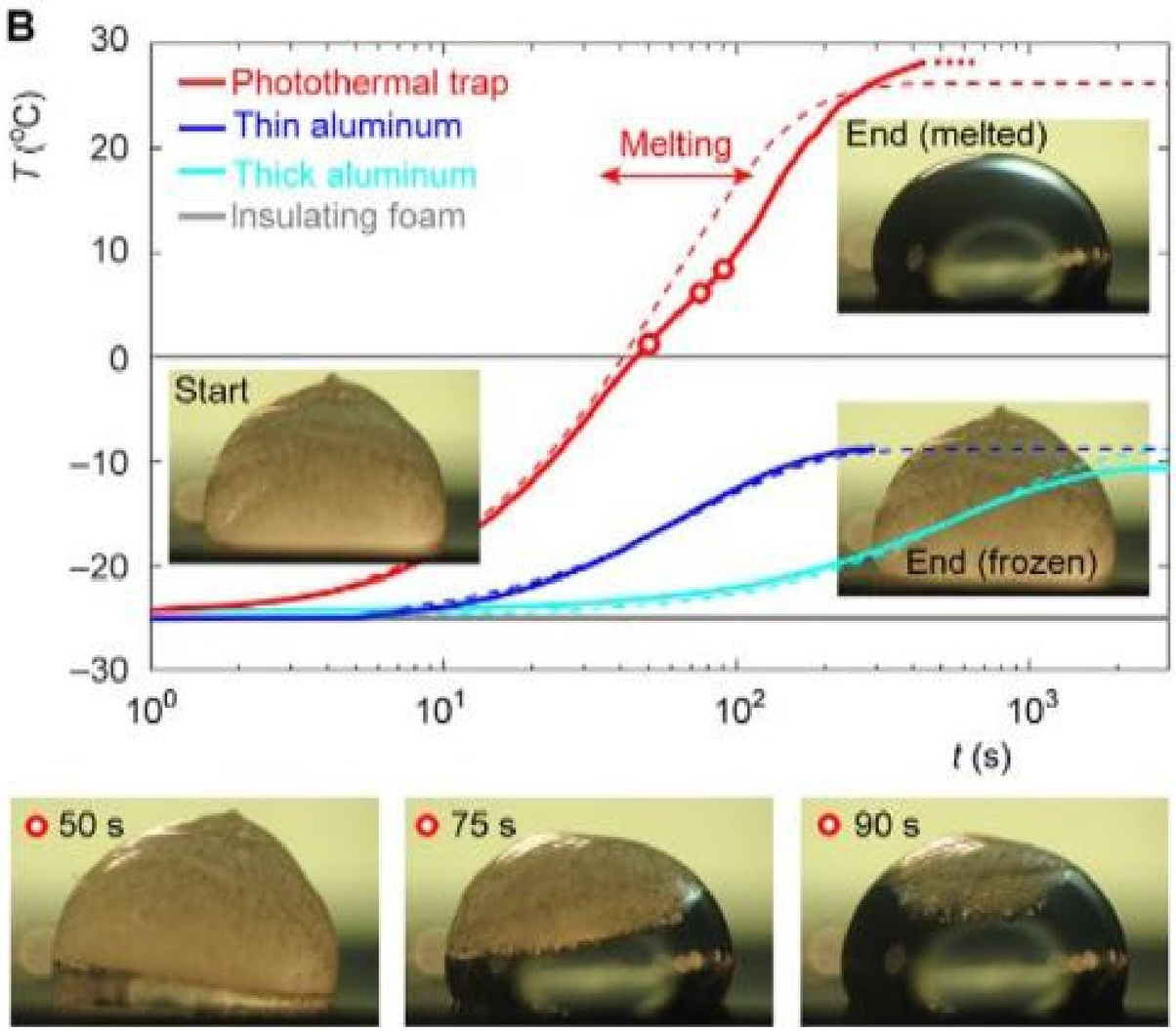
- Prof Jaywant H Arakeri
- Prof Saptarshi Basu
- Mr C Dharuman
- Prof Raghuraman N Govardhan
- Prof Aloke Kumar
- Prof Ratnesh K Shukla
- Prof Gaurav Tomar
- Dr Balachandra Suri

2.1.3 | Heat transfer and energy systems

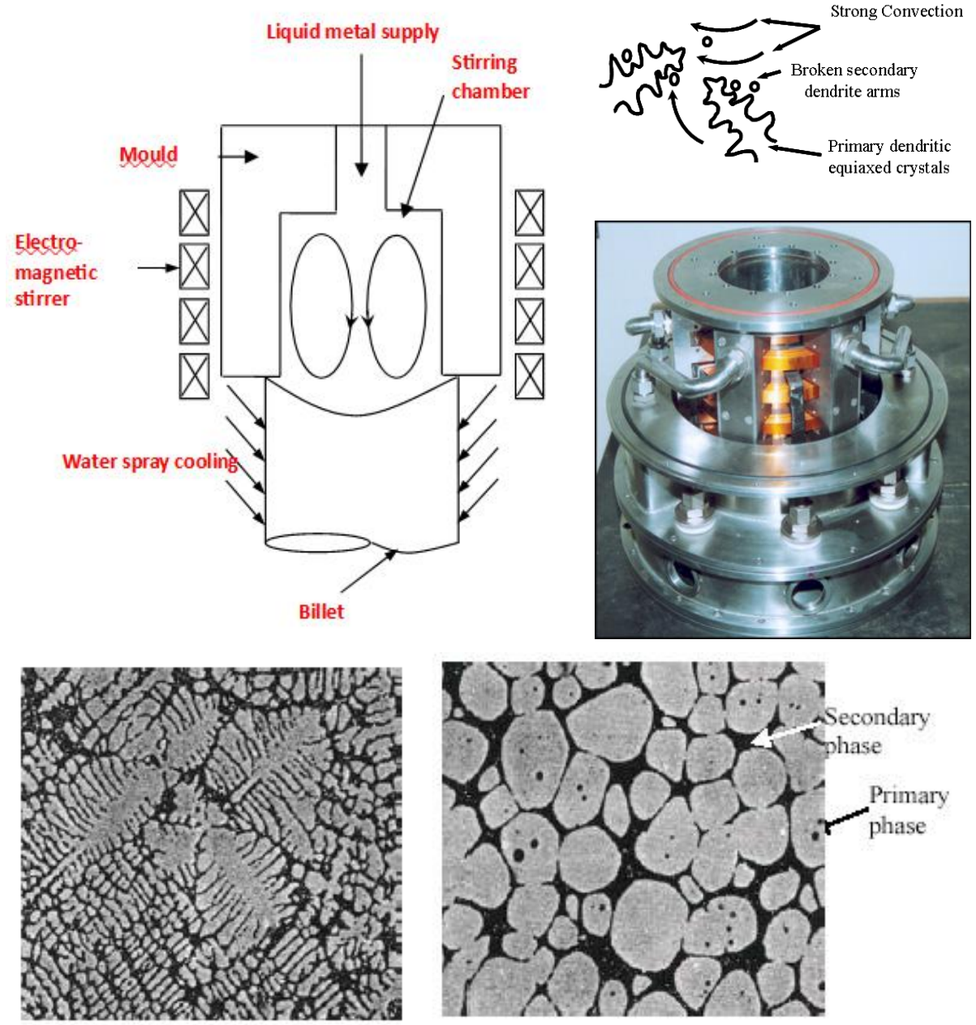
Research Areas

- IC Engines
- Surface-engineering and anti-scaling for enhanced fluid-thermal transport
- Supercritical CO2 Brayton cycle: power generation
- Thermal management and turbomachinery,
- High temperature solar receivers
- Solar cooling/desalination systems
- PCM-coupled heat-pipes for spacecrafts
- Combustion and spray design and analysis
- Fuel injectors for gas turbine combustion
- Surface Patterning
- Bio-fuels for Diesel Engines

Prof Arcot Ramachandran initiated the activities on heat transfer and energy systems in the department in the 1960s — a pioneering initiative that led to the establishment of major programmes in energy research across the country. Today, the research group in thermal sciences and energy systems is the largest one in the department, and has contributed significantly in fundamental and applied research. The newly founded Interdisciplinary Centre for Energy Research (ICER) at IISc, which emerged from this group's efforts, handles some of the biggest projects in the Institute: the Indo-US solar consortium (SERIIUS), the National Centre for Combustion Research and Development (NCCRD) and the National Centre for Clean Coal Research and Development (NCCCRD).



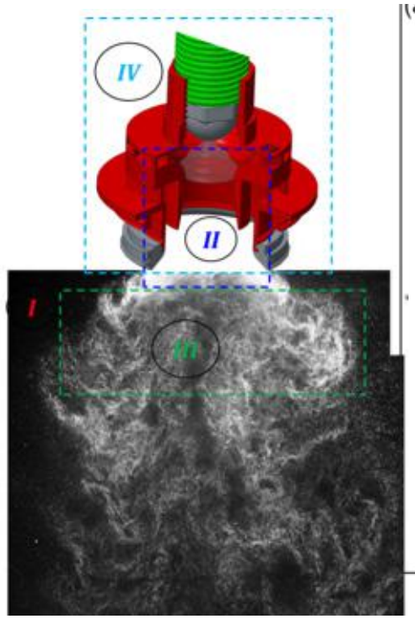
Photothermal trap for ice mitigation: *Design to increase the steady state temperature rise and reduce the time scale for heating*



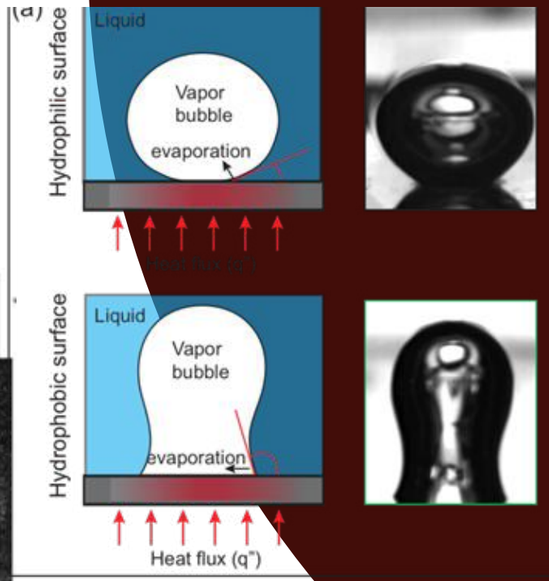
Multiphase convection: *Transformation from dendritic to globular microstructures*

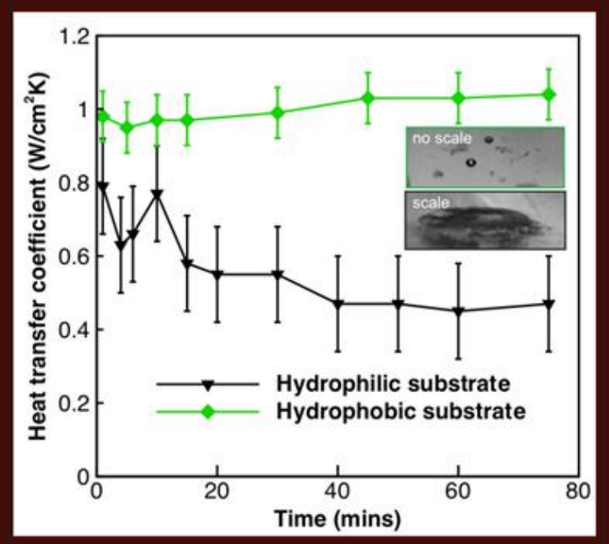
Closed loop simple recuperated s-CO2 Brayton cycle test system

Solar thermal energy storage: *Laser induced flow visualization imaging of thermal energy storage systems*



Gas turbine spray combustion





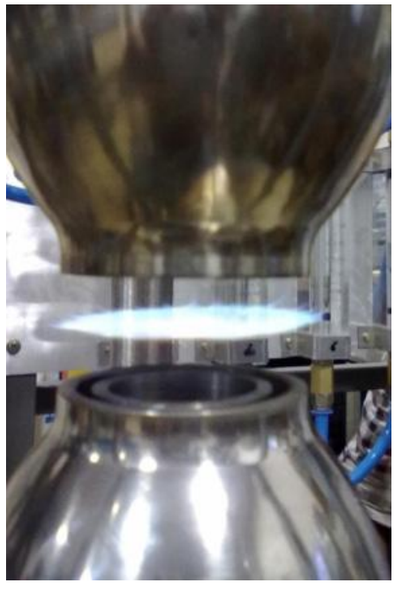
Antiscaling strategies: *Liquid microlayer during boiling altered by surface wettability that avoids crystallization-induced scaling*

The faculty of the group in the department pursue research in various areas under the theme of heat transfer. Prof Pradip Dutta's lab works on the development of cooling technologies (adsorption cooling, loop heat pipes, phase change materials) and high-temperature solar thermal receivers along with thermo-chemical storage technologies. Prof RV Ravikrishna initiated combustion research activities, which was subsequently augmented by Prof Saptarshi Basu's lab. The research areas in this subject include spray dynamics and atomisation, trapped vortex combustion, research on fuel injectors for gas turbine combustion, laser diagnostics, and combustion from levitated droplets.

Prof Pramod Kumar has developed India's first supercritical CO2 (s-CO2) Brayton test loop for power generation and is developing micro-channel heat exchangers for s-CO2. Research on IC engines is being carried out by Dr Himabindu and Dr R Thirumaleswara Naik. Dr GSVL Narasimham's lab works on cooling technologies and refrigeration. Our recent addition, Dr Susmita Dash, specialises in microscale thermal transport, while Dr Navaneetha K Ravichandran is exploring nanoscale energy transport.

Faculty

- Prof Saptarshi Basu
- Dr Susmita Dash
- Prof Pradip Dutta
- Dr M Himabindu
- Prof Pramod Kumar
- Dr R Thirumaleswara Naik
- Dr GSVL Narasimham
- Prof RV Ravikrishna
- Dr Navaneetha K Ravichandran



Counterflow Flame: *Canonical flame to study and evaluate combustion chemistry and emission formation*

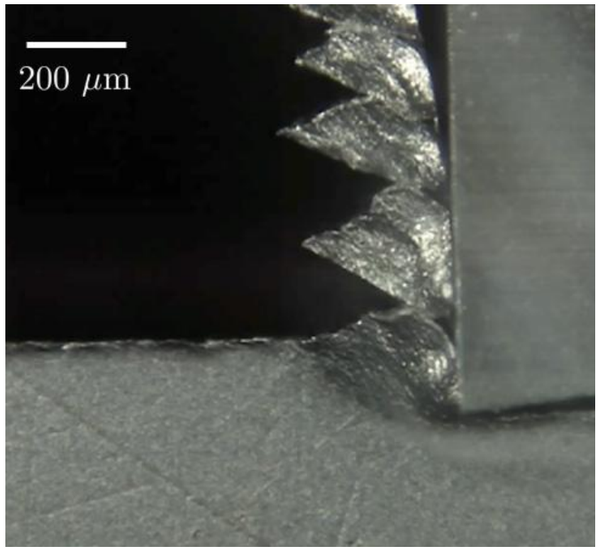
In addition to fundamental research, the group has also been actively collaborating with industries for technology development and translational research. Notable among them are the development of s-CO2 turbomachinery with Triveni Turbines by Prof Kumar, successful flight testing of loop heat pipe with ISRO by Prof Dutta, development of molten salt based thermal storage loop with HPCL by Prof Basu, and development of natural gas combustor for s-CO2 power cycle with GAIL by Prof Ravikrishna.

2.1.4 | Manufacturing and materials

Research Areas

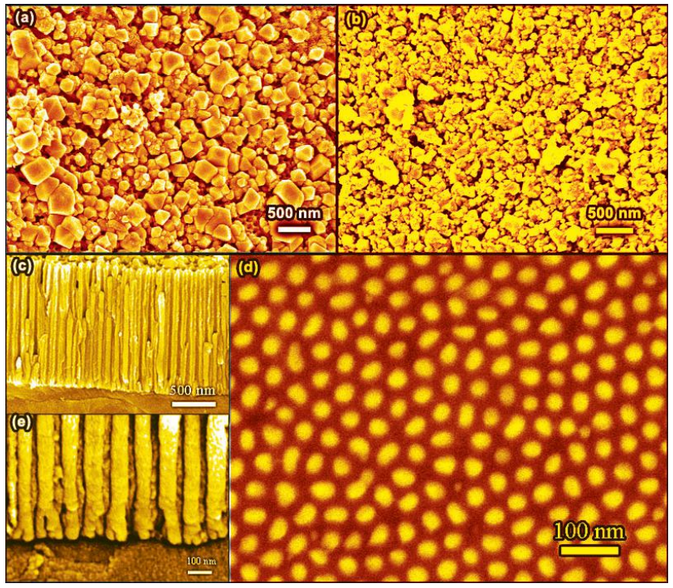
- Novel cutting and forming processes
- Processing mechanics of soft materials
- High-performance finishing processes
- Surface Roughness and Electropolishing
- Multiasperity Contacts
- Friction Stir Welding
- Metal matrix composites
- Metal Foams
- Mechanical Joining
- Heat Exchangers
- Tribology

The research groups in the area of manufacturing and materials conduct studies that aim to understand fundamental mechanisms that govern materials design, materials processing, component design and manufacturing processes and systems. Another aim of the group is to advance the state-of-the-art in materials and manufacturing technology. The labs are accordingly equipped with an array of characterisation tools and equipment including scanning electron microscopes, atomic force microscopes, contact angle goniometer, differential scanning calorimeter, dynamic light scattering particle analyser, Fourier transform infrared spectrometer, 3D optical profilometer, optical microscopes and universal testing machines.

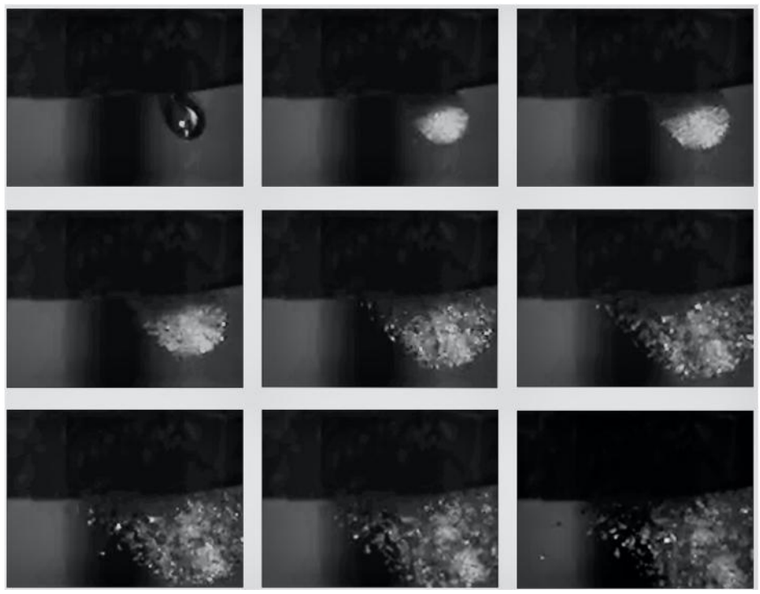


Sheet forming

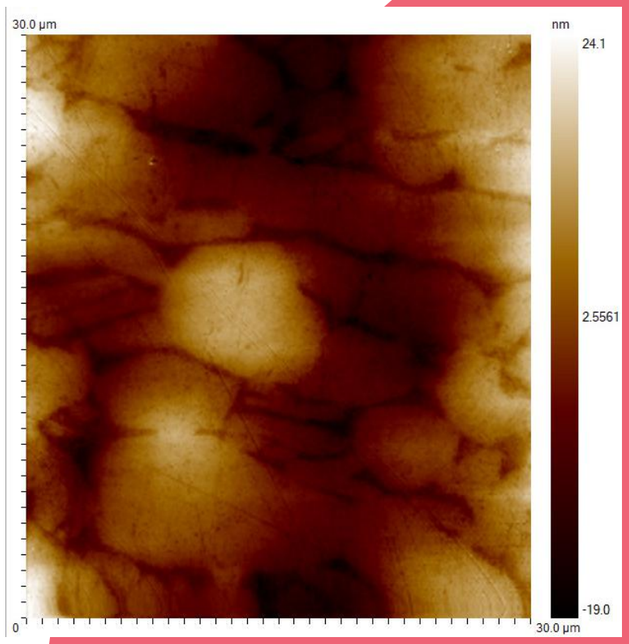
Metal foam Heat Exchangers of various pores size: *An aluminium foam heat sink*

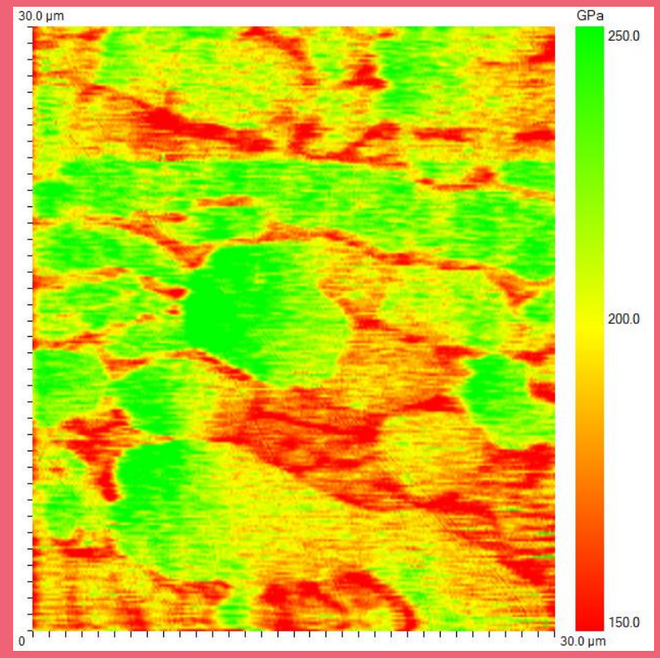


Nanocomposite coating for wear resistance

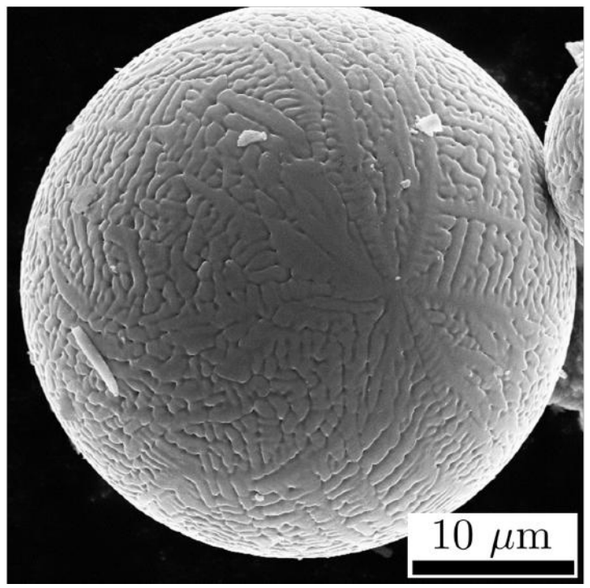


Research on tempering techniques in glass for enhanced fracture resistance. Shown here is a sequence of high-speed images depicting explosive fragmentation in tempered glass "drops"





Modulus mapping



Additive manufacturing research in ME@IISc ranges from investigating novel methods for production of metal powders (left) to the development of metal additive manufacturing systems (middle) and printing of complex multi-material geometries (right). The image in the right panel shows a complex contour print made using a combination of Inconel 718 and Stainless steel 304 on a stainless steel substrate

Prof Satish V Kailas' group has made extensive contributions to the department's capabilities in tribology. To that end, several machines have been custom-built to simulate conditions for the tribological systems under study. For example, a fretting wear tester that works under vacuum and high temperature has been built to simulate conditions of a fast breeder reactor where the primary and secondary loops work under liquid sodium at 550°C.

Several other machines like the high-temperature vacuum-based pin-on-disc machine to mimic conditions in a bearing channel during extrusion, and impact tribometer to study tribological phenomena during the start of sliding, have been designed and built. Another area of focus of Prof Kailas is friction stir welding and processing.

Prof MS Bobji examines the world of micro and nanoforces to assess the behaviour of materials at small scales in real time. His group is currently invested in developing special tools to mechanically, electrically and thermally probe things. Dr Koushik Viswanathan, studies the mechanics and physics of manufacturing processes with a focus on developing new paradigms that address the demands of emerging technologies.

Faculty

- Prof MS Bobji
- Prof Pradip Dutta
- Prof Namrata Gundiah
- Prof Satish V Kailas
- Prof Pramod Kumar
- Prof R Narasimhan
- Dr Koushik Viswanathan

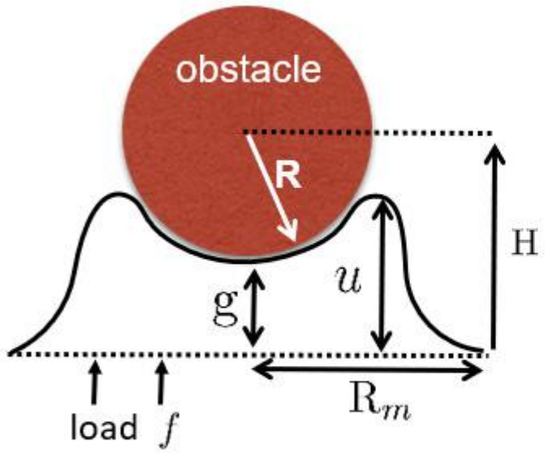
2.1.5 | Mechanics of solids and structures

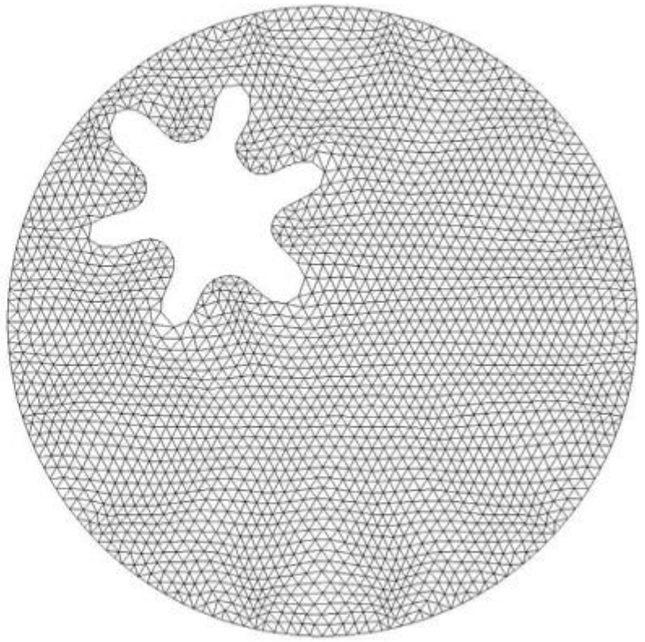
Research Areas

- Computing shapes through optimisation modelling
- Simulating and measuring shapes of buckled ribbons
- Mechanics of Soft Matter
- Mechanics of substrate boring by insects
- Computational Mechanics of solids Fracture Mechanics
- Mechanics, Optimisation, and Stability of Structures

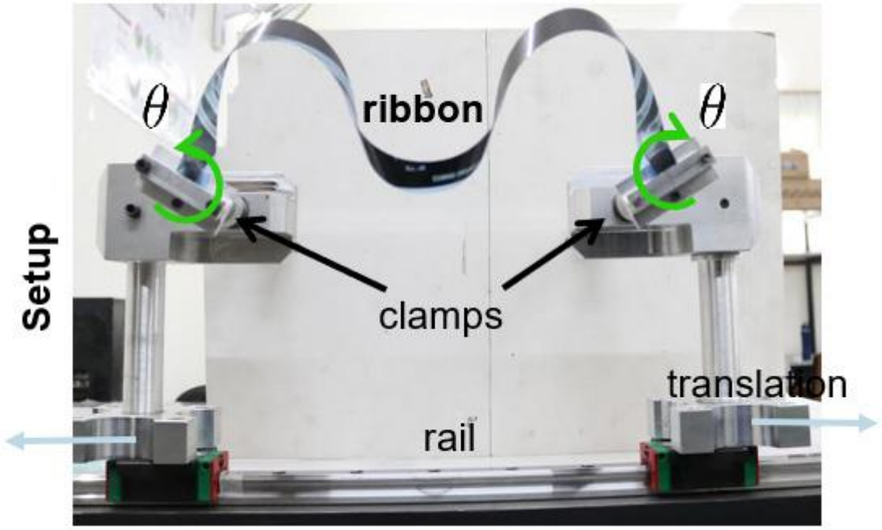
Mechanics of solids has been a longstanding interest of the department, spanning multiple scales (macro to micro) and multiple domains (fracture, MEMS, biomechanics). Research in this area involves analytical, computational, and experimental projects. Prof KRY Simha studies fracture in thin-film coating, dynamic loading on plates and shells for impact-resistant shields, and more recently, fracture in friction-stir welded joints. Prof R Narasimhan's group has been actively involved in analytical, experimental and computational studies on crack-tip fields and void growth in ductile face-centred cubic (FCC) single crystals.

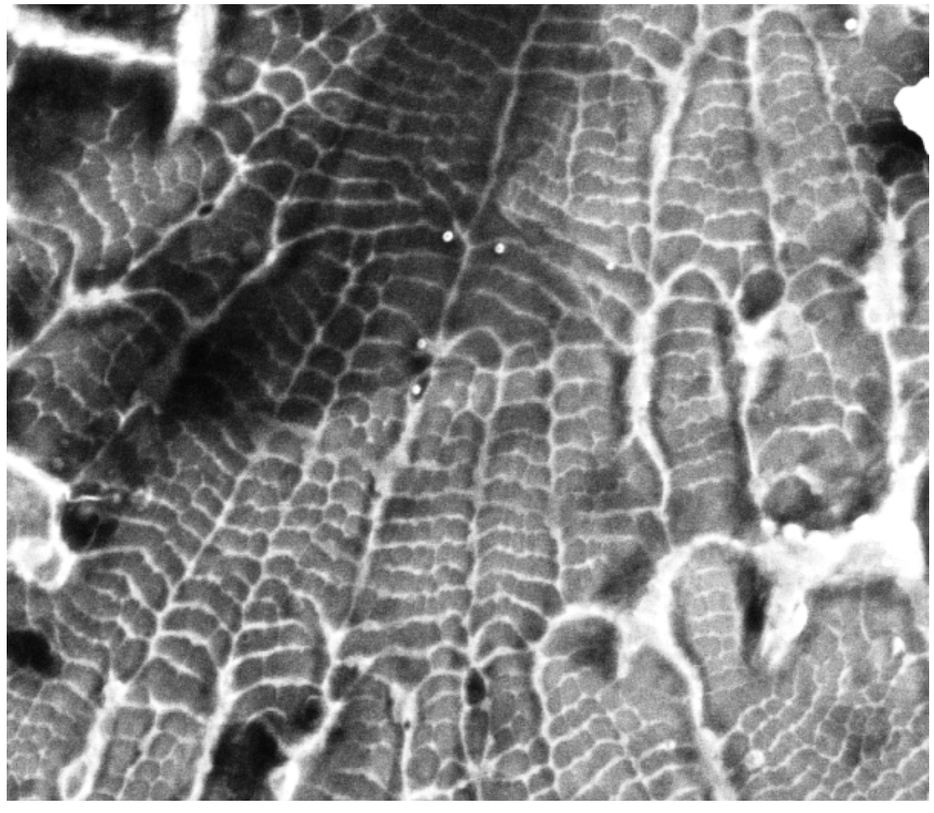
These investigations have established the structure of these fields for different lattice orientations, constraint levels and fracture configurations. He has also been working on the role of several factors such as pressure-sensitive yielding, internal friction, flow softening, Poisson's ratio and mode-mixity in the fracture response of bulk metallic glasses (BMGs). Prof CS Jog has made substantial strides on the formulation of the finite element method with the implementation of hybrid elements, wherein displacement and stress are independently interpolated for computational benefits in multiphysics simulations.



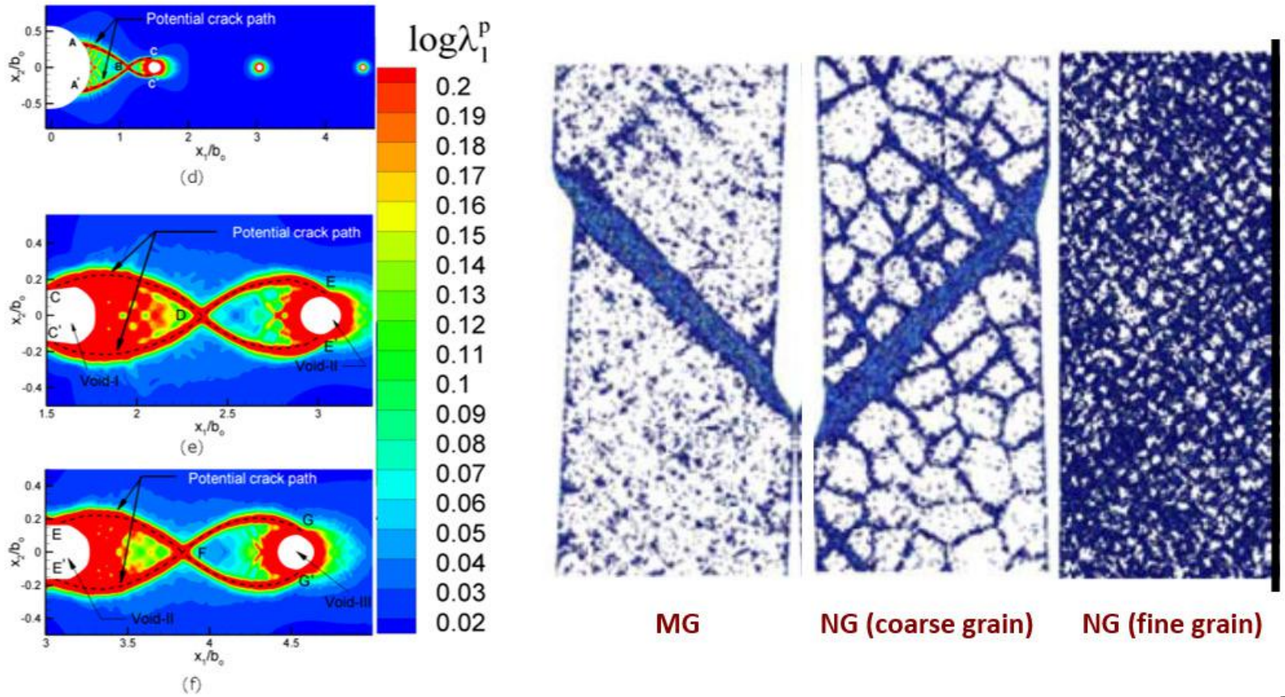


Obstacle contact problem

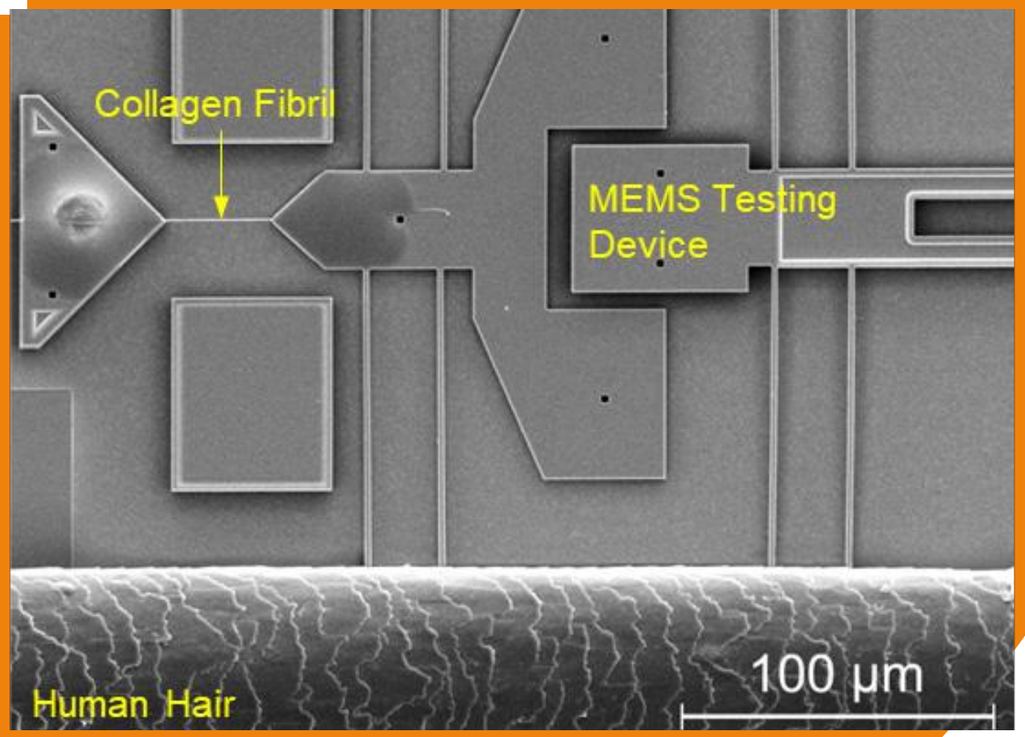




(Top): A setup to study the mechanics of elastic ribbons;
SEM fractography: *(Bottom): crack initiation and growth*

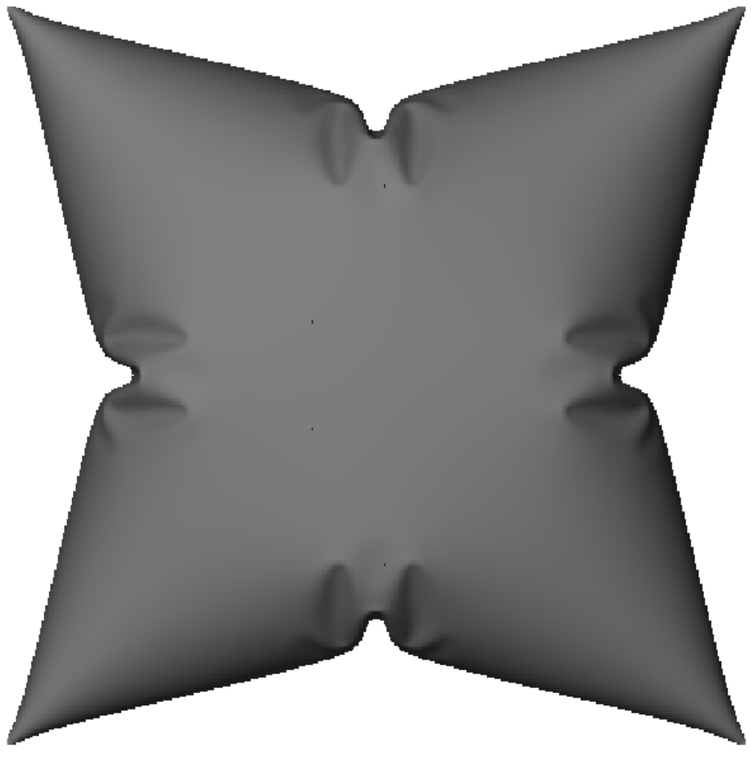


Tensile deformation behavior of nano-glasses: (Left) FEA and (Right) MD simulations



Deformation of Collagen Fibrils (~100 nm diameter)

In addition to extensive research in fracture and computational mechanics, recently a number of faculty are exploring other aspects of solid mechanics. Prof Gundiah is engaged in experimental and computational work in biomechanics of tissue and cells. She has also studied the mechanics of insect boring. Prof Rangarajan conducts research aimed at probing the role of geometry in slender structures such as beams, ribbons, and shells. Prof Ananthasuresh's group studies mechanics-based design of compliant mechanisms, growth modelling in plant leaves and inverse problems in elastic mechanics. His group has ongoing work in multiple pathways in bistable arches and shells with innovative designs of devices that exploit this feature.



Simulation of the inflation of an airbag using hybrid elements

Faculty

- Prof GK Ananthasuresh
- Prof MS Bobji
- Prof Namrata Gundiah
- Prof CS Jog
- Prof R Narasimhan
- Prof Ramsharan Rangarajan
- Prof KRY Simha
- Dr Koushik Viswanathan
- Dr Debashish Das

2.1.6 | Mechanisms, design and optimisation

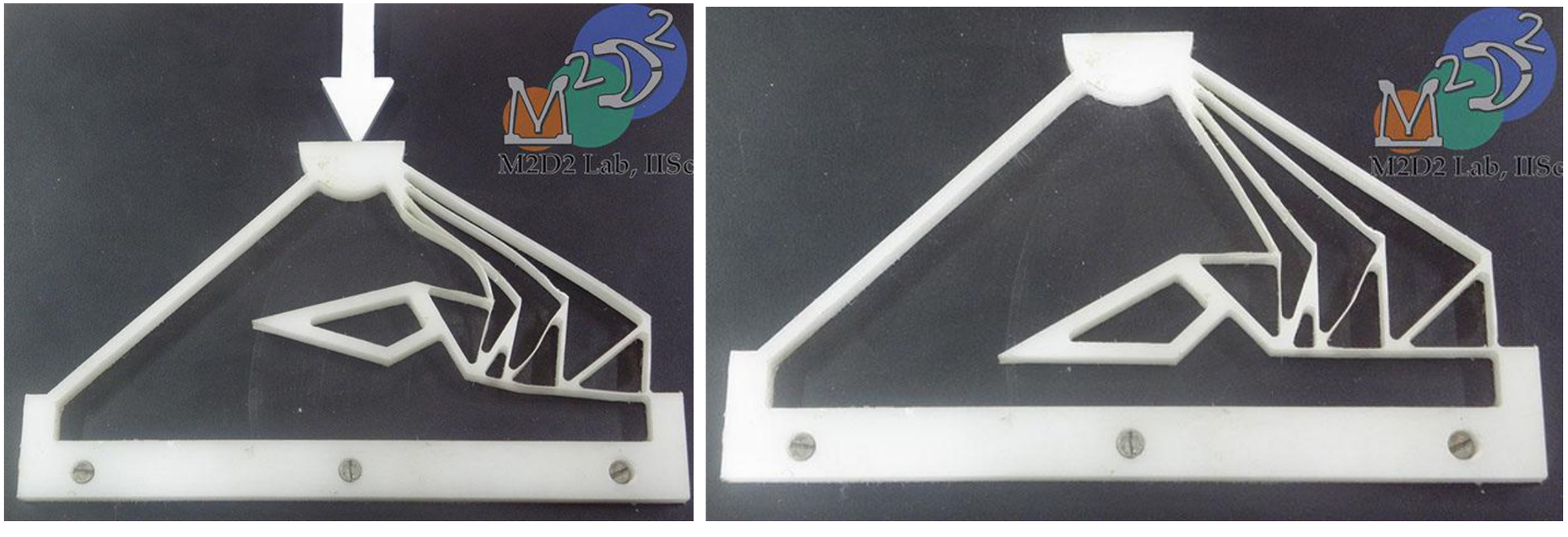
Research Areas

- Geometric approach to kinematics
- Compliant mechanisms
- Modelling of heterogeneous objects
- Mesh-based representation
- Topology and shape optimisation

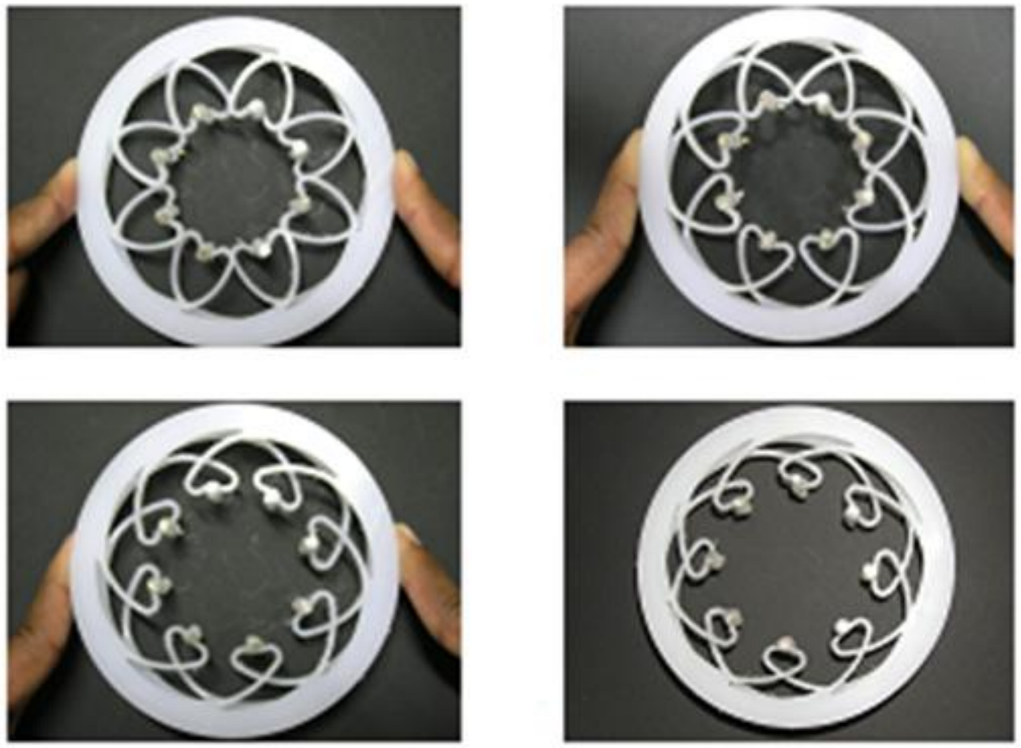
Research in mechanisms and design has been pursued in the department for a few decades now. It is worth noting that the Centre for Product Design and Manufacturing (CPDM) in IISc took shape primarily from the department faculty working in this area. Several faculty members hold secondary appointments in CPDM and undertake product design projects. Even after the inception of this centre, research in engineering design aspects continues in mechanical engineering. Geometric modelling and Computer-Aided Design (CAD), kinematics from the viewpoint of geometry, compliant mechanisms and topology optimisation are some research areas that are currently active in the department.

3D shape reconstruction: *Robust and automatic "SCAN to CAD" multipatch B-spline surfaces*

Compliant mechanisms



Displacement-amplifying compliant mechanism (DaCM) has applications in microsensors and compliant transmissions



A circumferentially-actuated radially deployable compliant mechanism

Tensegrity optimisation

Digital human modelling: *(Right): Live model digitisation;*
Transradial prosthesis: *(Left): PURAK – a frugal design with rich functionality*

Research in the area of CAD has delved on representation of and reasoning with 3D models by Prof B Gurumoorthy's group. While his earlier work focused on feature-based modelling and construction of 3D geometry from measured point data, the recent focus has been on the problems of capturing non-geometric product information in representation and reasoning with mesh-based representation. Prof Dibakar Sen's group studies multi-body contacts from the geometric perspective rather than that of algebra and considers both theoretical kinematics aspects and practical applications. On the theoretical side, for example, automatic generation of kinematic constraints is studied using the modular kinematics approach.

One of the practical applications his group had recently invested efforts in is the design of circuit breakers for a company. Prof Ananthasuresh's group works extensively on compliant mechanisms. Design methods, non-dimensional analysis, unconventional actuation, and a variety of multidisciplinary applications of compliant mechanisms at macro, meso, and micro scales are investigated. Topology optimisation has been used to design compliant mechanisms, tensegrity structures, and de novo proteins. Lately, topology derivative-based method combined with level-set approach is being investigated for devising computationally efficient methods for additive manufacturing of structures in collaboration with industrial partners.

Faculty

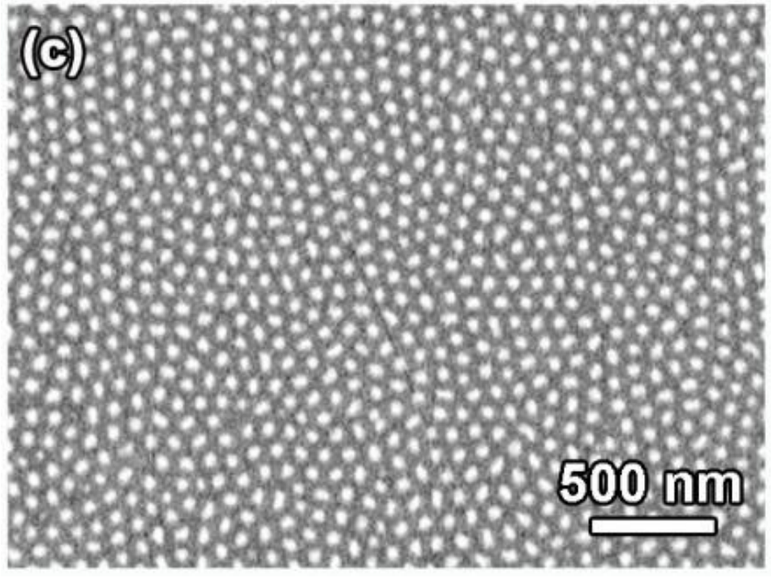
- Prof GK Ananthasuresh
- Prof B Gurumoorthy
- Prof GR Jayanth
- Prof Ramsharan Rangarajan
- Prof Dibakar Sen

2.1.7 | Micro and nanoscale processes and devices

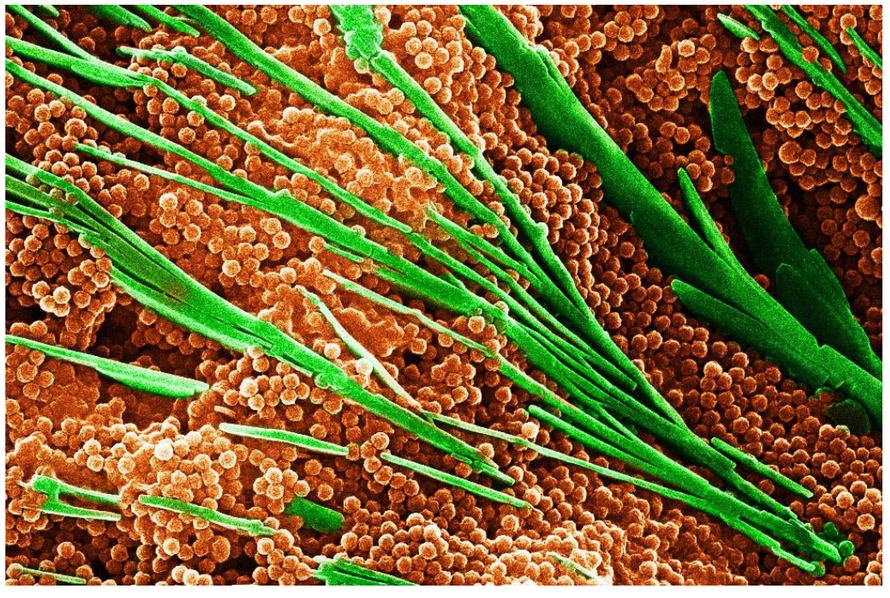
Research Areas

- Microscale transport phenomena
- Microfluidics
- Mechanics of sessile droplets
- Nano-composite processing
- Nanomechanics of solids
- Microsensors and microactuators
- Multi-physics simulation of MEMS Devices

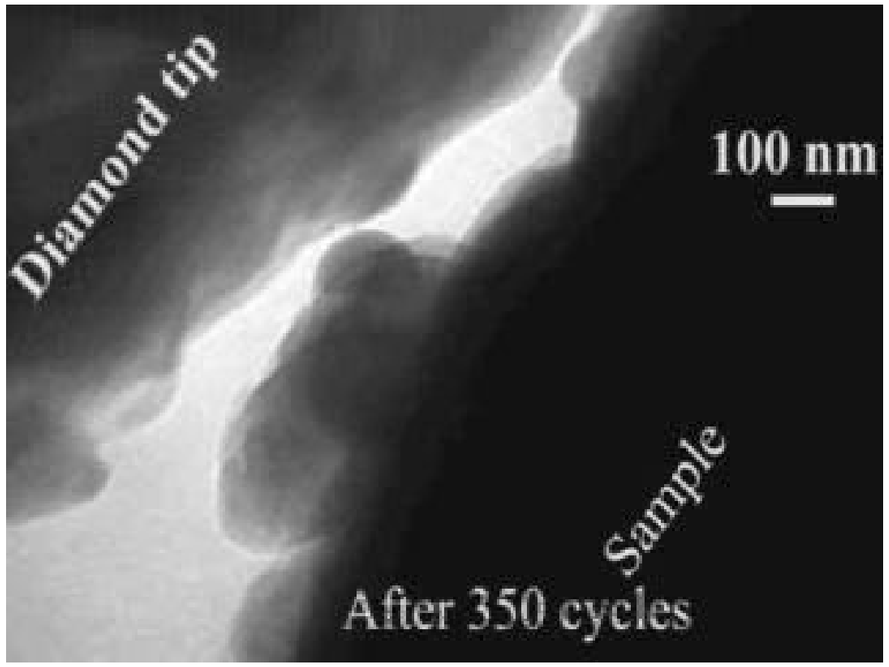
A number of groups in the department are engaged in research on micro and nanoscale phenomena with focussed investigations in this direction commencing about 30 years back in Prof Biswas' group. In microelectromechanical systems (MEMS), one of the first such groups in India was led by Prof Rudra Pratap in the department, which investigated dissipation in MEMS devices. Micro and nano research in the Department has now grown in multiple directions including topics like mechanics of solids and fluids at small length scales, microscale transport phenomena, computational micromechanics, development of numerous micro sensors and actuators. These efforts are now growing rapidly with new faculty recruits, besides inter-departmental collaborative ventures.



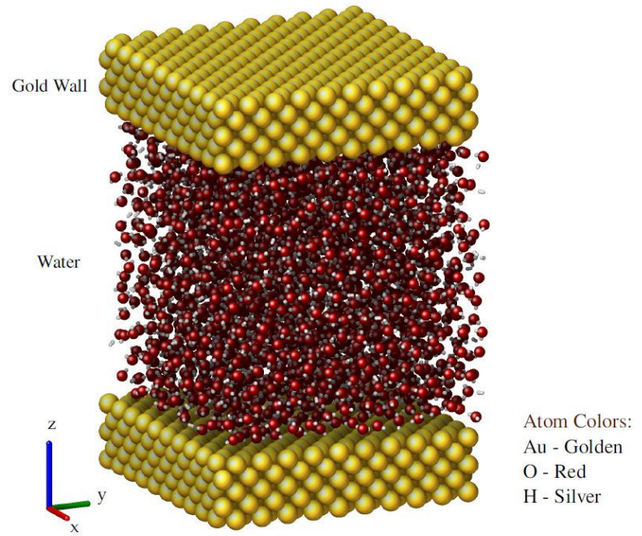
Fabrication of nanoscale structures



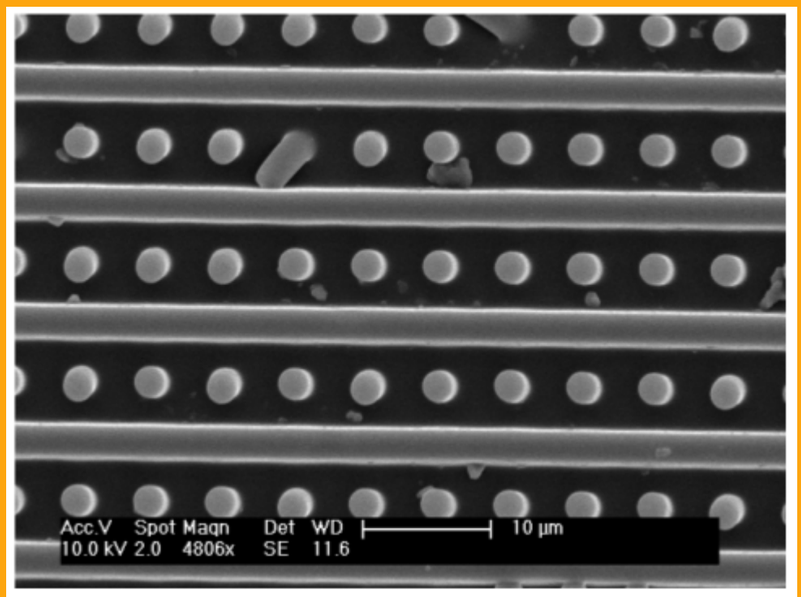
False-colored SEM image of a composite soft material formed by mixing high molecular weight PAM with particles.



In situ TEM



Continuum singularity resolved using atomistic simulations



Directing cell migrations using micro Patterned Array Detectors (mPAD): *Silicone pillars to quantify forces exerted by cells at discrete locations*

Microsensors: compliant mechanical amplifiers to improve the sensitivity and bandwidth of in-plane capacitive microaccelerometers

It may be noted that MEMS as well as micro and nanofabrication research initiated and nurtured by the groups of Prof Rudra Pratap and Prof Ananthasuresh played an important role in launching the Centre for Nano Science and Engineering (CeNSE) in IISc in 2010. They are also responsible for expanding the scope of MEMS research across India through engagement in two national research missions, namely the National Programme on Smart Materials (NPSM) and the National Programme on Micro and Smart Systems (NPMASS). Alongside, Prof MS Bobji has explored nanomechanics for over two decades now with novel experimentation in Transmission Electron Microscopy (TEM).

Profs Ananthasuresh, CS Jog and Rudra Pratap also led a multi-investigator project to develop a MEMS software suite for multiphysics simulation. Micromachined pressure sensors, accelerometers, gyroscopes, Capacitive Micromachined Ultrasonic Transducers (CMUTs), force sensors, xy-stages, RF switches, miniature grippers, micro-speakers, etc., were developed, tested and calibrated as part of this initiative. Some of these have been commercialised (e.g., pressure sensor, force sensor), while others are in the translation phase. Recently, new faculty like Prof Basu, Prof Kumar, and Dr Susmita Dash have shown keen interest in research on fluids and heat transfer aspects at small length scales.

More recently, Drs Navaneetha K Ravichandran and Debashish Das added to the work on micro and nanoscale devices. While Krishnan's group investigates heat transfer in micro and nanoscale devices using computational and experimental methods, Das' group works on understanding and harnessing multi-length scale and multi-physics phenomena for applications in bioengineering, sensors and actuators, energy, functional devices, etc.

Faculty

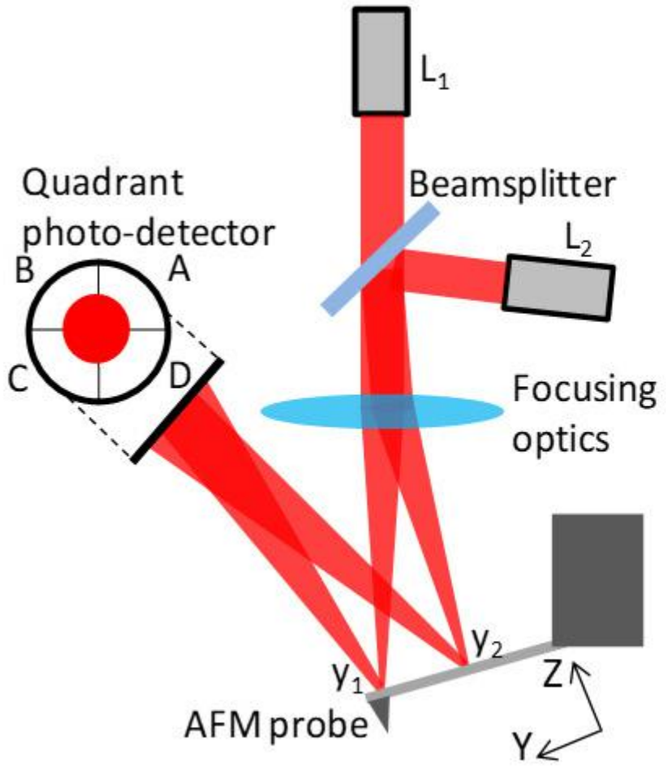
- Dr Susmita Dash
- Prof Aloke Kumar
- Prof Saptarshi Basu
- Prof MS Bobji
- Prof CS Jog
- Prof GK Ananthasuresh
- Dr Navaneetha K Ravichandran
- Dr Debashish Das
- Prof Namrata Gundiah

2.1.8 | Robotics and autonomous systems

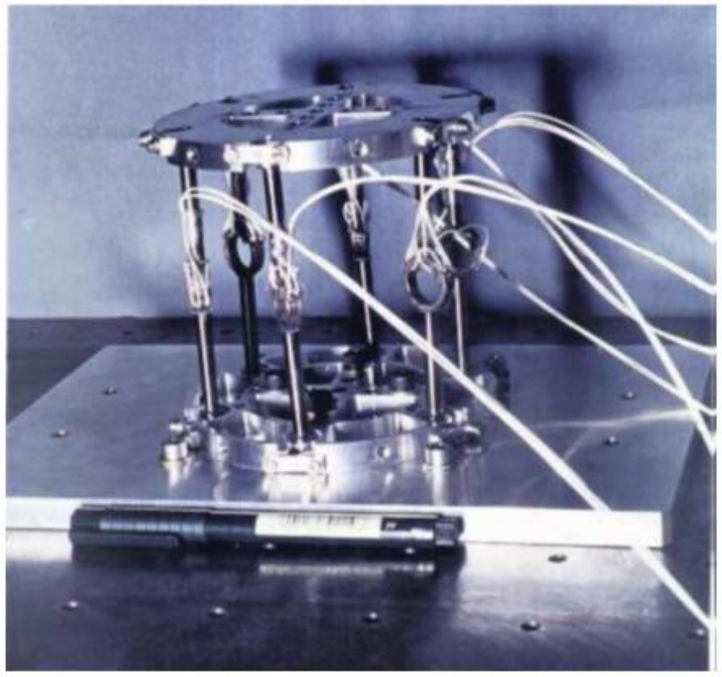
Research Areas

- Flexible robots
- Multi-fingered hands
- Automated sun-tracking devices
- Hyper-redundant and snake robots
- Motor learning and the role of variability
- Mobile and walking robots
- Pipe-crawling robot
- Haptic robotics
- Microrobotics

Research in robotics began in the department with Prof Ashitava Ghosal's group in the late 1980s. It continues to flourish today with focus on both fundamental and applied aspects of kinematics, dynamics, control and motion planning by development, implementation and validation of theories and algorithms associated. Research and development activities in this area have been funded by various government agencies and private companies in India and abroad. A large number of students have been trained in this area at doctoral and master's levels. Prof Ghosal's research topics of past and present include multi-fingered hands, wheeled and walking robots, hyper-redundant snake robots, and nonlinear control. Recently, he has collaborated with Prof Aditya Murthy's group at the Centre for Neuroscience, IISc, on motor learning and coordination.



Measurement systems: Direct measurement of 3D forces in AFM



Stewart platform based 6-axis force-torque sensor MMT 04

Robots for endoscopy

Stoch: *Robot developed in Robert Bosch Centre of Cyber Physical System at IISc*

Drone attitude tracking gimballed testbed

Two other groups in the department also have distinctive engagement in this field. Prof Ananthasuresh's group has developed a pipe-crawling robot, a haptic aid for cutting tissue, and a commercialised endoscopy simulator with haptics and graphics. Furthermore, on the basis of his work on SU-8 microrobots used in cell mechanics studies, he is involved in autonomous microrobotics with other colleagues in IISc. Recently, Prof Ramsharan Rangarajan has started to investigate flexible robots wherein slender beams are used for manipulation tasks. He is also interested in employing deep learning to solve complex problems in path planning.

Faculty

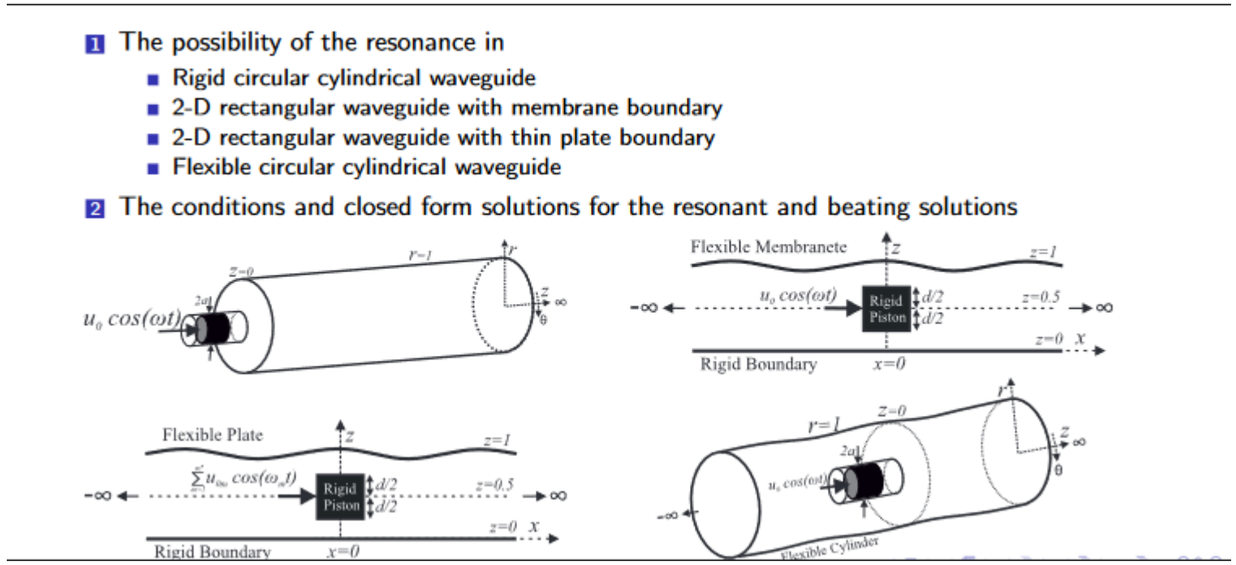
- Prof GK Ananthasuresh
- Prof Ashitava Ghosal
- Prof Ramsharan Rangarajan
- Dr Jishnu Keshavan
- Prof GR Jayanth

2.1.9 | Vibration, acoustics and control

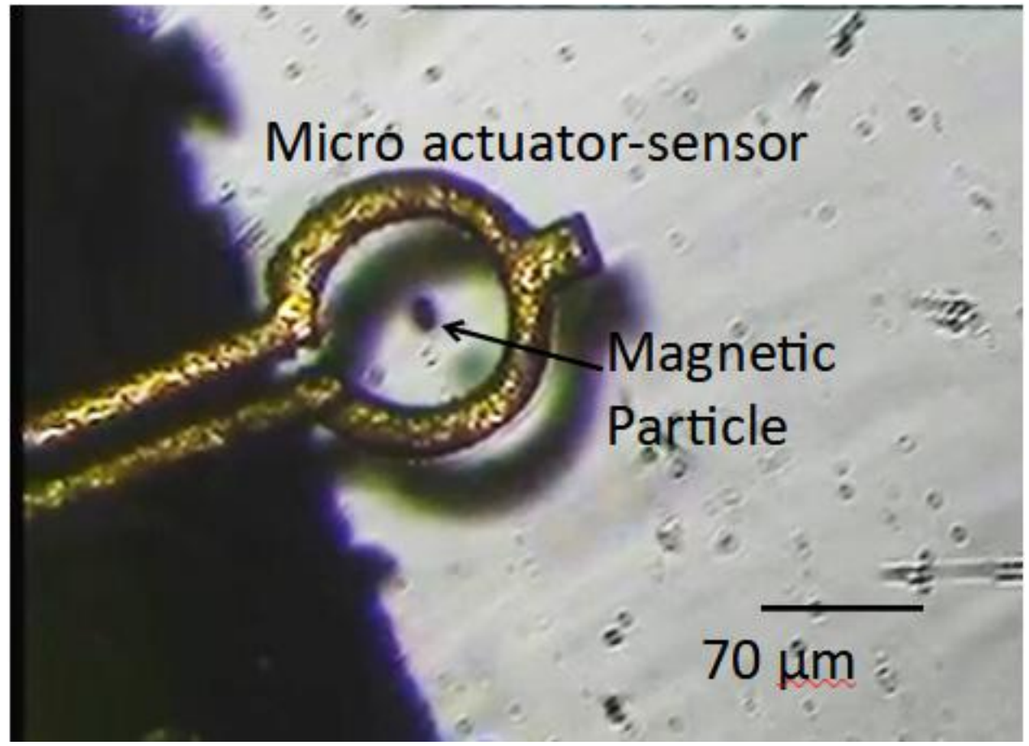
Research Areas

- Linear and non-linear sound-structure interactions
- Structural acoustics of perforated panels
- Sonic boom
- Probing systems for nanoscale imaging, characterization and manipulation
- Measurement and control of precision motion
- Nonlinear dynamics and control theory Design
- Microelectromechanical (MEMS) devices

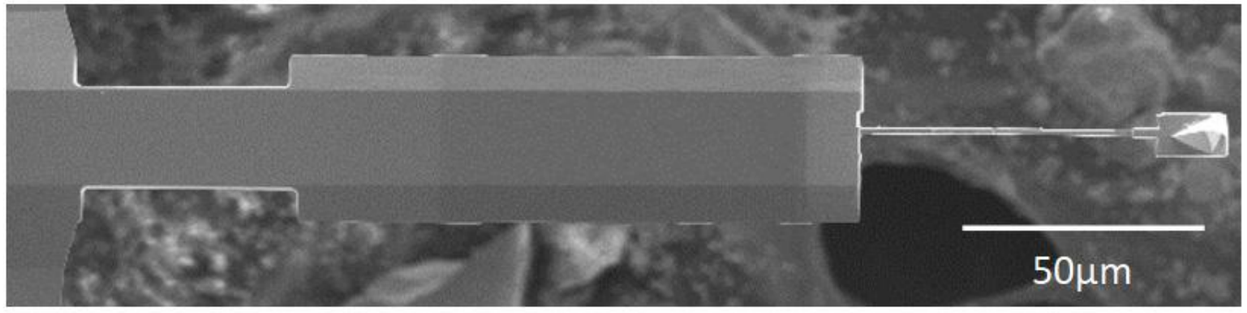
Prof ML Munjal initiated research in vibrations and acoustics in the department almost fifty years ago. The objective was to design industrial products for quietness, with a strong focus on automotive mufflers. The Ducts and Mufflers Laboratory carried out computational and experimental research in the department, leading to a commercial software that predicts the performance of industrial automotive mufflers. In order to popularise technical acoustics for education and research, Prof Munjal carried out industrial consultations and government projects, organised numerous workshops across the country, and offered continuing-education programs for college teachers. He was involved at the highest levels of government policymaking to bring forth noise-control norms across the country.



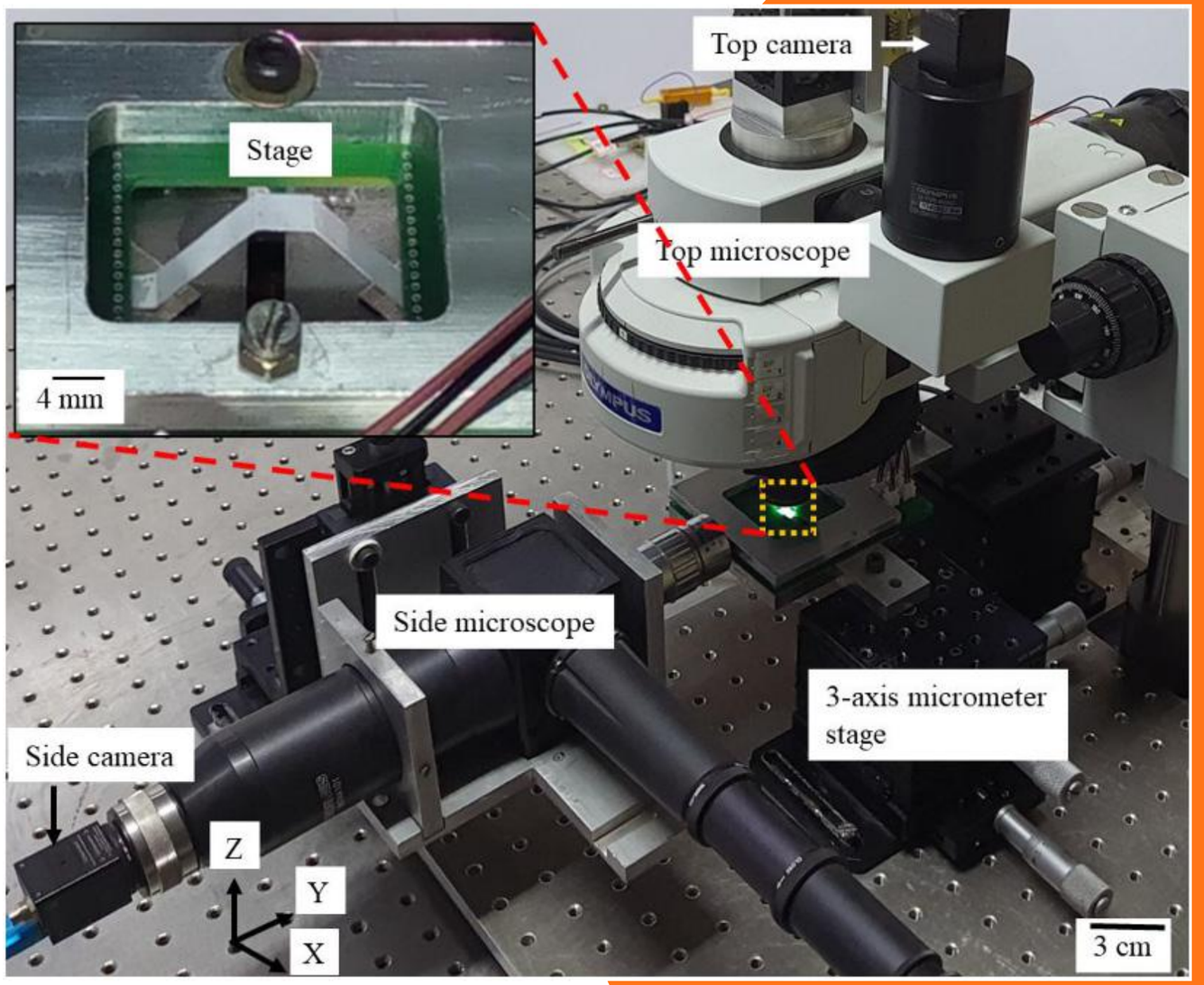
Nonlinear structural-acoustic waveguides



A magnetic microparticle being trapped in three dimensions and manipulated by employing parametric excitation



A harmonic Atomic Force Microscope probe, with its second natural frequency being the second harmonic of its fundamental natural frequency



An atomic force microscope (AFM) system integrated with a diamagnetically levitated stage for performing automated tip-exchange of the AFM probe

It was only natural for him to register his vast expertise in a comprehensive book titled 'Acoustics of Ducts and Mufflers.' In 1999, he was joined by Prof Venkata R Sonti, who had a background in structural acoustics. Prof Sonti and his group conduct analytical/semi-analytical studies on well-posed sound-structure interaction problems. Initially starting with linear problems, Prof Sonti has broadened his interests to include nonlinear structural acoustic systems. More recently, there has been an energy initiative, wherein a part of the objective is to understand the rotor dynamics of high-speed shafts (~ 70,000 rpm). Subsequent to these studies, research is expected to extend to the fluid-structure interaction domain.

Research activities in control in the department have been marshalled by Prof Ashitava Ghosal for close to three decades now, aligned with his long standing interest in the field of robotics. The scope of control research was expanded to new regimes in 2018 when Prof GR Jayanth joined the Department as an Associate Faculty. Prof Jayanth works on precision motion control, with applications in metrology and robotics, at the micrometre and nanometre length scales. Towards this end, his group is investigating the development of new measurement techniques, probes, actuation techniques, and advanced control. The latest addition to the group is Dr Jishnu Keshavan, whose research interests include autonomous aerial and ground systems, non-linear estimation and control theory, data-driven and learning based control, robust control systems design and vision-based navigation.

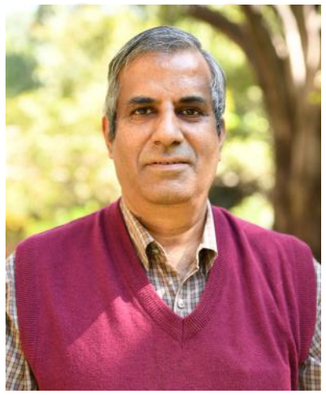
Faculty

- Prof Ashitava Ghosal
- Prof Ramsharan Rangarajan
- Prof Venkata R Sonti
- Dr Jishnu Keshavan
- Prof GR Jayanth

Faculty research

PROF ASHITAVA GHOSAL

Prof Ghosal's group has been modelling and analysing multi-fingered hands as parallel robots, and developing biomedical devices for minimally invasive surgeries



PROF B GURUMOORTHY

Prof Gurumoorthy leads the CAD laboratory, which addresses problems related not just with representing product models, but also reasoning with them.

PROF ALOKE KUMAR

Prof Kumar's group works on the behaviour of soft matter, trying to understand non-Newtonian fluids, soft robots, microfluidics, biocementation and its applications.

MR C DHARUMAN

Mr Dharuman's lab is currently working on using heat transfer and fluid mechanics principles to design and optimise polyhouses for agricultural purposes.

DR BALACHANDRA SURI

Prof Suri's lab works on nonlinear dynamics, fluid dynamics, hydrodynamic stability, and hydrodynamic quantum analogs.

PROF CS JOG

Prof Jog's research group is involved in the development of new finite element strategies for solving multi-physics problems.

DR DEBASHISH DAS

Dr Das' group investigates the fundamental properties of materials at micro and nanoscale length for applications in bioengineering, sensors and actuators, energy, etc.

PROF GR JAYANTH

Prof Jayanth's group measures and controls motion and forces at micrometre and nanometre length scales for applications in imaging and manipulation.

PROF DIBAKAR SEN

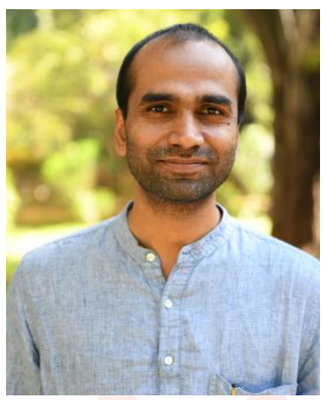
Prof Sen's group conducts research aimed at understanding shape, motion and their interaction using the knowledge of geometry, topology and kinematics.

DR GSVL NARASIMHAM

Dr Narasimham leads the R&AC lab, which works on flow and heat transfer problems in low, medium and high temperature systems.

PROF GK ANANTHASURESH

Prof Ananthasuresh leads the M2D2 lab, which explores designing elastically deformable bodies to realise desired motions in multi-disciplinary settings.



PROF GAURAV TOMAR

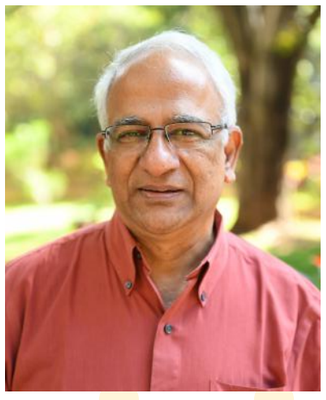
Prof Tomar's group investigates various fluid flow phenomena involving multiscale systems. The lab's major focus involves the simulations of two-phase flows.

DR HIMABINDU M

Dr Himabindu's lab explores advanced ignition and combustion concepts using alternative and biofuels to extend the limits of lean operation and understand the performance of small engines.

DR KOUSHIK VISWANATHAN

Dr Viswanathan's group addresses the technological challenges in manufacturing: from basic science to engineering implementation, and from consumer goods to next-gen space travel.



PROF JAYWANT H ARAKERI

Prof Arakeri's group applies experimental and computational methods to solve fluid mechanics problems.

PROF MS BOBJI

Prof Bobji leads the force microscopy lab, which specialises in measuring small forces, ranging from millinewtons to nanonewtons.

DR JISHNU KESHAVAN

Dr Keshavan's lab aims to develop novel bio-inspired sensing and learning-based control paradigms to realise autonomous robotic systems that work well in dynamic and unstructured terrain.

PROF NAMRATA GUNDIAH

Prof Gundiah's biomechanics laboratory works on the development and application of mechanics to study biological materials.

DR NAVANEETHA K RAVICHANDRAN

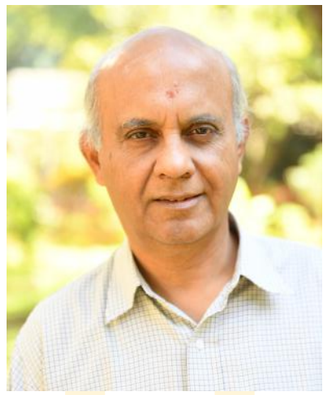
Dr Ravichandran's group works at the intersection of thermal sciences, energy sciences and applied physics. The group investigates the thermal and electronic properties of electrical insulators, semiconductors and metals.

PROF RATNESH K SHUKLA

Prof Shukla's Direct numerical simulations help to determine optimal surface actuation based flow control strategies to minimise net power consumption while effectively reducing hydrodynamic loads.

PROF PRADIP DUTTA

Prof Dutta's heat transfer lab aims to solve thermal and cooling challenges in various applications through fundamental research and innovation.



PROF R NARASIMHAN

Prof Narasimhan's group works on understanding crack tip fields for different lattice orientations and fracture configurations, guiding the choice of texture and microstructure in polycrystalline alloys for improved fracture resistance.

PROF PRAMOD KUMAR

Prof Kumar's lab specialises in research and development of green technologies involving natural refrigerants, hydrocarbon mixtures, and trans-critical co2 for cooling applications along with supercritical co2 based Brayton power cycles.

PROF RAGHURAMAN N GOVARDHAN

Prof Govardhan's flow physics lab explores a range of fluid mechanical phenomena with a focus on fluid structure interaction problems.

PROF RAMSHARAN RANGARAJAN

Prof Rangarajan's group works on understanding the influence of geometry in the mechanics of elastic structures.

PROF SAPTARSHI BASU

Prof Basu's lab explores transport processes in multiphase systems at different spatio-temporal scales with applications ranging from gas turbine combustion to surface patterning.

DR R THIRUMALESWARA NAIK

Dr Naik's lab studies the performance, emission and combustion characteristics of various engines using conventional fuels, alternate biofuels, combustion diagnostics and other engine-related phenomena.

DR SUSMITA DASH

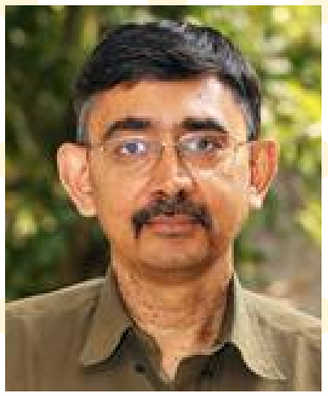
Dr Dash's microscale transport lab focuses on developing strategies to enhance thermal and fluid transport performance using micro- and nano-textured surfaces with specific wettability.

PROF RV RAVIKRISHNA

Prof Ravikrishna's group works on the fundamental aspects of combustion and spray processes and their application in internal combustion engines, gas turbines and industrial burners, using laser-based diagnostic techniques.

PROF SATISH V KAILAS

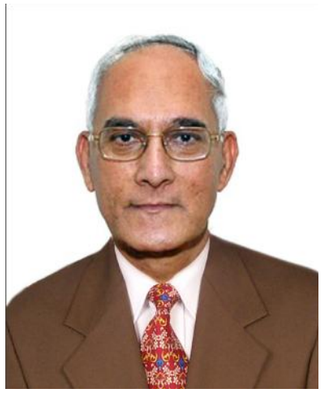
Prof Kailas' group addresses several topics in the fields of tribology and friction stir welding/processing.



PROF VENKATA R SONTI

The structural acoustics group develops closed form solutions to well-posed problems in the area of soundstructure interaction.

EMERITUS FACULTY



PROF ML MUNJAL

Prof Munjal works in the areas of muffler acoustics, industrial and automotive noise control, and acoustics of ducts and mufflers.

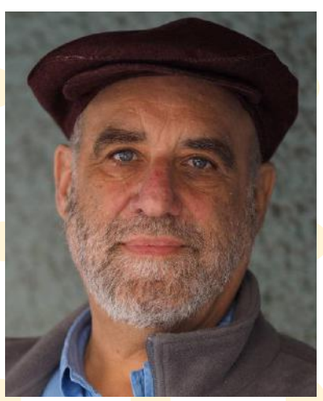
SHORT-TERM/VISITING FACULTY

PROF AMRIT AMBIRAJAN

Research Professor working in the area of Thermal management, Two-phase heat transport devices, Thermal property measurements, Radiation heat transfer and Thermo-acoustic devices

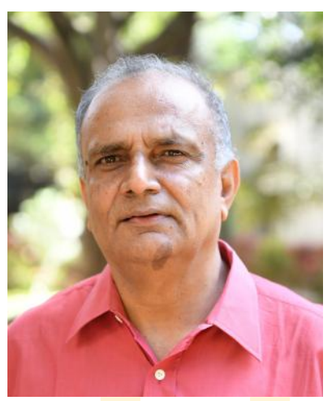
PROF S SESHAN

Prof Seshan works in the area of Advanced Manufacturing Processes, Science of Metal Casting – Alloy Development, Metal Matrix Composites, Non-conventional machining techniques.



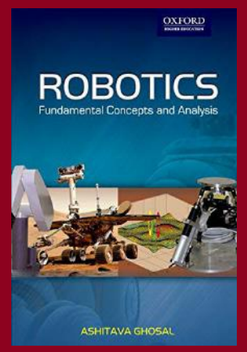
PROF ANDY L RUINA

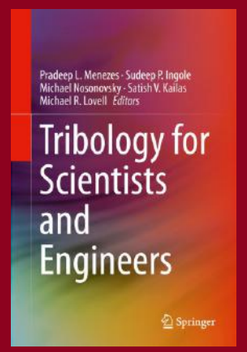
Satish Dhawan loE Visiting Chair Professor at IISc and 'John F. Carr' Professor of Mechanical Engineering at Cornell University. Research interests: rigid-object dynamics, robotics, biomechanics

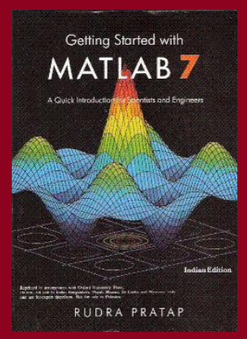


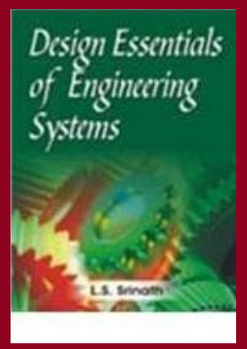
PROF KRY SIMHA

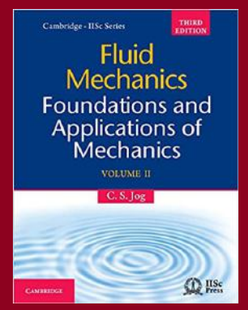
Prof Simha investigates the application of fundamental mechanics from contact and impact to failure and fracture in disks, plates, shells, tubes, rings, cylinders and honeycombs.

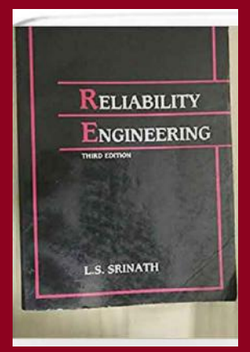

OXFORD
ROBOTICS
Fundamental Concepts and Analysis
ASHITAVA GHOSAL

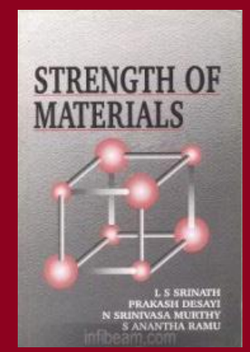

Pradeep L. Menezes · Sudeep P. Ingole
Michael Nosonovsky · Satish V. Kailas
Michael R. Lovell Editors
Tribology for Scientists and Engineers
Springer

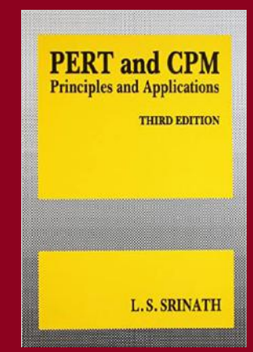

Getting Started with
MATLAB 7
A Quick Introduction for Scientists and Engineers
Indian Edition
RUDRA PRATAP

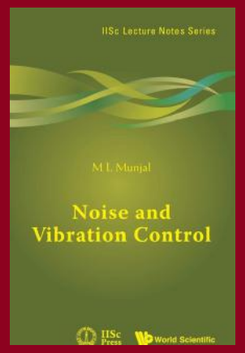

Design Essentials of Engineering Systems
L.S. Srinath

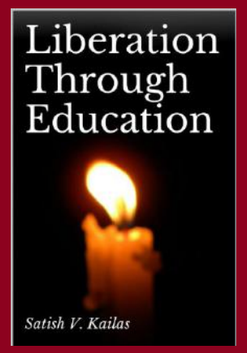

Cambridge - IISc Series
THIRD EDITION
Fluid Mechanics
Foundations and Applications of Mechanics
VOLUME II
C. S. Jog
CAMBRIDGE
IISc Press

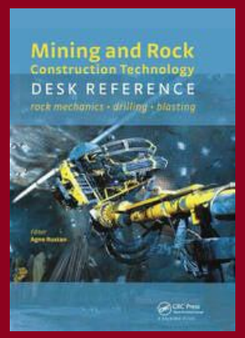

RELIABILITY
ENGINEERING
THIRD EDITION
L.S. SRINATH

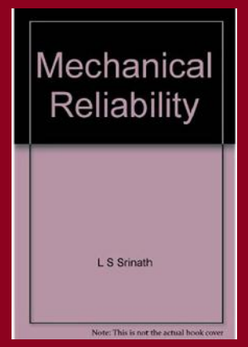

STRENGTH OF MATERIALS
L S SRINATH
PRAKASH DESAYI
N SRINIVASA MURTHY
S ANANTHA RAMU
infibeam.com

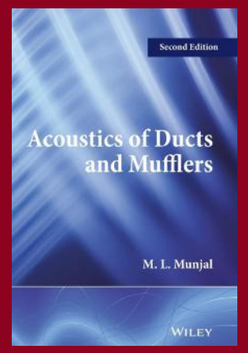

PERT and CPM
Principles and Applications
THIRD EDITION
L. S. SRINATH

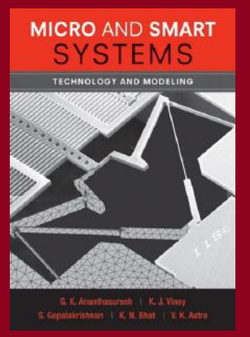

IISc Lecture Notes Series
M L Munjal
Noise and Vibration Control
IISc Press
World Scientific

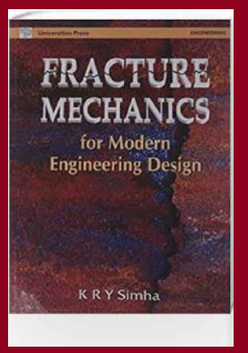

Liberation Through Education
Satish V. Kailas

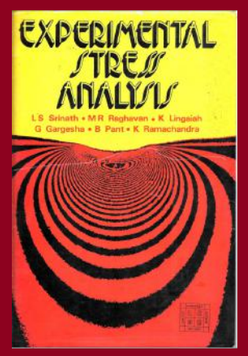

Mining and Rock Construction Technology
DESK REFERENCE
rock mechanics · drilling · blasting
CRC Press

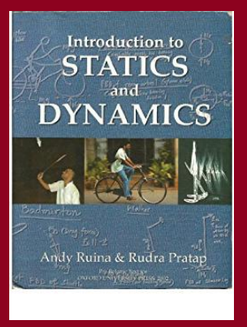

Mechanical Reliability
L S Srinath
Note: This is not the actual book cover

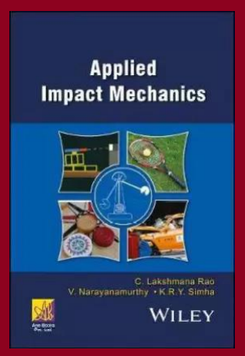

Second Edition
Acoustics of Ducts and Mufflers
M. L. Munjal
WILEY

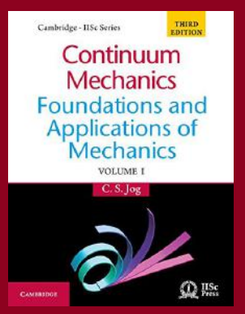

MICRO AND SMART SYSTEMS
TECHNOLOGY AND MODELING
I I Sc

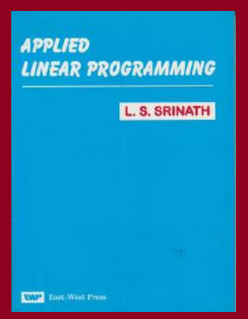

FRACTURE MECHANICS
for Modern Engineering Design
K R Y Simha

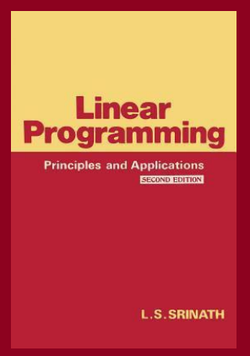

EXPERIMENTAL STRESS ANALYSIS
I.S Srinath • M.R Raghavan • K Lingaiah
G Gargesha • B Pant • K Ramachandra

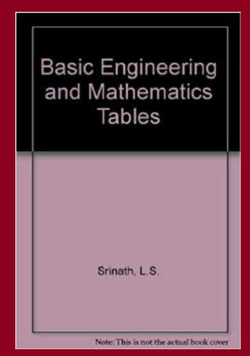

Introduction to
STATICS and DYNAMICS
Andy Ruina & Rudra Pratap

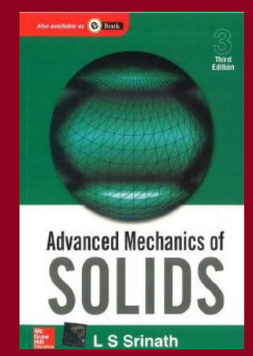

Applied Impact Mechanics
C. Lakshmana Rao
V. Narayanamurthy • K.R.Y. Simha
WILEY


Cambridge - IISc Series
THIRD EDITION
Continuum Mechanics
Foundations and Applications of Mechanics
VOLUME I
C. S. Jog
CAMBRIDGE
IISc Press


APPLIED LINEAR PROGRAMMING
L. S. SRINATH
East-West Press

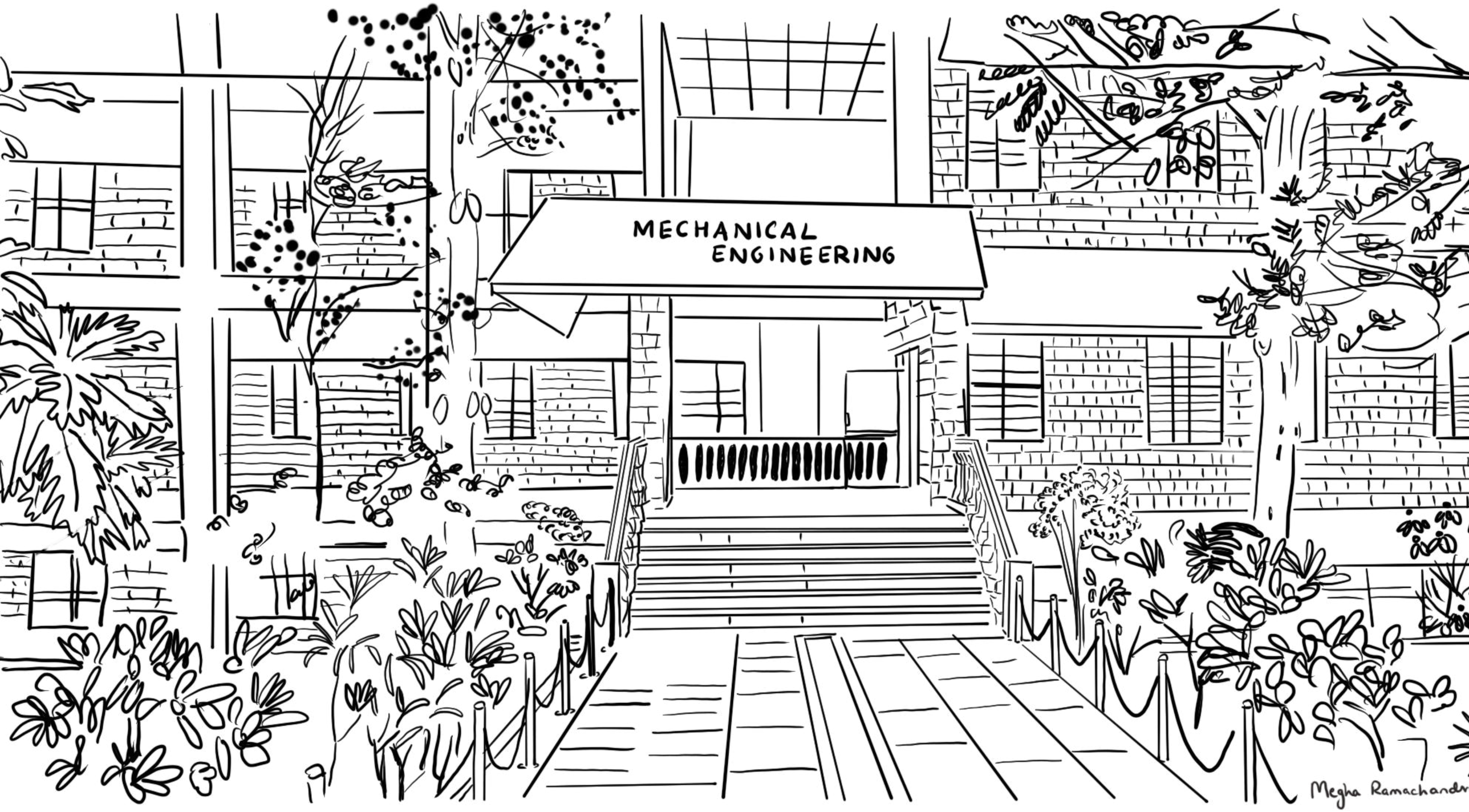

Linear Programming
Principles and Applications
SECOND EDITION
L.S. SRINATH


Basic Engineering and Mathematics Tables
Srinath, L.S.
Note: This is not the actual book cover


Third Edition
Advanced Mechanics of SOLIDS
L S Srinath

2.2 | Reading list
Books by the ME department faculty

Books, like beacons, light up the path for students to grasp fundamentals which are essential to comprehend papers published by experts in research journals. The ME department has contributed to Indian technical education over the years, through texts and monographs for undergraduate students, and MS/PhD research scholars. Along with other edited collections and proceedings, the ME department faculty have produced well over one hundred textbooks. The titles mentioned in this book are a small sample of the various areas that the faculty have taught in the department. Books authored by Profs P Srinivasan, LS Srinath, ML Munjal, J Srinivasan, KRY Simha, CS Jog, A Ghosal, GK Ananthasuresh, Rudra Pratap and Satish V Kailas provide a glimpse into a diverse range of subjects that highlight the universal scope of mechanical engineering activities. The subjects run through the gamut of topics such as thermodynamics, materials engineering and manufacturing, solid mechanics, fluid mechanics, fracture mechanics, acoustics, radiations, vibration, dynamics, optimization, tribology, MEMS, and robotics.


MECHANICAL
ENGINEERING
Megha Ramachandran

2.3 | Staying on course
ME curriculum over the years

The ME department's curriculum has always been designed to set students up to become ambitious engineers and researchers by trusting their capability to mature from undergraduates to independent thinkers. A cursory inspection of the department curriculum over the last 75 years highlights the lasting nature of fundamental principles in Mechanical Engineering, the evolution of new ones, and the interdisciplinary nature of modern engineering. Equally significant, curriculum revisions have been precursors of the new directions in the development of engineering in the country. "An indigenous industry, and its healthy growth and independent technical progress cannot be ensured unless the technical personnel is being trained and supplied with the knowledge and experience for those duties."

The emphasis on turbomachines or foundry engineering in the past, to nanoengineering and computer simulations in recent years, stand testament to this change. Methods of teaching and learning continue to evolve, thanks to technological advances and the dynamic stature of the mechanical engineers of today. However, the emphasis on hands-on learning through projects, development of breadth through a broad spectrum of electives, and a healthy faculty-student ratio is a legacy that endures.

INDIAN INSTITUTE OF SCIENCE
BANGALORE 3.

No.R(GL)311(E)/56(Cir.1) 7th November 1956

Proposal from the Professor of Mechanical Engineering for introducing a new course of 1½ year's duration in "Mechanical Design" with the object of preparing students to enter general field of Machine Design is circulated to the Members of the Engineering Faculty for approval.

Registrar

	I agree	I do not agree
Prof. Satish Dhawan (Dean)	Agree - But I should like the faculty to discuss whether such new courses should be routed through the Boards of Studies or taken up direct. C.H.K.	
Prof. K. Sreenivasan		
Prof.C.S. Ghosh		
Prof. H.A. Havemann		
Prof. N.S.Govinda Rao		
Prof. Brahm Prakash		
Prof. D.J. Badkas		
Prof. C.H.Kent		
Mr. H.N. Ramachandra Rao		
Mr. M.R. Krishnamurthy Rao		
Mr. C.V. Joga Rao	CVJR	
Dr. A. Ramachandran		
Dr. B.S. Ramakrishna		
Mr. K.Seetharamiah		
Mr. B.N. Narayana Iyengar		
Mr. R.G. Narayanamurthy		
Mr. S.K.Chatterjee		
Mr. H.V. Gopalakrishna		
Mr. T.N. Krishnaswamy		
Mr. S.Sampath		
Dr. S. Ramamurthy		
Mr. K.T. Sundararaja Iyengar		
Mr. K.V.Mahadevan		
Dr. T.R. Anantharaman		
Mr. A.G. Pai, Registrar (Secretary)		

ME.31/57-228

Mechanical Engineering Section,
11th March 1957

INDIAN INSTITUTE OF SCIENCE BANGALORE 3 — No. 1196 — Date 12 MAR 1957

The Director,
I.I.Sc.

Dear Sir,

With reference to the attached letter, please note that there are only three new subjects proposed for the course in Mechanical Design. They are :- Mechanical Design

1. Stress Analysis : Mathematical analysis of stresses in machine parts; advanced studies of flexure and torsion, energy methods, Castigliano's theorem, complimentary energy theorem, indeterminate machinery and structural members; inelastic action, introduction to ultimate load analysis of indeterminate members, elastic and inelastic instability.

2. Machine Design I : Geometry of constrained motion in two and three dimensions, kinematic synthesis, types of mechanisms and applications to design of mechanisms.

Gears: Tooth forms, geometric and kinematic relationships of tooth action, capacity ratings for strength and durability, effects of forming and finishing methods on design and rating of gears. Study of Gear strains and multiple speed drives.

Study of Cams, mechanical springs, rubber, and fluid shock absorbing elements, shafts and couplings. Behavior, selection and design of bearings.

Machine Design II : Investigation of typical problems to illustrate methods of analysis and development of solutions.

Original design of a simple high performance machine demonstrating the applicability of previous fundamental studies in the synthesis of the device.

3. Experimental Stress Analysis : Experimental measurement of stresses by means of: precision extensometers; lacquer methods; electronic strain gauges; Photo-elasticity. Instrumentation required and use of analogic methods. Flaw detection by means of: Magnetic method; sonic method; X-ray examination; examination by radio-active isotopes. Laboratory practice in measurement of stresses by all of above methods and examination of castings and forgings.

Other subjects included in the Mechanical Design Course are already being offered to present students. The description of these subjects are:

Heat Transfer : Fundamental principles of heat transmission by radiation, conduction and convection. Application of these principles to the solution of engineering problems.

Advanced Fluid Mechanics: Steady and unsteady flow of incompressible and compressible fluids, viscous flow, turbulance, boundary layer, principles of operation of fluid dynamical machines such as pumps, centrifugal and axial flow fans, compressors, fluid couplings and torque converters. Hydrodynamic theory of lubrication as applied to journal and thrust bearings.

Dynamics of Machines: Analysis of rotating disks and cylinders; Thick cylinders under pressure; Thermal stresses; Balancing of rotating and reciprocating machinery; Kinetics of machine parts; Governors; Valve gears; Gyroscopes; Brakes and Dynamometers.

- 2 -

Mechanical Properties of Metal and Design: Mechanical properties of metals subjected to static creep, fatigue and impact loadings. Tests and theories of failure for combined static, creep and fatigue loadings. Selection of working stress for various loading conditions. Application to design of machine and structural members as specified in design codes.

Mechanical Vibrations: Lateral and torsional vibrations with several degrees of freedom, vibration isolation and absorption, classical and mobility methods of solving torsional vibration problems of multiple degrees of freedom. Laboratory practice in use of instruments, experimental determination of frequency and amplitude of vibration.

Shop Processes: Metal processing, machining operations, hot and cold forging, casting and welding technology and their bearing on machine design.

Engineering Mathematics: I and II :- Partial Differentiation; Ordinary Differential Equations; Partial Differential Equations; Probability; Complex Variables; Vector Analysis; Dimensional Analysis.

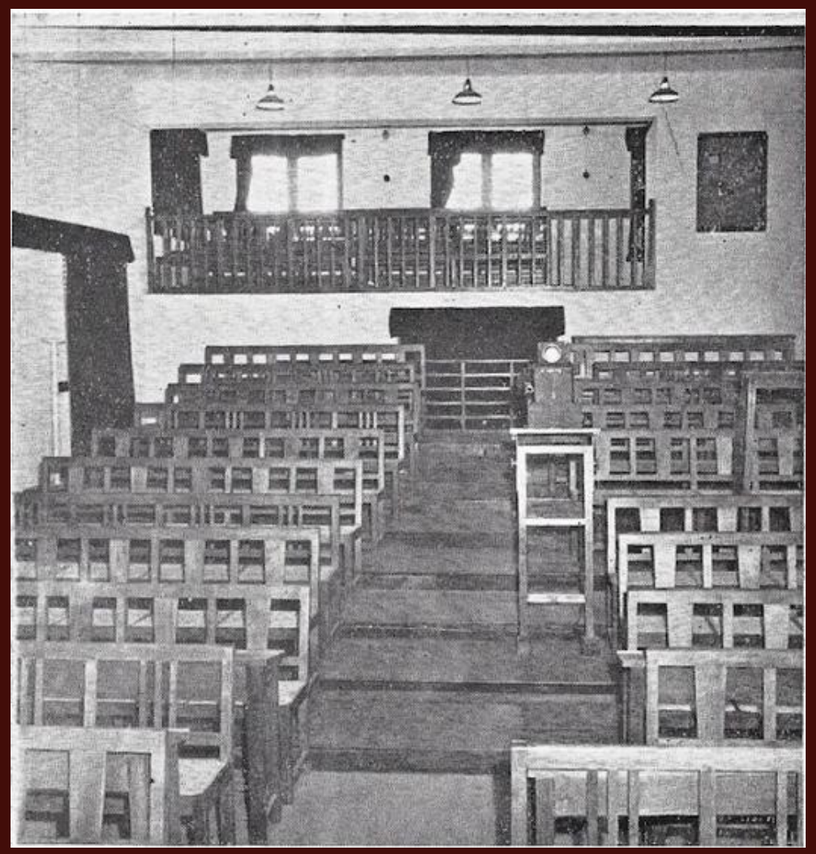
Yours faithfully,

CHK:km

Professor of Mechanical Engineering

Charting a new course: *(Far Left): A proposal, approved and signed off by Prof Satish Dhawan, where he says "I agree - But I should like the faculty to discuss whether such new courses should be routed through the Board of Studies or taken up direct"*

Focus of study: *The ME curriculum in 1957 signed by Visiting Professor CH Kent*



A SUGGESTED COURSE IN POWER ENGINEERING.

for ELECTRICAL ENGINEERS.

SUBJECTS:

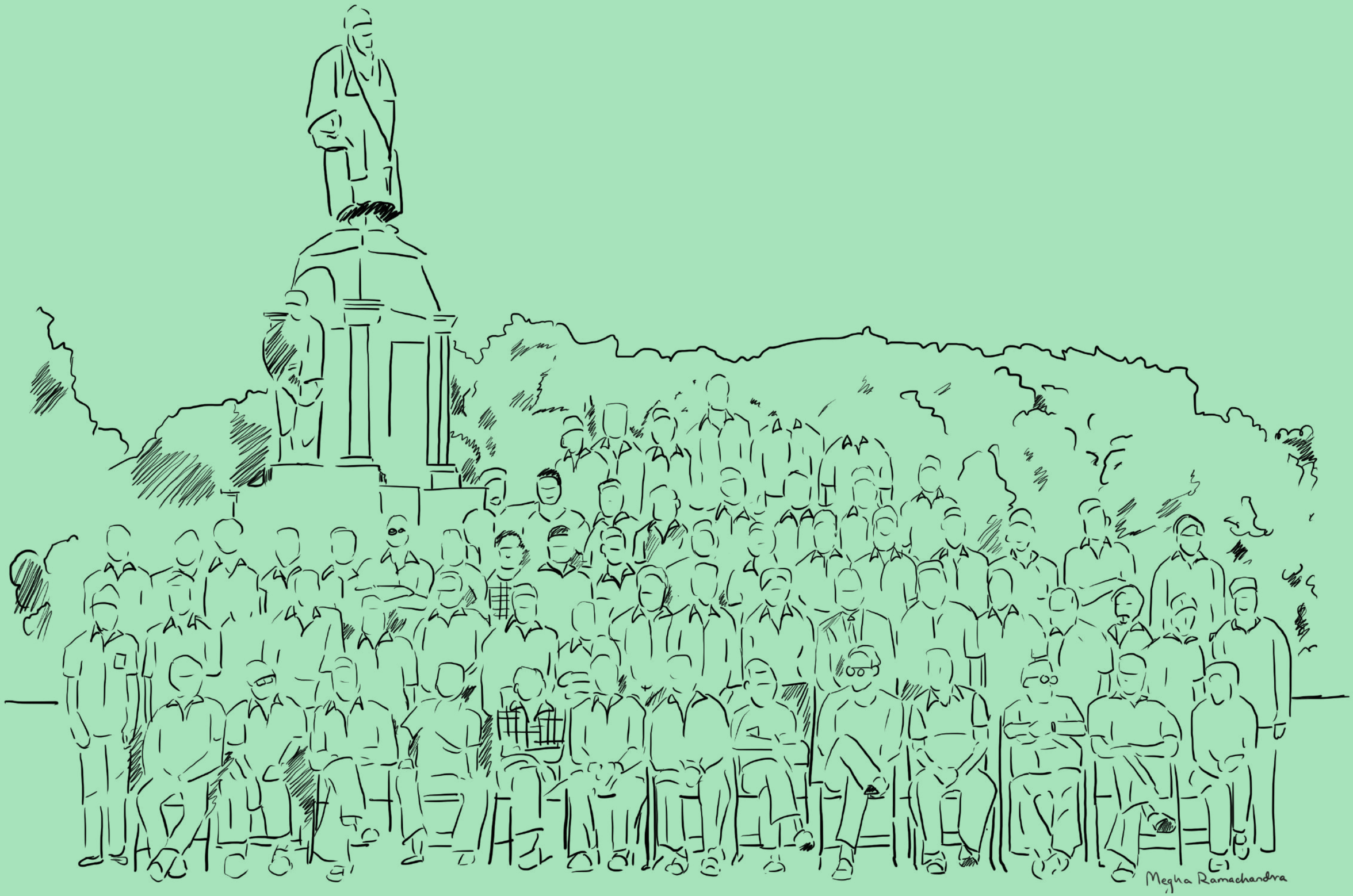
1. Advanced A.C. Machines.
2. Power System Analysis, Stability and Protection.
3. Metering and Electrical Measurements.
4. High Voltage Engineering.
5. Power Utilisation.
6. Advanced Hydro Power Plant Engineering & Design.
7. Elements of Power System Design.
8. Power Supply Economics.
9. Engineering Mathematics.

ELECTIVES.

1. Industrial Electronics.
2. Mechanical Vibrations.
3. Advanced Analysis of A.C. Machines.

A suggested course in PE for Electrical Engineers

(Top): A picture of an ICE classroom, 1953;
(Bottom): Students of the ME department, 2020


Megha Ramachandra

3 | People of ME

The ME department at IISc comprises 29 faculty members, with 15 full Professors, 5 Associate Professors, 1 Chief Research Scientist and 4 Scientific Officers. The faculty, research staff, and the students, along with students of the department, pursue research in a wide range of areas including solid mechanics, dynamics and control systems, robotics, geometric modeling, micro-electromechanical systems (MEMS), manufacturing and nanotechnology, tribology, fluid mechanics, thermal sciences and energy, vibrations and acoustics, and biomechanics. Through their vision and work, the faculty and students spread across different times in the history of the department have guided the evolution of research, to what we see today. The administrative staff and other employees ensure that the show runs smoothly by providing the much needed support.

ICE Department

BC Carter	1945-49
Hans A Havemann	1949-59
MRK Rao	1960-67
AV Sreenath	1968-74

Mechanical Division

A Ramachandran	1957-67
MA Thirunarayanan	1968-74

Mechanical Engineering Department

LS Srinath	1974-77
S Soundranayagam	1977-83
K Narayanaswamy	1983-87
MV Narasimhan	1987-91

Mechanical Engineering Department

ML Munjal	1991-94
S Seshan	1994-95
VH Arakeri	1996-01
SK Biswas	2001-06
JH Arakeri	2006-11
R Narasimhan	2011-15
Pradip Dutta	2015-20
GK Ananthasuresh	2020-21
Raghuraman N Govardhan	2021-Present

3.1 | Department Chairs

Over the years, several faculty of the department have served as Chairs and led the department forward, bearing in mind the needs of the times. The following is the complete list of Chairs of the ME department at IISc, including the erstwhile ICE department and Mechanical division of the erstwhile PE department, from 1945 to now.

3.2 | Women of ME

Mechanical engineering has traditionally been a male-dominated discipline worldwide, and the department at IISc has been no different. After her initial appointment as Junior Technical Assistant, Dr Prabha Venkatesh became a Scientific Assistant in 1976. Throughout her stay in the Institute, she had been "associated with the instrumentation section of the ICE and the ME departments." and was involved in the "instruments maintenance and servicing; research; development of new instruments and improving the performance of existing instruments and assistance in teaching." Dr Prabha's thesis on Laser Doppler Anemometry (LDA) under the guidance of Prof CR Prasad "involves measurement of radiation scattered by micron sized particles (either naturally present or artificially seeded into the flow) that follow the flow faithfully, when they are illuminated by a laser beam."

Dr Pramila Bai, who earned her PhD from the department a few years later in 1985, recalls that "the number of female engineering students on campus was [still] less than 10."

She was also the first doctoral student of Prof Biswas to work on the erosion of single crystals and wear of Al-Si alloys. Dr Pramila describes her former supervisor as a taskmaster. "I managed to complete my PhD in time because of his constant supervision, monitoring, and pressure." She recalls how Prof Biswas always encouraged his students to work hard and helped them reach their potential.

Dr Pramila worked in the Institute for about 10 years after earning her doctorate — first as a Senior Scientific Officer in the Department of Metallurgical Engineering, and next as an Assistant Professor in the ME department. She then left the Institute to join her husband, who had a PhD from the Inorganic and Physical Chemistry department at IISc, at a private material testing lab that he had established in 1980. The lab catered to the growing industrial demand for the characterization of material properties. After joining the lab, she fine-tuned the operation and obtained the NABL accreditation to the lab, all of which, in her words, she owes to training and exposure in IISc.

Prof Sangeeta Kohli, Professor at the Department of Mechanical Engineering at IIT Delhi, was also the only woman research scholar in the ME department during her stay at IISc. Prof Sangeeta, who earned her doctoral degree in January, 1993, echoes Dr Pramila's sentiments and recalls the mentorship she received from her advisers, Profs J Srinivasan and HS Mukunda.

Encouraging mentorship: *Prof Sangeeta Kohli with Prof J Srinivasan*

Women power: *Standing (L to R): Ms Joita Chakraborty, Ms Subhashree Mandal, Ms Deeksha Porwal, Ms Rashmi Dixit, Ms Omshree Mahapatra, Ms Dhanashri Tejpal Desai and Ms Deepika Gupta; Sitting (L to R): Ms Richie Garg, Prof Namrata Gundiah, Dr Pramila Bai, Dr Susmita Dash, Dr Himabindu M and Ms Manila Reddy Madhuri*

"Both my supervisors encouraged me to take up experimental as well as simulation work for my PhD. They gave me a lot of freedom." Reminiscing her experiences with the contemporaries at the department, Prof Sangeeta says, "The bonhomie between all the research scholars is something one cannot forget. The computer lab was newly established, and the senior research scholars were given the responsibility of managing it. That was a unique experience of feeling empowered as students."

The representation of women in mechanical engineering at the Institute has some way to go, although the department has more women researchers now than in its early years.

Dr Himabindu, who joined the department in 2007, is presently a Senior Scientific Officer and works on ICE combustion and develops alternative fuels. Prof Namrata, who joined shortly after and is now a full Professor, works on tissue biomechanics and cell mechanobiology.

Dr Susmita joined the department in 2018 as an Assistant Professor and works primarily in thermal management and interfacial science. The department also includes women students and postdoctoral researchers who work in research areas spanning energy storage, manufacturing, biomechanics and applied mechanics.

3.3 | Past and present faculty

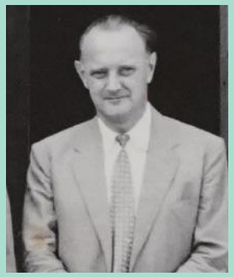
Major BC Carter
1945 - 1949
Professor

MRK Rao
1946-1967
Professor

MS Thacker
1947-1955
Director of IISc

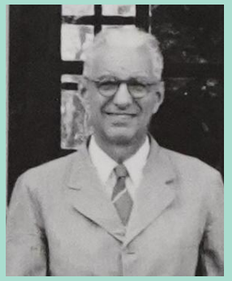
BN Narayana Iyengar
1947-1974
Professor

AV Sreenath
1948-1977
Professor



HA Havemann
1949-1957
Professor

P Srinivasan
1949-1981
Professor



CH Kent
1954/55 - 1957
Visiting Professor

S Nageswara Rao
1950s-
Professor

K Narayana Swamy
1950-1986
Professor

MR Raghavan
1951-1988
Professor

MA Thirunarayanan
1951-1986
Professor

A Ramachandran

1950-1967
Professor

KTS Iyengar

1951-1990
Professor

BK Subbarao

1953-1985
Assistant Professor

V Kuppu Rao

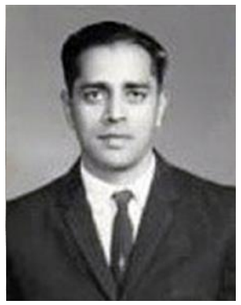
1954-
Assistant Professor

RG Narayana Murthy

1954-
Professor

NN Narayana Rao

1954-
Professor



MR Seshadri

1955-1992
Professor

N Srinivasa Murthy

1956-1988
Associate Professor

P Venkata Rao

1957-
Associate Professor

Gurudas Hazra

1957-
Lecturer

K Krishna Prasad

1958-
Professor

KS Sreenivasamurthy

1959-1997
Professor

S Narayan Das

1960s-
Scientific Officer

CR Prasad

1960s-
Assistant Professor

BC Dutta

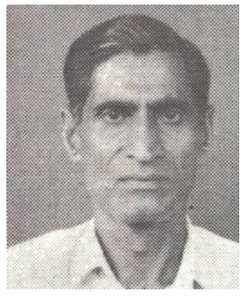
1960s-
Professor

V Easwaran

1960s-
Assistant Professor

Mandyam N Srinivasan

1960-2000
Professor



CL Sharma

1960s-
Principal Research Scientist

S Rama Murthy

1960s-
Assistant Professor

J Gururaja

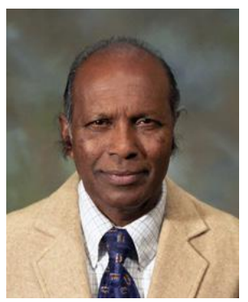
1961-1978
Associate Professor

VTVS Ramachandra Rao

1961-1966
Assistant Professor

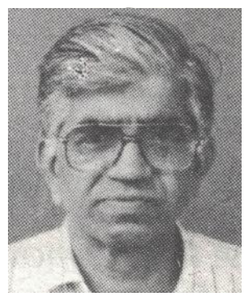
SS Tripathi

1961-1966
Lecturer



K Srinagesh

1962-1970
Assistant Professor



BG Nair

1962-1997
Principal Research Scientist

R Narasimhamurthy

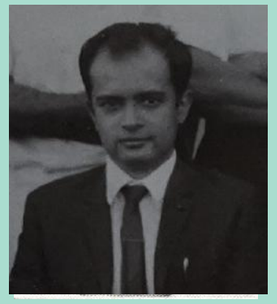
1964-1985
Professor

Malur N Srinivasan

1965-1988
Professor

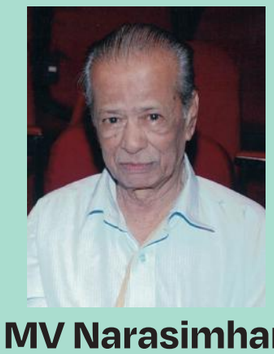
PV Sudhindra

1965-1968
Lecturer



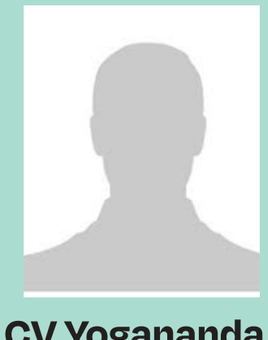
S Venkatesh

1965-1976
Assistant Professor



MV Narasimhan

1965-1994
Professor



CV Yogananda

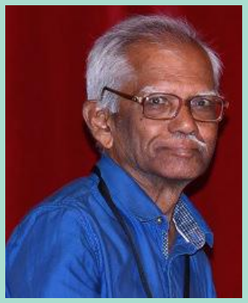
1965-1972
Assistant Professor

S Seshan

1966-2002
Professor

G Ramachandra Prasad

1966-1968
Lecturer



TS Mruthyunjaya

1966-2003
Professor

Jeevana Shankar

1967-2000
Assistant Professor

K Aprameyan

1967-1967
Lecturer

R Ganesh

1967-1969
Lecturer

R Hariharan

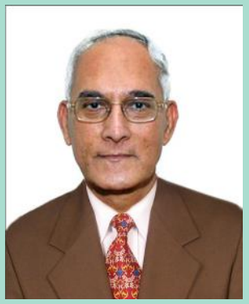
1960s-
Principal Research Scientist

HR Nagendra

1968-1975
Assistant Professor

N Raman

1968-2003
Principal Research Scientist



ML Munjal

1968-2010
Professor

A Suryanarayanan

1969-2006
Principal Research Scientist

NS Mahadevan

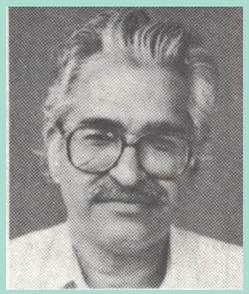
1970-1971
Lecturer

VA Bapat

1970-1980
Lecturer

Prabha Venkatesh

1970-1987
Senior Scientific Officer



Prithvi Raj Arora

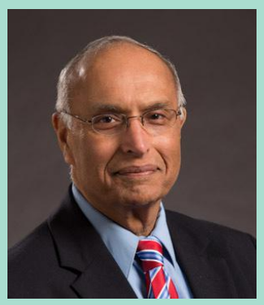
1970-1998
Principal Research Scientist

S Soudaranayagam

1971-1990
Professor

DL Prasanna Rao

1971-1983
Assistant Professor



PK Rohatgi

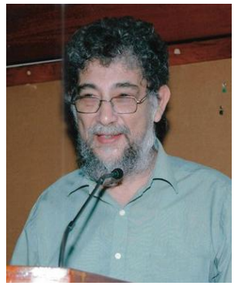
1972-1977
Professor

LS Srinath

1972-1984
Professor

JS Ansari

1973-1978
Assistant Professor



SK Biswas

1976-2010
Professor

AG Marathe

1977-1991
Assistant Professor

VH Arakeri

1977-2011
Professor

Udipi Shrinivasa

1982-2012
Professor

K Srinivasan

1982-2005
Professor

J Srinivasan

1982-2013
Profesor

BN Pramila Bai

1986-1995
Assistant Professor

MV Krishnamurthy

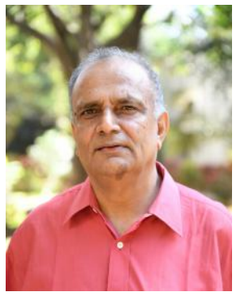
1986-2003
Professor

C Dharuman

1986- Present
Senior Scientific Officer

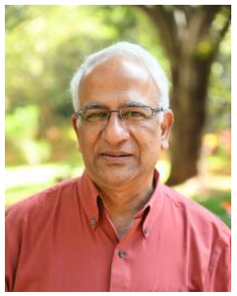
GSVL Narasimham

1987- Present
Chief Research Scientist



KRY Simha

1988-2020
Professor

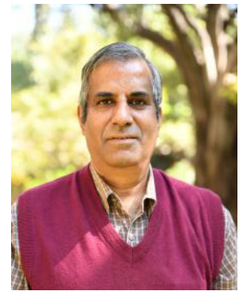


Jaywant H Arakeri

1988-Present
Professor

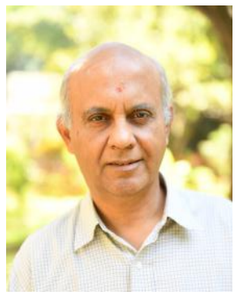
Ashitava Ghosal

1988-Present
Professor



B Gurumoorthy

1988-Present
Professor

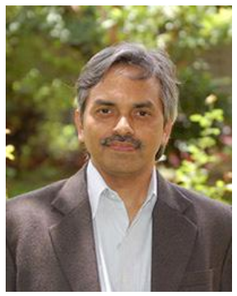


R Narasimhan

1991-Present
Professor

Uday Shirahatti

1994-1995
Assistant Professor



Rudra Pratap

1996-Present
Professor

Pradip Dutta

1996-Present
Professor

CS Jog

1997-Present
Professor

Satish V Kailas

1997-Present
Professor

Dibakar Sen

1998-Present
Professor

Venkata R Sonti

1999-Present
Professor

RV Ravikrishna

1999-Present
Professor

Anindya Chatterjee

2000-2009
Associate Professor

Raghuraman N Govardhan

2003-Present
Professor

MS Bobji

2003-Present
Professor

GK Ananthasuresh

2004-Present
Professor

Himabindu M

2007-Present
Scientific Officer Gr.II

Namrata Gundiah

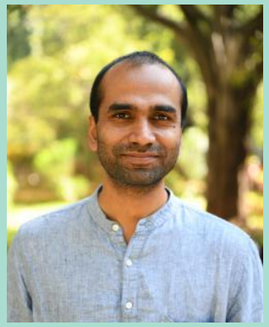
2008-Present
Professor

R Thirumaleswara Naik

2008-Present
Scientific Officer Gr.II

Ratnesh K Shukla

2009-Present
Professor



Gaurav Tomar

2010-Present
Associate Professor

Saptarshi Basu

2010-Present
Professor

GR Jayanth

2010- Present
Associate Professor

Pramod Kumar

2011-Present
Associate Professor

Vinod Srinivasan

2013-2015
Assistant Professor

Ramsharan Rangarajan

2015-Present
Associate Professor

Aloke Kumar

2017-Present
Associate Professor

Susmita Dash

2018-Present
Assistant Professor

Koushik Viswanathan

2018-Present
Assistant Professor

Navaneetha K Ravichandran

2020-Present
Assistant Professor

Jishnu Keshavan

2020-Present
Assistant Professor

Balachandra Suri

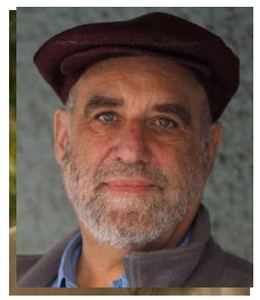
2021- Present
Assistant Professor

Amrit Ambirajan

2021- Present
Research Professor

Debashish Das

2022 - Present
Assistant Professor



Andy L Ruina

2022-Present
Visiting Professor (Cornell University)

3.4 | Staff pictures

Dr Alok Behera

Ms Mangala R

Ms FS Banu

Mr Raja K

Ms Chinnamma

Mr KG Haridasan

Mr G Babu

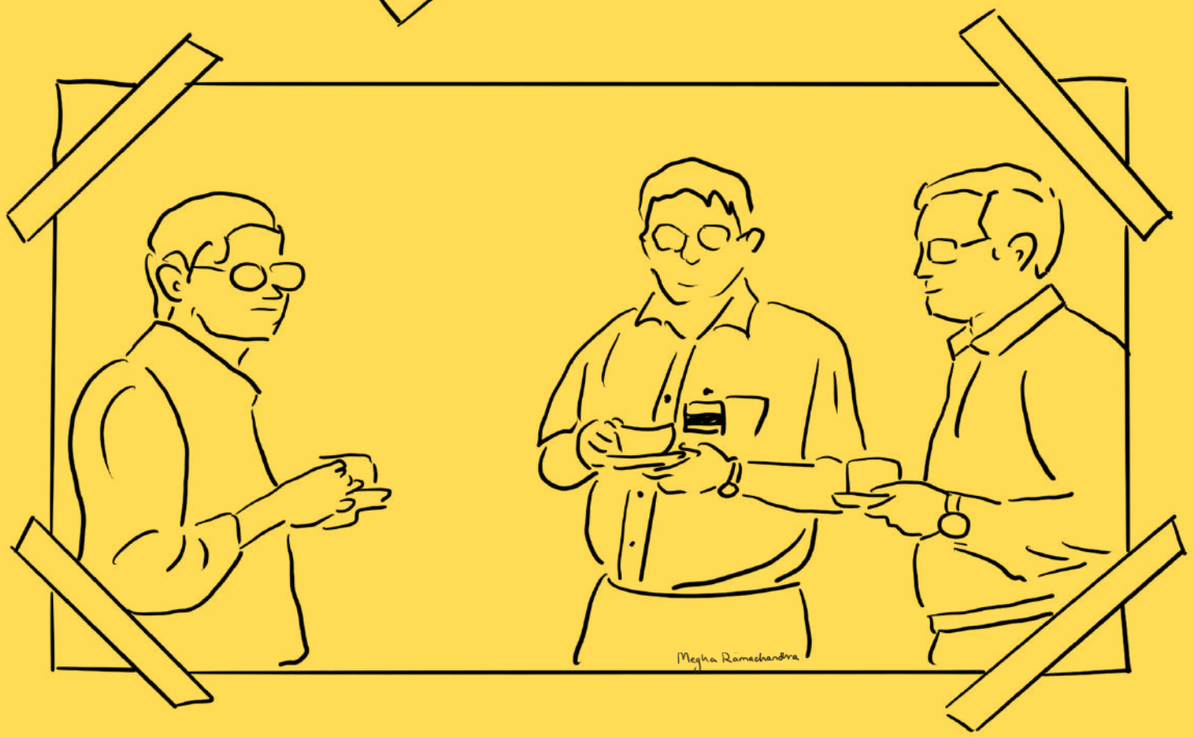
Mr Chandran

Mr Sampath P

Mr A Kareem


Megha Ramachandra


Megha Ramachandra


Megha Ramachandra

4 | Pictures and memories

For the ME faculty and students who have passed through the gates of IISc over the last few decades, the department, situated as it is in such verdant surroundings, has always been at the centre of long-standing friendships and joyous camaraderie.

The warmth is evident in the ME department even to this day. On any afternoon, you can see a group of faculty taking a walk during their coffee break, sharing thoughts on work and life. This shared experience — a daily ritual — lends an additional sliver of uniqueness to the department in the middle of the regular academic life at the Institute.

This bonding over coffee or tea is further nurtured even as faculty and students have enthusiastically participated, and continue to do so, in various sporting events: Volleyball, Kho-Kho, Cricket etc.

The Cricket team even bagged the cup at the recent intra-Institute sports meet, Spectrum. Public outreach events like the 'Open Day' have also helped these friendships grow, as students of the department come together to organise and conduct these events.

Over the years, the department has hosted and trained faculty from other engineering colleges through their doctoral programs, defense personnel, research engineers from ISRO, DRDO, among others.

Many of the alumni have fond recollections of their stay in the department, the activities they have participated in, and the life on campus. These recollections and reminiscences from the alumni speak to us across time and across boundaries of a warm and nurturing campus.

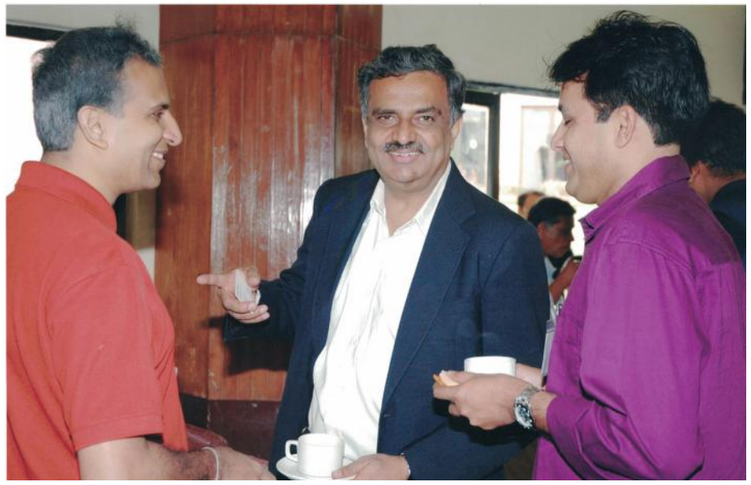
(Top): Prof S Seshan addressing the National Seminar on Developments in Moulding and Core Making, 1984; (Bottom): Profs G Padmanaban (left) and S Seshan at the Golden Jubilee, 1995

(Top): Prof P Balaram addressing the IISc Centenary International Conference on Advances in Mechanical Engineering, 2008; (Bottom): Prof A Ramachandran lighting the lamp at (the Alumni Meet 2008) as Profs P Balaram, (need to check the name), and Jaywant Arakeri look on

(Top, L to R): Profs GK Ananthasuresh, Sanjay K Biswas, Rudra Pratap and Venkata Sonti at the IISc Centenary Conference, 2008; (Bottom, L to R): Profs Jaywant Arakeri, Satish V Kailas, MV Narasimhan at the ME department Alumni Meet, 2008

Attending conferences and catching up

(Top-left, L to R): Prof ML Munjal, Mrs Somavathi, Profs A Ramachandran, Vijay Arakeri, Rudra Pratap, Satish V Kailas, Mr PN Sunderrajan, Mr R Hariharan, (Seated): Prof MV Narasimhan, at the AR auditorium inauguration in 2013; (Top-right): Standing (L to R): Profs Vijay Arakeri, Satish V Kailas, Udipi Shrinivasa, Jaywant Arakeri, Ashitava Ghosal. Sitting (L to R) Profs Rudra Pratap, MV Narasimhan. Sitting (Behind): Prof A Ramachandran; (Bottom-left):(R to L) Profs N Balakrishnan with S Seshan (centre) with a friend having a laugh at the AR auditorium inauguration, 2013



In good cheer: *(Top row): (L to R): Prof KRY Simha (centre) with the alumni in 2008;* ***Chatting over chai:*** *(L to R) Profs. MS Bobji, Anindya Chatterjee, with a department alumnus in 2008;* ***Listening on:*** *The attendees at the ME Department's alumni meet, 2015; (Bottom): Prof B Gurumoorthy (centre) with alumni*

The Alumni meets over the years

Group picture: *(Left): From the alumni meet, 2017;* ***Bidding adieu:*** *(Right): A picture from the batch of 2015's farewell*

I was in IISc from 1960 to 1964, when the ME department used to be Power Engineering. We were a small group of students, with five in the research group and about eight in the Master's program. My thesis adviser was Prof Arcot Ramachandran, who was extremely helpful in finishing my thesis at the last moment so that I could travel the next day.

- Mr S Kasturi, MSc (1964)

The students of the Department had such a cordial relationship with the faculty members that we could stop by and talk to them with ease. I distinctly remember the New Year get-together on the terrace of the old building organised by students in which all the faculty members participated, with Prof MV Narasimhan, the Chairman of the Department, especially encouraging all of us.

- Prof Sangeeta Kohli,
PhD (1993), Professor at IIT Delhi

‘Open Day’ magic

Showrunners: *ME faculty and students who participated in Open Day, 2017*

“It is a privilege to be in IISc, even for a short period. I remember waking up to the birds and looking up at the sky from the window in N-72 (where I stayed as a student) every morning and feeling blessed. There is much to learn even by observing the faculty and senior students; not just [to learn] how to perform research but also how to conduct oneself rationally and professionally.

- Dr Bhallamudi Ravi,
ME (1988); PhD (1992), Professor at IIT Bombay

“I was very excited and thrilled to secure admission to the institute. I saw an excellent ambiance in the campus and hostel zone, a calm and sober climate, a beautiful administrative building, and a tall chairman (Prof S Soundaranayagam) sitting in a tall chamber.

- Dr N Ramesh Babu
ME (1980)
Professor at IIT Madras

“As students, we worked through the weekdays. On Sundays, we had lunch outside, went for a movie in Brigade Road, or a music program in Malleshwaram.

- Prof Udipi Shrinivasa

Women power: *(Top): Members of the faculty and staff from the ME department at Open Day, 2017;* ***The showrunners:*** *(Bottom): ME faculty and students pose in front of the ME department, 2018*

You have our attention: *Children and other visitors listening attentively to a student at Open Day, 2018*

“Open Days taught me many things — from simple explanations to children to the in-depth understanding of any demonstration. Hidden physics behind simple phenomena and coming up with a more straightforward demonstration takes a lot of thinking, at least when some applications are connected to them.

- Dr Navneet Kumar
PhD (2017), Assistant Professor at IIT Jammu

“Campus recruitment was another great event. The Mechanical Engineering office would help us set up interviews. The big industries used to come to IISc first to take the cream away. We could choose 3 firms for being interviewed and once an offer was made the student was not entitled to attend any more interviews. All the students in our batch had received their job offer months before they graduated. Such was the popularity of the Mechanical Engineering Department.

- Mr PR Kishen, ME (1981)

“It was very homely, and I believe it still is. I felt very tentative on my first day and the last day arrived too soon. I wanted to live this life forever.

- Dr Subrata Chakrabarti
ME (2011)
Scientist at ISRO Trivandrum

Smiles and cheers to welcome all: *(Top): ME students ready for Open Day 2017;* ***Ready for take-off:*** *(Bottom): ME students displaying a model rocket in front of school children and college students;*

In motion: *(Top): An international ME student demonstrating turbulence to college students and school children;* ***Starting young:*** *(Bottom): School children trying their hand in experimenting on Open Day, 2017*

Children, our future: *Piquing the interest of school children who are shepherded by enthusiastic teachers through the institute grounds on Open Day*

Coming together: *The current Chair of the ME department, Prof Raghuraman N Govardhan (second from left), interacting with a college student*

"I loved my morning commute to the ME building. Quiet roads, animal sounds, cool — at least relatively cool — weather. My end-of-day commute, though warmer, still had its exciting moments. The fruit bats resting in the trees sometimes would take flight simultaneously as I returned to the guest house. At first, it was a bit disconcerting until I realised they had little interest in me!

- Prof Ron Lumia
Visiting Professor from the University of New Mexico (2008 - 09)

"The ME department was scattered in a few different locations, starting with the IC Engines building towards Malleswaram 18th Cross, then the main department next to the Electrical department, the Fluid Mechanics Lab, and the Mechanical Engineering workshop or Foundry near the Biochemistry department.

- Mr DD Sharma (1989)
Head of Enterprise GDI Engineering at Splunk

Four-legged machine: *An ME student demonstrating a robotic dog on Open Day, 2017*

Sands of time: *Chladni patterns on a vibrating plate*

> *Although this system [of using energy from exhaust to AC onboard ships, which I worked on as my project in the Department] is widely used in the western world and merchant navy ships, it was my long-term personal goal to implement it directly onboard the Indian Navy ships. The work is being undertaken by the Officer in research and policy level.*
>
> *- Cdr Karthik Bharadwaj*

> *Coming from the ship helped since a ship is an amalgamation of all fields of major fields of mechanical engineering. Background practical knowledge helped a lot while taking theory classes at IISc. Additionally, the professors were kind enough to help in the completion of the course.*
>
> *- Cdr Himanshu Raj*

ME Cricket teams: *(L to R): Batch of 2001-2003; Students and faculty after a match; Prof Satish Kailas and ME students after a match in 2015;* ***On the field:*** *Faculty and students playing cricket, 2015*

> ***Laws of Thermodynamics applied to PhD students***
>
> - *To get the work done from as PhD student, the supervisor turns the heat on.*
> - *Sometimes students will not work even if the heat is on. This leads to entropy generation.*
>
> *- Prof K Srinivasan*

Scenes from Spectrum, 2022

> *IISc campus allowed me to meet comrades from different parts of the organisation. IISc labs and the department gave me cognizance. I learned to ask questions and not accept.*
>
> *- Dr Sudipta Dutta*
> *PhD (2018), R&D Engineer at WDC Bangalore*

Staff members of the ME department with Prof Vijay Arakeri during his retirement function (L to R): Ms Fasiha Shaheen Banu, Mr N Chandran, Mr Raja, Prof Satish V Kailas, Prof Vijay Arikeri, Mr G Babu, Mr Divyarajan D, Mr R Srinivas, Mr C Ramaswamy

All smiles: *Members of the ME department's staff standing on the steps of the newly-inaugurated ME building, 1994; Bottom row (L to R): Mr C Subramani, Mr Kumar, Mr VP Raju, Mr Lakshmikanthaiah, Mr Shivaraya Shenoy M, Mr Radhakrishnan Nair, Mr Narayanaswamy, Mr Raja, Mr Srinivas; Top row (L to R): Mr Ramalingam, Mr Govindan, Mr Karimullah, Mr G Babu, Mr Sampath, Mr Dharuman, Mr Krishna, Mr Yusuf Khan*

“The work culture in the department is so good that I want to implement that in my time at IIT Roorkee.

- Dr Sudhakar Subudhi, PhD (2009)
Associate Professor at IIT Roorkee

“The most beautiful part of our Department is the entrance! Surrounded by a lot of beautiful trees and flowers. It is a peaceful place, and it will give you the feeling that everything is going to be okay, and you will complete your research.

- Dr Yogendra V Kuwar, PhD (2020)
Assistant Professor at NIT Surat

Some of the faculty and staff of the ME department

The faculty and staff of the ME department, 1995

The scholars of the ME department, 1995

Catching up after COVID-19 lockdowns

Heritage committee: *(Left to Right): Vaishali Chandra, Chetan Teki, Avaneesh Athreya V, Anushul Shrivastava, Ashish Kumar, Deepika Sharma, Prof Yogendra Simha (behind), Prof G K Ananthasuresh, Prof M L Munjal, Prof Koushal Verma, Gautham Vadlamudi, Vageesh Singh Baghel, Adarsh D, Visakh M G, Gannena K S Raghuram*

ME@75 Distinguished Lectures Series

Prof. Dr. Claus-Dieter Ohl

Cavitation Near Boundaries, in Boundaries, and Due to Boundaries

Department for Soft Matter, Institute for Physics, University of Magdeburg.

November 24, 2021

Prof. Chris Dames

Energy Applications of Thermal Switches and Diodes

Department Chair and Howard Penn Brown Professor, Department of Mechanical Engineering, University of California at Berkeley

August 24, 2021

Prof. Hideki Kawakatsu

Atomic Force Microscopy Related Techniques -application to Tribology, Colour Imaging, and Artificial Reproduction Technology

Institute of Industrial Science, The University of Tokyo

October 1, 2021

Dr. Murali S. Nair

Technology Startup Funding by the US National Science Foundation

Program Director, United States' National Science Foundation SBIR/STTR program

July 14, 2021

Dr. Charles A. Taylor

Patient-Specific Modeling of Blood Flow in Arteries - from the Academy to the Clinic

Founder, Chief Technology Officer (CTO), Heartflow Inc.

September 8, 2021

Prof. B. Balachandran

Data-Driven Nonlinear Dynamics

Minta Martin Professor, Department of Mechanical Engineering, University of Maryland.

June 15, 2021

Mr. Bhaskar Bhat

Titan Company: Leveraging Technology in the Fast-Changing World of Lifestyle

Retired, Managing Director of Titan Company Ltd.

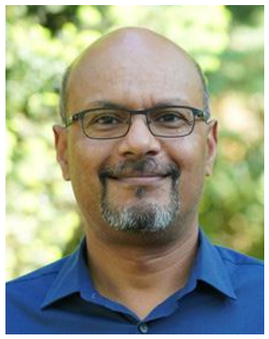
June 9, 2021

Prof. Karen E. Willcox

Predictive digital twins and the data-driven future of computational science

Director of the Oden Institute for Computational Engineering and Sciences, Associate Vice President for Research, and Professor of Aerospace Engineering and Engineering Mechanics, University of Texas, Astin

April 7, 2021



Prof. Rajat Mittal

From Beating Hearts to Buzzing Wings: Flow Physics and Computation at the Intersection of Mechanics and Bioengineering

Professor, Department of Mechanical Engineering, Johns Hopkins University, Whiting School of Engineering.

May 12, 2021

Prof. Sarah Bergbreiter

Microsystems-inspired robotics

Professor of Mechanical Engineering, Carnegie Mellon University.

March 17, 2021

Prof. Rudra Pratap

Reflections on Choices and Risks for Impact in Academic Life: A Personal Perspective

Professor of Centre for Nano Science and Engineering, Indian Institute of Science, Bengaluru.

April 29, 2021

Prof. Dennis M. Kochmann

Learning from the building blocks of nature in the design of periodic architected materials

Professor of Mechanics and Materials, Institute for Mechanical Systems, ETH Zurich.

February 17, 2021

Release of the ME@75 book on 29 June, 2022 at JN Tata Auditorium, IISc

Participants of the ME@75 Conference at JN Tata auditorium

भारतीय विज्ञान संस्थान

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