



KNOWLEDGE INCUBATION FOR TEQIP, IIT KANPUR

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# Pravartanā

July 19 - 26, 2014

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Pravartanā 2014, a TEQIP workshop in the field of Mathematics and Applied Mechanics was held at IIT Kanpur from July 19<sup>th</sup> to 26, 2014. This workshop was a step towards expanding the scope IIT Kanpur's engagement with TEQIP institutes in both research and pedagogy. It was divided into two parts - School and Symposium.

The school on mechanics and applied mathematics offered short refreshers in –

- Engineering Mathematics
- Dynamics
- Fluid mechanics
- Solid mechanics.

This part of Pravartanā was for educators who wish to discuss teaching methodologies and/or expand their pedagogical goals to meet the ever increasing demands of technical education. It was also planned in way to help students who intend to participate in the symposium to follow and/or pursue higher studies in mechanics.

The symposium brought together some of the best researchers from India and abroad in the broad fields of dynamics and continuum (fluid and solid) mechanics. In this part researchers from TEQIP institutes were encouraged to present their own work.

## **Topics Discussed**

### **School**

- Applied Math: Linear Algebra
- Applied Math: ODE; Numerical methods
- Mathematical preliminaries for Mechanics: Vector/tensor algebra and analysis
- Dynamics: Kinematics
- Dynamics: FBD Conservation laws; Inertial and rotating frames; Inertia tensor
- Fluid Mechanics :Kinematics; Balance laws; Constitutive laws
- Fluid Mechanics: Viscous flows; Flow past sphere; Lubrication theory; BVP
- Continuum Mechanics: Kinematics
- Continuum Mechanics: Balance laws and the notion of stress
- Applied Math: PDE; Numerical methods; Complex variables

- Applied Math: PDE; Numerical methods
- Dynamics: FBD; Conservation laws; Inertial and rotating frames; Inertia tensor
- Dynamics: Vibration of two-dimensional systems
- Fluid Mechanics: Potential flow; Bernoulli's equation
- Fluid Mechanics: Boundary layer theory
- Solid Mechanics: Linear elasticity and viscoelasticity; simple shear problem
- Solid Mechanics: Boundary value problems in linear elasticity

### **Symposium:**

- Analysis of two-dimensional rigid inclusions subjected to forces and moment.
- Elastic and material instabilities in hyperelastic materials
- Predictive mathematical models of human walking and running.
- Robust Control-An Uncertainty and Disturbance Estimation based Approach.
- Hydrodynamic stability: the role of the continuous spectrum.
- Creep and warping analyses of hot running railway wheels.
- Temperature Control in Molecular Dynamics
- Mathematical Modeling and control law design for rotational dynamics of launch vehicle and reusable launch vehicle.
- Aerodynamics of Birds' Flight and Design of an Ornithopter.
- Drop formation of a power-law fluid on a thin film coating a vertical fiber.
- Advanced numerical methods for modeling continuum phenomena on modern computer architectures.
- Importance of Fluid Flow in Optimization and Control of Industrial Reactors.
- Multivariate Data Analysis Techniques for Linear Mixing Models.
- Modeling micro structural phenomena using lattice spring networks.
- Taylor-Couette like vortices and the micro-mechanics of stress transmission in sheared granular materials.
- Heat and mass transport from particles and drops: role of convection.
- Explaining the flow of elastic liquids.
- Modeling human movement: Mechanics, energy, optimality, and stability

## **LIST OF SPEAKERS**

### **School**

- Prof. Anindya Chaterjee, IIT Kanpur
- Prof. Ishan Sharma, IIT Kanpur
- Prof. V. Shankar, IIT Kanpur
- Prof. Anurag Gupta, IIT Kanpur
- Prof. Atnau Mohanty, IISc. Bangalore
- Prof. Shakti Gupta, IIT Kanpur
- Prof. Debopam Das, IIT Kanpur
- Prof. Sovan Das, IIT Kanpur

### **Symposium**

- Tanmay Bhandakkar, IIT Bombay
- Prof. C S Jog, IISc Bangalore
- Prof. Manoj Srinivisan. Ohio State University
- Prof. S.E. Talole, Defense Institute
- Prof. Ganesh Subramaniam, JNCSR
- Vikranth Racherla, IIT Kharagpur
- Prof. Baidurya Bhattacharyya, IIT Kharagpur
- Prof. Gopal Jee, ISRO
- Prof. John Hinch, Cambridge University
- Prof. Shivsubramanian Gopalkrishnan IIT Bombay
- Prof. Venkat Runkana ,TRDDC
- Prof. Srikanth Vedantam, IIT Madras
- Prof. Prabhu Nott, IISc Bangalore

## **PARTICIPATING INSTITUTES**

<b>Institute</b>	<b>Number of Participants</b>
AMU	2
MNNIT, Allahabad	2
IFTM University, Moradabad	1
N.C.I.T ISRANA ,PANIPAT	3
L.E. College, Morbi	1
Govt. Engineering College , Gandhinagar	1
GBPEC, Pauri	5
IEST, Shibpur	14
UIET, Punjab University	3

PEC University of Technology	4
IET Lucknow	1
NIT, Raipur	4
HBTI, Kanpur	1
L.D.College of Engineering	1
Gujarat Technological University, Gujarat	1
Birla Vishvakarma Mahavidhyalaya	2
MKECIT Azamgarh	1
NIT, Kurukshetra	2

## **SCHEDULE**

### **Pravartanā School**

**July 19, 2014**

Time	Event
8:30 AM -9:00 AM	<b>Registrations/ Welcome</b>
9:00 AM – 10:30 AM	<b>Applied Math I (Linear Algebra)</b> Prof. Anindya Chaterjee
10:30 AM – 11:00 AM	<b>Coffee Break</b>
11:00 AM – 12:30 PM	<b>Applied Math II (ODE; Numerical methods)</b> Dr. Anindya Chatterjee
12:30 PM – 1:00 PM	<b>Tutorials</b>
1:00 PM – 2:30 PM	<b>Lunch Break</b>
2:30 PM – 4:00 PM	<b>Mathematical preliminaries for Mechanics (Vector/tensor algebra and analysis)</b> Dr. Ishan Sharma
4:00 PM – 4:30 PM	<b>Coffee/ Tutorials</b>
4:30 PM – 6:00 PM	<b>Dynamics I (Kinematics)</b> Dr. Ishan Sharma
6:00- 6:30	<b>Coffee Break</b>

**July 20, 2014**

Time	Event
9:00 AM – 10:30 AM	<b>Dynamics II (FBD; Conservation laws; Inertial and rotating frames; Inertia tensor)</b> Dr. Ishan Sharma

10:30 AM – 11:00 AM	<b>Coffee/ Tutorial</b>
11:00 AM – 12:30 PM	<b>Fluid Mechanics I (Kinematics; Balance laws; Constitutive laws)</b> Dr. V Shankar
12:30 PM – 1:00 PM	<b>Tutorial</b>
1:00 PM – 2:30 PM	<b>Lunch Break</b>
2:30 PM - 4:00 PM	<b>Fluid Mechanics II (Viscous flows; Flow past sphere; Lubrication theory; BVP)</b> Dr. V Shankar
4:00 PM – 4:30 PM	<b>Coffee/ Tutorial</b>
4:30 PM – 6:00 PM	<b>Continuum Mechanics I (Kinematics)</b> Dr. Anurag Gupta
6:00 PM- 6:15 PM	<b>Coffee Break</b>
6:15 PM – 7:15 PM	<b>Hydrology in ancient India</b> Prof. Veeravalli

**July 21, 2014**

<b>Time</b>	<b>Event</b>
9:00 AM – 10:30 AM	<b>Continuum Mechanics II (Balance laws and the notion of stress)</b> Dr. Anurag Gupta
10:30 AM – 11:00 AM	<b>Coffee/ Tutorial</b>
11:00 AM – 12:30 PM	<b>Applied Math III (PDE; Numerical methods; Complex variables)</b> Dr. Atanu Mohanty
12:30 PM – 1:00 PM	<b>Tutorial</b>
1:00 PM – 2:30 PM	<b>Lunch Break</b>
2:30 PM - 4:00 PM	<b>Applied Math IV (PDE; Numerical methods)</b> Dr. Atanu Mohanty
4:00 PM – 4:30 PM	<b>Tutorial</b>

4:30 PM – 6:00 PM	<b>Dynamics III (FBD; Conservation laws; Inertial and rotating frames; Inertia tensor)</b> Dr. Shakti Gupta
6:00 PM- 6:30 PM	<b>Tutorial/ Coffee</b>

**July 22, 2014**

<b>Time</b>	<b>Event</b>
9:00 AM – 10:30 AM	<b>Dynamics IV (Vibration of two-dimensional systems)</b> Dr. Shakti Gupta
10:30 AM – 11:00 AM	<b>Coffee/ Tutorial</b>
11:00 AM – 12:30 PM	<b>Fluid Mechanics III (Potential flow; Bernoulli's equation)</b> Dr. Debopam Das
12:30 PM – 1:00 PM	<b>Tutorial</b>
1:00 PM – 2:30 PM	<b>Lunch Break</b>
2:30 PM - 4:00 PM	<b>Fluid Mechanics IV (Boundary layer theory)</b> Dr. Debopam Das
4:00 PM – 4:30 PM	<b>Tutorial</b>
4:30 PM – 6:00 PM	<b>Solid Mechanics I (Linear elasticity and viscoelasticity; simple shear problem)</b> Dr. Sovan Das
6:00 PM- 6:30 PM	<b>Coffee</b>

**July 23, 2014**

<b>Time</b>	<b>Event</b>
9:00 AM – 11:00 AM	<b>Solid Mechanics II (Boundary value problems in linear elasticity)</b> Dr. Sovan Das
11:00 AM – 11:20 AM	<b>Coffee Break</b>
11:20 AM – 12:20 PM	<b>Tutorial</b>
12:20 PM – 12:45 PM	<b>Closure</b>

12:45 PM - 2:00 PM	<b>Lunch Break</b>
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**Pravartanā Symposium**

**July 23, 2014**

<b>Time</b>	<b>Event</b>
2:30 PM – 3:00 PM	<b>Welcome</b>
3:00 PM – 4:00 PM	<b>Analysis of two-dimensional rigid inclusions subjected to forces and moment</b> Tanmay Bhandakkar, IIT Bombay
4:00 PM – 5:00 PM	<b>Elastic and material instabilities in hyperelastic materials</b> Prof. C S Jog, IISc. Bangalore
5:00 PM	<b>Tea and Poster presentations</b>

**July 24, 2014**

<b>Time</b>	<b>Event</b>
9:00 AM – 10:00 AM	<b>Predictive mathematical models of human walking and running</b> Prof. Manoj Srinivisan, Ohio State University
10:00 AM – 11:00 AM	<b>Robust Control-An Uncertainty and Disturbance Estimation based Approach</b> Prof. S.E. Talole, Defense Institute
11:00 AM – 11:30 PM	<b>Tea Break</b>
11:30 PM – 12:30 PM	<b>Hydrodynamic stability: the role of the continuous spectrum</b> Prof. Ganesh Subramaniam, JNCSR
12:30 PM – 1:30 PM	<b>Creep and warping analyses of hot running railway wheels</b> Vikranth Racherla, IIT Kharagpur
1:30 PM - 3:00 PM	<b>Lunch Break</b>
3:00 PM - 4:00 PM	<b>Temperature Control in Molecular Dynamics</b> Prof. Baidurya Bhattacharyya, IIT Kharagpur
4:00 PM – 5:30 PM	<b>Mathematical Modeling and control law design for rotational dynamics of launch vehicle and reusable launch vehicle</b> Prof. Gopal Jee, ISRO

5:30 PM	<b>Tea and Poster</b>
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**July 25, 2014**

<b>Time</b>	<b>Event</b>
9:00 AM – 10:00 AM	<b>Aerodynamics of Birds' Flight and Design of an Ornithopter</b> Prof. Debopam Das, IIT Kanpur
10:00 AM – 11:00 AM	<b>Drop formation of a power-law fluid on a thin film coating a vertical fibre.</b> Prof. John Hinch (Cambridge University)
11:00 AM – 11:30 PM	<b>Tea Break</b>
11:30 PM – 12:30 PM	<b>Advanced numerical methods for modeling continuum phenomena on modern computer architectures</b> Prof. Shivsubramanian Gopalkrishnan, IIT Bombay
12:30 PM – 1:30 PM	<b>Importance of Fluid Flow in Optimization and Control of Industrial Reactors</b> Prof. Venkat Runkana, TRDDC
1:30 PM - 3:00 PM	<b>Lunch Break</b>
3:00 PM – 4:00 PM	<b>Multivariate Data Analysis Techniques for Linear Mixing Models.</b> Prof. Shankar Narasimhan , IIT Madras
4:00 PM – 5: 00 PM	<b>Modelling microstructural phenomena using lattice spring networks</b> Prof. Srikanth Vedantam, IIT Madras
5:00 PM – 6: 00 PM	<b>Taylor-Couette like vortices and the micro-mechanics of stress transmission in sheared granular materials.</b> Prof. Prabhu Nott, IISc. Bangalore

**July 26, 2014**

<b>Time</b>	<b>Event</b>
9:00 AM – 10:30 AM	<b>Heat and mass transport from particles and drops: role of convection</b> Prof. Ganesh Subramanian (JNCASR Bangalore)
10:30 AM – 11:00 AM	<b>Coffee Break</b>



11:00 AM – 1:30 PM	<b>Explaining the flow of elastic liquids</b> Prof. John Hinch, Cambridge University
1:30 PM – 3:00 PM	<b>Lunch Break</b>
3:00 PM – 4:00 PM	<b>Modeling human movement: Mechanics, energy, optimality, and stability</b> Prof. Manoj Srinivasan, Ohio State University
4:00 PM	<b>Coffee</b>

## Summary of Faculty Feedback

### Workshop session

<b>Questions</b>	<b>Excellent</b>	<b>Good</b>	<b>Ordinary</b>
Clarity of communication about workshop	10	07	00
Organization of the sessions	09	07	01
Quality of Posters	04	04	00
Quality of lectures	10	06	00
Effectiveness of discussions	07	06	00
Effectiveness of learning experience	07	08	00
	<b>Appropriate</b>	<b>Short</b>	<b>long</b>
Duration of workshops	15	00	02
	<b>Definitely</b>	<b>Maybe</b>	<b>No</b>

Would you like to have more such sessions?	12	04	00
Would you like e-lectures by experts on special	15	02	00
<b>Suggest specific topic that you would like additional expert lectures on</b>	<ul style="list-style-type: none"> <li>• Tensor, Dynamics &amp; Vibrations.</li> <li>• Design of m/c elements</li> <li>• Design and Robotics</li> <li>• Design of machine elements</li> <li>• Welding: submerged arc welding</li> <li>• Thermal Engineering</li> <li>• FEM and its application (FEM application with MATLAB)</li> <li>• Fluid dynamics.</li> <li>• MATLAB form basic to programming.</li> <li>• Open channel Hydraulics, Hydrology</li> <li>• FEM, XFEM, Non-Linear FEM and related methods like mesh free methods and their applications in solid Mechanics will be appreciated.</li> <li>• Computational Fluid Dynamics, IC Engines, HMT, Research Methodology</li> </ul>		
<b>Additional Suggestions</b>	<ul style="list-style-type: none"> <li>• A visit to Kanpur city help us to know more about Kanpur.</li> <li>• More exposure towards lab work, latest projects, latest technology available at IITK.</li> <li>• Organize workshop on Linear Algebra and its application only.</li> <li>• Copy of recorded lectures should be provided.</li> <li>• Course notes/material should be provided at starting.</li> <li>• If possible then text book related to course should also be provided.</li> </ul>		

## Teaching

<p><b>Which subjects do you teach?</b></p>	<ul style="list-style-type: none"> <li>• Design &amp; Dynamics of Machine, Metal Castings</li> <li>• Fluid Mechanics, Thermodynamics</li> <li>• BME</li> <li>• Machine design, Engg graphics, O.R</li> <li>• T.O.M</li> <li>• Machine Design</li> <li>• Refrigeration &amp; Air Conditioning</li> <li>• Thermodynamics.</li> <li>• Thermodynamics, CFD</li> <li>• Solid Mechanics</li> <li>• Mathematics at UG level.</li> <li>• Design of Hydraulics structure, Water Resources Engg.</li> <li>• Theory of elasticity and plasticity, FEM</li> </ul>	
<p><b>What is average student to teacher ratio in your institute?</b></p>	<p>15:01 14:01 20:01 20:01 50:01 25:01 20:01 15:01 60:01 16:01 12:01 15:01</p>	
<p><b>Questions</b></p>	<p><b>YES</b></p>	<p><b>NO</b></p>
<p>Do you have additional support for teaching (tutors, graders, teaching Assistants, etc)?</p>	<p>10</p>	<p>05</p>
<p>Do you give class projects for UG classes?</p>	<p>15</p>	<p>01</p>
<p>Do you give class projects for PG classes?</p>	<p>10</p>	<p>07</p>
<p>Do you have sufficient resources for laboratory courses?</p>	<p>12</p>	<p>05</p>
	<p><b>Sufficient</b></p>	<p><b>Inadequate</b></p>

Is the library/journal/e-connection support adequate?	10		06	
	<b>Definitely</b>	<b>May be</b>	<b>No</b>	
Would you like to have common (TEQIP) repository of course material?	15	02	00	
Would you like to visit IITK to participate in and develop course material (existing or new)	15	02	00	
Would you like to participate in creation of the repository material (course files/lab. Manuals/question bank/etc)	13	04	00	
	<b>e-courses</b>	<b>Workshops</b>	<b>Content</b>	<b>none</b>
How can IITK effectively help you prepare for teaching?	14	09	02	00
<b>How can TEQIP help improve your teaching?</b>	<ul style="list-style-type: none"> <li>• Providing such workshop sessions and STC.</li> <li>• We learn new methodology of teaching by seeing expertise of their field.</li> <li>• It helps us to see what's new is going around us in each field and each engineering field by visiting the institute.</li> <li>• By e-courses.</li> <li>• Help us to know about current research.</li> <li>• By attending workshop we got knowledge about various advance topic in a particular subject that we are not teaching UG students, and it also clears our doubts regarding different topic in particular subjects.</li> <li>• By organizing more such workshops on different fields.</li> <li>• Provide funds for books or desired books and journals should be provided.</li> <li>• By workshop and seminar.</li> <li>• By organizing such workshop in different topics.</li> <li>• More workshops and short term courses may be organized.</li> <li>• TEQIP has disseminated some new concepts which may be incorporated in the course content.</li> <li>• By giving an opportunity to interact with universities and colleges outside India via workshop, seminars, e-courses etc.</li> </ul>			

## Research

Questions	Definitely	Maybe	No
Would you like to visit an IIT for a visiting-faculty/post-doctoral fellow ,if offered(via TEQIP)?	13	03	01
Would you like to share/use research infrastructure at IITK, if made available?	16	00	00
Would you like to conduct collaborative research with IITK?	16	00	00
Would you like lectures by experts (Indian and international) on niche research areas/topics?	16	00	00
Do you want special-topic conferences?	07	07	00
<b>How can TEQIP help improve your research?</b>	<ul style="list-style-type: none"> <li>• Involve us in practical projects taken by the professor of IITK.</li> <li>• By TEQIP we come across various experts of our field, also we can see various research facilities at different places.</li> <li>• By conducting collaborative research.</li> <li>• By lab visit at IITK.</li> <li>• By providing various projects.</li> <li>• Sharing of experimental facilities.</li> <li>• Providing library access.</li> <li>• By conducting collaborative research programmes, e-courses.</li> <li>• Organizing workshop on current research area.</li> <li>• TEQIP has a good consortium of emerging/ element from different fields and organizations. So is always helpful in exploring new avenues of my research field.</li> </ul>		

## Summary of Student Feedback

### Workshop

Questions	Excellent	Good	Ordinary
Clarity of communication about workshop	09	05	00
Organization of the sessions	10	04	00
Quality of lectures	11	03	00
Quality of Posters	04	09	01
Effectiveness of discussions	05	09	00
Effectiveness of learning experience	09	05	00
	Appropriate	Short	long
Duration of workshop	08	05	01
	Definitely	Maybe	No
Would you like to have more such sessions?	11	03	00
Would you like e-lectures by experts on special topics?	11	03	00
Suggest specific topic that you would like additional expert lectures on	<ul style="list-style-type: none"> <li>• Dynamics</li> <li>• CFD</li> <li>• Fluid Power and hydraulic control system</li> <li>• FEM, Vibration, Elasticity &amp; Plasticity.</li> <li>• CFD related lectures, Fluid power.</li> <li>• Finite element analysis</li> <li>• Hydraulic machine, hydraulic control system, working principle of hydraulic power plant.</li> <li>• Magnets hydrodynamics</li> <li>• Flight mechanics</li> <li>• Modern manufacturing process.</li> <li>• Computational mechanics.</li> <li>• Thermodynamics, Manufacturing</li> </ul>		
Additional Suggestions	<ul style="list-style-type: none"> <li>• Some experimental workshop.</li> <li>• Its better if internet is accessible by visitors.</li> </ul>		

## Learning

Questions	Yes	No	
Do you get enough class projects?	9	05	
Is the learning adequate?	12	02	
Do you have sufficient resources for laboratory courses?	08	06	
What is your area of specialization	<ul style="list-style-type: none"> <li>• Mechanics of solid</li> <li>• Mechanics of fluid</li> <li>• Fluid Mechanics</li> <li>• Solid Mechanics</li> <li>• Aerospace Engg.</li> <li>• Abrasive flow machining (production Engg)</li> <li>• Fluid mechanics</li> </ul>		
	Sufficient	inadequate	
Is the library/journal support/e-connection adequate?	10	04	
	Definitely	Maybe	No
Would you like to have common (TEQIP) repository of course material?	10	04	00
Would you like to visit IITK to attend specialized courses?	13	01	00
Would you like MOOCS/e-resources based courses?	07	05	00
How can TEQIP help improve your learning?	<ul style="list-style-type: none"> <li>• By arranging experimental workshop.</li> <li>• Organizing similar workshop.</li> <li>• Arranging some experimental workshop.</li> <li>• Use ppt form for lectures.</li> <li>• It would have been better it workshop was conducted on either solid/fluid mechanics with deep topic coverage.</li> <li>• By providing more such programmes.</li> </ul>		

## Research

Questions	Definitely	Maybe	No
Would you like to visit an IIT for a short visit /internship/post-doctoral stint ,if offered(via TEQIP)?	12	02	00

Would you like to share/use research infrastructure at IITK, if made available?	10	03	00
Would you like to conduct collaborative research with IITK faculty?	11	03	00
Would you like lectures by experts (Indian and international) on niche research areas/ topics?	13	01	00
Do you want special-topic conferences?	11	03	00
How can TEQIP help improve your research?	<ul style="list-style-type: none"> <li>• By providing more no of research programme in different IIT &amp; IEST.</li> <li>• By providing more no of workshop at IITK.</li> <li>• Flow structures over a sphere are beneficial for my current project.</li> <li>• Definitely TEQIP helps in improving research work. It provides various resources to colleges to improve the quality education.</li> </ul>		

### OUTCOME

Pravartanā was a great success towards expanding the scope IIT Kanpur's engagement with TEQIP institutes in both research and pedagogy. Participants who attended Pravartanā were introduced to teaching methodologies of some broad fields of mechanics and applied mathematics. They learned new teaching concepts in these fields which can be practiced at their parent institute and expand their pedagogical goals. The symposium part of Pravartanā brought together some of the best researchers from abroad and India in fields of dynamics and continuum (fluid and solid) mechanics to present their research work. This was an excellent platform where researchers from TEQIP institutes could interact with some of the experts in these fields and also present their own work.