Association for Machines and Mechanisms News Bulletin

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Our Objectives and Activities

The main objective of AMM is to contribute to mechanical design at all levels starting from academic research to industrial initiatives, thereby enhancing the quality and reliability of indigenous machines. With this in view, AMM organises the National Conference on Machines and Mechanisms, NaCoMM, and the workshops on Industrial Problems on Machines and Mechanisms, IPRoMM regularly.

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Message from the Editor-in-Chief

Mechatronics Education in 21st Century

Over past few decades the development of a new multidisciplinary engineering philosophy has come into being in the industry that has become known as Mechatronics which involves the application of complex decision making to the operation of physical systems. Multidisciplinary engineering systems have as integral parts electronics, mechanical, computers and controls. Performance, reliability, low cost, robustness, and sustainability are absolutely essential. How engineering educators best transform students to make engineers poised to solve mankind's problems of the 21st century? How can a company transform itself to successfully design multidisciplinary engineering systems? The demand initiated by industry for engineers with such a different approach to the subject eventually guided universities towards creating dedicated degree programs for Mechatronics. When one talks about the elements needed for the next generation of engineering students, a list of keywords typically includes active learning, integrated learning, just in time instruction, theory versus practise, written and oral communication, multidisciplinary and interdisciplinary teams, lectures, tutorials, laboratories, workshops and design projects.

The question remained how to teach such a different philosophy within traditional engineering departments. A new approach towards teaching Mechatronics with the emphasis on developing a project-base supported by traditional teaching is the most effective way. Integration of constituent disciplines of Mechatronics through structured and open ended practical work, individual and group projects will have to be an essential element of a Mechatronics degree program. This radical approach aims to dispense with the concept of passive theoretical learning and encourages an attitude of active education. This has been attributed to the need for an engineer who can work across the boundaries of constituent disciplines to identify and apply the right combination of concurrent technologies which will provide cost-effective and reliable devices. The course should be designed to provoke reaction, thought and innovation in order to find the best solution to any given problem. In order to support the project work theoretical studies provide the basic building blocks without being directed at a specific project. This provides the necessary knowledge to apply to problem solving activities. Input from industry in the form of real-life design and development projects and supervision of such projects by experienced engineers is highly desirable. Going through the course the students will gain a global perspective of engineering systems. The ability to view a problem from an overall point of view rather than task or subject specific enables the engineer to remain flexible and adaptive within the industry or research work making the most of their skills.

Subhasis Bhaumik
Editor-in-Chief

Synthesis of Four-bar Mechanism for Rapier Drive

Anirban Guha and C. Amarnath
Department of Mechanical Engineering, IIT Bombay

An article in the previous AMM news bulletin (Vol. 3, No. 3, July 2011) had established the need for synthesising a four-bar mechanism for obtaining a coupler curve with the least possible deviation from a straight line over its entire path and using this to guide a rapier for a textile loom. Synthesis of symmetric coupler curves is a starting point for such an exercise. The procedure of obtaining symmetric coupler curves with two inflection points lying on a straight line has been outlined by Guha and Amarnath [1]. This requires positioning the symmetric coupler curve in a Cartesian coordinate system and choosing the axis of symmetry. Then from the knowledge of the geometry of such symmetric coupler curves [2], the coordinates of the coupler point (and its first and second derivatives) are related to the mechanism's dimensions. Application of the Freudenstein's equations to these relationships allows them to be reduced to a cubic equation which leads to at least one real solution -- the link lengths of the required mechanism. This allows a coupler of the kind shown in Fig. 1 to be synthesised. Trial and error allows the deviation D to be minimized. A couple of mechanisms with low D are shown in Fig. 2.

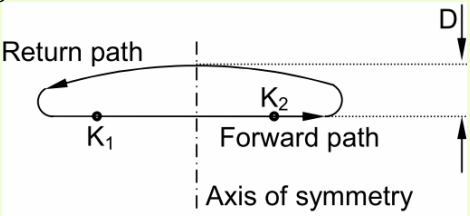

Fig. 1: Required coupler curve

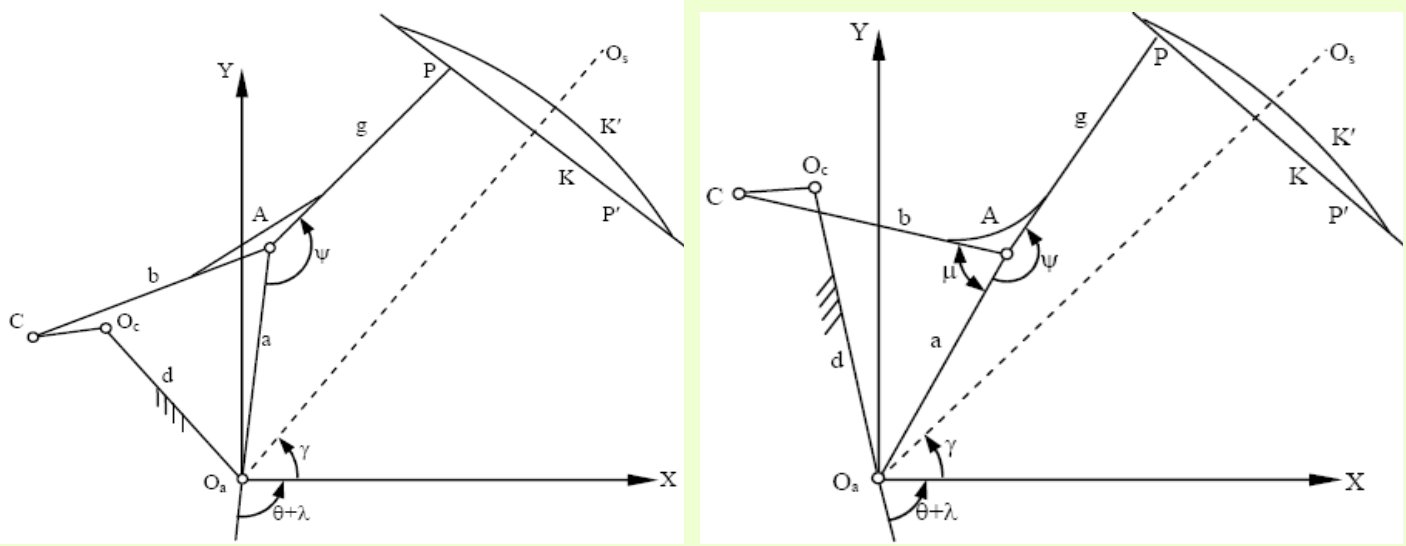

Fig. 2: Two mechanisms giving symmetric coupler curves with low deviation from the straight line

However, a proper comparison of such mechanisms could be done only by defining an objective criterion for comparing the coupler curves. The line joining two points on the coupler curve which are farthest from each other was defined as the "local x-axis." The distance between these two points is defined as the "extent." The perpendicular distance from a point on the coupler curve to the 'local x-axis' is a measure of the departure of the curve from the exact straight line and the maximum value of this departure (whether in the forward portion or the return portion of the coupler curve) was designated as the "deviation." One could thus define the deviation ratio as deviation/extent and this was used as a measure for comparing the coupler curves. The deviation ratios for the two mechanisms shown in Fig. 2 were 0.153 and 0.056. These two solutions were taken as the starting point for exercises in optimisation for improving the deviation ratio. All link lengths except the crank were varied. The extent was kept at least twice the crank length. Grid search algorithm gave a four-bar crank rocker with deviation ratio of 0.0116 whose link length ratios are as follows:

OcC = 100.00; CA = 333.08; AOa = 340.08; OcOa = 468.02CP = 468.87; AP = 326.17

One can claim that this four-bar mechanism (Fig. 3) gives the best possible straight line approximation to the entire coupler curve (for the current definition of deviation from the straight line).

This coupler point can be used to guide the rapier. However, in order to drive it, one needs a link in the mechanism to move parallel to itself in the path of this approximate straight line. An eight-bar solution for this is shown in Fig. 4. It has been obtained from the original mechanism by adding two parallelogram mechanisms OaAGH and APEG. The link PE moves parallel to itself and an appropriately profiled extension of this link can be used to mount the rapier.

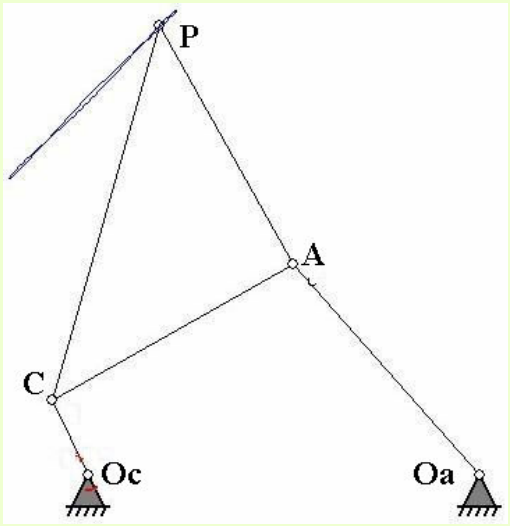

Fig. 3: Four-bar mechanism with best approximate straight line in the coupler curve

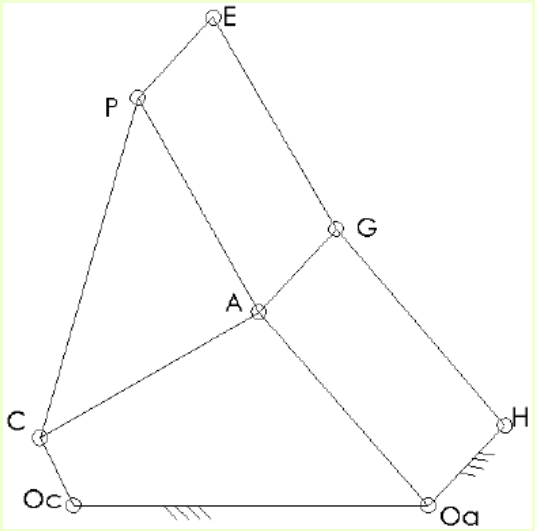

Fig. 4: Eight-bar mechanism for guiding and driving the rapier

A word of caution: The mechanism envelop is quite large compared to the extent of the approximate straight line. This makes the solution bulkier compared to the existing rapier drives. However, other mechanisms currently occupy significant space on both sides of a loom and appropriate profiling of links is expected to keep the proposed mechanism within the width of the current loom.

Use of a four-bar linkage with only revolute joints is only one approach for reducing the requirement of high precision manufacturing of rapier drives and stringent maintenance procedures for the user. The authors would like to explore other approaches for this application in future.

References

[1] Guha, A. and Amarnath, C., "Synthesis of Bar Linkage Mechanisms to Guide and Drive Rapiers," 13th World Congress in Mechanism and Machine Science, Guanajuato, México, 19-25 June, 2011.

[2] Hartenberg R.S. and Denavit J., "Kinematic Synthesis of Linkages," McGraw-Hill Book Company, New York, USA., pp. 150-152, Chap. 6., 1964.

Forthcoming Events

Innovative Teaching and Research

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In this article, innovative ways of teaching and research are proposed. They have emerged, mainly, due to the following reasons:

1. On the issue of employable graduates: In last one decade, there has been multi-fold increase in engineering institutions in India that has given rise to enhanced student enrolments. Even foreign universities have lined up to open their campuses in India. However, as BPO Watch India Bureau reported on April 07, 2011, "... of the graduates working in IT, only 25 per cent can be readily employed, said software lobby organisation NASSCOM." In reality, the technology companies would not be able to readily employ 10-25 per cent of the 550,000 engineering students graduating every year from approximately 3500 colleges. Such a situation is forcing the Indian outsourcing industry to spend almost US$ 1.0 billion every year to train these graduates from various institutions, said a report published in The Economic Times.
2. On the issue of Researchers' Social Responsibilities (RSR): It has been observed in the major research organisations in India, for example, in IISc, IITs, and other Government research laboratories like those in CSIR laboratories, ISRO, and others, that the research focus is on those areas which have already been established in the West or elsewhere. To name a few in last 2-3 decades are Robotics, Mechatronics, MEMS, etc. India as a follower of those areas will, probably, never be able to catch up with them. On the other hand, the research on the tools, devices and equipments, e.g., in farming and masonry processes, used by the grassroot-level people (estimated to be ~80%) is grossly neglected. Except few initiatives taken up by National Innovation Foundation (NIF), Rural Technology Action Group (RuTAG) from the Office of the Principal Scientific Advisor, Govt. of India, and others in last 10-15 years no concerted effort is visible in established research centres of India, as listed above. The above phenomenon is captured here in the phrase "Researchers' Social Responsibility" or RSR in-line with what is in known in the corporate sector, as CSR or "Corporate Social Responsibility".

In order to take care of the above issues, two steps are proposed here. They are:

a. RoCK-BEE or Robotic Competition Based Education in Engineering: Since the word "robot" attracts the young students, its design, fabrication, programming, testing, etc. to perform certain tasks as per the rules of a game (as specified by the organizer of a competition) can be exposed to students. Such exposure requiring a variety of subjects to be assimilated to successfully develop of a product (in this case robot), which is actually an objective of technical education. With the increasing number of student enrolments and proportionally decreasing number of faculty in the academic institutes it seems only feasible that the students learn themselves. Hence, the concept like RoCK-BEE appears to be a beginning towards that direction. In last ten years of the author's experience in guiding 20-30 students every year who take part in robotic competitions, it has been observed that several standard modules for robots have been realised. Hence, these people can be considered industry-ready. It is noteworthy that even robotics is used here to illustrate the concept; one can use any type of project-based education. However, competition is important, as this sets the goal for the students in a competitive mood. Hence, no self-manipulation is possible with regard to the final objective that typically happens in many academic projects.

b. MuDRA or Multibody Dynamics for Rural Applications: Here multi-body dynamics, the research area of the author, has been taken up for illustration only. The problems faced by the rural people of India or other developing countries, is grossly ignored. It may be due to the fear of not getting recognised by the established research organisations, as mentioned in item 2 above. However, it is a matter of correlations between the rural problems and the research topics that need to be established. For example, in order to run low-rpm machines in the absence of electricity one can use animals like bullocks, horses, etc. to drive a gearbox to increase the speed from about 2 rpm to about 500 rpm so that machines like chaff cutting, etc. can be run very easily. The challenge here is "what would be the gear design from mechanical failure and vibration point of view?" Such research is very much present for power-plant equipment designs, etc. In fact, many reputed universities abroad like Stanford Univ. (SU) in the USA and other countries have started realising such need. One such initiative by SU is "Entrepreneurship Design for Extreme Affordability." It is hoped that such attitudes will bring more enthusiasms among the researchers of IISc and IITs, and add more solutions to the social sectors.

The views expressed in this article are solely of the author as an individual faculty, not as a Patron of this news bulletin or as the Vice-president of AMM. For any comment/clarification, he should be contacted directly to his email address saha@mech.iitd.ac.in.

IIT Teams Win Awards in the ASME Competition

IIT Bombay

Team Members: Anish Kulkarni and Kshitij Thavare, Mech. Engg. Students
Mentor: Prof. C. Amarnath, Professor, Dept. of Mechanical Engineering

Competition: 2011 ASME Student Mechanism and Robot Design Competition was held during 2011 ASME International Design Engineering Technical Conference at Washington D.C. in August 2011. The competition called for submission of a paper and a working model. Selected teams were required to present their work as well as exhibit a prototype working model at the venue of the conference. The team was one of four selected for the finals and bagged the first prize in the competition.

Motivation: The motivation behind this project was to develop a steering mechanism for vehicles that can drastically improve their manoeuvrability so as to overcome the shortcomings of today's steering mechanisms. The functional requirements of the new steering mechanism were:

1. The mechanism should enable a vehicle to steer using just the two front wheels like the regular cars of today (Fig. 1a).
2. The mechanism should also enable the vehicle to steer with all four wheels, where direction of turn of rear wheels is opposite to that of the front wheels. With all four wheels steered thus, the vehicle has a smaller turning radius than normal front steering vehicles (Fig. 1b).
3. The mechanism should enable a vehicle to "Crab steer" or move sideways without turning the nose of the vehicle, which can be achieved if all the four wheels turn in the same direction (Fig. 1c).
4. The steering mechanism should enable a vehicle to turn around an axis that passes through the center of the vehicle. A vehicle possessing such functionality would appear to rotate in its place and change direction without having to translate on the ground. We call this a "Zero Turn" (Fig. 1d).

The driver should have an option to switch between all the above mentioned four modes of steering. The solution arrived at is shown in Fig. 2, and consists of an OR Gate in the form of an additional rack and pinion drive superimposed on a conventional steering gear. This additional mechanism permits one to execute the requisite steering modes.

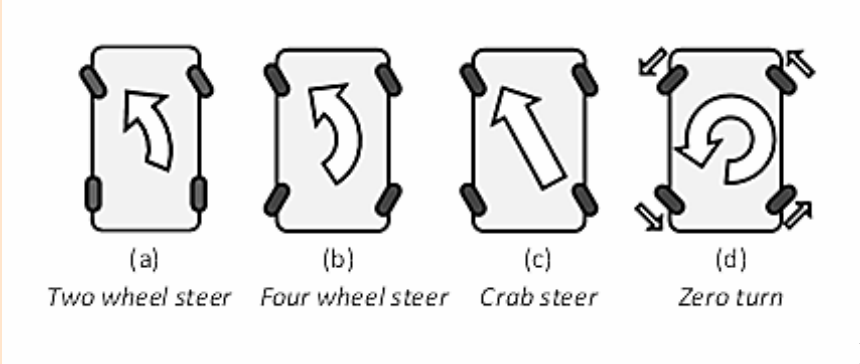

Fig. 1

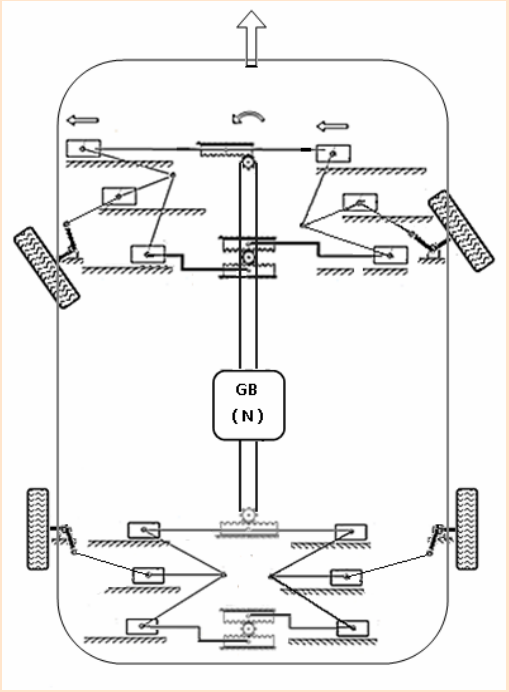

Fig. 2

IIT Madras

Team Members: R. Arun Srivatsan, 4th Yr. Dual Degree Student of Engg. Design
Mentor: Dr. Sandipan Bandyopadhyay, Assistant Professor, Engg. Design

The Madras Parallel Manipulator (MaPaMan) is a newly designed spatial parallel manipulator with three degrees-of-freedom. As the name suggests, the design has drawn some inspiration from the Cassino Parallel Manipulator (CaPaMan), in that both are actuated by four-bar linkages at the base. However, MaPaMan differs from CaPaMan in the arrangement of the four-bars, in the absence of passive prismatic joints, and thus has a very different kinematics as well as paltform motion.

The primary motivation behind this new design was to develop a motion platform with only rotary joints and actuators, with high stiffness. Among other applications, it is proposed to create a "balance master" type of rehabilitation device based on this motion platform.

A fully functional prototype was demonstrated at the event, which earned the entry the third prize. The prototype was manufactured at the Centre for Artificial Intelligence and Robotics (CAIR), Bangalore. The participant and the mentor acknowledge the help from CAIR thankfully.

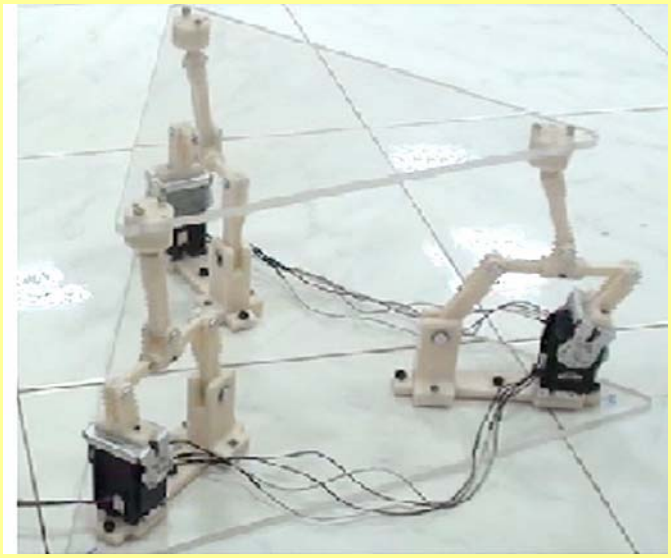

Fig. 1: MaPaMan prototype

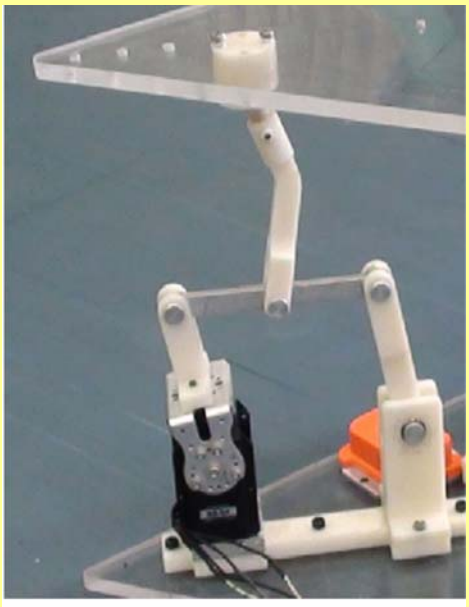

Fig. 2: Details of a single limb

Reports on Seminar and Workshop

All India Seminar on Recent Advancement in Robotics and Mechatronics, Kolkata

Mechanical Engineering Division (MED) of The Institution of Engineers India (IEI), West Bengal State Centre (WBSC) in association with Bengal Engineering and Science University, Shibpur, organised a two-day All India Seminar on "Recent Advancement in Robotics and Mechatronics" during August 19-20, 2011. The program was inaugurated by Prof. Ajay K. Roy, Vice Chancellor, BESU Shibpur in the presence of Prof. S. K. Saha, IIT Delhi, Er. A. K. Majumdar, Chairman, IEI-WBSC, Er. K. Datta, Chairman, MED of the IEI-WBSC & MD, Andrew Yule Kolkata. Prof. Saha in his keynote address asserted that technology should be much more proximal to mankind being the ultimate end-user.

Prof. S. N. Shome (CMERI Durgapur), Prof. B. Bepari (HIT Haldia) delivered the invited talks on the 2nd day. Eighteen technical papers were presented by the researches working in the field. A laboratory visit and demonstration of real systems were held by the researches and students of the School of Mechatronics & Robotics of BESU Shibpur. About 150 participants from academics, industry and R&D organizations participated in this seminar from across the country.

Two-day Workshop on Mechanisms, Bangalore

Reported by: Dr. B.P. Shivakumar, Head, Dept. of Mech. Engg., JSSATE Bangalore

Two-day workshop on "Mechanisms" was organised during October 20-21, 2011 at the JSS Academy of Technical Education, Bangalore, with the support of Association for Machines and Mechanisms, India, with the primary objective of improving the domain knowledge and teaching methodology of the participants in the subject of Kinematics and Dynamics of Machines. Another objective was to motivate the faculty to pursue higher studies and research in the field of Mechanisms. The program received good response from engineering fraternity both from academia and industry. A total of 61 participants attended the event. All the participants expressed good opinion about the workshop. The program was co-sponsored by VTU Belgaum, M/s. Rising Edge Systems Pvt. Ltd., Bangalore and M/s. IndLab Engineers, Bangalore.

Dr. Sandipan Bandyopadhyay, Department of Engineering Design, IIT Madras, was the Chief Guest of the inaugural function. Other dignitaries on the dais were Dr. T. S. Mruthyunjaya, Prof. (Retd.), IISc, Bangalore, Dr. J E Diwakar, Centre for Product Design & Manufacturing, IISc, Bangalore, Dr. B. T. Nijaguna, Professor Emeritus, JSSATE, Bangalore, Dr. Mrithyunjaya V. Latte, Principal, JSSATE, Bangalore and Dr. B. P. Shivakumar, HOD (Mech.). The function was presided over by Prof. M. V. Latte. Coordinator Dr. B. P. Shivakumar welcomed the participants, and Dr. T. S. Mruthyunjaya gave a brief introduction about the objectives of the workshop. Dr. B. T. Nijaguna stressed the importance of the workshop in his address, followed by the keynote address by the Chief Guest. This was followed by the presidential address by the Principal Dr. Mruthyunjaya V. Latte. Prof. B. V. Raghavendra proposed a vote of thanks.

Dr. T. S. Mruthyunjaya presented the first lecture on Degree of freedom, Gruebler's Equation, Grashof criteria, Centro and its significance and also talked about Kinematic analysis by Graphical method. Dr. T. S. Mruthyunjaya also delivered a lecture on Systematics of Mechanisms: A technique for active design of Mechanical system. Dr. J. E. Diwakar delivered a lecture on Examples of Practical Mechanisms. Dr. Sandipan Bandyopadhyay talked about Kinematic Analysis by Algebraic Method wherein he discussed about the mathematical basics of kinematic analysis of mechanisms, and demonstrated their use in interactive design and dynamic visualisation of mechanisms on computers.

Many participants expressed gladness about the conduct of program and provided valuable suggestions for improvement. Few participants requested to conduct another advanced course in Mechanisms and Dr. T. S. Mruthyunjaya promised to extend support for conducting another program at JSSATE Bangalore. After lively discussion in the feedback session Dr. T. S. Mruthyunjaya distributed the certificates, CDs and attendance certificates containing the course material to all the participants.

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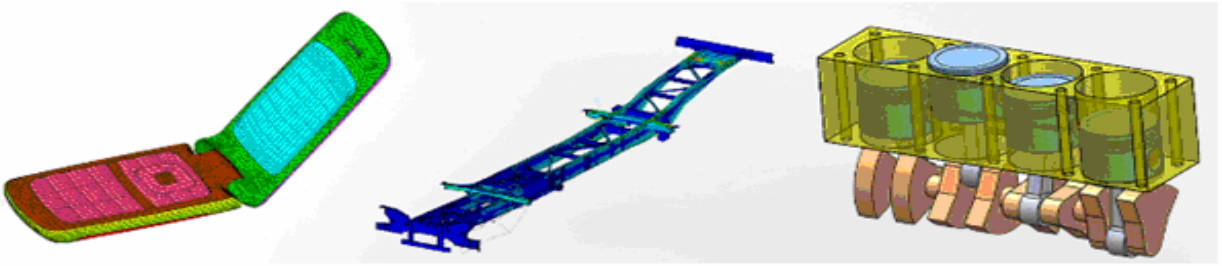

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