

The International Journal of Engineering Education

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Part I

Mechatronics Education

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| Michael Wald | 513 | Editorial |
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| Graham G. Rogers | 515–518 | The Teaching Philosophy of the REAL units of a Mechatronic Engineering Degree Program |

The paper outlines the teaching philosophy underlying the Real-world Engineering And Learning (REAL) units that provide the integrating core of the mechatronics engineering degree program at Curtin University of Technology. These units are based on the problem-based learning (PBL) pedagogy and teach, in addition to technical knowledge, essential generic skills such as problem solving, communication and teamwork. The paper details how this approach is implemented in one of the second-year units. The paper concludes by outlining the experiences in implementing this educational approach and describes the perceived benefits.

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| M. K. Ramasubramanian, M. N. Noori and G. K. Lee | 519–524 | Evolution of Mechatronics into a Graduate Degree Program in the United States: The NC State University Master of Science Program with Mechatronics Concentration |
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The evolution of mechatronics into a graduate degree program at North Carolina State University is described in detail. A curriculum has been developed which does not compromise academic depth, while providing the necessary breadth for a mechatronics degree. The curriculum is based on existing courses with a mechanism for continuous evolution towards an ideal mechatronics program. The master's thesis has a unique requirement that it should have members from at least two of the constituent areas to ensure the interdisciplinary nature of the program. Finally, the 'hands-on' aspect of mechatronics is emphasized through the requirement of a mechatronics design course.

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| Grace Lim, Kheng Swee Chua and Khee Yun Wee | 525–531 | Effects of Instructional Intervention Strategies on Students at Risk in Engineering Education |
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The study was conducted on repeat students (N = 139) from the second year Diploma in Mechatronics taking the Mechatronics Science 2 subject. Various forms of instructional support were provided. The students completed a pre-test and post-test self-report questionnaire to assess changes in their motivation and beliefs towards learning of the subject. A follow-up interview of students was conducted. Analyses of student responses indicated that the instructional intervention strategies did bring about significant changes in self-efficacy and intrinsic motivation among the students, perceived gain in knowledge and skills of the subject and positive correlations among various aspects of motivation. Implications for teaching are discussed.

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| Rudolf Scheidl, Hartmut Bremer and Kurt Schlacher | 532–536 | Mechatronics Education at the Johannes Kepler University: Engineering Education in its Totality |
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A fully academic mechatronics engineering course was established at Linz University in 1990 in response to the expressed needs of industry for this new type of engineer. Mechatronics is taught here in a balanced way, emphasizing mechanical and electrical engineering as well as computer sciences, equally. More than six years working experience of graduates in industry confirm the validity of this concept. A study with such a broad scope combined with a sound scientific depth can only be achieved by an articulated well-balanced curriculum.

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| M. J. E. Salami, N. Mir-Nasiri and M. R. Khan | 537–543 | Development of Mechatronics Engineering Degree Program: Challenges and Prospects |
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It is now becoming common practice to include some courses in mechatronics in the traditional electrical and mechanical engineering programs. Whilst many engineering faculties have realized the need for a full-fledged multidisciplinary mechatronics engineering program, only in very few places have such programs been developed along the lines of other engineering programs. The justification for the mechatronics engineering program becomes evident, as today's engineers must be acquainted with subjects that are not taught or given much emphasis in the traditional engineering curriculum. A good knowledge in those subjects, is however required if our graduate engineers are to be relevant to industry with time. The challenges in developing such program in terms of curriculum planning, laboratory facility needs and staff requirements are discussed in this paper. Whilst there are immense advantages of such a discipline, its success depends on a balanced curriculum with good laboratory facilities and appropriate industrial links, positive attitudes and well-oriented academic staff as well as students having the ability to cope with diversified subjects.

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| Alexandar Djordjevič and Patri K. Venuvinod | 544–549 | Integrating Mechatronics in Manufacturing and Related Engineering Curricula |
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Typical prototypes of manufacturing and related engineering programs are briefly reviewed. For the professionally aligned readers, arguments are presented in favour of orienting the electronics and controls courses towards automation by integrating them all to form a core of the mechatronics program stream. These courses would thus take an obviously common direction, allowing the manufacturing engineers to function better as technology integrators at the machine, workcentre or shopfloor levels of modern manufacturing organisations. This objective is difficult to realise when the electronics, controls and automation subjects are taught in isolation one from another. Paradoxically, it matters little whether the automation course is taught before or after the other two. Critical topics linking all three are usually missing. With different teaching departments involved, the lack of emphasis on the commonality of purpose is near total. Thus, with only disconnected stepping-stones made available, the graduates' ability for professional self-improvement through life-long learning is hampered.

This paper shows how a class of undergraduate students at Massey conducted an open-ended, less-specified mechatronics project, and to what extent they could integrate knowledge and skills across various subjects into the project. The intelligent robot PKBot introduced in this paper was one of the designs for the theme Robotic Lawnmower in 2001. The project was roughly specified in the following: the robot must simulate lawn mowing, by installing markers on its body, which can map where it has been on the surface provided; the robot must be able to distinguish any obstacles set up on the surface and navigate around them, without any outside interference; the entire surface provided to simulate the lawn mowing process must be totally covered by the robot, or as much of it as possible as the case may be; the robot should navigate the surface area as quickly as possible.

Eli Kolberg, Yoram Reich and Ilya Levin 557–562 Project-based High School Mechatronics Course

Mechatronics is a complex, highly technical, multidisciplinary subject that involves the design and manufacture of integrated products. In order to teach it properly in a course, student teams have to engage in designing a product. Due to the complicated nature of mechatronic products, such a project further complicates the administration of mechatronics courses. This paper presents a design of a course for non-technical high school students. The design includes elements that motivate students to devote extra hours for technology study; it leads students to successfully design products through managing a team project with little budget and scarce teaching resources. We present the structure of the course and its evaluation. We conclude that such a course can be taught to non-technical university students thus bringing them closer to understanding technology and engineering.

Swadesh K. Gupta, Shailendra Kumar and Lalit Tewari 563–568 A Design-Oriented Undergraduate Curriculum in Mechatronics Education

Mechatronics is bringing about an industrial paradigm shift with its multidisciplinary integrated approach to product design and development. It is poised to become the key enabling technology to use for gaining a competitive edge in the modern manufacturing era. The development of mechatronics will therefore be crucial to the continued competitiveness of national economies. In order to fulfil the changing requirements of industry, many universities worldwide have introduced course revisions and new courses in mechatronics. In the present paper, an attempt has been made to redefine mechatronics and synthesize various mechatronics programs being conducted all over the world. The proposed curriculum envisions mechatronics as a new engineering design strategy, perceives it as a systemic business philosophy and emphasizes interdisciplinary communication, team effort and industrially relevant project-based learning.

Martin Grimheden and Mats Hanson 569–574 Collaborative Learning in Mechatronics with Globally Distributed Teams

The subject of mechatronics has been taught at the Mechatronics Lab, Royal Institute of Technology (KTH) since 1984. The educational model is based on the four didactical questions: the questions of identity, legitimacy, selection and communication; and as a result there are strong intentions of communicating the subject of mechatronics in an interactive fashion, with an exemplifying selection. Due to the emerging issue of globalisation an attempt has been made to internationalise the education in mechatronics, and this article aims at investigating the possibilities of expanding the questions of selection and communication to also enrol the added aspects of international collaborative learning in mechatronics. Among the conclusions are, besides enhanced motivation for the students, signs of improved disciplinary learning, improved communicational skills and an education which better prepares students for future careers and work in a global area.

A. Geddam 575–580 Mechatronics for Engineering Education: Undergraduate Curriculum

Mechatronics is a synergistic combination of electrical and electronic engineering, computer technology and control engineering with mechanical engineering that forms a crucial part in the design, manufacture and maintenance of a wide range of engineering products and processes. Engineering education with a mechatronics curriculum provides the necessary core technologies for the future engineers with multi-disciplinary background. This paper outlines the mechatronic engineering curriculum of an undergraduate degree at the City University of Hong Kong, which aims to provide the integrated learning experience.

J. Edward Carryer 581–585 Teaching Embedded Programming Concepts to Mechanical Engineering Students

While the prerequisites to mechatronics courses often include a programming course, students are rarely prepared to deal with writing software for an embedded microcontroller. In typical introductory programming courses students write programs to run on relatively large computers with no mechanism for direct interaction with the hardware or real world. This paper describes the elements of Stanford's undergraduate mechatronics courses that are used to introduce students to programming on an embedded microcontroller directly connected to a simple autonomous mobile platform. The philosophy behind the approaches taken, the content of the lectures preceding the laboratory assignment, the assignment itself, the software framework provided as well as the physical platform are discussed.

Stojan Persin, Boris Tovornik and Nenad Muskinja 586–592 OPC-driven Data Exchange between Matlab and PLC-controlled System

Many manufacturing, and mechatronics systems, are controlled by PLCs and SCADA systems. These systems provide very limited possibilities for research, optimisation, testing and simulation. The main advantage of this proposed solution, which uses OPC, is an integration of the numerical, computational and graphical strengths of MATLAB[®] with the robustness of industrial systems. The experimental setup, the processing of the data and the results are presented with particular emphasis on student use in a laboratory environment but the techniques employed in the experiments will likely to be seen by the students in their subsequent employment after completion of their college careers.

William K. Durfee 593–596 Mechatronics for the Masses: a Hands-on Project for a Large, Introductory Design Class

The Department of Mechanical Engineering at the University of Minnesota has a new 'Introduction to Engineering' course with a hands-on approach to learning beginning engineering skills. Students undertake a series of design and dissection projects as a means for learning. The major project is a six-week assignment to 'design and build an autonomous machine that does something interesting for 45 seconds'. The machines are computer-controlled and require a combination of mechanics, electronics and software, the triad that comprises mechatronics. Resources, including extensive web-based tutorial information and take-home tool kits, were developed to allow students to design and fabricate their robots at home. Just-in-time lectures provide sufficient electronics and programming information to enable students to build robots to an appropriate level of sophistication. Each of the 200 students builds their own robot. During the six years the course has been offered, we have learned many lessons that make this mechatronics design project possible and a successful learning experience for students.

Josko Petric and Zeljko Situm 597–602 Inverted Pendulum Driven by Pneumatics

Teaching of the course mechatronics for undergraduate students at the Faculty of Mechanical Engineering and Naval Architecture on the University of Zagreb is described in the paper. Mechatronics has been taught through projects that students should complete during the semester. One of those projects, the inverted pendulum driven by pneumatics, is described in this paper.

A simple experiment, well suited for an undergraduate course in mechatronics, is described in which thermal time-constant information is extracted from a heater-blower table-top system. In the experiment, a thermistor measures the temperature of a resistive-heater that is cooled by a blower and a microcontroller is used for data acquisition. The student is asked to determine the thermal time response, and in particular the thermal time-constant of the system, for different blower speeds. The experiment prompts questions about modeling a thermal system, and exposes the student to basic concepts of mechatronics including measurement and data analysis.

Alexandar Djordjevich

610–614 Motion Control Demonstration for Easy Student Understanding

A combination of a selected teaching approach and content is presented in this paper that has succeeded repeatedly in capturing full attention of the entire class of professionally oriented mechatronics students to the problems of PID control, fuzzy logic control, and PID control with fuzzy adaptation. Students get absorbed in what otherwise they may perceive as a very dry and abstract material.

A. Al-Habaibeh and R. M. Parkin

615–622 Low-Cost Mechatronic Systems for Teaching Condition Monitoring

One of the biggest problems facing the mechatronics field is the high cost of sensors and systems, which makes it difficult for educational institutions to experimentally teach a large number of students the principles of mechatronics. This is particularly the case in developing countries. This paper reports a simple system to teach students the basics of mechatronics by experimentally implementing a condition monitoring system for bearings using sound waves. The experimental work is performed in a cost-effective way. The extracted signals are analysed using a variety of techniques, including time and frequency domain signal processing methods and neural networks, in order to recognise faulty and normal conditions. The experimental work described in this paper has been found to be a crucial stage for the students in developing the necessary knowledge of mechatronics and the concepts behind embedded monitoring and control systems using a low-cost approach.

Mark Nagurka

623–630 Aerodynamic Effects in a Dropped Ping-Pong Ball Experiment

This paper addresses aerodynamic modeling issues related to a simple experiment in which a ping-pong ball is dropped from rest onto a table surface. From the times between the ball-table impacts, the initial drop height and the coefficient of restitution can be determined using a model that neglects aerodynamic drag. The experiment prompts questions about modeling the dynamics of a simple impact problem, including the importance of accounting for aerodynamic effects. Two nonlinear aerodynamic models are discussed in the context of experimental results.

Part II

Engineering Education Research and Control Engineering

P. P. Parikh, R. Bindu and S. P. Sukhatme

631–638 Job Status and Career Profile of Women Engineers in India

The job profile and career status of women engineers who obtained their bachelor's degree during 1994–1998 has been studied. The study is motivated by the findings of an earlier study conducted during 1987–90 for the graduates of the period 1975–90. It was found that women enrolment in the engineering courses was on the increase but the job market was not open for them. Enrolment rates have gone up significantly since then. The estimated range today is 25–30%. Data reveals that 31% of the women engineers are unemployed. The job and career opportunities for them continue to be limited. Technical educational institutions are the main employment avenue with a noticeable increase in industrial employment. Unemployment is higher in the states and in the disciplines having higher enrolment. Getting the first job after graduation is the major hurdle in the career path of women engineers.

H. K. Sardana and P. P. Arya

639–645 Training Evaluation of Engineering Students: A Case Study

This paper looks at an evaluation of students who are training with the cooperation of the industry. The main objective of such a 'project-cum-training' programme is an improvement in the generic attributes of engineers. The ranking of four such attributes (motivation, attitude, skills and knowledge) is initially considered, both in terms of any improvement effected through training and their ultimate importance in an engineering career. Training evaluation is then carried out by considering improvements in these attributes according to students' self-assessment and assessment by faculty and industry supervisors. Finally, correlations are made among the three groups involved in order to see where there is consensus.

K. L. Shi, T. F. Chan, Y. K. Wong and S. L. Ho

646–654 Modelling and Simulation of Direct Self-Control Systems

This paper describes a generalized model of the three-phase induction motor and simulation of the direct self-control (DSC) system, using the Matlab Simulink software. The advantage of Simulink modelling is that program compilation is not required. Instead, the mouse and Simulink menu commands are used to link the basic function blocks to yield the complete DSC system simulation model. This paper also shows the techniques to simplify and solve high-order and nonlinear equations in the design of the DSC system. It is also demonstrated that the DSC method is sensitive to the current sensor noise and the controller time delay.