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Assessment of Transition from Mechanical Engineering to Mechatronics Engineering in Turkey*

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This paper gives an assessment of the transition from the mechanical engineering curriculum to the mechatronics engineering curriculum in Turkey. It looks at the requirements for the transition and analyses the approaches adopted by Turkish universities. To achieve this, the study provides a review of the mechanical engineering departments and the proportion of mechatronics courses taught within these departments. As presented in the paper, some universities prefer a separate department for mechatronics engineering; others introduce optional courses, while the rest replace some core modules with mechatronics engineering type courses. Therefore, this work classifies the universities into three groups. In addition to Turkish universities, some selected cases of universities from Asia, the USA, Canada, and Europe are also included as examples of each identified approach, thereby providing the necessary background for comparison. The comparative study reveals that there does not seem to be a definitive approach to updating a mechanical engineering curriculum or a mechatronics engineering curriculum with any clearly defined structure. Nevertheless, the proportions of mechatronics courses in mechanical engineering curricula in Turkish universities indicate that the required measures seem to have been taken in most of the cases. In this study an attempt was also made to identify the problems that Turkish universities are facing in mechanical engineering education and some suggestions were made to overcome these difficulties to improve the quality of such education in Turkey. The paper concludes with a general suggestion that consists of a set of solution models that may allow a smooth transition from a mechanical engineering to mechatronics engineering curriculum.

Keywords: mechatronics education; mechanical engineering curriculum; mechatronics in Turkey

INTRODUCTION

TECHNOLOGICAL ADVANCEMENTS and their reflections both in products and manufacturing processes have for some time defined the need for change in engineering disciplines. Although other disciplines seem to be able to adapt in a practical way, it is mechanical engineering education that has been reported to be failing to keep up with the pace of change [1–3]. The incredible rate of change of the technological revolution continues to put pressure on mechanical engineering education to improve practical skills and increase the technological knowledge of its graduates. The expected improvements include multiple cross-disciplinary areas and require analysis, modeling, design and control of interdisciplinary engineering systems [4–6]. These, in turn, require a knowledge and practical experience [7] of sensors, actuators, control and signal processing as well as related hardware, software and their integration problems.

Considering that the defined requirements for the new mechanical engineering education encompasses other engineering disciplines, such as electronics, programming and computing (mechatronics), there is a real need to update the mechanical engineering curriculum accordingly. However, this is not easy as it requires all these study areas to be integrated into a typically full curriculum [8, 9].

Educational institutions around the world have already recognized the problem, and solutions are being proposed and implemented [1, 10–17]. Interestingly, it is reported in the literature that mechanical engineering departments have already introduced some mechatronics courses into their curricula [18], and the results are being discussed in various platforms, such as symposiums, conferences and scientific journals. Although there seems to be a consensus that mechatronics courses should be introduced into the mechanical engineering curriculum, there is no clear guideline for curriculum development, and the content and details of the courses to be introduced are not well-defined. Thus, each institution approaches it in its own way, while taking into account the available facilities of the engineering departments and the faculty [16]. Thus, there is no perfect solution, but there do exist solutions that are suitable for each mechanical engineering department, depending on its resources.

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This paper presents an assessment of the transition from the mechanical engineering curriculum to the mechatronics engineering curriculum in Turkey. In the light of the discussions above, the paper also looks at the current state of mechanical engineering education, related curricula and future directions in terms of curriculum development. In this respect, the aim of the study is to identify the proportion of mechatronics courses with respect to conventional mechanical engineering courses in respective curricula for transition related assessments. The study also gives details of the credit scoring requirement for an average mechanical engineering diploma as well as how the scores vary from one university to another. The study also examines academic staff statistics to provide a closer look into the departmental structure. A discussion about the details of mechatronics teaching in mechanical engineering departments follows. Details of the Turkish and other mechatronics engineering departments are then discussed. Finally, a discussion of the results of the research with related suggestions is given.

CURRENT APPROACHES TO MECHANICAL ENGINEERING EDUCATION

Typically, a modern mechanical engineer is required to be competent in analysis, modeling, design and control of interdisciplinary engineering systems. In fact, the mechatronics engineering course matches the requirements of mechanical engineers as defined above. Therefore, mechatronics engineering is seen as the future of mechanical engineering [11]. This has long been recognized by some universities and, as a result, revisions to mechanical engineering curriculums have already been made. Although the structure of a typical curriculum allows the development and improvement of related practices, in most cases it is so heavily loaded that it is not very easy to restructure and adapt it to the technological trends.

A global overview of the problems gives some clues as to how to approach the problem and the solutions proposed. Although there is no distinct difference between regions, there are some obvious variations in the institutional approaches to the problem, proposed solutions and related implementations.

To get the complete picture, a number of institutions were studied to examine their approaches to the problem. To achieve this, some American, Asian, Australian and European institutions were studied. It was noted that these universities had already recognized the problem. As listed in Tables 1 and 2, some of the institutions have already put some effort into improving engineering education by introducing mechatronics related courses into conventional mechanical engineering curriculums as core modules [12–14, 16]. Others have favored setting up separate departments for mechatronics engineering programs [14, 16, 19, 20], whereas some mechatronics courses have chosen to have optional specialization for mechanical engineers [13, 14, 16]. These lead to three main philosophies in the teaching of mechatronics, reflecting the degree to which mechatronics is integrated with traditional mechanical engineering study. The definitions of these three philosophies according to Gorbet and Golnaraghi [14] are as follows.

- Philosophy 1: Core Module form. The curriculum is modified to include mechatronics courses as a part of the core mechanical engineering curriculum.
- Philosophy 2: Optional Module form. In this form, the students have the option of choosing mechatronics courses that may or may not necessarily need to be delivered by the mechanical engineering department. This form implies that mechatronics is an optional specialization for engineers, primarily for mechanical engineers.
- Philosophy 3: Separate Department form. In this form, mechatronics is an independent department with its own curriculum and it combines course materials from different departments.

Table 1. Key features of the mechatronics content of some Asian, Australian and American universities

Educational form	Canadian universities [4]	American universities [8, 9]	Asian and Australian universities [9]
Philosophy 1: *Core module*	Uni. de Sherbrooke	Uni. of South Carolina Uni. of Utah Uni. of Hardford Uni. of Washington Kettering Uni.	Hong Kong Uni. Sci. & Tech. Swinburne Uni. of Tech., AU
Philosophy 2: Optional module	Rensselaer Poly. Institute University of Toronto Uni. of Waterloo (current)	Minnesota State Uni. Uni. of Utah Colorado State Uni.	University of South, AU
Philosophy 3: Separate department	Uni. of British Columbia Uni. of Waterloo (proposed)	Colorado State Uni. Purdue Uni. California Polytech. Üni.	City Uni. of HK, HK. Chung Nam Nat. Uni, S. Korea Uni. of New South Wales, AU Uni. of Sydney, AU Ngee Ann Polytechnic, SG.

Table 1 lists some Canadian, Australian, American and Asian universities: the implementation of their mechatronics courses into engineering education is categorized according to the philosophy that they have adopted. It is clear that one philosophy is as valid as another, since there is no clear distinction to indicate a popular philosophy. It is rather that the available facilities of the department and the engineering education culture appear to be the determining factors of the type of philosophy adopted [16].

Table 2 shows that the same categorization applies in European and Turkish universities. Unlike the universities in Table 1, especially Asian universities, in which a separate department of mechatronics engineering is most favored, the Turkish universities appear to prefer the core module or mainly the optional module approach to improving mechanical engineering education.

The main difficulty that Turkish universities face is the necessary technological infrastructure and skilled personnel required for mechatronics education are not widely available [10]. Therefore, the state universities, except for a few, have financial and technical difficulties in meeting the requirements for setting up separate mechatronics engineering departments with the necessary infrastructure (except for a few privately owned universities labeled (*) in Table 2). The preferred solutions are to provide engineering students with optional mechatronics modules or to replace some mechanical engineering courses by mechatronics engineering courses. Both solutions show some improvement in the content of the curriculum, though the approach and related difficult-to-measure results may vary.

MECHANICAL ENGINEERING IN TURKEY

As of April 2008, there were 98 (68 state and 30 private) universities in Turkey. In total there are 46 mechanical engineering departments, 4 are in privately owned and 42 are in state owned universities (listed in Appendix C). In 2007, 4511 students were registered to these departments. Approximately, 18 044 students are currently studying in these departments [21]. Yildiz Technical University has the highest number of students, with a quota of 360, and the least number of students enrolled at Dicle and Inönü Universities, and Izmir Institute of Technology [21].

It has already been recognized that despite this potential for a high number of students to study mechanical engineering, the desired technological levels have not yet been reached [10]. However, there have been attempts to improve mechanical engineering education by introducing some mechatronics engineering courses into the mechanical engineering curriculum.

In order to provide a clearer view, these 46 mechanical engineering departments and their curriculum were studied; some details, such as the numbers of students and academic staff were also considered; they are listed in Table 3 and 4.

All the mechanical engineering departments at

Table 2. Key features of the mechatronics content of some European and Turkish universities

Educational form	European universities [9]	Turkish universities
Philosophy 1: *Core module*	Tech. Uni. of Denmark, Denmark Helsinki Uni. of Tech., Finland Darmstadt Ints. for Mechatronics., Germany Nort Karelia University of Applied Sciences, FI.	Dokuzeylül Uni. Çukurova Uni. Osman Gazi Uni.
Philosophy 2: Optional module	University of Parma, IT. University of Genoa, IT Graz University of Technology, AT. University of Navarra, ES.	Boğaziçi Uni. Gazi Uni. Mustafa Kemal Uni. Gaziantep Uni. Sabanci Uni. * Middle East Technical Uni. Istanbul Technical Uni.
Philosophy 3: Separate department	Lancaster University, UK. King's Collage London, UK. University of Leeds, UK University of Linz, Avustria	Atilim Uni. * Bahçeşehir Uni. * Kocaeli Uni.

Table 3. Qualifications of academic staff in mechanical engineering departments in Turkey.

	Academic staff			
	Prof. Dr.	Assoc. Prof. Dr.	Asst. Prof. Dr.	All academic staff
Total	302	142	387	831
Average	6.56	3.09	8.41	18.06
Minimum	0	0	1	3
Maximum	39	19	27	48

Table 4. Ratio of numbers of students to academic staff in mechanical engineering departments in Turkey

Number of students: Number of academic staff				Number of students: Number of all academic staff
	To number of Prof. Dr.	To number of Assoc. Prof. Dr.	To number of Asst. Prof. Dr.	
Average	77.59	135.30	53.77	24.26
Minimum	19	24	15.00	8.94
Maximum	213	560	160	53.33

Turkish universities (i.e. 46) were investigated in this study to give the statistical information presented in Table 3. As listed in the table, there are 831 academic staff in total in mechanical engineering departments in Turkey. The position of Assistant Prof. Dr. appears to be the dominant one, whereas the Associate Prof. Dr. position is filled by the least number of academicians. Naturally, an average mechanical engineering department in Turkey has approximately eight, three and six academicians in positions of Asst. Prof. Dr., Assoc. Prof. Dr. and Prof. Dr. positions, respectively. The minimum and maximum numbers for these positions, on the other hand, still reflects the same proportions. However, there are some departments where at least one of these academic positions is unfilled.

In Table 4, on the other hand, the ratio of number of students to academics are presented. As seen from the table, in an average mechanical engineering department there are approximately 77.59, 135.30 and 53.77 students for each Prof. Dr., Assoc. Prof. Dr. and Asst. Prof. Dr. positions, respectively. The minimum and maximum ratios ignore the 'nil' state of an academic position as it does not convey any message. Therefore, the second minimum number is considered for minimum ratio calculations. These ratios are also listed in the table.

In Fig. 1, the number of credits required to graduate from each of the 46 mechanical engineering departments is plotted. The universities are listed according to their grades [21] required to registrar at the university, where the lower places in the list corresponds to higher grade requirements. The lists of website addresses for all of the Turkish universities are given on the Higher Education Council's website [22]. Using these links, the curriculum of each university with a mechanical engineering department was studied. Each mechanical engineering department's mechatronics courses are identified using a pre-defined list of mechatronics courses (Appendix C) that are not usually found on a typical mechanical engineering course.

In Fig. 1, it is shown that the required credit score varies from one university to another. It is also shown that an average of approximately 158 total credit score is required to graduate from a mechanical engineering department in Turkey. In addition, it is surprising to note that the credit score required for graduation falls below the average line for 25 universities and above the line for the rest of the universities (i.e. 21), indicating that there is a need for regulation in the credit score requirements. If one fits a curve to the credit score line in Fig. 1, then the best match, in terms of minimizing the standard error, would be that plotted in the figure. This curve fit indicates a tendency an increase in credit score towards the end of the list of universities. In addition, the deviation also increases towards the middle of the list.

In this study, attention is also paid to gathering information on the philosophy adapted and the proportion of the curriculums modified. Figure 2 illustrates the results of this study.

The curriculum analysis results of mechanical engineering departments in Turkey are presented in Fig. 2. This analysis is performed to identify the number of 'credits of mechatronics engineering courses' (MCr) divided by the 'total credit required to graduate' (TCr) of a university. It can be seen from the figure that there is a tendency for the percentage of mechatronics course credits to drop over the total graduation credit scores. This becomes clearer with the curve fit illustrating the tendency; the University of Uludag appears to be an exceptional case. One might also argue that it is the course content, the skills and the knowledge

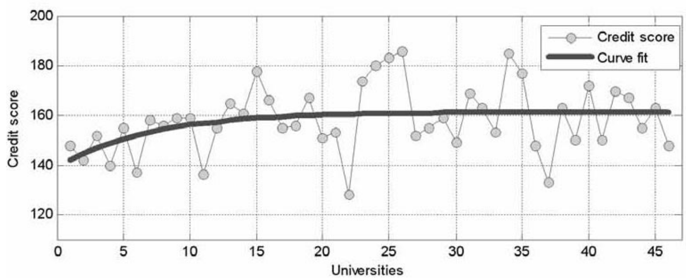

Fig. 1. Total credit score required to graduate from a mechanical engineering department in Turkey.

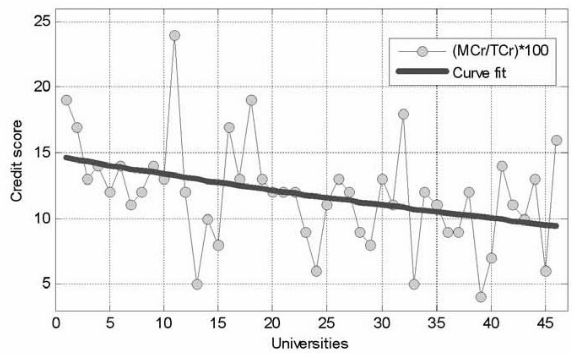

Fig. 2. Variation in the ratio of mechatronics to mechanical engineering courses in mechanical engineering departments. (MCr and TCr are defined as the 'Sum of Credits of Mechatronics' courses and 'Total Credit' score required for graduation.)

transferred to the students that matter rather than the course credits. That surely is the ultimate goal of every course in every curriculum. However, it is not easy to measure the effectiveness of a course and it is beyond the scope of the work presented here.

Considering that in a typical mechatronics engineering department the percentage is around 44 (Fig. 4, below), the overall average ratio of 12% indicates that mechatronics courses are already a part of mechanical engineering education in Turkey. This picture shows a similarity to the analysis results for the US universities reported in [15].

The optional and compulsory mechatronics courses in the mechanical engineering departments in Turkey were also analyzed in an attempt to categorize them according to their adapted philosophy in the teaching of these courses. Figure 3 illustrates the philosophy adapted by mechanical engineering departments of Turkish universities. The first ten universities appear to prefer optional modules and some others (such as universities 12, 13, 28, 33, 34 and 39) prefer a purely core module type approach, i.e. philosophy 1, where the peaks are apparent. It is also noticed that a purely optional module is adopted only by Atatürk University (number 37 in the list). The overall averages of preference for core and optional module approaches are 48% and 52%, respectively.

In spite of this bright picture of the teaching of mechatronics in mechanical engineering departments, the response of the curriculum development is not quite in line with the rest of the world and has been slower than expected. However, it is the pace of technological developments in products and manufacturing processes that has been so rapid. Therefore, mechanical engineering education in Turkey has been facing difficulties in catching up with the technological trends and their impact on the curriculum. Consequently, a typical mechanical engineer graduate still experiences difficulties in product or system design, development, manufacture and related automation technologies [10, 23]. This is partly because a typical mechanical engineering curriculum includes courses related mostly to understanding and dealing with purely mechanical systems that are mainly theoretical and involves insufficient practical work. In particular, if industry demands mechanical engineers who are good at analysis, design and development of new interdisciplinary engineering systems, then in-house industrial training by the employer becomes inevitable.

A closer look into the list of the identified courses (Appendix C) reveals that most of the courses are theoretical. In some cases the courses involve practical mechanical engineering sessions, although most are theory dominated, while some others involve only computer simulation based teaching as a part of practical training. In our opinion, a more appropriate teaching model should include courses that introduce the technology, know-how and theory in the first years. In the final years, the course should ensure that the techniques are practiced in a way that not only involves the theoretical side of the issues but also includes an integrated design application that is based on a multi-disciplinary system structure. This approach would certainly improve the skills and knowledge of mechanical engineers. Hence, the proposed model requires a project based approach to teaching of third and fourth year students, where individual and team projects would surely improve personal skills in profession practice as well as provide experience on project and team work management with shared responsibility in a tutor-supervised teaching environment.

Having said that, the demand for mechanical engineers with the necessary skills and knowledge is lower than would be expected. Interestingly enough, this is mainly because the manufacturing industry in Turkey typically avoids Research and Development (R&D) departments, apart from a few. Industrial establishments prefer to use an imported design with imported technology. Thus, there is not as much demand for such skilled engineers as one would expect [10]. Hence, these establishments are not concerned with the engineering curriculum and related developments, unlike their rivals around the world. Therefore, if something is to be done about all this, industry needs to be involved, based on technology development centers that allow collaboration between industry and universities.

The situation appears to be better for the mechatronics engineering departments in terms of course credit results compared with their foreign counterparts. The universities in Fig. 4 on the left are those with mechatronics departments from various parts of the world. Those that are towards the right of the figure with TR suffix are the Turkish universities with mechatronics engineering departments. The figure illustrates the proportion of credits for mechatronics courses over the total credits of the courses provided. It is surprising to note that the average ratios are in a similar range, although they differ from institution to institution.

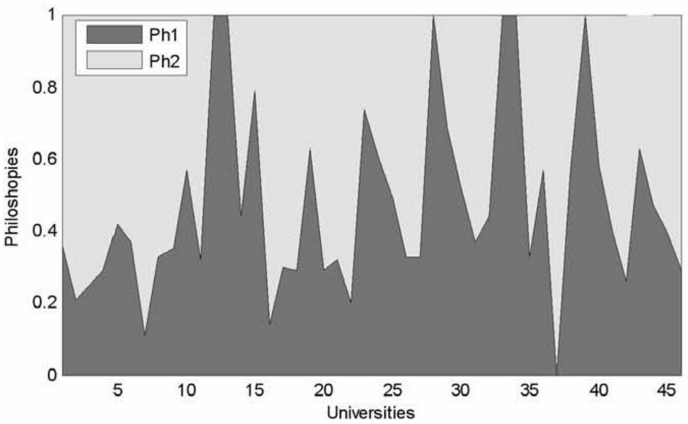

Fig. 3. The philosophy adopted by mechanical engineering departments of Turkish universities (Ph1: philosophy 1—core modules and Ph2: philosophy 2—optional modules).

The mechatronics courses and related credit sums are identified in a manner similar to the previous studies, using the same pre-defined course list provided in Appendix C.

Figure 4 shows that mechatronics departments in Turkey are also catching up with their foreign counterparts in teaching mechatronics course content. However, the difficulty of finding skilled teaching staff with the necessary qualifications appears to be a continuing problem. In addition, setting up the necessary infrastructure for mechatronics education is still a costly investment, thus there appears to be problems with providing the necessary practical training that is vitally needed for mechatronics engineering education. For both mechanical and mechatronics engineering education, it becomes clear, from the feedback from industry and graduates, that engineering education is needed in order to prepare engineers for their professional life in industry. Although it appears to be the main objective, it has been observed from the departmental curriculums that have been studied that engineering education is about not only providing the necessary know-how in theory, but is also about providing the support for practical application of the know-how. The main tool in engineering education for a practical application of the profession at student level is typically through project work, both in groups and as individuals. The objectives and boundaries of the projects may differ for engineering education in different departments; however, the aim of the training for the young engineers for their positions in industry should be achieved at all costs. Therefore, we believe that a better approach to engineering education should include project-based courses that are expected to involve interdisciplinary content [24]. This would push the contemporary engineering education boundary and allow mechanical engineering graduates to see the technical problems and related solutions from the viewpoint of other engineering disciplines. The skill of being able to look from an interdisciplinary point of view is crucial for team-based working environments and related project work, which are the basis of the design and the development of contemporary complex so-called mechatronics systems.

Another important issue is that the infrastructures of Turkish universities are typically not very suitable to provide the necessary work-shops and related technical support for the implementation of student projects and, even if they exist, as in the case of some universities, they are not of a desired standard. Therefore, a model based on a project-oriented curriculum is proposed [25]. The content of the curriculum and related courses may differ from one institution to another; however, it is believed that it should include project-based studies that increase in proportion towards the end of the course.

It the light of the issues presented above, the suggested approach to integrating mechatronics courses into the mechanical engineering curriculum is to provide some theoretical core modules along with some project-based optional modules. The core modules would provide the necessary background of general engineering knowledge and skills for interdisciplinary use, while the optional modules would allow specialization in various topics [26]. As one would expect, the core modules would provide the theoretical background

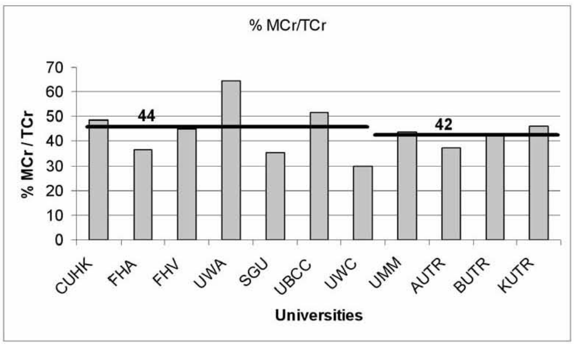

Fig. 4. The ratio of mechatronics related courses in mechatronics engineering departments at selected universities and their Turkish counterparts.

on interdisciplinary issues as well as mechatronics systems design. These courses would require no costly experimental setups, or equipment, therefore their integration in the early years of the curriculum would not cause any additional cost to the department.

The optional modules, on the other hand, would provide the opportunity to implement the skills [27, 28] learned. These courses could be financed by support from industry as well as research projects conducted by the university. The industrial support could be arranged to be based on the needs of the industry where applicable [29], while projects conducted by the university would define more clear topics of study due to their strict definition. In addition, the optional form of these courses in the final years would allow the students to choose specialized topics. This would provide the flexibility needed to meet the varying needs of industry and the ever changing technological developments. With the implementation of these core and optional modules based on the description provided above, all sides of the issue would be satisfied by minimizing the cost for departments [30], providing flexibility for students and addressing the need for trained skilled personnel by industry through cooperation.

RESULTS AND DISCUSSION

The study conducted on mechanical engineering education in Turkey has shown that there is a need for regulation in credit scoring. It is surprising to note that the mechanical engineering curricula of the departments studied varies widely, although the outcome is considered to be a diploma in all cases. Therefore, there is also a need for model curriculum development that would serve as a basis for mechanical engineering departments in all universities. This would still allow local adaptations but provide the common ground necessary for raising the overall educational quality as well as compatibility. In addition, teaching practicals costs much more than teaching theory and this seems to be a serious problem that each engineering department faces. Therefore, local training centers that serve a number of institutions may help to ease the financial situation of the shortcomings due to the high cost of setting up the infrastructure for mechatronics teaching in each department in Turkey. In addition, the proposed educational model would be suitable for central training centers, enabling inter-university as well as industrial collaboration.

CONCLUSIONS

The study results show that the Turkish Universities, along with many other universities throughout the world, are aware of the dynamic changes influencing the mechanical engineering curriculum. The lack of infrastructure and skilled staff appears to be the main problem for Turkish institutions. Therefore, it is not surprising to note that core course updates as well as optional module type approaches appear to be preferred. This is partly because these two options cost less than setting up a separate department under the title 'Mechatronics'. Also, the skilled personnel needed for setting up a separate department are not readily available. It is not only Turkish universities that are forced to make the choice between these two obvious options but so many other universities in the world too. Therefore, it is not surprising to observe curriculum updates in mechanical engineering education in almost in all regions of the world: from north to south and from west to east.

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APPENDIX A

Turkish universities with mechanical engineering departments

1	Boğaziçi						
2	Orta Doğu	13	Osman Gazi	24	Pamukkale	35	Nigde
3	Istanbul Teknik	14	Kocaeli	25	Trakya	36	Zonguldak Karaelmas
4	Marmara	15	Akdeniz	26	Erciyes	37	Atatürk
5	Ege	16	Gaziantep	27	Mersin	38	Aksaray
6	Izmir Teknoloji Enst	17	Sakarya	28	Dumlupinar	39	Cumhuriyet
7	Yildiz Teknik	18	Celal Bayar	29	Namik Kemal	40	Dicle
8	Gazi	19	Karadeniz Teknik	30	Kirikkale	41	Baskent*
9	Istanbul	20	Selçuk	31	Süleyman Demirel	42	Mustafa Kemal
10	Dokuz Eylül	21	TOBB*	32	Hitit	43	Bozok
11	Uludag	22	Koç*	33	Inönü	44	Firat
12	Çukurova	23	Balikesir	34	Usak	45	Harran
						46	Yeditepe*

* Privately owned universities; the others are state universities.

APPENDIX B

Abbreviations for the Turkish and world universities used in the tables

Abbreviation	Full name	Country
CUHK	City U. of HK	Hong Kong
FHA	FH Aschaffenburg	Almanya
FHV	Fachhochschule Vorarlberg	Avustria
UWA	University of Western	Australia
SGU	Swiss German University	Indonesia
UBCC	University of British Columbia	Canada
UWC	University of Waterloo	Canada
UMM	University of Maruti	Maruti
AUTR	Atilim University	Turkey
BUTR	Bahçeşehir University	Turkey
KUTR	Kocaeli University	Turkey

APPENDIX C

Pre-defined mechatronics courses not usually included in mechanical engineering curricula in Turkey

Algoritmalar ve Bilgisayar Prog.
Anoloji ve Simülasyon
Ansys ile Modelleme ve Analiz
Bilgisayar Bütünlesik Imalat
Bilgisayar Destekli Imalat
Bilg. Dest. Konstrüktif Sekillendirme
Bil. Destekli Kont. Sist.Tas. ve Analizi
Bilgisayar Destekli Modelleme
Bilgisayar Destekli Mühendislik
Bilgisayar Destekli Mühendislik Analizi
Bilgisayar Destekli Tasarim ve Üretim
Bilgisayar Destekli Tasit ve Dinamiği
Bilgisayar Destekli Üretim
Bilg. Uyg. Algoritma Gelistirme
Bina Otomasyonu
Biyomekanige Giriş
CAD-CAM
Computer Aided Engineering Application
Computer Aided Mechanical System Design
Computer Controlled System Design
Control Systems
Control Systems Design
Digital Control System Design
Dinamik Sistem Model ve Simülasyonu
Dinamik Sistem Modülü ve Kontrolü
Dynamic Modeling and Control
Dynamic System-Modeling and Analysis
Dynamic Systms Modelling & Simulation
Electric Actuation of Mechanic System
Electrical Actuation of Mech. System
Elektrik
Elektrik Elektronik Bilgisi
Elektrik Makinalari
Elektrik Mühendisligi
Elektrik Mühendisligi Giriş
Elektrik Mühendisligi Prensipleri
Elektrik Mühendisligi Temelleri
Elektrik Mühendisligi Temelleri
Elek. ve Elektro. Temelleri Labaratuvari
Elektrik ve Elktronik Müh. Temelleri
Elektrik-Elektronik
Elektrik-Elektronik Giriş
Elektro Teknik ve Elektrik Makineleri
Elektrohidrolik Denetim Sistemleri
Elektrohidrolik ve Ileri Programlama
Elektronik
Elektronik I
Elektronik II
Elektronik Labratuvari I
Elektronik Labratuvari II
Elektronik Sistemlerin Sogutulmasi
Elektropnömatik
Elektropnömatik Otomasyon Sistemleri
Elektroteknik
Elektroteknik-Elektrik Makinalari
Elementry Optimal Design
Endüstriyel Kontrol Sistemleri ve Ölçme
Endüstriyel Otomasyon
Endüstriyel Robotlar ve Otomasyon
Esnek Imalat Sistemleri
Fund. Electrical Engineering Laboratory
Fund. of Electric and Electirical Circuits
Fundamentals of Electrical Engineering
Introduction to Control System Technic
Introduction to DC AC Circuits
Introduction to Mechatronics
Introduction to Robotics
Isi Tekniğinde Otomatik Kontrol
Isil Sistemlerin Sim. ve Modelleme
Imalat Ortaminda Alg. ve Kontrol Sist.
Istatistiksel Proses Kontrol
Kontrol Elemanlari Uygulamalari
Kontrol Sistem Tasarimi
Kontrol Sistemi Tasarimina Giriş
Kontrol Sistemleri
Makina Dizayn Tekniği
Makina Dizayni Mühendislik Çözümleri
Makina Müh. Bilgisayar Uygulamalari
Makina Müh. Mikroislemci Uyg.
Makina Tas. ve Görsel Proglamlama
Makina Tasarimi ve Ileri Programlama
Matematiksel Programlama ve Opt.
Mathematic Model In Mechanical Eng.
Mekanik Sistem Tasarimi
Mekanik Sist. Bilgisayar Destekli Tas.
Mekanikte Bilgisayar Uygulamalari
Mekatronige Giriş
Mekatronik
Mekatronik Sistem Tasarimi
Mekatronik Sistemlere Giriş
Micromechanics
Modelleme ve Analiz
Nastran Prog. ile Makina Tas. ve Sim.
Müh. Prob. Bilg. Dest. Analiz ve Çözme
Mühendislik Sistem Tasarimi
Müh. Sist. Matematik Modellenmesi
Müh. Tas. Sonlu El. Metodu Uyg.
Mühendislikte Bilgisayar Uygulamalari
Müh. Bilgisayar Uyg. II CAD/CAM
Mühendislikte Deneysel Metotlar I
Mühendislikte Deneysel Tasarim
Müh. Matematik Modellemeye Giriş
Müh. Mikroislemci ve Uygulama
Mühendislikte Sayisal Analiz
Nümerik Analiz
Optik Ölçme Yöntemleri
Optimization of Mechanical Systems
Otomasyon ve Robotik
Otomatik Kontrol
Otomotiv Endüstrisinde Yeni Teknolojiler
Ölçme ve Sinyal Analizi
Ölçme Teknikleri ve Analizi
Ölçme ve Degerlendirme
Ölçme ve Veri Degerlendirme
Paket Programlar ile Analiz ve Çözüm
Rijid Cisimlerin Üç Boy. Din. Giriş
Robot ve Kinematigi
Robotige Giriş
Robotik
Robotik Sistemler
Sayisal Analiz
Sayisal çözümleme
Sayisal Yöntemler
Sinyal Analizi
Sistem Analizi ve Kontrol
Sistem Dinamiği ve Kontrolü
Sistem Modelleme ve Analizi
Sistem Modelleme ve Otomatik Kontrol
Sistem Simülasyonu
Sonlu Elemanlar Analizine Giriş
System Analysis and Control
System Dynamic and Control
Tasit Elektronigi ve Kontrol
Tasit Sistem Dinamiği ve Kontrolü
Temel Elektronik ve Elektronik
Üretim Simulasyonu
Yapay Zekaya Giriş

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