

A Look at the Ways in Which Universities Offer Common Civil-Mechanical Engineering Courses

Aiman Kuzmar, Ph. D., P. E.
Penn State Fayette, The Eberly Campus
ask2@psu.edu

Iyad Muslih, Ph. D.
Applied Science University, Amman, Jordan
iyad@iyadmuslih.com

Abstract

Civil and mechanical engineering share the areas of solid and fluid mechanics. Many undergraduate and graduate courses belong to these two vast educational areas. These courses include: Engineering Mechanics-Statics, Engineering Mechanics-Dynamics, Strength of Materials, Fluid Mechanics, Basics of the Finite Element Methods, and Numerical Methods in Engineering at the undergraduate level. They also include: Advanced Mechanics of Solids, Elasticity, Plasticity, Experimental Stress Analysis, Fracture Mechanics, Advanced Dynamics, Finite Element Methods, Numerical Engineering Analysis, Plates and Shells, and Non-Destructive Testing at the graduate level. Universities and colleges differ in the ways in which they offer these courses. It is important to understand the manner in which these courses are offered by various universities. This paper deals with this topic.

The paper analyses five categories in this regard. Some universities offer such common courses as pure civil engineering courses while others offer them through their mechanical engineering departments. Other universities offer such courses jointly between their civil and mechanical engineering departments. In the fourth category, some universities offer such courses to their civil engineering students through their civil engineering departments while at the same time offer the same courses to their mechanical engineering students through their mechanical engineering departments. This turns to be the least common among all five categories. Nonetheless, it is the best way to offer such courses from an educational point of view. In the fifth category, neither the civil engineering department nor the mechanical engineering department offers these common courses. Rather, different departments offer these courses at many universities. This turns to be the most popular among all five categories. Nonetheless, it is the least beneficial way of offering such courses from an educational point of view.

Introduction

Various engineering disciplines overlap with each other based on the fundamental definition of engineering, which is the application of science to practice [1-2]. The overlap occurs early in the engineering education process and later in the engineering practice phase. The areas of overlap are usually between two engineering branches like the overlap between civil and architectural

engineering disciplines on the theory of structures. However, three or even more engineering disciplines sometimes share a specific area. An example is the theory of elasticity, which is an established area in civil, mechanical, and biomedical engineering. Another example is fluid mechanics, which is critical to civil, mechanical, and chemical engineering.

Different institutes of higher education offer courses in such common areas between engineering disciplines in different ways. The way in which a specific engineering course is offered at an institute depends on several factors. These factors are generally academic, administrative and even economical in nature. This paper specifically deals with the common courses between civil and mechanical engineering disciplines.

Civil and Mechanical Engineering

Civil engineering is the oldest field in the profession of engineering [2-3]. Civil engineers design, construct, and maintain the infrastructure of our societies. This infrastructure includes buildings, roadways, bridges, dams, water supply systems, airports, tunnels, and sewage systems [4]. Mechanical engineering is one of the largest fields in the engineering profession. Mechanical engineers design, construct, and maintain machines and devices used by our societies [2-4].

It is easy to see that both groups of engineers design and construct objects. Generally speaking, such objects are either solids or fluids. Both civil and mechanical engineering fields therefore have to deal with either solids or fluids. As a result, the two vast specialties of mechanics of solids and fluid mechanics make an overlapping area in the civil and mechanical engineering education. The boundaries between civil and mechanical engineering branches in these two areas of mechanics of solids and fluid mechanics have not been well defined over the years. This prompts each discipline to claim these two specialties as ones of its own.

The above territorial dilemma influences the ways in which universities and colleges offer courses in the areas of mechanics of solids and fluid mechanics which are needed by both civil and mechanical engineering students.

A Comparison Study

The authors made a search on this subject to see how universities offer common courses in the above mentioned two areas. This search included dozens of US and international universities and colleges. This search was done through studying the educational curricula of the civil and mechanical engineering departments at the investigated colleges and universities. The curricula of a few other engineering branches were also investigated based on need and relevance. This included printed catalogues, Internet publications, and private conversations with instructors and professors [5]. A summary of this comparative search is presented along with observations and discussions in this paper.

The Importance of the Study

The importance of knowing the overlap between civil and mechanical engineering disciplines is illustrated elsewhere in the literature [6]. Understanding the ways in which colleges and universities offer such courses is also important. This study provides a tool for universities to compare the effectiveness and usefulness of their way of offering these courses to the ways in which other universities offer them. This will help these universities to better serve their engineering students, and it will help them to modernize their engineering education.

Common Civil Mechanical Engineering Courses

Common courses between civil and mechanical engineering disciplines are found in both undergraduate and graduate levels.

The undergraduate courses include:

- Engineering Mechanics-Statics
- Engineering Mechanics-Dynamics
- Strength of Materials, Fluid Mechanics
- Basics of the Finite Element Methods
- Numerical Methods in Engineering.

The graduate courses include

- Advanced Mechanics of Solids
- Elasticity
- Plasticity
- Experimental Stress Analysis
- Fracture Mechanics
- Advanced Dynamics
- Finite Element Methods
- Numerical Engineering Analysis
- Plates and Shells
- Non-Destructive Testing.

How do Universities and Colleges Offer These Common Courses

As mentioned earlier, universities and colleges differ on how they offer the above common courses. The ways in which these courses are offered also depends on the course itself. Based on this, and according to the information obtained from various colleges and universities in this study, we can classify universities and courses into five categories. Depending on how a certain course is offered, some universities may fall in more than one category. Similarly and depending on how universities design their engineering curricula, a course might fall in more than one category. These categories are explained with a few examples next.

Category I

In this category, both mechanical and civil engineering departments in many universities offer several of these common courses separately. For instance, the Department of Mechanical and Manufacturing Engineering at the University of Cyprus in Nicosia, Cyprus offers MME 205 Stress Analysis and Strength of Materials to its students, while the Department of Civil and Environmental Engineering at the same institute offers the different version of CEE 230 Strength of Materials to its own students.

Other examples in this category include the University of New Hampshire, Kansas University, Vanderbilt University, University of Arizona, University of Utah, and the University of Delaware. Tables 1, and 2 show some of the above courses as offered by the civil and mechanical engineering departments at two of these universities.

It is interesting to note here that the Mechanical Engineering Department at the University of Delaware offers the Strength of Materials course under the title of Mechanics of Solids MEEG 215, while the Civil Engineering Department's version of this course has the reversed title of Solid Mechanics CIEG 211.

Table 1. Civil and Mechanical Engineering Common Courses at the Univ. of New Hampshire.

| Common Course | Civil Engineering Department | | | Mechanical Engineering Department | | |
|-----------------------------|------------------------------|---|-----|-----------------------------------|---|-----|
| | Course # | Official Title | Cr. | Course | Official Title | Cr. |
| Statics | CIE 525 | Statics for Civil Engineers | 3 | ME 525 | Mechanics I | 3 |
| Strength of Materials | CIE 526 | Strength of Materials | 3 | ME 526 | Mechanics II | 3 |
| Dynamics | CIE 527 | Dynamics | 3 | ME 523 | Introduction to Statics and Dynamics | 3 |
| Fluid Mechanics | CIE 642 | Fluid Mechanics | 4 | - | - | - |
| Advanced Dynamics | CIE 787 & | Dynamics of Structures | 3 | ME 627 & | Mechanics III | 3 |
| | CIE 785 | Introduction to Structural Vibrations | 3 | ME 723 | Advanced Dynamics | 3 |
| Finite Element Method (FEM) | CIE 786 | Introduction to Finite Element Analysis | 3 | ME 786 | Introduction to Finite Element Analysis | 3 |

Table 2. Civil and Mechanical Engineering Common Courses at the University of Delaware.

| Common Course | Civil Engineering Department | | | Mechanical Engineering Department | | |
|-----------------------------|------------------------------|--|-----|-----------------------------------|-------------------------|-----|
| | Course # | Official Title | Cr. | Course | Official Title | Cr. |
| Statics | CIEG 211 | Statics | 3 | MEEG 112 | Statics | 3 |
| Strength of Materials | CIEG 212 | Solid Mechanics | 3 | MEEG 215 | Mechanics of Solids | 4 |
| Dynamics | CIEG 311 | Dynamics | 3 | MEEG 211 | Dynamics | 3 |
| Fluid Mechanics | | Fluid Mechanics | 3 | MEEG 331 & | Fluid Mechanics I | 4 |
| | CIEG 306 | Fluid Mechanics Laboratory | 1 | MEEG 332 | Fluid Mechanics II | 3 |
| Advanced Dynamics | CIEG 611 | Structural Dynamics Design | 3 | MEEG 620 | Intermediate Dynamics | 3 |
| Finite Element Method (FEM) | CIEG 401 | Introduction to Finite Element Method | 3 | MEEG 415 | Finite Element Analysis | 3 |
| | CIEG 601 | Introduction to Finite Element Method | 3 | - | - | - |
| | CIEG 605 & | Intermediate Topics in Finite Element Analysis | 3 | - | - | - |
| | CIEG 801 | Advanced Topics in Finite Element Analysis | 3 | - | - | - |

Category II

In this category, some of these common courses are offered as mechanical engineering courses at several universities. In almost all cases, both mechanical and civil engineering students take such courses. For instance, the Department of Mechanical and Manufacturing Engineering at the University of Cyprus in Nicosia, Cyprus offers MME 301 Fluid Mechanics to its students and to students in the Department of Civil and Environmental Engineering. Wayne State University offers the course of ME 3400 Dynamics to both civil and mechanical undergraduate engineering students. The University of California at Chico also offers Dynamics as the mechanical engineering course ME 135 Dynamics. As an example for advanced degrees, the University of New Hampshire offers ME 731 Fracture and Fatigue Engineering Material as a mechanical engineering graduate course. The University of California Los Angeles is another example, which offers the Elasticity course in its mechanical engineering department as ME 502 Theory of Elasticity.

Category III

The third category is the reverse of the second category mentioned above. That is, it includes universities offering some of the common courses as civil engineering courses. Again, in almost all cases, both mechanical and civil engineering students take such courses.

The Department of Civil Engineering at the University of California at Chico, offers the following four required undergraduate courses to both civil and mechanical engineering students:

- CE 035 Statics
- CE 101 Strength of Materials
- CE 150 Fluid Mechanics
- CE 121 Engineering Economy

It is worthwhile to repeat here that Dynamics at this institute belongs to the second category where it is offered as a mechanical engineering course (ME 135).

As a second example, the Department of Civil and Environmental Engineering at the University of Cyprus in Nicosia, Cyprus offers CEE 102 Engineering Statics to students in the Department of Mechanical and Manufacturing Engineering. It is interesting to see that the Department of Civil and Environmental Engineering offers a different version of this course, CEE 131 Engineering Mechanics- Statics, to its own students.

In the case of advanced programs, mechanical engineering graduate students at Marquette University who are specializing in solid mechanics can take the civil engineering course CEEN 242 Theory of Elasticity. The Civil and Environmental Engineering Department at Duke University also offers CE 206 Elasticity to mechanical engineering students in addition to its own students. Additionally, Duke University offers CE 203 Plasticity, and CE 254 Introduction to the Finite Element Method as civil engineering courses.

Category IV

This category includes institutes, which offer some of these courses simultaneously as both civil and mechanical engineering courses. That is, the class is considered a mechanical engineering course for mechanical engineering students, while civil engineering students take the same exact class, by the same instructor, as a civil engineering course. The two departments closely coordinate teaching these courses with each other. Sometimes, a faculty member from the civil engineering department teaches such courses while a member from the mechanical engineering faculty teaches them in other cases. Occasionally, a faculty member belonging to both of these departments teaches these courses. Examples of this classification include the University of California, Los Angeles, Duke University, Rice University, and the American University at Sharja in the United Arab Emirates. This can pertain totally to undergraduate courses like the case with the University of California, Los Angeles, or entirely to graduate courses like the Duke University's case. Rice University offers both undergraduate and graduate courses in this classification. For more details on this Category, Tables 3, 4, and 5 respectively list the common courses at these institutes.

Table 3. Mechanical/Civil Engineering Common Undergraduate Courses at the University of California, Los Angeles.

| Mechanical Engineering Designation | Civil Engineering Designation | Credits | Course Title |
|---|--------------------------------------|----------------|--|
| ME 201 | CE 201 | 4 | Statics |
| ME 205 | CE 205 | 4 | Strength of Materials I |
| ME 210 | CE 210 | 2 | Matrix Algebra for Engineers |
| ME 211 | CE 211 | 2 | Statistics and Probabilities for Engineers |
| ME 303 | CE 303 | 4 | Fluid Mechanics I |
| ME 312 | CE 312 | 1 | Strength of Materials Laboratory I |
| ME 313 | CE 313 | 1 | Fluid Mechanics Laboratory I |
| ME 320 | CE 320 | 4 | Dynamics |
| ME 413 | CE 413 | 1 | Fluid Mechanics Laboratory II |

Table 4. Mechanical/Civil Engineering Common Graduate Courses at Duke University.

| Mechanical Engineering Designation | Civil Engineering Designation | Credits | Course Title |
|---|--------------------------------------|----------------|--|
| ME 207 | CE 207 | 3 | Transport Phenomenon in Biological Systems |
| ME 210 | CE 210 | 3 | Intermediate Dynamics |
| ME 252 | CE 252 | 3 | Buckling of Engineering Structures |
| ME 263 | CE 263 | 3 | Multivariable Control |

It is of interest to us here to mention that other engineering departments offer some of these common courses in coordination with our two specific engineering fields of mechanical and civil engineering. For example, the Transport Phenomena in Biological Systems course at Duke University is offered as CE 207 to civil and environmental engineering graduate students, as ME 207 by the Department of Mechanical Engineering and Materials Science, and as BE 207 for biomedical engineering graduate students. Rice University also offers the course of Advanced Computational Mechanics as CEVE 654, MECH 654, and BIOE 654 for its civil, mechanical, and biomedical engineering graduate students respectively. The number of engineering departments offering the same course under its name even grows to four in some cases. For instance, the Finite Element Methods in Fluid Mechanics course at Rice University is offered as either MECH 554 in mechanical engineering, as CEVE 654 in civil engineering, as BIOE 654 in biomedical engineering, or as ENVI 654 in environmental engineering.

Table 5. Mechanical/Civil Engineering Common Undergraduate and Graduate Courses at Rice University.

| Mechanical Engineering Designation | Civil Engineering Designation | Credits | Course Title |
|---|--------------------------------------|----------------|---|
| MECH 211 | CEVE 211 | 3 | Engineering Mechanics |
| MECH 371 | CEVE 371 | 3 | Fluid Mechanics |
| MECH 417 | CEVE 417 | 3 | Finite Element Analysis (Undergraduate Version) |
| MECH 454 | CEVE 454 | 3 | Finite Element Methods in Fluid Mechanics (Undergraduate Version) |
| MECH 513 | CEVE 513 | 3 | Theory of Elasticity |
| MECH 517 | CEVE 517 | 3 | Finite Element Analysis (Graduate Version) |
| MECH 523 | CEVE 523 | 3 | Probabilistic Structural Dynamics |
| MECH 526 | CEVE 526 | 3 | Computational Methods in Structural Mechanics |
| MECH 554 | CEVE 554 | 3 | Finite Element Methods in Fluid Mechanics (Graduate Version) |
| MECH 610 | CEVE 610 | 3 | Structural Dynamic Systems and Control |
| MECH 654 | CEVE 654 | 3 | Advanced Computational Mechanics |
| MECH 678 | CEVE 678 | 3 | Advanced Stochastic Mechanics |
| MECH 679 | CEVE 679 | 3 | Applied Monte Carlo Analysis |

Category V

In the fifth and last category, some of these common courses between mechanical and civil engineering curricula are offered by a third party. This third party is usually the College of Engineering itself, but sometimes a different engineering department takes the responsibility for this task.

This is the most common and dominant case out of all five categories. Examples include Iowa State University, University of Maryland, Boise State University, University of Calgary, Western Kentucky University, University of Idaho, Widener University, University of Wyoming, Cleveland State University, University of Saskatchewan, Clarkson University, California National University, University of Texas at Tyler, and Oregon State University.

Penn State University belongs also to this group. All engineering mechanics courses are offered by the Department of Engineering Science and Mechanics to a wide range of undergraduate and graduate engineering students including those who major in civil and mechanical engineering. Table 6 lists these engineering mechanics courses at Penn State University.

Table 6. Common Mechanical and Civil Engineering Undergraduate and Graduate Courses offered by the Department of Engineering Science and Mechanics at Penn State University.

| Course No. | Course Title | Credits |
|------------|---|---------|
| EMCH 011 | Statics | 3 |
| EMCH 012 | Dynamics | 3 |
| EMCH 013 | Strength of Materials | 3 |
| EMCH 013D | Strength of Materials with Design | 3 |
| EMCH 110H | Equilibrium Mechanics, Honors | 5 |
| EMCH 112H | Mechanics of Motion | 3 |
| EMCH 120S | Adventures in Mechanics- First Year seminar | 1 |
| EMCH 210 | Strength of Materials and Statics | 5 |
| EMCH 215 | Mechanical Responses of Engineering Materials | 2 |
| EMCH 216 | Experimental Determination of Mechanical Responses of Materials | 1 |
| EMCH 313 | Statics of Deformable Bodies | 3 |
| EMCH 400 | Advanced Strength of Materials and Design | 3 |
| EMCH 402 | Applied and Experimental Stress Analysis | 3 |
| EMCH 403 | Strength Design in Materials and Structures | 4 |
| EMCH 407 | Computer Methods in Engineering Design | 3 |
| EMCH 408 | Elasticity and Engineering Applications | 3 |
| EMCH 409 | Advanced Mechanics | 3 |
| EMCH 412 | Experimental Methods in Vibrations | 3 |
| EMCH 416H | Failure and Failure Analysis of Solids | 3 |
| EMCH 440 | Nondestructive Evaluation of Flaws | 3 |
| EMCH 446 | Mechanics of Viscoelastic Materials | 3 |
| EMCH 461 | Applied Finite Element Analysis | 3 |

Despite its conspicuous popularity, this way of offering such courses does not address the needs of different engineering disciplines on an individual basis. This was perhaps what prompted the University of California, Los Angeles to switch from this category to a more individualized manner in offering their early engineering courses. Formerly, the College of Engineering at this institute offered the Statics, Strength of Materials, Dynamics, and Fluid Mechanics as ENGR 201, ENGR 205, ENGR 320, and ENGR 312 respectively. Instead, the above courses are currently being offered as CE 201 or ME 201, CE 205 or ME 205, CE 320 or ME 320, and CE 312 or ME 312 respectively by its civil and mechanical engineering departments. This operation even expanded to other disciplines like the electrical engineering course of EE 204 Circuit Analysis I, which was formerly offered as ENGR 204.

Universities and Courses Can Fall in More Than one Category

As can be seen from the above numerous examples in all of the five categories, it is possible for an institute to fall in more than one category in this classification. In fact, an institute can have a course or more in all five categories. Duke University serves as an example for this possibility. Table 7 illustrates this through listing courses it offers in each category.

Table 7. Common Mechanical and Civil Engineering Undergraduate and Graduate Courses offered by Duke University in all five categories.

| Category | Course Examples | Responsible Dept. at Duke University |
|----------|--|--|
| I | ME 217 Fracture of Engineering Materials | Offered by the Dept. of Mechanical Engineering and Materials Science |
| | CE 212 Fracture Mechanics | Offered by the Dept. of Civil and Environmental Engineering |
| II | ME 83 L Structure and Properties of Solids | Offered by the Dept. of Mechanical Engineering and Materials Science |
| III | CE 203 Plasticity | Offered by the Dept. of Civil and Environmental Engineering |
| IV | CE 252 Buckling of Structures ME 252 Buckling of Structures | Offered by both the Dept. of Mechanical Engineering and Materials Science and the Dept. of Civil and Environmental Engineering |
| V | EGR 123L Dynamics | Offered by the College of Engineering |

By the same token, it is possible for a course to fall in more than one category in this classification based on how it is offered by different universities and colleges. In fact, a course can be in all five categories. Statics, as Table 8 shows, is the best example for this situation.

Table 8. Statics is offered in all five categories at different institutes

| Category | Statics Course | Offering Institute |
|----------|--|---|
| I | ME 525 Mechanics I | Department of Mechanical Engineering at the University of New Hampshire |
| | CIE 525 Statics for Civil Engineers | Department of Civil Engineering at the University of New Hampshire |
| II | ME 221 Statics | Department of Mechanical Engineering at Michigan State University |
| III | CE 2450 Statics | Department of Civil Engineering at Louisiana State University |
| IV | ME 201 Statics CE 201 Statics | Department of Mechanical Engineering and the Department of Civil Engineering at the University of California, Los Angeles |
| V | ENGR 135 Statics & Mechanics of Materials I | College of Engineering at the University of Pittsburgh |

Engineering Educational Comparison between the Above Five Categories

From an educational point of view, the best category to offer common courses between civil and mechanical engineering in the authors' opinion is Category I. This is because each discipline can design the course using its own applications without being constrained with other disciplines.

On the contrast, Categories II and III seem to be equally the worst. In one of these categories, the course taught by a mechanical engineering department is bound to be biased towards mechanical engineering applications, and that hurts civil engineering students who are taking this course. The reverse case is also true for the other category.

The least common category seems to be Category IV. On one hand, if the instructor has a mechanical engineering background, this category automatically changes to Category II. On the other hand, if the instructor belongs to the civil engineering department, this category changes by default to Category III. That is, Category IV seems to have the same shortcomings of Categories II, and III.

As mentioned earlier, the most dominant category is Category IV. This dominance does not mean however that it is the best way in the business of engineering education.

Summary

Civil and mechanical engineering disciplines have several common courses. Universities offer these courses in five categories. The best way is to let each department provide its own version of the course if possible to fit the need of the students and not confuse mechanical students with CE applications and vice versa.

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Biographies

AIMAN S. KUZMAR is an assistant professor at Penn State. He holds a Ph. D. from Duke University. He has a Master's from Rice University. His B. S. is from the University of Petroleum and Minerals, Saudi Arabia. All degrees are in civil engineering. His industrial experience includes working for the NCDOT. He is a registered engineer in North Carolina.

IYAD MUSLIH is an assistant professor at the Applied Science University in Amman, Jordan. He holds a Ph. D. degree from West Virginia University. He has a B. S. and a Master's degrees from the University of Jordan, Amman, Jordan. All degrees are in mechanical engineering. He is a member in the ASME, AIAA, ASEE, JEA, and JES.