

Dual Master of Science Degree Program in Mechanical Engineering at Virginia Tech and at the Technische Universität Darmstadt

Summary

This document has its foundation in a Memorandum of Understanding (MOU) and an Implementation Agreement (IA) on student exchanges in effect between Virginia Tech and the Technische Universität Darmstadt. It details the application process, student eligibility criteria, and curricular issues concerning a two-year, dual Master of Science in Mechanical Engineering degree program at these two universities, in which the students, upon successful completion of approximately one year of prescribed studies at each university, receive the degree of Master of Science in Mechanical Engineering from both universities.

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1.0 Overview

It is increasingly important to educate and prepare engineers to function successfully in a global economy. To this effect, Virginia Tech and the Technische Universität Darmstadt have signed a Memorandum of Understanding (MOU) and an Implementation Agreement (IA) on student, staff, and faculty exchanges and on research collaborations. It is in this context that this document details a two-year, dual Master of Science in Mechanical Engineering degree program between these two universities.

A dual-degree program is here defined as two degree programs, one at each university, that the student pursues simultaneously, and, for which the student, upon successful completion of the requirements of each program, will receive, near-simultaneously, the respective degree from each university. Where appropriate, work done for one degree program will be credited to the other program as well.

In this particular dual-degree program, the student will spend approximately one year in residence at each university. The first year will primarily be concerned with course work; the second year will have some course work, but will primarily be concerned with the thesis research. The student can choose the order of these two residencies; hence, two equivalent versions of the dual-degree program are described herein. This program consists of 116-118 credit points (CP) or 58-59 semester credit hours that are divided into 82-83 CP (41-42 semester credit hours) of course work and 34 CP (17 semester credit hours) of thesis research. Each thesis examination committee will have a co-chair and a member from each university's Department of Mechanical Engineering.

The students should be prepared to complete the courses at Virginia Tech in English and the courses at the Technische Universität Darmstadt in German, though some courses and/or exams at the Technische Universität Darmstadt are occasionally offered in English at the discretion of the course professor. The thesis and its examination will be in English.

2.0 Admission process and financial issues

Admission into this dual-degree program is on a competitive basis and subject to the student's admission into each university's Master of Science in Mechanical Engineering degree program. The admission process will be administered at Virginia Tech by the chair of the Mechanical Engineering Graduate Affairs Committee, which at present is Prof. Ricardo A. Burdisso, Ph.D.; and at the Technische Universität Darmstadt by the *Studiendekan des Fachbereichs Maschinenbau* (Mechanical Engineering Dean of Student Affairs), which at present is Prof. Dr. rer. nat. Hermann Winner.

The preferred application deadline is in January prior to the August semester start at Virginia Tech or the October semester start at the Technische Universität Darmstadt, whichever comes first. This deadline is needed to ensure timely processing of applications and their associated financial and visa paperwork. Applications that are submitted later might not receive full consideration for financial support and might not permit sufficient processing time to secure a visa in time for semester start.

To the extent permitted by external law and statute, each university will grant and afford the graduates with a Bachelor of Science in Mechanical Engineering (BSME) from the other university, and students pursuing the BSME degree at the other university, the same considerations, rights, preferences, and priorities in the application process and in all subsequent matters, processes, and studies towards the dual-degree Master of Science in Mechanical Engineering (MSME), as it grants and affords its own BSME graduates and students. This includes access to financial assistance and employment.

The student will be ultimately responsible for his or her tuition and fees at his or her university of residence (nominally, one year at each university).

To support and facilitate the ongoing continuity and stability of the dual-degree program, each university will appoint a faculty member to serve as a program coordinator. Hence, these appointments should be renewed regularly, but frequent changes in personnel should be discouraged. The responsibilities of the program coordinators will include (1) advertising the program, (2) acting as ombudsmen for the students in the program, and (3) working with NSF, DAAD, and other agencies, foundations, and organizations, to secure funding in support of the dual-degree program. At present, the program coordinators are Prof. Jan Helge Bøhn, Ph.D. at Virginia Tech and Prof. Dr.-Ing. Manfred J. Hampe at the Technische Universität Darmstadt.

3.0 Language prerequisites

The language of instruction at the Technische Universität Darmstadt is German, and the language of instruction at Virginia Tech is English. Though, some lectures and/or exams at the Technische Universität Darmstadt are occasionally offered in English at the respective course professor's discretion, the students in the dual-degree MSME program are expected to be proficient in both languages. The deadline for attaining a given language proficiency is prior to taking up the residence where it will be needed.

English language proficiency for students requiring non-immigrant visas to the USA will typically be assessed using the standardized TOEFL exams. Virginia Tech requires a TOEFL score of 550 (paper based test) or 213 (computer based test). This is a university requirement.

German language proficiency for students originating from outside of Germany will typically be assessed using the standardized UNICert exam. *Fachbereich Maschinenbau* (Department of Mechanical Engineering) at the Technische Universität Darmstadt requires demonstration of UNICert level II proficiency or better for the dual-degree MSME program. Students that will be attending the Technische Universität Darmstadt during the first year of their dual-degree MSME program (primarily coursework) are advised to demonstrate UNICert level III proficiency. Other examination alternatives include:

- **Test Deutsch als Fremdsprache (Test DaF):** *Mittlere Stufe (4)* [UNICert level II equivalence]; **or** *Obere Stufe (5)* [UNICert level III equivalence];
- **Goethe Institut:** *Zentrale Mittelstufenprüfung* [UNICert level II equivalence]; *Kleines Deutsches Sprachdiplom, Zentrale Oberstufenprüfung* [UNICert level III equivalence]; *Großes Deutsches Sprachdiplom* [UNICert level IV equivalence]; **or**

- **Deutsche Sprachprüfung für den Hochschulzugang (DSH)** [UNICert level III equivalence].

The following outlines the approximate skill levels associated with UNICert level II:

Listening: You can understand extended speech and lectures and follow even complex lines of argument provided the topic is reasonably familiar. You can understand most TV news and current affairs programs.

Speaking: You can present clear, detailed descriptions on a wide range of subjects related to your field of interest, explain a viewpoint on a topical issue giving the advantages and disadvantages of various options, and interact with a degree of fluency and spontaneity that makes regular interaction with native speakers quite possible.

Reading: You can understand longer texts of middle difficulty using restricted general and subject-specific vocabulary and understand their main idea, viewpoint and some specific details.

Writing: You can write clear, detailed text on a wide range of subjects related to your interests. You can write text related to your studies using to a certain extent complex sentence structures and subject-specific vocabulary.

The following outlines the approximate skill levels associated with UNICert level III:

Listening: You can understand difficult authentic speech of general and subject-specific interest containing a broad vocabulary, picking up explicit and implicit information, even when it is not clearly structured. You can understand television programs and films and follow university lectures.

Speaking: You can speak without much hesitation and presents topics of your subject of studies, express your opinions using complex structures and a wide range of vocabulary and subject-specific terminology. You have a good familiarity with idiomatic expressions you might encounter during a study abroad program. You can give presentations including images, graphs and tables.

Reading: You can understand long authentic texts of a certain level of difficulty, understanding explicit and implicit information through intensive reading. You can understand texts of your subject of studies, being relatively familiar with the specific terminology. You can handle texts relevant for a studies abroad program.

Writing: You can express yourself in clear, accurate, well-structured text on general or subject-specific topics, expressing points of view at some length in an assured, personal style, appropriate to the reader in mind.

It is the opinion of the German Section of the Department of Foreign Languages and Literatures at Virginia Tech that completing the course *GER 2106 Intermediate German II* with the grade “B+” or better approximately equates to UNICert level II; and that completing the course *GER 3106 Grammar, Composition & Conversation II* with the grade “B” or better approximately equates to UNICert level III. The German language courses offered at Virginia Tech include the following course sequence:

GER 1105-1106 Elementary German

Fundamentals of the German language with emphasis on grammar, reading, composition, and conversation. 1105: for students with no prior knowledge of the language; 1106: for students who have completed 1105 or less than three years in high school. (3H,3C). I,II,III,IV.

GER 2105-2106 Intermediate German

Review of grammar with increasing emphasis on reading, writing, and oral communication. Pre: 1106. (3H,3C). I,II.

GER 3105-3106 Grammar, Composition & Conversation

Progressive and comprehensive review of German syntax and morphology. Practice in written and oral expression in German on a variety of topics in German culture. Pre: 2106. (3H,3C). I,II.

Typically, a student with three or more years of high-school German will have the GER 1105-1106 course sequence waived. Interested students should contact the German Section of the Department of Foreign Languages and Literatures at Virginia Tech for further information.

4.0 Course requirements

This section describes the two equivalent dual-degree MSME programs at Virginia Tech and the Technische Universität Darmstadt. Section 4.1 describes the program alternative with two semesters at Virginia Tech followed by two semesters at the Technische Universität Darmstadt, while Section 4.2 describes the alternative with two semesters at the Technische Universität Darmstadt followed by two semesters at Virginia Tech. Section 4.3 lists the approved electives.

4.1 Program Alternative 1: VT residence followed by TUD residence

In this dual-degree MSME program alternative, the students spend one year in residence at Virginia Tech, followed by one year in residence at the Technische Universität Darmstadt.

Fall semester (Virginia Tech)

Approximately August 15 – December 15

- ISE 5174 Engineering Program & Project Management..... 6 CP or 3 credit hours
- Laboratory intensive electives 6 CP or 3 credit hours
- Electives, area A (introductory technical electives)..... 6 CP or 3 credit hours
- Electives, area C (applied engineering)..... 6 CP or 3 credit hours
- TOTAL..... 24 CP or 12 credit hours

Spring semester (Virginia Tech)

Approximately January 15 – May 15

- Mathematics and statistics electives..... 12 CP or 6 credit hours
- Electives, area B (theory and methodology)..... 12 CP or 6 credit hours
- Electives, area C (applied engineering)..... 6 CP or 3 credit hours
- TOTAL..... 30 CP or 15 credit hours

Industry internship / university research

Approximately May 15 – October 1

- At least six weeks of a pre-approved industry internship, performing engineering research and/or development; or at least six weeks of pre-approved university research in the field of engineering. These activities may be performed at any appropriate location.

Winter semester (Technische Universität Darmstadt)

Approximately October 1 – March 31

• <i>Advanced Design Project</i>	4 CP or 2 credit hours
• <i>Wahlpflichtbereich D</i> (applied mathematics and statistics).....	10 CP or 5 credit hours
• <i>LV andere Fachbereich</i>	4 CP or 2 credit hours
• <i>Wahlpflichtbereich B</i> (theory and methodology).....	10 CP or 5 credit hours
TOTAL.....	28 CP or 14 credit hours

Summer semester (Technische Universität Darmstadt)

Approximately April 1 – September 30 (see Section 4.1.1)

• <i>Master-Thesis</i>	34 CP or 17 credit hours
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4.1.1 Curricular notes

The course *ISE 5174 Engineering Program & Project Management* is offered by the Department of Industrial and Systems Engineering at Virginia Tech. Hence, it satisfies both the *Projektmanagement* (2 CP, 1 semester credit hour) and the *LV anderer Fachbereiche* (4 CP, 2 semester credit hours) at the Technische Universität Darmstadt. This course is offered during the Fall semester at Virginia Tech. The Department of Industrial and Systems Engineering at Virginia Tech has agreed to let the students enrolled in the dual-degree MSME program take this course and assured that it will be offered annually.

The laboratory intensive electives listed in Section 4.3.6 (6 CP, 3 semester credit hours) satisfy the *Maschinenbaututorium oder Elektrotechnikpraktikum* (4 CP, 2 semester credit hours) and *Wahlpflichtbereich B* (theory and methodology) (2 CP, 1 semester credit hour) at the Technische Universität Darmstadt. This reflects the presence of theory and methodology in these laboratory intensive electives at Virginia Tech.

Relative to the standard MSME program at Technische Universität Darmstadt, 2 CP (1 semester credit hour) of *Wahlpflichtbereich A* (introductory technical electives) will be satisfied in part by the mathematics and statistics electives at Virginia Tech. This was done to accommodate that most courses at Virginia Tech are offered in 3 semester credit hour (6 CP) increments. Hence, the six semester credit hours of mathematics and statistics electives at Virginia Tech will satisfy 2 CP (1 semester credit hour) of *Wahlpflichtbereich A* (introductory technical electives) and 10 CP (5 semester credit hours) of *Wahlpflichtbereich D* (mathematics and statistics / other electives) at the Technische Universität Darmstadt.

The *Advanced Design Project* at the Technische Universität Darmstadt is a 4 or 6 CP (2 or 3 semester credit hour) course, depending on the project. In the above credit count, it is listed a 4 CP (2 semester credit hour) course to reflect the minimum amount required.

This dual-degree program alternative offers nearly five months between the residency at Virginia Tech and the residency at the Technische Universität Darmstadt that can be used for industry internships and/or university research in either country, subject to position availability and legal requirements. Students interested pursuing such opportunities need to plan ahead.

The end of the Technische Universität Darmstadt Summer semester is officially September 30. The student's effective end-date depends on the student's research progress and the official start

date of his or her full-time research. *Fachbereich Maschinenbau* (Department of Mechanical Engineering) at the Technische Universität Darmstadt requires that the student complete his or her research within six months of the official start date of the full-time thesis research activity. The official start date may be as early as in early-February, which would cause the last acceptable day for research completion to occur in early August.

Subject to the standard MSME program at the Technische Universität Darmstadt, the dual MSME students will be required to have at least six weeks (approximately 240 hours) of pre-approved industry internship experience, performing engineering research and/or development, during their MSME studies (i.e., after having completed at least one semester of the MSME program, but before starting the last semester of this program). Alternatively, this requirement may be satisfied with at least six weeks (approximately 240 hours) of pre-approved university and/or national laboratory research in the field of engineering. Examples of such national research laboratories include Sandia National Laboratories and NASA Langley. This experience may be for pay, though this is not required. Employment as a graduate research assistant (GRA) at either university may, if approved, count towards this requirement. It is suggested, but not required, that this experience be related to the area of the student’s intended MSME thesis research topic. The student is ultimately responsible for obtaining this opportunity.

4.2 Program Alternative 2: TUD residence followed by VT residence

In this dual-degree MSME program alternative, the students spend one year in residence at Technische Universität Darmstadt, followed by one year in residence at Virginia Tech.

Winter semester (Technische Universität Darmstadt)

Approximately October 1 – March 31

• <i>Projektmanagement</i>	2 CP or 1 credit hour
• <i>Maschinenbaututorium oder Elektrotechnikpraktikum</i>	4 CP or 2 credit hours
• <i>Wahlpflichtbereich A</i> (introductory technical electives).....	8 CP or 4 credit hours
• <i>Wahlpflichtbereich C</i> (applied engineering).....	12 CP or 6 credit hours
TOTAL.....	26 CP or 13 credit hours

Summer semester (Technische Universität Darmstadt)

Approximately April 1 – August 1 (see Section 4.2.1)

• <i>Wahlpflichtbereich B</i> (theory and methodology).....	12 CP or 6 credit hours
• <i>Wahlpflichtbereich D</i> (applied mathematics and statistics).....	8 CP or 4 credit hours
• <i>LV andere Fachbereich</i> (electives in other departments).....	8 CP or 4 credit hours
TOTAL.....	28 CP or 14 credit hours

Fall semester (Virginia Tech)

Approximately August 15 – December 15

• ME 5974 Independent Study (advanced design project).....	4 CP or 2 credit hours
• Mathematics and statistics electives.....	12 CP or 6 credit hours
• Electives, area B (theory and methodology).....	12 CP or 6 credit hours
TOTAL.....	28 CP or 14 credit hours
• Approximately 240 hours of pre-approved industry internship or university research (average of 16 hours per week). See Section 4.1.1 for details.	

Spring semester (Virginia Tech)

Approximately January 15 – May 15

- ME 5994 Research & Thesis 34 CP or 17 credit hours

Summer I semester (Virginia Tech)

Approximately May 15 – June 30 (see Section 4.2.1)

- ME 5994 Research & Thesis (defending student status)..... 0 CP or 0 credit hours

4.2.1 Curricular notes

Relative to the standard MSME program at the Technische Universität Darmstadt, 4 CP (2 semester credit hours) of *LV anderer Fachbereiche* in the third semester (Fall semester at Virginia Tech) is moved to the second semester (Summer semester at the Technische Universität Darmstadt), while 2 CP (1 semester credit hour) of *Wahlpflichtbereich B* and 2 CP (1 semester credit hour) of *Wahlpflichtbereich D* in the second semester is moved to the third semester. This was done to accommodate that most courses at Virginia Tech are offered in 3 semester credit hour increments.

The course *ME 5974 Independent Study (advanced design project)* at Virginia Tech may be an individual or a group effort, and it is graded on a PASS/FAIL basis. All 5974 courses at Virginia Tech are graded PASS/FAIL. This project may be scoped for either 2 or 3 semester credit hours (4-6 CP) such that it represents approximately 50 hours of effort per student per semester credit hour (i.e., approximately 100 hours effort for 2 semester credit hours, or approximately 150 hours effort for 3 semester credit hours). Sample topical project areas include: Ergonomic usability test; design with fiber composites; fluid machinery design; product innovation; and virtual product development. This course corresponds to the *Advanced Design Project* in the standard MSME degree program at the Technische Universität Darmstadt.

The formal end of the Technische Universität Darmstadt summer semester is September 30. However, most students complete their summer semester exams in August. Students in the dual-degree MSME program that need to transition from the Summer semester at the Technische Universität Darmstadt to the Fall semester at Virginia Tech should schedule their Summer semester exams in late-July or early-August to facilitate this transition. Such scheduling is seldom a problem. However, it remains the student's responsibility to verify with their course professors, prior to enrolling in their Summer semester courses, that such early exams will be allowed.

Fachbereich Maschinenbau (Department of Mechanical Engineering) at the Technische Universität Darmstadt requires that the student complete his or her research within six months of the official start date of the full-time thesis research activity. For the purpose of research activities at Virginia Tech, the official start date will be January 1, and, hence, the last day for the thesis defense will be June 30. The Summer I semester at Virginia Tech is not required if the *ME 5994 Research & Thesis* course credits and the thesis defense are completed during the Spring semester at Virginia Tech, though most students are expected to complete their thesis research during the Summer I session, which ends approximately June 30. Hence, students are advised to sign up for 17 semester hour credits of *ME 5994 Research & Thesis* during the Spring semester at Virginia Tech, followed by "degree completion" during summer Session I.

4.3 Lists of approved technical electives

The following subsections list the approved courses offered at Virginia Tech and at the Technische Universität Darmstadt in the areas of methodologies and theory, applied engineering, and mathematics and statistics.

For the purpose of academic level equivalence, all AREA A electives (undergraduate technical electives) at the Technische Universität Darmstadt will be counted as 4000-level courses at Virginia Tech (because the AREA A courses are approved for graduate credit at the Technische Universität Darmstadt, they will also be considered approved for graduate credit at Virginia Tech); whereas all AREA B, C, and D electives (graduate technical electives) and the courses *Advanced Design Project* and *Projektmanagement* at the Technische Universität Darmstadt will be counted as 5000-level courses at Virginia Tech.

4.3.1 Introductory technical electives (AREA A)

Wahlpflichtbereich A

The following approved courses are offered at Virginia Tech:

Not all 4000-level undergraduate courses at Virginia Tech are approved for graduate credit. The following list shows the courses that were approved for graduate credit as of May 8, 2006:

Mechanical Engineering

<u>COURSE NUMBER AND NAME</u>	<u>SEMESTER CREDIT HOURS</u>
4204: Internal Combustion Engines.....	3
4224: Aircraft Engines and Gas Turbines	3
4424: Thermodynamics of Fluid Flow.....	3
4524: Introduction to Robotics and Automation	3
4534: Land Vehicle Dynamics	3
4554: Advanced Technology for Motor Vehicles	3
4614: Mechanical Design II.....	3
4624: Finite Element Practice in Mechanical Design	3
4634: Introduction to Computer Aided Design and Manufacturing	3
4724: Engineering Acoustics.....	3
4734: Mechatronics (same as ECE 4734)	3

Aerospace and Ocean Engineering

<u>COURSE NUMBER AND NAME</u>	<u>SEMESTER CREDIT HOURS</u>
4054: Stability of Structures	3
4064: Fluid Flow in Nature	3
4084: Engineering Design Optimization (ESM 4084).....	3
4114: Applied Computational Aerodynamics	3
4140: Spacecraft Dynamics and Control.....	3
4204: Ocean Acoustics.....	3
4214: Ocean Wave Mechanics	3
4274: Computer Based Design of Ocean Structures.....	3
4334: Ship Dynamics	3

Industrial and Systems Engineering

<u>COURSE NUMBER AND NAME</u>	<u>SEMESTER CREDIT HOURS</u>
4244: Fundamentals of Computer Integrated Manufacturing	3
4264: Industrial Automation.....	3

Chemical Engineering

<u>COURSE NUMBER AND NAME</u>	<u>SEMESTER CREDIT HOURS</u>
4134: Chemical Process Modeling	2
4214: Introduction to Polymer Materials	3
4224: Introduction to Polymer Processing	3

Materials Science and Engineering

<u>COURSE NUMBER AND NAME</u>	<u>SEMESTER CREDIT HOURS</u>
4554: Polymer Engineering.....	3
4604: Composite Materials.....	3

The following approved courses are offered at the Technische Universität Darmstadt:

The following list of courses is current as of May 8, 2006, and is subject to standard update procedures. The most current list is maintained online at:

http://www.maschinenbau.tu-darmstadt.de/studium_lehre/studienangebot/allg_mb/allg_mb_wpa.php

The FORMAT describes how many hours per week the course meets as lectures (V) and/or recitations (Ü). The CP describes the number of CPs the course carries.

<u>COURSE NAME</u>	<u>FORMAT</u>	<u>CP</u>
Auslegung von Mensch-Maschine-Schnittstellen	2V+1Ü	4
Druckmaschinen und -systeme I	4V	8
Einführung in die Papierfabrikation	2V	4
Energiesysteme I	2V	4
Energiesysteme II	2V	4
Flugantriebe und Gasturbinen I	4V	8
Konstruieren mit Faser-Kunststoff-Verbunden I	4V	8
Kraftfahrzeuge I	3V	6
Nachhaltige Verbrennungstechnologien in der Energieumwandlung I	4V	8
Maschinenakustik I	2V+1Ü	4
Mechanische Verfahrenstechnik	2V	4
Produktentwicklung I	2V+2Ü	4
Produktentwicklung II	2V+2Ü	4
Thermische Verfahrenstechnik I	2V+1Ü	4
Thermische Verfahrenstechnik II	2V+1Ü	4
Turbomaschinen I	4V	8
Umformtechnik I	2V	4
Umformtechnik II	2V	4

Verbrennungskraftmaschinen I	3V	6
Werkstofftechnologie und -anwendung I	3V	6
Werkzeugmaschinen und Industrieroboter I	4V	8

4.3.2 Electives with emphasis on theory and methodology (AREA B)
Wahlpflichtbereich B

The following approved courses are offered at Virginia Tech:

Virginia Tech does not differentiate between courses that emphasize theory and methodology and those that emphasize applied engineering. Hence, the appropriate distribution of these courses taken at Virginia Tech is left at the discretion by the student’s thesis examination committee, with the approval by the chair of the Virginia Tech Mechanical Engineering Graduate Affairs Committee and the Technische Universität Darmstadt *Studiendekan des Fachbereichs Maschinenbau* (Mechanical Engineering Dean of Student Affairs) or their designees.

The following restrictions apply to the courses (not research credits) taken at Virginia Tech:

1. All courses must be approved for graduate credit. No courses below the 4000-level may be counted towards this requirement;
2. At least 1/2 of these credits must be in the Department of Mechanical Engineering;
3. At least 2/3 of these credits must be taken at the 5000- and/or 6000-level;
4. 5974 and/or 6974 (independent study) may not be used towards this requirement; and
5. At most 9 semester credit hours of 4984, 5984, and/or 6984 (temporary or special courses) may be used towards this requirement. Courses that are subsequently approved as regular courses are exempt from this limitation.

For instance, assuming that 27 semester credit hours of courses (typically 9 courses) are to be taken at Virginia Tech, which is typical of Program Alternative 1, then

- At least 14 semester credit hours (typically 5 or more courses) will be courses in the Department of Mechanical Engineering; and
- At least 18 semester credit hours (typically 6 or more courses) will be at the 5000- and/or 6000-level.

The following approved courses are offered at the Technische Universität Darmstadt:

The following list of courses is current as of May 8, 2006 and is subject to standard update procedures. The most current list is maintained online at:

http://www.maschinenbau.tu-darmstadt.de/studium_lehre/studienangebot/allg_mb/allg_mb_wpb.php

The FORMAT describes how many hours per week the course meets as lectures (V) and/or recitations (Ü). The CP describes the number of CPs the course carries.

COURSE NAME	FORMAT	CP
Ergonomie I	4V+2Ü	8

Farbwiedergabe in den Medien	4V	8
Höhere Regelungstechnik (z. Zt. nicht angeboten)	3V	6
Höhere Strömungslehre und Dimensionsanalyse	4V+2Ü	8
Höhere Wärmeübertragung	2V+1Ü	4
Konstruktiver Leichtbau I	2V+1Ü	4
Konstruktiver Leichtbau II	2V+1Ü	4
Maschinendynamik II	3V+1Ü	6
Mechatronische Systeme I	2V+1Ü	4
Mechatronische Systeme II	2V+1Ü	4
Mehrphasenströmungen A	2V	4
Mehrphasenströmungen B	2V	4
Modellierung turbulenter technischer Strömungen I	2V	4
Modellierung turbulenter technischer Strömungen II	2V	4
Numerische Strömungssimulation	3V+1Ü	6
Produktdatentechnologie A	2V	4
Produktdatentechnologie B	2V	4
Simulation und Optimierung energietechnischer Anlagen	4V	8
Systemverfahrenstechnik	4V	8
Systemzuverlässigkeit im Maschinenbau	2V	4
Zuverlässigkeit im Maschinenbau	2V	4

4.3.3 Electives with emphasis on applied engineering (AREA C)

Wahlpflichtbereich C

The following approved courses are offered at Virginia Tech:

See Sections 4.3.2 and 4.3.6.

The following approved courses are offered at the Technische Universität Darmstadt:

The following list of courses is current as of May 8, 2006 and is subject to standard update procedures. The most current list is maintained online at:

[http://www.maschinenbau.tu-darmstadt.de/studium_lehre/
studienangebot/allg_mb/allg_mb_wpc.php](http://www.maschinenbau.tu-darmstadt.de/studium_lehre/studienangebot/allg_mb/allg_mb_wpc.php)

The FORMAT describes how many hours per week the course meets as lectures (V) and/or recitations (Ü). The CP describes the number of CPs the course carries.

COURSE NAME	FORMAT	CP
Arbeits- und Prozessorganisation	2V+1Ü	4
Digitale Drucktechnologien	2V	4
Druckmaschinen und -systeme II	2V	4
Energiesysteme III (Reaktortechnik)	2V	4
Flugantriebe und Gasturbinen II	2V	4
Fluidtechnische Antriebe	2V	4
Flugmechanik I	3V	6
Grenzflächenverfahrenstechnik	2V	4

Grundlagen der Adaptronik	2V	4
Konstruieren mit Faser-Kunststoff-Verbunden II	2V	4
Kraftfahrzeuge II	3V	6
Nachhaltige Verbrennungstechnologien in der Energieumwandlung II	2V	4
Laser in der Fertigung	2V	4
Management industrieller Produktion I	2V	4
Maschinenakustik II	2V+1Ü	4
Maschinen der Umformtechnik I	1V	2
Maschinen der Umformtechnik II	1V	2
Messtechnik I	2V	4
Papierfabrikation, deren Maschinen und Anlagen I	2V	4
Thermische Verfahrenstechnik III (Höhere Stoffübertragung)	2V	4
Turbomaschinen II	2V	4
Verbrennungskraftmaschinen II	3V	6
Werkstofftechnologie und -anwendung II	2V	4
Werkzeugmaschinen und Industrieroboter II	2V	4

4.3.4 Mathematics and statistics electives (AREA D)

Wahlpflichtbereich D

The mathematics and statistics electives at Virginia Tech must satisfy the requirement for such electives within the graduate program in mechanical engineering at Virginia Tech. At least 6 CP (3 semester credit hours) of *Wahlpflichtbereich D* at the Technische Universität Darmstadt must satisfy this category as well.

The following courses are **offered at Virginia Tech** and satisfy both the Technische Universität Darmstadt *Wahlpflichtbereich D* requirements and the Virginia Tech mathematics and statistics requirements. The following list of courses is current as of May 1, 2005 and is subject to standard update procedures.

Mathematics

<u>COURSE NUMBER AND NAME</u>	<u>SEMESTER CREDIT HOURS</u>
4124: Introduction To Abstract Algebra	3
4134: Number Theory	3
4144: Linear Algebra II.....	3
4214: Linear Analysis	3
4225: Elementary Real Analysis I	3
4226: Elementary Real Analysis II.....	3
4234: Elementary Complex Analysis.....	3
4245: Intermediate Differential Equations I.....	3
4246: Intermediate Differential Equations II.....	3
4254: Chaos and Dynamical Systems	3
4324: Elementary Topology	3
4344: Topics in Geometry	3
4404 (AOE 4404): Applied Numerical Methods.....	3
4425: Fourier Series and Partial Differential Equations I.....	3

4426: Fourier Series and Partial Differential Equations II.....	3
4445: Introduction to Numerical Analysis I.....	3
4446: Introduction to Numerical Analysis II.....	3
4514: Applied Algebra.....	3
4525: Principles of Advanced Calculus I.....	3
4526: Principles of Advanced Calculus II.....	3
4544: Ordinary and Partial Differential Equations.....	5
4554: Numerical Methods for Engineers.....	3
4564: Operational Methods for Engineers.....	3
4574: Vector and Complex Analysis for Engineers.....	3
5114: Specialized Topics in Algebra.....	3
5125: Abstract Algebra I.....	3
5126: Abstract Algebra II.....	3
5135: Topics in Number Theory I.....	3
5136: Topics in Number Theory II.....	3
5144 (GEOL 5144): Inverse Theory & Geoscience Applications.....	3
5214: Specialized Topics in Analysis.....	3
5225: Real Analysis I.....	3
5226: Real Analysis II.....	3
5235: Complex Analysis I.....	3
5236: Complex Analysis II.....	3
5244: Systems & Stability of Differential Equations.....	3
5245: Ordinary Differential Equations I.....	3
5246: Ordinary Differential Equations II.....	3
5344: Specialized Topics in Topology & Geometry.....	3
5415: Specialized Topics in Applied Math I.....	3
5416: Specialized Topics in Applied Math II.....	3
5425: Applied Partial Differential Equations I.....	3
5426: Applied Partial Differential Equations II.....	3
5435: Principles & Techniques of Applied Mathematics I.....	3
5436: Principles & Techniques of Applied Mathematics II.....	3
5444: Numerical Methods for Ordinary Differential Equations.....	3
5454: Graph Theory.....	3
5464: Combinatorics.....	3
5465 (CS 5465): Numerical Analysis I.....	3
5466 (CS 5466): Numerical Analysis II.....	3
5474 (CS 5474): Finite Difference Methods for Partial Differential Equations.....	3
5484 (CS 5484): Finite Element Methods for Partial Differential Equations.....	3
5485 (CS 5485): Numerical Analysis & Software I.....	3
5486 (CS 5486): Numerical Analysis & Software II.....	3
5495 (ESM 5725): Mathematical Methods in Engineering I.....	3
5496 (ESM 5726): Mathematical Methods in Engineering II.....	3
5515 (GBCB 5515): Mathematical Methods for Modeling and Simulation of Biological Systems I.....	3
5516 (GBCB 5516): Mathematical Methods for Modeling and Simulation of Biological Systems II.....	3

5524: Matrix Theory	3
5545: Calculus of Variations & Optimal Control Theory I.....	3
5546: Calculus of Variations & Optimal Control Theory II	3
5554: Approximation Theory	3
5754 (ESM 5754): Introduction To Perturbation Methods	3
6105 (STAT 6105): Measure & Probability I.....	3
6106 (STAT 6106): Measure & Probability II	3
6125: Topics in Algebra I.....	3
6126: Topics in Algebra II.....	3
6225: Topics in Analysis I.....	3
6226: Topics in Analysis II	3
6255: Functional Analysis I.....	3
6256: Functional Analysis II	3
6324: Topics in Topology and Geometry.....	3
6425: Top in Applied Math I.....	3
6426: Top in Applied Math II.....	3
6745 (PHYS 6745): Mathematical Foundations of Statistical Mechanics I.....	3
6746 (PHYS 6746): Mathematical Foundations of Statistical Mechanics II	3
6755 (PHYS 6755): Mathematical Foundations of Quantum Mechanics I	3
6756 (PHYS 6756): Mathematical Foundations of Quantum Mechanics II	3

Statistics

<u>COURSE NUMBER AND NAME</u>	<u>SEMESTER CREDIT HOURS</u>
5104: Probability & Distribution Theory	3
5114: Statistical Inference	3
5124: Linear Models Theory	3
5204: Experimental Design & Analysis I.....	3
5304: Statistical Computing	3
5314: Statistical Simulation.....	3
5324: Statistical Methods for Analyzing Unbalanced Data	3
5334: Exploratory & Robust Data Analysis	3
5344: Linear and Nonlinear Programming	3
5404: Nonparametric Statistics	3
5414: Time Series Analysis I.....	3
5424: Statistical Decision Theory.....	3
5434: Markov Chains and Renewal Theory	3
5444: Bayesian Statistics	3
5454: Reliability Theory.....	3
5464 (ISE 5464): Queueing Theory.....	3
5474 (ISE 5474): Statistical Theory of Quality Control	3
5484: Sequential Analysis	3
5504: Multivariate Statistical Methods	3
5514: Regression Analysis	3
5524: Sample Survey Theory	3
5534: Analysis of Multivariate Categorical Data	3
5544: Spatial Statistics	3

5554: Variance Components.....	3
5564: Statistical Genetics	3
5574: Response Surface Design & Analysis I.....	3
5594: Topics in Biostatistics.....	3
5615: Statistics in Research I.....	3
5616: Statistics in Research II	3
6105 (MATH 6105): Measure & Probability I.....	3
6106 (MATH 6106): Measure & Probability II.....	3
6114: Advanced Topics in Statistical Inference	3
6404: Advanced Topics in Nonparametric Statistics.....	3
6414: Time Series Analysis II	3
6424: Multivariate Statistical Analysis	3
6464 (ISE 6464): Queueing Networks.....	3
6494: Advanced Topics in Mathematical Statistics.....	3
6504: Experimental Design & Analysis II	3
6514: Advanced Topics in Regression.....	3
6574: Response Surface Design & Analysis II.....	3

Engineering

<u>COURSE NUMBER AND NAME</u>	<u>SEMESTER CREDIT HOURS</u>
ME 5744: Methods of Mechanical Engineering Analysis	3
AOE 4404 (MATH 4404): Applied Numerical Methods	3
CS 5465 (MATH 5465): Numerical Analysis I.....	3
CS 5466 (MATH 5466): Numerical Analysis II	3
CS 5474 (MATH 5474): Finite Difference Methods for Partial Differential Equations	3
CS 5484 (MATH 5484): Finite Element Methods for Partial Differential Equations.....	3
CS 5485 (MATH 5485): Numerical Analysis & Software I.....	3
CS 5486 (MATH 5486): Numerical Analysis & Software II.....	3
ESM 5725 (MATH 5495): Mathematical Methods in Engineering I.....	3
ESM 5726 (MATH 5496): Mathematical Methods in Engineering II.....	3
ESM 5754 (MATH 5754): Introduction To Perturbation Methods.....	3
ISE 6464 (STAT 6464): Queueing Networks	3

The following courses are **offered at the Technische Universität Darmstadt** and satisfy both the Technische Universität Darmstadt *Wahlpflichtbereich D* requirements and the Virginia Tech mathematics and statistics requirements. The following list of courses is current as of May 1, 2005 and is subject to standard update procedures. The most current list is maintained online at:

http://www.maschinenbau.tu-darmstadt.de/studium_lehre/studienangebot/bm_mpe/bm_mpe.php

The FORMAT describes how many hours per week the course meets as lectures (V) and/or recitations (Ü). The CP describes the number of CPs the course carries.

<u>COURSE NAME</u>	<u>FORMAT</u>	<u>CP</u>
Einführung in die Theorie der partiellen Differentialgleichungen	4V+2Ü	8
Einführung in die mathematische Statistik.....	3V+2Ü	6

Optimierung für Ingenieure.....	4V+2Ü	8
Grundlage der geometrischen Datenvereinbarung	4V+2Ü	8
Höhere Numerische Mathematik I.....	4V+2Ü	8
Höhere Numerische Mathematik II	4V+2Ü	8
Rotordynamik und Auswuchttechnik	3V+1Ü	4
Nichtlineare und chaotische Schwingungen.....	3V+1Ü	6
Experimentelle Methoden der Schwingungstechnik(Schwingungsmesstechnik) ..	3V+1Ü	6
Dynamik von Mehrkörpersystemen.....	3V+1Ü	6
Elastizitätstheorie I.....	3V+1Ü	6
Elastizitätstheorie II	3V+1Ü	6
Stabilitätstheorie	3V+1Ü	6
Viskoelastizität und Plastizität.....	3V+1Ü	6

4.3.5 Other electives (AREA D)

Wahlpflichtbereich D

In addition to the courses listed above, *Fachbereich Maschinenbau* (Department of Mechanical Engineering) at the Technische Universität Darmstadt offers additional technical electives (e.g., new courses, special topics courses, temporary courses, and other technical electives not explicitly listed under the categories Wahlpflichtbereich A, B, C, or D), which their students may take under the category *Wahlpflichtbereich D*. Such courses may be approved on a case-by-case basis as substitute technical electives towards the dual-degree MSME program to the extent they do not conflict with the mathematics and statistics requirement as stated in Section 4.3.4.

4.3.6 Laboratory intensive electives

Maschinenbaututorien oder Elektrotechnikpraktikum

The following courses are **offered at Virginia Tech** and satisfy the Technische Universität Darmstadt *Maschinenbaututorien oder Elektrotechnikpraktikum* requirement. These are 5000-level courses that are offered by the Department of Mechanical Engineering at Virginia Tech and that have significant laboratory and/or project components where the students get to practice the application of theory and methodology using state of the art software and/or equipment. The following list of courses is current as of May 1, 2005 and is subject to standard update procedures.

These courses, if not counted towards the laboratory intensive requirement, can be counted towards the AREA C (applied engineering) requirement (Section 4.3.3).

ME 5534 Experimental Model Analysis.....	6 CP or 3 credit hours
ME 5604 Graphics for Computer Aided Design	6 CP or 3 credit hours
ME 5624 Finite Elements in Machine Design	6 CP or 3 credit hours
ME 5624 Rapid Prototyping.....	6 CP or 3 credit hours
ME 5714 Digital Signal Processing for Mechanical Measurements	6 CP or 3 credit hours
ME 5724 Advanced Instrumentation & Signal Processing.....	6 CP or 3 credit hours

The following courses are **offered at the Technische Universität Darmstadt** and satisfy its *Maschinenbaututorien oder Elektrotechnikpraktikum* requirement. The following list of courses is current as of May 1, 2005 and is subject to standard update procedures. The most current list is maintained online at:

[http://www.maschinenbau.tu-darmstadt.de
studium_lehre/studienangebot/bm_mpe/bm_mpe.php](http://www.maschinenbau.tu-darmstadt.de/studium_lehre/studienangebot/bm_mpe/bm_mpe.php)

COURSE NAME	LAB HOURS	CP
Arbeitswissenschaft (Landau)	4	4
Arbeiten mit 3D-CAD-Systemen (Anderl)	4	4
CAD-Mechatronik mit CATIA V5 (Anderl)	4	4
CFD und Verbrennung (Janicka)	4	4
Energiesysteme (Loth)	4	4
Fahrzeugtechnik (Winner)	4	4
Faserverbundtechnik (Schürmann)	4	4
Fertigung und Werkzeugmaschinen (Abele)	4	4
Flugantriebe und Gasturbinen (Henecke)	4	4
Flugmechanisches Praktikum (Kubbat)	4	4
Industrielle Fertigung und Organisation (Abele)	4	4
Maschinenakustik (Nordmann)	4	4
Maschinendynamik - Experimentelle Verfahren (Wölfel)	4	4
Maschinendynamik - Numerische Simulation (Wölfel)	4	4
Mechatronische Systeme im Maschinenbau (Nordmann)	4	4
Messtechnisches Praktikum in Mechanik (Markert, FB 6)	4	4
Numerische Berechnungsverfahren im Maschinenbau (Schäfer)	4	4
Numerische Simulation strömungsmechanischer Probleme (Schäfer)	4	4
Numerische Simulation strukturmechanischer Probleme (Schäfer)	4	4
Ölhydraulik und fluidtechnische Antriebe (Stoffel)	4	4
Praktische Problemstellungen aus der Betriebsfestigkeit (Hanselka)	4	4
Produktentwicklung (Birkhofer)	4	4
Tutorium Drucktechnologie (Dörsam)	4	4
Tutorium Strömungsmesstechnik (Tropea)	4	4
Tutorium Thermische Verfahrenstechnik (Hampe)	4	4
Tutorium Turbomaschinen (Stoffel)	4	4
Tutorium Umformtechnik (Groche)	4	4
Tutorium Verbrennungskraftmaschinen (Hohenberg)	4	4
Tutorium Werkstoffkunde (Berger)	4	4
Tutorium Werkzeugmaschinen und Automatisierung (Abele)	4	4

5.0 Thesis advising and examination committee

The student's dual-degree MSME thesis advising and examination committee should consist of four members. Two of these members should be faculty members in the Department of Mechanical Engineering at Virginia Tech, and two should be faculty members *Fachbereich Maschinenbau* (Department of Mechanical Engineering) at the Technische Universität Darmstadt. One committee member from each university should serve as co-chairs and co-research advisors (major professors) to the student.

Students are expected to take the initiative to form their thesis advising and examination committee, starting with the major professors. Working with his or her major professors, the student will be responsible for recruiting the two remaining committee members. The committee membership is by mutual agreement between the respective members and the student. When a student is employed as a graduate research assistant (GRA) or as a researcher, then the faculty member(s) providing the research funding will normally serve as the major professor(s).

The student is expected to submit a **draft plan of study** by July 1 prior to commencing the dual-degree MSME program. This plan of study should identify the specific courses and the semesters in which they are to be taken, the major professors, and the general area of proposed research. For preliminary planning purposes, the draft plan of study should also indicate any requests for courses and/or exams to be offered in English at the Technische Universität Darmstadt. However, it should be noted that the faculty at the Technische Universität Darmstadt are under no obligation to honor such requests. The plan of study should be signed by the major professors to signify their approval of the plan of study and agreement to serve on the committee.

The student is expected to submit an **initial plan of study** within one month of commencing the dual-degree MSME program. The plan of study should identify the specific courses and the semesters in which they are to be taken, the two major professors and the two supporting thesis committee members, and the general area of proposed research. The plan of study should be signed by the thesis committee to signify their approval of the plan of study and their agreement to serve on the committee. If the plan of study includes any requests for courses and/or exams to be offered in English at the Technische Universität Darmstadt, then the plan of study will also need the signatures of these respective course professors to signify their voluntary agreement to honor such requests.

The two major professors are responsible for providing guidance in defining a program of study and in monitoring the student's progress. The student is responsible for arranging and meeting with his or her thesis examination committee and/or their designees at appropriate times. It is strongly recommended that the two major professors meet with the student (with the two other supporting committee members being invited but not required to attend) when the student is starting his or her research, to discuss the undertaking. The committee members and/or their designees should also meet similarly at least one other time when the student and the major professors feel that a significant portion of the research has been completed. A brief progress report, presentation slides, and a presentation by the student is expected. Subsequently, the two

major professors are expected to provide a brief, joint statement assessing the progress of the student.

The student should meet with his or her major professors and/or their designees on a regular basis to discuss the status of his or her graduate program. For a student is enrolled in *ME 5994 Research & Thesis* or *ME 7994 Research & Dissertation*, the failure to meet with his or her major professors and/or their designees during the semester may result in receiving no credit for those thesis or dissertation hours.

To ensure a timely progress, an official start date for the full-time research effort will be established: For Program Alternative 1 (see Section 4.1), where the research is predominantly completed at the Technische Universität Darmstadt, the start date will be set by the major professor at the Technische Universität Darmstadt in consultation with the major professor at Virginia Tech. For Program Alternative 2 (see Section 4.2), where the research is predominantly completed at Virginia Tech, the start date will be January 1. The student will be required to complete and defend their thesis within six months of that date.

The thesis and its examination will be in English. The student is ultimately responsible for observing and ensuring that the examination process and the quality and standard of the thesis document conform and meet the requirements of both universities. Where there is a conflict, as determined by the examination committee, the requirements and standards of the university of the second year of residence will prevail (the Technische Universität Darmstadt in the case of Program Alternative 1; Virginia Tech in the case of Program Alternative 2). The examination committee members should be presented with a final draft of the thesis at least seven (7) days prior to the examination.

The thesis examination and the thesis will, with respect to Virginia Tech, be graded on a pass/fail basis, subject to the rules of examination at Virginia Tech. This includes the appointment of substitute examiners. This examination may be in person, by telephone, and/or by videoconference.

The thesis examination and the thesis will, with respect to the Technische Universität Darmstadt, be graded on a numeric scale. The major professor at the Technische Universität Darmstadt will determine this grade in consultation with the rest of the thesis examination committee.

The thesis advising and examination committee is furthermore responsible for working with the program coordinators, the chair of the Virginia Tech Mechanical Engineering Graduate Affairs Committee, and the *Studiendekan des Fachbereichs Maschinenbau* (Mechanical Engineering Dean of Student Affairs) at the Technische Universität Darmstadt, to ensure that the requirements and standards of the dual-degree MSME program meet or exceed those of the regular MSME programs at both Virginia Tech and at the Technische Universität Darmstadt, respectively.