AMTLICHE BEKANNTMACHUNG RWTH AACHEN UNIVERSITY

NUMMER 2015/012 **SEITEN** 1 - 219 **DATUM** 30.01.2015 **REDAKTION** Sylvia Glaser

Prüfungsordnung

für den Master-Studiengang

Simulation Sciences

der Rheinisch-Westfälischen Technischen Hochschule Aachen

vom 19.02.2010

in der Fassung der 4. Ordnung zur Änderung der Prüfungsordnung

vom 28.01.2015

veröffentlicht als Gesamtfassung

Aufgrund der §§ 2 Abs. 4, 64 des Gesetzes über die Hochschulen des Landes Nordrhein-Westfalen (Hochschulgesetz – HG) vom 31. Oktober 2006 (GV. NRW S. 474), zuletzt geändert durch Artikel 1 des Hochschulzukunftsgesetzes Nordrhein-Westfalen vom 16.09.2014 (GV. NRW S. 547), hat die Rheinisch-Westfälische Technische Hochschule Aachen (RWTH) folgende Prüfungsordnung erlassen:

HERAUSGEGEBEN IM AUFTRAGE DES REKTORS VON DER ABTEILUNG 1.1 DES DEZERNATES 1.0 DER RWTH AACHEN
Templergraben 55, 52056 Aachen | Tel. +49 241 80-99087 | Fax. +49 241 80-92664 | akad@zhv.rwth-aachen.de

Inhaltübersicht

I. Allgemeines

§ 1 Geltungsbereich und akademischer Grad
§ 2 Ziel des Studiums und Sprachenregelung
§ 3 Zugangsvoraussetzungen
§ 4 Regelstudienzeit, Studienumfang und Leistungspunkte
§ 5 Anmeldung und Zugang zu Lehrveranstaltungen
§ 5a Anwesenheitspflicht in Lehrveranstaltungen
§ 6 Prüfungen und Prüfungsfristen
§ 7 Formen der Prüfungen
§ 8 Zusätzliche Module
§ 9 Bewertung der Prüfungsleistungen und Bildung der Noten
§ 10 Prüfungsausschuss
§ 11 Prüfende und Beisitzende
§ 12 Anrechnung von Studienzeiten, Studienleistungen und Prüfungsleistungen und Einstufung in höhere Fachsemester
§ 13 Wiederholung von Prüfungen, der Master-Arbeit und Verfall des Prüfungsanspruchs
§ 14 Abmeldung, Versäumnis, Rücktritt, Täuschung, Ordnungsverstoß

II. Master-Prüfung und Master-Arbeit

§ 15 Art und Umfang der Master-Prüfung
§ 16 Master-Arbeit
§ 17 Annahme und Bewertung der Master-Arbeit
§ 18 Bestehen der Master-Prüfung

III. Schlussbestimmungen

§ 19 Zeugnis, Urkunde und Bescheinigungen
§ 20 Ungültigkeit der Master-Prüfung, Aberkennung des akademischen Grades
§ 21 Einsicht in die Prüfungsakten
§ 22 Inkrafttreten, Veröffentlichung und Übergangsbestimmungen

Anlagen:

1. Studienverlaufsplan
2. Modulkatalog

I. Allgemeines

§ 1
Geltungsbereich und akademischer Grad

(1) Diese Prüfungsordnung gilt für den Master-Studiengang Simulation Sciences.

(2) Bei erfolgreichem Abschluss des Master-Studiums verleiht die Fakultät für Maschinenwesen den akademischen Grad eines Master of Science RWTH Aachen University (M.Sc. RWTH).

§ 2
Ziel des Studiums und Sprachenregelung

(1) Im Master-Studiengang Simulation Sciences werden die im Bachelor-Studiengang erworbenen Kenntnisse so verbreitert und vertieft, dass die Absolventin bzw. der Absolvent zur Behandlung komplexer Fragestellungen und insbesondere zur selbstständigen wissenschaftlichen Arbeit befähigt wird.

(2) Bei dem Studiengang handelt es sich um einen interfakultativen Studiengang in Kooperation mit dem Forschungszentrum Jülich. Beteiligt sind die Fakultät für Mathematik, Informatik und Naturwissenschaften (1), die Fakultät für Maschinenwesen (4), die Fakultät für Georessourcen und Materialtechnik (5), die Fakultät für Elektrotechnik und Informationstechnik (6) und die Fakultät für Medizin (10). Die Federführung liegt bei der Fakultät für Maschinenwesen. Die German Research School for Simulation Sciences unterstützt die Fakultät für Maschinenweisen bei der Organisation und Durchführung.

(4) Das Studium findet in überwiegend englischer Sprache statt.

(5) Die Master-Arbeit wird in englischer Sprache abgefasst.

§ 3
Zugangsvoraussetzungen

(1) Zugangsvoraussetzung ist ein anerkannter erster Hochschulabschluss im Bereich der Natur- oder Ingenieurwissenschaften, durch den die fachliche Vorbildung für den Masterstudiengang nachgewiesen wird. Anerkannt sind Hochschulabschlüsse, die durch eine zuständige staatliche Stelle des Staates, in dem die Hochschule ihren Sitz hat, genehmigt oder in einem staatlich anerkannten Verfahren akkreditiert worden sind.

(2) Für die fachliche Vorbildung im Sinne des Absatzes 1 ist es erforderlich, dass die Studienbewerberin bzw. der Studienbewerber in den nachfolgend aufgeführten Bereichen über die für ein erfolgreiches Studium im Masterstudiengang Simulation Sciences erforderlichen Kenntnisse nachweist:

Insgesamt müssen in den Fächerbereichen Mathematik, Natur- und Ingenieurwissenschaften sowie Informatik Kenntnisse im Umfang von 120 CP nachgewiesen werden. Diese 120 CP müssen die in der folgenden Tabelle aufgelisteten Kenntnisse im angegebenen Mindestumfang beinhalten.

HERAUSGEGEBEN IM AUFTRAGE DES REKTORS VON DER ABTEILUNG 1.1 DES DEZERNATES 1.0 DER RWTH AACHEN
Templergraben 55, 52056 Aachen | Tel. +49 241 80-99087 | Fax. +49 241 80-92664 | akad@zhv.rwth-aachen.de

Mathematik	
Kerngebiete	**10 CP**
• Lineare Algebra (Vektor- und Tensorrechnung, Matrizen, Eigenwerte) • Analysis (Serien, Differential- und Integralrechnung, Taylor-Entwicklung, Funktionen mehrerer Variablen, Fourier-Analyse, gewöhnliche und partielle Differentialgleichungen)	**(beiden Punkte müssen abgedeckt sein)**
Weitere Gebiete	**5 CP**
• Numerische Methoden (Diskretisierung, direkte Lösungsmethoden für lineare Gleichungssysteme) • Wahrscheinlichkeit und Statistik	**(mindestens einer von beiden Punkte muss abgedeckt)**
Natur- und Ingenieurwissenschaften	
Chemie und Physik	**10 CP**
• Elektro- und Magnetostatik • Struktur der Materie einschließlich Atome und Moleküle und Materie-Zustände • Chemische Bindungen	**(mindestens einer der drei Punkte muss abgedeckt sein)**
Ingenieurwissenschaften	**20 CP**
• Statik und Dynamik • Thermodynamik • Fluid- und Festkörpermechanik	**(alle Punkte müssen abgedeckt sein)**
Informatik	
• Prozedurale Programmierung • Linux / Unix-Betriebssystem • Programmierkenntnisse in einer interpretierten Sprache (Shell-Scripting, Python oder gleichwertig).	**5 CP** **(mindestens einer der drei Punkte muss abgedeckt sein)**

(3) Der Prüfungsausschuss kann eine Zulassung mit der Auflage verbinden, bestimmte Kenntnisse bis zur Anmeldung der Master-Arbeit nachzuweisen. Art und Umfang dieser Auflagen werden vom Prüfungsausschuss individuell auf Basis der im Rahmen des vorangegangenen Studienabschluss absolvierten Studieninhalte festgelegt, dies geschieht in Absprache mit der Studienkoordinatorin bzw. dem Studienkoordinator bzw. der Fachstudienberaterin bzw. dem Fachstudienberater.

Eine Zulassung zum Masterstudiengang Simulation Sciences ist nicht möglich, wenn

- aufgrund der in Absatz 2 definierten fachlichen Grundlagen Auflagen im Umfang von mehr als 20 CP notwendig sind,
- in mehr als einem der in Absatz 2 aufgeführten Bereiche Auflagen erforderlich sind oder
- Auflagen im Bereich Mathematik notwendig sind.

(4) Für den Studiengang in überwiegend englischer Sprache ist die ausreichende Beherrschung der englischen Sprache von den Studienbewerberinnen und -bewerbern nachzuweisen, die ihre Studienqualifikation nicht an einer ausschließlich englischsprachigen Einrichtung erworben oder Englisch als Muttersprache erlernt haben. Es werden folgende Nachweise anerkannt:

a) Test of English as Foreign Language (TOEFL) “Internet-based” Test (iBT) mit einem Ergebnis von mindestens 90 Punkten
b) TOEFL “Paper-based“ Test (PBT) mit einem Ergebnis von mindestens 577 Punkten
c) IELTS-Test mit einem Ergebnis von mindestens 5.5
d) Cambrigde Test – Certificate in Advanced English (CAE)
e) First Certificate in English (FCE) mit einer Note von mindestens B
f) ein Zeugnis, das englische Sprachkenntnisse auf dem Niveau B2 des "Gemeinsamen europäischen Referenzrahmens (GeR)" ausweist. Dieser Nachweis wird z.B. durch die Vorlage eines deutschen Abiturzeugnisses erbracht, aus dem ersichtlich ist, dass Englisch bis zum Ende der Qualifikationsphase 1 (Jahrgangsstufe 11 bei G8-Abitur, sonst Jahrgangsstufe 12) durchgängig belegt und mit mindestens ausreichenden Leistungen abgeschlossen wurde
g) Placement-Test des Sprachenzentrums der RWTH Aachen mit dem Niveau B2

(5) Die Feststellung, ob die Zugangsvoraussetzungen erfüllt sind, trifft der Prüfungsausschuss in Absprache mit dem Studiengangsbetreuer und dem Studierendensekretariat, bei ausländischen Studienbewerberinnen bzw. -bewerbern in Absprache mit dem International Office.

(6) Studienbewerberinnen und Studienbewerber, die schon einen Masterstudiengang an der RWTH oder an anderen Hochschulen studiert haben, müssen vor der Einschreibung bzw. bei der Umschreibung in diesen Studiengang beim hiesigen Prüfungsausschuss die Anrechnung bisher erbrachter positiver und negativer Prüfungsleistungen beantragen, um eingeschrieben bzw. umgeschrieben werden zu können.

(7) Auf Antrag kann der Prüfungsausschuss bei Bachelorabsolventen von Studiengängen mit sieben oder mehr Semestern Regelstudienzeit individuell Prüfungsleistungen im Umfang von bis zu 30 Leistungspunkten erlassen.

§ 4
Regelstudienzeit, Studienumfang und Leistungspunkte

(1) Die Regelstudienzeit beträgt einschließlich der Anfertigung der Master-Arbeit vier Semester (zwei Jahre). Das Studium wird zum Wintersemester aufgenommen.

(2) Das Studium besteht aus Pflicht- und Wahlpflichtveranstaltungen. Die Pflichtveranstaltungen werden von allen Studierenden des Studiengangs Simulation Sciences belegt. Die Wahlpflichtveranstaltungen werden neben den Pflichtveranstaltungen individuell im Studienplan festgelegt.

(3) Das Studium ist modular aufgebaut. Die einzelnen Module beinhalten die Vermittlung bzw. Erarbeitung eines Stoffgebietes und der entsprechenden Kompetenzen. Eine Beurteilung der Studienergebnisse durch eine Prüfung oder eine andere Form der Bewertung kann vorgesehen werden. Das Studium enthält einschließlich des Moduls Master-Arbeit insgesamt minimal 15 und maximal 28 Module. Alle Module sind im Modulkatalog definiert (s. Anlage 2).

(4) Die in den einzelnen Modulen erbrachten Prüfungsleistungen werden gemäß § 9 bewertet und gehen mit Leistungspunkten (Credit Points (CP)) gewichtet in die Gesamtnote ein. CP werden nicht nur nach dem Umfang der Lehrveranstaltung vergeben, sondern umfassen den durch ein Modul verursachten Zeitaufwand der Studierenden für Vorbereitung, Nacharbeit und Prüfungen (Selbststudium). Ein CP entspricht dem geschätzten Arbeitsaufwand von etwa 30 Stunden. Ein Semester umfasst in der Regel 30 CP, der Master-Studiengang umfasst daher insgesamt 120 CP.

(5) Der Studienumfang beläuft sich zuzüglich der Master-Arbeit auf 45 Semesterwochenstunden (SWS) bei den Pflichtmodulen und ca. 29 SWS bei den Wahlpflichtmodulen (Kontaktzeit in SWS). Eine SWS entspricht einer 45-minütigen Lehrveranstaltung pro Woche während der gesamten Vorlesungszeit eines Semesters. Die angegebenen SWS beziehen sich auf die reine Dauer der Veranstaltungen. Darüber hinaus sind Zeiten zur Vor- und Nachbereitung der Lehrveranstaltungen aufzubringen. Diese Zeiten gehen gemäß Absatz 3 in die Zuweisung der entsprechenden Creditanzahl ein.

(6) Die RWTH stellt durch ihr Lehrangebot sicher, dass die Regelstudienzeit eingehalten werden kann und dass insbesondere die für einen Studienabschluss erforderlichen Module und die zugehörigen Prüfungen sowie die Master-Arbeit im vorgesehenen Umfang und innerhalb der vorgesehenen Fristen absolviert werden können.

§ 5
Anmeldung und Zugang zu Lehrveranstaltungen

(1) Die Lehrveranstaltungen des Master-Studiengangs Simulation Sciences stehen den für diesen Studiengang eingeschriebenen oder als Zweithörerin bzw. Zweithörer zugelassenen Studierenden sowie grundsätzlich Studierenden anderer Studiengänge und Gasthörerinnen und Gasthörern der RWTH zur Teilnahme offen. Für jede Lehrveranstaltung ist eine Anmeldung über ein modulares Anmeldeverfahren erforderlich. Anmeldefrist und Anmeldeverfahren werden im CAMPUS-Informationssystem rechtzeitig bekannt gegeben. Eine Orientierungsabmeldung von einer Lehrveranstaltung, die über ein Semester läuft, ist bis zum letzten Freitag im Mai bzw. November möglich (Orientierungsphase). Abweichend davon ist bei Blockveranstaltungen eine Abmeldung bis einen Tag vor dem ersten Veranstaltungstag möglich.

(2) Machen es der angestrebte Studienerfolg, die für eine Lehrveranstaltung vorgesehene Vermittlungsform, Forschungsbelange oder die verfügbare Kapazität an Lehr- und Betreuungspersonal erforderlich, die Teilnehmerzahl einer Lehrveranstaltung zu begrenzen, so erfolgt dies nach Maßgabe des § 59 Abs. 2 HG. Dabei sind Studierende, die im Rahmen ihres Studiengangs auf den Besuch einer Lehrveranstaltung angewiesen sind vorrangig zu berücksichtigen (semesterfixierte Pflichtleistung bzw. Wahlpflichtleistung). Als weitere Kriterien werden in der nachfolgenden Reihenfolge gesetzt: die semestervariable Pflichtleistung bzw. Wahlpflichtleistung, die Wahlleistung (§ 6 Abs. 1) und die freiwillige Zusatzleistung (gemäß § 8 Abs. 1) und der freie Zugang (Absatz 1).

§ 5a
Anwesenheitspflicht in Lehrveranstaltungen

(1) In Lehrveranstaltungen kann die Anwesenheit der Studierenden verpflichtend vorgesehen werden, wenn das Lernziel nicht ohne aktive Beteiligung der Studierenden in der Lehrveranstaltung erreicht werden kann.

(2) Lehrveranstaltungen des Masterstudiengangs Simulation Sciences, in denen Anwe- senheit vorgesehen werden kann, sind ausschließlich Veranstaltungen des folgenden Typs:

1. Übungen
2. Seminare und Proseminare
3. Kolloquien
4. (Labor)praktika
5. Projekte

(3) Die Veranstaltungen für die Anwesenheit nach Absatz 1 erforderlich ist, werden im Modulkatalog (Anhang 2) gekennzeichnet.

(4) Die Anzahl der Fehltermine richtet sich nach der Veranstaltung. Je Veranstaltungsinhalt kann sie zwischen 10 und 30 % der angesetzten Kontaktzeit umfassen. Inbegriffen sind hier auch durch Attest entschuldigte Fehlzeiten. In der Regel beträgt die zulässige Fehlzeit zwei Termine bei einer Veranstaltung im Umfang von 2 SWS.

(5) Überschreitet die Fehlzeit den angesetzten Umfang, so können in Rücksprache mit der Dozentin bzw. dem Dozenten Ersatzleistungen vereinbart werden, um das Lernziel dennoch zu erreichen.

(6) Die Anzahl der zulässigen Fehltermine nach Absatz 4 sowie die Zulässigkeit und Form etwaiger Ersatzleistungen nach Absatz 5 gibt die Dozentin bzw. der Dozent spätestens zu Veranstaltungsbeginn bekannt.

§ 6
Prüfungen und Prüfungsfristen

(1) Die Gesamtheit der Master-Prüfung besteht aus den Prüfungsleistungen zu den einzelnen Modulen sowie der Master-Arbeit. Die Prüfungen und die Master-Arbeit werden studienbegleitend abgelegt und sollen innerhalb der festgelegten Regelstudienzeit abgeschlossen sein. Während der Prüfung müssen die Studierenden eingeschrieben sein. Die Module innerhalb des Curriculums gliedern sich in Pflicht- und Wahlpflichtmodule sowie ggfs. Wahlmodule. Pflichtmodule sind verbindlich vorgegeben. Wahlpflichtmodule gestatten eine Auswahl aus einer vorgegebenen Aufstellung alternativer Module durch die Studierenden. Darüber hinaus kann ein definierter Wahlbereich vorgesehen werden, aus dem von den Studierenden frei gewählt werden kann. Dieser Wahlbereich ist nicht mit den in § 8 genannten Zusatzmodulen gleichzusetzen. Zusatzmodule stellen Module dar, die im Studienplan nicht vorgesehen sind, sondern von den Studierenden zusätzlich - auf freiwilliger Basis - belegt werden.

(2) Für den Besuch von Lehrveranstaltungen ist eine modulare Anmeldung erforderlich. Mit der Anmeldung zur Lehrveranstaltung in Pflichtmodulen und Wahlpflichtmodulen ist eine automatisierte Folgeanmeldung zu der dazugehörigen Prüfung möglich. Diese Folgeanmeldung erfolgt automatisch zum 1.12. für das Wintersemester bzw. 1.6. für das Sommersemester des jeweiligen Jahres. § 5 Abs. 1 bleibt davon unbenommen.

(3) Die Studierenden sollen die Lehrveranstaltungen zu dem im Studienplan vorgesehenen Zeitpunkt besuchen. Die genauen An- und Abmeldeverfahren werden im CAMPUS-Informationssystem bekannt gegeben.

(4) Der Prüfungsausschuss sorgt dafür, dass in jedem Prüfungszeitraum zu den zur Master-Prüfung gehörenden Fächern des jeweiligen Semesters Prüfungen erbracht werden können.

In den Fächern sind mindestens zwei Prüfungstermine pro Jahr anzubieten, im Falle von Klausuren sind diese zu Vorlesungsbeginn anzukündigen.

(5) Die gesetzlichen Mutterschutzfristen, die Fristen der Elternzeit und die Ausfallzeiten aufgrund der Pflege und Erziehung von Kindern im Sinne des § 25 Abs. 5 Bundesausbildungsförderungsgesetz sowie aufgrund der Pflege der Ehegattin bzw. des Ehegatten, der eingetragenen Lebenspartnerin bzw. des eingetragenen Lebenspartners oder eines in gerader Linie Verwandten oder ersten Grades Verschwägerten sind zu berücksichtigen.

(6) Macht die Kandidatin bzw. der Kandidat durch ein ärztliches Zeugnis glaubhaft, dass sie bzw. er wegen länger andauernder oder ständiger körperlicher Behinderung oder chronischer Krankheit nicht in der Lage ist, eine Prüfung ganz oder teilweise in der vorgesehenen Form abzulegen, hat die bzw. der Vorsitzende des Prüfungsausschusses der Kandidatin bzw. dem Kandidaten zu gestatten, gleichwertige Prüfungsleistungen in einer anderen Form zu erbringen. Bei der Festlegung von Pflichtpraktika bzw. verpflichtenden Auslandsaufenthalten sind Ersatzleistungen zu gestatten, wenn diese aufgrund der Beeinträchtigung auch mit Unterstützung durch die Hochschule nicht nachgewiesen werden können.

(7) Beurlaubte Studierende sind nicht berechtigt, an der RWTH Leistungsnachweise zu erwerben oder Prüfungen abzulegen. Dies gilt nicht für die Wiederholung von nicht bestandenen Prüfungen und für Leistungsnachweise (Erfahrungsberichte) für das Auslands- oder Praxissemester selbst. Außerdem gilt dies nicht, wenn die Beurlaubung aufgrund der Pflege und Erziehung von Kindern im Sinne des § 25 Abs. 5 Bundesausbildungsförderungsgesetz sowie aufgrund der Pflege der Ehegattin bzw. des Ehegatten, der eingetragenen Lebenspartnerin bzw. des eingetragenen Lebenspartners oder eines in gerader Linie Verwandten oder im ersten Grad Verschwägerten erfolgt.

§ 7
Formen der Prüfungen

(1) Eine Prüfung ist im Regelfall eine Klausurarbeit oder eine mündliche Prüfung. Prüfungen können aber auch in Form eines Referates, einer Hausarbeit, einer Studienarbeit, einer Projektarbeit oder eines Kolloquiums erbracht werden. Im Rahmen eines Moduls kann die Vorlage von Teilnahmenachweisen sowie Leistungsnachweisen verlangt werden. Ein Leistungs- oder Teilnahmenachweis kann als Zulassungsvoraussetzung für weitere zu erbringende Leistungen innerhalb eines Moduls definiert werden. Leistungsnachweise können in den gleichen Formen wie die Prüfungen erworben werden. Ein Teilnahmenachweis bescheinigt die aktive Teilnahme an einer Lehrveranstaltung.

(2) Die endgültige Form der Prüfung im Fall von alternativen Möglichkeiten und die zugelassenen Hilfsmittel werden in der Regel zu Beginn der Lehrveranstaltung, spätestens bis vier Wochen vor dem Prüfungstermin bekannt gegeben. §13 Abs. 5 bleibt davon unberührt. Ebenso ist mitzuteilen, wie die Einzelbewertung der Prüfungen in die Gesamtbewertung der Prüfung zu der Lehrveranstaltung einfließt.
Der Prüfungstermin und der Name der oder des Prüfenden müssen spätestens bis Mitte Mai bzw. Mitte November im CAMPUS-Informationssystem bekannt gegeben werden. Für mündliche Prüfungen kann auch ein Termin individuell vereinbart werden, der Name des Prüfers muss jedoch feststehen.

(3) In den **mündlichen Prüfungen** soll die Kandidatin bzw. der Kandidat nachweisen, dass sie bzw. er die Zusammenhänge des Prüfungsgebietes erkennt und spezielle Fragestellungen in diese Zusammenhänge einzuordnen vermag. Durch die mündliche Prüfung soll ferner festgestellt werden, ob die Kandidatin bzw. der Kandidat über breites Grundlagenwissen verfügt. Mündliche Prüfungen werden entweder von mehreren Prüfenden (Kollegialprüfung) oder von

einer bzw. einem Prüfenden in Gegenwart einer bzw. eines sachkundigen Beisitzenden als Gruppenprüfung mit nicht mehr als vier Kandidatinnen bzw. Kandidaten oder als Einzelprüfung abgelegt. Hierbei wird jede Kandidatin bzw. jeder Kandidat in einem Prüfungsfach bzw. Stoffgebiet grundsätzlich nur von einer Prüfenden bzw. einem Prüfenden geprüft. Vor der Festsetzung der Note gemäß § 9 Abs. 1 hat die bzw. der Prüfende die Beisitzende bzw. den Beisitzenden zu hören. Die wesentlichen Gegenstände und Ergebnisse der mündlichen Prüfung sind in einem Protokoll festzuhalten. Das Ergebnis der Prüfung ist der Kandidatin bzw. dem Kandidaten im Anschluss an die mündliche Prüfung bekannt zu geben. Die Dauer einer mündlichen Prüfung beträgt pro Kandidatin bzw. Kandidat mindestens 15 und höchstens 45 Minuten. Im Fall von mündlichen Ergänzungsprüfungen gemäß § 13 Abs. 2 ist die Bewertung durch eine Prüfende bzw. einen Prüfenden ausreichend. Im Rahmen einer Gruppenprüfung ist darauf zu achten, dass der gleiche Zeitrahmen pro Kandidatin bzw. Kandidat wie bei einer Einzelprüfung eingehalten wird.

(4) Studierende, die sich in einem späteren Prüfungszeitraum der gleichen Prüfung unterziehen wollen, können nach Maßgabe der räumlichen Verhältnisse als Zuhörerinnen bzw. Zuhörer zugelassen werden, sofern die Kandidatin bzw. der Kandidat nicht widerspricht. Die Zulassung erstreckt sich nicht auf die Beratung und Bekanntgabe des Prüfungsergebnisses.

(5) In den **Klausurarbeiten** soll die Kandidatin bzw. der Kandidat nachweisen, dass sie bzw. er in begrenzter Zeit und mit begrenzten Hilfsmitteln ein Problem mit den geläufigen Methoden des Faches erkennen und Wege zu einer Lösung finden kann. Die Dauer einer Klausur sollte sich an der folgenden Vorgabe orientieren:

- Bei der Vergabe von 1 bis 3 CP: 1 bis 2 Zeitstunden
- Bei der Vergabe von 4 bis 9 CP: 2 bis 3 Zeitstunden
- Bei der Vergabe von 10 bis 15 CP: 3 bis 4 Zeitstunden
- Bei der Vergabe von 16 oder mehr CP: 4 bis 5 Zeitstunden

Die genaue Prüfungsdauer ist im Modulkatalog angegeben. Eine Einlesezeit, die nicht in die Bearbeitungszeit eingeht, ist darüber hinaus möglich.

(6) Im Rahmen von Klausuren können auch Multiple Choice Aufgaben gestellt werden. Einzelheiten der Bewertung sind § 9 Abs. 2 bis 3 zu entnehmen.

(7) Jede Klausurarbeit ist von der bzw. dem Prüfenden zu bewerten. Wird eine Klausurarbeit gemäß § 13 Abs. 4 von zwei Prüfenden bewertet, so ergibt sich die Note der Klausurarbeit aus dem arithmetischen Mittel der Einzelbewertungen. Die Prüfenden können fachlich geeigneten Mitarbeiterinnen bzw. Mitarbeitern, die einen entsprechenden Mastergrad oder einen vergleichbaren oder höherwertigen Abschluss haben, die Vorkorrektur der Klausurarbeit übertragen. Im Fall von mündlichen Ergänzungsprüfungen gemäß § 13 Abs. 2 ist die Bewertung durch eine Prüfende bzw. einen Prüfenden ausreichend.

(8) Ein **Referat** ist ein Vortrag von mindestens 30 und höchstens 90 Minuten Dauer auf der Grundlage einer schriftlichen Ausarbeitung. Dabei sollen die Studierenden nachweisen, dass sie zur wissenschaftlichen Ausarbeitung eines Themas unter Berücksichtigung der Zusammenhänge des Faches in der Lage sind und die Ergebnisse mündlich vorstellen können.

(9) Im Rahmen einer **schriftlichen Hausarbeit** wird eine Aufgabenstellung aus dem Bereich der Lehrveranstaltung ggf. unter Heranziehung der einschlägigen Literatur und weiterer geeigneter Hilfsmittel sachgemäß bearbeitet und geeigneten Lösungen zugeführt. Die Hilfsmittel werden zusammen mit der Aufgabenstellung bekannt gegeben. § 7 Abs. 7 Satz 2 gilt entsprechend.

(10) In **schriftlichen Hausaufgaben**, die begleitend während des Semesters ausgegeben und bewertet werden, soll die bzw. der Studierende schrittweise auf nachfolgende Prüfungsleistungen vorbereitet werden. Bei diesen semesterbegleitenden Hausaufgaben besteht die Möglichkeit einer Anrechnung bis zu einem Umfang von 10 % auf eine nachfolgende abschließende Prüfungsleistung in der jeweiligen Lehrveranstaltung. Die Dozentin bzw. der Dozent gibt zu Beginn des Semesters, spätestens jedoch bis zum Termin der ersten Veranstaltung im Campus-System, die genauen Kriterien für den Erwerb von Bonuspunkten an.

(11) Prüfungen gemäß Absatz 8 bis 10 können auch als Gruppenleistung zugelassen werden, sofern eine individuelle Bewertung des Anteils eines jeden Gruppenmitglieds möglich ist.

(12) Im **Kolloquium** sollen die Studierenden nachweisen, dass sie im Gespräch mit der bzw. dem Prüfenden und weiteren Teilnehmerinnen und Teilnehmern des Kolloquiums Zusammenhänge des Faches erkennen und spezielle Fragestellungen in diesem Zusammenhang einordnen vermögen. Das Kolloquium kann mit einem Referat gemäß Absatz 8 begonnen werden. Die Prüfungsdauer ergibt sich gemäß § 7 Abs. 3.

(13) Die mündliche Präsentation ist eine Prüfungsleistung, die zu einem vorgegebenen Thema in Form eines Vortrages mit visueller Unterstützung – ggf. vor dem Teilnehmerkreis der Lehrveranstaltung – erbracht wird. Die Bewertung der mündlichen Präsentation durch den Prüfenden wird der Kandidatin oder dem Kandidaten bekannt gegeben und an Hand eines vom Prüfenden verfassten Protokolls nachvollziehbar dokumentiert.

(14) Die Forschungsarbeit ist eine Prüfungsleistung und besteht in der selbstständigen Bearbeitung einer wissenschaftlichen Problemstellung mit einer schriftlichen Dokumentation der Ergebnisse in Berichtsform. Sie kann in Zusammenhang mit einer Lehrveranstaltung von der bzw. dem Dozenten ausgegeben und betreut werden. Wissenschaftliche Mitarbeiterinnen bzw. Mitarbeiter können bei der Betreuung mitwirken.

§ 8
Zusätzliche Module

(1) Die Kandidatin bzw. der Kandidat kann sich in weiteren, frei wählbaren Modulen einer Prüfung unterziehen (zusätzliche Module). Diese müssen vor Anmeldung der Prüfung beim Prüfungsausschuss beantragt werden.

(2) Das Ergebnis der Prüfung in diesen Modulen wird auf Antrag der Kandidatin bzw. des Kandidaten in das Zeugnis aufgenommen, jedoch bei der Festsetzung der Gesamtnote nicht mit einbezogen.

§ 9
Bewertung der Prüfungsleistungen und Bildung der Noten

(1) Die Noten für die einzelnen Prüfungsleistungen werden von den jeweiligen Prüfenden festgesetzt. Für die Bewertung sind folgende Noten zu verwenden:

1 = sehr gut	eine hervorragende Leistung;
2 = gut	eine Leistung, die erheblich über den durchschnittlichen Anforderungen liegt;
3 = befriedigend	eine Leistung, die durchschnittlichen Anforderungen entspricht;
4 = ausreichend	eine Leistung, die trotz ihrer Mängel noch den Anforderungen genügt;
5 = nicht ausreichend	eine Leistung, die wegen erheblicher Mängel den Anforderungen nicht mehr genügt.

Durch Erniedrigen oder Erhöhen der einzelnen Noten um 0,3 können zur differenzierten Bewertung Zwischenwerte gebildet werden. Die Noten 0,7; 4,3; 4,7 und 5,3 sind dabei ausgeschlossen. Nicht benotete Leistungen erhalten die Bewertung „bestanden“ bzw. „nicht bestanden“.

(2) Multiple Choice (Mehrfachauswahl) ist ein in Prüfungen verwendetes Format, bei dem zu einer Frage mehrere vorformulierte Antworten zur Auswahl stehen. Die Bewertungskriterien müssen auf dem Klausurbogen sowie 14 Tage vor der Prüfung per Aushang oder im Campus-Informationssystem bekannt gegeben werden. Eine Klausur mit ausschließlich Multiple Choice Aufgaben gilt als bestanden, wenn

a) 60 % der gestellten Fragen zutreffend beantwortet sind oder
b) die Zahl der zutreffend beantworteten Fragen um nicht mehr als 22 % die durchschnittliche Prüfungsleistung der Kandidatinnen und Kandidaten unterschreitet, die erstmals an der Prüfung teilgenommen haben.

Die Vergabe von Negativpunkten ist nicht zulässig.

(3) Hat die Kandidatin bzw. der Kandidat gemäß Absatz 2 die Mindestzahl der Aufgaben richtig beantwortet und damit die Prüfung bestanden, so lautet die Note wie folgt:

- sehr gut, falls sie bzw. er mindestens 75%
- gut, falls sie bzw. er mindestens 50% aber weniger als 75%
- befriedigend, falls sie bzw. er mindestens 25% aber weniger als 50%
- ausreichend, falls sie bzw. er keine oder weniger als 25%

der darüber hinausgehenden Aufgaben zutreffend beantwortet hat.

(4) Besteht eine Klausur sowohl aus Multiple Choice als auch aus anderen Aufgaben, so werden die Multiple Choice Aufgaben nach den Absätzen 2 und 3 bewertet. Die übrigen Aufgaben werden nach dem für sie üblichen Verfahren beurteilt. Die Note wird aus den gewichteten Ergebnissen beider Aufgabenteile errechnet. Die Gewichtung erfolgt nach dem Anteil der Aufgabenarten an der Klausur.

(5) Eine Bewertung der Prüfung erfolgt nur, wenn die Kandidatin bzw. der Kandidat zum Zeitpunkt der Prüfung bzw. bei der Abgabe einer zu bewertenden Leistung im Studiengang eingeschrieben ist. Die Bewertung für die Prüfungen ist nach spätestens sechs Wochen mitzuteilen, dabei muss sichergestellt werden, dass die Bewertung spätestens zehn Tage vor einer möglichen Wiederholungsprüfung vorliegt. Eine Benachrichtigung der Studierenden zur Benotung erfolgt automatisiert über das CAMPUS-Informationssystem an die RWTH-E-Mail-Kontaktadresse sowie über Aushang. Studierende können ihren aktuellen Notenspiegel im CAMPUS-Informationssystem abfragen.

(6) Eine Prüfung ist bestanden, wenn die Note mindestens ”ausreichend” (4,0) ist. Wenn eine Prüfung aus mehreren Teilleistungen besteht, ergibt sich die Note unter Berücksichtigung aller Teilleistungen. Hierbei muss jede Teilleistung mindestens mit der Note „ausreichend“ (4,0) bewertet worden oder bestanden sein. Für die Noten gilt Absatz 8 entsprechend.

(7) Ein Modul ist bestanden, wenn alle zugehörigen Prüfungen mit einer Note von mindestens „ausreichend“ (4,0) bestanden sind, und alle weiteren zugehörigen CP (z.B. Teilnahme- und Leistungsnachweise) erbracht sind. Für jedes Modul werden die CP gemäß Anlage (Modulkatalog) angerechnet.

(8) Die Gesamtnote wird aus den Noten der Module und der Note der Master-Arbeit gebildet. Die Gesamtnote der bestandenen Master-Prüfung lautet:

bei einem Durchschnitt bis 1,5	= sehr gut,
bei einem Durchschnitt von 1,6 bis 2,5	= gut,
bei einem Durchschnitt von 2,6 bis 3,5	= befriedigend,
bei einem Durchschnitt von 3,6 bis 4,0	= ausreichend.

Die schlechteste der gewichteten Modulnoten bleibt auf Antrag der bzw. des Studierenden an den Prüfungsausschuss unberücksichtigt, sofern alle Modulprüfungen innerhalb der Regelstudienzeit bestanden wurden. Hiervon ist das Modul Masterarbeit ausgeschlossen. Sollten mehrere Module dieselbe gewichtete Modulnote besitzen, muss eines dieser Module ausgewählt und im Antrag auf Streichung benannt werden.

(9) Bei der Bildung der Noten und der Gesamtnote wird nur die erste Dezimalstelle hinter dem Komma berücksichtigt. Alle weiteren Stellen werden ohne Rundung gestrichen.

(10) Anstelle der Gesamtnote „sehr gut" nach Absatz 8 wird das Gesamturteil „mit Auszeichnung bestanden" erteilt, wenn die Master-Arbeit mit 1,0 bewertet und der gewichtete Durchschnitt aller anderen Noten der Master-Prüfung nicht schlechter als 1,3 ist.

§ 10
Prüfungsausschuss

(1) Für die Organisation der Prüfungen und die durch diese Prüfungsordnung zugewiesenen Aufgaben bildet die Fakultät für Maschinenwesen einen gemeinsamen Prüfungsausschuss, dessen Mitglieder aus den Fakultäten 1, 4, 5, 6, 10 der RWTH Aachen und aus dem Forschungszentrum Jülich kommen. Der Prüfungsausschuss besteht aus der bzw. dem Vorsitzenden aus der Fakultät 4 der RWTH Aachen, deren bzw. dessen Stellvertretung, die am Forschungszentrum Jülich tätig ist und eine Professur in der Fakultät 1, 5, 6, 10 inne hat, sowie sechs weiteren stimmberechtigten Mitgliedern. Die bzw. der Vorsitzende, die Stellvertretung und zwei weitere Mitglieder werden aus der Gruppe der Professorinnen und Professoren, zwei Mitgliedern wird aus der Gruppe der wissenschaftlichen Mitarbeiterinnen und Mitarbeiter und zwei Mitglieder werden aus der Gruppe der Studierenden gewählt. Für die Mitglieder des Prüfungsausschusses werden Vertreterinnen bzw. Vertreter gewählt. Die Amtszeit der Mitglieder aus der Gruppe der Professorinnen und Professoren und aus der Gruppe der wissenschaftlichen Mitarbeiterinnen und Mitarbeiter beträgt zwei Jahre, die Amtszeit der studentischen Mitglieder ein Jahr. Wiederwahl ist zulässig.

(2) Der Prüfungsausschuss ist Behörde im Sinne des Verwaltungsverfahrens- und des Verwaltungsprozessrechts.

(3) Der Prüfungsausschuss achtet darauf, dass die Bestimmungen der Prüfungsordnung eingehalten werden, und sorgt für die ordnungsgemäße Durchführung der Prüfungen. Er ist insbesondere zuständig für die Entscheidung über Widersprüche gegen in Prüfungsverfahren getroffene Entscheidungen. Darüber hinaus hat der Prüfungsausschuss regelmäßig, mindestens einmal im Jahr, der Fakultät über die Entwicklung der Prüfungen und Studienzeiten zu berichten. Er gibt Anregungen zur Reform der Prüfungsordnung und des Studienverlaufsplanes und legt die Verteilung der Noten und der Gesamtnoten offen. Der Prüfungsausschuss kann die Erledigung seiner Aufgaben für alle Regelfälle auf die Vorsitzende bzw. den Vorsitzenden übertragen. Dies gilt nicht für Entscheidungen über Widersprüche und den Bericht an die Fakultät.

(4) Der Prüfungsausschuss ist beschlussfähig, wenn neben der bzw. dem Vorsitzenden oder deren bzw. dessen Stellvertretung zwei weitere stimmberechtigte Professorinnen bzw. Professoren oder deren Vertretung und mindestens zwei weitere stimmberechtigte Mitglieder oder deren Vertreterinnen bzw. Vertreter anwesend sind. Er beschließt mit einfacher Mehrheit. Bei Stimmengleichheit entscheidet die Stimme der bzw. des Vorsitzenden. Die studentischen Mitglieder des Prüfungsausschusses wirken bei der Anrechnung von Studien- und Prüfungsleistungen nicht mit.

(5) Die Mitglieder des Prüfungsausschusses haben das Recht, der Abnahme der Prüfungen beizuwohnen.

(6) Die Sitzungen des Prüfungsausschusses sind nichtöffentlich. Die Mitglieder des Prüfungsausschusses und die Vertreterinnen bzw. Vertreter unterliegen der Amtsverschwiegenheit. Sofern sie nicht im öffentlichen Dienst stehen, sind sie durch die Vorsitzende bzw. den Vorsitzenden des Prüfungsausschusses zur Verschwiegenheit zu verpflichten.

(7) Der Prüfungsausschuss bedient sich bei der Wahrnehmung seiner Aufgaben der Fakultät 4 und der Verwaltungshilfe des Zentralen Prüfungsamts (ZPA).

(8) Der Prüfungsausschuss bestellt eine Studiengangsbetreuerin bzw. einen Studiengangsbetreuer zur Studienberatung und zur fachlichen Beratung des Prüfungsausschusses. Auf Empfehlung der Studiengangsbetreuerin bzw. des Studiengangsbetreuers genehmigt der Prüfungsausschuss die individuellen Studienpläne im Wahlpflichtbereich und das Thema der Masterarbeit. Die Amtszeit der Studiengangsbetreuerin bzw. des Studiengangsbetreuers beträgt drei Jahre.

§ 11
Prüfende und Beisitzende

(1) Die bzw. der Vorsitzende des Prüfungsausschusses bestellt die Prüfenden. Die Prüfenden bestellen ggfs. die Beisitzenden. Die Bestellung ist aktenkundig zu machen. Zu Prüfenden dürfen nur Personen bestellt werden, die mindestens die entsprechende oder eine vergleichbare Abschlussprüfung abgelegt und, sofern nicht zwingende Gründe eine Abweichung erfordern, in dem der Prüfung vorangehenden Studienabschnitt eine selbständige Lehrtätigkeit in dem betreffenden Modul ausgeübt haben. Zu Beisitzenden dürfen nur Personen bestellt werden, die über einen entsprechenden oder gleichwertigen Abschluss verfügen.

(2) Die Prüfenden sind in ihrer Prüfungstätigkeit unabhängig. § 10 Abs. 6 Satz 2 gilt entsprechend. Dies gilt auch für die Beisitzenden.

(3) Die Kandidatin bzw. der Kandidat kann für die Master-Arbeit sowie die schriftlichen bzw. mündlichen Prüfungen Prüfende vorschlagen. Auf die Vorschläge der Kandidatin bzw. des Kandidaten soll nach Möglichkeit Rücksicht genommen werden. Die Vorschläge begründen jedoch keinen Anspruch.

(4) Die bzw. der Vorsitzende des Prüfungsausschusses sorgt dafür, dass der Kandidatin bzw. dem Kandidaten die Namen der Prüfenden rechtzeitig, bis Mitte Mai bzw. November bekannt gegeben werden. Die Bekanntmachung durch Aushang oder im CAMPUS-Informationssystem ist ausreichend.

§ 12
Anrechnung von Studienzeiten, Studienleistungen und Prüfungsleistungen und Einstufung in höhere Fachsemester

(1) Bestandene und nicht bestandene Leistungen, die an einer anderen Hochschule im Geltungsbereich des Grundgesetzes in einem gleichen Studiengang erbracht worden sind, werden von Amts wegen angerechnet. Bestandene und nicht bestandene Leistungen in anderen Studiengängen oder an anderen Hochschulen sowie an staatlichen oder staatlich anerkannten Berufsakademien im Geltungsbereich des Grundgesetzes sind auf Antrag anzurechnen, sofern keine wesentlichen Unterschiede nachgewiesen, festgestellt und begründet werden können; dies gilt auf Antrag auch für Leistungen an Hochschulen außerhalb des Geltungsbereichs des Grundgesetzes. Auf Antrag kann die Hochschule sonstige Kenntnisse und Qualifikationen auf der Grundlage der eingereichten Unterlagen anrechnen.

(2) Wesentliche Unterschiede bestehen insbesondere dann, wenn die erworbenen Kompetenzen den Anforderungen im Masterstudiengang Simulation Sciences nicht entsprechen. Dabei ist kein schematischer Vergleich, sondern eine Gesamtbetrachtung und Gesamtbewertung vorzunehmen. Für Studienzeiten, Studienleistungen und Prüfungsleistungen, die außerhalb des Geltungsbereichs des Grundgesetzes erbracht wurden, sind die von der Kultusministerkonferenz gebilligten Äquivalenzvereinbarungen sowie Absprachen im Rahmen der Hochschulpartnerschaft zu beachten. Im Übrigen kann bei Zweifeln die Zentralstelle für ausländisches Bildungswesen gehört werden.

(3) Die bzw. der Studierende hat die für die Anrechnung erforderlichen Unterlagen in deutscher Sprache vorzulegen. Von Unterlagen, die nicht in deutscher Sprache abgefasst sind, sind auf Verlangen des Prüfungsausschusses beglaubigte Übersetzungen beizufügen. Die Unterlagen müssen Aussagen zu den erworbenen Kompetenzen und in diesem Zusammenhang bestandenen, nicht-bestandenen oder erbrachten Leistungen sowie den sonstigen Kenntnissen und Qualifikationen enthalten, die jeweils angerechnet werden sollen. Bei einer Anrechnung von Studienzeiten und Leistungen aus Studiengängen sind in der Regel die entsprechenden Modulbeschreibungen sowie das Transcript of Records oder ein vergleichbares Dokument vorzulegen.

(4) Die Studien- und Prüfungsleistungen von Schülerinnen und Schülern, die im Einzelfall aufgrund besonderer Begabungen als Jungstudierende außerhalb der Einschreibungsordnung zu Lehrveranstaltungen und Prüfungen zugelassen wurden, werden bei einem späteren Studium auf Antrag angerechnet.

(5) Zuständig für Anrechnungen nach den Absätzen 1 bis 4 ist der Prüfungsausschuss. Vor Feststellungen darüber, ob wesentliche Unterschiede vorliegen, ist in der Regel eine Fachvertreterin bzw. ein Fachvertreter zu hören.

(6) Werden Studien- und Prüfungsleistungen angerechnet, sind die Noten - soweit die Notensysteme vergleichbar sind - zu übernehmen und in die Berechnung der Gesamtnote einzubeziehen. Bei unvergleichbaren Notensystemen wird der Vermerk „angerechnet" aufgenommen. Die Anrechnung wird im Zeugnis gekennzeichnet.

§ 13
Wiederholung von Prüfungen, der Master-Arbeit und Verfall des Prüfungsanspruchs

(1) Bei „nicht ausreichenden" Leistungen können die Prüfungen zweimal, die Master-Arbeit kann einmal wiederholt werden. Die Rückgabe des Themas der Master-Arbeit ist jedoch nur zulässig, wenn die Kandidatin bzw. der Kandidat bei der Anfertigung der ersten Master-Arbeit von dieser Möglichkeit keinen Gebrauch gemacht hat.

(2) Erreicht eine Kandidatin bzw. eine Kandidat in der zweiten Wiederholung einer Klausur die Note „nicht ausreichend" (5,0) und wurde diese Note nicht auf Grund eines Täuschungsversuchs, eines Versäumnisses oder eines Rücktritts ohne triftige Gründe gemäß § 14 Abs. 2 festgesetzt, so ist ihr bzw. ihm vor einer Festsetzung der Note „nicht ausreichend" die Möglichkeit zu bieten, sich einer mündlichen Ergänzungsprüfung zu unterziehen. Für die Abnahme der mündlichen Ergänzungsprüfung gilt § 7 Abs. 3 entsprechend. Aufgrund der mündlichen Ergänzungsprüfung wird die Note „ausreichend" (4,0) bzw. die Note „nicht ausreichend" (5,0) festgesetzt.

(3) Die wiederholte Master-Arbeit muss spätestens drei Semester nach dem Fehlversuch der ersten Arbeit angemeldet werden. Die Inanspruchnahme von Schutzbestimmungen entsprechend den §§ 3, 4, 6 und 8 des Mutterschutzgesetzes und entsprechend den Fristen des Bundeserziehungsgeldgesetzes über die Elternzeit sowie die Berücksichtigung von Ausfallzeiten durch die Pflege von Personen im Sinne von § 48 Abs. 5 S. 2 Nr. 5 HG werden auf diese Frist nicht angerechnet. Wer diese Frist überschreitet, verliert ihren bzw. seinen Prüfungsanspruch, es sei denn, dass sie bzw. er das Versäumnis nicht zu vertreten hat.

(4) Prüfungsleistungen in schriftlichen und mündlichen Prüfungen, mit denen ein Studiengang laut Studienverlaufsplan abgeschlossen wird, und in Wiederholungsprüfungen, bei deren endgültigem Nichtbestehen keine Ausgleichsmöglichkeit vorgesehen ist, sind von mindestens zwei Prüfenden zu bewerten. § 7 Abs. 7 bleibt davon unberührt.

(5) Wiederholungsprüfungen können von den Prüfenden in schriftlicher oder mündlicher Form abgenommen werden. Die Studierenden werden spätestens zwei Wochen vor der Wiederholungsprüfung per Aushang darüber informiert, ob die Wiederholungsprüfung mündlich oder schriftlich durchgeführt wird.

(6) Setzt sich eine Prüfung aus mehreren Prüfungsteilen zusammen, muss im Falle des Nichtbestehens eines Prüfungsteils lediglich der nicht bestandene Prüfungsteil wiederholt werden.

(7) Ein Modul ist endgültig nicht bestanden, wenn noch zum Bestehen erforderliche Prüfungen nicht mehr wiederholt werden können.

(8) Die Master-Prüfung ist endgültig nicht bestanden, wenn zum Bestehen eines Moduls notwendige Leistungen nicht mehr wiederholt werden können oder wenn die zweite Master-Arbeit mit „nicht ausreichend" bewertet wurde oder als „nicht ausreichend" bewertet gilt.

§ 14
Abmeldung, Versäumnis, Rücktritt, Täuschung, Ordnungsverstoß

(1) Die Kandidatin bzw. der Kandidat kann sich bis eine Woche vor dem jeweiligen Prü- fungstermin ohne Angabe von Gründen von Prüfungen abmelden.

(2) Eine Prüfungsleistung gilt als mit „nicht ausreichend" (5,0) bewertet, wenn die Kandidatin bzw. der Kandidat zu einem Prüfungstermin ohne triftige Gründe nicht erscheint oder wenn sie bzw. er nach Beginn der Prüfung ohne triftige Gründe von der Prüfung zurücktritt. Dasselbe gilt, wenn eine schriftliche Prüfungsleistung nicht innerhalb der vorgegebenen Bearbeitungszeit erbracht wird. In diesem Fall besteht kein Anrecht auf eine mündliche Ergänzungsprüfung.

(3) Die für den Rücktritt oder das Versäumnis geltend gemachten Gründe müssen dem Prüfungsausschuss unverzüglich schriftlich angezeigt und glaubhaft gemacht werden. Bei Krankheit der Kandidatin bzw. des Kandidaten ist die Vorlage eines ärztlichen Attestes erforderlich. Die bzw. der Vorsitzende des Prüfungsausschusses kann im Einzelfall die Vorlage eines Attestes einer Vertrauensärztin bzw. eines Vertrauensarztes, die bzw. der vom Prüfungsausschuss benannt wurde, verlangen. Erkennt der Prüfungsausschuss die Gründe nicht an, wird der Kandidatin bzw. dem Kandidaten dies schriftlich mitgeteilt. Die bereits vorliegenden Prüfungsergebnisse sind anzurechnen.

(4) Die Kandidatin bzw. der Kandidat hat bei schriftlichen Prüfungen - mit Ausnahme von Klausuren unter Aufsicht - an Eides statt zu versichern, dass die Prüfungsleistung von ihr bzw. von ihm ohne unzulässige fremde Hilfe erbracht worden ist.

(5) Versucht die Kandidatin bzw. der Kandidat das Ergebnis einer Prüfungsleistung durch Täuschung, z.B. Benutzung nicht zugelassener Hilfsmittel, zu beeinflussen, gilt die betreffende Prüfungsleistung als mit „nicht ausreichend" (5,0) bewertet. Die Feststellung wird von der bzw. dem jeweiligen Prüfenden oder von der für die Aufsichtführung zuständigen Person getroffen und aktenkundig gemacht. Eine Kandidatin bzw. ein Kandidat, die bzw. der den ordnungsgemäßen Ablauf der Prüfung stört, kann von der bzw. dem jeweiligen Prüfenden oder der aufsichtführenden Person in der Regel nach Abmahnung von der Fortsetzung der Prüfungsleistung ausgeschlossen werden. In diesem Fall gilt die betreffende Prüfungsleistung als mit „nicht ausreichend" (5,0) bewertet. Die Gründe für den Ausschluss sind aktenkundig zu machen. Im Falle eines mehrfachen oder sonstigen schwerwiegenden Täuschungsversuches kann die Kandidatin bzw. der Kandidat zudem exmatrikuliert werden.

(6) Belastende Entscheidungen sind der Kandidatin bzw. dem Kandidaten unverzüglich schriftlich mitzuteilen, zu begründen und mit einer Rechtsbehelfsbelehrung zu versehen.

II. Master-Prüfung und Master-Arbeit

§ 15
Art und Umfang der Master-Prüfung

(1) Die Master-Prüfung besteht aus

1. den Prüfungen aus dem Pflicht- und Wahlpflichtbereich, die im Modulkatalog gemäß Anlage 2 aufgeführt sind
2. der Master-Arbeit und dem Master-Vortragskolloquium.

In den einzelnen Studienabschnitten sind CP im folgenden Umfang zu erbringen:

Studienabschnitt	**Credit Points**
Pflichtbereich	56
Wahlpflichtbereich	34
Master-Arbeit und -Kolloquium	30
	120

(2) Die Reihenfolge der Lehrveranstaltungen sowie der Prüfungen und Leistungsnachweise sollte sich am Studienverlaufsplan orientieren. Prüfungen und Leistungsnachweise werden studienbegleitend abgelegt. Das Thema der Master-Arbeit kann erst ausgegeben werden, wenn 75 CP erreicht sind.

(3) Die Gegenstände der Prüfungen und Leistungsnachweise werden durch die Inhalte der zugehörigen Lehrveranstaltungen gemäß Modulkatalog bestimmt.

§ 16
Master-Arbeit

(1) Die Master-Arbeit besteht aus einer schriftlichen Arbeit der Kandidatin bzw. des Kandidaten. Sie soll zeigen, dass die Kandidatin bzw. der Kandidat in der Lage ist, ein Problem innerhalb einer vorgegebenen Frist nach wissenschaftlichen Methoden unter Anleitung selbstständig zu bearbeiten.

(2) Die Master-Arbeit kann von jeder bzw. jedem an der RWTH Aachen im Studiengang Simulation Science in Forschung und Lehre tätigen Professorin bzw. Professor sowie aufgrund entsprechender Regelung des zuständigen Prüfungsausschusses durch habilitierte Mitarbeiterinnen und Mitarbeiter, außerplanmäßige Professorinnen bzw. Professoren, Junior-Professorinnen bzw. Professoren, Honorarprofessorinnen bzw. Professoren und Gastprofessorinnen und Professoren ausgegeben und betreut werden. Darüber hinaus kann der Prüfungsausschuss Personen mit selbstständiger Lehrbefugnis mit der Aufgabe der Betreuung beauftragen. Wissenschaftliche Mitarbeiterinnen bzw. Mitarbeiter können bei der Betreuung mitwirken. In Ausnahmefällen kann die Master-Arbeit mit Zustimmung des Prüfungsausschusses außerhalb der Fakultäten 1, 4, 5, 6, 10 und des Forschungszentrums Jülich bzw. außerhalb der RWTH ausgeführt werden, wenn sie von einer der in Satz 1 genannten Personen ausgegeben und betreut wird. Externe Betreuer können nach Maßgabe des § 65 Abs. 1 HG NRW durch den Prüfungsausschuss zu Zweitprüfern bestellt werden.

(3) Auf besonderen Antrag der Kandidatin bzw. des Kandidaten sorgt die bzw. der Vorsitzende des Prüfungsausschusses dafür, dass sie bzw. er zum vorgesehenen Zeitpunkt das Thema einer Master-Arbeit erhält. Der Kandidatin bzw. dem Kandidaten ist Gelegenheit zu geben, für das Thema Vorschläge zu machen.

(4) Die Master-Arbeit ist in englischer Sprache abzufassen.

(5) Die bzw. der Vorsitzende des Prüfungsausschusses teilt der Kandidatin bzw. dem Kandidaten den Abgabetermin mit. Der Zeitpunkt der Ausgabe sowie die Themenstellung sind aktenkundig zu machen.

(6) Die Bearbeitungszeit für die Master-Arbeit beträgt in der Regel sechs Monate (inklusive Kolloquium). Der Umfang der schriftlichen Ausarbeitung sollte ohne Anlage 80 Seiten nicht überschreiten. Thema und Aufgabenstellung müssen so beschaffen sein, dass eine Fertigstellung innerhalb der vorgegebenen Frist mit einem äquivalenten Arbeitsaufwand von sechs Monaten Vollzeitarbeit erreicht werden kann. In Absprache mit der Betreuerin bzw. dem Betreuer und der Fachstudienberatung kann eine Bearbeitung in Teilzeit in einem Zeitraum von maximal 12 Monaten stattfinden. Dies ist beim Prüfungsausschuss zu beantragen und muss von diesem genehmigt werden. Das Thema kann nur einmal und nur innerhalb des ersten Monats der Bearbeitungszeit zurückgegeben werden. Ausnahmsweise kann der Prüfungsausschuss im Einzelfall auf begründeten Antrag der Kandidatin bzw. des Kandidaten und bei Befürwortung durch die Aufgabenstellerin bzw. den Aufgabensteller die Bearbeitungszeit um bis zu vier Wochen verlängern.

(7) Die Ergebnisse der Master-Arbeit präsentiert die Kandidatin bzw. der Kandidat im Rahmen eines Master-Vortragskolloquiums. Hinsichtlich der Durchführung gilt § 7 Abs. 14 entsprechend.

(8) Bei der Abgabe der Masterarbeit hat die Kandidatin bzw. der Kandidat schriftlich zu versichern, dass sie bzw. er die Arbeit selbständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt sowie Zitate kenntlich gemacht hat. Die Masterarbeit muss in gedruckter und elektronischer Form abgegeben werden.

§ 17
Annahme und Bewertung der Master-Arbeit

(1) Die Master-Arbeit ist fristgemäß in zweifacher Ausfertigung beim ZPA abzuliefern. Der Abgabezeitpunkt ist aktenkundig zu machen. Wird die Master-Arbeit nicht fristgemäß abgeliefert, gilt sie als mit ”nicht ausreichend” (5,0) bewertet. Eine Bewertung erfolgt nur, wenn die Kandidatin bzw. der Kandidat zum Zeitpunkt der Abgabe im Studiengang eingeschrieben ist.

(2) Prüfende bzw. Prüfender soll diejenige bzw. derjenige sein, die bzw. der das Thema gestellt hat. Die Arbeit stellt regelmäßig die letzte Prüfungsleistung dar und ist stets von zwei Prüfenden gemäß § 9 Abs. 1 zu bewerten und schriftlich zu begründen. Die Note für die Arbeit wird aus dem arithmetischen Mittel der Einzelbewertungen gemäß § 9 Abs. 1 gebildet, sofern die Differenz nicht mehr als 2,0 beträgt. Beträgt die Differenz mehr als 2,0 oder lautet eine Bewertung „nicht ausreichend“, die andere aber „ausreichend“ oder besser, wird von der bzw. dem Vorsitzenden des Prüfungsausschusses eine dritte Prüfende bzw. ein dritter Prüfender zur Bewertung der Master-Arbeit bestimmt, die bzw. der die Note im Rahmen der Vornoten innerhalb von vier Wochen abschließend festlegt.

(3) Die Bekanntgabe der Note soll – mit Ausnahme des Absatz 2 Satz 4 - spätestens acht Wochen nach dem jeweiligen Abgabetermin erfolgen. Erfolgt diese Bekanntgabe nicht fristgerecht, ist der Prüfungsausschuss berechtigt, andere Prüfende zu bestimmen.

(4) Für die Masterarbeit inklusive des Kolloquiums werden 30 Credit Points vergeben.

§ 18
Bestehen der Master- Prüfung

Die Master-Prüfung ist bestanden, wenn alle erforderlichen Module bestanden sind und die Note der Master-Arbeit mindestens „ausreichend” (4,0) lautet. Mit Bestehen der Master-Prüfung ist das Master-Studium beendet.

III. Schlussbestimmungen

§ 19
Zeugnis, Urkunde und Bescheinigungen

(1) Hat die Kandidatin bzw. der Kandidat die Master-Prüfung bestanden, so erhält sie bzw. er spätestens drei Monate nach der letzten Prüfungsleistung über die Ergebnisse ein Zeugnis. Das Zeugnis enthält die Module und die Master-Arbeit mit den jeweiligen Noten und Leistungspunkten (CP) sowie die Gesamtnote. In das Zeugnis werden auch das Thema der Master-Arbeit sowie die zusätzlichen Module aufgenommen. Die Gesamtnote wird sowohl verbal und als Zahl mit einer Dezimalstelle angegeben. Das Zeugnis ist von der bzw. dem Vorsitzenden des Prüfungsausschusses zu unterzeichnen.

(2) Das Zeugnis trägt das Datum des Tages, an dem die letzte Prüfung bestanden oder der letzte Leistungsnachweis erbracht wurde.

(3) Das Zeugnis wird in deutscher und englischer Sprache abgefasst.

(4) Gleichzeitig mit dem Zeugnis wird der Kandidatin bzw. dem Kandidaten eine in deutscher und englischer Sprache abgefasste Urkunde mit dem Datum des Zeugnisses ausgehändigt. Darin wird die Verleihung des Mastergrades beurkundet. Die Masterurkunde wird von der Dekanin bzw. dem Dekan der Fakultät für Maschinenwesen und der bzw. dem Vorsitzenden des Prüfungsausschusses unterzeichnet.

(5) Mit dem Zeugnis wird der Absolventin bzw. dem Absolventen ein in deutscher und englischer Sprache abgefasstes Diploma Supplement ausgehändigt. Das Diploma Supplement informiert über das individuelle fachliche Profil des absolvierten Studienganges. Das Diploma Supplement weist auch eine ECTS-Bewertungsskala aus.

(6) Ist die Master-Prüfung endgültig nicht bestanden, erteilt die bzw. der Vorsitzende des Prüfungsausschusses der Kandidatin bzw. dem Kandidaten hierüber einen schriftlichen Bescheid, der mit einer Rechtsbehelfsbelehrung zu versehen ist.

(7) Studierende, welche die Hochschule ohne Studienabschluss verlassen, erhalten auf Antrag ein Leistungszeugnis über die insgesamt erbrachten Studien- und Prüfungsleistungen.

§ 20
Ungültigkeit der Master- Prüfung, Aberkennung des akademischen Grades

(1) Hat die Kandidatin bzw. der Kandidat bei einer Prüfung getäuscht und wird diese Tatsache erst nach Aushändigung des Zeugnisses bekannt, kann der Prüfungsausschuss nachträglich die Noten für diejenigen Prüfungsleistungen, bei deren Erbringung die Kandidatin bzw. der Kandidat getäuscht hat, entsprechend berichtigen und die Prüfung ganz oder teilweise für nicht bestanden erklären.

(2) Waren die Voraussetzungen für die Zulassung zu einer Prüfung nicht erfüllt, ohne dass die Kandidatin bzw. der Kandidat hierüber täuschen wollte, und wird diese Tatsache erst nach der Aushändigung des Zeugnisses bekannt, wird dieser Mangel durch das Bestehen der Prüfung geheilt. Hat die Kandidatin bzw. der Kandidat die Zulassung vorsätzlich zu Unrecht erwirkt, entscheidet der Prüfungsausschuss unter Beachtung des Verwaltungsverfahrensgesetzes für das Land Nordrhein-Westfalen über die Rechtsfolgen.

HERAUSGEGEBEN IM AUFTRAGE DES REKTORS VON DER ABTEILUNG 1.1 DES DEZERNATES 1.0 DER RWTH AACHEN
Templergraben 55, 52056 Aachen | Tel. +49 241 80-99087 | Fax. +49 241 80-92664 | akad@zhv.rwth-aachen.de

(3) Vor einer Entscheidung ist der bzw. dem Betroffenen Gelegenheit zur Äußerung zu geben.

(4) Das unrichtige Prüfungszeugnis ist einzuziehen und gegebenenfalls ein neues auszustellen. Eine Entscheidung nach Absatz 1 und Absatz 2 Satz 2 ist nach einer Frist von fünf Jahren nach Ausstellung des Prüfungszeugnisses ausgeschlossen.

(5) Ist die Prüfung insgesamt für nicht bestanden erklärt worden, sind der akademische Grad durch die Fakultät abzuerkennen und die Urkunde einzuziehen.

§ 21
Einsicht in die Prüfungsakten

(1) Der Kandidatin bzw. dem Kandidaten ist die Möglichkeit zu geben, nach Bekanntgabe der Noten Einsicht in die korrigierte Klausur bzw. schriftlichen Prüfungsarbeiten zu nehmen. Zeit und Ort der Einsichtnahme sind während der Prüfung, spätestens mit Bekanntgabe der Note mitzuteilen. Für die Einsichtnahme muss den Studierenden mindestens 30 Minuten Zeit gegeben werden.

(2) Sofern Absatz 1 keine Anwendung findet, wird der Kandidatin bzw. dem Kandidaten nach Abschluss des Prüfungsverfahrens auf Antrag Einsicht in die schriftlichen Prüfungsarbeiten, die darauf bezogenen Gutachten der Prüfenden und in die Prüfungsprotokolle gewährt.

(3) Der Antrag ist binnen eines Monats nach Aushändigung des Prüfungszeugnisses bei der bzw. dem Vorsitzenden des Prüfungsausschusses zu stellen. Die bzw. der Vorsitzende des Prüfungsausschusses bestimmt Ort und Zeit der Einsichtnahme.

§ 22
Inkrafttreten, Veröffentlichung und Übergangsbestimmungen

(1) Diese Prüfungsordnung, in der Fassung der vierten Ordnung zur Änderung der Prüfungsordnung, tritt zum Wintersemester 2014/2015 in Kraft, wird in den Amtlichen Bekanntmachungen der RWTH veröffentlicht und findet auf alle in den Master-Studiengang Simulation Sciences eingeschriebenen Studierenden Anwendung.

(2) Die Änderung in § 17 Abs. 4 findet für alle Studierenden Anwendung, die ihre Masterarbeit ab dem 01.02.2015 anmelden.

(3) Studierende, die die durch diese Ordnung zur Änderung der Prüfungsordnung geänderten Module vor dem Wintersemester 2014/2015 begonnen haben, können diese nach den bisherigen Bedingungen bis zum Ende des Wintersemesters 2015/2016 beenden. Auf Antrag an den Prüfungsausschuss können die neuen Module gewählt werden.

HERAUSGEGEBEN IM AUFTRAGE DES REKTORS VON DER ABTEILUNG 1.1 DES DEZERNATES 1.0 DER RWTH AACHEN
Templergraben 55, 52056 Aachen | Tel. +49 241 80-99087 | Fax. +49 241 80-92664 | akad@zhv.rwth-aachen.de

Ausgefertigt aufgrund des Beschlusses des Fakultätsrates der Fakultät für Maschinenwesen vom 13.01.2015.

Der Rektor
der Rheinisch-Westfälischen
Technischen Hochschule Aachen

Aachen, den 28.01.2015

gez. Schmachtenberg
Univ.-Prof. Dr.-Ing. E. Schmachtenberg

Anlage 1: Studienverlaufsplan

Studienverlaufsplan	**SWS**	**LP**
1. Semester (WS)		
Numerical Methods for PDEs	V4 Ü2	8
From Molecular to Continuum Physics I	V3 Ü2	6
Applied Quantum Mechanics	V3 Ü1 P2	6
Data Analysis and Visualization	V2 Ü1	4
Parallel Programming I	V3 Ü2	6
		30
2. Semester (SS)		
Fast Iterative Solvers	V2 Ü1	4
Parallel Computing in Simulation Sciences	V3 Ü2	6
From Molecular to Continuum Physics II	V3 Ü2	5
Model Based Estimation Methods	V2 Ü2	5
Elective Courses		10
		30
3. Semester (WS)		
SiSc Laboratory	P3	6
Elective Courses		24
		30
4. Semester (SS)		
Masterarbeit und -Kolloquium		30
		30
Gesamt		**120**

Anlage 2: Modulkatalog

Modulkatalog für
Simulation Sciences (M.Sc.)

HERAUSGEGEBEN IM AUFTRAGE DES REKTORS VON DER ABTEILUNG 1.1 DES DEZERNATES 1.0 DER RWTH AACHEN
Templergraben 55, 52056 Aachen | Tel. +49 241 80-99087 | Fax. +49 241 80-92664 | akad@zhv.rwth-aachen.de

Prüfungsordnungsbeschreibung: Simulation Sciences (M.Sc.) [MSSiSc]

Titel	Simulation Sciences (M.Sc.)
Kurzbezeichnung	SiSc (M.Sc.)

Modul: Applied Quantum Mechanics [MSSiSc-1001]

MODUL TITEL: Applied Quantum Mechanics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
1	1	6	6	jedes 2. Semester	WS 2010/2011	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Why quantum mechanics? • Time-dependent Schrödinger equation • Wave packets • 1-dimensional examples: potential steps, quantum wells, linear potentials, harmonic oscillator • Formalism: Hilbert space, state vectors, operators, uncertainty relations • Angular momentum	• Understanding of basic notions of quantum mechanics and its relevance to materials science and design
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Applied Quantum Mechanics [MSSiSc-1001.a]		6	0
Vorlesung Applied Quantum Mechanics [MSSiSc-1001.b]		0	3
Übung Applied Quantum Mechanics [MSSiSc-1001.c]		0	3

Modul: From Molecular to Continuum Physics I [MSSiSc-1002]

MODUL TITEL: From Molecular to Continuum Physics I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
1	1	6	5	jedes 2. Semester	WS 2010/2011	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Ab initio molecular dynamics: principle and practical implementation with planewaves and pseudopotentials • Classical molecular dynamics and hybrid classical and ab initio molecular dynamics methods • Molecular simulation in the NVT and NPT ensembles • Fee energy calculations • Langevin dynamics, Brownian dynamics • Computational molecular spectroscopy	• Achieve a basic insight into the fundamental difference of processes on quantum-mechanical length- and time-scales, as compared to the everyday classical experience • Achieve a basic understanding of the complexity of quantum-mechanical wave-functions for predicting molecular properties • Acquire knowledge of the power and limitations of effective potentials based calculations • Presentation • For engineers: acquire new scientific vocabulary
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in physics	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung From Molecular to Continuum Physics I [MSSiSc-1002.a]		6	0
Vorlesung From Molecular to Continuum Physics I [MSSiSc-1002.b]		0	3
Übung From Molecular to Continuum Physics I [MSSiSc-1002.c]		0	2

Modul: Numerical Methods for PDEs [MSSiSc-1003]

MODUL TITEL: Numerical Methods for PDEs

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
1	1	8	6	jedes 2. Semester	WS 2008/2009	English

INHALTLICHE ANGABEN

Inhalt

- Modeling of physical/technical processes by PDEs
- Classification of PDEs and qualitative properties
- Finite difference method, finite volume method
- Variational formulation and weak solutions
- Sobolev spaces
- Finite element method: construction, high order
- Finite element method: analysis and implementation
- Basic iterative solvers, conjugate gradients
- A posteriori error estimates and adaptive mesh refinement
- Eigenvalue problems
- Discontinuous Galerkin methods
- Time integration for parabolic PDEs
- Time integration for hyperbolic PDEs
- Saddle point problems, Boundary integral equations

Lernziele

Fachbezogene Lernziele:

- Modeling of physical/technical processes by partial differential equations
- Understanding the properties of discretization methods
- Convergence analysis of discretization methods
- Modern algorithms: Iterative solvers, Adaptivity
- Choosing the right methods for the specific application

Nicht fachbezogene Lernziele:

- Solving problems in team work
- Presentation

Voraussetzungen

recommended:

- Basic knowledge in linear algebra, analysis, differential equations, basic numerical methods

Benotung

- 1 written or oral exam

The final grade is calculated from the exam plus the so-called Bonuspunkteregelung for homework (up to 10% of the exam points).

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Numerical Methods for PDEs [MSSiSc-1003.a]		8	0
Vorlesung Numerical Methods for PDEs [MSSiSc-1003.b]		0	4
Übung Numerical Methods for PDEs [MSSiSc-1003.c]		0	2

Modul: Data Analysis and Visualization [MSSiSc-1004]

MODUL TITEL: Data Analysis and Visualization

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
1	1	4	3	jedes 2. Semester	WS 2008/2009	English

INHALTLICHE ANGABEN

Inhalt

- Introduction to the rendering pipeline: data structures, transformations, homogeneous coordinates, culling, projection
- Introduction to the rendering pipeline: clipping, hidden surface removal, Phong reflection model, shading, antialiasing, computer graphics hardware
- Introduction to visualization, the visualization pipeline, classification of data types (scalars, vectors, graphs)
- Scalar field visualization: transfer function design, isocontouring, volume rendering
- Vector field visualization: glyphs, flow lines, streak lines, iso-lines, vector field integration schemes, line integral convolution
- Introduction to data analysis, dimension reduction, principal component analysis, manifold detection and reconstruction
- Tutorial: visualization of simulated unsteady flow phenomena with the visualization toolkit VTK and Paraview: glyphs, volume rendering, cutplanes, iso-surfaces, particle tracing
- Explorative analysis of simulation datasets in Virtual Reality: stereoscopic projections, Virtual Reality hardware, parallel software architectures for virtual environments, 3D interaction methodology, navigation in space and time
- Tutorial: interactive visualization of simulation datasetss with the Virtual Reality toolkit ViSTA exploration of the results in hte immersive VR system CAVE
- Tutorial: realtime scalar field visualization, GPU supported volume rendering OR introduction to visualization with matlab
- Advanced realtime rendering
- Introduction to biomolecular structure, secondary structure elements of proteins, graphical representations of proteins, the Protein Data Bank, visualization of proteins, elements of molecular dynamics
- Tutorial: visualization of a protein from the PDB file and analysis of a molecular dynamics simulation dataset

Lernziele

- Understanding of basic computer graphics, visualization and Virtual Reality techniques and methods
- Understanding of the entire computer graphics and visualization pipeline from simulation raw data to meaningful images, animations and interactive visualization in 3-D space

Voraussetzungen

recommended:

- Basic programming knowledge
- Data structures and algorithms

Benotung

1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Data Analysis and Visualization [MSSiSc-1004.a]		4	0
Vorlesung Data Analysis and Visualization [MSSiSc-1004.b]		0	2
Übung Data Analysis and Visualization [MSSiSc-1004.c]		0	1

Modul: Parallel Programming I [MSSiSc-1005]

MODUL TITEL: Parallel Programming I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
1	1	6	5	jedes 2. Semester	WS 2010/2011	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Principles of parallel performance Parallel architectures • Memory architectures • Interconnection network Processes and threads Message Passing Interface • Point-to-Point communication • Collective communication • Derived data types • Process topologies Open MP • Execution model • Work sharing • Loop-level parallelism • Synchronization Parallel programming tools • Debuggers • Performance tools Patterns of parallel programming	• Students should be enabled to write correct and efficient parallel programs • Students should understand the principles of concurrent problem solving
Voraussetzungen	**Benotung**
recommended: • Knowledge of the C programming language	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Parallel Programming I [MSSiSc-1005.a]		6	0
Vorlesung Parallel Programming I [MSSiSc-1005.b]		0	3
Übung Parallel Programming I [MSSiSc-1005.c]		0	2

Modul: Model Based Estimation Methods [MSSiSc-2001]

MODUL TITEL: Model Based Estimation Methods

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	4	jedes 2. Semester	SS 2009	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
1 • The students know the problem classes of inverse problems. 2 • The students can name the models of measurement errors (distributions). • The students are familiar with the fundamentals of applied stochastic and know for example the meaning of a random variable. 3 • The students know estimation techniques and their applications. • The students know the maximum-likelihood method and can apply it. • The students know the least squares method and can demonstrate that it is a 'best linear unbiased estimator' (BLUE). 4 • The students are able to formulate linear inverse problems and can analyze the ill-posedness. • The students know the solution characteristics of ill-posed problems. 5 • The students can explain the eigenvector decomposition and apply it to exemplary problems. • The students know the singular value decomposition and can apply it. 6 • The students are able to explain the link from eigenvalues to ill-posedness. • The students can apply the truncated singular value decomposition to solve ill-posed problems and can explain how this method works. • The students can explainknow the Tikhonov regularizationsingular value decomposition and can apply it. 7 • The students can explain the regularizing character of discretization methods. • The students can explain the regularizing nature of iterative solvers. • The students can explain the Tikhonov regularization. 8 • The students can explain and apply the discrepancy principle criterion. • The students know the most important methods to determine the regularization parameter. • The students can explain and apply the L-Curve criterion. • The students can explain and apply the discrepancy principle criterion.	With respect to the subject • The students are able to identify and solve inverse problems. • The students can analyze ill-posed problems. • The students know different regularization techniques for ill-posed problems and can apply these techniques to given problems. • The students know the classes of input-, state- and parameter-estimation problems and can solve these types of problems. • The students are able to judge a models quality based on measurement data. • The students know the concepts of optimal design of experiments and can apply these techniques to given problems. Not with respect to the subject • The students are able to implement simple programs in Matlab.

• The students can apply the regularization techniques to state estimation problems. • The students can illustrate observability of LTI-systems. 9 • The students are able to explain and analyze the Luenberger observer. • The students can apply the regularization techniques to 'unknown input estimation'state estimation problems. • The students can illustrate observability of LTI-systems. 10 • The students can explain the system inversion. • The students can apply the regularization techniques to 'unknown input estimation' problems. 11 • The students can choose a suitable objective function and explain why a particular objective function is well suited. • The students can analyze and solve input estimation problems via state extensions. • The students can solve parameter estimation problems. 12 • The students can chooseperform a suitable objective function and explain why a particular objective function is well suitedconfidence analysis. • The students can analyze and question the solution of a parameter estimation problem. 13 • The students can perform a confidence analysischoose between rival models and justify their choice. • The students know the concepts of optimal experimental design and can apply them to exemplary problems. • The students can choose between rival models and justify their choice. 14 • The students know research-examples of ill-posed, inverse problems and can classify them. 15 • The students know Industrial examples of ill-posed, inverse problems and can classify them.	
Voraussetzungen	**Benotung**
recommended: • Module *Numerical Methods for PDEs* • Basic programming knowledge in stochastics	1 written exam (120 min)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Model Based Estimation Methods [MSSiSc-2001.a]	120	5	0
Vorlesung Model Based Estimation Methods [MSSiSc-2001.b]		0	2
Übung Model Based Estimation Methods [MSSiSc-2001.c]		0	2

Modul: From Molecular to Continuum Physics II [MSSiSc-2002]

MODUL TITEL: From Molecular to Continuum Physics II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	5	jedes 2. Semester	SS 2011	English

INHALTLICHE ANGABEN

Inhalt

- An Overview of Statistical Mechanics
- Lattice Models
- From Lattices to Molecules
- Discrete interactions, statics, and modeling
- Thermodynamics and averaging
- Phase field modeling
- Continuum mechanics
- Kinematics
- Balance laws and constitutive equations
- Finite-element methods

Lernziele

Fachbezogene Lernziele:

- Have an introduction to basic continuum methods, in particular for electro-magnetics, fluid dynamics, structural mechanics and materials aspects.
- The combination of this and the previous lecture should give a fair understanding of difficulties and concepts for solutions associated with multiscale-problems of all sorts of materials science applications

Nicht fachbezogene Lernziele:

- Achieve abilities to rely on mathematical formulations rather than on standard intuitions when making quantitative predictions
- presentation

Voraussetzungen

recommended:

- Module From Molecular to Continuum Physics I

Benotung

The final grade will be the grade of the final exam. The form of the exam depends on the semester (in summer semester, a written exam is planned; for the winter semester, an oral exam is planned because of the smaller number of registrants).

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung From Molecular to Continuum Physics II [MSSiSc-2002.a]		5	0
Vorlesung From Molecular to Continuum Physics II [MSSiSc-2002.b]		0	3
Übung From Molecular to Continuum Physics II [MSSiSc-2002.c]		0	2

Modul: Fast Iterative Solvers [MSSiSc-2003]

MODUL TITEL: Fast Iterative Solvers

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2009	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction: Properties of discretized system • Krylov space methods (GMRes, CG) • Krylov space methods (QMR, BiCG, ...) • Preconditioning overview • Schwarz theory (ASM, MSM) • One-grid and Two-grid methods • Multigrid methods: algorithmic aspects • Multigrid methods: smoothing/approximation properties • Multilevel methods (BPX), analysis • Algebraic multigrid methods (AMG) • Domain decomposition (DD) preconditioning • Dirichlet - DD: Extension operators, Schur complement • Neumann - DD: FETI und FETI-DP methods • Eigenvalue solvers: Rayleigh-Ritz methods, Eigenvalue solvers: Inexact inverse iteration, Jacobi Davidson	Fast solvers for large scale linear systems as arising from the discretization of partial differential equations
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in linear algebra, analysis • Module Numerical Methods for PDEs	• 1 written or oral exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Fast Iterative Solvers [MSSiSc-2003.a]		4	0
Vorlesung Fast Iterative Solvers [MSSiSc-2003.b]		0	2
Übung Fast Iterative Solvers [MSSiSc-2003.c]		0	1

Modul: Parallel Computing in Simulation Sciences [MSSiSc-2004]

MODUL TITEL: Parallel Computing in Simulation Sciences

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	5	jedes 2. Semester	SS 2009	English

INHALTLICHE ANGABEN

Inhalt

- Introduction: Motivation, application examples.
- Computational mechanics code (1): idealization, discretization, mesh generation.
- Computational mechanics code (2): equation system formation and solution, visualization.
- Computer performance: memory hierarchy, current CPUs.
- Scalar optimization: manual code restructuring, automatic optimization.
- Introduction to parallelism: motivation, taxonomy of parallel computers.
- Review of loop-level parallelism: algorithm selection, OpenMP directives, exercises, limitations.
- Review of task-level parallelism: message passing, PVM and MPI implementations, MPI-2
- Good software engineering practice: code management, collaboration, performance analysis tools.
- Paralllel computational mechanics code (1): unstructured data decomposition, single-step gather and scatter
- Paralllel computational mechanics code (2): two-step gather and scatter, partitioning, reordering, renumbering
- Paralllel computational mechanics code (3):iterative solvers, GMRES, preconditioning
- Paralllel computational mechanics code (4): data decomposition libraries, structured mesh parallelization patterns
- Future of supercomputing, recent developments, discussion of projects

Lernziele

- The students are familiar with the general structure of continuum mechanics computational analysis code: finite elements, difference or volumes applied to structural or fluid mechanics problems. They can relate such general structure to own experiences.
- The students are conversant in the latest scalar optimization techniques for modern cache-based microprocessors. They are aware of potential bottlenecks that can severly limit computer performance, and are trained in how to avoid them.
- The students understand the need for exploiting parallelism in engineering practice and know the current developments in the field regarding both software and hardware.
- The students are able to utilize OpenMP and MPI standards to obtain parallel speed-up of most typical continuum mechanics analysis tasks.

- The students have learned how to write a short equipment funding proposal.
- The students have performed literature search on some of the topics of interest and presented the results in front of the class.
- The students have had hands-on experience with high-performance computing.

Voraussetzungen

recommended:

- Programming ability (Fortran / C)
- Familiarity with Unix systems
- Module *Numerical Methods for PDEs*
- Module *Applied Quantum Mechanics*
- Module*Parallel Programming I*

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Parallel Computing in Simulation Sciences [MSSiSc-2004.a]		6	0
Vorlesung Parallel Computing in Simulation Sciences [MSSiSc-2004.b]		0	3
Übung Parallel Computing in Simulation Sciences [MSSiSc-2004.c]		0	2

Modul: SiSc Laboratory [MSSiSc-3001]

MODUL TITEL: SiSc Laboratory

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Preparatory Course: • Presentation of example problems from science and engineering • Summary of methods and tools to be used during the Lab; Link with module: Scientific Software Engineering Software Development Lab: • Development of numerical simulation software on a high-performance computer architecture • Application to a selected example problem • Software tests and documentation • Presentation	• to develop the ability to develop state-of-the-art numerical simulation software • to work in a team • to manage a software development project • to present the results of the project work to a larger audience
Voraussetzungen	**Benotung**
recommended: • Module Parallel Programming I • Module Numerical Methods for PDEs • Module Parallel Computing in SiSc	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung SiSc-Laboratory [MSSiSc-3001.a]		6	0
Labor SiSc-Laboratory [MSSiSc-3001.d]		0	3

Modul: Master's Thesis [MSSiSc-4001]

MODUL TITEL: Master's Thesis

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
4	1	30	40	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• The working steps will be fixed individually with the advisor. A possible sequence could look like the following: • Familiarization with the subject and state of the art • Formulation / choice of methods for solving the problem • Development of a solution • Implementation / realization of the individual concept / ansatz • Validation and evaluation of the results • Presentation of the results in written form and as report with subsequent discussion	• The students are able to work independently on a problem in the field of simulation sciences within a given time frame according to scientific methods and by using the theory and methods knowledge of simulation sciences. • They are able to document the results according to scientific standards. • They are able to present and defend their results in front of a group. • They deepened their competence in solving problems as well as transferring knowledge in theory and methods of simulation sciences to applications • Self and time management • Project management • Presentation
Voraussetzungen	**Benotung**
After reveiving 75 CP, the master's thesis can be registered. The thesis must be registered not later than the end of the semester which is following the semester, in which 90 CP have been obtained. If the candidate does not file the application for registering the thesis until then, the examiner's board will assign an advisor and a thesis, which fits to the candidate's study program. The date of assignment has to be put on records.	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Anfertigung einer Arbeit und darauf folgende Praesentation der Ergebnisse [MSSiSc-4001.a]		30	40

Modul: Internal Combustion Engine Fundamentals [MSSiSc-5101]

MODUL TITEL: Internal Combustion Engine Fundamentals

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English (and German)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction • Kinematics and forces of combustion engines • Thermodynamic fundamentals • Characteristic numbers of combustion engines • Spark-Ignition Engines • Compression-Ignition Engines • Emission formation and exhaust gas aftertreatment	• The students are able to systematically analyze the various principles of fuel conversion and the main requirements of combustion engines. • They are capable to transfer the basic thermodynamic fundamental calculation procedures to the related combustion process by means of ideal models of engine cycles. • With these fundamentals the students are capable to calculate and evaluate the various efficiencies and important characteristic numbers of internal combustion engines. • The students are able to systematically differentiate the various combustion engines by the different combustion systems with its particular heat release, the ignition process and the kinematics of valve train and crank train and to relate them to current engine developments. • Due to the increasing environmental pollution the students are given the ability to comprehend the emission formation and to find best suited solutions for the exhaust gas after treatment for different types of engines. Not with respect to the subject (e.g. Team work, Presentation, Project Management, etc.):
Voraussetzungen	**Benotung**
recommended: • Contents of module Thermodynamics (e.g. from BSc Mechanical Engineering) • Contents of module Machine Dynamics (e.g. from MSc Mechanical Engineering)	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Internal Combustion Engine Fundamentals [MSSiSc-5101.a]	120	4	0
Vorlesung Internal Combustion Engine Fundamentals [MSSiSc-5101.b]		0	2
Übung Internal Combustion Engine Fundamentals [MSSiSc-5101.c]		0	1

Modul: Internal Combustion Engines I [MSSiSc-5102]

MODUL TITEL: Internal Combustion Engines I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2009	English (and German)

INHALTLICHE ANGABEN

Inhalt

- Introduction
- Fuels Classification, manufacturing processes, chemical structure and physical properties of fuels based on mineral oil Energy reserves, consumption and energy industry. Alternative fuels based on coal, natural gas and non-fossil sources of energy.
- Energy flow in the combustion engine process Open cycle simulation Energy balance and definition of losses
- Heat flow in combustion engines Mechanisms of heat transfer Calculation methods of heat transfer coefficients in the combustion chamber, conduction and heat transfer to the coolant Temperatures and thermal stresses of engine components
- Layout of combustion engines Rules of geometrical, mechanical and thermal similarity Indices and mechanical power limits Engine base data, typical plan of an engine development process
- Forces and moments in engines Gas forces and inertia forces, excitation by forces in crank drive mechanism Engine balancing Torsional vibration of crankshafts
- Engine components Requirements on crankshaft, connecting rod, piston, crankcase, cylinder head and liner Materials, concepts and specific design features Cooling and lubrication systems

Lernziele

- The students are able to systematically analyze the various types of fuels as energy resources.
- They are capable to transfer the basic thermodynamic fundamental calculation procedures to the related combustion process by means of ideal models of engine cycles and simulations.
- The students are capable to systematically apply calculation methods of heat transfer, heat conduction and thermal stresses based on the principal mechanisms of heat flux.
- They are able to assess similarity rules and indices to transfer this knowledge in order to layout engines and to estimate mechanical power limits.
- The students are also capable to determine forces and moments in engines resulting from crank drive mechanism and are able to assess the requirement of engine components as well as the layout of the cooling and lubrication systems with subsequent components

Voraussetzungen

recommended:

- Module Internal Combustion Engines Fundamentals

Benotung

1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Internal Combustion Engines I [MSSiSc-5102.a]	120	6	0
Vorlesung Internal Combustion Engines I [MSSiSc-5102.b]		0	2
Übung Internal Combustion Engines I [MSSiSc-5102.c]		0	2

Modul: Internal Combustion Engines II [MSSiSc-5103]

MODUL TITEL: Internal Combustion Engines II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	4	jedes 2. Semester	WS 2009/2010	English (and German)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction • Load exchange and valve train • Supercharging • Heat flow in combustion engines • Mixture preparation for gasoline and Diesel engines • Exhaust emissions • Engine Acoustics	• By the end of this lecture the students are able to systematically analyze the load exchange of the different types of combustion engines (4-stroke engine, rotary engine, 2-stroke engine). • They are capable to comprehend the basic physical mechanisms of the load exchange, such as wave effects, and to relate its influence on constructive characteristics by the acoustic theory. Given this ability the students are ready to asses the tasks, types and dynamic effects of valve trains and recommendations for construction. • They are able to differentiate between the different methods of supercharging as well as mixture formation, e.g. port fuel injection and direct injection of gasoline engines as well as direct injection of Diesel engines, and to relate them to their influences on performance and efficiency. • Due to the increasing environmental pollution the students are given the ability to comprehend the emission formation and to find best suited solutions for controlling measures and exhaust gas after treatment for different types of engines.
Voraussetzungen	**Benotung**
recommended: • ModuleInternal Combustion Engines I • Module Internal Combustion Engine Fundamentals	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Internal Combustion Engines II [MSSiSc-5103.a]	120	6	0
Vorlesung Internal Combustion Engines II [MSSiSc-5103.b]		0	2
Übung Internal Combustion Engines II [MSSiSc-5103.c]		0	2

Modul: Alternative Vehicle Propulsion Systems [MSSiSc-5104]

MODUL TITEL: Alternative Vehicle Propulsion Systems

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2009	English (and German)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction • Alternative drive systems • Alternative fuels • Variable transmissions and power split drive train • Regenerative drives • Drive concepts • Control Strategies	• After having successfully passed this lecture the student is able to systematically analyze alternative concepts for vehicle power trains. • He/she are theoretically capable to comprehend the different purposes of alternative drive systems, such as unconventional types of combus-tion engines with the consideration of alternative fuels (alcohol, natural gas, hydrogen), gas turbines, Stirling engines and fuel cells as well as electric drives. • Furthermore, the student has the ability to link the knowledge about alternative power trains to the different types of variable transmissions and power split drive trains. • The main skill of the student is the transfer of basic calculation procedures of power train efficiencies. • He/she is able to assess regenerative drives e.g. electric, flywheel and hybrid drives. • The student is able to find the most suitable control strategies (intgrated engine-transmission management) according to the various drive concepts.
Voraussetzungen	**Benotung**
recommended: • Module Internal Combustion Engine Fundamentals • Modules Internal Combustion Engines I + II	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Alternative Vehicle Propulsion Systems [MSSiSc-5104.a]	120	4	0
Vorlesung Alternative Vehicle Propulsion Systems [MSSiSc-5104.b]		0	2
Übung Alternative Vehicle Propulsion Systems [MSSiSc-5104.c]		0	1

Modul: Molecular Thermodynamics [MSSiSc-5105]

MODUL TITEL: Molecular Thermodynamics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• 1. Introduction • 2. Foundations • 2.1 Classical Thermodynamics • 2.2 Statistical Mechnics • 2.3 Classical Mechanics • 2.4 Classical Electrostatics • 2.5 Quantum Mechanics • 2.6 Computer Simulation • 3. The Ideal Gas • 3.1 Definition and Significance • 3.2 The Canonical Partition Function • 3.3 Factorization of the Molecular Partition Function • 3.4 The Equation of State • 3.5 Mixing Properties • 3.6 Individual Contributions • 3.7 Equilibrium Constant • 4. Excess Function Models • 4.1 General Properties • 4.2 Intermolecular Potential Energy • 4.3 Simple Model Molecules • 4.4 Complex Model Molecules • 5. Equation of State Models • 5.1 General Properties • 5.2 Intermolecular Potential Energy • 5.3 The Statistical Viral Equation • 5.4 Conformal Potential Models • 5.5 Perturbation Models	• Understanding of basics from the fields classical, statistical and quantum mechanics as well as electrodynamics that are applied in the field of molecular thermodynamics. • Founding on these wide basics, a comprehensive framework to derive properties of fluid systems will be formulated. • The framework will be used to introduce property models that are applied in the fields gas technology, chemical high temperature reactions, processing of simple and complex mixtures, for electrolyte and bio systems.

Voraussetzungen	Benotung
none	1 oral exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Molecular Thermodynamics [MSSiSc-5105.a]		4	0
Vorlesung Molecular Thermodynamics [MSSiSc-5105.b]		0	2
Übung Molecular Thermodynamics [MSSiSc-5105.c]		0	1

Modul: Energy Systems Engineering [MSSiSc-5106]

MODUL TITEL: Energy Systems Engineering

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	3	jedes 2. Semester	SS 2009	German (exam can be offered in English, as well as some lecture notes)

INHALTLICHE ANGABEN

Inhalt

- Lecture: Heat Pumps and Chillers
- Tutorial: Adsorption chillers and mechanical exhaust vapour compressors
- Lecture: Technology and Dimensioning of Heat Pumps
- Tutorial: Dimensioning of an electrical heat pump
- Lecture: Combined Heat and Power (CHP) Generation Technologies
- Tutorial: CHP with steam turbines, dimensioning of heat supply with CHP
- Project: Dimensioning of a Gas-Engine Heat Pump
- Lecture: Combined Heat and Power (CHP) Generation Economics
- Tutorial: Primary energy consumption of a CHP energy supply system
- Project: CHP Electricity Supply of a Building Complex, CHP Energy Supply for an Industrial Park
- Lecture: Heat Exchanger and Heat Storages
- Tutorial: Enthalpy-Temperature diagram of heat exchangers, pinch analysis
- Lecture: Hot and Cold Water Networks
- Tutorial: Water pipeline network dimensioning
- Lecture: Industrial and Municipal Energy Management
- Tutorial: Analysis of LCP measure for room lighting
- Lecture: Industrial Heat Management, Heat Recovery and Integration
- Tutorial: Heat Integration
- Lecture: Integration of Thermal Plant Units, Dimensioning of Heat Exchanger Networks
- Tutorial: Dimensioning of heat exchanger networks
- Lecture: District Heating with Industrial Waste Heat
- Tutorial: District heating with industrial waste heat, Organic Rankine Cycle (ORC) processes

Lernziele

- Energy system engineering is the science of connecting different energetic components to energy systems, for example power plants and boilers, heat pumps and refrigerators, heat exchangers and accumulators.
- Typical energy systems are buildings, industrial workshops, settlement areas and communes. Their supply with mechanical energy, electricity, space and process heat, refrigeration and other energy-like supply services, such as water and compressed air, can be realised by different energetic components in different circuits. Thereby, many technical solutions result, whose evaluation and optimisation should be based on criteria such as supply security, economic efficiency and environmental friendliness.
- The lecture "Energy System Engineering" imparts the basics of the synthesis of energy producing plants and miscellaneous energetical components to complete systems, as well as to their economical and ecological valuation. This lecture is meant for students of higher semesters who are aware of the contents of the "Energy Economics" lecture.

Voraussetzungen

- Previous degree in engineering or physics

recommended:

- Basic knowledge in thermodynamics
- Module Energy Economics

Benotung

1 written (120 min) or oral (max. 45 min) exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Energy Systems Engineering [MSSiSc-5106.a]		5	0
Vorlesung Energy Systems Engineering [MSSiSc-5106.b]		0	2
Übung Energy Systems Engineering [MSSiSc-5106.c]		0	1

Modul: Energy Economics [MSSiSc-5107]

MODUL TITEL: Energy Economics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2009	German

INHALTLICHE ANGABEN

Inhalt

- Energy economics (the energy supply in the world/ Europe/ Germany, resources).
- Evaluation sizes, demand of electric energy, load courses, (efficiency, cumulated energy demand, payback period).
- Ecological aspect.
- Fossil energy source (extraction of hard coal, lignite, natural gas, crude oil).
- Steam cycle plants (concept, efficiency, coal gasification improvement, emission und flue gas cleaning).
- Gas cycle plants (thermodynamic basics, technical details, improvement).
- Combined cycle plants (gas and steam cogeneration plant).
- Combined heat and power (principle, operating figures, technical variation).
- Nuclear power plant (fission, nuclear fuel cycle, concepts of the nuclear power plants, safety).
- Regenerative energy (overview, potential).
- Solar energy, (thermal use, photovoltaic solar power plant).
- Heat pumps.
- Hydropower (river, storage lake, OTEC).
- Wind energy.
- Biomass.
- Geothermic energy.
- Fuel cell.
- Energy transport.
- Energy storage (compressed-air store, battery, hydrogen storage).
- Questions of economical efficiency in the energy engineering (cost assessments and parameters, questions of optimization).
- Technical Energy Services.
- Annual Duration Curve.
- The Energy Demand of Technical Energy Systems.
- Calculation of a Building's Annual Heat Requirement.
- Thermodynamic Evaluation of Energy Transformation.
- Exergetic Analysis
- Transformation of Primary Energy into Work.
- Process Enhancements for the Transformation of Primary Energy into Technical Work.
- Heat Generation.
- Exergetic Analysis of Cogeneration.
- Economic Analysis of Energy Systems.
- Calculation of Profitability.
- Emission Trading.
- Exercise concerning Emission Trading.

Lernziele

- The lecture "Energy Economics" gives an introduction to the energy industry as well as to the economy and efficiency of energy systems.
- The students are able to systematically analyse and assess different energy systems regarding their efficiency as well as economic issues.
- They are theoretically capable of choosing and designing the best suited energy system to a given energy demand taking into account both conventional fossil fuelled energy systems including nuclear power as well as regenerative energy sources.
- The students know the basic theories of the thermodynamic evaluation and optimisation of energy conversion into heat and mechanical power.

Voraussetzungen	Benotung
• Previous Degree of Engineering or Physics recommended: • Module Thermodynamics (e.g. from BSc Mechanical Engineering) or equivalent knowledge	1 written exam The exams is offered by the chairs EBC and LRST in two parts. Both parts are done subsequently and the results are collected. The time frames are 90 min each. Minimal points for passing each part as well as the overall points will be defined.

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Energy Economics [MSSiSc-5107.a]	180	4	0
Vorlesung Energy Economics [MSSiSc-5107.b]		0	2
Übung Energy Economics [MSSiSc-5107.c]		0	1

Modul: Heat and Mass Transfer [MSSiSc-5108]

MODUL TITEL: Heat and Mass Transfer

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	7	5	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Introduction Mechanisms of heat transport • Radiation • Heat conduction • Convection **Heat radiation** Radiation properties • Wave/Quantum characteristics • Stefan-Boltzmann law • Planck's distribution law • Reflection, Absorption, Transmission • Kirchhoff's law • Radiation from a diffuse surface and direction-dependent radiation Radiation transfer • Radiation flux -radiosity • Radiation transfer between two bodies • Radiation between two grey surfaces • Radiation transfer between two infinitely long grey plates • Radiation transfer between two self-enclosed grey bodies **Heat conduction** Differential equation of the temperature field Steady state, one-dimensional heat conduction without heat sources • Plane walls with given surface temperatures • Thick-walled tube with constant temperatures on the inner and outer walls • Plane walls with convective heat transfer • Tube wall with convective heat transfer • Heat conduction in fins • Rod and plane fins • Circular fins Steady state, one-dimensional heat conduction with heat sources Steady state, multi-dimensional heat conduction without heat sources Unsteady state heat conduction without heat sources • Bodies with high values of thermal conductivity • One-dimensional, unsteady state heat conduction examples • Semi-infinite plate with given temperatures • Semi-infinite plate with non negligible heat transfer resistance • Semi-infinite plate with time-dependent surface temperatures	• In the context of engineering terms, the students will be able to identify problems of the heat and mass transfer mechanisms radiation, heat conduction, diffusion and convection. They are able to formulate the parameters of these transport mechanisms in form of dimensionless characteristic numbers. The are familiar with the analogy between heat and mass transfer. They are able to judge the permissibility of different simplifying assumptions which are relevant for the description of technical systems • The students master the mathematical description and analytic solution of problems and the interpretation of results with respect to a given application.

• Dimensionless coefficients and diagrams used to describe heat conduction processes • Graphical and numerical approximation methods for unsteady state heat conduction • The Binder-Schmidt method **Convection** Conservation laws for laminar, steady state, two-dimensional flow • Equation of continuity • Momentum equations (equations of motion) • Equation of energy conservation Forced convection Boundary layer equations for laminar, steady state flow • Exact solutions of the boundary layer equations • Analogy between momentum and heat exchange • A simple approximation method for the boundary layer equations Natural convection Boundary layers equations for laminar, steady state flow Heat transfer for turbulent flow Application of the analogy theory for heat transfer **Heat transfer laws** Introductory remarks Summary of heat transfer correlations • Heat transfer laws for forced convection, flows around bodies • Forced convection in tubes • Natural convection, flow along bodies • Natural convection **Heat Transfer with boiling and condensation** Heat Transfer in condensation • Condensation of pure vapours - film condensation • Condensation of pure vapours - dropwise condensation • Condensation of pure mixtures Heat transfer in boiling • Boiling in vessels • Evaporation in tubes **Mass transfer** Mass transfer by diffusion Mass transfer in a flowing medium Diffusive mass transfer on a surface Analogy between the heat and mass transfer Evaporation on a liquid surface **Literature** **Appendix** Appendix A - Material properties Appendix B - Functions Mathematical summary	
Voraussetzungen	**Benotung**
• Basic knowledge in thermodynamics • Basic knowledge in higher mathematics	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Heat and Mass Transfer [MSSiSc-5108.a]	120	7	0
Vorlesung Heat ans Mass Transfer [MSSiSc-5108.b]		0	3
Übung Heat and Mass Transfer [MSSiSc-5108.c]		0	2

Modul: Turbulent Flows [MSSiSc-5109]

MODUL TITEL: Turbulent Flows

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	3	2	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction to the turbulence • Equation of fluid motion • Statistical description of turbulence • Mean flow equations • Turbulent kinetic energy • Mixing layer, homogeneous shear flow • Grid turbulence, intermittency • Energy cascade, Kolmogorov hypotheses • Energy transfer • Velocity spectra • Kolmogorov spectrum • Channel flow • Boundary layer • Coherent structures • Turbulent Viscosity Models • Large eddy simulations	Turbulence is different from the basic courses in Fluid Mechanics. Here, equations will be important, but much of the theory is based on scaling arguments. The comprehension of dimensional analysis and scales will be important. The objective of the course is to provide the theory and knowledge for understanding, for example, of publications and seminar talks on the subject, and to serve as a basis for making contributions to the field.

Voraussetzungen	Benotung
none	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Turbulent Flows [MSSiSc-5109.a]	120	3	0
Vorlesung Turbulent Flows [MSSiSc-5109.b]		0	2
Übung Turbulent Flows [MSSiSc-5109.c]		0	1

Modul: Combustion I [MSSiSc-5110]

MODUL TITEL: Combustion I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2009	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Mass and Energy Balance in Combustion Systems • Elementary gas phase kinetics • Systematic Reduction of Reaction Kinetics for Hydrogen and Methane Flames • Ignition and extinction in Homogeneous Systems • Fluid Dynamics and Basic Equations for Flames • Laminar Premixed Flames: laminar and turbulent burning velocities • Laminar and turbulent Diffusion Flames	The students know the basic differences between premixed and non-premixed combustion. They have the ability to transfer the acquired knowledge in elementary gas phase chemistry to ignition in combustion engines and explosions in general. They know the basic theories of laminar flame propagation for one-step and four step kinetics. They are able to use laminar flamelet models in non-premixed combustion.
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in thermodynamics • Basic knowledge in fluid mechanics	1 Written exam of 150 minutes or 1 oral exam of max. 45 minutes

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Combustion I [MSSiSc-5110.a]		4	0
Vorlesung Combustion I [MSSiSc-5110.b]		0	2
Übung Combustion I [MSSiSc-5110.c]		0	1

Modul: Combustion II [MSSiSc-5111]

MODUL TITEL: Combustion II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Turbulent Combustion: Introduction and Overview • Laminar Flamelet Models for Non-Premixed Turbulent Combustion • Turbulent Diffusion Flames: Experiments and Modelling Aspects • Models for Premixed Turbulent Combustion, the Level Set Approach • Partially Premixed Combustion: Lifted Flames	The students are able to interpret different models in turbulent combustion. They know how to transfer the acquired knowledge from conservation equations for turbulent flows to different modeling approaches in turbulent combustion. They are able to interpret numerical solutions provided by CFD-codes and check their correctness.
Voraussetzungen	**Benotung**
recommended: • Module *Combustion I*	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Combustion II [MSSiSc-5111.a]	120	5	0
Vorlesung Combustion II [MSSiSc-5111.b]		0	2
Übung Combustion II [MSSiSc-5111.c]		0	1

Modul: Fuel Cells: Today's Challenges in Modeling [MSSiSc-5112]

MODUL TITEL: Fuel Cells: Today's Challenges in Modeling

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	4	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction (basic function, basic components, basic types of fuel cells) • Thermodynamics and Kinetics (with respect to cells, stacks and reformers) • Simplified models / abstract modeling (Asking the right questions - making the right simplifications - understanding the results) • Flow related problems (reformer, cell, stack) • System simulations	• Fuel cells are efficient energy converters. The development of these devices is pushed by the world-wide increasing energy demand and the rising prices for fossil and renewable fuels. At the moment the development takes place in laboratories and universities, but the beginning of the market entry can already be observed. • After introduction the students get an overview over the recent questions and problems in fuel cell modeling. The students should be able to recognize the connections between physics, chemistry and engineering in this complex field and get an idea about the principle tools to answer the questions. • The lecture is divided into several blocks. Each block will give an introduction into one main area of fuel cell simulation and describe the simulation tools, which can be applied. • The tutorials will give hands on practice with the simulation tools which were presented during the lectures. Some selected problems will be discussed.
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in chemistry, physics and engineering	1 oral exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Fuel Cells: Today's challenges in modeling [MSSiSc-5112.a]		5	0
Vorlesung Fuel Cells: Today's challenges in modeling [MSSiSc-5112.b]		0	2
Übung Fuel Cells: Today's challenges in modeling [MSSiSc-5112.c]		0	2

Modul: Computational Radiation Protection and Shielding [MSSiSc-5113]

MODUL TITEL: Computational Radiation Protection and Shielding

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt

- Source and characteristics of radiation (nuclear radiation)
- Interaction of particle and radiation with matter
- Modelling nuclear interaction processes (collision, (in)elastic scattering, capture)
- Radiation transport and cascade simulation, particle distribution functions
- Phase-space Boltzmann transport equation
- Numerical and analytical solution methods -Discrete ordinates (Sn)
- Generation of quadrature sets for Sn method
- Convergence, stability, accuracy of the method
- Monte-Carlo method for radiation transport simulation (ray tracing method)
- Mean values, statistical sampling, error estimation
- Radiation attenuation properties of shielding materials
- Removal cross sections
- Calculation of gamma-ray attenuation, neutron penetration and transport
- Neutron and photon heating
- Radiation related quantities and units: Exposure, Dose and dose equivalent
- Computational shield design
- Source modelling
- Geometry modelling
- Pathway simulations
- Ray and particle Albeos
- Computer code application: Geometry nodalization of an radiation facility with shielding components
- Application: Analysis of shielding performance for an irradiation facility ->with distributed neutron source (reactor component) ->with gamma source (irradiation facility) ->with charged particle beam (accelerator)
- Complementary topics on radiation attenuation and transport simulations

Lernziele

- Radiation is present in every system which utilizes nuclear processes for any purposes. This is the case in a wide range in modern technology like in nuclear reactors, irradiation facilities, accelerators as well as in the equipments for the use in nuclear medicine. The design of such systems must include shielding components for the optimum operation of the facility on the one hand and for the protection of the whole staff and public on the other hand.
- Due to the complex and multi-scale nature of the interaction processes of radiation and particles with matter high sophisticated numerical models are employed to study the radiation transport phenomena and performance of the radiation protection and shielding measures. In this respect students are extensively taught on computational and simulation methods in radiation transport study.
- In particular following topics are covered:
oRadiation interaction with matter
oMath. Models in radiation transport simulation
oNumerical and analytical solution methods
oRadiation attenuation properties of materials
oComputational shield design
oInteraction, pathway and whole effect simulation
oComputation of dose and exposure
- The theoretical lectures will be combined with tutorial simulation work by applying computer codes for selected radiation transport problems.

- Presentation
- Interdisciplinary learning and ability
- Teamwork

Voraussetzungen

recommended:
- Background in nuclear physics or engineering

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Computational Radiation Protection and Shielding [MSSiSc-5113.a]		4	0
Vorlesung Computational Radiation Protection and Shielding [MSSiSc-5113.b]		0	2
Übung Computational Radiation Protection and Shielding [MSSiSc-5113.c]		0	1

Modul: Simulation Methods in Nuclear Engineering [MSSiSc-5114]

MODUL TITEL: Simulation Methods in Nuclear Engineering

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2009	English

INHALTLICHE ANGABEN

Inhalt

Review of Nuclear physics
Neutron interaction with nuclear materials
Reactor physics modeling and simulation
Math. Model for neutron moderation (collision theory and probability function)
Neutron cross section and nuclear data: math. Models for scattering, fission, capture process
Neutron multiplication and nuclear chain reaction
Slowing down density and resonance escape function
Homogeneous and heterogeneous system
Thermal and fast elements of Leakage and loss terms in neutron balance equation
Steady state phase-space Boltzmann equation for neutron transport (Eigen value approach)
Analytical solution methods

- Discrete ordinates (Sn)
- Perturbation and Variational Methods
- Isotropic diffusion model

Numerical solution of neutron transport problem (Iterative deterministic approach, Sn based)
Solution by statistic Monte-Carlo method

- Concept of cross section and probability function
- Track length (ray tracing) and neutron history modeling

Multiscale reactor calculation: cell, lattice and full core model

- Neutron spectrum und flux distribution
- Fission power distribution

Modeling reactor kinetics
Space-Time Neutron and reactor Kinetics
Non-linear reactor dynamics
Modeling feedback mechanisms
Numerical code applications in reactor physics

Lernziele

Nowadays nuclear reactors account for a significant portion of the electrical power generation and widely utilized for scientific and industrial applications and developments. To cope with the challenge of this engineering area, high level experts are needed to provide for optimum design, operation and utilization of such facilities and for the development of advanced nuclear systems with enhanced safety and performance.

Due to the complexity of nuclear processes taking place in a reactor in-depth reactor physics education of energy and nuclear engineering students is mandatory. The complexity of the processes requires also application of computational tools for the simulation and modeling of the system response and behavior. The module aims at the in-depth qualification of the students by teaching the main physical/mathematical and numerical fundamentals of nuclear engineering science.

The course begins with an overview of basic nuclear physics, nuclear data and continues with computational methodology needed to understand the process of chain reaction and behavior of nuclear reactors. This is then followed by in-depth treatment of neutron transport computational methods. As an aid to computational skills, some simulations are run to demonstrate the method for performing sophisticated multiscale reactor calculations.

In particular following topics are covered:

- Neutron interaction with nuclear materials
- Neutron multiplication and chain reaction modeling
- Numerical solution of neutron transport problem
- Flux and spectrum, fission power distribution
- Modeling reactor kinetics and dynamics

Presentation
Interdisciplinary learning and ability
Teamwork

Voraussetzungen

recommended:

- Background in nuclear physics or engineering

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Simulation Methods in Nuclear Engineering [MSSiSc-5114.a]		4	0
Vorlesung Simulation Methods in Nuclear Engineering [MSSiSc-5114.b]		0	2
Übung Simulation Methods in Nuclear Engineering [MSSiSc-5114.c]		0	1

Modul: Computational Nuclear Reactor Dynamics and Safety [MSSiSc-5116]

MODUL TITEL: Computational Nuclear Reactor Dynamics and Safety

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2011	English

INHALTLICHE ANGABEN

Inhalt

Steady state physics of a nuclear reactor
Time dependent Boltzmann equation for neutron transport
Generation of nuclear data for neutronic equations
Solution methods (point kinetics as first approach)
Space-time kinetic method for solving the Boltzmann equation
Temperature effect on neutronic parameter (description of feedback mechanisms)
Steady state space time reactor kinetics
Single and 2-phase flow fluid flow: introduction to transient heat transfer

- Analytical solution methods
- Discrete ordinates (Sn)
- Perturbation and Variational Methods
- Isotropic diffusion model

Numerical solution of neutron transport problem (Iterative deterministic approach, Sn based)

- Solution by statistic Monte-Carlo method
- Concept of cross section and probability function
- Track length (ray tracing) and neutron history modeling

Multiscale reactor calculation: cell, lattice and full core model

- Neutron spectrum und flux distribution
- Fission power distribution

Modeling reactor kinetics
Space-Time Neutron and reactor Kinetics
Non-linear reactor dynamics
Modeling feedback mechanisms
Numerical code applications in reactor physics

Lernziele

Nowadays nuclear reactors account for a significant portion of the electrical power generation and widely utilized for scientific and industrial applications and developments. Safety behavior of a nuclear reactor is a result of the complex interaction of multiphysics and multiscale processes taking place during a nuclear transient and accident. The temperature distribution, which varies as a function of time is of substantial importance and determines the integrity and stability of the reactor core component and structures. In the case of critical heat flux and load, and resulting nuclear instability conditions, significant temperature transients take place resulting in severe consequences to the core and components, to whole system

The lectures are concentrated on the discussion of models and approaches for the simulation of different physical processes such as power transients -due to neutronic instability-, heat transfer and removal in the case of a disturbed head load and balance. The module will enable the students to understand and to model the physical process on the basis of by application of model the In detail following aspects are covered in the module:

- Steady state physics of a nuclear reactor
- Phenomenological analysis of transient processes of nuclear and thermo-hydraulic type
- Modeling and simulation of the time dependant neutronic process and power generation (time dependant Boltzmann equation)
- Modeling the complex process of heat load and transfer including the assessment of two phase flow
- Simulation of feed back mechanisms of temperature as coupling interface between thermo hydraulics and neutronics.
- Simulation of different transient scenarios and event sequences in view of analyzing the safety features and behavior of a reactor system.
- Modeling reactor kinetics and dynamics

Presentation
Interdisciplinary learning and ability
Teamwork

Voraussetzungen

recommended:

- Background in nuclear physics or engineering

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Computational Nuclear Reactor Dynamics and Safety [MSSiSc-5116.a]		4	0
Vorlesung Computational Nuclear Reactor Dynamics and Safety [MSSiSc-5116.b]		0	2
Übung Computational Nuclear Reactor Dynamics and Safety [MSSiSc-5116.c]		0	1

Modul: Chemical Process Engineering [MSSiSc-5201]

MODUL TITEL: Chemical Process Engineering

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	3	jedes 2. Semester	SS 2009	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Ideal reactors with heat influence 1 • Mass and energy balance • Continuous stirred tank reactor (CSTR) and continuous plug flow tubular reactor (PFTR), isothermic/adiabatic • Ideal reactors with heat influence 2 • CSTR, heat generation and heat removal curve, stable operating point, hysteresis • Reversible exothermic reactions, optimal temperature management • Microkinetics of chemical reactions • Homogeneously catalysed reactions • Heterogeneously catalysed reactions: Adsorption/desorption, catalytic surface reaction, rate determinig step, deactivation • Kinetics of mass and heat transfer phenomena 1 • Molecular transport • Modelling of diffusion mechanisms (approach of Fick, Stefan-Maxwell) • Kinetics of mass and heat transfer phenomena 2 • Diffusion in porous media • Molecular, Knudsen, Poiseuille flow • Kinetics of mass and heat transfer phenomena 3 • Transfer at phase boundaries • Mass transfer without chemical reaction • Interaction of chemical reactions and transport phenomena -macrokinetics 1 • Influence of chemical reaction on mass transfer • Gas/solid reactions • Interaction of chemical reactions and transport phenomena -macrokinetics 2 • Heterogeneously catalysed gas phase reactions: External/internal mass transfer and chemical reaction • Interaction of chemical reactions and transport phenomena -macrokinetics 3 • Liquid/liquid reactions • Modelling of chemical reactions 1 • Mixing and chemical reaction: Residence time distribution, Dispersion model • Macro-, meso- and micromixing, influence of early and late mixing • Modelling of chemical reactions 2 • Reactors for heterogeneous fluid/solid reactions: Solid/liquid, solid/gas • New technologies 1 • Membrane reactors • Microreactors • New technologies 2 • Fuel cells and reforming • Heterogeneous reactions in environmental protection • Group project tutorial 1 • Dimensioning a fixed bed reactor for heterogeneously	• The students are familiar with dimensioning ideal chemical reactors with heat transfer. • They can estimate and model the influence of mass transfer phenomena on chemical reactions. • The students can describe the behaviour of real reactors with the help of modelling approaches (group project on design of a fixed bed reactor for heterogeneously catalysed gas phase reactions). • They are acquainted to novel reactors and process technologies in chemical process engineering. • By means of a group project included in the tutorials the students improve their team work and presentation skills.

catalysed gas phase reactions • How to find data on chemical compounds • Group project tutorial 2 • Modelling heat transfer, mass transfer and pressure drop • Dimensioning and presentation	
Voraussetzungen	**Benotung**
none	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Chemical Process Engineering [MSSiSc-5201.a]	120	6	0
Vorlesung Chemical Process Engineering [MSSiSc-5201.b]		0	2
Übung Chemical Process Engineering [MSSiSc-5201.c]		0	1

Modul: Industrial Environmental Engineering [MSSiSc-5202]

MODUL TITEL: Industrial Environmental Engineering

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	3	jedes 2. Semester	WS 2009/2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction to industrial environmental technology • Way of looking at a problem • Objectives • History and development of industrial environmental technologies • Fundamentals of environmental legislation • Emission/Imission control • Water legislation • Impact of emissions • Ecotoxicology • Industrial toxicology • Assessment Tools: • Risk assessment, environmental impact and • Life cycle analysis of products • Noise • Endangering potential • Diminution means • Solid Wastes: • Waste management and • Recycling • Dust • Emissions • Impact of emissions • Dust separation • Gas and vapour • Emissions • Exhaust air decontamination methods • Thermal and oxidation processes for sewage treatment • Examples of application • Chemi-physical and biological processes for sewage treatment • Fundamentals • Examples of application • Integration of environment protection into production I • Fundamentals, methods • Integration of environment protection into production II • Application on special examples • Field trip • Outstanding/open aspects, discussion	• The students are familiar with the essential sources of industrial emissions. They are able to asses typical industrial sewage and exhaust gas compositions and they know adequate detection methods. Further, they are acquainted with the main legal founda-tions of emission and imission control legislation. By means of assessment tools they can evaluate environmental risks of products or their production process. • The students know the physical fundamentals of the main processes for industrial sewage and exhaust gas purification. By means of numerous examples the students gain insight into practical tasks of industrial environment protection. At the same time they get to know the advantages and disadvantages of "end-of-pipe"-technology as well as fundamentals for integration of environment protection into production. Simple design calculations provide an insight into the dimensions of industrial environment protection complexes. • During a relevant field trip the students get to know application examples in companies. Together with operators they can discuss topics, which have not been dealt in lectures. • By autonomously elaborating and presenting a relevant topic of industrial environment protection the students especially become familiar with modern inquiry and presentation tools.
Voraussetzungen	**Benotung**
none	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Industrial Environmental Engineering [MSSiSc-5202.a]	90	5	0
Vorlesung Industrial Environmental Engineering [MSSiSc-5202.b]		0	2
Seminar Industrial Environmental Engineering [MSSiSc-5202.e]		0	1

Modul: Medical Process Engineering [MSSiSc-5203]

MODUL TITEL: Medical Process Engineering

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction: Blood, blood separation, kidney, lung, heart, generation of pure water, sterilisation, compartiment methods • Terms of medical process engineering, demarcation from neighbouring engineering areas • Examples of application of chemical engineering basic knowledge in physiological areas, e.g. fluid mechanics in development of blood pumps • The human body as "chemical plant" • Introduction to medical engineering, historic development and aims of medical engineering • Diagnostic and therapeutic means of medicine, market situation of medical engineering • Interesting statistics on health markets, health expenses, cost elements of hospitalisation, average life expectancy and age distribution of the German population • Functioning and composition of blood • Blood rheology and mechanical stability as basics for calculation and engineering of devices in which blood is mechanically stressed, e.g. blood pumps • Blood rheology and behaviour in macro and micro circulation • Important mechanisms of blood deterioration • Minimisation of these deterioration mechanisms within device engineering for blood treatment • Milestones of transfusion medicine • Donation of blood components and different separation processes for blood fractionation like sedimentation or centrifugation • More separation processes for blood fractionation: Chromatography • Separation methods for blood plasma • Future of blood separation: New developments and challenges for chemical engineering • Physical knowledge of the human kidney: Task, structure and function • Separation functions of the kidney in comparison to chemical engineering devices • Indispositions of the kidney • Artificial kidney • Application of membrane processes as artificial kidney or as periphery of such devices • Lung: Respiratory tract and organs • Mass transfer mechanisms of respiratory gases • Malfunctions of the lung • History of the artificial lung • Application of membrane processes as artificial lung: The blood oxygenator • Structure and functioning of the heart and heart valves • Vascular system and blood circuit • Technology of the blood pump: The artificial heart • Requirements for water quality for medical and pharma-	• The lecture deals with selected issues of pharmaceutical and medical engineering being of interest in chemical engineering. Hence, the students are familiar with interdisciplinary aspects of chemical and medical engineering. • The students are able to apply knowledge of chemical engineering like fluid mechanics or mass and heat transfer on problems of medical engineering. • They understand the behaviour of blood and the functioning of human organs with respect to chemical engineering. • Thus, they are able to solve problems arising in the development of chemical engineering apparatuses for medical applications like artificial organs or apparatuses for blood fractionation.

ceutical applications • Technology of pure water generation for medical and pharmaceutical applications • Sterilisation methods in pharma and medical engineering • Compartiment Methods • Development of pharmaceuticals, kinetics of active agent dispensing • Correlation between active agent - location of application - elimination of the active agent • New technologies in medical engineering • e.g. artificial liver	
Voraussetzungen	**Benotung**
none	1 oral exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Medical Process Engineering [MSSiSc-5203.a]		4	0
Vorlesung Medical Process Engineering [MSSiSc-5203.b]		0	2
Übung Medical Process Engineering [MSSiSc-5203.c]		0	1

Modul: Membrane Processes [MSSiSc-5204]

MODUL TITEL: Membrane Processes						
ALLGEMEINE ANGABEN						
Fachsemester	**Dauer**	**Kreditpunkte**	**SWS**	**Häufigkeit**	**Turnus Start**	**Sprache**
3	1	4	4	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	**Lernziele**
• Introduction to membrane processes • Driving forces • Transport resistances • Membranes - materials and structures • Organic membranes • Inorganic membranes • Membranes - materials and structures • Organic membranes • Inorganic membranes • Module constructions • Requirements for module construction • Modules for tubular, flat and immersed membranes • Mass transport at membranes • Driving force reducing effects • Influence of installation direction of asymmetric membranes • Means for improvement of mass transport at membranes • Module optimisation • Flow modes in modules • Definition of an optimisation function • Examples of applications • Plant design • Module arrangement • Investment, operating and specific costs • Plant design • Module arrangement • Investment, operating and specific costs • Reverse Osmosis (RO) • Membrane stability, osmotic pressure • Influence of viscosity, membrane blockage, energy consumption • Examples and dimensioning of a sea water desalination plant • Nanofiltration (NF) • Membranes, applications, separation behaviour • Influence of pressure and concentration on retention • Comparison NF / RO • Pervaporation / Vapour permeation • Membranes and modules, critical parameters • Process design, examples • Electrodialysis (ED) • Process description, applied membranes • Design and costs, process variants, calculation examples • Gaspermeation • Membranes, separation mechanisms, module construction, local separation characteristics • Module and plant design, examples	• The students are familiar with all established membrane separation processes. • They know common membrane materials and respective production methods. • They have a good grasp of basic methods to model mass transfer in and at membranes, which they can transfer to related problems in other separation technologies. • They are acquainted with construction and optimisation methods of common membrane modules with respect to fluidmechanics. • The students are able to dimension for membrane modules and units and can assess their applicability to perform specific separation tasks as well as their capacity and costs. • The students are familiar with the english terminology in the area of membrane processes.

• Membrane contactors • Process principle, membranes, module constructions, design of membrane contactors • Applications and outlook • Simulation and optimisation using ASPEN+	
Voraussetzungen	**Benotung**
none	1 oral exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Membrane Processes [MSSiSc-5204.a]		4	0
Vorlesung Membrane Processes [MSSiSc-5204.b]		0	2
Übung Membrane Processes [MSSiSc-5204.c]		0	2

Modul: Product Design in Chemical Engineering [MSSiSc-5205]

MODUL TITEL: Product Design in Chemical Engineering

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2009	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction to product design • Changed demands on engineers due to altered market situation • Methods, structures and essential background knowledge for modern product design • Introduction to product design II • Difference between process and product design • Economy of product design • Presentation of a systematic method for product design • Four-step-process as a possible approach to product design • Step 1: Assessment of needs - identification of consumer demands on a product, assessment of first specifications • Step 2: Ideas • Methods of idea generation for successful new products: • Brainstorming, natural product screening, combinatorial chemistry • Presentation of methods for • sorting, screening and reduction of ideas to a reasonable number before the selection step • Assessment of criteria for sorting, valuation methods • Means for protection of intellectual property (patent legislation) • Step 3: Selection • Selection of 2 promising product ideas • Selection based on objective criteria like thermodynamics or kinetics • Selection based on subjective criteria like safety, comfort, consumer behaviour; method: selection matrix • Risk assessment in product design • Step 4: Manufacture • Identification and supplying missing information on the product idea required for production (synthesis route, experimental investigations, kinetic data etc.) • Determining final specifications (product structure, material etc.) • Particularities in chemical product design • Discussion of various example products whose functionality is based on a key concept (thermodynamics, chemistry, fluid mechanics) • Particularities in design of microstructured products • Characteristics of microstructured products • Thermodynamics and colloid chemistry of microstructured products • Nanostructured products • Production of specialty chemicals • Particularities in process design/customization • Separation and purification of specialty chemicals • Scale-up of processes for production of specialty chemicals • Team project	• As future designers of chemical products, the students are familiar with altered conditions of modern product design. • They are able to develop products according to a four step strategy. • The students know methods for assessing product requirements with special concern on customer demands on the future product. • Further they are acquainted with methods for generation, sorting and reduction of product ideas. Finally, they are able to select among the most promising product ideas based on objective as well as subjective criteria and risk assessment. • The students know the relevant background for developing a product from idea status to production status. • The students are aware of the special requirements concerning technology and soft skills in modern product design. • The students train soft skills like presentation and communication skills within a small team project with intermediate presentation of results

Voraussetzungen	Benotung
none	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Product Design in Chemical Engineering [MSSiSc-5205.a]	90	4	0
Vorlesung Product Design in Chemical Engineering [MSSiSc-5205.b]		0	2
Übung Product Design in Chemical Engineering [MSSiSc-5205.c]		0	1

Modul: Fundamentals of Air Pollution Control [MSSiSc-5206]

MODUL TITEL: Fundamentals of Air Pollution Control

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Definition of pollutants: • Effects of pollutants on human beings and environment • Formation of pollutants: • Combustion processes • Other technical processes • Acquisition of pollutant emissions: • Measurement principles and methods for dust and pollutant gases • Continuous and discontinuous measurement methods • Primary measures for air pollution control: • Low-emission production methods and fuels • Reduction of primary energy demand, process optimisation • Dust removals, fundamentals: • Characterisation of dust, particle size distribution • Dust removal, principle: • Aerodynamic behaviour of dust particles • Devices for dust removal • Mass force separator, electric precipitator • Devices for dust removal: • Filter separator, wet separation • Waste gas removal, srubbing methods: • Absorption, fundamentals • Design types of absorbers • Waste gas removal, srubbing processes: • Design • Cleaning agents • Waste gas removal, semi-dry methods: • Fundamentals • Waste gas removal, dry methods: • Adsorption, fundamentals • Selection of adsorbent • Removal of nitric oxides: • Selective non-catalytic reduction (SNCR) • Selective catalytic reduction (SCR) • Membrane processes • Biologic gas conditioning • Linking concepts of gas cleaning systems: • Industrial examples of application	• The students are familiar with different pollutant gases occurring in technical processes and their environmental effects. They are able to select and interlink the necessary process steps for any waste gas treatment task in an industrial process on their own. • The students are capable of correctly designing apparatusses for dust or other solid pollutant separation as well as processes for separation of hazardous gases (e.g. CO2, NOx, SO2). • In addition to the waste gas treatment methods mentioned above the students get to know the possibilities of minimizing waste gas emissions by means of appropriate process design.
Voraussetzungen	**Benotung**
none	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Fundamentals of Air Pollution Control [MSSiSc-5206.a]	120	4	0
Vorlesung Fundamentals of Air Pollution Control [MSSiSc-5206.b]		0	2
Übung Fundamentals of Air Pollution Control [MSSiSc-5206.c]		0	1

Modul: Multiphase Flow [MSSiSc-5207]

MODUL TITEL: Multiphase Flow						
ALLGEMEINE ANGABEN						
Fachsemester	**Dauer**	**Kreditpunkte**	**SWS**	**Häufigkeit**	**Turnus Start**	**Sprache**
3	1	6	3	jedes 2. Semester	WS 2009/2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	**Lernziele**
• Mathematical description of flow phenomena: • Conserved entities • Transport approaches • Mathematical description of flow phenomena: • Description of multiphase flows (continuous approach, kinetic theory) • Motion of single particles: • Drag laws for single particles • Motion of single particles: • Impact of shape, concentration and walls • Impact of turbulence in the continuous phase • Motion of single particles in force fields: • Gravity field • Electric field (example: electric precipitator) • Centrifugal field • Motion of bubbles and drops • Surface tension, pressure jump across a curved surface • Quasistatic formation of bubbles and drops • Motion of bubbles and drops • Dynamic formation of bubbles and drops • Spraying • Motion of bubbles and drops • Drag laws for bubbles and drops • Modelling of particle laden flows: • Continuous approach • Euler-Euler-approach • Modelling of particle laden flows: • Euler-Lagrange-approach (example: cyclone) • Fluidised beds: • Drag laws fo particle fixed beds • Fluidised beds: • States of fluidised beds, pressure loss	• Multiphase flows play a big role in almost all unit operations in process engineering. Therefore, the students are familiar with the fundamental concepts of the mathematical description of multiphase and especially fluid-particle flows. They are able to classify multiphase flow systems as well as to select and realize appropriate modeling methods. • The students have a good command not only of describing multiphase flows on an engineer´s level but also of more rigorous modeling methods, which are applied in current CFD tools. • The students aer familiar with the design fundamentals for important unit operations in process engineering that feature multiphase flows (cyclones, fluidised beds, pneumatics and hydraulic conveying).

• Fluidising velocity, velocity of operations • Pneumatic and hydraulic conveying: • Conveying states, pressure loss • Fluid-gas-systems: • Film systems • Bubble systems • (optional)Numerical treatment of multiphase flows - case studies	
Voraussetzungen	**Benotung**
None	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Multiphase Flow [MSSiSc-5207.a]		6	0
Vorlesung Multiphase Flow [MSSiSc-5207.b]		0	2
Übung Multiphase Flow [MSSiSc-5207.c]		0	1

Modul: Rheology [MSSiSc-5208]

MODUL TITEL: Rheology

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	3	jedes 2. Semester	SS 2009	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction to rheology - basic terms: • Shear experiment • Elongation experiment • Introduction to rheology - classification of fluids and solids: • Newtonian fluids • Non linear-viscous fluids • Introduction to rheology - classification of fluids and solids: • Fluids with time dependent properties • Viscoelasticity, thixotropie, rheopexy • Plastic materials • Simple flows and strain patterns • Pipe flow • Plain laminar flow • Motion of continua: • Mathematical description • Stress tensor • Momentum balance • Rheological equation of state: • Generell state functions • Frame-invariance, isothermal flow, inner constraints • Rheological equation of state: • Newtonian fluids • Reiner-Rivlin-fluid • Rheological equation of state: • Maxwell's spring and dashpot model (fluid) • Rheological equation of state: • Kelvin-Voigt's spring and dashpot model (solid) • Jeffrey's model and generalisation • Rheometry: • Viscosimetric flow • Capillary rheometer • Steady-state rheometry: • Couette- / Searle rheometer • Cone and plate rheometer • Steady-state rheometry: • Measurement evaluation • Transient rheometry: • Relaxation and retardation experiments • Transient rheometry: • Oscillation experiments • Rheological flow problems: • Rod climbing • Die swell • Centripetal pumping	• Fluid systems like suspensions or solutions that show complex flow properties are often dealt with in process engineering. The students are able to identify and mathematically model the behaviour of such systems. • The students are familiar with the mathematical description of flowing continua. They are able to apply these concepts to fluids featuring complex flow properties. • The students know about classical models describing complex flow properties and they are able to apply these to practical problems in simple geometries. • The students hav a good command of the fundamentals of rheometry. They know common measurement systems and evaluation mthods

Voraussetzungen	Benotung
none	1 written or oral exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Rheology [MSSiSc-5208.a]		6	0
Vorlesung Rheology [MSSiSc-5208.b]		0	2
Übung Rheology [MSSiSc-5208.c]		0	1

Modul: Thermal Separation Processes [MSSiSc-5209]

MODUL TITEL: Thermal Separation Processes

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	3	jedes 2. Semester	SS 2009	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction and overview of thermal separation processes Discontinuous destillation • Continuous simple distillation Concept of counter current processes, cascade connection Common description of thermal separation processes Modeling of the enriching section on the basis of the • common description of thermal separation processes Design of the enriching section according to the McCabe-Thiele method • Choice of ideal reflux ratio Design of a destillation column according to the McCabe-Thiele process • Design of the stripping section Design of the inflow position Short-Cut methods according to Fenske, Underwood and Gilliland • Design of tray column Design of regular and irregular filled columns • Efficiency of column internals Operating limits • Introduction into liquid-liquid extraction Graphical solution of single stage and cross flow extraction with and without simplification Analytical design of single stage and cross flow extraction processes • Counter current extraction in the triangular diagram Minimal solvent to feed ratio Requirement for the solvent Design of industrial extraction columns • Introduction into absorption Requirements for the solvent HTU-NTU method • Ponchon-Savarit method, generalization of the McCabe-Thiele method Design of distillation columns in the enthalpy-composition diagram • Multicomponent distillation Crystallization Detailed overview of adsorption, chromatography and liquid-liquid separation processes • Detailed overview of absorption, chromatography and liquid - liquid separation processes	The students • are able to classify and compare the various available separation processes • are able to choose the proper separation process for a given separation task • are able to model separation processes in detail • are able to estimate the instrumentation expenditure with short-cut methods • have knowledge about the industrial design of separation columns • have knowledge of the influence of the operating parameters on the separation process • Solution of exercises in teams • Computer-aided group exercise • Laboratory tutorial
Voraussetzungen	**Benotung**
recommended: • Module Thermodynamics of Mixtures	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
PrüfungThermal Separation Processes [MSSiSc-5209.a]	90	6	0
Vorlesung Thermal Separation Processes [MSSiSc-5209.b]		0	2
Übung Thermal Separation Processes [MSSiSc-5209.c]		0	1

Modul: Thermodynamics of Mixtures [MSSiSc-5213]

MODUL TITEL: Thermodynamics of Mixtures

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction into the basic ideas of thermodynamics of mixtures • Definition of a thermodynamic system and its boundaries • Graphical representation of the pVT-behavior of pure components • Material equations for the description of the pVT-behavior of pure components: the ideal-gas equation, the Virial equation, the van der Waals equation • Derivation of the principle of corresponding states based on the van der Waals equation, discussion of the relevance of this principle • Discussion of the necessity of thermodynamic relations for mixtures beyond material equations • Derivation of required mathematical basic relations • Changes of state in an open system • Fundamental equations of thermodynamics • Differential relations between the state variables • General condition for phase equilibrium, Gibbs' phase rule • Phase equilibria of pure components • Conditions for stability of a thermodynamic system • The fundamental equations A(T,V,xi) as basis for equations of state • Derivation and interpretation of the individual terms • Derivation of the equation for the chemical potential, introduction of fugacity and fugacity coefficient • Description of phase equilibria based on these variables • Presentation and discussion of common equations of state: modifications of the Virial equation, cubic equations of state, non-cubic modifications of the van der Waals equation • Introduction of partial molar quantities and relations of these • Presentation of the terms of the fundamental equation G(T,p,xi) • Calculation of phase equilibria with GE models • Models for the description of GE: Wilson model, NRTL, UNIQUAC, UNIFAC. • Molecular properties: molecular geometry, van der Waals interactions, polar components, hydrogen bonds, ions, polymers • Methods for measuring phase equilibria • Gibbs-Duhem equation for consistency tests • Measurement of the enthalpy of mixing • The behavior of real pure components and mixtures • Vapor-liquid and liquid-liquid equilibria for binary systems • Triangular diagram for ternary mixtures • Derivation of the fundamental relation for chemical equilibrium, Gibbs phase rule	The students • are able to select and apply appropriate methods for the description of phase and chemical equilibria in mixtures. • have good knowledge of the necessary basics in thermodynamics as well as the relevant material equations, especially equations of state and GE models. • Developed an idea of the structure and interaction of molecules, which allows them to evaluate these material equations for specific applications, to select the appropriate model, and to apply it.

• Application of the general relation to real mixtures with equations of state and GE models • Equilibrium with heterogeneous reaction • Equilibrium with simultaneous reactions • Reaction kinetics of elementary reactions	
Voraussetzungen	**Benotung**
Recommended: • Module *Thermodynamics I*	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Thermodynamics of Mixtures [MSSiSc-5213.a]	120	4	0
Vorlesung Thermodynamics of Mixtures [MSSiSc-5213.b]		0	2
Übung Thermodynamics of Mixtures [MSSiSc-5213.c]		0	1

Modul: Applied Numerical Optimization [MSSiSc-5214]

MODUL TITEL: Applied Numerical Optimization

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	4	jedes 2. Semester	WS 2010/2011	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
1 • Definition: Mathematical Optimization • Problem formulation: objective functional, model und constraints • Examples of Optimization Problems • Classification of Optimization Problems • Mathematical basics 1: continuity, differentiability 2 • Mathematical basics 2: gradient, Hesse matrix, convexity • Optimality conditions for unconstrained problems • Solution concepts for unconstrained problems, direct, indirect numerical solution, principle of line search and trust region 3 • Line search strategies: Armijo and Wolfe conditions • Methods for the Determination of the descent direction: Steepest Descent, Conjugate Gradients 4 • Methods for the determination of a descent direction: Newton method • Practical Newton methods: Inexact, Modified and Quasi-Newton method • Trust Region methods: the Dogleg method 5 • Regression problems: method of Least-Squares • Gauss-Newton solution method for regression problems • Levenberg-Marquardt solution method for regression problems 6 • Example of an optimization problem: Ethanol extraction • Derivation of the KKT optimality conditions 7 • Linear programming (LP): • Interior point methods for LPs • Simplex method for LPs 8 • Quadratic programming (QP): • Solving the KKT system for QPs • Active-Set methods for QPs • Solution strategies for non-convex QPs 9 • Gradient-Projection method for QPs • Interior-Point methods for QPs • Solution of general nonlinear problems (NLP): • Penalty Methods for NLPs	With respect to the subject • The studentsunderstand the statement of mathematical optimization problems with objective functional, model and constraints as a basis to solve arbitrary problems • The students master the derivation of the optimality conditions for constrained and unconstrained problems with non-linear constraints. The students understand the need for the numerical solution for arbitrary mathematical optimization problems and are able to implement the basic numerical concepts in their own algorithms. • Every student understands the classification of the optimization problems and is able to allocate arbitrary problems to the corresponding class. Moreover, every student knows which numerical solution method is to be used for the solution of such problems. • Every student applied the optimization methods exemplarily upon problems from mechanical/chemical engineering Not with respect to the subject • The student gains the ability of working in a team via small group-tutorials by programming exercises including Matlab programming tools (team work). • The students will be enabled to analyse the problem statement and to produce the concrete solution of the problem by means of the home-works (method competence).

10 • Log-Barrier method for NLPs • Augmented Lagrangian method for NLPs • SQP methods: Line Search SQP 11 • Examples for optimization problems: • Layer Crystalliser • Distillation Column 12 • Introduction to mixed-integer optimization: • Branch and Bound • Outer-Approximation 13 • Introduction to Dynamic Optimization: • Optimality conditions • Simultaneous solution methods: full discretisation • Continuous problem formulation: adjunct equations / Hamilton form 14 • Dynamic Optimization: Sequential Solution Method • Derivation of the sensitivity equation • Examples for dynamic optimization problems • Short introduction to State Estimation	
Voraussetzungen	**Benotung**
none	1 oral exam 3 programming excercises

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Applied Numerical Optimization [MSSiSc-5214.a]		4	0
Vorlesung Applied Numerical Optimization [MSSiSc-5214.b]		0	2
Übung Applied Numerical Optimization [MSSiSc-5214.c]		0	2

Modul: Computer-Aided Process Design [MSSiSc-5215]

MODUL TITEL: Computer-Aided Process Design

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	3	3	jedes 2. Semester	SS 2009	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt

Remarks:

- The lectures are given in units of 90 minutes each; for this reason there are only 7 lectures.
- The tutorials are given in units of 3 full hours each; for this reason there are only 7 tutorials.

- Lecture 1: Introduction, overview on computer-aided tools for process engineering, presentation of the project; introduction to the ethylene glycol process
- Lecture 2: Presentation of thermodynamic models, acquisition of thermodynamic data, examples of incorrect choices of thermodynamic models, introduction to the linear model of the ethylene glycol process.
- Lecture 3: Simulation strategies, tearing
- Tutorial 1: Discussion of the linear model, adjustments of the model to the required task (thermodynamic data, product amount, purge stream, …)
- Lecture 4: Modeling approach: from linear to rigorous models, introduction to rigorous modeling of important process units, modeling examples of complex units
- Tutorial 2: Simple cost calculations and energy integration, sensitivity analysis of the recycle stream in the ethylene glycol process Homework: prepare a short presentation of the results for the next lecture
- Lecture 5:Presentation and comparison of the results of the linear process calculations and the cost estimations, division of the process into different sections for further investigation with rigorous models, assignment of tasks to individual groups, distribution of literature
- Lecture 6: Numerical methods I
- Tutorial 3: Modeling of the selected process parts
- Lecture 7: Numerical methods II
- Tutorial 4: Modeling of the selected process parts, first simulation studies

Opportunity to work on project without supervision

- Tutorial 5: Sensitivity Analysis to rigorously design the process units and to optimize the process parts

Opportunity to work on project without supervision

- Tutorial 6: Design and cost calculation for the different units Homework: Summarize results of the design and cost calculations of the different units and provide other groups with these results

Tutorial 6: Design and cost calculation for the different units Homework: Summarize results of the design and cost calculations of the different units and provide other groups with these results

- Tutorial 7: Economic assessment of the entire process, write project report
- Opportunity to work on project without supervision

Lernziele

- In the chemical industry, computers are widely used for the design of processes and plants. Simulation tools like Aspen Plus, ChemCAD, or gPROMS play a major role in most design projects. Simulators enable the user to build a mathematical model of a plant and simulate its behavior. These simulation experiments provide the necessary information to select and design appropriate process units and to determine process parameters such as temperatures, pressures, and flow rates.
- After an introduction to the design problem, the students practice acquiring and analyzing property data, flowsheet synthesis, parameter optimization and heat integration. After the course the students will be able to understand the simulation software and its underlying numerical methods. They will be able to apply simulation software to design chemical processes.
- During the tutorials the participants will design a process for the production of ethylene glycol with the help of the simulator Aspen Plus. Alternatively, the students can design a process for the production of biodiesel. Due to the complexity of the case studies, the participating students will split up and form small teams of two to three people. Each team will examine different section of the overall process in detail; various design alternatives will be analyzed and evaluated with respect to cost, safety, and environmental impact. The intermediate results will be presented and discussed during the tutorials. In addition, each team will document their results in a short project report and will present their results in a final colloquium.
- The coursework will take place in the computer lab of the institute. Previous knowledge of the simulator Aspen Plus is not required.

- Teamwork
- Presentation
- Self dependent project work

Voraussetzungen	Benotung
recommended: • Module Chemical Process Engineering • Module Thermodynamics of Mixtures	1 written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Computer-Aided Process Design [MSSiSc-5215.a]	60	3	0
Vorlesung Computer-Aided Process Design [MSSiSc-5215.b]		0	1
Übung Computer-Aided Process Design [MSSiSc-5215.c]		0	2

Modul: Introduction to Molecular Simulations [MSSiSc-5216]

MODUL TITEL: Introduction to Molecular Simulations

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	3	jedes 2. Semester	SS 2011	English

INHALTLICHE ANGABEN

Inhalt

- General introduction
- Basics: probabilities, statistics, Monte Carlo sampling
- Connections to statistical mechanics
- Monte Carlo methods for atomic systems
- Molecular dynamics: basic principles
- Molecular dynamics: advanced concepts
- Analyzing results of molecular simulations
- Challenges: efficiency and accuracy
- Special topics

Lernziele

The students will

- understand the capabilities and limitations of different forms of molecular simulation, and be able to evaluate which approach is most suitable for a particular application,
- be able to develop tools to manipulate and analyze the large data sets associated with molecular simulations,
- be able to evaluate new algorithms and methods for suitability, correctness, and efficiency,
- be able to understand the role molecular simulation can play in interaction with other kinds of simulation, and within the larger scientific and engineering community

- have the opportunity to use high-performance computing applications
- be able to work on their communication skills in written English

Voraussetzungen

recommended:

- Basic thermodynamics, chemistry and physics
- Previous programming experience (programming or scripting languages)

Benotung

1 oral or written exam

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Introduction to Molecular Simulations [MSSiSc-5216.a]		5	0
Vorlesung Introduction to Molecular Simulations [MSSiSc-5216.b]		0	2
Übung Introduction to Molecular Simulations [MSSiSc-5216.c]		0	1

Modul: Process Control Engineering [MSSiSc-5301]

MODUL TITEL: Process Control Engineering

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction • Modelling Techniques • Structural Description • Process Control Systems: System Functions • Process Control Systems: Software Architecture • Communication Systems • Technical Plant • Control Engineering: Actor Units • Control Engineering: Discrete Control • Control Engineering: Hybrid Control • Control Engineering • Control Engineering: Hierarchical Control Schema • Examination Tutorial / Reserve	• ability to analyse basic control problems • ability to construct hierarchical control solutions • ability to handle industrial control languages • ability to work with structural models of plants and processes • basic knowledge of industrial control systems • basic knowledge of requirements in industrial control
Voraussetzungen	**Benotung**
None	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Process Control Engineering [MSSiSc-5301.a]		4	0
Vorlesung Process Control Engineering [MSSiSc-5301.b]		0	2
Übung Process Control Engineering [MSSiSc-5301.c]		0	1

Modul: Process Measurement [MSSiSc-5302]

MODUL TITEL: Process Measurement						
ALLGEMEINE ANGABEN						
Fachsemester	**Dauer**	**Kreditpunkte**	**SWS**	**Häufigkeit**	**Turnus Start**	**Sprache**
3	1	3	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	**Lernziele**
• Basics of measurement technique • Processing and valuation of measuring data • Flow measurement • Level measurement • Temperature measurement • Process and product description • Mechanical quantities • Industrial Environment	• Students learn the basis of industry measurement technology (level, temperature, pressure, flow) • Learn how to work with data and handle with statistical methods (statistical errors, regression analysis, quality control) • Knowing how to characterize product and production attributes
Voraussetzungen	**Benotung**
None	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	**Prüfungsdauer (Minuten)**	**CP**	**SWS**
Prüfung Process Measurement [MSSiSc-5302.a]		3	0
Vorlesung Process Measurement [MSSiSc-5302.b]		0	2
Übung Process Measurement [MSSiSc-5302.c]		0	1

Modul: Inline Spectroscopy for Chemical Processes [MSSiSc-5303]

MODUL TITEL: Inline Spectroscopy for Chemical Processes

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	3	3	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction to process analytics • Basics of optical spectroscopy • Spectral ranges • UV-Vis-spectroscopy: measurement techniques • Material aspects Technical aspects NIR-spectroscopy: measurement techniques Material aspects • Technical aspects • Mid-IR-spectroscopy: measurement techniques Material aspects • Technical aspects • Raman-Spectroscopy: measurement techniques • Material aspects • Technical aspects • Fluorescence-spectroscopy: measurement techniques • Material aspects • Technical aspects • Comparison of spectroscopy techniques • Selection with given measurement problems • Complementarity of different methods • Spectra analysis • Deconvolution • Solid state body spectroscopy • Kubelka-Munk-function • Diffuse reflection • Example VPO-catalyst • Time-resolved UV-Vis-spectroscopy • Correlation spectra - oxidation state Examples	• The students know all established optical spectroscopy methods. • For a given chemical system they are able to choose the appropriate spectroscopy method, based on the chemical composition. • The master basic methods to obtain and analyze spectroscopic data, in order to give quantitative statements about the investigated system. • They are familiar with potential artifacts and intrinsic measurement problems, they can identify them and know techniques to avoid them. The students are able to design the control of a chemical production process on the basis of spectroscopic measurements. • The students master technical terms in the field of process analytics in English. By solving homework the students learn how to analyze problems and how to find tangible solutions.

Voraussetzungen	Benotung
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Inline Spectroscopy for Chemical Processes [MSSiSc-5303.a]		3	0
Vorlesung Inline Spectroscopy for Chemical Processes [MSSiSc-5303.b]		0	2
Übung Inline Spectroscopy for Chemical Processes [MSSiSc-5303.c]		0	1

Modul: Modeling Technical Systems [MSSiSc-5304]

MODUL TITEL: Modeling Technical Systems

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	3	jedes 2. Semester	SS 2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
1 • Introduction • Description of and differentiation of the terms "process behavior" and "model" • General derivation of balance equations • • "Process variable" and "model equations" as basics concept of model design • Presentation of the model equation structure consisting of balance equations, constitutive equations and other equations to describe the behavior of chemical processes 2 • General differential balance equation for phases • Linking of phenomena of the process with the terms of the differential balance equation, ie, capacity term, convective and diffusive transport term and source term • Derivation of the differential total mass balance and mass balance of a substance in the mixture of the general differential balance equation 3 • Derivation of the differential momentum balance, balance sheets for different forms of energy and the entropy 4 • General differential balance equation for surfaces • Dimension reduction of differential balances • Reduction of the with only two or one local dimension of differential balancesconsidered • 5 • General integral balance equation for phases • Linking of phenomena of the process with the terms of the integral balance equation, i.e., capacity term transport term, source term and exchange term • Derivation of the integral mass balance and mass balance of a substance in the mixture momentum balance, energy balance and entropy from the general integral balance equation 6 • Derivation of the integral balances for the special case of ideally mixed systems • • Model completion with constitutive equations I • Constitutivefor transport terms and source terms in the balance equations IIfor phases • 7 • Model completion with constitutive equations for transport terms and source terms in the balance equations for surfaces • Model completion with further constitutive equations and constraints	With respect to the subject • The students are familiar with the central ideas behind the systematic modeling of chemical processes. They know analytical methods for the evaluation of mathematical models, and can name the characteristics of generalized building blocs for models. • Students understand the meaning of individual mathematical terms of the model equations, they are able to interprete them and draw conclusions about the behavior of the modeled process. • Students are able to apply the methods of model development and analysis to new, unknown processes. • Due to the broadly based interdisciplinary nature of industrial chemical processes, students are able to apply knowledge from other areas of fields, for example chemical reaction engineering, mechanical unit operations, bioreaction engineering and thermal unit operations as well as technology of industrial plants and process control engineering. • Students are able to isolate individual phenomena of a chemical process, evaluate their process specific relevance and consequently develop models with varying levels of detail. • Students are able to evaluate the quality of process models through analytical methods, critically compare alternate models and if necessary improve them.

8 • Introduction to Systems Theory • Model structure - components and associationsSystem design, system representation and system development as tools to methodically address any system • Model structure - basic elements • Model structure - general building blocs for models • Model analysis I • Model analysis II • The9 • Application of the methods of system theory to models as special systems • Introduction of model blocks for model structuring within the meaning of the system development • "Components" and "links" as special model components for model representation for the purposes of system representation 10 • Elementary model components • Characterization of elementary model components by means of feature lists within the meaning of the system concept 11 • Non-elementary model components and their features lists 12 • Classification of the structure of equation systems of typical process engineering models • Criteria and methods of analysis for the solvability of stationary models 13 • Criteria and methods of analysis for the solvability of dynamic models 14 • Application of the complete modeling process using a concrete example	
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in unit operations in chemical engineering • Module Chemical Process Engineering • Module Thermodynamics of Mixtures	• 1 written exam (120 min)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Modeling Technical Systems [MSSiSc-5304.a]		6	0
Vorlesung Modeling Technical Systems [MSSiSc-5304.b]		0	2
Übung Modeling Technical Systems [MSSiSc-5304.c]		0	1

Modul: Computational Fluid Dynamics I [MSSiSc-5401]

MODUL TITEL: Computational Fluid Dynamics I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt

- Introduction to CFD
- Examples of flow simulatiaons
- The basic PDE's of Fluid Mechanics
- Different Notations
- Physical meaning of characteristic lines
- Determination of the type of PDE's
- Characteristic form of PDE's
- The basics of discretization of partial differentials
- Truncation error and consistency
- Solution schemes for scalar equations
- Stability analysis of initial value problems
- Discrete disturbance theory
- von Neumann ananlysis
- CFL-condition
- Hirt's stability analysis
- Introduction to the numerical solution of boundary value problems
- Classical iterative solution methods, Jacobi, Gauß-Seidel methods
- Convergence of iterative solution methods
- ILU, Krylov subspace methods
- Multigrid methods
- Transformation of PDE's in curvlinear coordinates
- Truncation error on curvelinear grids
- Discretization on different unstructured meshes, solution adaptive methods
- Triangle or tetrahedral based meshes
- Hierarchical Cartesian meshes
- Vectorization and parallelization of solution algorithms
- Different applications and examples

Lernziele

- Knowledge of the partial differential equations (PDE'S) of fluid mechanics
- Basics of the discretization of PDE's
- Learn how to formulate numerical methods for the solution of PDE's
- Ability to determine und understand the properties of truncation errors of numerical solution schemes
- Understand stability and sonsistency of solution schemes
- Solution of boundary value problems with iterative solution schemes
- Discretization on different mesh types
- Implementation of solution schemes on different computer architectures

- The discussion of several examples of numerical flow simulation allows to understand different theoretical aspects in proactical mpplications

Voraussetzungen

recommended:
- Basic knowledge in advanced mathematics
- Basic knowledge in thermodynamics

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Computational Fluid Dynamics I [MSSiSc-5401.a]		4	0
Vorlesung Computational Fluid Dynamics I [MSSiSc-5401.b]		0	2
Übung Computational Fluid Dynamics I [MSSiSc-5401.c]		0	1

Modul: Computational Fluid Dynamics II [MSSiSc-5402]

MODUL TITEL: Computational Fluid Dynamics II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	3	2	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt

- Introduction to the solution of initial value problems
- Heat conduction equation
- Program example
- Numerical solution of the boundary-layer equations
- Linearization of the implicit solution scheme
- Program example
- Introduction to the solution of linear hyperbolic equations
- Numerical solution of the potential flow equation
- Program example
- Upwind and central discretization
- Transport properties of discretizations
- Dissipative and dispersive truncation errors
- Introduction to the solution of the Euler equations
- Integral, differential, conservative, non-conservative, and characteristic forms
- Discontinuous solutions of the Euler equations
- Rankine-Hugoniot relations
- Introduction to upwind discretizations for the Euler equations
- Derivation of the Flux-Difference Splitting scheme
- Flux-Vector Splitting schemes
- High-order schemes
- Explicit solution schemes for the Euler equations
- MacCormack, Runge-Kutta methods etc.
- Convergence acceleration methods
- FAS Multigrid method, local time stepping etc.
- Implicit solution schemes for the Euler equations
- Linearization of the non-linear equations
- Dual time stepping schemes
- Discretization of the Euler equations on unstructured meshes
- Formulation of upwind schemes
- Numerical solution of the Euler equations for the shock tube problem
- Program example

Lernziele

- Basics for the numerical solution of Boundary Layer, Euler and Navier-Stokes equations for compressible flows
- Fundamental properties and different forms of Euler and Navier-Stokes equations
- Understand central and upwind discretization schemes for Euler and Navier-Stokes equations
- Formulatiaon of efficient explicit and implicit solution schemes for Euler and Navier-Stokes equations

- Several program examples show how the theory is applied in the nuermical simulation of different flow problems

Voraussetzungen

- Module Computational Fluid Dynamics I

recommended:
- Basic knowledge in advanced mathematics
- Basic knowledge in thermodynamics

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Computational Fluid Dynamics II [MSSiSc-5402.a]		3	0
Vorlesung Computational Fluid Dynamics II [MSSiSc-5402.b]		0	1
Übung Computational Fluid Dynamics II [MSSiSc-5402.c]		0	1

Modul: Boundary-Layer Theory [MSSiSc-5403]

MODUL TITEL: Boundary-Layer Theory

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	3	2	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Discussion of the state variables and the transport coefficients • phenomenological descritpion of the boundary layer • Discussion of the matched-asymptotic expansion theory and derivation of the boundary-layer equations of zero and higher order • Exact solution of the boundary-layer equations • Derivation of the integral method of von Kámán and Pohlhausen • Introduction to the theory of turbulent flow: isotropic, homogeneous, and shear turbulence • Hydrodynamic instability and laminar-turbulent transition • Discussion of solutions of the Orr-Sommerfeld equation • Derivation of the Reynolds stress equations and discussion of the transport equation • Discussion of the turbulent length scales and the energy cascade • Approximations to the transport equations • Presentation of semi-empirical computational methods based on the transport equations • Laminar temperature boundary layers • Temperature boundary-layer equations at forced convection for incompressible and compressible fluids • Exact solutions for the heat transfer on the flat plate • Approximate solutions for the heat transfer for Pr > 1 • Approximate solutions for the heat transfer for Pr << 1 and símilar solutions • Derivation of the temperature boundary-layer equations at free convection • Exact solution for the vertical plate • Approximate solution of the velocity and temperature boundary layer for the vertical plate	The student know to analyze viscous flows at high Reynolds numbers
Voraussetzungen	**Benotung**
Contents of modules Fluid Mechanics I and II (e.g. from BSc CES) recommended: • Basic knowledge in mathematics • Basic knowledge in thermodynamics	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Boundary-Layer Theory [MSSiSc-5403.a]		3	0
Vorlesung Boundary-Layer Theory [MSSiSc-5403.b]		0	2

Modul: Finite Elements in Fluids [MSSiSc-5404]

MODUL TITEL: Finite Elements in Fluids

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Introduction • course outline • history of the finite element method Conservation laws (1) • kinematical description, Arbitrary Lagrangian-Eulerian description • Reynolds transport theorem Conservation laws (2) • mass, momentum, energy conservation • Euler, Navier-Stokes equations Foundations of finite elements (1) • function spaces, norms • Poisson equation strong and weak forms Foundations of finite elements (2) • Lax-Milgram lemma, discrete forms • Cea's lemma, computational aspects Advection-diffusion equation (1) • weak, Galerkin, matrix forms • history of stabilization • Petrov-Galerkin forms • accuracy estimates • Finite Increment Calculus, Variational Multiscale method Time discretization (1) • theta-family, Lax-Wendroff, leap-frog stencils • discretization of a transient advection equation. Time discretization (2) • stability and accuracy • Fourier analysis Time discretization (3) • modified-equation method • Taylor-Galerkin schemes Time discretization (4) • space-time discretization • linear multi-step methods Stokes equation (1) • constitutive equation, boundary conditions • saddle-point nature Stokes equation (2) • Galerkin and matrix forms	• The students know the mathematical foundations and fundamental concepts of the finite element method applied to fluid mechanics problems: advection-diffusion equation, evolution equations, Stokes equation and Navier-Stokes equations.The students know the practical aspects of the finite element discretization for multi-field problems. • The students are aware of the numerical difficulties that may occur as the result of discretization, including high-Peclet number effects and incompatibility of interpolation functions. • The students understand the concept of finite element stabilization, including residual-based methods, finite increment calculus, and variational multiscale approaches. • The students acquire experience in research fluid flow simulation software, including visualization.

• LBB condition, interpolation pairs, stabilization • Unsteady Navier-Stokes equations • Galerkin, stabilized forms • summary	
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Finite Elements in Fluids [MSSiSc-5404.a]		4	0
Vorlesung Finite Elements in Fluids [MSSiSc-5404.b]		0	2
Übung Finite Elements in Fluids [MSSiSc-5404.c]		0	1

Modul: Supercomputing in Engineering [MSSiSc-5405]

MODUL TITEL: Supercomputing in Engineering

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Intro. Why we need supercomputers. • Modeling of engineering problems: flows and structures • Basic equations: conservation of mass, momentum, energy • Basic numerical methods for systems: Finite Volume • Phenomena in compressible and incompressible flows • Tutorial: program example • Simulation on supercomputers. History and state of the art Supercomputer architectures and large multi-core clusters. Basic parallelization techniques for shared/distributed memory • Software and Memory: Arrays, pointers, Table lookups. Examples: Memory needs in high resolution turbulent flows. Data structures for structured/unstructured meshes Table look-ups in real gas/combustion • Tutorial: program example • Software development: How to deal with multi-core systems Examples: Plasma thruster simulation Domain Decomposition (MPI) for the fields, loop parallelization (OpenMP) for the particles • Software development: How to deal with multi-core systems Examples: Load balancing for moving particles in fields • Tutorial: program example • Basic numerical methods for flow and structure: Finite Elements • From structured to unstructured meshes: Sparse data representation • Tutorial: program example • Multi-scale / Multi-physics simulations Example Hierarchical representation of physical phenomena • Basics of aero-elastics • Tutorial: program example • Coupling techniques for multi-scale problems • Coupling techniques for multi-physics problems • Tutorial: presentation	• Modeling of engineering problems like compressible / incompressible fluid flow, plasma flows, electromagnetic fields, particle loaden flows, flows with real gas effects • Understanding the properties of FV / FE methods and their data representation • Knowledge about computer architectures and implications on software • Understanding of efficiency and performance • Choosing the right numerical method for a given combination of engineering problem and computing system • Solving problems in team work • Presentation

Voraussetzungen	Benotung
recommended: • Basic knowledge in advanced mathematics • Basic knowledge in modeling and simulation techniques • Parallelization I	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Supercomputing in Engineering [MSSiSc-5405.a]		6	0
Vorlesung Supercomputing in Engineering [MSSiSc-5405.b]		0	2
Übung Supercomputing in Engineering [MSSiSc-5405.c]		0	2

Modul: Lattice-Boltzmann Methods [MSSiSc-5406]

MODUL TITEL: Lattice-Boltzmann Methods

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	4	jedes 2. Semester	WS 2011/2012	German or English (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
Introduction:kinetic and continuum mechanic flow description • Simple kinetic models • Equations in continuum mechanics Basics of kinetic gas theory • Maxwell-Boltzmann distribution • Derivation from statistical mechanics Kinetic theory of non-equilibrium • Basic principles • Derivation of Boltzmann equation Boltzmann equation • Characteristics of Boltzmann equation • Simplified models (BGK approximation) Equations of continuum mechanics • Chapman-Enskog solution of Boltzmann and BGK equations • Derivation of Euler and Navier-Stokes equations via Chapman-Enskog method Introduction: Numerical methods • Monte Carlo Simulation • Kinetic finite differences and finite volume methods Introduction: Lattice methods • Cellular machines • Lattice gas models Lattice Boltzmann and BGK models • Statistical considerations • Derivation of models • Single and multiple time relaxation for LBGK • Various velocity models Analysis of Lattice models • Consistency with equations of continuum mechanics • Numerical stability Numerics of Lattice models regarding fluid dynamics • Boundary conditions • Implementation Lattice methods for complex fluids • Gas mixtures: kinetic considerations • Implementation as Lattice model • Multi phase systems	The students… • know the basics of kinetic gas theory • can derive fluid dynamics equations of continuum mechanics from kinetic models • understand the basic idea behind Lattice based numerical methods and their relation to macroscopic equations • know the different formulations of Lattice Boltzmann / BGK models and understand their background and the numerical properties • particularly know the special application areas in the scope of complex fluids, e.g. multi phase systems

• Particle transport • Porous media Overview: Applications outside of fluid dynamics • Examples from various disciplines	
Voraussetzungen	**Benotung**
Recommended: • Basics of partial differential equations Required: • Classical fluid mechanics	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Lattice-Boltzmann Methods [MSSiSc-5406.a]		5	0
Vorlesung Lattice-Boltzmann Methods [MSSiSc-5406.b]		0	2
Übung Lattice-Boltzmann Methods [MSSiSc-5406.c]		0	2

Modul: Hypersonic Flight: Computational Propulsion Design [MSSiSc-5407]

MODUL TITEL: Hypersonic Flight: Computational Propulsion Design

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2014	englisch

INHALTLICHE ANGABEN

Inhalt

Content of the lecture is the scramjet, an air-breathing hypersonic propulsion system for future space transportation systems. The problems of the scramjet propulsion are mainly in the field of aero-thermodynamics, whereby the scramjet is an interesting content and challenging application area for flow simulation. Based on the scramjet important sub-points of the simulation are developed, such as the physical modeling, grid generation, solution approaches of different degrees of complexity, constraints, validation and verification of the results, etc.. In this case, the overall design of the drive system of the numerical simulation is available as a guiding concept ahead:
Questions about the efficiency of individual engine components and the application range of the drive must be answered with the help of simulation techniques.

Lernziele

Fachbezogene Lernziele:

- Understanding of the basic function of a Scramjet gear and the specific problems of air-breathing hypersonic propulsion system, practical application of various simulation and design tools to create an overall design of a Scramjet gear (eg. Characteristic method for inlet and nozzle, 1 D combustion model, 3D flow simulations, etc.)

Nicht fachbezogene Lernziele (z.B. Teamarbeit, Präsentation, Projektmanagement, etc):

-
- Understanding of how a complex system can be analyzed by establishing a scientific working procedure. The students will work in small teams during the exercises to solve the specific problems of the engine component.

Voraussetzungen

Notwendige Voraussetzungen:

- Basic knowledge in numerical methods (eg by the lecture / lecture series simulation techniques for mechanical engineers or CES), basic knowledge in aerodynamics and gas dynamics

Empfohlene Voraussetzungen:

- Programming experience

Benotung

- 1 oral exam (100%)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Hypersonic Flight: Computational Propulsion Design [MSSiSc-5407.a]		4	0
Vorlesung/Übung Hypersonic Flight: Computational Propulsion Design [MSSiSc-5407.bc]		0	3

Modul: Numerical Methods for Fluid-Structure Interaction [MSSiSc-5408]

MODUL TITEL: Numerical Methods for Fluid-Structure Interaction

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2014/2015	

INHALTLICHE ANGABEN

Inhalt	Lernziele
Think of a flag moving in the wind or blood flowing in arteries in order to get an idea off what fluid-structure-interaction (FSI) phenomena are. They are characterized by an interplay between deforming structure and a surrounding fluid. On the one hand, the structure deforms as a result of the load exerted by the flow field. On the other hand, this deformation effects the flow field so that the load on the structure changes. For the modeling and simulation of FSI phenomena, neither the fluid nor the solid can be viewed separately. This lecture focuses on the simulation of FSI phenomena. Strong and weak coupling of the two fields are discussed from a physical, mathematical, and implementational point of view. As application we will work on aeroelasticity problems, such as static aeroelasticity and aeroelastic flutter as well as give an introduction to aerothermoelasticity. In the practical sessions, we will use the OpenFOAM solver to gain some first hand experiences with numerically solving FSI problems.	Fachbezogene Lernziele: During the first half of the semster, the lecture will be followed by a tutorial from 13:30 to 15:00 in room 327 of the Rogowski building. During those practical sessions, the students will learn how to use the software Openfoam to solve fluid-structure interaction problems. During the second half of the semester, the students will work on a specific FSI problem themselves using Openfoam. There will be an option of writing a report on the performed project work that will count 50% of the final grade. Nicht fachbezogene Lernziele: During the homework problem, the students will learn to manage their own project and establish a scientific working procedure for their research.
Voraussetzungen	**Benotung**
Basic understanding of fluid or structural dynamics and numerical methods. Interest in aeroelasticity.	• 1 oral exam (100%)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Numerische Methoden der Fluid-Struktur-Interaktion [MSSiSc-5408.a]		4	0
Vorlesung/Übung Numerische Methoden der Fluid-Struktur-Interaktion [MSSiSc-5408.bc]		0	3

Modul: Aerothermal Design of Space Transportation Systems [MSSiSc-5409]

MODUL TITEL: Aerothermal Design of Space Transportation Systems

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes Semester	SS 2014	English and German

INHALTLICHE ANGABEN

Inhalt

- Space missions and spacecraft
- Atmospheric characteristics of the planets
- Flow regime in dependence of the Mach number
- Flow regime as a function of Reynolds number
- Flow regime as a function of the Knudsen number
- Preliminary methods for spacecraft
- Viscous effects on the spacecraft design
- Influence of the boundary layer transition on the space-craft design
- Methods for the reduction of transition effects
- Influence of the strong current interactions on the spacecraft design
- High enthalpy effects during hypersonic flight
- Heat transfer in high enthalpy flows
- Catalytic surfaces
- Thermal protection systems
- CMC structures
- ablation materials
- Fluid-Structure Interaction during hypersonic flight
- Spectroscopic methods for the flow characterization
- Methods for material characterization
- Aerodynamic stability of spacecraft
- Methods for the determination of the static and dynamic coefficients
- Health monitoring in spacecraft
- Thermal Management
- Plasma flow control
- Qualification systems for spacecraft components
- Numerical simulation tools
- Design of hypersonic flight experiments
- Critical aspects of hypersonic flight
- Post flight analysis

Lernziele

Fachbezogene Lernziele:

- Students get in-depth knowledge of space transport technologies

Nicht fachbezogene Lernziele:

- Project management

Voraussetzungen

Recommended requirements:

- fluid mechanics I, II
- thermodynamics
- gas dynamics

Benotung

- 1 oral exam (100%)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Exam Aero Thermal Design of Space Transportation Systems [MSSiSc-5409.a]	45	4	0
Lecture/Tutorial Aero Thermal Design of Space Transportation Systems [MSSiSc-5409.bc]		0	3

Modul: Fundamentals of Lightweight Design [MSSiSc-5501]

MODUL TITEL: Fundamentals of Lightweight Design

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	4	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt

- Introduction to Lightweight Design
- Motivation, Definitions, Concepts
- Special Aspects of Light Structures
- Materials used in Lightweight Design
- Basic equations of Continuum Mechanics
- Idealization of structures
- Equilibrium conditions
- Statically determined support of 2-dim and 3-dim structues
- Determination of external and internal forces
- 2-dim and 3-dim truss type structures
- General equations
- Design concepts
- Balken unter Biegung und Querkraft
- Grundgleichungen
- Lösung der Differentialgleichung des schubstarren Balkens
- Matrix formulations: transfer matrix, stiffness matrix
- Shear flexible beam
- Matrix formulation
- Shear deformation
- Shear flow in thin walled beams
- Open cross section
- Closed cross section
- Shear center
- Plastic bending
- Combined normal and bending load
- Torsion of beams (St. Venants Torsion)
- Solid sections
- Closed thin walled sections
- Torsion of beams (St. Venants Torsion)
- Open thin walled sections
- Bending Torsion
- Introduction to shear panel theory
- Open and closed section beams
- 2-dim shear panel structures
- rectangular, parallelogram, trapezoidal and general 4node panels
- 3-dim shear panel structres

Lernziele

The students are able to realize special aspects of thin-walled lightweight structures and to design them properly. They know methods to design structures at the beginning and are thus able to find sufficient solutions. Further, they achieve knowledge, allowing to check the correctness of results of numerical simulation software.

Voraussetzungen

- Basic knowledge in mechanics
- Basic knowledge in materials science

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Fundamentals of Lightweight Design [MSSiSc-5501.a]		5	0
Vorlesung Fundamentals of Lightweight Design [MSSiSc-5501.b]		0	2
Übung Fundamentals of Lightweight Design [MSSiSc-5501.c]		0	2

Modul: Machine Design Process [MSSiSc-5502]

MODUL TITEL: Machine Design Process

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	5	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Topic: Introduction Topic: Drawing Standards I • Projection drawing and axonometric views • Elements of technical drawings • Dimensioning Topic: Drawing Standards II • Section views • Broken views Topic: Joins and Connections • Connection types • Bolted connections • Shaft and hub connections Topic:Geometrical Irregularities and Tolerances • Dimension tolerances • Form and position tolerances • Technical surfaces Topic: Bearing of Shafts • Bearing principles • Bearing arrangements • Seals Topic: Power Transmission • Definitions and principles • Technical representation • Examples Topic: Engineering Design Process, Requirements List • Introduction to design methodology • General process of engineering design • Requirements list Topic: Conceptual Design I • Function structures and principle solutions • Design catalogues • Heuristic and analogy methods Topic: Conceptual Design II • Systematic variation, classification schemes • Overall solutions: morphological matrix	The studens • know the most common machine elements and applicable design rules. They are able to draft such solutions according to ISO drawing standards and understand production drawings including dimensions and tolerances. • know structured problem solving strategies, esp. the engineering design process acc. to VDI 2221. They are able to identify possible restrictions on a design task and to develop and select applicable concept solutions with a systematic approach. • know the body of design rules and are able to determine applicability depending on effective design restrictions. Basic rules of embodiment design, design principles and guidelines can be applied to draw up technical drafts.

Topic: Design Rules I - Basic Rules • Introduction to design rules • Basic rules ´simple´ and ´clear´ • Basic rule ´safe´ Topic: Design Rules II - Principles • Principles of fault-free design, force transmission, stability and bi-stability, self-help, division of tasks Topic: Design Rules III - Guidelines / DFX • Selected examples: design for assembly and production...	
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Machine Design Process [MSSiSc-5502.a]		6	0
Vorlesung Machine Design Process [MSSiSc-5502.b]		0	2
Übung Machine Design Process [MSSiSc-5502.c]		0	3

Modul: Dynamics of Multi Body Systems [MSSiSc-5503]

MODUL TITEL: Dynamics of Multi Body Systems

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	4	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Introduction Fundamentals Fields of application Model Building • Methods of Approach for Equivalent Models • Multi-body Systems • Determination of the Model Parameters • General mathematical description Kinematics of Multi Body Systems • Position and Orientation of Bodies • Translational Kinematics • Rotational Kinematics Equations of Motion • Lagrangian Equations of 2nd Kind • Newton-Euler equations • Linearisation • Eigen Value Approach • Undamped non-gyroscopic systems • Damped gyroscopic systems • Eigen Value Stability Criteria Linear Systems with Harmonic Excitation • Real Frequency Matrix • Complex Frequency Matrix State Equation • System Matrix • Eigen Value Approach • Fundamental Matrix • Modal Matrix • Theorem of Cayley-Hamilton • Analytical Solution • Numerical Solution • Step Excitation • Harmonic Excitation • Periodical Excitation Introduction of Multi Body Simulation Software • ADAMS • SIMPACK • SimMechanics Hands-On-Laboratory for Multi Body Simulation Software • ADAMS • SIMPACK • SimMechanics	• The students have a profound knowledge of theory of vibrations. • The students are capable of comprehending, describing and analysing vibratory systems. • The students have the ability of describing mathematically any mechanical system with its inherent physical effects like elasticity, damping and friction. • The students are familiar with the most important matrix based procedures for the calculation of eigen motions and the behaviour of linear systems under forced excitations. • For the calculation of nonlinear system the students can select suitable program systems and carry out proper simulations. • The students are able to properly interpret simulation results especially under consideration of simplifications within the model compared to the real system.- • The students are able to derive from their knowledge the necessary methods and proceedings for the analysis and synthesis of the systems in regard. Thus they are capable to solve - accessing their acquired theoretical knowledge - complex problems concerning the choice and design of industrial vibratory systems.

Example • Modelling • Determination of Parameters • Calculation • Evaluation	
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Dynamics of Multi Body Systems [MSSiSc-5503.a]		6	0
Vorlesung Dynamics of Multi Body Systems [MSSiSc-5503.b]		0	2
Übung Dynamics of Multi Body Systems [MSSiSc-5503.c]		0	2

Modul: Machine Dynamics of Rigid Bodies [MSSiSc-5504]

MODUL TITEL: Machine Dynamics of Rigid Bodies

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt

- Introduction
- Basic principles and plane motion of rigid bodies
- Dynamic force analysis of plane mechanisms with rigid links:graphical technique
- Dynamic force analysis of plane mechanisms with rigid links:analytical approach
- Dynamic motion analysis of plane mechanisms with rigid links
oSystems without friction
oSystems with friction
- Dynamics of slider-crank mechanism
- Analytical expressions for kinematic parameters
- Dynamical equivalence of connecting rod
- Turning moment in single cylinder engines
- Dynamics of mechanisms considering link elasticity
- Balancing of inertial forces and moments for single slider reciprocating machines
oDetermination of inertial forces
oBalancing of inertial forces
oDetermination of inertial moments
oBalancing of inertial moments
- Balancing of inertial forces and moments for multi slider reciprocating machines (In-Line configuration)
oInertial forces by analytical approach
oInertial forces by graphical approach
oAnalysis of inertial moments
- Balancing of inertial forces and moments for multi slider reciprocating machines (V and Radial configuration)
oInertial forces in V-configuration
oInertial forces in radial configuration
- Balancing of planar linkages
- Power smoothening in machines
- Power balance
- Power balancing in the field of piston engines
- Equations of motion
oExternal forces and moment
oKinetic energy
oPotential energy
- General solution of equation of motion
- Solution of equation of motion for constant inertia
- Solution of equation of motion for constant speed
- Solution of equation of motion for specified instantaneous speed and acceleration
- Solution of equation of motion for constant energy
- Fluctuation of angular velocity
- Non uniformity factor
- Control of speed fluctuation by flywheels
- Determination of flywheel inertia (graphical approach)
- Determination of flywheel inertia (analytical approach)
- Wittenbauer's method of flywheel analysis

Lernziele

- The students have the ability of describing mathematically any mechanical system with its inherent physical effects like balancing inertial forces and torques, and power smoothing especially of piston engines
- The students have the ability to perform an analysis of the motion behaviour and dynamics of rigid bodies. They are able to evaluate the impact of the different model parameters on inertial forces and to derive measures for the improvement of balancing an.

Voraussetzungen	Benotung
• Modules Mechanics I - III (e.g. from BSc Mechanical Engineering) or equivalent knowledge • Modules Mathematics I - III and Numerical Mathematics (e.g. from BSc Mechanical Engineering) or equivalent knowledge	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Machine Dynamics of Rigid Bodies [MSSiSc-5504.a]		6	0
Vorlesung Machine Dynamics of Rigid Bodies [MSSiSc-5504.b]		0	2
Übung Machine Dynamics of Rigid Bodies [MSSiSc-5504.c]		0	2

Modul: Continuum Mechanics [MSSiSc-5505]

MODUL TITEL: Continuum Mechanics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt

- Material bodies, configuration, coordinates
- Rigid body motion
- Deformation gradient
- Deformation of surface and volume elements
- Strain, stretch and shear
- Spectral decomposition of strain tensors
- Strain invariants
- Polar decomposition of the deformation gradient, stretch tensors
- Strain measures
- Velocity gradient
- Cauchy stress tensor
- Linear momentum balance
- Scalar form of the linear momentum balance
- Rotational momentum balance
- Balance of mechanical energy
- Work-conjugate stress-strain pairs
- General principles of the constitutive theory, Noll axioms
- Change of frame, objectivity
- General constitutive relation, simple materials
- Elastic materials
- Material symmetry, isotropic materials
- Hyperelastic materials
- Mock-Examination

Lernziele

During the course, the students will obtain knowledge of the principles of continuum mechanics and exercise the subject matter by considering realistic problems.

In particular, attending students will

- learn how to describe the state of strain and stress in a material body that undergoes large elastic deformations
- calculate the usual strain and stress tensors
- understand and apply the principle of balance equations
- understand the principles of the constitutive theory
- learn to apply material laws
- be able to read scientific literature on continuum mechanics.

Throughout the course, the students will use and practice the nowadays usual absolute notation for tensors. Furthermore, examples based on Cartesian and curvilinear coordinates will be considered.

Voraussetzungen

recommended:

- Module Tensor Algebra and Tensor Analysis for Engineers I

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Continuum Mechanics [MSSiSc-5505.a]		6	0
Vorlesung Continuum Mechanics [MSSiSc-5505.b]		0	2
Übung Continuum Mechanics [MSSiSc-5505.c]		0	2

Modul: Tensor Algebra and Tensor Analysis for Engineers I [MSSiSc-5506]

MODUL TITEL: Tensor Algebra and Tensor Analysis for Engineers I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	4	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt

- Notion of the vector space
- Geometrical illustration of vectors
- Examples of vector spaces
- Basis and dimension of the vector space
- Components of a vector, summation convention
- Scalar product of vectors, Euclidean space
- Orthonormal basis
- Dual basis
- Second-order tensor as a linear mapping
- Right and left mapping
- Tensor product
- Representation of a tensor with respect to a basis
- Change of the basis, transformation rules
- Special operations with second-order tensors
- Tensor functions, exponential tensor function
- Transposition, symmetric and skew-symmetric tensors
- Inversion
- Scalar product of tensors
- Decomposition of second-order tensors
- Vector and tensor valued functions, differential calculus
- Coordinates in Euclidean space, tangent vectors
- Coordinate transformation, covariant and contravariant components
- Gradient, covariant derivative
- Christoffel symbols, representation of the covariant derivative
- Mock-Examination

Lernziele

Tensor algebra is the language of modern continuum mechanics and material theory. Due to the course the students will be able to read and understand modern scientific literature in this area, formulate and interpret tensor identities in absolute as well as index notation. The knowledge obtained within the course is also very helpful for the numerical implementation of finite element procedures.

Voraussetzungen

recommended:

- Basic knowledge of mathematics and in particular matrix algebra

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Tensor Algebra and Tensor Analysis for Engineers I [MSSiSc-5506.a]		6	0
Vorlesung Tensor Algebra and Tensor Analysis for Engineers I [MSSiSc-5506.b]		0	2
Übung Tensor Algebra and Tensor Analysis for Engineers I [MSSiSc-5506.c]		0	2

Modul: Tensor Algebra and Tensor Analysis for Engineers II [MSSiSc-5507]

MODUL TITEL: Tensor Algebra and Tensor Analysis for Engineers II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt

- Three-dimensional vector fields
- Divergence and curl
- Eigenvalue problem for second-order tensors
- Eigenvalues and eigenvectors
- Characteristic polynomial
- Principal invariants of a second-order tensor
- Relationships between principal invariants, principal traces and eigenvalues
- Spectral representation and eigenprojections
- Spectral decomposition of symmetric tensors
- Cayley-Hamilton theorem
- Scalar-valued isotropic tensor functions
- Representations of isotropic tensor functions
- Scalar-valued anisotropic tensor functions
- Rychlewski´s theorem
- Material symmetry
- Isotropic, transversely isotropic and orthotropic materials
- Derivatives of scalar-valued tensor functions
- Tensor differentiation rules
- Derivatives of principal invariants, principal traces and eigenvalues of a second-order tensor
- Constitutive relations for hyperelastic materials
- Tensor-valued isotropic tensor functions
- Representation theorem
- Example: constitutive relations for isotropic and anisotropic elastic materials
- Mock-Examination

Lernziele

Additionally to the results of the first part of the course, the students obtain a basic knowledge of material symmetry. They will be able to formulate constitutive relations for isotropic and anisotropic materials like fiber-reinforced composites or soft biological tissues. Due to the lectures and exercises on the field theory and differential calculus they will also be able to formulate various balance equations for solids and fluids in absolute and index notation.

Voraussetzungen

- Module Tensor Algebra and Tensor Analysis for Engineers I

recommended:

- Basic knowledge of mathematics and in particular matrix algebra

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Tensor Algebra and Tensor Analysis for Engineers II [MSSiSc-5507.a]		6	0
Vorlesung Tensor Algebra and Tensor Analysis for Engineers II [MSSiSc-5507.b]		0	2
Übung Tensor Algebra and Tensor Analysis for Engineers II [MSSiSc-5507.c]		0	2

Modul: Nonlinear Structural Mechanics [MSSiSc-5508]

MODUL TITEL: Nonlinear Structural Mechanics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	3	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction and motivation: • Brief review of FE discretisation (solid vs. shell elements) • Brief review of linear statics and dynamics of structures • Structural nonlinearity: stress stiffening/softening, buckling, effect on nonlinear vibrations • Review of classical kinematical hypotheses (Bernoulli / Kirchhoff-Love), shortcomings, necessity of refined hypotheses • Index notation, Einstein summation convention • Kronecker symbol and associated rules • Scalar and vector product, matrix multiplication in index notation • Convected coordinates, parameter lines for a 3-D body • Co- and contravariant base vectors • Examples: cylindrical and spherical geometry • Co- and contravaiant metric tensor components • Co- and contravariant vector and tensor components • Vector product of base vectors, permutation tensor, metric tensor determinant • Surface parameter lines • Co- and contravariant surface base vectors, normal vector • Surface metric and permutation tensor • Equations of Gauss and Weingarten • Christoffel symbols • Curvature tensor of a surface • Geometrical considerations (length, area and volume elements) in the shell space, at the reference surface, at the bounding surfaces, and at the lateral boundary • Deformed configuration • Base vectors of the deformed configuration • Covariant derivative • Shifter tensor, mean and Gaussian curvature • Principle of virtual displacements • Internal and external virtual work • Definition of stresses and strains • Strain tensor for von Kármán-type nonlinearity • Strain-displacement relations for tangential, transverse shear and transverse normal strains • First-order shear deformation hypothesis • Interpretation of the kinematical variables, rotations at the reference surface • Outlook: Refined hypotheses • Nonlinear strain-displacement relations for first-order shear deformation (Reissner-Mindlin) plate and shell theory • Transition to Kirchhoff-Love plate and shell theory / Bernoulli beam theory • Internal virtual work • Internal stress resultants • Theorem of Gauss	• The students know the important steps and features of consistent modelling of 2-D and 1-D structures for linear and nonlinear static and dynamic analysis. • The students are able to understand structural theories (e.g. in commercial FE-codes, in scientific publications etc.), to classify them, and to estimate the consequences of underlying hypotheses for the quality of obtainable simulation results. • The students can transfer theoretical models to actual engineering problems (e.g. arbitrary geometries, arbitrary boundary conditions). • The students are able to analyse simulation results with respect to the quality of the adopted structural model. • The students are able to use their obtained knowledge in order to develop new theoretical models in the sense of a generalisation. • The students are able to critically assess the consistency and correctness of structural models.

• External virtual work (surface tractions, body forces, inertia forces) • Surface load couples, boundary load couples • Body couples, inertia couples • Nonlinear equilibrium equations • Static boundary conditions	
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in mechanics (statics, strength of materials, dynamics)	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Nonlinear Structural Mechanics [MSSiSc-5508.a]		5	0
Vorlesung Nonlinear Structural Mechanics [MSSiSc-5508.b]		0	2
Übung Nonlinear Structural Mechanics [MSSiSc-5508.c]		0	1

Modul: Computational Contact Mechanics [MSSiSc-5509]

MODUL TITEL: Computational Contact Mechanics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	4	jedes 2. Semester	WS 2010/2011	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Introduction • Course outline • Historical review • Overview of current research topics Rigid body contact and impact mechanics • Sticking and sliding contact • Momentum balance during impact Contact illustrated on a simple test case • Mathematical formulation of contact constraints • Overview of numerical contact algorithms Review of continuum mechanics • Tensor algebra and analysis • Kinematics, balance laws and constitution • Energy methods Analytical contact mechanics • Half-space theory • Hertzian contact and the JKR theory • Elastic foundation approach The contact boundary value problem • Contact equilibrium • Strong form and weak form statements Contact kinematics • Normal contact • Tangential contact Contact constitution • Normal contact: repulsion and adhesion • Tangential contact: sticking and sliding Review of finite element methods • Finite element discretization • Solution strategies • Consistent linearization Contact discretization: Frictionless contact with a rigid body • Penalty method • Lagrange multiplier method • Augmented Lagrange multiplier method Contact discretization: Frictional contact with a rigid body • Slip criterion • Evolution law	• The students have clear knowledge of the foundations and methods of contact mechanics • The students understand the mechanisms governing contact, friction and adhesion • The students can identify the various contact formulations used in commercial finite element packages and know their advantages and disadvantages • The students understand the difficulties of complex contact simulations • The students are capable of deriving and implementing the basic finite element relations for general contact problems.

• Predictor-corrector algorithm Contact discretization: Contact between deformable bodies • General formulation • Contact linearization • Segment to segment formulations Contact algorithms • Global contact search • Local contact search Multiscale contact • Nanoscale contact • Multiscale methods Advanced topics in contact mechanics • Thermo-mechanical contact • Rolling contact • Cohesive zone modeling	
Voraussetzungen	**Benotung**
recommended: • a course on Continuum Mechanics • a course on Finite Element Methods	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Computational Contact Mechanics [MSSiSc-5509.a]		5	0
Vorlesung Computational Contact Mechanics [MSSiSc-5509.b]		0	2
Übung Computational Contact Mechanics [MSSiSc-5509.c]		0	2

Modul: Finite-Element-Technology [MSSiSc-5510]

MODUL TITEL: Finite-Element-Technology

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	3	jedes 2. Semester	SS 2011	German or English (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Repetition of the basic equations of mechanics (linear elasticity theory) • Discussion of the performance of different finite element formulation taking numerical efficiency and accuracy into account • Explanation of terms locking, hourglass-instability • Introduction of different finite element technologies which are also being utilized in practical applications for improving the behavior of the standard finite element method: • Reduction of integration with hourglass stability • Enhanced strain method • B Bar method Practical examples: structures from steel and ferro-concrete Practical training: computing with commercial software / programming systems	• Knowledge of classical finite element method • Understanding of arising problems using the method • Knowledge of appropriate finite element technology to improve the numerical results • Security in applying the finite element method • Safe use of commercial software systems
Voraussetzungen	**Benotung**
For attending the exam: successful passing of practical training	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Finite-Element-Technology [MSSiSc-5510.a]		6	0
Vorlesung Finite-Element-Technology [MSSiSc-5510.b]		0	2
Übung Finite-Element-Technology [MSSiSc-5510.c]		0	1

Modul: Plasticity and Fracture Mechanics [MSSiSc-5511]

MODUL TITEL: Plasticity and Fracture Mechanics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	3	jedes 2. Semester	SS 2011	German or English (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Discussion of the plastic behavior of metallic materials in one-dimensional experiment • Multi-axial stress and strain state, principal stresses, invariants • Principles of plasticity theory according to von Mises: yield condition, evolution equations, Kuhn-Tucker conditions, elasto-and viscoplasticity, isotropic and kinematic hardening • Numerical treatment of evolution equations on the basis of explicit and implicit proceedings • Algorithmic implementation of the plastic material laws in the finite element method • Design criteria in fracture mechanics, Griffith theory • Practical training: Computing and dealing with commercial FE programs	• Understanding of the plastic behavior of metallic building materials • Knowledge about the formulation of a plastic material model • Understanding of the numerical implementation and integration of the plastic material law in the finite element method • Safe handling in the application of the finite element method • Knowledge of the fundamentals of fracture mechanics
Voraussetzungen	**Benotung**

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Plasticity and Fracture Mechanics [MSSiSc-5511.a]		6	0
Vorlesung Plasticity and Fracture Mechanics [MSSiSc-5511.b]		0	2
Übung Plasticity and Fracture Mechanics [MSSiSc-5511.c]		0	1

Modul: Mechanics of Materials [MSSiSc-5512]

MODUL TITEL: Mechanics of Materials

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	8	5	jedes 2. Semester	WS 2010/2011	

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Discussion of material behavior of steel according to experimental results • Development of suitable material models regarding: flow behavior, hardening, anisotropy • Discussion of material behavior of reinforced concrete (steel) according to experimental results • Development of suitable material models regarding: Material heterogeneity, compression tension asymmetry, shrinkage, creep • Numerical implementation in the scope of the finite element method • Involving the effect of temperature • Comparing experiment-simulation, parameter identification • Practical training: computing with commercial software/programming systems	• Understanding of various styles in material behavior of important building materials • Knowledge of various three-dimensional material models • Knowledge of the integration of material modeling in the finite element method • Security in applying the finite element method • Knowledge of typical processes regarding mechanics of materials; experimental observation, modeling, simulation, parameter identification
Voraussetzungen	**Benotung**

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Mechanics of Materials [MSSiSc-5512.a]		8	0
Vorlesung Mechanics of Materials [MSSiSc-5512.b]		0	3
Übung Mechanics of Materials [MSSiSc-5512.c]		0	2

Modul: Practical Introduction to FEM-Software I [MSSiSc-5513]

MODUL TITEL: Practical Introduction to FEM-Software I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	3	jedes 2. Semester	SS 2014	Englisch

INHALTLICHE ANGABEN

Inhalt

- General introduction, development of FEM program, ANSYS (graphical interface)

Modeling and calculation of frameworks with ANSYS
Modeling of beam structures
ANSYS commandos, Working with input data
Post processing for beam elements

- General introction in FEM program CALCULIX

Modeling and calculation of beam structures with CALCULIX
Data exchange between ANSYS - CAlCULIX

- Introduction in 2D modeling with ANSYS (part 1)

2D element types, free networking, boundary conditions, network density, post processing
Commandos for 2D modeling in CALCULIX
boundary conditions, network density, post processing

- Introduction in 2D modeling with ANSYS (part 2)

Structured networking (mapped mesh), 'bottom up'-/ 'top down' - approach
ANSYS commandos for heat transfer problems

- APDL, Element types, boundary conditions, h- and p-method

Post processing, estimation of errors

- ANSYS 3D modeling (part 1), geometry creation, selection and grouping commands
- 3D models (part 2), ANSYS- and CALCULIX commandos, 3D element types
- 3D models (part 3), ANSYS- and CALCULIX commandos, extrusion of 2D models.
- Project work, modeling
- Project work, modeling, calculation, post processing
- Project work, documentation, report
- Revision course

Lernziele

Fachbezogene Lernziele:

Providing an overview and introduction to Finite Element Software The students will: - Have sufficient practical and theoretical knowledge for the use of ANYSS and CALCULIX - be able to create smaller 2D and 3D FE models - be able to solve linear structural and heat transfer problems - Understand the concept of 'Solid Modelling' and networking - Know the most important commands for creating input files - Know how to define boundary conditions and loading cases - Be able to test smaller FE models and to analyze possible errors - Be able to critically review the computing results in the post processor - Be able to deduce practical construction instructions from an FE calculation
Nicht fachbezogene Lernziele:

The students will - learn to work on a task in a team and to document and present the results in the form of a report - learn how to analyze problems - learn how to develop solutions and to evaluate them

Voraussetzungen

Empfohlene Voraussetzungen (z.B. andere Module, Fremdsprachenkenntnisse, …):

- Command of English

Voraussetzung für (z.B. andere Module, ...):

- Practical Introduction to FEM-Software II

Benotung

- 1 written exam, 120 min (100%)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Klausur Practical Introduction to FEM-Software I [MSSiSc-5513.a]	120	5	0
Vorlesung/Labor Practical Introduction to FEM-Software I [MSSiSc-5513.bd]		0	3

Modul: Nonlinear Finite Element Methods for Solids [MSSiSc-5514]

MODUL TITEL: Nonlinear Finite Element Methods for Solids

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	4	jedes 2. Semester	SS 2014	englisch (auf Wunsch der Hörer auch auf Deutsch)

INHALTLICHE ANGABEN

Inhalt	Lernziele
1. Introduction: Course outline, Historical review, Overview of current research topics 2. Mechanics of a nonlinear 1D bar: Equilibrium, kinematics and material modeling, Strong form and weak form 3. FE formulation of the 1D bar: FE discrezation and interpolation, Derivation of FE arrays, Newton-Raphson iteration 4. 1D FE code structuring: FE solution algorithm, Boundary conditions, Efficient coding 5. Elastoplasticity of a 1D bar: Elasto-plastic material behavior, Corresponding solution algorithms, FE implementation 6. Review of continuum mechanics: Tensor algebra and analysis, Kinematics and balance laws, Variational methods 7. Continuum constitutive theory: Hyperelasticity, Stress tensors and matrial tangent 8. 2D FE formualtions: FE discretization and interpolation, Derivation of the finite element arrays, Isoparametric concept, numerical quadrature 9. Consistent linearization: Derivation of the FE tangent matrices, Voigt notation 10. 2D FE code structuring: Solution algorithm, Efficient coding, Data management 11. Boundary conditions: Application of Direchlet and Neumann BC, Periodic BC 12. FE mesh generation: Basic mesh generation, Commercial mesh generation tools 13. Postprocessing: Stress smoothing, Data visualization 14. Error estimation: Convergence, Error measures 15. Advanced topics in nonlinear FEM: Adaptivity, FE^2, Isogemetric analysis	Fachbezogen: The Students • have clear knowledge of the foundations and methods of solid mechanics • understand the principles behind FE formulations for solids • can contruct FE formulations for given solid models • can implement these fomulations into FE codes • understand the difficulties and disadvantages of FE approaches
Voraussetzungen	**Benotung**
Empfohlene Voraussetzungen: • A course on Continuum Mechanics or Strength of Materials (Technische Mechanik II)	• one oral exam (max. 45 min) (50%) • one written report (50%)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Mündl. Prüfung Nonlinear Finite Element Methods for Solids [MSSiSc-5514.a]	45	5	0
Vorlesung/Übung Nonlinear Finite Element Methods for Solids [MSSiSc-5514.bc]		0	4

Modul: Medical Technology I [MSSiSc-5601]

MODUL TITEL: Medical Technology I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	4	jedes 2. Semester	WS 2009/2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• **Introduction to medical technology:** • Development, fields of action and boundary conditions of medical technology; overview on diagnosis and therapy technology • **Medical imaging (I):** • Basics, in particular of X-ray imaging (incl. CT), magnetic resonance tomography and ultrasound imaging • Imaging of materials and structures (morphology / physical / mechanical properties,...,function) • Consideration of specific interactions when choosing materials and design • **Biocompatibility und biofunctionality:** • Definition und meaning of biocompatibility and biofunctionality; test methods; tissue properties; reactions of the human organism • **Biomechanics:** • Overview and basics of biomechanics, meaning in diagnosis and therapy technology • Biomechanics of supporting and locomotor apparatus, implants, endo- and exoprotheses (selected examples) • Short overview on biomechanics of heart and circulation, breathing, kidney, replacement and supporting systems • **Hygiene and hygiene technology:** • Basics of hygiene; techniques and active principles of disinfection and sterilization; components and designs of sterilizable instruments and devices; hospital hygiene • **Biomaterials:** • Introduction and overview; mechanical properties, corrosion resistance, biocompatibility and main application fields of metallic substances (incl. FGL) • Production and processing, sterilization and biocompatibility, properties and applications of biocompatible synthetic polymers • Degradation mechanisms of biodegradable polymers; structure and properties, extraction, processing and application of natural polymers • Production, properties and applications of ceramic substances and fiber composites in medical technology • **Selected production techniques in medical technology:** • Generative production of individual implants, coating of implants, production of cell supporting systems • **Medical device legislation, quality and security:** • Overview, legal framework, conformity evaluation processes, quality and risk management, security concepts, protective measures and safety	The students • have basic knowledge of medical technology (materials, designs, requirements and boundary conditions, ...) as introduction, in particular for the mechanical design part of the development of instruments and devices or organ replacement and supporting systems, and with this they have a basis for further lectures in the field medical technology, • are able to list and explain different application areas and examples as well as specific boundary conditions in medical technology for diagnosis and therapy, • know the most important image processing techniques in medicine and are able to explain their physical principles; they are able to apply this knowledge when choosing materials for the construction of components and systems, • know the basics of displaying biological as well as artificial materials and structures in medical image data and are able to interpret these correspondingly or to choose image processing modalities for their representation, • are able to explain the terms biocompatibility and biofunctionality and their meaning for medical technical products; in this context, they know test criteria and test procedures for substance and surface properties and are able to assign and explain these; they know basic tissue properties and tissue reactions, • know the basics of biomechanics and are able to explain the meaning for the design of medical technological products, • know the meaning of hygiene in medical technology, are able to explain procedures and active principles of disinfection and sterilization and to apply this knowledge for the development and evaluation of technological solutions, • know appropriate construction materials and design principles for different medical technological applications and are able to explain their special aspects with respect to characteristics, production and application, and to use this knowledge during design synthesis and evaluation, • know the basics of selected manufacturing methods for the production of individual implants, for the coating of implants as well as of cell carrier systems, are able to explain them and to use and deepen this knowledge when choosing or developing design solutions, • know the basics of legislative as well as normative requirements for the approval of medical products and their consequences for the development; they are able to apply their knowledge regarding special boundary conditions und safety requirements in medical technology on the evaluation of medical technological solutions. • The students are able to individually work on a topic with the help of given interdisciplinary literature, to supplement it with own research and to analyze and evaluate it from the engineering point of view. They are able to present, explain and discuss interdisciplinary as well as engineering aspects of the topic.

Voraussetzungen	Benotung
recommended: • Module *Introduction to Medicine* (e.g. from BSc Mathematics) or equivalent knowledge • Basic knowledge in physics, mathematics • Basic knowledge of mechanical engineering	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Medical Technology I [MSSiSc-5601.a]		6	0
Vorlesung/Übung Medical Technology I [MSSiSc-5601.bc]		0	4

Modul: Computer Assisted Surgical Technology [MSSiSc-5602]

MODUL TITEL: Computer Assisted Surgical Technology

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• **Introduction to surgery and surgical technology:** • History, tasks and goals, ´minimal invasive surgery (MIS)´ • Workplace Operating Room (OR) • Surgery instruments and equipment technology (overview) • **Specific boundary conditions:** • Hygiene • Technical safety • Regulations by law and normative requirements • **Data acquisition / perception:** • Image processing techniques in surgery (2-3D fluoroscopy, CT, (open) MR, ultrasound, endoscopy, ...), context specific characteristics, techniques, integration in the intraoperative work process, application areas • Intraoperative measurement techniques (3D position and force sensors, ...), ´smart instruments´ • Further data / information sources (morphological and functional atlases, implant databases, statistical models, ...) • **Extraction and combination of information / cognition I:** • Signal and image analysis techniques, segmentation (basics) • Multi-modal reference techniques (PTP, ICP, rigid / elastic) • **Cognition II / Planning:** • Pre- vs. intra-operative planning systems: basics and applications (orthopaedic and trauma surgery, dental and craniofacial surgery, neuro and radiation therapy, ...) • Production and application of physical planning models • Computer assisted planning and production of individual implants and devices • **Design I / navigation techniques:** • Stereotaxy • Intraoperative registration techniques (mechanical / kinematical, optical, ultrasonic and fluorescopical techniques, 3D morphing) • Dynamic referencing, measurement techniques, medical and technical limits and trends • Planning-based power regulation (´navigated control´) • Image based and image-free navigation • Man-machine-interaction (MMI) / limits • **Design II / robotics:** • Systems and safety approaches of surgical robotic systems; embodiments, kinematics • Semiactive / synergistic and active robotic systems • Applications: robots in orthopedics, neuro surgery and radiation therapy ... • Developments and trends	The students • know and understand the basics, developments and trends of computer assisted surgery and the features of the medical-technical context, • know basic technological components and process steps and are able to explain their functionality, • know the relevant multi-modal data sources and imaging methods in computer assisted therapy and are able to explain the most important characteristics and limits in this context, • know and understand procedures for the extraction and combination of multi-modal information on the basis of signal and imaging analysis techniques as well as referencing techniques and are to explain these, • are able to apply the knowledge learned and to experimentally test it, • know and understand the basics and techniques of computer assisted planning and production of individual physical planning models and are able to explain them, • know and understand components and techniques of intraoperative referencing and navigation as well as their theory basics, characteristics and limits, are able to explain and apply them on examples, • know embodiments, characteristics and applications of robotic and manipulator systems in surgery and are able to explain these. • The students are able to apply the knowledge learned in practical tutorials on examples in the fields of mathematics, measurement technology, image processing, mechanics and programming in C++ on the basis of an independent problem analysis and to experimentally verify it (method competence). • The implementation and experimental tests in tutorials are partially done in small groups, in order to enhance collective learning processes (team work).

• **Surgical (tele-) manipulators:** • Requirements in MIS • Embodiments, kinematics, systems • Applications and technical features • Challenges, limits, trends • Repetitorium (on request)	
Voraussetzungen	**Benotung**
recommended: • Module *Medical Technology I* • Module *Introduction to Medicine* (e.g. from BSc Mathematics) or equivalent knowledge • Basic knowledge in physics, mathematics • Basic knowledge of mechanical engineering	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Computer Assisted Surgical Technology [MSSiSc-5602.a]		6	0
Vorlesung Computer Assisted Surgical Technology [MSSiSc-5602.b]		0	2
Übung Computer Assisted Surgical Technology [MSSiSc-5602.c]		0	2

Modul: Approval and Usability of Technical Medical Devices [MSSiSc-5603]

MODUL TITEL: Approval and Usability of Technical Medical Devices

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• **Introduction to medical device legislation** • Development, goals and regulations of medical device legislation - Norms and standards • General aspects of German and international regulations (Europe, USA, ...) • Classification of medical devices • **Market approval and use of medical devices** • Regulations, requirements and process steps • National and international procedures • Operation of medical devices • Actions in case of critical incidents / adverse events • **Concept and procedure of the usability engineering process** • Normative background • Motivation and goals • Integration into the product development process • Definition of intended use and use scenarios • Methods and tools • User participation • **System ergonomics in medicine: basics of medical device ergonomics** • Motivation and goals • Definition and basics of ergonomics • Perception and mental models • Requirements of the medical work environment • Methods for the design process • Methods for ergonomic evaluation • **System ergonomics for medical devices** • Standards and guidelines • Components and system interaction in the operating room workspace • Load and stress • Reliability, fault tolerance and context acceptability • **Human-machine-interaction in the clinical context** • Problem examples and use errors • Contextual suitability of different human-machine-interfaces of information in- and output • Dialogue and information design • Medical software ergonomics • **Procedures and methods for the validation of clinical usability** • Normative guidelines • Aspects of clinical usability • Influence and definition of the validation environment • Planning, execution and evaluation of usability tests • Integration in the product development process • **Risk management for medical devices** • Definition and evaluation of risks in the clinical context	• The students learn basic knowledge and develop general understanding regarding requirements and approaches to the approval/market authorization of medical technological products. • Main emphasis is put on the field of medical product ergonomics, risk management regarding man-machine-interaction as well as usability engineering as substantial normative requirements for approval. • Here the students learn and experimentally experience the concept and realization of a usability engineering process, as well as appropriate design and validation methods and tools. • The basic knowledge of system ergonomics forms the fundamental basis for the understanding and realization of the usability processes and is reflected in the learning targets as well as in the lecture itself. Practical exercises deepen the gained knowledge by instructed individual application on tangible examples.

• Normative guidelines • Integrated risk management process • FMEA and FTA, resp. Combination • Planning and execution of a system risk analysis • Classification and impact of countermeasures • **Usage and use errors - risk analysis of human-machine-interaction in the clinical workflow** • Classification of human error • Stress and strain model and analysis methods • Determination high-risk fields in clinical workflows • ´Risk factor´ human • Methods of quantification of human error • Experiences of other technical fields (nuclear power, airplane control) • **Clinical evaluation** • Legal and normative background of clinical evaluation as market approval requirements • Clinical evaluation and clinical tests • Prerequisites, requirements and execution of clinical tests • Therapy trial and therapy freedom • **Quality management as market authorization pre-requisites** • Legal and normative background • Classification as market approval precondition • V-model, procedure and documents of the quality management process • **Repetitorium, examples**	
Voraussetzungen	**Benotung**
recommended: • Module Medical Technology I	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Approval and Usability of Technical Medical Devices [MSSiSc-5603.a]		4	0
Vorlesung Approval and Usability of Technical Medical Devices [MSSiSc-5603.b]		0	2
Übung Approval and Usability of Technical Medical Devices [MSSiSc-5603.c]		0	1

Modul: Cell Culture and Tissue Engineering [MSSiSc-5604]

MODUL TITEL: Cell Culture and Tissue Engineering

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	3	jedes 2. Semester	WS 2012/2013	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Laboratory Setup • Biology of the cultured cell • Stem cell biology • The differentiated phenotype • Biochemical analysis of cells • Biosafety and ethics • Regulatory affairs • Fermentation technology • Bioreactors • Exam • TE Soft Tissues and Meshes • TE Nerve Tissue • TE Bone and Cartilage • TE Cardiovascular • Exam	• Cell Culture • Tissue Engineering
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Cell Culture and Tissue Engineering [MSSiSc-5604.a]		5	0
Vorlesung Cell Culture and Tissue Engineering [MSSiSc-5604.b]		0	2
Seminar Cell Culture and Tissue Engineering [MSSiSc-5604.e]		0	1

Modul: Artificial Organs I [MSSiSc-5605]

MODUL TITEL: Artificial Organs I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	3	jedes 2. Semester	WS 2011/2012	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
This module deals with application of artificial internal organs with some examples for other organs e.g. sensory organs, their pathophysiological backgrounds, and clinical indication. In this module, the students will learn the application of heart lung assist devices for short and long term therapies. They will learn the different types and functions of membrane lungs (oxygenators) and their membrane properties such as gas transfer capacity. Furthermore, the various types of blood pumps such as pulsatile and non-pulsatile flow systems for intra- and extracorporeal applications are included. In addition, they will learn the current and future technologies, designs, and the industrial realizations of the above mentioned devices, as well as for the heart valve repair or replacement.	The course should provide the students with a sufficient theoretical knowledge combined to the acquired practical skills necessary for a solid and competent background demanded for this specific field.
Voraussetzungen	**Benotung**
Anatomy, Physiology, Physics, Chemistry. The mark of the modul is composed of the mark of the exam, attendance at the lectures, practical courses and / or exercises. Attendance at the lectures is voluntary, but attendance at the practical courses and / or exercises is compulsory.	Written exam, duration 90 - 120 min; 50% of points are necessary to pass

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Artificial Organs I [MSSiSc-5605.a]		5	0
Vorlesung Artificial Organs I [MSSiSc-5605.b]		0	2
Praktikum Artificial Organs I [MSSiSc-5605.g]		0	1

Modul: Artificial Organs II [MSSiSc-5606]

MODUL TITEL: Artificial Organs II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	3	jedes 2. Semester	WS 2011/2012	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Students will learn how to assess the kidney and liver functions in man. They will be introduced to clinical physiology of these organs, and their pathophysiological aspects and also the complex syndromes resulting from renal and liver failure. On the other hand, they will learn the extracorporeal techniques, membrane properties for mass transport operations based on diffusion, and on filtration including adsorption for detoxification. Such membranes are used in haemodialysis, haemofiltration, and haemodiafiltration. Students will be also introduced to the current devices of non-cell-based liver dialysis systems, as well as cell-based liver support therapeutic systems.	The students have to learn the technical aspects of membrane-technology and mass-transfer procedures involved in extracorporeal circulations. The course should provide the students with a sufficient theoretical knowledge combined to the acquired practical skills necessary for a solid and competent background demanded for this specific field.
Voraussetzungen	**Benotung**
Anatomy, Physiology, Physics and Chemistry. The mark of the modul is composed of the mark of the exam, attendance at the lectures, practical courses and / or exercises. Attendance at the lectures is voluntary, but attendance at the practical courses and / or exercises is compulsory.	Written exam, duration 90 - 120 min; 50% of points are necessary to pass

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Artificial Organs II [MSSiSc-5606.a]		5	0
Vorlesung Artificial Organs II [MSSiSc-5606.b]		0	2
Praktikum Artificial Organs II [MSSiSc-5606.g]		0	1

Modul: Biological & Medical Fluid Mechanics I [MSSiSc-5607]

MODUL TITEL: Biological & Medical Fluid Mechanics I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	3	3	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction: Transport processes in the human body (exchange of respiratory gases, uptake of nutrients, Pfortader & Lymphe, removal of urine-compulsory substances, blood circulation) • Introduction: Transport processes in medical technical systems, tasks of fluid mechanics in medicine • Blood as a transport medium: Tasks, composition and distribution, red blood cells (RBC), red blood dye, membrane of the red blood cells, Decomposition of the red blood cells • Rheology of the blood: Definitions, flow behaviour of suspensions, blood as a suspension of flexible particles • Viscosity of the blood: Methods to measure viscosity (sphere drop viscosmeter, capillar viscosimeter for Newtonian and Non-Newtonian fluids, Cone-Plate-Rheometer, Couette-Rheometer) • Viscosity models for blood plasma and whole blood: Copley, Chmiel, Casson, Merville & Pelletier • Influences on the blood viscosity: Explication of the experiments, physiological meaning of the Fafraeus-Lindquist-Effect • Blood flow: Summary of the flow behaviour of blood in small vessels, patho-physiological influences on the viscosity of blood • Blood damage, haemolysis: General remarks, blood damages conditioned by the flow, observation in medical systems, measurement of the haemolysis • Blood damage, haemolysis: Investigations on haemolysis in inductor organs, investigations of the influence of static pressure, investigations on the influence of the shear stresses • Blood damage, haemolysis: Historical overview, experimental determination of the influences of shear stress amount and load period on erythrocytes, sub-lethal damage of the red blood cells • The heart circulation system: Task and anatomy of the heart, Volume- and pressure course in the heart during heart contraction • The heart circulation system: Important heart measures and their normal values, regulating mechanisms of the heart, Frank-Sterling-Mechanism • The heart circulation system: The PV-diagram of the heart, anatomy of blood vessels	The students will learn the fundamental characteristics of medical and biological flows
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungs-dauer (Minuten)**	**CP**	**SWS**
Prüfung Biological & Medical Fluid Mechanics I [MSSiSc-5607.a]		3	0
Vorlesung Biological & Medical Fluid Mechanics I [MSSiSc-5607.b]		0	2
Übung Biological & Medical Fluid Mechanics I [MSSiSc-5607.c]		0	1

Modul: Biological & Medical Fluid Mechanics II [MSSiSc-5608]

MODUL TITEL: Biological & Medical Fluid Mechanics II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	3	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction: Fluid mechanics in medicine and biology • Mathematical models for flow simulation of biological systems: The healthy human heart • Technical models for flow simulation of biological systems: Tasks, similarity rules, prerequisites (anatomy, physiology, technical prerequisites) • Measurement techniques: Pressure measurements, Particle-Image Velocimetry, flow visualization techniques • Flow in flexible vessels: Basic equations, propagation of pressure waves • Respiratory system: Fundamentals, components, tasks, the nose (anatomy, task, flow field in the human nasal cavity) • Respiratory system: Task and function of the lung (physical and physiological description), gas exchange in the respiratory system (diffusion, convection) • Respiratory system: pressure-volume diagram of the lung, flow field in the upper human airways, flow in bifurcations • Artificial organs: Introduction, definitions, oxygenators (function, types, basic equations) • Artificial organs: Heart valves, heart assist devices, mechanical hearts • Quality assurance for medical devices: Fundamentals, methods, certification, measurement and testing technology • Biological receptors and sensors for flow fields: Introduction, tasks, examples (baroreceptor, regulation of the cardiovascular system, hearing organ, equilibrium organ, lateral line system of fish) • Locomotion of animals in fluids: submerged bodies, Reynolds number dependence, adaption of bodies to flow fields, Drag of submerged bodies • Examples for flows around biological system: aerodynamics of bird flight and insect flight, fluid mechanical concepts for drag reduction (optimized body shape, surfaces for friction reduction, formation flight, winglets)	The students will learn the fundamental characteristics of medical and biological flows

Voraussetzungen	Benotung
• Module Biological & Medical Fluid Mechanics I	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Biological & Medical Fluid Mechanics II [MSSiSc-5608.a]		3	0
Vorlesung Biological & Medical Fluid Mechanics II [MSSiSc-5608.b]		0	2
Übung Biological & Medical Fluid Mechanics II [MSSiSc-5608.c]		0	1

Modul: Basic Physics of Medical Imaging [MSSiSc-5609]

MODUL TITEL: Basic Physics of Medical Imaging

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Diagnostic Radiology • Nuclear Medicine • Magnetic Resonance Imaging	• understand the basic physics of medical imaging including conventional diagnostic radiology with a focus on x-ray techniques, nuclear medicine with a focus on photon emission tomography (PET), and magnetic resonance imaging (MRI) • outline key hardware components used in x-ray, Pet and MRI • survey clinical applications • gain an insight into potential career opportunities • lead and practice team work during tutorials
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in physics • Basic knowledge in mathematics, in particular Fourier transformation	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Basic Physics of Medical Imaging [MSSiSc-5609.a]		6	0
Vorlesung Basic Physics of Medical Imaging [MSSiSc-5609.b]		0	2
Labor Basic Physics of Medical Imaging [MSSiSc-5609.d]		0	2

Modul: Computational Molecular Biology [MSSiSc-5610]

MODUL TITEL: Computational Molecular Biology

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	3	jedes 2. Semester	SS 2011	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
PART A: Structural Biology • Structure of cytoplasmatic and membrane proteins, structure of the nucleic acids • Disordered proteins • Thermodynamics of protein/ligand interactions • Computer-aided drug design • Physical basis of protein function, metabolism, cytoskeleton • Molecular basis of human perception • HIV-1 attack of human cell: a molecular perspective • Protein assembly (protein-protein complexes, protein-protein interactions in protein dimers, crystals and virus capsids) Exercises: • Presentation by each student regarding structure and function of a protein PART B: Structural Bioinformatics • Evolutionary processes and phylogenetic trees • Sequence searching: pattern matching and BLAST • Sequence alignment • Principles of Information Theory and Thermodynamics • Secondary structure assignment and prediction • Tertiary structure: from random coil to stable fold • Tertiary structure prediction and modeling • Protein interactions: complexes and networks • Genome analysis and comparison • Programming guidelines and algorithms Exercises: • Homology modeling (including BLAST, multiple alignment, target selection, model evaluation • Data analysis with R (principles of R, benchmarking (ROCR), structure analysis (BIO3D)) PART C: Molecular modeling • Electrostatic modeling • Energy minimization based on force fields • Molecular dynamics • Molecular docking	Provide a molecular basis of life processes for students who are willing to use informatics and calculus.

Exercises: • Setting up and running of an MD simulation of a small peptide (Ala-Ala-Ala) using the open source codes NAMD code (www.ks.uiuc.edu/Research/namd/) and gromacs (www.gromacs.org) • Energy minimization • Molecular dynamics in aqueous solution • Conformational analysis • MD-based structural predictions in molecular medicine: High-throughput analysis of all of prion-diseases linked mutations involving the prion's globular domain	
Voraussetzungen	**Benotung**
Basic knowledge of electrostatics, thermodynamics, statistical mechanics, quantum mechanics	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Computational Molecular Biology [MSSiSc-5610.a]		5	0
Vorlesung Computational Molecular Biology [MSSiSc-5610.b]		0	2
Übung Computational Molecular Biology [MSSiSc-5610.c]		0	1

Modul: Introduction to System Biology [MSSiSc-5611]

MODUL TITEL: Introduction to System Biology

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	3	2	jedes 2. Semester	WS 2011/2012	German or English (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• The course covers the basics of quantitative analysis and modeling of biological systems with a focus on biomedical engineering. The basic statistical and mathematical methods will be presented and discussed with examples. • Statistical concepts of multivariate data analysis for arrays • Model reduction method for corregulated data (PCA, SVD, NMF) • Validation of array analysis • Dynamic modeling of metabolic and signal transduction pathways • Modeling of networks • Modeling concepts of organs and tissues	The students know the • basic concepts for multivariate data analysis, application and validation. They know the strengths and weaknesses of the most common approaches for pattern recognition • concepts of dynamic systems theory with relevance for modeling of biological systems (Fix point, linearization, limit cycle) • The students know the concepts and workflow of reaction kinetic modeling and the constraints in modeling metabolism and signal transduction. • concepts of population dynamic models
Voraussetzungen	**Benotung**
Recommended: • Basic knowledge in linear algebra, ordinary differential equations and reaction kinetics Required: • Basic knowledge of bioinformatics and statistics	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Introduction to System Biology [MSSiSc-5611.a]		3	0
Vorlesung Introduction to System Biology [MSSiSc-5611.b]		0	2

Modul: Physiology [MSSiSc-5612]

MODUL TITEL: Physiology

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	2	4	3	jedes 2. Semester	WS 2010/2011	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
The physiology is introduced by cell- and epithelial physiology followed by general features of the organization of nervous system and endocrinology, muscle, blood and other body fluids, heart, circulation, respiration, kidney, liver and digestive system.	The aim is to provide a fundamental understanding of the general and cellular physiology and normal function of the major systems of the human body. Patho-physiological aspects are concerned as well as application of engineering skills e.g. knowledge in haemorheology, haemodynamic as well as gas exchange and mass transfer into the study of physiological functions of organs such as kidney, lung and cardio vascular system and their regulation and autoregulation mechanisms. The students should be prepared optimally and have the background knowledge for the study of the major modules in the following year.
Voraussetzungen	**Benotung**
Basic physics and chemistry. The mark of the modul is composed of the mark of the exam, attendance at the lectures, practical courses and / or exercises. Attendance at the lectures is voluntary, but attendance at the practical courses and / or exercises is compulsory.	Written exam after the second semester, duration 90 minutes. Minimum requirement for a pass is 50%.

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Physiology [MSSiSc-5612.a]		4	0
Vorlesung Physiology [MSSiSc-5612.b]		0	2
Praktikum Physiology [MSSiSc-5612.g]		0	1

Modul: Virtual Machine Tool - Modeling and Simulation [MSSiSc-5701]

MODUL TITEL: Virtual Machine Tool - Modeling and Simulation

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	4	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• L1: Introduction to the Machine Tool Construction • E1: WZL Machine Shop Guiding • L2: Construction of a Machining Centre • E2: Introduction to CAD Modelling • L3: Construction and Design of Structural Components • E3: Introduction to the FEA-Simulation • L4: Structure Optimisation of Stand Component • E4: Structure Optimisation of Stand Components • L5: Guiding Mechanisms • E5: Guiding Mechanisms • L6: Bearings, Main Spindle Systems • E6: Bearings, Main Spindle Systems • L7: Mechanical Drive Components • E7: Mechanical Drive Components • L8: Gears • E8: Gears • L9: Feed Drives • E9: Feed Drives • L10: Multi Body Simulation with Rigid Bodies • E10: Multi Body Simulation with Rigid Bodies • L11: Multi Body Simulation with Flexible Bodies • E11: Multi Body Simulation with Flexible Bodies	The students know the most important parameters which are relevant to model and simulate production machinery. They are aware of common simulation methods, are able to use basic features of simulations tools independently and can interpret the results.
Voraussetzungen	**Benotung**
None	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Virtual Machine Tool - Modeling and Simulation [MSSiSc-5701.a]		5	0
Vorlesung Virtual Machine Tool - Modeling and Simulation [MSSiSc-5701.b]		0	2
Übung Virtual Machine Tool - Modeling and Simulation [MSSiSc-5701.c]		0	2

Modul: Information Theory and Source Coding [MSSiSc-5801]

MODUL TITEL: Information Theory and Source Coding

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	2	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
The contents are divided into two parts: First, the fundamentals of information technology will be introduced and applied to the field of source coding. The theory part consists of the following elements which will be amended by various examples: • Discrete memoryless sources and sources with memory • Entropy, conditional entropy, and mutual information, entropy coding (Shannon code, Fano code, Huffman code, facsimile) • Performance limits of data compression The second part broadens the information theory and explains the principles of speech signal encoding. Eventually, the lecture gives an overview of state-of-the-art speech encoding technologies and their applications, for example mobile communications. Especially the following topics will be covered: • Continuous (analog) sources with memory • Sampling and quantization of analog signals • Introduction to rate-distortion theory • Linear prediction theory and differential waveform coding • Overview on the standards and applications of speech coding The lecture will be accompanied by a weekly tutorial. Usually, the training exercises will be given one week in advance. Combined with the module 'Forward Error Correction & Digital Modulation', the lecture 'Information Theory and Source Coding' can give a wide understanding of digital communication systems.	The students shall get basic understanding of information technology and source coding.
Voraussetzungen	**Benotung**
Fundamentals of communication technology	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Information Theory and Source Coding [MSSiSc-5801.a]		2	0
Vorlesung Information Theory and Source Coding [MSSiSc-5801.b]		0	2
Übung Information Theory and Source Coding [MSSiSc-5801.c]		0	1

Modul: Forward Error Correction and Digital Modulation [MSSiSc-5802]

MODUL TITEL: Forward Error Correction and Digital Modulation

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	4	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
The lecture Forward Error Correction and Digital Modulation covers several aspects of channel coding and digital modulation in modern transmission systems. The first part covers standard techniques of channel coding regarding error identification and error correction: • Linear block codes • Cyclic codes • Conventional codes and their decoding • Turbo codes In the second part we will look at baseband and the bandpass transmission. • Digital modulation • Intersymbol interference • Matched filter Examples of applications will be discussed, such as: • GSM (cyclic codes, conventional codes) • UMTS (turbo codes) Combined with the module 'Information Theory and Source Coding', the lecture 'Forward Error Correction & Digital Modulation' can give a wide understanding of digital communication systems.	The students shall obtain a fundamental understanding of digital information transmission via defect channels.
Voraussetzungen	**Benotung**
Basics of information theory	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Forward Error Correction and Digital Modulation [MSSiSc-5802.a]		4	0
Vorlesung Forward Error Correction and Digital Modulation [MSSiSc-5802.b]		0	3
Übung Forward Error Correction and Digital Modulation [MSSiSc-5802.c]		0	1

Modul: Cryptography I [MSSiSc-5803]

MODUL TITEL: Cryptography I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Classical cryptography: crypto analysis of classical codes, frequency analysis, general types of attacks • Entropy and perfect security: equivocation, redundancy, one-time pad • Fast block ciphers: DES, AES, IDEA, modes of operation • Number theoretic reference problems: primality testing, integer factorization, extended Euklidean algorithm, Chinese reminder theorem, discrete logarithm, Diffie-Hellman key agreement, Shamir´s no-key protocol • Pubilic-key encryption: basic concept, RSA encryption, security of RSA, implementation aspects • Authentification and digital signatures: challenge-and-response, RSA authentification and digital signature	The students acquire the fundamentals of modern encrypting and authentication techniques as well as of the underlying protocols and mathematical issues.
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Cryptography I [MSSiSc-5803.a]		4	0
Vorlesung Cryptography I [MSSiSc-5803.b]		0	2
Übung Cryptography I [MSSiSc-5803.c]		0	1

Modul: Cryptography II [MSSiSc-5804]

MODUL TITEL: Cryptography II						
ALLGEMEINE ANGABEN						
Fachsemester	**Dauer**	**Kreditpunkte**	**SWS**	**Häufigkeit**	**Turnus Start**	**Sprache**
2	1	4	3	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	**Lernziele**
• Advanced public key encryption • Side channel attacks • Cryptographic hash functions • Identification and entity authentication • Elliptic curve cryptography • Quantum cryptography	Students will acquire advanced knowledge about cryptographic protocols and their foundation in mathematics. They will understand corresponding standards, modern implementations and applications
Voraussetzungen	**Benotung**
recommended: Basic knowledge of cryptographic primitives, elementary number theoretic foundations	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	**Prüfungsdauer (Minuten)**	**CP**	**SWS**
Prüfung Cryptography II [MSSiSc-5804.a]		4	0
Vorlesung Cryptography II [MSSiSc-5804.b]		0	2
Übung Cryptography II [MSSiSc-5804.c]		0	1

Modul: Fundamentals of Patent and Utility Model Law [MSSiSc-5903]

MODUL TITEL: Fundamentals of Patent and Utility Model Law						
ALLGEMEINE ANGABEN						
Fachsemester	**Dauer**	**Kreditpunkte**	**SWS**	**Häufigkeit**	**Turnus Start**	**Sprache**
3	1	5	4	jedes 2. Semester	WS 2014/2015	German or English (on request)

INHALTLICHE ANGABEN	
Inhalt	**Lernziele**
The lecture procures information about German patent law and registered design rights. Students achieve knowledge in assignation, virtue and enforcement of patents and utility models. Other points of focus lie in employee invention and license agreement. The lecture is addressed to engineers confronted with questions regarding industrial property protection in their careers. It provides basics to get along with different kinds of patents in everyday life. The exercise affords the opportunity to deepen the content of practical relevant cases by means of lecture and discussion.	see content
Voraussetzungen	**Benotung**
	• 1 oral exam (20 min)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN			
Titel	**Prüfungsdauer (Minuten)**	**CP**	**SWS**
Exam Fundamentals of Patent and Utility Model Law [MSSiSc-5903.a]	20	5	0
Lecture Fundamentals of Patent and Utility Model Law [MSSiSc-5903.b]		0	2
Tutorial Fundamentals of Patent and Utility Model Law [MSSiSc-5903.c]		0	2

Modul: Electronic Structure Theory I [MSSiSc-6201]

MODUL TITEL: Electronic Structure Theory I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	8	6	jedes 2. Semester	SS 2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Atoms, molecules, electronic states, chemical bond • Electronic and ionic degrees of freedom, Born Oppenheimer approximation, molecular dynamics • Structure of Matter, crystals and symmetries, Bravais lattice • Bloch theorem, bandstructure, density of states • Homogenous electron gas, Fermi distribution, Fermi statistics • Nearly free electrons, tight binding • Metals, semiconductors and insulators • Hartree and Hartree Fock approximation • Screening, Lindhards dielectric constant • Density functional theory, mean field approaches • Random phase approximation, GW-Approximation • Local correlations, Hubbard model • Magnetism in localized electron systems • Magnetism in itinerant electron systems, Stoner Model • Relativistic effects	• Develop a basic understanding of the electronic structure of solids fundamental to all material properties. • Achieve a knowledge of the basic terms, concepts and approximations in electronic structure theory. • Learn the underlying mathematical formalism to describe electrons in solids • Develop the fundamentals needed for the application of simulation techniques. • Make contact with scientific literature in the field
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Electronic Structure Theory I [MSSiSc-6201.a]		8	0
Vorlesung Electronic Structure Theory I [MSSiSc-6201.b]		0	4
Übung Electronic Structure Theory I [MSSiSc-6201.c]		0	2

Modul: Group Theory in Solid State Physics [MSSiSc-6204]

MODUL TITEL: Group Theory in Solid State Physics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Mathematical background: basic definitions, representation theory • Character of a representation, reducible and irreducible representations; Shoenflies and Hermann-Mauguin symmetry notation • Basis functions, projection operators • Applications to quantum systems: crystal field splitting, selection rules • Electronic states of molecules and molecular vibrations • Periodic lattice: Bravais lattice, space groups • Reciprocal lattice: translational group, Bloch´s theorem, group of the wave vector • Phonons: examples of different lattices • Electronic energy levels in a crystal; Spin-orbit coupling • Double groups: properties and basis functions • Energy bands with spin • Time reversal symmetry: effect on the energy bands with and without the spin-orbit coupling • Magnetic groups • Permutation groups • Symmetry properties of tensors	• Learn the basics of the group theory and ways to simplify complex problems by using symmetry considerations • Gain understanding of symmetry-dependent properties of solids, such as phonons and electronic structure • Management of smaller team projects
Voraussetzungen	**Benotung**
recommended: • Module *Electronic Structure Theory I*	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Group Theory in Solid State Physics [MSSiSc-6204.a]		4	0
Vorlesung Group Theory in Solid State Physics [MSSiSc-6204.b]		0	2
Übung Group Theory in Solid State Physics [MSSiSc-6204.c]		0	1

Modul: Quantum Theory of Particles and Fields: 1 - Quantum Mechanics [MSSiSc-6207]

MODUL TITEL: Quantum Theory of Particles and Fields: 1 - Quantum Mechanics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	8	6	jedes 4. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• WAVE MECHANICS, One dimensional problems, • numerical solution of differential equations • WAVE MECHANICS, Problems in three dimensions, • Special functions • Scattering theory • Numerical methods for reaction theory • The hydrogen atom • External fields, Stationary Perturbation theory • Many body systems • Second quantization • Numerical methods: mean field approximation • Numerical method: Matrix iterative techniques • Linear response theory • Numerical simulation of nuclear excitations • Stability analysis • Superconducting systems • Case study: ginzburg equations • Case study: phase shift analysis	• Ability to formulate and solve problems in quantum scattering theory and many-particle theory • Independent Project Work • Team Work in the group • Presentation of the method applied and the science motivation
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Quantum Theory of Particles and Fields: 1-Quantum Mechanics [MSSiSc-6207.a]		8	0
Vorlesung Quantum Theory of Particles and Fields: 1-Quantum Mechanics [MSSiSc-6207.b]		0	4
Übung Quantum Theory of Particles and Fields: 1-Quantum Mechanics [MSSiSc-6207.c]		0	2

Modul: Quantum Theory of Particles and Fields: 2 - Quantum Field Theory [MSSiSc-6208]

MODUL TITEL: Quantum Theory of Particles and Fields: 2 - Quantum Field Theory

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	8	6	jedes 4. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt

- Classical field theories and many-particle systems. ^
- Transition from N particle to continuum and quantization in 1+1 dimensions.
- Field operators. energy, momentum and particle spectrum.
- The free scalar field, Klein-Gordon equation.
- Poincare group, scalar, vector and tensor representations.
- Symmetry transformations, Noether theorem and energy¬momentum tensor.
- Field quantization.
- The complex scalar field, normal ordering, charge operator, particles and anti-particles, charge conjugation,
- micro causality.
- Spinor representations and Dirac equation.
- Covariant transformation of the Dirac spinor, discrete symmetries.
- Majoran and Weyl spinors.
- Quantization of the Dirac field.
- Interacting fields: Pion-nucleon model.
- Time-evolution, interacting picture and Dyson's expansion.
- Asymptotic states, S-matrix and LSZ formalism.
- Wick's theorem and propagators.
- Processes of second order, symmetry factor.
- Feynman rules in position and momentum space.
- Cross sections and decay widths, phase space factors.
- Tree-level processes: nucleon-nucleon scattering.
- Quantum electrodynamics (QED):
- Classical electrodynamics and gauge principle.
- Quantization of the electromagnetic field.
- Photon propagator, Feynman rules for QED.
- Tree-level processes in QED:
- Loops and radiative corrections.
- Degree of divergence and dimensional analysis.
- Vaccum polarization in Pauli-Villars and dimensional regularization.
- Running coupling constant, Lamb shift.
- Path integrals: non-relativistic quantum mechanics.
- Scalar field theories and Feynman rules.
- Path integral formulation of Maxwell fields.
- Photon propagator and Faddeev-Popov method.
- Grassmann algebra and fields.
- Path integral formulation of fermionic fields.
- Generating functional and connected Green's functions.
- Effective action and Legendre Transformation.
- Ward-Takahashi identities and renormalization of QED to all orders.

Lernziele

- Introduction to the Quantum Theory of Field
- Optional: in continuation of the module
- Quantum Theory of Particles and Fields: 1 - Quantum Mechanicswe offer a project on the numerical analysis of an effective theory for a quantum mechanical two-body system. This deepens numerical techniques acquired in the class and introduces into the concept of the renormalization group.

- Presentation skills
- Independent project work

Voraussetzungen	Benotung
• Module Quantum Theory of Particles and Fields 1 - Quantum Mechanics	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Quantum Theory of Particles and Fields: 2 - Quantum Field Theory [MSSiSc-6208.a]		8	0
Vorlesung Quantum Theory of Particles and Fields: 2 - Quantum Field Theory [MSSiSc-6208.b]		0	4
Übung Quantum Theory of Particles and Fields: 2 - Quantum Field Theory [MSSiSc-6208.c]		0	2

Modul: Quantum Theory of Particles and Fields: 3 - Effective Field Theory [MSSiSc-6209]

MODUL TITEL: Quantum Theory of Particles and Fields: 3 - Effective Field Theory

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	8	6	jedes 4. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt

- Introduction to effective field theories (EFT) I
- Introduction of EFT II
- The concept of power counting
- The fate of symmetries: Spontaneous symmetry breaking and the Goldstone theorem
- QCD and its symmetries
- Chiral perturbation theory and pion-pion scattering
- Inclusion of heavy fields: pion-nucleon scattering
- Two-nucleon systems: extension to non-perturbative systems
- Renormalization of the two-nucleon amplitudes
- Extension to few-nucleon systems
- Partial wave decomposition of the three-nucleon system
- Faddeev equations for the three-nucleon bound state problem
- Three-nucleon scattering problem: treatment of singularities
- Inclusion of three-nucleon interactions
- Selected applications and external probes

Lernziele

- Concept of Effective Field Theory
- Introduction to Chiral Perturbation Theory
- Introduction to Chrial Effective Theory: non-perturbative, nucleonic systems based on Chiral Effectiv Theory
- Numerical techniques to solve few-nucleon system
- Project work: numerical solution of three-nucleon Faddeev equations for bound states
- Understanding the structure of complex systems
- Teamwork
- Presentations
- Self dependent project work

Voraussetzungen

- Module Quantum Theory of Particles and Fields 1 - Quantum Mechanics
- Module Quantum Theory of Particles and Fields 2 - Quantum Field

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Quantum Theory of Particles and Fields: 3 - Effective Field Theory [MSSiSc-6209.a]		8	0
Vorlesung Quantum Theory of Particles and Fields: 3 - Effective Field Theory [MSSiSc-6209.b]		0	4
Übung Quantum Theory of Particles and Fields: 3 - Effective Field Theory [MSSiSc-6209.c]		0	2

Modul: Advanced Molecular Dynamics Simulations [MSSiSc-6212]

MODUL TITEL: Advanced Molecular Dynamics Simulations

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	3	4	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction • Basics of classical mechanics: Equations of motion • Basics of statistical physics: Phase space, ensembles, expectation values, fluctuations • Basics of molecular dynamics simulations: Integration schemes, time reversible integration schemes, periodic boundary conditions, neighbor lists, long-range interactions • Advanced molecular dynamics simulations: Constant temperature and constant pressure molecular dynamics simulations, extended phase-space methods for simulations of various ensembles	• Molecular dynamics simulations (MD) are routinely used in theoretical studies of atomistic and molecular systems, ranging from solid state physics to biological molecules. Moreover, MD is an integral part of various advanced simulation methods. The simulation technique provides the time dependence and structural properties of the system under investigation. In order to obtain the desired system behavior, advanced simulation approaches are desirable, such as isothermal or isobaric simulation extensions of the basic molecular dynamics simulation method. • In this course, various aspects of advanced molecular dynamics simulations will be presented. This comprises adequate integration schemes of the underlying equations of motion for the various ensembles. Appropriate force fields are required for the simulation of molecular systems and will be discussed in the lectures. Moreover, various schemes for constant temperature simulations will be presented, such as stochastic simulations and extended phase-space approaches. • In the seminar, the students are expected to write a basic molecular dynamics simulation program under the guidance of the lecturer.
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Advanced Molecular Dynamics Simulations [MSSiSc-6212.a]		3	0
Vorlesung Advanced Molecular Dynamics Simulations [MSSiSc-6212.b]		0	2
Übung Advanced Molecular Dynamics Simulations [MSSiSc-6212.c]		0	2

Modul: Statistics and Dynamics of Macromolecules and Biopolymers [MSSiSc-6213]

MODUL TITEL: Statistics and Dynamics of Macromolecules and Biopolymers

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	3	4	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction • Equations of motion: Langevin equation, Fokker-Planck equation • Stokes equation • Hydrodynamic interactions • Models for macromolecules • Solutions of the equations of motion for macromolecular systems • Simulations of stochastic systems: Brownian dynamics simulations • Introduction to mesoscopic simulation methods: Dissipative Particle Dynamics, Lattice Boltzmann and Multiparticle Collison Dynamics methods • Examples of mesoscale simulations of macromolecular and colloidal systems	• Macromolecular and colloidal systems in solution exhibit specific dynamical features. Of particular importance is the solvent induced interaction between solute particles, which is denoted as hydrodynamic interactions. In this course, the basic equations of motion of macromolecular systems are presented with and without inclusion of hydrodynamic interactions. Analytical solutions are discussed for certain limiting cases. • Solutions of the equations of motions for more complicated systems can only be obtained by simulations. Various of such simulation approaches will be discussed.
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Statistics and Dynamics of Macromolecules and Biopolymers [MSSiSc-6213.a]		3	0
Vorlesung Statistics and Dynamics of Macromolecules and Biopolymers [MSSiSc-6213.b]		0	2
Übung Statistics and Dynamics of Macromolecules and Biopolymers [MSSiSc-6213.c]		0	2

Modul: Quantum Information [MSSiSc-6218]

MODUL TITEL: Quantum Information

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	10	6	jedes 2. Semester	SS 2013	Englisch

INHALTLICHE ANGABEN

Inhalt	Lernziele
- What is quantum computation and information: protocols & algorithms. - Physical realizations of quantum information in the solid-state. - Techniques for manipulating and protecting quantum information.	Learning fundamental concepts and tools of quantum information.
Voraussetzungen	**Benotung**
- Course in quantum mechanics - Module linear algebra or equivalent course in higher mathematics	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Quantum Information [MSSiSc-6218.a]		10	0
Vorlesung Quantum Information [MSSiSc-6218.b]		0	4
Übung Quantum Information [MSSiSc-6218.c]		0	2

Modul: Correlated Electrons [MSSiSc-6219]

MODUL TITEL: Correlated Electrons

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	3	jedes 2. Semester	SS 2014	English and German

INHALTLICHE ANGABEN

Inhalt	Lernziele
- Atoms and transition metal ions - Adding angular momenta - Relativistic corrections - Many-electrons: mean-field approximation - Numerical solution of the radial Schrödinger equation - Many-electrons: second quantization - Atomic multiplets - Exchange mechanisms - Hubbard and Heisenberg model, Mott transition - Crystal field theory	Fachbezogene Lernziele: • Understanding the effects of electron correlation in finite systems and of the methods for their efficient simulation. Nicht fachbezogene Lernziele: • Planning and managing of a small scientific software project. • Presentation and discussion of the results.
Voraussetzungen	**Benotung**
Recommended requirements: • module Applied Quantum Mechanics	• 1 oral or written exam (100%), depending on the number of students

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Exam Correlated Electrons [MSSiSc-6219.a]	60	5	0
Lecture Correlated Electrons [MSSiSc-6219.b]		0	3

Modul: Introduction to Polymer Physics [MSSiSc-6220]

MODUL TITEL: Introduction to Polymer Physics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	3	2	jedes 2. Semester	WS 2014/2015	English

INHALTLICHE ANGABEN

Inhalt

- General Introduction
- Simple models of polymers: freely-jointed chains and self-avoiding walks
- Thermodynamic models of polymers
- Phase bevavior of polymers
- Polymer solutions
- Polymer networks and gels
- Mechanical properties
- Entanglements and diffusion
- Numerical modeling and simulation of polymers

Lernziele

Fachbezogene Lernziele:

- Students will learn the basic models of polymer physics and their application to thermodynamic and mechanical properties
- Students will learn how to estimate the solution properties of polymers
- Students will learn how to numerically model and simulare polymers and tools for how to perform these tasks.
- Students will learn how to corrrelate the basic properties of real-world polymers with the results of the standard polymer models

Nicht fachbezogene Lernziele:

- Students will have the opportunity to engage in teamwork in the preparation of the final project
- Students will also be able to work on their communication skills in written English.

Voraussetzungen

Recommended requirements:

- Mathematics
- Thermodynamics
- Chemistry
- Physics

Benotung

The final grade will be the grade of the final project, the topic of which is selected by each individual student in consultation with the instructor.

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Introduction to Polymer Physics [MSSiSc-6220.a]		3	0
Vorlesung/Übung Introduction to Polymer Physics [MSSiSc-6220.bc]		0	2

Modul: Theory of Magnetic Resonance [MSSiSc-6302]

MODUL TITEL: Theory of Magnetic Resonance

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	2	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction, formal structure of spin interactions • Theory of chemical shifts • Theory of J-coupling • The vector model in NMR • Bloch equations and FT-NMR • Product operators I and 1-D NMR • Product operators II, 1-D NMR • 2-D NMR I • 2-D NMR II • Density matrix & Liouville equation • Relaxation theory • Dynamic phenomena in NMR • Hyperpolarization technology I • Hyperpolarization technology II	• Understanding the concepts of Quantum Mechanics by example of NMR • Ability to compute NMR spectra • Understanding the concepts of coupled spin systems • Mathematics: Fouriertransformation, Hilbert- and Liouville space, Vectoranalysis, Operatoralgebra, Grouptheory, differential equations, density matrix • Other sciences: boundaries to Analytical Chemistry, Particle Physics, Thermodynamics, Atomic Physics and Quantum Optics
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in quantum mechanics	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Theory of Magnetic Resonance [MSSiSc-6302.a]		4	0
Vorlesung Theory of Magnetic Resonance [MSSiSc-6302.b]		0	2

Modul: ab initio Phase Prediction of Solid-State Materials [MSSiSc-6303]

MODUL TITEL: ab initio Phase Prediction of Solid-State Materials

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	10	12	jedes 2. Semester	unregelmäßig	English

INHALTLICHE ANGABEN

Inhalt

- Introduction into structural chemisty, solid-state chemistry, applied quantum chemistry and computational methods
- First numerical calculations
- Refined numerical calculations and in-depth analysis of the results

Lernziele

- Modern methods of quantum chemistry enable the prediction and rational design of new materials with desired physiochemical properties.
- After an introduction to solid-state and structural chemistry, the students learn to work with numerical computational methods for the ab initio modeling of solid state materials such as density-functional theory using pseudopotential and plane waves.
- The students run numerical calculations based on the above-mentioned quantum-chemical tools as well as using chemical expertise.
- The results are analyzed and extrapolated using the laws of thermodynamics such as to provide useful data for the synthetic experimentalists.
- All results will be documented, presented and discussed in a final colloquium.
- The research project will take place in the computer lab of the institute

- Teamwork
- Presentation
- Self-dependent research project

Voraussetzungen

- Basic knowledge in quantum mechanics

recommended:
- Module Atomistic Aspects of Modern Chemistry
- Basic knowledge of the German language helpful

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung ab initio Phase Prediction of Solid-State Materials [MSSiSc-6303.a]		10	0
Labor ab initio Phase Prediction of Solid State Materials [MSSiSc-6303.d]		0	12

Modul: Quantum-Chemical Modeling of Complex Intermetallics [MSSiSc-6304]

MODUL TITEL: Quantum-Chemical Modeling of Complex Intermetallics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	10	12	jedes Semester	unregelmäßig	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction into structural chemistry, itinerant magnetism, applied quantum chemistry and computational methods • First numerical calculations • Refined numerical calculations and in-depth analysis of the results	• Modern methods of quantum chemistry enable the understanding and rational design of new intermetallics with desired magnetic properties. • After an introduction to structural chemistry and itinerant magnetism, the students learn to work with numerical computational methods for the ab initio modeling of magnetic materials such as density-functional theory using short-ranged atomic-like basis sets. • The students run numerical calculations based on the above-mentioned quantum-chemical tools as well as using chemical expertise. • The results are analyzed in terms of the local electronic structure such as to provide an in-depth understanding of the chemical-bonding scenario. • All results will be documented, presented and discussed in a final colloquium. • The research project will take place in the computer lab of the institute. • Teamwork • Presentation • Self-dependent research project
Voraussetzungen	**Benotung**
• Basic knowledge in quantum mechanics recommended: • Module Atomistic Aspects of Modern Chemistry • Basic knowledge of the German language helpful	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Quantum-Chemical Modeling of Complex Intermetallics [MSSiSc-6304.a]		10	0
Labor Quantum-Chemical Modeling of Complex Intermetallics [MSSiSc-6304.d]		0	12

Modul: Simulation of Interactions in Molecular Crystals [MSSiSc-6305]

MODUL TITEL: Simulation of Interactions in Molecular Crystals

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	10	12	jedes Semester	unregelmäßig	English (and German if required)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction into structural chemistry and molecular crystals • Analysis of intermolecular interactions • Hands-on work on modelling of intermolecular interactions by empirical methods	• Mathematical description of crystals • Packing principles in molecular crystals • Interactions in molecular crystals: hydrogen bonds, Coulomb interactions, van-der-Waals interactions • Interpretation of experimental diffraction results in terms of intermolecular interactions • Analysis of data retrieved from the Cambridge Structural Database in terms of intermolecular interactions • Simulation of van-der-Waals interactions with the help of an intermolecular force field • Advantages and shortcomings of force fields • visualization of results • presentation • data mining
Voraussetzungen	**Benotung**
• Module A*tomistic Aspects of Modern Chemistry* recommended: • Basic knowledge in quantum mechanics • Basic knowledge of the German language helpful but not mandatory	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Simulation of Interactions in Molecular Crystals [MSSiSc-6305.a]		10	0
Labor Simulation of Interactions in Molecular Crystals [MSSiSc-6305.d]		0	12

Modul: Computational Magnetochemistry [MSSiSc-6306]

MODUL TITEL: Computational Magnetochemistry

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	10	12	jedes Semester	unregelmäßig	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction into the chemistry of magnetic molecules and the electronic structure of their spin centers, general theories of magnetism and magnetic characterization methods • First numerical simulations and code analysis • Modeling of the magnetic properties of a small set of related magnetic molecules, based on available experimental data.	• Understanding the complex magnetic properties of molecules and molecule-based networks, i.e. low-dimensional magnets, requires the combination of several computational analysis and simulation techniques. In turn, these results aid the design of molecular materials with pre-determined magnetic and electronic properties. • Following an introduction to magnetochemistry and the specifics of quasi-zero-dimensional inorganic magnetic molecules, students will learn to use and study existing code that allows calculating magnetic properties based on quantum mechanical arguments, linking results to thermodynamic and spectroscopic experimental data. • Starting with analytical methods, students will continue to explore approximate methods, for instance the possibilities and limits of state-of-the-art Monte Carlo simulations (both on quantum mechanical and classical levels). • Students will focus on a set of specific molecules and analyze their magnetic properties and correlate them with the results of in-house experiments. • All results will be documented, presented and discussed in a final colloquium. • The research project will take place in one of the group laboratories where students can be aided by experienced group members. • Teamwork • Presentation • Team-oriented research project
Voraussetzungen	**Benotung**
recommended: • Module Atomistic Aspects of Modern Chemistry • Basic knowledge in linear algebra • Basic knowledge in quantum mechanics • Basic knowledge in simulation methods	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Computational Magnetochemistry [MSSiSc-6306.a]		10	0
Labor Computational Magnetochemistry [MSSiSc-6306.d]		0	12

Modul: Computational Chemistry for the Investigation and/or Prediction of the Properties of Homogenous Catalysts [MSSiSc-6307]

MODUL TITEL: Computational Chemistry for the Investigation and/or Prediction of the Properties of Homogenous Catalysts

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	10	12	jedes Semester	unregelmäßig	English and German

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction to computational chemistry with a detailed focus on homogeneous catalysis • First numerical calculations • Refined numerical calculations and in-depth analysis of the results	• Representative areas of computational chemistry (force field-, ab initio- and density functional calculations, respectively). • After an introduction to computational chemistry, the students learn to work with common programs in the area. • The students run calculations based on the above-mentioned quantum-chemical tools as well as using chemical expertise. • The results are analyzed and evaluated aiming at the generation of useful input for the experimentalists. • All results will be documented in a written report and presented in a colloquium • The research project will take place in the computer lab of the institute. • Teamwork • Presentation • Self-dependent research project
Voraussetzungen	**Benotung**
• Basic knowledge in quantum mechanics • BSc in chemistry or equivalent chemistry knowledge is necessary recommeded: • Module Atomistic Aspects of Modern Chemistry • Basic knowledge of the German language helpful	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Computational Chemistry for the Investigation and/or Prediction of the Properties of Homogenous Catalysts [MSSiSc-6307.a]		10	0
Labor Computational Chemistry for the Investigation and/or Prediction of the Properties of Homogenous Catalysts [MSSiSc-6307.d]		0	12

Modul: Computational Chemistry - Quantum Monte Carlo Methods [MSSiSc-6308]

MODUL TITEL: Computational Chemistry - Quantum Monte Carlo Methods

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	10	12	jedes Semester	unregelmäßig	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction to computational chemistry and quantum Monte Carlo methods • First numerical calculations • Refined numerical calculations and in-depth analysis of the results	• Modern methods of quantum chemistry enable the prediction of thermodynamic data as well as reaction mechanisms. • After an introduction to molecular quantum chemistry, the students learn to work with computational methods for ab initio modeling of molecules using quantum Monte Carlo and orbital-based methods. • The students run numerical calculations to investigate reaction energies, activation energies and/or reaction mechanisms. • All results will be documented, presented and discussed in a final colloquium. • The research project will take place in the computer lab of the institute. • Teamwork • Presentation • self-dependent research project
Voraussetzungen	**Benotung**
• Basic knowledge in quantum mechanics recommended: • Module Atomistic Aspects of Modern Chemistry	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Computational Chemistry - Quantum Monte Carlo Methods [MSSiSc-6308.a]		10	0
Labor Computational Chemistry - Quantum Monte Carlo Methods [MSSiSc-6308.d]		0	12

Modul: Atomistic Simulation of Defects in Solids [MSSiSc-6309]

MODUL TITEL: Atomistic Simulation of Defects in Solids

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	10	12	jedes Semester	unregelmäßig	English or German (as required)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction to defect chemistry and computational methods • First numerical calculations • Refined numerical calculations and in-depth analysis of the results	• Modern methods of simulation of defects in solids. • After an introduction to defect chemistry, the students learn to work with numerical computational methods for the ab initio modeling of defects in solids. • The students run numerical calculations based on existing semi-empirical and/or quantum-chemical tools. • The results are analyzed in terms of the defect formation and /or defect migration energies. • All results will be documented, presented and discussed in a final colloquium. • The research project will take place in the lab of the institute. • Teamwork • Presentation • self-dependent research project
Voraussetzungen	**Benotung**
recommended: • Module Atomistic Aspects of Modern Chemistry • Basic knowledge of the German language helpful	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Atomistic Simulation of Defects in Solids [MSSiSc-6309.a]		10	0
Labor Atomistic Simulation of Defects in Solids [MSSiSc-6309.d]		0	12

Modul: Quantum Chemical Modelling of Small and Medium Sized Molecules [MSSiSc-6310]

MODUL TITEL: Quantum Chemical Modelling of Small and Medium Sized Molecules

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	10	12	jedes Semester	unregelmäßig	English

INHALTLICHE ANGABEN

Inhalt

- Introduction to molecular quantum mechanics and their application to quantum chemistry and the corresponding computational methods. chemistry and computational methods
- Calculations on molecular many electron systems.
- Evaluation and analysis of the computational results.

Lernziele

- Ab initio prediction of molecular properties facilitates the design of new compounds and reduce the number of sometimes costly experiments.
- After an introduction to the quantum chemistry of molecular many electron systems the students become acquainted with the most frequently used quantum-chemical computational methods (ab initio methods, density functional theory based methods).
- The students apply the methods mentioned above to predict certain properties of small and medium-sized molecules and to elucidate their observed chemical reactivity.
- The computational results are compared with experimental data to demonstrate the applicability and the limitations of quantum-chemical methods.
- All results will be documented, presented and discussed in a final colloquium.
- The research project will take place in the computer lab of the Institute of Organic Chemistry employing local facilities as well as the computers of the RWTH computing center.

- Interdisciplinary work.
- Presentation of research results.
- Planning of independent research.

Voraussetzungen

- Fundamentals of quantum mechanics

recommended:

- Fundamentals of the quantum theory of many electron systems
- Basic knowledge of the German language helpful

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Qunatum - Chemical Modelling of Small and Medium Sized Molecules [MSSiSc-6310.a]		10	0
Labor Quantum-Chemical Modelling of Small and Medium Sized Molecules [MSSiSc-6310.d]		0	12

Modul: Hydrogeophysics [MSSiSc-6401]

MODUL TITEL: Hydrogeophysics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	3	2	jedes 2. Semester	WS 2009/2010	English (German as required)

INHALTLICHE ANGABEN

Inhalt

- Lectures are given in units of 90 minutes
- Introduction to Hydrogeophysics and Hydrogeological methods
- Geostatistics
- Relationships between electrical and hydrogeological properties of rocks and soils
- Relationships between the electrical and hydrogeological properties of Rocks and Soils
- Resistivity & Joint hydrogeophysical inversion
- Electromagnetic induction & joint hydrogeophysical inversion
- Ground Penetrating Radar & joint hydrogeophysical inversion
- Seismics & joint hydrogeophysical inversion
- Geophysical well logging
- Spontaneous potential & induced polarisation
- NMR
- Group presentations case studies
- Discussion recently published hydrogeophysical joint inversion papers
- Discussion recently published hydrogeophysical joint inversion papers
- Excursion Research Center Jülich

Lernziele

- The shallow subsurface of the earth is an extremely important geological zone that yields much of our water resources, supports our agriculture and ecosystems. Safe and effective management of our natural resources is a major challenge, that is, not to overexploit and pollute the aquifer systems. The hydrogeophysics discipline has emerged in recent years to investigate the potential that geophysical methods hold for providing quantitative information about subsurface hydrogeological parameters and processes. Hydrogeophysical importance relies on its multidisciplinarity.That is, the joint interpretation of geophysical and hydrogeological data to get better approach and more constrained/reliable hydrogeologic models.
- The principal geophysical methods (resistivity, electromagnetic induction, Ground Penetrating Radar, Seismics, Nuclear Magnetic Resonance, Induced Polarization) that have actually been applied to hydrogeological problems are reviewed and inversion and interpretation are discussed. For each method, the multidisciplinary approach of joint hydrogeophysical inversion and interpretation is discussed in detail.
- To discuss in-depth the use of hydrogeophysical methods, each student will present a recent paper from literature. This presentation is part of the examination.
- Presentation skills

Voraussetzungen

recommended:

- Knowledge in mathematics and physics similar as taught in the Beachelor "Angewandte Geowissenschaften"

Benotung

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Hydrogeophysics [MSSiSc-6401.a]		3	0
Vorlesung Hydrogeophysics [MSSiSc-6401.b]		0	2

Modul: Modeling Flow and Transport Processes in Terrestrial Systems [MSSiSc-6402]

MODUL TITEL: Modeling Flow and Transport Processes in Terrestrial Systems

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	2	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• General introduction to modeling of flow and transport processes in terrestrial systems, with a special focus on uncertainty. • Subsurface flow processes (vadose zone, saturated zone, river- aquifer interaction): terminology, equations and their numerical solutions. • Inverse modeling for calibration of parameters of subsurface flow models: identifiably, non-uniqueness, parameterization, objective function. Methods: maximum a posteriori likelihood method, Pilot Points Method, Monte-Carlo type inverse modeling (derivative-based, non-derivative based). • Heat transport processes in the subsurface: general principles and equations. • Land-atmosphere interaction: latent and sensible heat fluxes, subsurface heat transport, potential evapotranspiration and climatological data, actual evapotranspiration, boundary layer flows, role of vegetation, parameterization of evapotranspiration in climate models. • Catchment hydrology, rainfall-runoff processes, different types of models, model calibration & uncertainty assessment • Sequential data assimilation techniques for improving model predictions in real-time with measurement data. Classical Kalman Filter, Ensemble Kalman Filter, Particle Filter. Example of application: assimilation of remotely sensed soil moisture data for improving hydrological and meteorological predictions	

Voraussetzungen	Benotung
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Modeling Flow and Transport Processes in Terrestrial Systems [MSSiSc-6402.a]		4	0
Vorlesung Modeling Flow and Transport Processes in Terrestrial Systems [MSSiSc-6402.b]		0	1
Übung Modeling Flow and Transport Processes in Terrestrial Systems [MSSiSc-6402.c]		0	1

Modul: Computational Differentiation [MSSiSc-7101]

MODUL TITEL: Computational Differentiation

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	4	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• forward and reverse modes of AD • exploitation of program structure (sparsity, interface contraction) • checkpointing • parallelism in derivative codes • AD on computational graphs • further topics in modern AD	• Understanding of both basic and advanced topics in Automatic Differentiation (AD) • Ability to evaluate computational and memory complexity of the main AD algorithms • Ability to select the appropriate AD method for a given problem • Basic understanding of program reversal techniques
Voraussetzungen	**Benotung**
• Understanding of basic concepts of imperative and object-oriented programming languages; ability to write simple programs in these langeuages (see e.g. BSc CES module "Introduction to Computer Science / C++ Programming") • Knowledge of elementary discrete data structures, in particular graphs (see e.g. BSc CES module "Algorithms and Data Structures")	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Computational Differentiation [MSSiSc-7101.a]		6	0
Vorlesung Computational Differentiation [MSSiSc-7101.b]		0	3
Übung Computational Differentiation [MSSiSc-7101.c]		0	1

Modul: Derivative Code Compilers [MSSiSc-7102]

MODUL TITEL: Derivative Code Compilers

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	3	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Motivation • Lexical Analysis • Syntax Analysis • First derivative models • Second derivative models • Attribute grammars • Syntax-directed tangent-linear code • Syntax-directed adjoint code • Activity analysis	• Ability to write a compiler front-end for a simple language • Ability to write a back-end that produces derivative code • Understanding of first- and second.order tangent-linear and adjoint models • Basic understanding of data-flow analysis algorithms • Presentation of solutions to tutorial exercises
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Derivative Code Compilers [MSSiSc-7102.a]		4	0
Vorlesung Derivation Code Compilers [MSSiSc-7102.b]		0	2
Übung Derivation Code Compilers [MSSiSc-7102.c]		0	1

Modul: Combinatorial Problems in Scientific Computing [MSSiSc-7103]

MODUL TITEL: Combinatorial Problems in Scientific Computing

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	unregelmäßig	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• solution of sparse linear systems • matrix-vector products in iterative algorithms • LU factorization • Cholesky factorization • differentiation • efficient computation of Jacobians by dynamic programming • elimination techniques on linearized computational graphs • further current combinatorial problems in Scientific Computing	• Understanding of the taught combinatorial problems in modern Scientific Computing and knowledge of various related approaches to their solution • Knowledge of fundamental methods for solving combinatorial problems
Voraussetzungen	**Benotung**
recommended: • Knowledge of elementary discrete data structures, in particular graphs (see e.g. BSc CES module Algorithms and Data Structures)	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Combinatorial Problems in Scientific Computing [MSSiSc-7103.a]		4	0
Vorlesung Combinatorial Problems in Scientific Computing [MSSiSc-7103.b]		0	2
Übung Combinatorial Problems in Scientific Computing [MSSiSc-7103.c]		0	1

Modul: Parallel Algorithms [MSSiSc-7104]

MODUL TITEL: Parallel Algorithms						
ALLGEMEINE ANGABEN						
Fachsemester	**Dauer**	**Kreditpunkte**	**SWS**	**Häufigkeit**	**Turnus Start**	**Sprache**
3	1	4	3	jedes 2. Semester	WS 2009/2010	English and German

INHALTLICHE ANGABEN

Inhalt	**Lernziele**
• Parallel numerical algorithms • Parallel graph algorithms • Parallel Fast Fourier Transform algorithms • Further selected topics	• Understanding of design patterns and analysis of parallel algorithms • Knowledge of parallel algorithms for different problem classes
Voraussetzungen	**Benotung**
recommended: • Basic knowledge of serial programming, algorithms and data structures as well as concepts of parallel computing	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	**Prüfungsdauer (Minuten)**	**CP**	**SWS**
Prüfung Parallel Algorithms [MSSiSc-7104.a]		4	0
Vorlesung Parallel Algorithms [MSSiSc-7104.b]		0	2
Übung Parallel Algorithms [MSSiSc-7104.c]		0	1

Modul: Object Oriented Software Construction [MSSiSc-7105]

MODUL TITEL: Object Oriented Software Construction

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	5	jedes 2. Semester	WS 2009/2010	German (in future English, date not yet fixed)

INHALTLICHE ANGABEN

Inhalt	Lernziele
The following topics will be covered: • basic concepts of object orientation • polymorphy and inheritance • object oriented analysis with use cases • conceptual design and notations • architecture design and object oriented pattern design • frameworks • tools and materials approach • refactoring • process models for object oriented developments	After completing the module the students have the following knowledge and skills.They • know how to apply important object oriented modeling concepts • are able to perform use case based object oriented analysis • know important design patterns and are able to apply patterns in architectural design • know how to improve code and architecture by refactoring • know foundations of modern software development processes
Voraussetzungen	**Benotung**
• Basic knowledge in C++/Java programming	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Object Oriented Software Construction [MSSiSc-7105.a]		6	0
Vorlesung Object Oriented Software Construction [MSSiSc-7105.b]		0	3
Übung Object Oriented Software Construction [MSSiSc-7105.c]		0	2

Modul: Software Quality Assurance [MSSiSc-7106]

MODUL TITEL: Software Quality Assurance

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	5	jedes 2. Semester	SS 2010	German (in future English, date not yet fixed)

INHALTLICHE ANGABEN

Inhalt	Lernziele
The following topics are covered: • ideas and concepts of quality assurance • methods of static software inspections • types and techniques of software tests • systematic selection of test cases • test of object oriented programs • considerations on efficiency of tests • measurements and software metrics • evaluation of software development processes	After completing the module the students have the following knowledge and skills. They • know the goals, concepts, models, and basic terms of software quality assurance • know important methods of static software inspections • are able to apply test case selection techniques and know important test exit criteria • are able to systematically develop test specifications • know the fundamentals of software measurement and are able to define
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Software Quality Assurance [MSSiSc-7106.a]		6	0
Vorlesung Software Quality Assurance [MSSiSc-7106.b]		0	3
Übung Software Quality Assurance [MSSiSc-7106.c]		0	2

Modul: Introduction to Embedded Systems [MSSiSc-7107]

MODUL TITEL: Introduction to Embedded Systems

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2010	German or English

INHALTLICHE ANGABEN

Inhalt	Lernziele
The following topics are covered: • Technological basics of embedded systems (basics structure, microcontroller, stored-program controllers) • Special requirements for designing embedded software • Life cycle model • Analysis of functional and non-functional requirements • Architectural design and analysis • Architecture elements (operation systems, busses, middleware) • Modeling and analysis techniques for behavior and structure • Validation (simulation, tests)	Acquisition of the following knowledge and abilities: • Knowledge and mastery of modern sofftware engineering for embedded systems • Acquisition of sensitivity for the particular qualitative requirements for designing embedded software
Voraussetzungen	**Benotung**
• Basic knowledge in computer engineering	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Introduction to Embedded Systems [MSSiSc-7107.a]		6	0
Vorlesung Introduction to Embedded Systems [MSSiSc-7107.b]		0	3
Übung Introduction to Embedded Systems [MSSiSc-7107.c]		0	1

Modul: Compiler Construction [MSSiSc-7108]

MODUL TITEL: Compiler Construction

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	5	jedes 3. Semester	WS 2009/2010	German or English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Lexical analysis of progams (Scanner) • Syntactical analysis of programs (Parser) • Semantic analysis • Tools for compiler construction (lex, yacc	Acquisition of the following knowledge and abilities: • Understanding of the construction and working principles of compilers for higher programmin languages • Knowledge on methods of formalizing syntax (regular expressions, context-free and attribute grammars, EBNF) • Ability to implement simple compiler components (Scanner, Parser) • Knowledge in applying compiler-generating tools
Voraussetzungen	**Benotung**
recommended: • Mastering the essential concepts of imperative and object-oriented programming languages as well as elementary programming techniques in these languages • Knowlegde of data structures like lists, stacks, queues and trees • Knowledge of basic automata models like finite automata and pushdown automata	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Compiler Construction [MSSiSc-7108.a]		6	0
Vorlesung Compiler Construction [MSSiSc-7108.b]		0	3
Übung Compiler Construction [MSSiSc-7108.c]		0	2

Modul: Pattern Recognition and Neural Networks [MSSiSc-7109]

MODUL TITEL: Pattern Recognition and Neural Networks

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	8	6	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction/motivation • Bayes´ decision Rule • Training and learning • Model-free methods • Mixture densities and cluster analysis • Stochastic finite automata • Feature extraction	• Intuition for the basic methods of pattern recognition and neural networks • Learning of basic algorithms and principles of pattern recognition and neural networks • Acquirement of the ability of independent handling of the contents of this module and confident command of basic methods of pattern recognition neural networks • Practice of the presented content by exemplary realization of specific problems from pattern recognition and neural networks and corresponding basic classification tasks
Voraussetzungen	**Benotung**
none	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Pattern Recognition and Neural Networks [MSSiSc-7109.a]		8	0
Vorlesung Pattern Recognition and Neural Networls [MSSiSc-7109.b]		0	4
Übung Pattern Recognition and Neural Network [MSSiSc-7109.c]		0	2

Modul: Advanced Pattern Recognition Methods [MSSiSc-7110]

MODUL TITEL: Advanced Pattern Recognition Methods

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	5	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction/motivation • Summary of module pattern recognition • Discriminants and neural networks • Training criteria • Log-linear modeling • Support vector machines • Boosting • Model selection	• Deepened comprehension of advanced methods and formalisms of pattern recognition • Learning of advanced methods of pattern recognition • Acquirement of the ability of independent handling of the contents of this module and confident command of advanced techniques of pattern recognition • Practice of the presented content by exemplary realization of specific problems from pattern recognition • Overview of the state of the art in pattern recognition
Voraussetzungen	**Benotung**
• Module Pattern Recognition and Neural Networks	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Advanced Pattern Recognition Methods [MSSiSc-7110.a]		6	0
Vorlesung Advanced Pattern Recognition Methods [MSSiSc-7110.b]		0	3
Übung Advanced Pattern Recognition Methods [MSSiSc-7110.c]		0	2

Modul: Automatic Speech Recognition [MSSiSc-7111]

MODUL TITEL: Automatic Speech Recognition

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	8	6	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction/motivation. • Digital signal processing. • Spectral Analysis. • Time alignment and isolated word recognition. • Statistical interpretation and models. • Connected Word Recognition. • Large Vocabulary Speech Recognition	• Intuition for the basic properties and methods of automatic speech recognition. • Learning of basic algorithms of automatic speech recognition and their integration into a complete recognition system. • Acquirement of the ability of independent handling of the contents of this module and confident command of basic techniques of automatic speech recognition. • Application of decision theory to the speech recognition problem. • Practice of the presented content by exemplary realization of specific problems from automatic speech recognition.
Voraussetzungen	**Benotung**
reommended: • BSc Computer Science	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Automatic Speech Recognition [MSSiSc-7111.a]		8	0
Vorlesung Automatic Speech Recognition [MSSiSc-7111.b]		0	4
Übung Automatic Speech Recognition [MSSiSc-7111.c]		0	2

Modul: Advanced Automatic Speech Recognition [MSSiSc-7112]

MODUL TITEL: Advanced Automatic Speech Recognition

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	5	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Summary of large vocabulary speech recognition using a linear lexicon. • Search using lexical pronunciation prefix trees. • Word graph method using word pair approximation. • Time-conditioned search. • Across-word modeling. • Confidence measures and system combination. • Discriminative training. • Speaker adaptation and normalization. • Current issues.	• Deepened comprehension of advanced methods and formalisms of automatic speech recognition. • Learning of advanced methods of automatic speech recognition. • Acquirement of the ability of independent handling of the contents of this module and confident command of advanced techniques of automatic speech recognition. • Practice of the presented content by exemplary realization of specific problems of automatic speech recognition. • Overview of the state of the art in automatic speech recognition
Voraussetzungen	**Benotung**
• Module Automatic Speech Recognition	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Advanced Automatic Speech Recognition [MSSiSc-7112.a]		6	0
Vorlesung Advanced Automatic Speech Recognition [MSSiSc-7112.b]		0	3
Übung Advanced Automatic Speech Recognition [MSSiSc-7112.c]		0	2

Modul: Statistical Natural Language Processing [MSSiSc-7113]

MODUL TITEL: Statistical Natural Language Processing

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	8	6	jedes 2. Semester	SS 2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction/motivation • Linguistic and statistical foundations • Text and document classification • Language modeling • POS tagging • Information extraction buy tagging • Machine Translation	• Develop intuition for the basic problems of natural language processing • Learning of basic methods of statistical natural language processing • Acquirement of the ability of independent handling of the contents of this module and confident command of basic techniques of statistical natural language processing • Experience with the processing of large text corpora • Learning of robust estimation methods for statistical modeling in natural language processing
Voraussetzungen	**Benotung**
• ModulePattern Recognition and Neural Networks	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Statistical Natural Language Processing [MSSiSc-7113.a]		8	0
Vorlesung Statistical Natural Language Processing [MSSiSc-7113.b]		0	4
Übung Statistical Natural Language Processing [MSSiSc-7113.c]		0	2

Modul: Advanced Topics in Statistical Natural Language Processing [MSSiSc-7114]

MODUL TITEL: Advanced Topics in Statistical Natural Language Processing

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	5	jedes 2. Semester	unregelmäßig	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction/motivation. • Probabilistic context-free grammars and parsing. • Phrase-based machine translation. • Search for phrase-based machine translation. • Hierarchical phrase-based machine translation.	• Develop intuition for advanced problems in natural language processing • Learning of advanced methods for natural language processing and machine translation • Acquirement of the ability of independent handling of the contents of this module and confident command of advanced techniques of statistical natural language processing and machine translation • Competence for independent analysis of the properties and performance of machine translation systems and their corresponding optimization
Voraussetzungen	**Benotung**
• Module Statistical Natural Language Processing	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Advanced Topics in Statistical Natural Language Processing [MSSiSc-7114.a]		6	0
Vorlesung Advanced Topics in Statistical Natural Language Processing [MSSiSc-7114.b]		0	3
Übung Advanced Topics in Statistical Natural Language Processing [MSSiSc-7114.c]		0	2

Modul: Basic Techniques in Computer Graphics [MSSiSc-7115]

MODUL TITEL: Basic Techniques in Computer Graphics

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	5	jedes 2. Semester	WS 2009/2010	English and German (alternating)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Foundations of geometry representations (polygonal meshes, volumetric representations, freeform curves and surfaces) • Local illumination (3D transformations, clipping, rasterization, lighting, shading) • Global illumination (visibility problem, shadow computation, ray tracing), radiosity • Foundations of image processing (transformations, color coding, image compression) • Volume rendering	• Knowledge of the most important data structures for the representation of 3-dimensional objects and scenes • Basic operations and methods for the transformation of a 3D model into a realistic 2-dimensional image (rendering pipeline) • Overview of the the central problems and their efficient solutions in the whole area of Computer Graphics
Voraussetzungen	**Benotung**
• Basic knowledge in algorithms and data structures • Basic knowledge in linear algebra	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Basic Techniques in Computer Graphics [MSSiSc-7115.a]		6	0
Vorlesung Basic Techniques in Computer Graphics [MSSiSc-7115.b]		0	3
Übung Basic Techniques in Computer Graphics [MSSiSc-7115.c]		0	2

Modul: Geometry Processing [MSSiSc-7116]

MODUL TITEL: Geometry Processing

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	5	jedes 2. Semester	SS 2010	English and German (alternating)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Methods for the generation of polygonal meshes (laser scanning, registration and integration of mesh patches, etc.) • Optimization of polygonal meshes: surface fairing, remeshing, decimation, refinement • Hierarchical representations: coarse-to-fine and fine-to-coarse hierarchies, mesh editing approaches • Parametrization and texturing • Efficient data structures and mesh compression	• Techniques for the generation of highly detailed 3-dimensional models of real objects • Advanced knowledge of current algorithms for the optimization, processing and storage of geometry data with a focus on polygonal meshes
Voraussetzungen	**Benotung**
• Basic knowledge in algorithms and data structures • Basic knowledge in linear algebra recommended: • Module *Basic Techniques in Computer Graphics*	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Geometry Processing [MSSiSc-7116.a]		6	0
Vorlesung Geometry Processing [MSSiSc-7116.b]		0	3
Übung Geometry Processing [MSSiSc-7116.c]		0	2

Modul: Computer Vision [MSSiSc-7117]

MODUL TITEL: Computer Vision

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	4	jedes 2. Semester	WS 2009/2010	English and German (alternating)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Image processing basics: Image formation, Binary image processing, Linear filters, Edge detection & structure extraction, Radiometry & color • Segmentation as clustering, k-Means, EM, Mean-shift • Segmentation as energy minimization: Normalized cuts, Graph cuts • Object recognition: Global approaches, Subspace representations • Local invariant features: Detection and description, Efficient feature matching and indexing • Object recognition with local features • Object categorization: Sliding-window techniques, Bag-of-features models, Part-based models • 3D Reconstruction: Epipolar geometry, Camera calibration, Multi-view stereo, Structure-from-motion • Motion & Tracking: Optical flow, Tracking with linear dynamic models, Kalman filters, Particle filters, Tracking-by-detection	The goal of Computer Vision is to develop methods that enable a machine to "understand" or analyze images and videos. This lecture will teach the fundamental Computer Vision techniques that underlie such capabilities. In addition, it will show current research developments and how they are applied to solve real-world tasks. The lecture is accompanied by Matlab-based exercises that will allow students to collect hands-on experience with the algorithms introduced in the lecture (there will be one exercise sheet roughly every two weeks).
Voraussetzungen	**Benotung**
• Basic knowledge in linear algebra recommended: • Module *Basic Techniques in Computer Graphics*	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Computer Vision [MSSiSc-7117.a]		6	0
Vorlesung Computer Vision [MSSiSc-7117.b]		0	3
Übung Computer Vision [MSSiSc-7117.c]		0	1

Modul: Polynomial Curves and Surfaces [MSSiSc-7118]

MODUL TITEL: Polynomial Curves and Surfaces

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	5	jedes 2. Semester	WS 2009/2010	English and German (alternating)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Foundations of geometry: affine spaces, parametric curves and surfaces • Bezier-curves: Bernstein-polynomials, algorithm of de Casteljau, derivatives, integration, conversion, polar form, subdivision • Bspline-curves: definition, algorithm of de Boor, derivatives, knot insertion, interpolation and approximation of scattered data • Tensor product surfaces: definition, polar form, evaluation, derivatives • Bezier surface patches: multivariate Bernstein-polynomials, multivariate algorithm of de Casteljau, polar form, derivatives degree elevation, subdivision • Construction of smooth surfaces: Clough-Tocher interpolant, analytic and geometric continuity	• Knowledge of the basic mathematical representations and properties of curves and surfaces in CAGD • Understanding of algorithms for the efficient construction, modification and evaluation of freeform curves and surfaces • Understanding of the concept of geometric continuity and approaches for the construction of surfaces of arbitrary topology
Voraussetzungen	**Benotung**
• Basic knowledge in analysis • Basic knowledge in linear algebra	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Polynomial Curves and Surfaces [MSSiSc-7118.a]		6	0
Vorlesung Polynomial Curves and Surfaces [MSSiSc-7118.b]		0	3
Übung Polynomial Curves and Surfaces [MSSiSc-7118.c]		0	2

Modul: Subdivision Curves and Surfaces [MSSiSc-7119]

MODUL TITEL: Subdivision Curves and Surfaces

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	5	jedes 2. Semester	SS 2010	English and German (alternating)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Simple techniques for curves: Lane-Riesenfeld, 4-point-scheme, corner-cutting • Analysis of curve techniques: concept of convergence, difference scheme, z-transform • Boxsplines: definition and properties, boxspline subdivision • Surface techniques: Catmull-Clark, Doo-Sabin, Loop • Analysis of surface techniques in regular areas • Analysis of surface techniques in singular points: subdivision matrix, characteristic map • Advanced techniques, e.g.: interpolation and approximation of scattered data, curve networks, and normals, representation of sharp features, texturing, variational subdivision, Boolean operations, adaptive subdivision (red-green triangulation, sqrt(3), 4-8-subdivsion)	• Knowledge of common subdivision methods for curves and surfaces • Understanding of mathematical methods for the analysis and construction of subdivision schemes • Ability to choose a suitable subdivision method for a given geometrical problem
Voraussetzungen	**Benotung**
• Module Polynomial Curves and Surfaces	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Subdivison Curves and Surfaces [MSSiSc-7119.a]		6	0
Vorlesung Subdivision Curves and Surfaces [MSSiSc-7119.b]		0	3
Übung Subdivision Curves and Surfaces [MSSiSc-7119.c]		0	2

Modul: Virtual Reality [MSSiSc-7120]

MODUL TITEL: Virtual Reality

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	3	jedes 2. Semester	WS 2009/2010	English and German

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction into Virtual Reality (VR) • History of VR • Basics of interactive 3-D computer graphics • 3-D vision • Stereoscopic, viewer-centered projections • Virtual acoustics • Haptics • Collision detection • Physically-based modelling • Display, graphics and interaction hardware • Tracking • Applications in medicine and scientific visualization	• Understanding of basic Virtual Reality techniques and methods • Development of Virtual Reality applications in the scientific and technical field
Voraussetzungen	**Benotung**
recommended: • Basic programming knowledge	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Virtual Reality [MSSiSc-7120.a]		4	0
Vorlesung Virtual Reality [MSSiSc-7120.b]		0	2
Übung Virtual Reality [MSSiSc-7120.c]		0	1

Modul: Languages for Scientific Computing [MSSiSc-7121]

MODUL TITEL: Languages for Scientific Computing

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	4	jedes 2. Semester	WS 2009/2010	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• We compare and contrast languages especially suitable for numerical, symbolic, and high-performance computations: Mathematica, Matlab, C, (Python, schell scripting, Fortran). We also cover the standard high- performance libraries for scientific computations: BLAS, LAPACK, MPI, (OpenMP. • Different programming paradigms are introduced: functional vs. imperative, discrete vs. numerical vs. symbolic. Programs are evaluated with respect to metrics like performance, size, elegance. • The core messages are: 1) fast prototyping through high-level languages that allow users to express algorithms at the same level of abstraction as their mathematics; 2) fast computations through low-level languages.	• Programming languages • Theory and tools for numerical computations
Voraussetzungen	**Benotung**
recommended: • Basic programming knowledge • Basic knowledge of numerical methods, numerical linear algebra, algorithms	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Languages for Scientific Computing [MSSiSc-7121.a]		6	0
Vorlesung Languages Scientific Computing [MSSiSc-7121.b]		0	3
Praktikum Language Scientific Computing [MSSiSc-7121.e]		0	1

Modul: Parallel Programming II [MSSiSc-7123]

MODUL TITEL: Parallel Programming II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	5	jedes 2. Semester	SS 2011	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• POSIX Threads • Advanced MPI features • Partitioned Global Address Space (PGAS) languages • Programming of Graphics Processing Units j(GPUs) • Parallel I/O	• Building on knowledge of the course Parallel Programming I, the students should gain deeper insights into parallel programming as well as learn about recent developments in the area of parallel programming models. • The students should understand the principles of concurrent problem solving.
Voraussetzungen	**Benotung**
recommended: • Knowledge of the C programming language • Module Parallel Programming I	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Parallel Programming II [MSSiSc-7123.a]		6	0
Vorlesung Parallel Programming II [MSSiSc-7123.b]		0	3
Übung Parallel Programming II [MSSiSc-7123.c]		0	2

Modul: Seminar Parallel Programming [MSSiSc-7124]

MODUL TITEL: Seminar Parallel Programming

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	1	jedes 2. Semester	WS 2011/2012	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Students attending this seminar will be assigned topics related to state-of-the-art technology in the field of parallel programming. Based on the assignment, every student will perform the following tasks under the guidance of a supervisor: • Search for relevant literature • Write a topic summary • Prepare a talk of 40 min during which the topic is presented to other participants	The learning targets will be pursued by practice of (personally assigned) advanced scientific topics as well as active participation at the presentation dates. The organizer chooses the specific subject areas. To acquire the following skills and knowledge, in order to be able to prepare and present concepts, approaches and results of a scientific topic of computer science: • Ability to independently work on an advanced topic in computer science on the basis of appropriate literature, especially scientific original articles, to incorporate and narrow the topic appropriately and to develop a critical assessment • Ability to elaborate the concepts, approaches and results of a given topic of computer science within a clear structure, with reasonable formalisms and in a defined scope of time in written form; proof of independent elaboration by showing own examples • Ability to timely prepare and clearly present an advanced topic of computer science using appropriate media and examples • Ability to actively participate in in-depth discussions on topics in computer science
Voraussetzungen	**Benotung**

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Seminar Parallel Programming [MSSiSc-7124.a]		4	1

Modul: Automatic Generation and Analysis of Algorithms [MSSiSc-7125]

MODUL TITEL: Automatic Generation and Analysis of Algorithms

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 4. Semester	SS 2012	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• This course is research-oriented; it covers novel techniques on automation. In this course automation means that a computer makes decisions and performs operations much like a human would do. The objective is a software system that creates algorithms without human intervention. • We introduce the concepts of automation, autotuning, program correctness and numerical stability. • First we review a variety of methodologies to automatically generate algorithms in different fields. Then we restrict ourselves to linear algebra and introduce a symbolic technique based on program correctness, pattern matching and textual substitution. Such technique is applied to generate parallel algorithms for multi-core processors, cost analysis and error analysis.	• Programming languages • Theory and tools for symbolic computations
Voraussetzungen	**Benotung**
recommended: • Principles of algorithms and programming • Basic knowledge of numerical linear algebra • Familiarity with at least one of the following languages: Mathematica, Maple, Matlab, Sage	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Automatic Generation and Analysis of Algorithms [MSSiSc-7125.a]		6	0
Vorlesung Automatic Generation and Analysis of Algorithms [MSSiSc-7125.b]		0	3
Praktikum Automatic Generation and Analysis of Algorithms [MSSiSc-7125.e]		0	1

Modul: High-Performance Matrix Computations [MSSiSc-7126]

MODUL TITEL: High-Performance Matrix Computations

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 4. Semester	SS 2011	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• We explore high-performance algorithms and implementations for the most common numerical linear algebra operations: linear systems and eigenproblems. The focus is on attaining high-performance on a variety of parallel architectures: multi-core processors, GPUs, distributed and hybrid systems. • Topics covered: generalized, stadard and tridiagonal eigenproblems, matrix factorizations, linear systems. • Students are expected to participate in practical programming exercises. • The languages of choice are Matlab and C.	• Programming languages • Theory and tools for numerical computations
Voraussetzungen	**Benotung**
recommended: • Basic knowledge of numerical linear algebra • Principles of algorithms and programming	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung High-Performance Matrix Computations [MSSiSc-7126.a]		6	0
Vorlesung High-Performance Matrix Computations [MSSiSc-7126.b]		0	3
Praktikum High-Performance Matrix Computations [MSSiSc-7126.e]		0	1

Modul: Functions of Matrices with Applications [MSSiSc-7127]

MODUL TITEL: Functions of Matrices with Applications

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2015	English

INHALTLICHE ANGABEN

Inhalt

This course is research-oriented; it covers novel techniques related to the use of matrix functions in applications such as computational physics, complex networks, statistics and biology. The semester is divided in 4 parts:

- A general introduction to definitions, properties and equations.
- A description of the basic techniques for computing generic functions of general matrices;
- A detailed treatment of special functions (exponential, logarithm, square root, etc..);
- An illustration of the special methods for functions of large and sparse matrices.
- Theory will be integrated with many examples based on real life applications extracted from recent research topics.
- Students are expected to participate in practical programming exercises.

Lernziele

Fachbezogene Lernziele:

- Numerical Linear Algebra
- Matrix Approximation
- Theory and Tools for Numerical Computations

Nicht fachbezogene Lernziele:

- Ability of reading and understanding specialised technical articles
- Implement simple numerical algorithms in a high-level programming language
- Develop team working skills

Voraussetzungen

Mandatory requirements:

- Basic knowledge of numerical linear algebra
- Familiarity with Matlab or similar programming languages

Recommended requirements:

- Basic knowledge of numerical linear algebra
- Familiarity with Matlab or similar programming languages

Benotung

The oral exam and the homework will contribute to the final score by 90% and 10% respectively.

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Exam Functions of Matrices with Applications [MSSiSc-7127.a]		6	0
Lecture Functions of Matrices with Applications [MSSiSc-7127.bc]		0	3
Tutorial Functions of Matrices with Applications [MSSiSc-7127.c]		0	1

Modul: Seminar: Topics in High-Performance and Scientific Computing [MSSiSc-7128]

MODUL TITEL: Seminar: Topics in High-Performance and Scientific Computing

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	4	2	jedes 2. Semester	WS 2014/2015	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Students attending this seminar will be assigned topics related to state-of-the-art technology in the field of high-performance and scientific computing. Based on the assignment, every student will perform the following tasks under the guidance of a supervisor: • Search for relevant literature • Write a topic summary • Prepare a talk of 40 min during which the topic is presented to other participants	Fachbezogene Lernziele: Advanced topics in high-performance computing and scientific computing will be chosen every semester. Students are first expected to read up or research on a personally assigned subject, and then to synthesize the acquired knowledge in the form of oral presentation and written report. Additionally, through class participation the students will be exposed to a range of cutting edge techniques and topics. Nicht fachbezogene Lernziele: Students will acquire the following skills and knowledge, in order to be able to prepare and present concepts, approaches and results of a scientific topic of computer science: • Ability to independently investigate and learn an advanced topic in computer science on the basis of appropriate literature, especially scientific original articles • Ability to identify and critically assess unfamiliar computer science concepts and topics • Ability to elaborate -in written form and within a given timeframe- concepts, approaches and results of a given topic, following a clear structure. Proof of independent thinking through construction of suitable examples. • Ability to timely prepare an oral presentation using appropriate media and independently developed examples. Delivery of a scientific talk in front of a computer science audience • Ability to actively participate and contribute to in-depth discussions on topics in computer science.
Voraussetzungen	**Benotung**
	The final score is 50% of the oral exam and 50% of a written report.

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Topics in High-Performance and Scientific Computing [MSSiSc-7128.a]		4	0
Seminar Topics in High-Performance and Scientific Computing [MSSiSc-7128.d]		0	2

Modul: Seminar: Topics in Automation, Compilers and Code-Generation [MSSiSc-7129]

MODUL TITEL: Seminar: Topics in Automation, Compilers and Code-Generation

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	4	2	jedes 2. Semester	SS 2014	English

INHALTLICHE ANGABEN

Inhalt

Students attending this seminar will be assigned topics related to state-of-the-art technology in the field of high-performance and scientific computing. Based on the assignment, every student will perform the following tasks under the guidance of a supervisor:

- Search for relevant literature
- Write a topic summary
- Prepare a talk of 40 min during which the topic is presented to other participants

Lernziele

Fachbezogene Lernziele:

Advanced topics within the areas of automation, compilers and code generation will be chosen every semester. Students are first expected to read up or research on a personally assigned subject, and then to synthesize the acquired knowledge in the form of oral presentation and written report. Additionally, through class participation the students will be exposed to a range of cutting edge techniques and topics.

Nicht fachbezogene Lernziele:

Students will acquire the following skills and knowledge, in order to be able to prepare and present concepts, approaches and results of a scientific topic of computer science:

- Ability to independently investigate and learn an advanced topic in computer science on the basis of appropriate literature, especially scientific original articles
- Ability to identify and critically assess unfamiliar computer science concepts and topics
- Ability to elaborate -in written form and within a given timeframe- concepts, approaches and results of a given topic, following a clear structure. Proof of independent thinking through construction of suitable examples.
- Ability to timely prepare an oral presentation using appropriate media and independently developed examples. Delivery of a scientific talk in front of a computer science audience
- Ability to actively participate and contribute to in-depth discussions on topics in computer science.

Voraussetzungen

Benotung

The final score is 50% of the oral exam and 50% of a written report.

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Topics in Automation, Compilers and Code-Generation [MSSiSc-7129.a]		4	0
Seminar Topics in Automation, Compilers and Code-Generation [MSSiSc-7129.d]		0	2

Modul: Multicore Laboratory [MSSiSc-7130]

MODUL TITEL: Multicore Laboratory

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	7	4	jedes 2. Semester	SS 2014	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
Preparatory Course: • Presentation of examples and exercises from different programming models for multicore programming • Summary of methods and tools to be used during the lab Software Development Lab: Development of multicore software project on a modern shared-memory architecture • Requirement engineering (software requirements specification) • Design and implementation • Program analysis, profiling and tuning • Testing, debugging and documentation • Presentation	Fachbezogene Lernziele: Achieve the ability to develop efficient parallel programs on modern multicore systems. Nicht fachbezogene Lernziele: • communication skills • work in a team • manage a software development project • present the results of the project work to a larger audience
Voraussetzungen	**Benotung**
Recommended requirements: • module Parallel Programmin I	The final score is 60% of the project report, 30% of the final presentation and 10% of the homework.

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Exam Multicore Laboratory [MSSiSc-7130.a]		7	0
Labor Multicore Laboratory [MSSiSc-7130.d]		0	4

Modul: Performance and Correctness Analysis of Parallel Programs [MSSiSc-7131]

MODUL TITEL: Performance and Correctness Analysis of Parallel Programs

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	5	jedes 2. Semester	WS 2014/2015	English and German

INHALTLICHE ANGABEN

Inhalt

- Scalability of parallel applications
- Performance monitoring (profiling, tracing, event-driven, sample-driven)
- Instrumentation
- Methods of performance analysis - error classes (deadlocks, race conditions)
- Traditional debugging technology - methods for error detection (Static program analysis, runtime, Formal Methods)
- Error in programming with MPI
- Deadlock detection
- Design methods for error prevention and detection (assertions, Correctness-by-Construction)

Lernziele

- Methods for performance analysis of parallel programs
- Validation and error detection in parallel programs

Voraussetzungen

Recommended requirements:

- Knowledge of serial programming and elementary programming techniques (Lecture Programming)
- Mastery of essential concepts of parallel processing (lecture Introduction to High-Performance Computing)

Benotung

A written exam or an oral exam. 100% of the final exam for the module.

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Exam Performance and Correctness Analysis of Parallel Programs [MSSiSc-7131.a]	120	6	0
Lecture Performance and Correctness Analysis of Parallel Programs [MSSiSc-7131.b]		0	3
Tutorial Performance and Correctness Analysis of Parallel Programs [MSSiSc-7131.c]		0	2

Modul: Approximation Theory and Data Analysis [MSSiSc-8101]

MODUL TITEL: Approximation Theory and Data Analysis

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	9	6	jedes 2. Semester	unregelmäßig	English or German (as required)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• B-spline-Bezier-representations • recursive evaluation schemes • subdivision techniques • quasi-interpolation • Fourier analysis • fast Fourier transform • wavelet transform • function spaces	The students should get acquainted with major constructive approximation concepts such as spline approximation, Bezier representation of polynomials, sparse grids, rational approximation, wavelet and multiscale expansions as well as procedural methods for curve and surface generation such as subdivision schemes. They should acquire the necessary theoretical foundations for properly using these concepts and assessing their effectiveness. This includes the capability of carrying out error and convergence analyses, the understanding of relevant stability notions as well as appraising the effectiveness of nonlinear approximation techniques like best n-term approximation or adaptive mesh refinement. The students should master the most important modern techniques for numerically implementing such methods in at least one application context, for instance, free form curve and surface modeling, signal and image analysis or data mining.
Voraussetzungen	**Benotung**
• Module Numerical Analysis I and II (e.g. from BSc Mathematics) or equivalent prerequisites recommended: • Basis knowledge in linear algebra and functional analysis	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Approximation Theory and Data Ananalysis [MSSiSc-8101.a]		9	0
Vorlesung Approximation Theory and Data Analysis [MSSiSc-8101.b]		0	4
Übung Approximation Theory and Data Analysis [MSSiSc-8101.c]		0	2

Modul: Dynamical Systems [MSSiSc-8102]

MODUL TITEL: Dynamical Systems

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	9	6	jedes 2. Semester	unregelmäßig	English or German (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Discrete dynamical systems (iteration of maps) • prototypes (logistic map, symbolic dynamics and so on) • basic concepts (attractor, repeller, periodic points, topological conjugation, chaotic behavior) • examples • continuous dynamical systems (ordinary differential equations) • prototypes • basic concepts and examples • Poincaré map • hyperbolic invariant sets • bifurcation of dynamical systems (classification of local bifurcations and examples) • homoclinic points.	Students should learn to apply techniques of Analysis and linear Algebra, particularly in modelling
Voraussetzungen	**Benotung**
• Modules Analysis I and II (e.g. from BSc Mathematics) or equivalent • Module Linear Algebra I (e.g. from BSc Mathematics) or equivalent recommended: • Basic knowledge of ordinary differential equations	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Dynamical Systems [MSSiSc-8102.a]		9	0
Vorlesung Dynamical Systems [MSSiSc-8102.b]		0	4
Übung Dynamical Systems [MSSiSc-8102.c]		0	2

Modul: Finite Element and Volume Techniques [MSSiSc-8103]

MODUL TITEL: Finite Element and Volume Techniques

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	9	6	jedes 2. Semester	WS 2009/2010	English or German (as required)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Selected topics of Finite Element Methods for elliptic and parabolic differential equations: stability, weak and mixed formulations, saddle point problems, Stokes- and Navier-Stokes equations, nonconforming discretizations, error estimates and adaptivity. • Finite Volume and Discontinuous Galerkin Methods for hyperbolic conservation laws, shocks, weak solutions, entropy principles, conservative discretization, TVD techniques, approximate Riemann solvers, entropy stability, convergence, error estimates and adaptivity	The students should extend their comprehension of partial differential equations to include saddle point problems and nonlinear systems such as various models of continuum mechanics. They should understand the derivation and fundamental stability properties of advanced discretization concepts and their algorithmic realization, and master error control and adaptive refinement. Thus they shall prepare to contribute with new ideas to current research topics in this field.
Voraussetzungen	**Benotung**
• Module Numerical Analysis IV recommended: • Module Partial Differential Equations I (e.g. from BSc Mathematics) or equivalent knowledge	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Finite Elemente and Volume Techniques [MSSiSc-8103.a]		9	0
Vorlesung Finite Element and Volume Techniques [MSSiSc-8103.b]		0	4
Übung Finite Element and Volume Techniques [MSSiSc-8103.c]		0	2

Modul: Iterative Solvers [MSSiSc-8104]

MODUL TITEL: Iterative Solvers

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	9	6	jedes 2. Semester	SS 2010	English or German (as required)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• basic iterative solvers for large sparse linear systems • Krylov subspace methods • Preconditioning techniques • Mulrigrid methods • Domain decomposition methods • Convergence analysis of iterative solvers	The students should • master fundamental iterative solution techniques that can be used for the solution of descretized partial differential equations • deepen their understanding of these techniques and achieve the ability to develop and adapt these methods flexibly for new problems • develop an understanding for basic notions related to the analysis of iterative solvers, such as rate of convergence, efficiency and robustness
Voraussetzungen	**Benotung**
recommended: • Module Numerical Methods for PDEs • Module Numerical Analysis IV	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Iterative Solvers [MSSiSc-8104.a]		9	0
Vorlesung Iterative Solvers [MSSiSc-8104.b]		0	4
Übung Iterative Solvers [MSSiSc-8104.c]		0	2

Modul: Control Theory [MSSiSc-8105]

MODUL TITEL: Control Theory

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	9	6	jedes 2. Semester	unregelmäßig	English (or German)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Dynamic systems • Linearity and time invariance • Stability • Controllability • State feedback and stabilisation • Observability • Observer design and detectability • Frequency domain transfer matrix, realisation theory, controller design	The students should • understand the basic ideas of controlling linear systems • acquire the basic knowledge of dealing with nonlinear control problems • develop understanding for algebraic analysis of differential equations • get to know a practical application of linear algebra • deepen the theory of modules over principal ideal domains in the context of a concrete case
Voraussetzungen	**Benotung**
recommended: • Contents of modules Linear Algebra I and II (BSc Mathematics) • Contents of modules Analysis I and II (BSc Mathematics)	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Control Theory [MSSiSc-8105.a]		9	0
Vorlesung Control Theory [MSSiSc-8105.b]		0	4
Übung Control theory [MSSiSc-8105.c]		0	2

Modul: Nonlinear Functional Analysis [MSSiSc-8106]

MODUL TITEL: Nonlinear Functional Analysis

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	9	6	jedes 2. Semester	WS 2009/2010	German, possibly English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Fixed point theorems of Brouwer and Schauder • apping degree by Brouwer and Leary-Schauder • Nonlinear equations • Calculus in Banach spaces • Bifurcation theory • Monotone operators	Based on the module Functional Analysis I students will be introduced to nonlinear problems. Important tools such as fixed point theory and mapping degree are often applied in phyics and engineering.
Voraussetzungen	**Benotung**
• Modules Lineare Algebra I and II (e.g. from BSc Mathematics) or equivalent knowledge • Modules Analysis I, II and III(e.g. from BSc Mathematics) or equivalent knowledge recommended: • Module Functional Analysis(e.g. from BSc Mathematics) or equivalent knowledge	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Nonlinear Functional Analysis [MSSiSc-8106.a]		9	0
Vorlesung Nonlinear Functional Analysis [MSSiSc-8106.b]		0	4
Übung Nonlinear Functional Analysis [MSSiSc-8106.c]		0	2

Modul: Numerical Analysis III [MSSiSc-8107]

MODUL TITEL: Numerical Analysis III

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	9	6	jedes 2. Semester	WS 2009/2010	English or German (as required)

INHALTLICHE ANGABEN

Inhalt	Lernziele
Numerical methods for ordinary- and algebro-differential equations	The students shall • develop an understanding of the fundamental discretisation principles of ordinary differential equations • understand basic techniques such as one- und multistep methods, step size control, extrapolation and semi-implicit as well as implicit approaches and master them actively • penetrate fundamental concepts such as stiffness of a problem and stability of an algorithm • deepen their ability to understand the working principles of fundamental numerical methods and to assess the scope of applicability of the methods • achieve the ability to develop and adapt methods flexibly for new problems. • The tools acquired in this course will form the basis to master further algorithmic concepts for solving scientific and technological problems in future courses.
Voraussetzungen	**Benotung**
• Module Numerical Analysis II (e.g. from BSc Mathematics) or equivalent knowledge recommended: • Two 4+2 classes in calculus / analysis • Two 4+2 classes in numerical analysis	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Numerical Analysis III [MSSiSc-8107.a]		9	0
Vorlesung Numerical Analysis III [MSSiSc-8107.b]		0	4
Übung Numerical Analysis III [MSSiSc-8107.c]		0	2

Modul: Numerical Analysis IV [MSSiSc-8108]

MODUL TITEL: Numerical Analysis IV

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	9	6	jedes 2. Semester	SS 2010	English or German (as required)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Finite difference, finite element and finite volume methods for partial differential equations • Variational framework and weak formulations • Linear stability theory for time-dependent problems • Convergence and error estimates • Fast iterative solvers (relaxation, conjugate gradients, Krylov subspace methods, multigrid)	The students shall • penetrate the classification of partial differential equations and develop a solid understanding of the underlying physical processes of energy-minimization, diffusion and transport • develop an understanding of the fundamental discretisation principles of partial differential equations • deepen their ability to understand the working principles of fundamental numerical methods and to assess the scope of applicability of the methods • based on this, achieve th ability to develop and adapt methods flexibly for new problems • master fundamental techniques such as finite difference methods and finite element methods • develop an understanding for the stability concepts related to methods for different types of differential equations
Voraussetzungen	**Benotung**
• Module Numerical Analysis III or equivalent background recommended: • Three 4+2 classes in calculus / analysis • Two 2+2 classes in introductory numerical analysis	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Numerical Analysis IV [MSSiSc-8108.a]		9	0
Vorlesung Numerical Analysis IV [MSSiSc-8108.b]		0	4
Übung Numerical Analysis IV [MSSiSc-8108.c]		0	2

Modul: Partial Differential Equations II [MSSiSc-8109]

MODUL TITEL: Partial Differential Equations II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	9	6	jedes 2. Semester	WS 2009/2010	German (WS09/10), English (WS 10/11 on)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• evolution equations • special equations • maximum principles • weak formulations • subsistence rate • regularity • nonlinear equations • qualitative theory	The student should apply techniques of basics analysis lectures and basic lectures on differential equations to a key area of modern mathematics. They will learn how to become acquainted with a current research topic and will be introduced to the central role of partial differential equations in science and engineering.
Voraussetzungen	**Benotung**
• Modules Analysis I and II (e.g. from BSc Mathematics) or equivalent knowledge • Module Linear Algebra I (e.g. from BSc Mathematics) or equivalent knowledge recommended: • Module Partial Differential Equations (e.g. from BSc Mathematics) or equivalent knowledge	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Partial Differential Equations II [MSSiSc-8109.a]		9	0
Vorlesung Partial Differential Equations II [MSSiSc-8109.b]		0	4
Übung Partial Differential Equations II [MSSiSc-8109.c]		0	2

Modul: Calculus of Variations I [MSSiSc-8110]

MODUL TITEL: Calculus of Variations I

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	9	6	jedes 2. Semester	WS 2009/2010	German, possibly English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Euler-Lagrange equations of one-dimensional variational integrals • Sobolev functions on bounded domains • Dirichlet principle • Compactness criteria • Lower semicontinuity • Existence theory • Regularity of weak solutions • Variational applications	The students will be introduced to a classic area of mathematics. Terms as minimium, maximum and critical point, known from basic analysis lectures, will be extended and classic one-dimensional minimization problems presented. The students will learn how to formulate and solve minimization problems on their own
Voraussetzungen	**Benotung**
Modules Analysis I, II and III (e.g. from BSc Mathematics) or equivalent knowledge	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Calculus of Variations I [MSSiSc-8110.a]		9	0
Vorlesung Calculus of Variations I [MSSiSc-8110.b]		0	4
Übung Calculus of Variations I [MSSiSc-8110.c]		0	2

Modul: Calculus of Variations II [MSSiSc-8111]

MODUL TITEL: Calculus of Variations II

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	9	6	jedes 2. Semester	SS 2010	German, possibly English

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Euler-Lagrange equations of higher-dimensional variational integrals • Sobolev functions on bounded domains • Dirichlet principle • Compactness criteria • Lower semicontinuity • Existence theory • Regularity of weak solutions • Variational applications	Based on the module Calculus of Variations I, the students will be introduced to higher-dimensional calculus of variations. Many examples from physics and engineering can be formulated as minimization problems or in the framework of a critical point theory. Basic techniques for finding solutions to such problems will be taught.
Voraussetzungen	**Benotung**
• Modules Analysis I, II and III (e.g. from BSc Mathematics) or equivalent knowledge • Module Calculus of Variations I	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Calculus of Variations II [MSSiSc-8111.a]		9	0
Vorlesung Calculus of Variations II [MSSiSc-8111.b]		0	4
Übung Calculus of Variations II [MSSiSc-8111.c]		0	2

Modul: Optimization A [MSSiSc-8113]

MODUL TITEL: Optimization A

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	9	6	jedes 2. Semester	SS 2010	German or English (on request)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Optimality criteria for problems without constraints • Optimality criteria for problems with constraints, Lagrange function, proposition of Karush-Kuhn-Tucker • Parametric and semi-infinite optimization • Convexity, duality, separation theorems • Linear inequality systems, constraint qualifications • Linear optimization, Simplex methods, ellipsoid algorithm of Khachyan, Karmarkar algorithm • Convergence concepts, gradient and Newton methods, SQP methods, conjugate directions, DFP and BFGS methods • Selected topics of current optimization research, e.g., non--smooth optimization, Morse theory, bundle methods, control problems	• Knowledge of local and global analysis of (non) linear optimization problems • Knowledge of modern methods to solve (non) linear optimization problems
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in analysis and linear algebra	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Optimization A [MSSiSc-8113.a]		9	0
Vorlesung Optimization A [MSSiSc-8113.b]		0	4
Übung Optimization A [MSSiSc-8113.c]		0	2

Modul: Optimization B [MSSiSc-8114]

MODUL TITEL: Optimization B

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	9	6	jedes 2. Semester	WS 2009/2010	German or English (depending on the students)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Graph theoretical problems • Flows in networks • integer linear optimization • Complexity theory (class P and NP, NP complete problems) • Approximation algorithms • Probabilistic analysis	• Knowledge of the most important algorithmic methods and structure propositions of discrete optimization • Ability to classify complexity theoretical optimization problems
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in analysis and linear algebra	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Optimization B [MSSiSc-8114.a]		9	0
Vorlesung Optimization B [MSSiSc-8114.b]		0	4
Übung Optimization B [MSSiSc-8114.c]		0	2

Modul: Optimization C [MSSiSc-8115]

MODUL TITEL: Optimization C

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	9	6	jedes 4. Semester	SS 2009	German or English (on request)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Differentiability in Banach spaces • Optimization with ordinary differential equations (e.g. Pontryagin´s maximum principle, Hamilton-Jacobi Belmann equation) • Optimization problems with partial differential equations (e.g. variation problems, Lagrange multiplication theorems, functional analytical approaches) • Current topics of research in this field	• Knowledge of the most important concepts of infinite dimensional optimization • Ability to work independently on continuous optimization problems
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in analysis and linear algebra • Module *Optimization A*	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Optimization C [MSSiSc-8115.a]		9	0
Vorlesung Optimization C [MSSiSc-8115.b]		0	4
Übung Optimization C [MSSiSc-8115.c]		0	2

Modul: Mathematical Models in Science and Engineering (PDEs) [MSSiSc-8116]

MODUL TITEL: Mathematical Models in Science and Engineering (PDEs)

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	6	4	jedes 2. Semester	SS 2012	German or English (on request)

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Mathematical basics • Kinematics • Field equations • Solid state mechanics • Thermodynamics • Fluid mechanics • Kinetic gas theory • Electrodynamics • Magnetohydrodynamics	• The class presents a cohesive mathematical derivation and discussion of different partial differential equations as models for technical and physical processes. Basic framework will be the balance laws of mass, momentum and energy, as well as the Maxwell equations. Different constitutive material laws will yield different models. • We will consider among others: solid mechanics, fluid and gas dynamics, chemical reactions, magnetohydrodynamics. As application examples we study models for rubber, earthquakes, flames, shock waves, electric arcs, etc. • The aim is to view the connections of relevant PDEs in applied mathematics and master the process of modeling from the physical concept, the mathematical equation up to a concrete result.
Voraussetzungen	**Benotung**
recommended: • Basic knowledge in mathematics • Experience with Mathematica, Maple, Matlab	

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Mathematical Models in Science and Engineering (PDEs) [MSSiSc-8116.a]		6	0
Vorlesung Mathematical Models in Science and Engineering (PDEs) [MSSiSc-8116.b]		0	3
Übung Mathematical Models in Science and Engineering (PDEs) [MSSiSc-8116.c]		0	1

Modul: Model Order Reduction Techniques [MSSiSc-8117]

MODUL TITEL: Model Order Reduction Techniques						
ALLGEMEINE ANGABEN						
Fachsemester	**Dauer**	**Kreditpunkte**	**SWS**	**Häufigkeit**	**Turnus Start**	**Sprache**
2	1	9	6	jedes 2. Semester	SS 2013	English or German

INHALTLICHE ANGABEN

Inhalt	**Lernziele**
- Introduction, motivation, and review of finite element analysis - Reduced Basis (RB) methods for linear elliptic PDEs - RB for linear parabolic PDEs - Geometric parametrizations, RB for noncoercive and saddle point problems - Empirical Interpolation Method (nonaffine and higher-order nonlinear problems) - Proper Orthogonal Decomposition (POD)	With respect to the subject: - The students know different model order reduction techniques for high-dimensional systems, more specifically parametrized partial differential equations (PDEs). - The students know the theoretical foundations and are able to assess the limitations of the various methods. - The students are able to apply these methods to problems in science and engineering and implement numerical schemes to solve them.
Voraussetzungen	**Benotung**
Numerical Analysis	- Written or oral examination (100%)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	**Prüfungsdauer (Minuten)**	**CP**	**SWS**
Exam Model Order Reduction Techniques [MSSiSc-8117.a]		9	0
Lecture Model Order Reduction Techniques [MSSiSc-8117.b]		0	4
Exercise Model Order Reduction Techniques [MSSiSc-8117.c]		0	2

Modul: Introduction to Transport Theory [MSSiSc-8119]

MODUL TITEL: Introduction to Transport Theory

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	3	unregelmaes-sig	SS 2014	English

INHALTLICHE ANGABEN

Inhalt	Lernziele
- From Newton's equations to Boltzmann's equation - Linear transport - Scaling issues - Properties of kinetic equations (existence & uniqueness, H theorem) - The diffusion limit - From Boltzmann to Euler & Navier-Stokes - Boundary layer analysis - Method of Moments - Closure techniques - Selected numerical methods	With respect to the subject: - Mesoscopic and Macroscopic description of particle systems - Multiscale methods (asymtotic analysis, method of moments) - Numerical methods
Voraussetzungen	**Benotung**
Mandatory: - Analysis and linear algebra - Partial Differential Equations Recommended: - Functional Analysis	1 Written or Oral Examination (100%)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Introduction to Transport Theory [MSSiSc-8119.a]		5	0
Vorlesung Introduction to Transport Theory [MSSiSc-8119.b]		0	2
Übung Introduction to Transport Theory [MSSiSc-8119.c]		0	1

Modul: Advanced Topics in Transport Theory [MSSiSc-8120]

MODUL TITEL: Advanced Topics in Transport Theory

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
2	1	5	3	unregelmaes-sig	SS 2014	Englisch

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Introduction - transport equation • Mixing statistics in random binary media • The atomic mix model • The multiscale expansion technique • Asymptotic limits of the atomic mix model • The Liouville master equation approach • The Levermore-Pomraning equations • The stochastic balance method • Alternate closures and higher-order moments • Non-classical transport	Understanding particle transport in stochastic media; learning transport models for random binary media (atomic mix, Levermore-Pomraning, etc.); understanding the basics of non-classical transport; developing the ability to apply these methods to practical problems
Voraussetzungen	**Benotung**
	1 written or oral exam (100%)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Advanced Topics in Transport Theory [MSSiSc-8120.a]		5	0
Vorlesung Advanced Topics in Transport Theory [MSSiSc-8120.b]		0	2
Übung Advanced Topics in Transport Theory [MSSiSc-8120.c]		0	1

Modul: Uncertainty Quantification [MSSiSc-8121]

MODUL TITEL: Uncertainty Quantification

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	5	3	unregelmaes-sig	WS 2013/2014	Englisch

INHALTLICHE ANGABEN

Inhalt	Lernziele
• Concepts of probability theory • Concepts of approximation theory • Spectral expansions: Karhunen-Loeve, polynomial chaos, generalized polynomial chaos • Non-intrusive methods: spectral projection, Monte-Carlo sampling, collocation • Intrusive methods: spectral Galerkin, moment methods • Connection to kinetic theory • Sensitivities and adjoints	Knowledge and comprehension of different methods for uncertainty analysis, ability to evaluate different techniques, ability to apply these methods to practical problems.
Voraussetzungen	**Benotung**
Modules Mathematische Grundlagen, Analysis I und II, Lineare Algebra I or equivalent knowledge	1 written or oral exam (100%)

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungs-dauer (Minuten)	CP	SWS
Prüfung Uncertainty Quantification [MSSiSc-8121.a]		5	0
Vorlesung Uncertainty Quantification [MSSiSc-8121.b]		0	2
Übung Uncertainty Quantification [MSSiSc-8121.c]		0	1

Modul: Isogeometric Analysis [MSSiSc-8122]

MODUL TITEL: Isogeometric Analysis

ALLGEMEINE ANGABEN

Fachsemester	Dauer	Kreditpunkte	SWS	Häufigkeit	Turnus Start	Sprache
3	1	6	3	jedes 2. Semester	WS 2014/2015	English

INHALTLICHE ANGABEN

Inhalt

- Basics of isogeometric analysis (IGA), especially compared to classical finite element methods.
- Refinement strategies within IGA
- Application to structurural mechanic problems, heat transfer and fluid mechanics
- Comparison to 'NURBS Enhanced Finite Elements', an approach similar to IGA

Lernziele

Fachbezogen:

- Understanding of the basic approaches regarding modeling in CAD systems and in the classical finite element simulation; combination of these two approaches to isogeometric analysis and its application to various classes of problems (structural mechanics, heat transfer and CFD) under consideration of the pros and cons.

Nicht fachbezogene Lernziele:

- none

Voraussetzungen

Recommended requirements:

- Basic knowledge of numerical methods
- Programming knowledge in Matlab, Octave, or similar

Benotung

Eine 20-minütige mündliche Prüfung und Hausaufgaben.
Die Endnote ergibt sich zu aus der mündlichen Prüfung plus Bonuspunkteregelung für Hausaufgaben.

LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Titel	Prüfungsdauer (Minuten)	CP	SWS
Prüfung Isogeometric Analysis [MSSiSc-8122.a]	20	6	0
Vorlesung/Übung Isogeometric Analysis [MSSiSc-8122.bc]		0	3