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SCIMATH101 - Calculus for Scientists

Fall 2019 Course Manual

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Contents

Course code:	SCIMATH101 **(GROUP A)**
Course title:	Calculus for Scientists
Semester:	Fall 2019
Classroom no:	Burg 24
Class times:	TUE 11:00 - 13:00 and FRI 08:45 - 10:45
Instructor:	Dr. L.R. (Richard) van den Doel
Email:	`r.vandendoel@ucr.nl`
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Office no. & Location:	E0.05 in Eleanor
Office hours:	MON to FRI 09:00 - 17:00

Course code:	SCIMATH101 **(GROUP B)**
Course title:	Calculus for Scientists
Semester:	Fall 2019
Classroom no:	Elliott C-19
Class times:	MON 16:00 - 18:00 and THU 16:00 - 18:00
Instructor:	Dr. İlke Ercan
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Tel:	0118 - 655 532
Office no. & Location:	E2.03 in Eleanor
Office hours:	By appointment

1 Track Information

a) Prerequisites for this course: SCIMATH101 does not have any formal prerequisites. Students enrolling in SCIMATH101 are expected to have learned all the standard functions, rules for differentiation and integration as subjects in their high school Mathematics program!
b) This course serves as prerequisite for: SCIMATH202 and SCIMATH203.
c) Other courses which are relevant to this course - *e.g.* as part of a minor: SCIMATH202, SCIMATH203, SCIMATH301, SCIMATH302, SCIPHYS101, SCIPHYS201, SCIPHYS202, SCIPHYS301, SCIPHYS302, SCICOMP102, SCICOMP301, SCICOMP302.

For further information about the track, please see the track document available on the UCR intranet.

2 Course Description

Mathematics is the language used to grasp understanding of, to explore, and to gain insight in any of the sciences: physics, chemistry, biology, and so forth, cannot be well understood or appreciated without sufficient skills in mathematics. The aim of this introductory course in the mathematics track is to learn basic widely-used mathematical techniques, such as differentiation, various techniques for integration, complex numbers and differential equations. These techniques are put into context in projects related to real situations in the fields of physics, chemistry, biology, economics, sociology, etc. In this course students will continue to construct knowledge on their mathematical bases already founded. Students will solve many problems as homework assignments. Furthermore, two exams will assess the students for their level of understanding and their ability to solve relevant mathematical problems. A lot of class time will be used to solve and discuss textbook problems.

3 Study Load

This course earns students 7.5 EC. The class meets twice a week for two hours. Preparation time is approximately 10 hours per week.

4 Course Materials

The following textbook is required for this course:

Calculus,
Concepts & Connections
by **Robert T. Smith** and **Roland B. Minton**
published by **McGraw-Hill**
ISBN-number is 0-07-282623-1

Furthermore, four additional handouts are available on Moodle. These handouts are also part of the required course material. The topics of these five handouts are

- Standard Functions,
- Complex Numbers,
- Taylor Series,
- Difference and Differential Equations.

A formula sheet is available on Moodle. Students can use the formula sheet for the exams; it will be attached to the mid-term exam and the final exam.

5 Course Organization and Requirements

a) General format of class meetings: all classes start with summarizing the most important results from the previous class(es). Student get the opportunity to ask questions regarding the material discussed earlier in class or regarding homework assignments. The remainder of the class is used to discuss new material and examples. The classes prior to an exam are meant for revision; students can ask questions regarding the material for the upcoming exam, including problems from old exams.

b) Students are expected to come to class prepared and to participate actively during discussions and problem solving. Students are strongly encouraged to work together on the homework assignments.
c) Rules for missing classes and deadlines: the rules of the UCR Student Handbook apply. Homework assignments submitted after the deadline will not be corrected and graded. Students missing an exam are expected to notify the instructor before the actual exam and they are expected to retake the exam as soon as possible, preferably in the same week as the scheduled exam.
d) Procedures for communication and use of Moodle: contact the instructor via e-mail to schedule an appoint for discussing any issue in the course. Moodle will be used to make additional material available to students.

This course is subject to UCR academic rules and procedures. Both students and instructors are required to know and follow these rules and procedures.

6 Assessment

The student will be assessed several times during this course: five times written homework must be submitted, a project must be done and two times a written exam will be given. Table 1 shows the contributions of these various assessments to the final grade for this course.

Table 1. Type of assessment, its contribution to the final grade and a column for your own grades.

Assessment:	**Weight:**	**Your Grades:**
Homework series 1	5%	
Homework series 2	5%	
Homework series 3	5%	
Homework series 4	5%	
Homework series 5	5%	
Homework average:	25%	
Mid-term exam:	25%	
Project:	20%	
Final exam:	30%	
Final grade:		

Homework series: Each of the five homework series consists of 20 problems related to the course material under discussion. Most of these problems must be solved using pen and paper. A number of these problems must be solved using the computer algebra software (CAS) package *Mathematica*. Write the solution of each problem down step-by-step; just writing down a final answer will not earn you any points! Write legible and make sure that your work follows the ordering of the homework series in order to streamline the assessment of your work. Check for every problem in the homework series if you answer the right question. Print the relevant parts of the *Mathematica* commands (and comments) and output and attach it to your homework. Submit your homework as a stapled and sorted set of A4 papers. Write your name and / or student number on the

first page of your work. Detailed solutions of the homework series will be made available via Moodle. You are strongly encouraged to compare your approach with these detailed solutions. The level of difficulty of the problems in the five homework series is indicative for the level of difficulty of the exam problems. You are strongly encouraged to work together with other students on the homework series. Furthermore, you can use all the resources you can find. You can ask the instructor for additional explanations of specific homework assignments. This implies that you should aim for a very high score for the five homework series. The contribution of the homework series to the final grade for the course is very much based on effort. Working on these homework series should prepare you very well for the exam. Evaluate your level of understanding of the material prior to the exam by solving other relevant problems, for instance, in the review exercises at the end of every chapter.

Project: In the second half of the semester you will work in a team of in total three students on a dynamical model. The starting point of your project is a working *Mathematica* notebook presenting a basic dynamic model. All dynamic models consists of a set of coupled differential equations. Each differential equation defines factors contributing to the rate of change of a quantity. The challenge of the project is to investigate what the meaning is of each of these factors. Furthermore, each project team is expected to expand this basic dynamic model. In week 14 of the semester, all project teams will discuss their findings during a presentation. This presentation should discuss the background of the dynamic model and explain the reasoning behind the coupled differential equations. Furthermore, the project team should explain how they adapted the basic model step-by-step. Finally, the project team should discuss the limitations of the model. The project is assessed on the level of difficulty of the expanded models, the correctness and clarity of the explanations, the quality of the presentation, the quality of the *Mathematica* notebooks, the level of independence, the quality of answers to questions, and so forth. There is no explicit breakdown of the grade for the project in terms of these items. All project teams will get extensive feedback regarding their own project. The grade for the project is the translation of this feedback into a grade. Similar to the homework series, serious collective effort for this project will translate into a good grade for this part of the course!

Exams: Right before the break and right before the end of the semester, students will be assessed on their level of understanding of the course material by writing an exam. The mid term exam deals with the course material discussed in the first part of the semester. The second exam focuses on the course material discussed in the second half of the semester. Note that a large part of the course material in the second half of the course requires good understanding of the course material in the first half of the course! The mid-term exam is somewhat more difficult compared to the final exam, since the course material in the first part of the course provides unlimited ways of assessing. A significant part of the course material in the second half of the course does not provide for this. This makes it somewhat easier for you to evaluate your own level of understanding. The final exam is more straightforward in terms of the type of the problems that can be put in the final exam. You should prepare for the exams by carefully comparing your approach to the homework series with the available solutions, by solving additional exercises from the textbook, especially the review exercises, and by solving some old exams. The length of an exam is the full two hours of a class. This implies that you should be able to solve

the exam problems at a reasonable speed; there is no unlimited time to solve each and every problem. A useful strategy when writing the exams is to carefully read all the exam problems and to start with the easy problems and do the most difficult problems at the end of the exam. Note that all exam questions require you to show the details of your work! Answers to problems on the exam are assessed as follows:

(3 out of 3)	**(2 out of 3)**	**(1 out of 3)**	**(0 out of 3)**
The given answer is completely correct; student demonstrates clear reasoning and shows intermediate steps in sufficient detail; answer follows logically from the available information. In case the reasoning is crystal clear, but the final answer is derived from incorrect information, *e.g.* student used incorrect results from previous parts, then the student will earn full credit for the problem.	The given answer is not completely correct; student demonstrates sufficient understanding and shows intermediate steps in some detail, but with some minor mistakes. There are minor flaws in the reasoning.	The given answer is wrong, but the student demonstrates some understanding how the final answer to the problem can be found, but the student does not master that approach. There are serious short comings in the answer and in the reasoning.	The answer is completely wrong and the student does not demonstrate sufficient understanding how to answer the given problem, or the correct answer is given, but not supported by any reasoning. The problem is not at all answered.

7 Course schedule

The course schedule may be subject to small changes; as a result of class dynamics, some topics will be discussed earlier *cq.* later compared to the schedule below.

Time	**Topics**	**Course material**	**Assignments & assessment**
Week 1 MON, 26-08 TUE, 27-08	Introduction to the course *Preliminaries*: Equations of lines; quadratic equation, polynomials, rational functions, inverse functions; exponential and logarithmic functions, introduction to *Mathematica* (1)	Ch. 0 (1), handout Standard Functions	Homework series 1 out
Week 1 THU, 29-08 FRI, 30-08	*Preliminaries*: Trigonometric functions, inverse trigonometric functions, trigonometric identities, introduction to *Mathematica* (2)	Ch. 0 (2), handout Standard Functions	
Week 2 MON, 02-09 TUE, 03-09	*Preliminaries*: Parametric functions, composition of functions	Ch. 0 (3), handout Standard Functions	
Week 2 THU, 05-09 FRI, 06-09	*Limits and Continuity*: Concept of limit; computation of limits	Ch. 1 (1)	
Week 3 MON, 09-09 TUE, 10-09	*Limits and Continuity*: continuity; limits involving infinity	Ch. 1 (2)	
Week 3 THU, 12-09 FRI, 13-09	*Differentiation*: tangent lines; computation of derivatives; power rule; product and quotient rule	Ch. 2 (1)	Homework series 2 out
Week 4 MON, 16-09 TUE, 17-09	*Differentiation*: chain rule; derivatives of standard functions; implicit differentiation; mean value theorem	Ch. 2 (2)	Submit homework series 1
Week 4 THU, 19-09 FRI, 20-09	*Applications of Differentiation*: linearization; Newton's method; l'Hôpital's rule	Ch. 3 (1)	
Week 5 MON, 23-09 TUE, 24-09	*Applications of Differentiation*: extreme values and concavity; optimization	Ch. 3 (2)	
Week 5 THU, 26-09 FRI, 27-09	*Applications of Differentiation*: Taylor Series	handout Taylor Series	

Week 6 MON, 30-09 TUE, 01-10	*Complex Numbers*: Standard Form, Polar Form, Geometric Interpretation Addition, Multiplication, Division	handout Complex Numbers (1)	Submit Homework Series 2, Homework Series 3 out
Week 6 THU, 03-10 FRI, 04-10	*Complex Numbers*: Complex Exponential Form, Euler Equations, de Moivre's Theorem: Trigonometric Identities, Square Roots and Quadratic Equations	handout Complex Numbers (2)	

Week 7 MON, 07-10 TUE, 08-10	Review Session	-	Submit Homework Series 3
Week 7 THU, 10-10 FRI, 11-10	**Mid-Term Exam**	-	

14-10/18-10	Fall Break

Week 8 MON, 21-10 TUE, 22-10	*Integration*: Definite Integral; Antiderivatives	Ch. 4	Homework Series 4 out; form project teams and choose dynamic model
Week 8 THU, 24-10 FRI, 25-10	*Integration*: Substitution Method	Ch. 4	

Week 9 MON, 28-10 TUE, 29-10	*Integration*: Integration by Parts	Ch. 4	
Week 9 THU, 31-10 FRI, 01-11	Moderation **NO CLASS**	-	

Week 10 MON, 04-11 TUE, 05-11	*Integration*: Partial Fractions and Improper Integrals	Ch. 4	
Week 10 THU, 07-11 FRI, 08-11	*Integration*: Methods for Numerical Integration	Ch. 4	Submit Homework Series 4

Week 11 MON, 11-11 TUE, 12-11	*Diff. Equations*: Ordinary Differential Equations; Separation of Variables	Ch. 6 and handout Diff. Equations (1)	Homework Series 5 out
Week 11 THU, 14-11 FRI, 15-11	**Project I**	-	Work on Project in Class

Week 12 MON, 18-11 TUE, 19-11	*Diff. Equations*: First-Order Linear Diff. Eqns	handout Diff. Equations (2)	
Week 12 THU, 21-11 FRI, 22-11	**Project II**	-	Work on Project in Class

Week 13 MON, 25-11 TUE, 26-11	*Diff. Equations*: Second-Order Linear Homogeneous Diff. Eqns	handout Diff. Equations (3)	
Week 13 THU, 28-11 FRI, 29-11	*Diff. Equations*: Second-Order Linear Inhomogeneous Diff. Eqns	handout Diff. Equations (4)	

Week 14 MON, 02-12 TUE, 03-12	**Project Presentations I**	-	Present Project Results
Week 14 THU, 05-12 FRI, 06-12	**Project Presentations II**	-	Present Project Results

Week 15 MON, 09-12 TUE, 10-12	Review Session		Submit Homework Series 5
Week 15 THU, 12-12 FRI, 13-12	**Final Exam**	-	

8 Student learning outcomes

Period	Teaching activities	Student learning outcomes
weeks 1-2	Introduce a set of important standard functions and discuss their properties	Student can smoothly apply standard functions and their properties. Students can solve problems involving these standard functions.

Period	Teaching activities	Student learning outcomes
weeks 2-3	Introduce the concept of a limit and discuss how to evaluate limits. Emphasize the role of limits in relation to differentiation, integration and differential equations. Discuss the concept of continuity.	Student understand the concept of limits and are able to evaluate limits. Students understand the concept of continuity and are able to check whether a function is continuous.

Period	Teaching activities	Student learning outcomes
weeks 3-5	Introduce the formal definition of the derivative and derive all rules for differentiation from this formal definition. Derive the derivatives of all standard functions. Discuss linearization, Newton's method, l'Hôpital's rule, extreme values, concavity and optimization.	Student understand the formal definition of the derivative and can solve this limit to find derivatives. Students train to become fluent in finding derivatives of any function. Students can linearize functions. Students can apply l'Hôpital's rule. Students can determine extreme values. Students can determine concavity. Students can apply optimization of simple problems.

Period	Teaching activities	Student learning outcomes
week 6	Introduce the concept of complex numbers in standard form, hybrid polar form and exponential form. Explain how students can convert complex numbers from one form to another form. Explain the meaning of the complex conjugate and its properties. Explain the meaning of multiplication and division of complex numbers. Derive the trigonometric identities using complex numbers. Discuss the square root of complex numbers.	Student are able to smoothly solve problems involving complex numbers in any form.

Period	**Teaching activities**	**Student learning outcomes**
week 8	Review first part of course material. Emphasize the structure of the course material and support students to prepare for the mid term exam.	Students show that they master the first part of the course material by writing the mid term exam.

Period	**Teaching activities**	**Student learning outcomes**
weeks 8-10	Introduce the concept of integration. Derive the primitives of the standard functions. Explain various integration methods: substitution, integration by parts, integration of partial fractions, standard integrals	Student are able to solve integrals using various integrations methods. Students are able to recognize which integration method to apply.

Period	**Teaching activities**	**Student learning outcomes**
weeks 8-14	Explain to students what their dynamic model is about and what they are supposed to do using *Mathematica*. Explain to students what is expected of them in their presentation about their dynamic model	Students work in small groups and collect and study extra information about their dynamic model. Students implement variations of the initial dynamic model in *Mathematica*. Students are able to interpret the simulation results. Students are able to report their findings in a structured presentation.

Period	**Teaching activities**	**Student learning outcomes**
weeks 11-13	Discuss the solution strategy of linear first and second order homogeneous and inhomogeneous difference and differential equations. Discuss the solution strategy of simple separable differentiation equations.	Students are able to recognize the type of differential equation and they can apply the solution strategy to find the solution of these differential equations. Students are able to verify if their solutions are correct.

Period	**Teaching activities**	**Student learning outcomes**
week 15	Review second part of course material. Emphasize the structure of the course material and support students to prepare for the final exam.	Students show that they master all the course material by writing the final exam.