MATH 102 - Differential Calculus with Applications to Life Sciences - course outline (hardcopy summary long)

From UBCMATH WIKI
(Redirected from MATH 102 - Differential Calculus with Applications to Life Sciences - course outline (hardcopy summary))

2017W Term 1, September-December 2017

Contents

Course overview

As with any course on differential calculus, the central character in this course is the derivative. The course starts by building up to the limit definition of the derivative and proceeds through analytical, graphical and numerical approaches to build students' understanding of several types of functions and their derivatives. Next, we cover optimization, with applications to biological systems as well as principles of data fitting. A section on growth, decay and periodic phenomena precedes an introduction to differential equations and their use in modeling of biological systems.

One big difference between this course and a more traditional calculus course is the inclusion of examples and applications from the life sciences in place of the more traditional emphasis on physics. These examples and applications come from a wide range of fields including biochemistry, cell biology, ecology, genetics, population biology and evolution.

Course policies

Prerequisites

See the UBC Calendar entry for Math 102 for course prerequisites. If you do not satisfy the course prerequisites, you may find yourself automatically de-registered from the course once the term begins. The fact that you were able to register does not mean you satisfy the prerequisites.

Marking scheme

- Final exam 50%
- Midterm 15%
- Online WeBWorK homework 10%
- Quizzes 15%
- Written assignments (OSH) 10%

WeBWorK points and the 5% rule: Each problem submitted to WeBWorK is given a point-weight and your total WebWork score will be counted out of 95% of the total number of WeBWork points. Thus, if there are a total of 400 WeBWork points this term, you can get 20 points worths of them wrong and still get the full 15% allocated to WeBWork problems. This is not intended as a point give-away. It is intended to account for the fact that, early in the semester, you will take some time to master using WeBWorK and we do not have the resources to evaluate every request for accommodation for every technical glitch you run into. Any requests for accommodation regarding WeBWorK points due to alleged WeBWorK glitches, computer crashes etc. are by default covered by the 5% rule.

For more information on WeBWorK and OSH assignments, see the Assignments page.

A minimum mark of 44% on the final exam is required to pass the course, independent of all others marks in the course. A student who has a total term average of above 50%, but scores lower than 44% on the final exam, will receive a term grade of 48%.

Independent work

You are encouraged to work in groups on homework assignments although independent effort is also crucial to learning. However, any misrepresentation of another person's work as your own is considered to be academic dishonesty. In particular, directly copying someone else's homework will be treated as a violation of UBC's Academic Integrity Code. See UBC's policy on plagiarism for details.

Midterm absences, late or non-existent homework

If you are unable to attend the midterm, you must notify your instructor beforehand (preferred) or within two days after (in the case of emergencies) the exam date. In either of these two cases (and only in these two cases), suitable accommodations will be made. Undocumented absence from the midterm will be given a score of zero.

No midterm rewrites will be granted.

No late homework will be accepted.

Final and midterm exam regulations

For a full description of the final exam regulations, see the UBC Calendar page on Student Conduct during Examinations. In particular, notes, calculators, cell phones and other electronic devices are strictly prohibited from use during the exam. This includes use of cell phones for checking the time. The same regulations apply for the

midterm.

Registration

Add/drop forms must be brought to the math department office. An instructor's signature is neither sufficient nor necessary on an add/drop form. See the Mathematics Department registration information page for more information.

Re-marking requests

If you feel that a returned homework assignment or midterm is incorrectly marked, you can appeal that mark by writing a note that details your concern, attaching it to the assignment, and resubmitting it to the instructor within one week of the return of the marked assignment. The note should include a summary of what you feel was incorrectly evaluated with some justification of the claim. Your work will be re-evaluated in accordance with the established grading procedures, and re-marked if necessary. Note in unusual circumstances, if you accidentally received a higher grade than earned, your final grade might decrease upon re-marking.

Course calendar

	Date	What's due	Lecture topic	Course notes	Videos
Week 1	Sep 6		Cell size: volume, area. Power functions.	Sec 1.1-1.2	video link
	Sep 8		Power functions (cont). Sketching simple polynomials (y=x^3-ax).	Sec 1.1, 1.4,1.6	video link
Week 2	Sep 11	PL2.1	Sketching simple polynomials (cont). Rational functions, Michaelis-Menten and Hill functions, "limits" at infinity.	Sec 1.4, 1.5	video link
	Sep 13	PL2.2	Average rate of change and secant lines. Definition of the derivative. Instantaneous rate of change.	Sec 2.2-2.5	video link
	Sep 15	OSH 1, CL	Limits and continuity, examples. One example of computing derivative of $y = ct^2$ from the definition.	Sec 2.5, 3.2, Appendix D.	video link
	Sep 17	WW DT			
Week 3	Sep 18	PL3.1	Derivatives: analytic, and geometric (zoom in on a point). Sketching $f'(x)$ given $f(x)$ (intro).	Sec 3.1-3.2	video link
	Sep 20	PL3.2	Derivatives (cont): computational (spreadsheet example in class). More examples of sketching $f'(x)$ given $f(x)$ (intro).	Sec 3.2-3.3	video link
	Sep 21	WW 2			
	Sep 22	Quiz 1	Rules of differentiation: Power rule, sum rule, product rule.	Sec 4.1	video link
Week 4	Sep 25	PL4.1	Chain rule (intro) and quotient rules. Antiderivatives of power functions and applications.	Sec 4.1-4.2	video link
	Sep 27	PL4.2	Sketching $f(x)$ given $f'(x)$ (intro using polynomial). Tangent lines.	Sec 4.3, 5.1-5.2	video link
	Sep 28	WW 3			
	Sep 29	OSH 2	Linear approximation. Newton's method (intro).	Sec 5.3-5.5	video link
Week 5	Oct 2	PL5.1	Newton's method (examples). Sketching the graph of a function using calculus tools: increasing, decreasing, critical points, concavity and inflection points.	Sec 6.1-6.3	video link
	Oct 4	PL5.2	Sketching (cont).	Sec 6.1-6.3	video link
	Oct 5	WW 4			

	Oct 6	Quiz 2	Sketching (cont).	Sec 6.1-6.3	video link
Week 6	Oct 9		THANKSGIVING - no classes.		
	Oct 11	PL6.2	Absolute (global) extrema. Optimization, examples.	Sec 6.3.1, 7.1-7.3	video link
	Oct 12	WW 5			
	Oct 13	OSH 3	Kepler's wedding.	Sec 7.2	video link
Week 7	Oct 16	PL7.1	Optimal Foraging - an optimization problem emphasizing biological interpretation.	Sec 7.4	video link
	Oct 17		Least Squares - minimizing residuals to find the best fitting model for a set of data points: (1) $y =$ constant and (2) $y = ax$.	Supplement	video link
	Oct 19		Least Squares spreadsheet demo. Chain Rule: examples, applications to optimization problems.	Supplement, Chap 8	video link
	Oct 20	PL8.1	Related Rates.	Sec 9.1	video link
Week 8	Oct 23	WW 6			
	Oct 24	PL8.2	Implicit differentiation	Sec 9.2	video link
	Oct 25	WW 7			
	Oct 26	MIDTERM	Midterm information		
	Oct 27	OSH 4	Exponential functions: intro and motivation, derivative of exponential functions.	Sec 10.1-10.2	video link
Week 9	Oct 30	PL9.1	Inverse functions and logarithm, applications of logs.	Sec 10.3-10.4	video link
	Nov 1	PL9.2	Exponential growth and decay, intro to differential equations, population growth and/or other examples.	Sec 11.1; 11.2 or 11.3	video link
	Nov 2	WW 8			
	Nov 3		Introduction to nonlinear ODEs, qualitative analysis.	Sec 13.1	
Week 10	Nov 6	PL10.1	Slope fields with logistic equation as example.	Sec 13.2	video link
	Nov 8	PL10.2	State-space diagrams and examples (logistic).	Sec 13.2	video link
	Nov 9	WW 9			
	Nov 10	OSH 5	Remembrance Day. University closed.		
Week 11	Nov 13	PL11.1	Solving differential equations of the type $dy/dt = a - by$.	Sec 12.1-12.3	video link
	Nov 15	PL11.2	Solving differential equations of the type $dy/dt = a - by$ (cont). Newton's Law of Cooling.	Sec 12.3	video link
	Nov 16	WW 10			
	Nov 17	Quiz 3	Solving differential equations approximately using Euler's Method.	Sec 12.4	
Week 12	Nov 20	PL12.1	Disease dynamics.	Sec 13.3	video link
	Nov 22	PL12.2	Introduction to Trigonometric Functions.	Sec 14.1-14.2	video link
	Nov 23	WW 11			
	Nov 24	OSH 6	Trigonometric Functions and cyclic processes, phase, amplitude, etc. (fitting a sin or cos to a cyclic process),	Sec 14.2-14.3	video link

			Inverse trig functions.		
Week 13	Nov 27	PL13.1	Derivatives of trig functions, related rates examples.	Sec 15.1-15.2	video link
	Nov 29	PL13.2	The Escape Response and inverse trig functions.	Sec 15.3	video link
	Nov 30	WW 12			
	Dec 1		Complete and/or review trig.		
		WW 13	The final WeBWorK assignment will be due during the week following the end of classes.		

Course notes

These course notes were written and have been provided voluntarily for many years by Prof. Leah Keshet (UBC Math). They have been based on material she developed and taught in Math 102.

You can optionally get a full printed copy of the notes at [1] Copiesmart (5728 University Blvd #103, Vancouver, BC V6T 1K6).

Or: download the Full version (see below), which has internal links from the table of contents and index.

They are being updated over time. These notes are provided for all interested in learning. Copyrights are reserved by Keshet. Last update: September, 2015. (A list of known errors appears below)

The latest version of the Math 102 Course Notes:

- Chapter 1: Power functions as building blocks
- Chapter 2: Average rates of change, average velocity and the secant line
- Chapter 3: Three faces of the derivative: geometric, analytic, and computational
- Chapter 4: Differentiation rules, simple antiderivatives and applications
- Chapter 5: Tangent lines, linear approximation, and Newton's method
- Chapter 6: Sketching the graph of a function using calculus tools
- Chapter 7: Optimization
- Chapter 8: Introducing the chain rule
- Chapter 9: Chain rule applied to related rates and implicit differentiation
- Chapter 10: Exponential functions
- Chapter 11: Differential equations for exponential growth and decay
- Chapter 12: Solving differential equations
- Chapter 13: Qualitative methods for differential equations
- Chapter 14: Periodic and trigonometric functions
- Chapter 15: Cycles, periods, and rates of change
- Review Problems, Appendices, Table of Contents, Answers and Index

The Full version (below) has embedded html links. Download that version to your laptop or ipad to have full capability of the internal links.

- Full pdf version with internal links

Known errors in Course Notes

- Chap 1: The solution to 1.26 (a) should be 0,1.
- Chap 2: Defn 2.13: should be (change in y)/(change in x)
- last paragraph of p 10: "column" should be replaced by "row" in referring to Fig 1.4
- The solution in Example 2.11 and the graph in Figure 2.2 have swapped the data for Tuna 1 and Tuna 2.
- The y-intercept of the secant line in the solution to problem 2.7 should be -8.918 not -2.226.
- Definition of linear differential equation is confusing as independent variable/dependent variable are not clear in this context
- The graph in Figure 15.6 should start with a zero slope.
- The period of $tan(x)$ and $cot(x)$ is $T = \pi$. On page 274, the text seems to say that the period is 2π.

Supplements

- Earth's energy balance
- Fitting data - least squares
- Optimal foraging and other repeated processes
- Numerical integration
- Degrees or radians - why you should always use radians

Hard copies

You can buy a printed paper copy of this material from Copiesmart on University Boulevard.

Address: Copiesmart, #103 5728 University Blvd. Tel: 604-222-3189, 604-222-3194.

Additional references

- Stewart's *Calculus: Early Transcendentals* is available at the UBC bookstore and can be found secondhand as it is used for a number of other first year calculus courses on campus. It does not cover all the topics we cover in this course and covers some topics we do not cover but there is a significant overlap and, for some topics, especially the basic ones, you might find useful worked examples.

- CLP Calculus, written by several UBC faculty members, is a free online textbook with accompanying book of exercises, including hints and fully worked-out solutions.

- Paul's online notes, written by Prof. Paul Dawkins at Lamar University provides a good, free and online resource for a standard calculus course.
