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))

2018W Term 1, September-December 2018

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.

You should have taken a calculus course already if you are enrolled in this course. If you have never taken a calculus course, you should talk to your advisor at the beginning of the year about transferring to Math 180, 184, or 110.

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 15%
- Written assignments (OSH) 20%

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 assessment is incorrectly marked, you can appeal that mark by writing a note that details your concern, attaching it to the assignment (if appropriate), and resubmitting it to the instructor within one week of the return of the marked assignment. For assessments marked on Crowdmark, this means you email your instructor these details. 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

The calendar is based on sections meeting MWF; sections will naturally diverge somewhat from each other and from the calendar.

Abbreviations:

- OSH: Old-School Homework. Apply principals from class to solve contextual problems. Practice thinking critically and creatively.
- WW: WeBWorK weekly assignments.
- PL: Pre-Lecture WeBWorK assignments. Read the text **before** class to prepare; answer questions in WeBWorK based on your reading.
- WW CL: WeBWorK course logistics assignment
- WW DT: WeBWorK diagnostic test

	Date	What's due	Lecture topic	Course notes	Videos
Week 1	Sep 5		Cell size: volume, area. Power functions.	Sec 1.1-1.2	video link
	Sep 7		Power functions (cont). Sketching simple polynomials (y=x^3-ax).	Sec 1.1, 1.4,1.6	video link
Week 2	Sep 10	WW CL	Sketching simple polynomials (cont). Rational functions, Michaelis-Menten and Hill functions, "limits" at infinity.	Sec 1.4, 1.5	video link
	Sep 11	PL2.1			
	Sep 12	OSH 0	Average rate of change and secant lines. Definition of the derivative. Instantaneous rate of change.	Sec 2.2-2.5	video link
	Sep 13	PL2.2			

	Sep 14	OSH 1	Limits and continuity, examples. One example of computing derivative of $y=c t^2$ from the definition.	Sec 2.5, 3.2, Appendix D.	video link
	Sep 16	WW DT			
Week 3	Sep 17	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 19	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 20	WW 2			
	Sep 21		Rules of differentiation: Power rule, sum rule, product rule.	Sec 4.1	video link
Week 4	Sep 24	PL4.1	Chain rule (intro) and quotient rules. Antiderivatives of power functions and applications.	Sec 4.1-4.2	video link
	Sep 26	PL4.2	Sketching $f(x)$ given $f'(x)$ (intro using polynomial). Tangent lines.	sec 4.3, 5.1-5.2	video link
	Sep 27	WW 3			
	Sep 28	OSH 2	Linear approximation. Newton's method (intro).	Sec 5.3-5.5	video link
Week 5	Oct 1	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 3	PL5.2	Sketching (cont).	Sec 6.1-6.3	video link
	Oct 4	WW 4			
	Oct 5		Sketching (cont).	Sec 6.1-6.3	video link
Week 6	Oct 8		THANKSGIVING - no classes.		
	Oct 10	PL6.2	Absolute (global) extrema. Optimization, examples.	Sec 6.3.1, 7.1-7.3	video link
	Oct 11	WW 5			
	Oct 12	OSH 3	Kepler's wedding.	Sec 7.2	video link
Week 7	Oct 15	PL7.1	Optimal Foraging - an optimization problem emphasizing biological interpretation.	Sec 7.4	video link
	Oct 17	PL7.2	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 18	WW 6			
	Oct 19	OSH4	Least Squares spreadsheet demo. Chain Rule: examples, applications to optimization problems.	Supplement, Chap 8	video link
Week 8	Oct 22	PL8.1	Related Rates.	Sec 9.1	video link
	Oct 24	PL8.2	Implicit differentiation	Sec 9.2	video link
	Oct 25	MIDTERM	Midterm information		
	Oct 26	WW 7	Exponential functions: intro and motivation, derivative of exponential functions.	Sec 10.1-10.2	video link
Week 9	Oct 29	PL9.1	Inverse functions and logarithm, applications of logs.	Sec 10.3-10.4	video link
	Oct 31	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 1	WW 8			

	Nov 2		Introduction to nonlinear ODEs, qualitative analysis.	Sec 13.1	
Week 10	Nov 5	PL10.1	Slope fields with logistic equation as example.	Sec 13.2	video link
	Nov 7	PL10.2	State-space diagrams and examples (logistic).	Sec 13.2	video link
	Nov 8	WW 9			
	Nov 9	OSH 5	Solving differential equations of the type $dy/dt=a-by$.		
Week 11	Nov 12		Remembrance Day. University closed.	Sec 12.1-12.3	video link
	Nov 13	PL11.1		Sec 12.1-12.3	video link
	Nov 14	PL11.2	Solving differential equations of the type $dy/dt=a-by$ (cont). Newton's Law of Cooling.	Sec 12.3	video link
	Nov 15	WW 10			
	Nov 16		Solving differential equations approximately using Euler's Method.	Sec 12.4	
Week 12	Nov 19	PL12.1	Disease dynamics.	Sec 13.3	video link
	Nov 21	PL12.2	Introduction to Trigonometric Functions.	Sec 14.1-14.2	video link
	Nov 22	WW 11			
	Nov 23	OSH6	Trigonometric Functions and cyclic processes, phase, amplitude, etc. (fitting a sin or cos to a cyclic process), Inverse trig functions.	Sec 14.2-14.3	video link
Week 13	Nov 26	PL13.1	Derivatives of trig functions, related rates examples.	Sec 15.1-15.2	video link
	Nov 28	PL13.2	The Escape Response and inverse trig functions.	Sec 15.3	video link
	Nov 29	WW 12			
	Nov 30		Complete and/or review trig.		
		WW 13	The final WeBWorK assignment will be due during the week following the end of classes.		

Course notes

Open Textbook for this course, pdf

Download the latest Full version here.

This open book was written and is provided voluntarily by Prof. Leah Keshet (UBC Math). It is based on material she developed and taught in Math 102 over many years, and is being updated over time. It is licensed under Creative Commons, and is provided free of charge for all interested in learning. Copyrights are reserved by Keshet. Last update: September 15, 2017. (As errors/typos are found, the book will be updated. Kindly contact keshet@math.ubc.ca with typos or errors to be fixed.)

Open textbook updates and fixes

Sept 7: Fixed Mastered Material 19 on p 34 to avoid overlapping fig 1.5

Sept 11: Fix figure 2.6 f(b)—> f(a) corresponding to the lower point on graph

Sept 15: Fixed several typos in the Solution to Example 2.8:

- the expression c(2t0 + h) approaches 2ct0 as h shrinks to zero

- the velocity of an object at time t = 1 s after it is released is v(1) = 9.8 m/s.

Sept 16: Fixed p40 link to interactive graph to indicate P(x) = G(x)

Sept 19: Fixed the information in Exercise 1.23 (to supply the c-axis intercept)

Sept 22: p 30 “A similar strategy also allows us [to] consider” (thanks Sarah!)

Sept 26: The book now includes Short Answers to problems (up to chap 12.. more to come)

Oct 1: fixed multiple errors in Example 5.15 - Thanks Maria! Fixed the right and left limits in Appendix D4 - Thanks, Davy!

Oct 9: Replaced (wrong) figure in problem 5.18 with correct figure.

Oct 22: Corrected the labels on Fig 1.2

Nov 11: Corrected the answer to Problem 11.17. Corrected an error in the table for Example 2.4 in which Tuna 1 and Tuna 2 were switched. (Thanks Jennie!)

Nov 15: Added answers to Chapter 13-16 problems (Thanks, Fiona!)

Nov 17: Corrected the DE in Problem 11.22, Corrected the answer to Problem 11.17 (Thanks, Elyse!)

Hard copies

The best way to use the open course book is to download the .pdf file to your laptop or tablet. Then you can use all the internal links to interactive material. You do NOT need to buy a printed copy. This calculus "open book" is now part of the Open Textbook initiative that is meant to save you money. You can use the usual .pdf tools to highlight or annotate the file, just as you would annotate a printed copy.

You can optionally buy a printed paper copy of this material from Copiesmart on University Boulevard. The cost after tax will be $25. Be aware, though, that the printed copy will not have the full functionality of the .pdf file version.

Address: Copiesmart, #103 5728 University Blvd. Tel: 604-222-3189, 604-222-3194. Call first to see whether they are in stock, or need to have more printed. Copies should be available from the morning of Thursday Sept 6.

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

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.