SYLLABUS

MATH 12021 –Calculus for Life Sciences

(4 Credit Hours)

Catalog Information: Differential and integral calculus using examples and problems in life sciences. Prerequisite: MATH 11022 or MATH 12011 with a minimum grade of C (2.0); or ALEKS® placement score of 78 or higher.

Text: Modeling the Dynamics of Life: Calculus and Probability for Life Scientists, 3rd Edition, Adler.

Discrete Time Dynamic Systems (10 days)

- Updating functions (recurrence equations)
- Cobwebbing
- Equilibria of discrete systems— graphical and algebraic approaches
- Exponential models for growth and decay— discrete time
- Examples: population growth, drug concentration decay
- Review of the logarithm function and its properties
- Review of the trigonometric functions
- Use of trigonometric functions to model cyclic phenomena — discrete time
- * Discrete time model of gas exchange in the lung with and without absorption
- * Nonlinear dynamics: competition for an ecological niche
- Stability of equilibria
- * Modeling the heart's electrical system— AV block and Wenckenbach Phenomenon

Limits, Derivatives, and Continuous Time Phenomena (10 days)

- Average and instantaneous rate of change
- Limits (intuitive approach— no ε , δ)
- Special limits: $\lim\limits_{h\to 0}\left(\dfrac{e^h-1}{h}\right)$, $\lim\limits_{h\to 0}\left(\dfrac{\sin(h)}{h}\right)$, $\lim\limits_{h\to 0}\left(\dfrac{1-\cos(h)}{h}\right)$
- Continuity: definition in terms of limits, and graphical interpretation
- Derivatives and differentiability: elementary algebraic and transcendental functions; derivatives of sums, products, quotients, and composite functions. Emphasize derivative as a rate of change.
- Higher order derivatives: curvature, acceleration, concavity.
- Brief discussion of application of derivatives to curve-sketching.

Applications of the Derivative (8 days)

- Assessing stability of time-dynamic systems
- The logistic dynamic system for population growth
- Optimization: first and second derivative tests

- Examples: maximizing a bee's food intake; maximizing fish harvest
- The mean value theorem (optional)
- $\lim\limits_{x\to\infty} f(x)$, $\lim\limits_{x\to-\infty} f(x)$
- Asymptotic behavior, attenuation of a cyclic process
- limit of a sequence
- *l'Hôpital's* Rule
- Polynomial approximation: Taylor's theorem
- Newton-Raphson iteration
- * Oxygen absorption as a function of breathing frequency

First Order Differential Equations and the Integral (12 days)

- Terminology: pure-time equation, autonomous equation, initial condition
- Euler's method (central to this course)
- Antiderivatives as solutions to the pure-time equation $\frac{df}{dt} = \Phi(t)$
- Computational rules and formulas
- Antidifferentiation methods: substitution and integration by parts
- Sigma notation
- The definite integral, and the fundamental theorem of calculus
- The integral as a tool to legitimize Euler's method
- Elementary applications of the integral: area, mean value of a function, total change of a quantity
- Improper integrals

The Solution of Autonomous (Separable) Equations $\frac{dy}{dt} = g(y)$ (12 days)

- Newton's law of cooling
- * Diffusion across a membrane
- Continuous model of natural selection
- Equilibria and phase line diagrams
- Stability of equilibria
- Method of separation of variables
- Predator/prey problems: systems of equations
- Solutions in the phase plane
- * A model for neuron firing: Fitzhugh-Nagumo Equations

Review and Exams (8 days)

* Items in red are hallmark applications. They should drive the overall presentation of the material. This is not a course in calculus, but rather a course in modeling that uses calculus as required.