# MATH 162: LEARNING OUTCOMES

**General:**

- Student should understand a concept well enough to explain it in their own words
- Student should undestand a concept well enough to apply it to a problem formulated differently than a standard textbook problem
- Student should write the response to a problem using correct mathematical notation, logic and algebra, clearly showing all steps, so that neither the writer nor the reader has any questions about the process nor the result
- Student should be able to read a problem framed within an application (eg from physics, biology or engineering) and discern what the question is and which of the given information is relevant to answer the question
- Student must be able to work with functions containing parameters.
- Student should be able to to take several approaches to solve a given problem
- Student should learn to take personal responsibility for their learning

**Basics skills:**

- Student should be able to graph basic functions without relying on a table of values. Functions include polynomials, $1/x$, $e^x$, $\sqrt{x}$, $x^p, p > 0$, $|x|$, and their translations, functions defined piecewise, functions involving parameters. Graphs must be clear and neat. Axes must be labeled. Arrows on axes point in direction of increasing variable only. Graphs of functions do not have arrows, unless they are directed graphs. Important features on the graph, such as points of zero or infinite slope, extrema, roots, asymptotes must be clearly shown.
- Use algebra to simplify expressions, solve equations, and solve inequalities, including expressions with parameters.

**The Concept of Limit:**

- Draw a sketch illustrating what it means for a limit to exist and explain in words.
- Determine when the limit of a function exists and when it does not exist.
- Find finite limits, limits at infinity and infinite limits algebraically as well as from the graph of a function.
- Find limits of functions defined piecewise.
- Find vertical and horizontal asymptotes. Find the limiting behaviour of functions near vertical asymptotes and incorporate information in graph.

**Continuity:**

- State the definition of continuity, and draw a sketch illustrating it graphically.
- Determine when a function is continuous from its graph as well as algebraically.
- State and use consequences of continuity, such the Intermediate and Extreme Value Theorems.

**Derivatives:**

- State the definition of the derivative. Explain in your own words how this definition is motivated and illustrate with a graph. Use the definition to find derivatives.
- Understand the connection between the derivative, instantaneous rates of change and slopes of graphs. If the value of a function has units, what are the units of the derivative?

- Estimate derivatives from graphs of functions or from tabulated values.
- Use the rules to differentiate several types of functions, including trigonometric and exponential functions, functions defined implicitly, or functions defined piecewise. Use the Fundamental Theorem to differentiate functions defined as integrals.
- Apply derivatives to graph functions showing extreme values and inflection points.
- Apply derivatives solve optimization problems.
- Find equations of tangent lines. Find the linear approximation of a function near a base point. Use linear approximation to approximate function values or changes in functions.
- Given a relation between functions, find a relation between their derivatives ("related rates")

**Differential Equations:**

- Find anti-derivatives.
- Solve simple first and second order differential equations with initial conditions (Initial value problems). Include problems where the derivative is given by a piecewise function.
- Write down the initial value problem described in words in a paragraph of text, including applications from physics, biology and engineering.
- Write down solutions to the harmonic oscillator differential equation, and understand the resulting trigonometric functions.

**Integration:**

- State the steps used to obtain the area under a graph as a limit of a sum.
- Approximate definite integrals by finite sums.
- Evaluate definite integrals by interpreting them as areas, in simple cases.
- When integrating a physical function with units, determine the units of the integral.
- Use the Fundamental Theorem of Calculus and the rules of integration to evaluate definite integrals, with or without substitution. When using substitution, change bounds of integration.
- Use the Fundamental Theorem of Calculus to differentiate definite integrals.
- Use the definite integral to find areas under curves, volumes, arclength, and work done by a force.
- Interpret the definite integral of a rate of change as a total change. Given a rate of change of a quantity and an initial condition, state both the definite integral defining the quantity, as well as the corresponding initial value problem.
- Interpret the definite integral as an averaging process. Find average values of functions over given intervals.

*Last updated: Feb 8th, 2017.*