Mid Michigan Community College
Board of Trustees Meeting
Schedule For
February 6, 2018

Cafeteria and Houghton Room, Harrison Campus

The February Board Workshop/Meeting schedule will be as follows:

1. 6:00 p.m. – Dinner – Cafeteria

2. 6:30 p.m. – David Kedrowski, Full time Mathematics Professor, will review his proposal to write a Conceptual Calculus Companion book, provide an update on his progress, and share how this project is influencing his approach to teaching Calculus I. A draft copy of his project is attached. – Houghton Room

3. 7:00 p.m. – The regular board meeting will be called to order – Houghton Room
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Introduction

Rationale

I began teaching mathematics at a community college in the fall of 2002. In 2006 I taught my Calculus I for the first time and I began teaching the course regularly in 2012. I have typically taught the course the way it was taught to me, especially when I was teaching it for the first time. Most calculus textbooks are written this way and I assume most calculus courses at colleges nationwide are fairly similar. Over time I have found that this approach is good for helping students learn how to do calculus, but not particularly good for helping students learn what calculus is and what it’s really about. Many mathematicians, myself included, will explain to anyone who asks that calculus is really about how things change. Yet I’ve watched a lot of students finish the course without this basic conceptual understanding.

Thinking back to when I took calculus in college, I can say the same thing about myself. I could do calculus very well, but it wasn’t until I’d used it quite a bit in other courses that I really began to see what it is and what it does. Some say that’s part of learning, that we often have to carry knowledge with us and use it in new ways before we really begin to understand it. There is truth in statements like that, but I don’t believe it gives educators a license to ignore the deeper understanding that can be so crucial to making calculus an important and powerful tool for students.

After trying a variety of little things to help students with the concepts behind calculus, little things which worked a little bit but not as much as I hoped, I decided to write this book. In the pages that follow I attempt to share the basic underlying concepts of calculus without the traditional clutter of lots of symbols and notation. I want readers to gain basic conceptual insight into calculus. That is, I strive to separate the main ideas of calculus from the practice of doing calculus, practice in which any college calculus
course will give students plenty of instruction.

**Audience(s)**

My principal target audience is students who are taking a first calculus course. This book is designed to parallel the development of most first calculus textbooks:

1. a brief introduction to differential calculus (rates of change) and integral calculus (accumulation),
2. some basic review of precalculus mathematics,
3. the notions of limit and continuity,
4. a more detailed look at differential calculus along with applications, and
5. an introduction to integral calculus (a second calculus course usually picks up from here).

While my general intent is for this book to be used by students as a companion to more traditional materials, I hope that others may find it useful as well.

- Anyone who has ever taken a first calculus course and felt that they didn't really get what it was all about can enjoy this book and may find that the subject becomes clearer and makes more sense. ☺
- Someone who is interested in learning more about calculus without actually taking a calculus course may find this book useful and interesting. I strongly recommend that you have some prior experience with the topics covered in the Foundations chapter, though a general aptitude for and interest in mathematics may be enough to get you through.

**What You Can Expect from This Book**

I have already made some hints as to what you should expect (and not) from this book. The following table is meant to give you a bit more idea. The
big thing to notice is that this book was not written to teach you how to *do* calculus, but rather to help you *understand* what calculus is, as the following table shows.

<table>
<thead>
<tr>
<th>What You Can Expect From This Book</th>
<th>What This Book Won’t Help You With</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learn what a limit is, how a limit is different from a function, and why limits are important</td>
<td>Rules for evaluating limits</td>
</tr>
<tr>
<td>Learn what an instantaneous rate of change is and how calculus is used to find instantaneous rates of change</td>
<td>Rules for finding derivatives of specific functions</td>
</tr>
<tr>
<td>Learn what it means to “accumulate” area and how calculus is used to accumulate area from instantaneous rates of change</td>
<td>Rules for finding antiderivatives of specific functions</td>
</tr>
<tr>
<td>The underlying concepts behind calculus</td>
<td>Lots of exercises and story problems</td>
</tr>
</tbody>
</table>

Table 1: What This Book Is (And What It Is Not)

There are excellent books that deal with all of these ideas. Some are found in the Bibliography. What I hope is different about this book is the way it isolates certain conceptual ideas from the practice of doing calculus.

I have purposefully skimmed over, briefly alluded to, or even skipped some of the particular details that are present in an actual calculus textbook and course. I’ve tried to make choices to include or exclude information based on what I thought would most help someone gain a conceptual understanding of calculus. This book is meant to be a companion to a more traditional calculus textbook where all of those wonderful and important details are provided. However, it is possible I haven’t always made the best choices – any such shortcomings or errors are my responsibility. If
you would like to share thoughts, suggestions, or errors, please contact me at dkedrowski@midmich.edu.

Suggestions for Reading This Book
Chapter 1

Two Classic Problems

1.1 Rate of Change

The world is changing. Big things, small things, everything is changing in some way or another. Things move, like the sun in the sky, fish in the sea, and continental plates. Living things are born, grow, age, and die. Gas prices fluctuate, your pay increases as you work more hours, the length of a day shortens and lengthens with the change of seasons, and weather changes from day to day and hour to hour. Some changes are so small they seem imperceptible, some so large they seem overwhelming.

Calculus is concerned with how things change. It tells us when things are increasing or decreasing, and how rapidly. It can even tell us if the way something changes is itself changing. Calculus is always, in some way, dealing with rates of change. The pitch of a roof or grade of hill are rates of change. They tell us how a vertical distance changes with respect to a horizontal distance. Inflation is a rate of change. It tells us how prices change with respect to time. Gas mileage, hourly wages, and velocity are all examples of rates of change. Each tells us how one thing (gallons of gasoline, dollars of earnings, position in miles) change relative to something else (miles driven, hours worked, hours driven).

Most things we experience change continuously; that is, they change from one value to another value by taking on all values in between. For example, consider your distance from some fixed location, like your home. If you travel 10 miles away from your home, at some point you must have been every possible distance between 0 and 10 miles from your home. To skip
over some value or values would imply you had teleported, which we know is not possible (yet, anyway). Calculus is especially good at determining how continuous quantities change\textsuperscript{1}.

As an example of how calculus works, let us consider how we can look at the rate of change of position. Imagine you start from home and walk down your street. Your initial position is 0. As you leave you start a stop watch so that your initial position is 0 when the time on the stop watch is 0. After 100 seconds you have traveled 300 feet. Your average rate of change of position with respect to time is 300 feet divided by 100 seconds or 3 ft/sec. I call this an average rate of change since it only involves information from the beginning and the end of your (brief) walk and does not consider any details of what happened in between.

\[
\frac{300 - 0}{100 - 0} = \frac{300 \text{ feet}}{100 \text{ seconds}} = 3 \text{ ft/sec}
\]

To truly understand your rate of change during your walk, it turns out that what happens in between can be very important. It is unlikely that you managed to maintain exactly the same pace the whole time. Maybe you had to slow down, or even stop, for someone in your path. Maybe you sped up to pass another walker or a barking dog. It is possible you did both of these things and more, even in the less than 2 minutes we are considering. Figure 1.1 provides one possible scenario of position (vertical axis) and time (horizontal axis).

\textsuperscript{1}Calculus can also be used to consider how discrete quantities change, though this is often done by thinking of discrete values in a continuous fashion. For example, prices tend to change in a discrete way, but we can use modeling techniques to make the change look continuous.

Discrete quantities can jump from one value to another without taking on values in between. For example, when you roll a standard die you can get a 1 or 2 but no numbers in between.
An important question that led to the development of calculus is: can we know your *instantaneous* velocity (rate of change of position) at any given moment during your walk? We can and here is how. We will assume we would like to know your instantaneous velocity when the stop watch reads 50 seconds. Instead of considering your position at 0 seconds and 100 seconds, we could consider your position at 45 seconds and 55 seconds. If it was 146 feet and 154 feet, respectively, then your average velocity during these 10 seconds would be 8 feet divided by 10 seconds or 0.8 ft/sec. This is still an average velocity, but it is probably much closer to your instantaneous velocity than our initial value of 3 ft/sec since it uses information closer to 50 seconds.

$$\frac{154 - 146}{55 - 45} = \frac{8 \text{ feet}}{10 \text{ seconds}} = 0.8 \text{ ft/sec}$$

To get a better estimate, consider your position at 49 and 51 seconds, maybe 149.9 and 150.1 feet. Your average velocity during this interval is now 0.2 feet divided by 2 seconds or 0.1 ft/sec. This is a better approximation of

---

Footnote: Speed is a component of velocity. Velocity tells us the speed of an object as well as the direction of the object. Here we think of the direction as simply away from our starting point (positive velocity) or toward our starting point (negative velocity). The number part, without a positive or a negative sign, is the speed.
the instantaneous velocity at 50 seconds since it uses information very close to that time.

\[
\frac{150.1 - 149.9}{51 - 49} = \frac{0.2 \text{ feet}}{2 \text{ seconds}} = 0.1 \text{ ft/sec}
\]

To get better and better approximations of your instantaneous velocity at exactly 50 seconds you just keep picking smaller and smaller intervals around 50 seconds. Assume an interval from 49.999 to 50.001 seconds during which your position changed by 0.000000296 feet. Your average velocity is 0.000148 ft/sec.

\[
\frac{150.000000148 - 149.999999852}{50.001 - 49.999} = \frac{0.000000296 \text{ feet}}{0.002 \text{ seconds}} = 0.000148 \text{ ft/sec}
\]

It's beginning to look like you paused in your walk at exactly 50 seconds! We draw this conclusion because we notice that your walking velocity is getting closer and closer to zero as we pick smaller and smaller intervals around 50 seconds. This fact is not at all obvious if we only consider your average velocity between the beginning and end of your walk! The ability to know your exact velocity at any time can provide an immense amount of information that you might otherwise miss. Maybe you even walked backward at one point, which we would know if we found a negative velocity!

At this point you may be beginning to wonder: at what point is it no longer possible to accurately measure such small values, or, how small does the time interval have to get before we can call our value an instantaneous velocity (or maybe both)? For the purposes of this book we will not address the first question, assuming we can measure any value we need to whatever level of accuracy we need. As you'll see later, the answer has little to no affect on our results. Still, it is an important question but one that goes beyond the scope of what this book is trying to convey.

The second question will be addressed in more detail later, but the short answer is that we need the time interval to be infinitely small to get an instantaneous velocity. It cannot be zero, because then our velocity is 0 feet divided by 0 seconds, a mathematical operation that is called indeterminate. So how small is infinitely small? I will address that in a bit more detail later (see Chapter 3).

What you have here is the basic mechanism for how calculus can be used to determine instantaneous rates of change: pick a point where you would like
to know the instantaneous rate of change and then consider what happens as you look at average rates of change over smaller and smaller intervals. Mathematically it can get quite complex, but the idea is reasonably straightforward. We’ll fill in a few more details later in Chapter 4.

1.2 Accumulation

In the example above, what if you knew the instantaneous velocity at every moment from 0 seconds to 100 seconds but did not have a way to measure your position? This may sound odd, but knowing how something changes without knowing its actual values happens quite frequently. Sir Isaac Newton determined how the temperature of a cooling object changes. Today we use that knowledge to determine how long a body has been dead (among many other uses).

In general, if you knew that your average velocity was 3 ft/sec and that you walked at that velocity for 100 seconds your distance traveled would be 3 ft/sec times 100 seconds or 300 ft.

\[
3 \frac{\text{ft}}{\text{sec}} \cdot 100 \text{ sec} = 300 \text{ ft}
\]

But we are assuming that we know time and instantaneous velocity and nothing more, which means we do not know what our average velocity was. How can we determine our distance traveled (final position) from this information?

Our basic plan is simple:

1. take our interval of 0 to 100 seconds and break it into smaller intervals,
2. pick one instantaneous velocity value in each small interval and pretend it’s the average velocity in that interval,
3. multiply the velocity value we choose by the width of the interval it is from for every small interval, and
4. add all of the results together.

We can start with two intervals, one from 0 to 50 seconds and the other from 50 to 100 seconds. Let’s assume we know that at some point during the first interval our velocity was 2 ft/sec and at some point during the second interval our velocity was 3.5 ft/sec. Our approximate final position (distance
traveled) is then 2.5 ft/sec times 50 seconds plus 3.5 ft/sec times 50 seconds,
or 275 feet. That value is not too far from our actual 300 feet, but we should try to do better.

\[
2 \text{ ft/sec} \cdot 50 \text{ sec} + 3.5 \text{ ft/sec} \cdot 50 \text{ sec} = 100 \text{ ft} + 175 \text{ ft} = 275 \text{ ft}
\]

One way to do better is to pick different velocity values in each interval to see if we can get the 300 feet value. But wait, we don’t know the 300 feet value so we do not actually know that we were close on our first choice. We only know the answer because we have extra information from the example in the previous section.

A better way to improve our estimate is to use more intervals. We could choose four this time: 0 to 25 seconds, 25 to 50 seconds, 50 to 75 seconds, and 75 to 100 seconds. We know that at some point during the first interval our velocity was 2.2 ft/sec, during the second interval our velocity was 2.8 ft/sec, during the third interval our velocity was 3.1 ft/sec, and during the fourth interval our velocity was 4 ft/sec. Our approximate final position is now 302.5 feet.

\[
2.2 \text{ ft/sec} \cdot 25 \text{ sec} + 2.8 \text{ ft/sec} \cdot 25 \text{ sec} + 3.1 \text{ ft/sec} \cdot 25 \text{ sec} + 4 \text{ ft/sec} \cdot 25 \text{ sec} = 55 \text{ ft} + 70 \text{ ft} + 77.5 \text{ ft} + 100 \text{ ft} = 302.5 \text{ ft}
\]

Pictorially, Figure 1.2 shows the graph of velocity versus time (in red) from the earlier example. To find the distance traveled we’re essentially looking to accumulate the area under the two red arcs. The blue rectangles show the estimate we’ve just completed. Note how we can think of each intervals distance (position) as the area of one of the blue rectangles.
CHAPTER 1. TWO CLASSIC PROBLEMS

Figure 1.2: Velocity \(v(t)\) While Walking 300 feet in 100 seconds \(t\)

The problem with this is that we are randomly choosing a velocity within each interval. When the intervals are large there may be a lot of variation between the slowest velocity and the largest velocity and there is no guarantee we select a reasonably appropriate one. We can minimize this problem by using more intervals. Instead of two intervals that are each 50 seconds wide or four intervals that are each 25 seconds wide, why not 100 intervals that are each one second wide, or 1000 intervals that are each 0.1 seconds wide?

To get an exact answer we would need to consider infinitely many intervals that are each infinitely small \(\text{(the sum of infinitely many infinitely small quantities is another indeterminate form like dividing zero by itself)\footnote{There is no smallest among the small and no largest among the large, but always something still smaller and something still larger.” – Anaxagoras}}\). This is a significantly more complicated process than the one we used for finding an instantaneous rate of change. Oddly enough, it is more difficult to think about and conceptualize, but it is not that much more difficult to accomplish once you have the appropriate calculus methods available to you.

There are some strong similarities between this process and the one we used to find instantaneous rates of change. The biggest is the reliance on infinitely small intervals, although now instead of just a series of shrinking intervals we use an infinite number of infinitely small intervals. Notice how notions of infinity arise in both processes, both the infinitely small \(\text{(interval size)}\) and the infinitely large \(\text{(number of intervals in the second example)}\). Historically calculus was not well accepted by everyone, often due to concerns about the infinite. Today the notion of infinity is well-understood thanks to
the work of many mathematicians over the last few hundred years.

We'll discuss accumulation in more detail in Chapter 5.

1.3 What is Missing?

For rates of change we need the horizontal interval between two points to be "infinitely small". For accumulation we need to be able to sum the areas of infinitely many rectangles that are infinitely thin along one side. The process for doing these things was a major source of criticism for calculus for many years. It wasn't until the idea of a limit was well-formulated within mathematics that these criticisms were put to rest. We'll take a look at limits in Chapter 3. First we'll take a look at some foundation material that is important to helping you understand limits, rates of change, and accumulation in more detail.
Chapter 2

Foundations

2.1 Arithmetic, Algebra, and Trigonometry

The study of calculus requires a solid knowledge of arithmetic and algebra, as well as a working knowledge of trigonometry. Many students who struggle in a first calculus class have difficulties in one or more of these areas, not necessarily with the ideas of calculus itself. But the processes of learning and doing calculus are strongly interwoven with arithmetic and algebra (and trigonometry), so knowing these topics well helps keep the focus on calculus.

For the purposes of this book, you won’t need to know any trigonometry. You should be very comfortable with arithmetic (adding, subtracting, multiplying, dividing) and it will help if you’ve had some algebra, but since this book is focused on concepts you don’t need to be an expert to follow along.

I recommend everyone at least skim through this chapter. Even if your skills are strong in these areas, there are different ways to notate some of these ideas and it will be useful for you to be aware of choices I have made.

2.1.1 Numerical Work

We will begin many topics from a numerical standpoint. That means that we’ll try to stay away from algebra as much as possible and just work with

\[\text{There are calculus courses that do not require trigonometry so this isn’t true for everyone. If you will be using calculus in a field that does not use trigonometric functions you may take this type of calculus course. The basic concepts are the same regardless of what types of functions you are or are not using.}\]
numbers and basic operations (addition, subtraction, multiplication, and division). While this means we’ll typically be looking at approximations, you will see that we can get some really good approximations from some fairly simple arithmetic.

2.1.2 Graphical Work

Graphs allow us to visualize what is happening with numbers, data, functions, etc. They can be very powerful tools to see patterns and shapes that aren’t readily apparent from other ways of doing mathematics. I have quite a few graphs throughout this book. If you’re unfamiliar or a bit rusty with reading graphs, there’s a short introduction coming up soon.

2.1.3 Written Work

Obviously this book is a written work. Historically, mathematics was largely done in writing before graphs and good symbolism were used. Today mathematics is communicated using the written word as well as numbers, graphs, and symbols. Math can be difficult to read (and write!) but you can get better at it through practice. A good reader of mathematics understands that paper and pencil are crucial (try things out on your own to make sure they work, take notes, annotate, write down questions, etc.) and that reading a mathematics book is not always a linear process but may involve rereading passages (or sections or chapters) as well as jumping back to early material for a refresher. Sometimes it also requires looking up information elsewhere.

2.1.4 Symbolic Work

While it is my intent to leave as much symbolic work for your actual calculus class, some symbolism is unavoidable. Our current system of using symbols to represent numbers, operations, variables, functions, ideas, and more in mathematics is only about 500 years old but it was a factor in how much math has been able to grow and expand in that time period. Sometimes it is just easier to express complex ideas in a more simplified symbolic form. The use of symbols allows us to move beyond numerical techniques and find ways to do much better than arithmetic approximations. But I will try to use them only as necessary.
2.1.5 Hybrid Work

Ultimately mathematics is a hybrid of all of these, and you’ll find all throughout this book: numerical analysis, graphical representations, written explanations, and symbolic work. I’ve tried to pick the best form throughout to help make the ideas as clear as possible.

2.2 Functions

In calculus you will spend the vast majority of your time working with functions. I will refer to functions regularly throughout this book so it will help if you have a basic understanding of what they are and their basic notation.

2.2.1 Definition

A function is a type of relation between one variable and another variable. The first variable is called independent because we typically get to choose its values. It is also referred to as the input. The second variable is called dependent because its value depends on what we choose for the first variable. It is also referred to as the output.

In a function, the relationship between the two variables has one specific property: for each choice of the independent (input) variable there is only one possible value of the dependent (output) value. We say that the function “maps” the input value to the output value, and often refer to a function as a mapping.

Here are two examples of relations using the same relationship but changing which variable is the input and which is the output. In Figure 2.1, the relation is a function. This is because each input value, or car model, has only one possible output value associated with it. We don’t care that some of the inputs share the same output – what’s vitally important is that each input, considered by itself, has only one output associated with it.

Footnote:\footnote{Functions can have multiple variables related to another variable, but we’ll consider just one variable related to one other variable in this book.}
In Figure 2.1 the relation is also a function. Each input value has two different output values associated with it. All we need is one. As soon as any one input has more than one possible output the relation cannot be a function.

In Figure 2.2 the relation is not a function. Each input value has two different output values associated with it. All we need is one. As soon as any one input has more than one possible output the relation cannot be a function.

In math there are a wide array of properties that you can expect any and every function to have. Functions also have the benefit of having a single output value for each input value so you don’t have to decide between
multiple output values when you evaluate them – there’s just one output value for each input value and that’s it!

2.2.2 Notation

While this book strives to use as little symbol manipulation as possible, I will occasionally refer to functions using their typical mathematical notation. A typical name (unimaginative, but those names are often easiest to remember) for a function is \( f \). Other common names are \( g \) and \( h \), though other names are also used. For example position functions are often called \( s \) (from the German \( Strecke \)). We can get a bit more informative by including the name of the input variable. For example, if the function \( f \) depends on the variable \( x \) we would write \( f(x) \). Position usually depends on time, or \( t \), so we write \( s(t) \). Where \( x \) and \( t \) represent input values, \( f(x) \) and \( s(t) \) represent output values (the output value of each function when applied to a given input value).

2.2.3 Domain

The set of all input values for a function is called the domain. There are typically two different types of domains. One is the set of all values that can be used as input to the function such that a useful output is obtained. For many functions this is any real number. For some functions we have to omit any values of the input variable that would cause us to divide by zero. Other functions might require us to take the square root of a negative number (we assume that we want both real numbers as input and as output) if we aren’t careful.

The other way to think about domain arises when our function describes something in the real world. Then we want to restrict the domain such that both the inputs and outputs are realistic and possible. It doesn’t make sense to input negative prices or times. If we have a function that describes government spending during the 1990s it wouldn’t make sense to input 1985 or 2013. For a function that outputs the altitude of a plane it wouldn’t make sense to use input values that result in altitudes of thousands of miles.

To use a function properly it is important to know its domain to make sure that both input and output values are reasonable.
2.2.4 Range

The set of all output values for a function is called the range. The range obviously depends on the domain. Determining the range of a function falls outside the scope of this book, but that’s not to say it isn’t important. It can be very important, especially when considering restricted domains as noted above.

2.2.5 Graphs

It will be useful to look at graphs of functions at various points throughout this book. Figure 2.3 is a graph of the function \( s(t) = -16.1t^2 + 24.15t + 96.6 \). Don’t worry if this looks a bit frightening, it’s not necessary for you to actually do anything with this function. Just follow along with the general ideas of what it means to graph a function and you’ll be fine.

![Graph of s(t) = -16.1t^2 + 24.15t + 96.6](image)

Figure 2.3: Graph of \( s(t) = -16.1t^2 + 24.15t + 96.6 \)

When graphing a function, the independent variable (input) is graphed along the horizontal axis and the dependent value (output) is graphed along the vertical axis. We can create a graph like this by plotting points. For
example, we can choose input, or \( t \), values like \(-2, -1, 0, 1, 2, \) and \(3\). We evaluate the function at each of those \( t \) values to get the corresponding output, or \( s(t) \), values. Each pair is then plotted as seen in Figure 2.4.

![Figure 2.4: Plotting points for the function \( s(t) = -16.1t^2 + 24.15t + 96.6 \)](image)

We can plot additional points in between these if we want to get a better feel for its shape. Once we’re confident we have a good feel for the shape of the graph we can sketch it, making sure to go through all of the points we’ve plotted. Figure 2.5 includes the graph with the points.
Graphs are useful for a variety of reasons. In calculus we’ll primarily be interested in two features: how fast is a graph changing at various points and how much area is captured between a graph and the horizontal axis. The first feature deals with rates of change (steepness and direction, or slope). The second feature deals with accumulation.

2.3 Intervals

It’s quite common in calculus to talk about how functions behave on some given interval. An interval in this case is simply a set of input values. While these sets can get quite complicated in their composition, we’re typically interested in intervals that include all numbers between two given numbers. That may sound quite simple, and it is, but it may not be quite as simple as you hope.

2.3.1 Types

Intervals come in three common types: open, closed, and half-open (or half-closed if you prefer). An open interval contains all of the numbers between
two given numbers, but it does not include the two given numbers themselves. Open intervals are usually written using parentheses. The open interval that represents all of the numbers between (but not including) 2 and 10 looks like \((2, 10)\). It can be graphed on a number line as seen in Figure 2.6. The entire set of real numbers is an open interval that can be written as \((-\infty, \infty)\). Its graph is the entire number line itself.

![Figure 2.6: Open interval \((2, 10)\)](image)

Closed intervals contain all of the numbers between two given numbers and include the two given numbers as well. Closed intervals are typically written using brackets. The closed interval that represents all of the numbers between (and including) 2 and 10 looks like \([2, 10]\). It can be graphed on a number line as seen in Figure 2.7. It is impossible for a closed interval to contain the entire set of real numbers.

![Figure 2.7: Closed interval \([2, 10]\)](image)

Half-open intervals are open at one end and closed at the other. The number at the open end is not included in the interval but the number at the closed end is. There are two half-open intervals from 2 to 10. They look like \((2, 10]\) and \([2, 10)\). You can see these half-open intervals on number lines in Figure 2.8 and Figure 2.9.

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\(^{3}\)Some textbooks use open circles instead of parentheses at the open ends of intervals and solid (closed) circles instead of brackets at the closed ends of intervals.
2.3.2 Open Endpoints

It is important to understand how the endpoints of the different types of intervals work. Open endpoints will probably seem the oddest to you. Consider the open interval $(2, 10)$. Clearly there are numbers in this interval like 3, 7, 2.5, $\pi$, etc. Any number, no matter how many decimal places it may have, that is bigger than 2 yet smaller than 10 is in the interval. But what happens near one of those two end numbers?

Let’s consider what happens near 2. Numbers in the interval must be bigger than 2. This includes values like 2.1, 2.01, 2.001, and 2.0001. As a matter of fact, no matter how close we get to 2, being careful to stay above it, we can always get a bit closer by using more decimal places. These intervals are called open because of this behavior – no matter how close you get to the endpoint you can always get closer. It’s like there is no endpoint and the interval is therefore “open” at that end. Mathematicians say there is no smallest number greater than two. Figure 2.10 shows how you can always find numbers in between 2 and some number larger than 2, no matter how small that second number is.
Similarly near 10 you can stay in the interval by choosing values like 9.9, 9.99, 9.999, 9.9999, etc. You can always get closer to 10, being careful to stay below it, by using more decimal places.

One very important consequence of this behavior is that, regardless of what number you pick in the interval (2, 10), there are always numbers on both sides of it that are also in the interval. If a number is in the middle of the interval this is easy to see. If a number is near, but bigger than, 2 there are definitely bigger numbers in the interval, but we can also use more decimal places to find values smaller than the number that are still bigger than 2. If a number is near, but smaller than, 10 there are definitely smaller numbers in the interval and we can use more decimal places to find values bigger than the number that are still smaller than 10.

As you will learn in your calculus course, it is often quite important to know you can get to any value in an open interval from both sides.
2.3.3 Closed Endpoints

Closed endpoints are easier to think about. You can get close to 2 on the interval $[2, 10]$, just like on the interval $(2, 10)$, but you can actually get to 2 as well. You can also get really close to 10 at the other end of the interval, and you can go all the way to 10 if needed.

A drawback to closed endpoints is that you cannot get to the end values from both sides. Once you’re at 2, you find numbers in the interval bigger than 2, but there are no numbers in the interval smaller than 2. Similarly, once you’re at 10 you can’t go any bigger, though you can find numbers that are smaller on the interval.

As you will learn in your calculus course, sometimes this can be a problem.

2.4 Lines and Rectangles

As you probably noticed in Chapter 1, the slopes of straight lines and the areas of rectangles are two important ideas underpinning calculus. Here is a quick refresher on each of these topics.

2.4.1 Slope of a Straight Line

The slope of a straight line tells us how quickly the vertical changes with respect to the horizontal. When given units the slope is a rate of change. For example, if you drive at a constant rate of 30 mph and we graphed the distance you travel (in miles) against the time you travel (in hours) you get a straight line with a slope of 30. It means that you travel 30 miles for every 1 hour you are driving. On the graph the vertical change is 30 units for every 1 unit of horizontal change (see Figure 2.11).
If you know two points on a straight line you can determine the slope by calculating $\frac{\Delta y}{\Delta x}$. This is often referred to as “rise over run” or “change in $y$ divided by change in $x$” in algebra classes. If you think of the two points as $(x_1, y_1)$ and $(x_2, y_2)$, then

$$\Delta y = y_2 - y_1 \text{ and } \Delta x = x_2 - x_1.$$ 

We can therefore write

$$\frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}.$$ 

Regardless of how you think of it, slope measures the steepness of a straight line. It also measures direction. A line that slopes up from left-to-right, like in Figure 2.11 above, has a positive slope. A line that slopes down from left-to-right has a negative slope. For example, if the car you bought new for $24,000 loses $3000 in value every year you get a graph with a slope of $-3000$ (see Figure 2.12).
There are two other possibilities for straight lines and their slopes, two possibilities that are just as important in calculus as positive and negative slopes.

- A horizontal line has a slope of 0 (see Figure 2.13). If you move along a horizontal line the $\Delta y$ is zero. When divided by whatever $\Delta x$ is you end up with a slope of 0.

- A vertical line has no slope (see Figure 2.14). We often say the slope of a vertical line is undefined. If you move along a vertical line you can’t move to the left or the right so the $\Delta x$ is zero. Since dividing by zero is an undefined operation in mathematics, the slope of a vertical line is undefined.

Be careful with your language on these two lines: a horizontal line has a slope of zero and a vertical line has no slope. It is tempting to say that the horizontal line has no slope since we equate ’no’ with the idea of zero, but that can cause some confusion in this case!
Finally, don’t forget that slope is a rate of change when units are involved!
2.4.2 Area of a Rectangle

The area of a rectangle is a product of its base and its height. This tells us how many squares of a given size it takes to “fill in” the rectangle. For example, if a rectangle measures 3 feet on one side and 2 feet on the other side its area will be 6 square feet, meaning it takes six squares measuring 1 foot on each side to “fill in” the rectangle. It doesn’t make any difference how the rectangle is oriented (it could even be at an angle!), its area is the same (see Figure 2.15 and Figure 2.16).

![Figure 2.15: Rectangle with landscape orientation](image)

![Figure 2.16: Rectangle with portrait orientation](image)
Chapter 3

Limits

3.1 “Bridge to Calculus”

You can learn calculus without learning about limits, but you would likely never develop a good understanding of how it works. Limits help us deal with instantaneous rates of change by allowing us to define what it means for two points to be infinitely close to each other (and the slope of the straight line through those two points). Limits also help us deal with accumulation by allowing us to define what it means to sum infinitely many infinitely small quantities. That is, limits help us deal with the indeterminate quantities that arise while doing calculus.

3.2 A Brief History

While the notion of limit was part of the development of calculus, found in the work of Newton and others who came before him, it wasn’t really defined in a rigorous way until the 19th century. In early work on calculus there was reference to quantities called infinitesimals that can be considered precursors to the use of limits in calculus. Since they weren’t well defined they were met with considerable resistance from some important people during the 17th and 18th centuries. This didn’t stop the development and use of calculus, however, since mathematicians and scientists were getting good results using this new tool – it worked, even if some of the details of why seemed a bit vague.
3.3 What You Really Need to Know

While limits can be used in lots of ways and for lots of things, there are just a few specific cases we need to worry about for beginning calculus: the indeterminate forms

\[
\frac{0}{0} \text{ and } 0 \cdot \infty.
\]

An indeterminate form is a mathematical expression where the result can be pretty much anything, which is why it is called indeterminate. Consider the expressions

\[
\frac{2x}{x} \text{ and } \frac{3x}{x}.
\]

In algebra you learn to cancel the common factor of \(x\) from the top and bottom of each fraction. That makes

\[
\frac{2x}{x} = 2 \text{ and } \frac{3x}{x} = 3.
\]

To make matters more simple in algebra we ignore one fact: this works for any value of \(x\) except for \(x = 0\). When \(x = 0\) each expression becomes indeterminate with the form \(\frac{0}{0}\). If we tried to graph the expressions they would each have a hole in their graph at \(x = 0\). But what value would make sense when \(x = 0\) if we could assign a value? It turns out the value is 2 for the first expression and 3 for the second expression.\(^1\)

How do we know these values make sense? It is because of limits. In this case we consider \(x\) values that get closer and closer to 0 and look at the pattern of values of the expression that result. For the first expression we can see that no matter how close we get to 0 (like \(-0.1, -0.01, -0.001, \ldots\), or \(0.1, 0.01, 0.001, \ldots\)) we always get 2. Therefore the limit of \(\frac{2x}{x}\) is 2 as \(x\) approaches 0. That’s a mouthful, so to make things easier we write

\[
\lim_{x \to 0} \frac{2x}{x} = 2, \text{ which reads "the limit of } \frac{2x}{x} \text{ as } x \text{ approaches 0 is 2".}
\]

\(^1\)Note that this is different from having a nonzero value over zero. In that case the result is undefined since dividing something into zero parts is not possible.

It’s also different from having zero over a nonzero value. That is zero since no matter how many parts you divide zero into, each part still has the value of zero.

\(^2\)Which is why we can gloss over this problem in algebra.
In general, we say the limit of an expression as the input variable approaches some number (call it \(c\)) is equal to a number (call it \(L\)). More generally we might write

\[
\lim_{x \to c} f(x) = L,
\]

where \(f(x)\) represents the expression under consideration.

For the second expression (or function) above we have

\[
\lim_{x \to 0} \frac{3x}{x} = 3.
\]

For the other indeterminate form mentioned above, \(0 \cdot \infty\), we can use the same expressions but we'll write them a bit differently. Consider

\[
2x \cdot \frac{1}{x} = \frac{2x}{x} \quad \text{and} \quad 3x \cdot \frac{1}{x} = \frac{3x}{x}.
\]

In each case as \(x \to 0\) we have \(2x \to 0\) and \(\frac{1}{x} \to \infty\). But we’ve already seen that

\[
\lim_{x \to 0} 2x \cdot \frac{1}{x} = \lim_{x \to 0} \frac{2x}{x} = 2.
\]

Similarly

\[
\lim_{x \to 0} 3x \cdot \frac{1}{x} = \lim_{x \to 0} \frac{3x}{x} = 3.
\]

### 3.4 Continuity

Another use for limits is to establish whether or not a function is continuous at a point. Informally, a function’s graph is continuous at a point if you can draw the graph through the point without needing to lift your pencil as you go from one side of the point to the other. Notice that continuity is defined at a point but it requires an open interval (no matter how small) that contains the point. You can consider continuity on an interval by looking at all of the points in the interval. This is impossible since every open interval,
every half-open interval, and almost every closed interval has infinitely many points in it. Therefore, this is typically done by looking for points that aren’t continuous (discontinuities). If you can find all of those, then the open intervals between them must be continuous.

Continuity is important because many of the most important definitions and theorems require continuous functions. The properties of continuity, differentiability (existence of a derivative), and integrability (existence of an antiderivative) are closely related. There are also a lot of properties that pertain automatically to continuous functions.

Most of the functions you will deal with in a beginning calculus course will either be continuous everywhere on their domain or they will be discontinuous at vertical asymptotes. Here are the most common types of discontinuities in Figure 3.1. The first is a hole. Holes are removable discontinuities because changing just one point would “fix” the discontinuity. The second is a jump and the third is infinite, the kind you get at a vertical asymptote. Both of these are not removable.

Figure 3.1: Discontinuity Examples (Hole, Jump, and Infinite)

3.4.1 Intermediate Value Theorem

One important result of continuity is the Intermediate Value Theorem. It’s a fairly basic idea that has some very interesting consequences.

Imagine driving your car to a friend’s home. Roads are continuous (we hope!) and it is necessary for you to travel over every bit of the distance from your home to your friend’s home. Let’s say that distance is 10 miles. Even if you go over a bump and your car goes airborne for a moment, you still will, at some time, be every possible distance between zero and 10 miles from home. You may drive on a winding road and be 5.2 miles away three different
times. You may take a detour to a store and spend some time more than 12.7 miles away from your home. Regardless, if I pick any number between 0 and 10 there is a point during your journey when you are exactly that far from home.

Figure 3.2 provides a graph of your distance from home \( s(t) \) as a function of time \( t \). Notice how if you pick any distance along the vertical axis between 0 and 10, there is at least one time \( t \) along the horizontal axis where the graph has the distance you picked. Try finding the values mentioned in the previous paragraph.

That’s a result of the Intermediate Value Theorem: for a continuous function on a given closed interval, the function has to take on every possible value between the initial value on the interval and the final value on the interval. It may take on any given value multiple times, and it may take on values that are outside the range from initial to final, but it must take on every value between the initial and final value at least once. This is guaranteed to be true for any function that is continuous on a given closed interval. It can be true or false for functions that aren’t continuous on the given closed interval.
Chapter 4

Derivatives

4.1 Rates of Change

The world is full of things changing. Here are just a few examples of some simple rates of change.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>Rate of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>miles driven</td>
<td>gallons of gas used</td>
<td>miles per gallon (mpg)</td>
</tr>
<tr>
<td>miles driven</td>
<td>total time of trip</td>
<td>miles per hour (mph)</td>
</tr>
<tr>
<td>prices of goods &amp; services</td>
<td>time</td>
<td>inflation</td>
</tr>
<tr>
<td>weight of a beam</td>
<td>length of the beam</td>
<td>weight per length (linear density)</td>
</tr>
<tr>
<td>price of a product</td>
<td>amount of the product</td>
<td>unit price</td>
</tr>
</tbody>
</table>

Table 4.1: Rates of Change

I’m sure you can think of a few more to add to this list.

4.1.1 Slope

You may not realize this, but the slope of a straight line is really about rate of change. Typically when we calculate rates of change we find two different instances of our dependent and independent variable, find the change in each, and then divide.
This is just the slope formula, which we typically think of as
\[
\frac{\text{change in } y}{\text{change in } x} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}.
\]

This is a great approach in a lot of instances, but its drawback is that it only gives us an average change in the dependent variable per some unit change (change of just one) in the independent variable. Calculus allows us to move past average rates of change and consider instantaneous rates of change. You may see a point of difficulty here: how do we find a rate of change at a given instant, since that instant only has one value of each variable associated with it? You’ll see how calculus deals with this problem shortly!

### 4.2 Average Rates of Change to Instantaneous Rates of Change

A secant line is a straight line that passes through two points of the graph of a function. For some examples, let’s look back to the first part of Chapter 1 (see section 1.1) near the beginning of this book. Here’s a graph of the function that defines how far you’ve walked as a function of the amount of time you’ve been walking.
Now here are graphs of the secant lines we used to get estimates of the rate of change near \( t = 50 \) seconds. As the two points get closer together the slopes of the lines get closer to zero and the lines get closer to horizontal. Notice in the third graph that the two points are so close together it’s pretty much impossible to tell them apart and the slope is so close to zero that the secant line looks horizontal.
Our goal is to turn these secant lines into a tangent line that intersects the graph at exactly the point we’re interested in. We can do that by using the idea of a limit. Notice that using just the point of interest would give us a slope of $\frac{\Delta y}{\Delta x} = \frac{0}{0}$, one of the indeterminate forms that limits are so helpful with. To do this we’ll need to introduce some notation and think about things a little differently than we did in the original example\footnote{The concept is the same, but we’ll choose the two points for our secant lines a bit differently. That will help us get the math set up in a way that works more easily.}.

4.2.1 The Secant Line and Average Rate of Change

Since we’re trying to create a tangent line that passes through the actual point of interest, it will be useful to make that one of the two points on our secant lines. For the other point we’ll choose $x$ values that are a bit away from our point of interest, then we’ll move this second point toward the point we’re interested in.

Let’s call our function $f$ and the $x$-value of the point we’re working with $c$. That is, we’re going to try to find the instantaneous rate of change of the function $f$ when $x = c$. That means our point of interest can be written as $(c, f(c))$.

Our second point, which we’ll allow to move around, is going to have $x$-values that are close to $c$. Since we’ll be changing the $x$-value by just a bit, we can think of this value as being $c$ plus some small change in $x$ away from $c$. Notationally we’ll use the descriptor $\Delta$ to denote the idea of change (as we’ve done earlier) in the $x$-value. Therefore the $x$-value of this new point is $c + \Delta x$ ($c$ plus a small change in $x$). The $y$-value, or function value, at this point is $f(c + \Delta x)$, and the point can be written as $(c + \Delta x, f(c + \Delta x))$.

Whew! This is part of what makes the conceptual side of calculus challenging. Don’t be afraid to take notes, draw sketches, and try to work things out for yourself as we go along to aid in your understanding. Here’s a graph for some function $f$ that shows our secant line with the described notation.
In the graph you can see our point of interest, our second point that we will move closer and closer to the first point, and the secant line that passes through these two points. The slope of the secant line is the average rate of change of \( f(x) \) with respect to \( x \). You should note that the quantity \( \Delta x \) can be either positive or negative, so the second point can be to the right or to the left of the point of interest. This is important because we’ll want to look at what happens for both positive and negative values of \( \Delta x \).

We can use the slope formula to find the slope of the secant line shown in the graph.

\[
\frac{\Delta y}{\Delta x} = \frac{f(c+\Delta x) - f(c)}{(c+\Delta x) - c} = \frac{f(c+\Delta x) - f(c)}{\Delta x}
\]

By making \( \Delta x \) smaller and smaller we can get better and better approximations of the instantaneous rate of change at the point \((c, f(c))\). We should be sure to look at what happens for negative \( \Delta x \) values that get closer and closer to zero and we should also look at what happens for positive \( \Delta x \) values that get closer and closer to zero. In order to say some value is the instantaneous rate of change at \((c, f(c))\) we should get the same value for both negative and positive values of \( \Delta x \).
Notice that if we let $\Delta x = 0$ we get

$$\frac{\Delta y}{\Delta x} = \frac{f(c + 0) - f(c)}{0} = \frac{0}{0} = 0,$$

one of our indeterminate forms. If you guessed that we need a limit next, you’re right!

### 4.2.2 The Tangent Line and Instantaneous Rate of Change

In calculus we use a bunch of words and phrases interchangeably that all mean the same thing. Notice that sometimes there are qualifiers and sometimes not. As you move forward you’ll find that mathematicians use qualifiers when referring to average rates of change or secant line slope, but not as much with instantaneous change. That can be confusing since the math you’ve studied up to this point hasn’t needed to distinguish average from instantaneous because everything was an average rate of change. Now the focus becomes instantaneous rate of change and the contextual meaning of some words changes.\(^2\) Table 4.2 gives six different ways to refer to one concept.

<table>
<thead>
<tr>
<th>instantaneous rate of change</th>
<th>slope</th>
<th>slope of the tangent line</th>
</tr>
</thead>
<tbody>
<tr>
<td>derivative</td>
<td>first derivative</td>
<td>rate of change</td>
</tr>
</tbody>
</table>

Table 4.2: Different Phrases Meaning Instantaneous Rate of Change

To make things even more confusing, we have multiple symbols for representing the idea of instantaneous change as well. Here are a few ways to represent the slope of the tangent line to a function $f$ when $x = c$.

$$f'(c) = \frac{dy}{dx}\bigg|_c = \lim_{\Delta x \to 0} \frac{\Delta y}{\Delta x} = \lim_{\Delta x \to 0} \frac{f(c + \Delta x) - f(c)}{\Delta x}$$

Perhaps the most important thing to notice here is that we’ve taken the basic slope idea for a secant line and turned it into the slope of a tangent line by adding in limit notation. That’s it – if you understand what a limit is and how we formulated our notation for the slope of a secant line, you now have the slope of a tangent line. This works for any function at any point where

\(^2\)When I started my graduate studies in mathematics I remember having to adjust to the use of log to represent the natural logarithm. In my undergraduate work it was always represented by $\ln$. 


the limit exists (that is, you get the same numerical value for the limit when using negative $\Delta x$ values as when you use positive $\Delta x$ values).

Once you know the slope of the tangent line at a point, you can find the equation of the tangent line as well. From algebra one way to write the equation of a straight line is point-slope form. Using the notation we’ve been developing in this chapter, the equation of the tangent line at the point $(c, f(c))$ (assuming the slope exists), is

$$y - f(c) = f'(c)(x - c),$$

or

$$y = f'(c)(x - c) + f(c),$$

or

$$y = f'(c) \cdot x + (f(c) - c \cdot f'(c)).$$

Personally, I find the middle one to be the most useful.

### 4.2.3 Linear Approximations

One way to think of derivatives is as linear approximations to more complex functions. That is to say that once you know the equation of a tangent line at a given point on a function’s graph, you have a tool that will approximate values of the function near that given point. The function and the tangent line have exactly the same value at the given point. The difference between the two (or the error in the linear approximation) will typically grow the further you get from that point. Perhaps surprisingly, the approximation is good enough for a wide array of applications and can be especially useful in computer programs that deal with derivatives. We’ll look at three different ways we can use linear approximations.

#### Linear Approximation I

Consider a function $f$ and the point $(c, f(c))$. It is assumed that $f'(c)$ exists. We’ll let $g$ represent the tangent line to $f$ at the given point, so $g(x) = f'(c)(x - c) + f(c)$. Note that when $x = c$ this gives us exactly $g(c) = f(c)$. For values of $x$ that are near $c$, we have $f(x) \approx g(x)$ and the relative (think percent) error is given by $\frac{g(x) - f(x)}{f(x)}$. Someone using this approximation would need to decide how much relative error is too much and
then only use the approximation for values of $x$ near enough to $c$ that the relative error is smaller than the maximum acceptable relative error.

Figure 4.4 shows a function $f$ (in blue) and the tangent line $g$ (in red) to $f$ at $c$. In the first graph you can see that the error (vertical distance between the two graphs) gets large quickly as you move away from $c$. The second graph is zoomed in near the point $(c, f(c))$. You can see that it is hard to distinguish between the two graphs near $c$ where the approximation is best.

Figure 4.4: Linear Approximations

Linear Approximation II

Another way to make use of linear approximations is very similar to the first but the notation changes. We make the same assumptions as before with the additional assumption that values of $f$ near $c$ are difficult to calculate (for instance, maybe $f(x) = \sqrt{x}$, $c = 9$, and we’re interested in $f(8) = \sqrt{8}$). First we remember that $\frac{dy}{dx}\bigg|_c = f'(c)$ which can be approximated as $\frac{\Delta y}{\Delta x} \approx f'(c)$. Then $\Delta y \approx f'(c) \Delta x$. Since $f(c + \Delta x) = f(c) + \Delta y$ we can write that $f(c + \Delta x) \approx f(c) + f'(c) \Delta x$.

Used properly, this method requires values that are easy to calculate and easy operations as well. For example, If $f(x) = \sqrt{x}$, $c = 9$, and we’re interested in $f(8) = \sqrt{8}$, then we can choose $\Delta x = -1$ since $9 + (-1) = 8$. In this particular case, the approximation has an error of less than 0.2%.
Linear Approximation III

The last method I'll mention is called Newton's method. It is useful for approximating the values of \( x \) that make a function equal zero. In this case you need formulas for both \( f \) and \( f' \). You have to start with a guess as to the correct value, which is typically called \( x_0 \). At that value the function will have a tangent line that looks like

\[
y - f(x_0) = f'(x_0)(x - x_0).
\]

Remember that we're looking for zeros of \( f \); therefore, we will approximate the function with the tangent line and look for its zero. We set \( y = 0 \) and then solve for \( x = x_1 \). After a little algebra we get the formula

\[
x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}.
\]

The process is repeated until the error between two successive approximations is smaller than some maximum acceptable error that the user has chosen. It’s a very powerful method that tends to converge (find an acceptable answer) very quickly. In more general terms we write

\[
x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}
\]

where we start at \( n = 0 \) and go as high as needed (rarely into double-digits).

In Figure 4.5 two iterations of Newton’s Method have been used to approximate \( \sqrt{2} \). The initial guess is 1. The tangent line for that guess leads to a new guess of 1.5. The tangent line for that second guess leads to a value of \( \frac{17}{12} \) which differs from the exact value by less than 0.2%. Greater accuracy can be found by using this value as a new guess and repeating the procedure.
4.3 Mean Value Theorem

For continuous functions, the average rate of change and instantaneous rates of change are linked. For example, remember the position function from when we discussed the Intermediate Value Theorem. You can see a graph of this function, which showed how far you were from home as you drove to a friend’s home 10 miles away, on the left of Figure 4.6. According to this graph you end up 10 miles from home after 24 minutes of driving. This leads to an average speed of 25 miles per hour. Since our position function is continuous, the mean value theorem says there will be at least one time during those 24 minutes when your instantaneous speed is exactly 25 miles per hour. There may be more than one time, but for a continuous function on an interval the mean value theorem guarantees that there will be at least one point in the interval where the average rate of change (over the entire interval) and the instantaneous rate of change are equal.

The second graph in Figure 4.6 shows the average rate of change, which is the secant line connecting the two endpoints of the graph, and three points where the instantaneous rate of change, the three tangent lines, is equal to the average rate of change. All of the lines are parallel so they have the same slope and therefore the same rate of change.
A special case of the Mean Value Theorem is called Rolle’s Theorem. Rolle’s Theorem applies when the average rate of change is exactly zero. Then, according to the Mean Value Theorem, there must be at least one time the instantaneous rate of change was zero. Imagine backing out of your driveway, stopping at the end, realizing you forgot something, and then driving back up the driveway. You end up where you started so your displacement is zero giving you an average velocity of zero. When you stopped at the end of the driveway, in between backing out and pulling back in, your instantaneous velocity was zero, which Rolle’s Theorem predicts since your position is a continuous function.

4.4 Optimization

Derivatives can be used to help solve optimization problems. An optimization problem is one where we’re trying to find either a maximum value or a minimum value of a function (output) and the associated input value. Maximum values occur where a function’s graph changes from uphill (increasing) to downhill (decreasing). Minimum values occur where a function’s graph changes from downhill (decreasing) to uphill (increasing). Figure 4.7 gives examples of each, with maximums in the top row and minimums in the bottom row.
In the two leftmost images of Figure 4.7 the maximum and minimum points occur where the rate of change is zero (the derivative is zero or the slope of the tangent line is zero\(^3\)). In the four images to the right the maximum and minimum points occur where the rate of change is undefined (the derivative doesn’t exist – in the middle images there is no tangent line and in the right images the tangent line is vertical).

This gives us a useful tool for solving optimization problems: look for where the derivative is either zero or undefined. However, it’s not quite enough. The derivative can be zero or undefined at points that aren’t maximum or minimum points.

In Figure 4.8 you can see a graph with a slope of zero that is not a minimum or a maximum as well as a graph with an undefined slope that is not a maximum or a minimum.

\(^3\)That is, the tangent line is horizontal.
To determine if a point with a zero or undefined slope is a maximum or a minimum you can look at the point on the graph. You can also use the First Derivative Test. This test says to look at the point that has a zero or undefined slope. If the rate of change is positive (uphill or increasing) to the left of that point and negative (downhill or decreasing) to the right, then the point is a maximum. Conversely, if the rate of change is negative to the left of that point and positive to the right, then the point is a minimum. If the rate of change is positive on both sides or negative on both sides, then the point is neither a maximum nor a minimum.

4.5 Concavity (How Rates of Change Change)

It is often interesting to look at how rates of change themselves change. That is, consider the rate of change of a rate of change. This may sound strange, but here are two examples you may be familiar with.

We started talking early on about functions that keep track of someone’s position over time, helping us understand how far they are from some starting point at different points in time. We saw that the rate of change of position gave us velocity, how fast their distance from the starting point was changing at any given moment in time. But what if we consider the rate of change of velocity? We know from walking or driving that our velocity is often changing so it makes sense to ask about how it changes. That quantity is
called acceleration\(^4\). It tells us how many mph, for instance, our velocity is changing by at any given moment. When our velocity is constant our acceleration is zero, but when we’re speeding up or slowing down we are accelerating (or decelerating).

The rate of change of a rate of change is often referred to as a second derivative. Second derivatives show up in economics frequently. They even show up in the newspaper in economic stories. When discussing the rate of inflation (the rate of change of the cost of goods and services) an economist might mention that inflation is “picking up” or “slowing down”. These types of statements talk about how the rate of inflation itself is changing – it may increase or decrease over time. If you listen to the news carefully you’ll hear about second derivatives more often than you may think!

Graphically these second derivatives speak to the idea of concavity. If you look at Figure 4.9 the first graph has a positive second derivative and is concave up. That is, the first derivative is increasing, in this case going from very negative values to zero to very positive values. The second graph has a negative second derivative and is concave down. Its first derivative is decreasing, going from very positive values to zero to very negative values.

While we don’t get much useful information about its graph, it can be useful to look at other derivatives of a function as well. A third derivative looks at the rate of change of the rate of change of the rate of change of a function. The rate of change of acceleration is called \textit{jerk}, so called because you feel a physical \textit{jerk} when your acceleration changes quickly.

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\(^4\)The rate of change of acceleration is called \textit{jerk}, so called because you feel a physical \textit{jerk} when your acceleration changes quickly.
function (which is really hard to follow!). We can talk about fourth derivatives, fifth derivatives, and even 542nd derivatives (although they become pretty useless after the first handful or so).

4.6 Related Rates

One very useful application of derivatives is to related rate problems. Sometimes it is easier to compare how the different quantities in a problem are changing than it is to consider the quantities themselves. For example, consider a situation where two cars are approaching a given point from different angles. We can diagram this situation with a simple triangle: one side is the distance between the two cars and the other two sides are the distance between each car and the given point. If the angle between the cars is a right, or $90^\circ$, angle, then the Pythagorean Theorem can be used to describe the positions of the cars and the given point. If we assume each car is driving directly at the point and we know their speeds then we can make predictions about when they will arrive at the given location and if there may be a problem (like a crash!). However, it might be more useful to know how fast the two cars are approaching each other. That would be the rate of change of the length of the third side of the triangle, the one between the two cars. All three rates of change are related geometrically since they come from a triangle, so we have a related rate problem.

Related rate problems show up in lots of different contexts – speed (velocity), volume (like a fluid flowing in or out of a tank), angles (like how fast a camera has to turn to track a moving object), and many more.

4.6.1 Newton

It turns out that Isaac Newton saw differential calculus in terms of related rates. When given a function that related two variables, say $x$ and $y$, he called each variable a fluent. How a given fluent changed with respect to time was a fluxion\footnote{His terms were meant to reflect the fact that the value of a variable changes, or flows, and that the speed of that change is typically changing as well, or fluxing.}. That is, he didn’t think of $y$ changing with respect to $x$ the way we do today, he thought of $y$ changing with respect to time and $x$ changing with respect to time. This is pretty much the approach we take when we tackle related rate problems. The governing equations often
represent the physical reality of the problem, but since the physical setup is changing in time we can look at how each variable changes with respect to time.

### 4.6.2 Implicit derivatives

NOTE: This section has the most symbol manipulation you’ll see throughout the book. Don’t worry if you don’t follow it, just focus on the two main ideas: we can find derivatives of equations that aren’t functions and we can consider derivatives with respect to variables that aren’t present in a function.

Today we think of what Newton did and related rate problems as dealing with implicit derivatives. In their most basic sense implicit derivatives allow us to look at situations where our governing equation isn’t a function, or where it is hard to write the function in explicit form. (Explicit form means it can be written as \( y = f(x) \) with just the one \( y \) on one side and no \( y \)'s on the other side). For example the equation of a circle that has its center at the origin of a graph and has a radius of 1 is \( x^2 + y^2 = 1 \). Circle equations are not functions (some \( x \) values have two different \( y \) values associated with them). Yet it is still possible to apply the idea of a derivative to this equation if we just think of \( y \) as being more complex than just a variable – it is a “function” of \( x \). That means we have to be a little careful when we take its derivative.

\[
x^2 + y^2 = 1 \quad \Rightarrow \quad \frac{d}{dx}[x^2] + \frac{d}{dx}[y^2] = \frac{d}{dx}[1] \\
2x + 2y\frac{dy}{dx} = 0 \\
\frac{dy}{dx} = -\frac{x}{y}
\]

We can take this idea a step further with related rate problems. Instead of thinking of \( y \) as a “function” of \( x \), we can consider \( x \) as a function of \( t \) (time) and \( y \) as a function of \( t \) as well. Now each “variable” is really a function. Notice that we don’t have to know what those specific functions look like, either \( x(t) \) or \( y(t) \). It is enough to know that each varies with time.

---

\footnote{This is different from the approach of Leibniz, from whom we take most of the modern approach and notation.}
While Newton’s notation was different, this is essentially how he would have thought of that circle. If it helps, imagine a dot on the circle going around the circle. It can speed up, slow down, even change directions. At any given moment its position can be described in terms of its $x$- and $y$-coordinates, and how that position is changing can be described by how each of those coordinates is changing with respect to time ($t$).

\[
\begin{align*}
x^2 + y^2 &= 1 \\
[x(t)]^2 + [y(t)]^2 &= 1 \\
\frac{d}{dt} \left( [x(t)]^2 + [y(t)]^2 \right) &= \frac{d}{dt} [1] \\
2x(t)x'(t) + 2y(t)y'(t) &= 0 \\
x \frac{dx}{dt} + y \frac{dy}{dt} &= 0
\end{align*}
\]

One last comment here: with a bit of algebra you can turn Newton’s result into the result we saw above; that is,

\[
x \frac{dx}{dt} + y \frac{dy}{dt} = 0 \text{ is equivalent to } \frac{dy}{dx} = -\frac{x}{y}.
\]
Chapter 5

Antiderivatives

There are two sides to calculus which are typically called differential calculus and integral calculus. Differential calculus deals with rates of change as we’ve been discussing. Integral calculus deals with accumulating quantities, typically rates of change. That may sound vague, but it’s basically just reversing the process of finding rates of change. In integral calculus we start with a rate of change and then work to discover more about the quantity that is changing. For example, if we know position as a function of time, the derivative gives us the rate of change of position with respect to time, or velocity. However, if we know about velocity, an integral can give us information about position as a function of time.

In many ways this reverse process is the more powerful of the two halves of calculus. It turns out that it is often easier to describe (find functions for) rates of change than it is for the actual quantities themselves. For example, Newton knew that objects cool at a rate that is proportional to the temperature of their surroundings; that is, they cool faster when they’re hotter and slower when they’re cooler. The rate of cooling is a rate of change. From there, using integral calculus, it’s possible to determine information about the temperature of the object at different times.

Since integral calculus is essentially reversing the process of derivatives, we often refer to integrals as dealing with antiderivatives.
5.1 Accumulation

Let’s assume for a moment that we know about the rate of change of some quantity. Maybe we have a function, \( v(t) \), that describes the velocity of an object. This type of equation, since it begins with a rate of change in it, is called a differential equation (since derivatives are rates of change and differential calculus deals with derivatives). For now let’s keep our velocity function simple and think of it as \( v(t) = 10 \). We’ll assume our units are mph (miles per hour). This is a constant function, meaning there is no variable on the right-hand side of the function. Our object is always moving at 10 mph.

From here it is easy to see that, from some starting point, the object moves 10 miles after 1 hour, 20 miles after 2 hours, 30 miles after 3 hours, etc. As time goes on we accumulate more distance. For every hour that passes we accumulate another 10 miles. Basically, given some starting point, we can find the distance our object has traveled from that starting point by simply multiplying 10 by the number of hours that have passed.

You may be wondering why I keep referring to some starting point. In this case we began with a constant velocity function and that’s all we know. One thing we don’t know is how far the object may have traveled before we start keeping track of time and accumulating miles traveled. If the object was at its starting point then multiplying 10 by time works extremely well. But if the object was already 25 miles from the starting point when we started working with it, all of our values will be off by 25 miles because there’s no way for us to know about that distance based on the information we were given.

Our position function, \( s(t) \), therefore looks like \( s(t) = 10t + C \) where \( C \) is some initial displacement that we need additional information to establish. When working with integrals (both definite and indefinite) as well as antiderivatives, it’s important to keep this issue in mind. We’ll talk more about this \( C \) and how we may determine it later.

5.1.1 Area

Let’s continue to consider the velocity function \( v(t) = 10 \). Figure 5.1 shows a graph of this function.
Keeping in mind our result from above that we can multiply the velocity of 10 mph by the number of hours traveled, notice that you end up with a rectangle of exactly that same area on the graph. For example, as shown in the first graph of Figure 5.2, if the time is $t = 6$ hours we end up with a rectangle that is 10 mph high by 6 hours wide. The distance traveled by the object in this time is $10 \text{ mph} \times 6 \text{ hours} = 60 \text{ miles}$, which is exactly the area of the rectangle.
For most functions, calculating this area exactly can get quite complicated, but it’s useful to see that there’s a geometric interpretation of accumulation. Note that it’s not necessary to have the time start at zero, as we see in the second graph of Figure 5.2. As long as the difference in time is 6 hours, the time traveled during that time interval is 60 miles. That’s an important point: in the first graph we find out how far the object has traveled during the time period of 0 to 6 hours, whereas in the second graph we find out how far the object has traveled during the time period 2 to 8 hours. For most velocity functions these values would be different (but remember we’re using a very simple constant function here).

Before we move on, please note two things. One is that the area here is defined as being bounded by two $t$-values on the left and the right, the function at the top, and the $t$-axis at the bottom. This is by design and makes everything work out the way we expect (as we’ve been finding). The other is that if the function’s graph is below the $t$-axis then the area will bounded at the top by the $t$-axis and the function at the bottom; that is, the area is always between the function and the horizontal axis (and between two independent variable values). Further, area above the horizontal axis is always positive and area below the horizontal axis is always negative. This follows from the fact that the dependent variable values are positive above the horizontal axis and negative below.

### 5.1.2 Definite Integrals

The fact that accumulation can be thought of as area is at the heart of the method for finding the appropriate area exactly for any function. This method is referred to as a definite integral. There are two basic ideas at work in a definite integral. One is this idea of thinking of accumulation as area. The other is from our work in derivatives. You may remember that we can approximate a function by its tangent line over short intervals. We’ll adapt that idea a little bit and say that we can approximate a function with a horizontal line over a short interval. That horizontal line gives us the top of a rectangle.

Since this approximation only works over short intervals, it will take a lot of rectangles to get a good approximation of the area. As an example let’s consider a more complex velocity function like $v(t) = 10 + \sin t$ as seen in Figure 5.3.
We definitely don’t have a rectangle here so finding the area under this curve is not going to be as easy as it was before. But what if we used 10 rectangles and added them up? It’s pretty easy to see in Figure 5.4 that our horizontal approximation for the top of each rectangle doesn’t work very well. It’s also easy to see that some rectangles have too much area and others not enough. We can hope that this averages out, but there are no guarantees.
So what if we used 100 rectangles and added them up? Or 1000 rectangles? Or maybe 1,000,000 rectangles? As you can probably imagine, we get better and better approximations as we use more and more rectangles. But, wow, that’s starting to sound like a ridiculous amount of work!

So let’s return to our friend the limit. What we really want to do here is consider what happens as the number of rectangles becomes infinite; that is, consider the limit of the sum of lots of very thin rectangles as the number of rectangles approaches infinity. This, it turns out, is easier than it sounds (though it isn’t necessarily easy) and is definitely easier than trying to add up the areas of 1,000,000 (or more) rectangles.

I’ve tried to keep symbols to a minimum, but we need to introduce a few here. Remember that our function is \( v(t) = 10 + \sin t \). What we’re going to do is take values of that function (rectangle heights) and multiply them by really small intervals (rectangle widths). We’ll call those really small widths \( \Delta t_i \) since each one is a really small interval of time. Don’t worry too much about the \( i \) you see there – we’ll be assuming every rectangle has the same width, but we don’t have to make that assumption. If we don’t then we need to keep track of the width of every rectangle and the \( i \) is just a way to note that we’re doing this. The \( i \) starts with the value 1 for the first rectangle,
then is 2 for the second rectangle, and so on. Similarly we’ll define the height of a rectangle as a function of some \( t \) value in its width, which we’ll call \( t_i \). This will make the height of any given rectangle \( v(t_i) \). The area of any one rectangle (the \( i \)th rectangle, if you will) is now \( v(t_i) \cdot \Delta t_i \) (height multiplied by width).

In math we use the Greek letter \( \Sigma \) to represent the idea of summation. We use expressions above and below the \( \Sigma \) to indicate where we start and end our summation. First we need a variable, or index, that keeps track of which item we’re currently adding to our total. This is typically \( i \) (the same \( i \) we’ve used above). Below the \( \Sigma \) we set \( i \) to some starting value. We’ve already said we’ll use \( i \) to count rectangles, so it makes sense to start with the first rectangle, giving us \( i = 1 \) to start. Above the \( \Sigma \) we put the final value for our index. Since we’re not interested in a fixed number of rectangles, we’ll just let this be represented by \( n \).

Putting everything together, the total approximate area is

\[
\sum_{i=1}^{n} v(t_i) \Delta t_i
\]

where \( n \) represents the number of rectangles used for the approximation. We want the number of rectangles to approach infinity, so the exact area is

\[
\lim_{n \to \infty} \sum_{i=1}^{n} v(t_i) \Delta t_i.
\]

That’s a pretty complicated mathematical expression, but it just means what we’ve said above: see what happens when you try to add up infinitely many infinitely thin rectangles. This starts to feel like adding up infinitely many zeros, but it turns out that adding up infinitely many zeros (or multiplying zero by infinity) is an indeterminate form, like dividing zero by zero. It can be anything depending on the context!

In beginning calculus we define the definite integral as follows:

\[
\int_{a}^{b} v(t) \, dt = \lim_{n \to \infty} \sum_{i=1}^{n} v(t_i) \Delta t_i.
\]

We generally assume that \( v(t) \) is continuous, though it doesn’t always have to be. The variables \( a \) and \( b \) are the left and right input values, respectively,
that define the interval we’re working on. They are called the upper (b) and lower (a) limits of integration. The function \( v(t) \) is called the integrand. In much the same vein that \( \Delta x \) became \( dx \) when we considered the limit as \( \Delta x \to 0 \), the symbol \( \Sigma \) becomes \( \int \) when we consider the limit as \( n \to \infty \).

Definite integrals have numbers (areas) for answers like the 60 miles in the preceding example (this isn’t always true, as you’ll soon see, but it’s a good way to think of things for now). This is as opposed to indefinite integrals, which have functions for answers. You saw the result of an indefinite integral earlier with the position function \( s(t) = 10t + C \).

### 5.2 The Fundamental Theorem of Calculus

I’m going to give you two of the most important results in calculus, briefly talk about why they’re important, and then see if I can explain where they come from without getting too technical (your calculus textbook can show you proofs of these theorems in much more technical detail). They are sometimes named and/or written differently but each is considered to be a Fundamental Theorem of Calculus (FTC). The first says that

\[
\int_{a}^{b} f'(x) \, dx = f(b) - f(a).
\]

The second says that

\[
\text{if } A(x) = \int_{a}^{x} f(t) \, dt \text{ then } A'(x) = \frac{d}{dx} \left[ \int_{a}^{x} f(t) \, dt \right] = f(x).
\]

For both we assume we’re working in the domains of the given functions, that the integrands are continuous on the given intervals, and any underlying limits exist.

The second FTC guarantees the existence of antiderivatives when the integrand is continuous. That is, the differential equation

\[
dA/dx = f
\]

has a solution for every continuous function \( f \), meaning every continuous function \( f \) has an antiderivative \( A \), or every continuous function \( f \) is the derivative of some other function \( A \).
To get a conceptual feel for how this works, let’s consider one rectangle in the area finding process. We’ll let this rectangle have area $\Delta A = f(x) \cdot \Delta x$, where the height of the rectangle $f(x)$ is some value of $f$ in the interval defined by $\Delta x$. If we apply a limit and let $\Delta x$ approach 0 we will end up with $dA = f(x) \, dx$. Just a touch of algebra gives us

$$\frac{dA}{dx} = f(x), \text{ or } A'(x) = f(x).$$

That last bit says the rate of change of the area is the same as the function value. You can visualize the area we’re talking about in Figure 5.5. On the left the area of the rectangle is $\Delta A = f(x) \cdot \Delta x$. On the right, after letting $\Delta x \to 0$, the area becomes $dA = f(x) \, dx$. That touch of algebra does the rest.

![Figure 5.5: The Second Fundamental Theorem of Calculus](image)

The first FTC,

$$\int_a^b f'(x) \, dx = f(b) - f(a),$$

allows us to find the values of definite integrals without having to go through the limit process. If we can find an antiderivative $f$ of our rate of change function $f'$ then we simply evaluate $f$ at $b$ and at $a$ and find the difference. However, the process of finding antiderivatives can be difficult. We now
know they exist for any continuous function, but knowing they exist and finding them are two very different things. Luckily, as you will find in your calculus course, there are shortcuts available for the common functions you will typically encounter.

Why does this work? How can such a complicated process of rectangles, sums, and limits be boiled down to finding a function and evaluating it twice? Let’s consider the accumulation function

\[ f(x) = \int_a^x f'(t) \, dt. \]

This is called an accumulation function because \( f(x) \) is a function that, for any input value of \( x \), gives the definite integral of \( f' \) from \( a \) to \( x \). That is, \( f \) is a function that accumulates \( f' \).

If we let \( x = a \) we end up with \( f(a) = 0 \) because we would be considering the integral from \( a \) to \( a \) which has no width and therefore zero area. We can therefore write that

\[ f(b) - f(a) = \int_a^b f'(t) \, dt - \int_a^a f'(t) \, dt = \int_a^b f'(t) \, dt. \]

This works for the specific antiderivative \( f \) of \( f' \), but what about any antiderivative? The only difference between the antiderivatives of a given function is the constant, so let’s consider

\[ f(x) + C = \int_a^x f'(t) \, dt. \]

Then

\[ (f(b) + C) - (f(a) + C) = f(b) + C - f(a) - C = f(b) - f(a) = \int_a^b f'(t) \, dt. \]

These are two very powerful results. They show that integration and differentiation are inverses of each other, that differential calculus and integral calculus are inextricably linked in how they create the subject of calculus.

5.2.1 Average Value of a Function

Now that you know something about definite integrals we can talk about a neat result that allows us to find the average value of a function on an
interval. The typical way we calculate an average is to calculate the mean value of a quantity. To calculate a mean we have to add up a bunch of values and divide the result by the number of values. This sounds easy until we consider that a function has infinitely many values on even very small intervals. So how do definite integrals solve this problem?

You have already seen that we can interpret the result of a definite integral as an area. To find the average value of a function on an interval we find a rectangle that has the same area. The base of the rectangle will be the distance along the horizontal axis \((b - a)\) if you’re interested in the details) and the height we find by dividing the area by the base; that is,

\[
\frac{\int_a^b f(x) \, dx}{b - a}.
\]

We define that height to be the average value of the function.

Visually we can see this in Figure 5.6. In the first graph we see a function in blue and its average value in red. That is, if you could add up every \(y\)-value for every \(x\)-value from 0 to 10 and then divide by the number of \(y\)-values (infinitely many, remember), the height of the red line would be the result. In the second image you see both areas shaded. The two areas are equal! This is a fairly geometric approach to the idea of average, or mean, value.

Figure 5.6: Average Value of a Function
While it's actually possible to show that the mean of an infinite number of values will give us the same value, I think this is a more intuitive way to think of this average. If you're interested in learning more, check your calculus text for the Mean Value Theorem for Integrals. It's the actual theorem from which this idea of average value comes (though it doesn't show the connection to the mean).

5.2.2 Net Change Theorem

We've pretty much covered this idea already, but we'll link it to a name here. The Net Change Theorem simply says that the number you get from a definite integral is the net change of some quantity between two values of the independent variable. For example, remember the velocity function \( v(t) = 10 \). It didn't make any difference whether we looked at our object from 0 seconds to 6 seconds, 2 seconds to 8 seconds, or any other 6 second interval – the object was always 60 miles further on from wherever it started. This is pretty simple in the case of our overly simple velocity function.

Where this gets tricky is when the time interval involves both positive and negative velocities. In this case a positive velocity can be interpreted as getting further from some starting point and a negative velocity can be interpreted as getting closer to that starting point. Let's imagine a bungee jumper. She initially jumps from the top of a bridge and falls until the bungee cords stretch enough to begin to pull her back up. We'll take this distance to be 100 feet from the top of the bridge. As the cords pull her back up we can think of her velocity as negative because it is shrinking the distance between her and the top of the bridge. At some point gravity pulls her back down and the cycle repeats. Each time she travels a little less away from the bridge and bounces back up a shorter distance until she eventually hangs suspended and not moving from the bungee cords.
Our bungee jumper has probably traveled a good distance in her up and down bounces (based on Figure 5.7 I estimate about 300 feet after 20 seconds), but a definite integral of her velocity from the time she started until the time she stopped moving would give an answer that showed her final distance from the bridge (about 58 feet) and would ignore all of the ups and downs she traveled in between. We call her final position relative to her initial position displacement. This should make some intuitive sense as a definite integral only uses these two values in its calculation.

Displacement is the net change in position. If I started at home, drove to school, came home for lunch, drove back to school, drove home to pick up my family, drove out to eat, and drove back home again, my displacement (net change) would be 0 since I ended up where I started. This is true regardless of how much driving I did in between.

You can get distance traveled using definite integrals, but it can take a bit of work. For my driving example, I would do separate intervals for each time I drove – to school, back home, to school again, back home, out to eat, and back home once more. Each time I left home I would expect to get a positive value since I was increasing my distance from home. Each time I returned home I would expect to get a negative value since I was decreasing
my distance from home. Change all of the negative values to positive, add them to the original positive values, and you’ll get distance traveled.

For the bungee jump example every time she falls away from the bridge is a positive displacement and every time she bounces back toward the bridge is a negative displacement. Change every negative displacement to positive and add them to all of the positive displacements to get the total distance she traveled.

5.2.3 Numerical Methods (and Error Analysis)

While it is obviously advantageous to solve accumulation problems exactly, even with the Fundamental Theorems of Calculus this isn’t always easy. Some functions are very difficult to antidifferentiate while no antiderivative has yet been found for other functions. And while there are now software tools that can deal with integrals symbolically, they run up against some of the same problems just mentioned — that is, they’re only as smart as their programmers!

Luckily the fact that we can use lots of rectangles means we have a method for approximating integrals without ever dealing with antiderivatives. We can get as accurate as we need to be by using ever more rectangles or trapezoids or, as with Simpson’s rule, “rectangles” with parabolic tops (see Figure 5.8). Simpson’s Rule can be quite cumbersome to do by hand but computers can do it very quickly and it gets very accurate results without needing a lot of these “rectangles.”

1Though we’re guaranteed that antiderivatives exist for continuous functions, there is no guarantee as to whether we can determine what those antiderivatives look like.

2Mathematica (and Wolfram|Alpha), Maple, and Sage are a few.
Figure 5.8: Simpson’s Rule Using Only Two Subintervals

It’s even possible to put a bound\(^3\) on how much error is likely to be present in any given approximation. The actual error can be anything from 0 to the upper bound. We don’t know exactly how big it is, but we know that it can’t be bigger than the bounding value. This makes it possible to determine in advance how many rectangles (or other shapes) to use to get the desired accuracy.

5.3 Antiderivatives as Functions

As I mentioned before, some antiderivative problems yield numbers for answers (definite integrals) and some yield functions for answers (indefinite integrals and accumulation functions). While it is very useful to get a number for an answer to many problems, if we need to look at the same function for different limits of integration this can be a time consuming process. And if we’re interested in specific values of a quantity, not how the quantity changes, definite integrals really don’t help at all.

If we need to solve multiple definite integrals problems using the same function, we can more quickly use an accumulation function if one of the

\(^3\)In this situation I mean a maximum when I say “bound.”
limits of integration is a constant. For example, considering our earlier function \( v(t) = 10 + \sin t \), we might be interested in the object’s displacement between 0 and any number of hours. Since the 0 is constant we could consider the accumulation function

\[
d(x) = \int_0^x v(t) \, dt = 1 + 10x - \cos x.
\]

Once we have this function, \( d(1) \) gives us the displacement after 1 hour, \( d(2) \) gives us the displacement after 2 hours, etc. Now we’ve done the integration once and just need to evaluate a function to find more solutions.

When we want to actually know about a quantity itself we need to consider an indefinite integral. The problem with indefinite integrals is that they come with a constant of integration, denoted by +\( C \). This is because the derivative of a constant is 0 so the antiderivative of 0 is a constant. We need some additional information, often called an initial condition\(^4\) to find the value of this constant.

We began our look at derivatives with the function \( v(t) = 10 \) and I eventually said that the associated position function was \( s(t) = 10t + C \). That constant, \( C \), could be any of infinitely many values. But what if we knew that our object started with a displacement of 0; that is, \( s(0) = 0 \) or the object was 0 miles from the starting point at \( t = 0 \) hours. If that is true then \( C \) would have to be 0 and our function would be \( s(t) = 10t \). Alternatively, if we measure everything from home but picked our car up from the repair shop which is 15 miles from home, then \( s(0) = 15 \) which implies \( C = 15 \) and therefore \( s(t) = 10t + 15 \).

A famous example of this type of problem is Newton’s Law of Cooling. It says that the rate at which an object cools is proportional to the difference between its temperature and the temperature of whatever is cooling it\(^5\). It can be expressed as

\[
\frac{dT}{dt} = -k(T - T_a) \quad \text{where} \quad \frac{dT}{dt} \quad \text{is the rate at which the object is cooling at any given time} \quad t, \quad T \quad \text{is the temperature of the object at any time} \quad t, \quad T_a \quad \text{is the temperature of the coolant (assumed to be kept constant), and} \quad k \quad \text{is a constant}\(^6\) that is specific to each given situation and must be calculated. When we integrate to solve this kind of problem a +\( C \) shows

\(^4\)Initial condition implies the independent variable is 0, but this does not need to be true.

\(^5\)It is called the coolant and is typically air, water, etc.

\(^6\)The constant of proportionality.
up so we need to know some additional information to finish the solution. Typically it’s useful to know something about the temperature of the object at $t = 0$ and at some other point in time (we need two pieces of information because there are two constants, $k$ and $C$).
Conclusion

If you’ve made it this far I hope that the fundamental concepts behind calculus are clearer to you now than they were before. If you are taking (or have taken) a calculus course you should be able to see the difference between understanding the purposes of calculus and the act of actually doing calculus. It’s possible to learn one without the other, but calculus is a much more powerful tool if you know both and can understand how they work together.

Ultimately I hope you have a better understanding of what calculus is. Even more I hope I’ve increased your interest in the subject. It is something that forever changed the way I look at and think about the world around me. I look at things that change differently thanks to calculus and believe I’m a better person and citizen for it.

Thank you for reading my book.
Acknowledgments

- Mid Michigan Community College and the MMCC Faculty Senate made the sabbatical during which this book was initially drafted possible.
- Many, many thanks to those who provided feedback on early drafts of this book.
  - Ann Kedrowski
  - Lori Recker
- This book was created using LyX.
- Graphs were created using Graphe, written by Ivan Johansen and available at [http://www.padowan.dk/](http://www.padowan.dk/).
- Some images and graphs were created and/or modified using Microsoft PowerPoint.
- Bubble diagrams for functions were created using David Richeson’s TikZ solution, posted on his blog [Division by Zero](http://divisionbyzero.com) on April 9, 2013.
- The bungee jump equation is based on a function posted by Jill Saulnier on [Prezi](http://prezi.com) on June 7, 2011.
- The online tools [Desmos](https://www.desmos.com) and [Wolfram|Alpha](http://www.wolframalpha.com) were invaluable, as was my trusty [TI-84 Plus CE](https://www.ti.com).
Glossary

accumulation
The process of summing up lots of similar quantities. In integral calculus we can think of accumulation functions as accumulating changes in a variable to find out the total (net) change in that variable. Graphically this is often thought of as accumulating area. For more, see page 9.

accumulation function
A function that comes from a definite integral with one limit of integration (typically the upper) left as a variable. The resulting function gives definite integral values between the constant limit of integration (typically the lower) and the variable limit of integration without having to repeat the integration process. For more, see page 60.

antiderivative
An antiderivative of a function is a second function that has as its derivative function the original function. For more, see page 51.

average rate of change
The rate of change over some interval of time or some interval of the input variable. For more, see page 5.

continuous
A function or variable that takes on every possible value between two values without holes or jumps. Informally we can think of a continuous function as one where the graph can be drawn without needing to lift the pencil from
the paper. Contrast with discrete. For more, see page 31.

**derivative**

This can refer to the rate of change of a function at a specific point on its graph or it can refer to a function that gives the rate of change of another function at any valid point on its graph. For more, see page 34.

**differential calculus**

The branch of calculus that uses derivatives and is concerned with rates of change. For more, see page 34.

**differential equation**

An equation that includes derivatives (rates of change). For more, see page 52.

**discrete**

Discrete values have gaps between them. For example, when you roll a standard die you expect to get an integer value from 1 to 6. You cannot roll a 2.5 or $\pi$ or $\frac{34}{7}$. Contrast with continuous.

**function**

For the purposes of this book, a relation between two variables (typically some sort of equation) where each value of one of the variables leads to just one possible value of the other variable. Much of calculus assumes we’re working with functions. For more, see page 15.

**indeterminate**

A mathematical expression that has no obvious value but to which a value can be assigned from context. For more, see page 30.

**instantaneous rate of change**

The rate of change at an exact instant in time or at some specific value of the input variable. For more, see page 5.

**integral calculus**

The branch of calculus that uses antiderivatives and is concerned with accumulating area. For more, see page 51.
**CHAPTER 5. ANTIDERIVATIVES**

integrand  When dealing with integrals (definite or indefinite), the integrand is the function you’re looking for an antiderivative of.

interval  A set of all real numbers between two given real numbers, possibly containing neither (open interval), one (half-open interval), or both (closed interval) of these two numbers. For more, see page 20.

limit  A mathematical process of determining an expression’s value for a specific input value by considering values very near the input value. For more, see page 29.

position function  Position functions, typically denoted by $s(t)$, are taken throughout this book to give a distance away from some fixed point, often a starting point. This is a simple version of position (GPS is more complicated) but works for the purposes herein.

rate of change  How quickly one value changes with respect to another value; for example, speed is a rate of change of distance with respect to time. For more, see page 5.

secant line  A secant line is straight line that passes through two points of the graph of a function. Its slope is the average rate of change of the function between those two points. For more, see page 35.

slope  A way to talk about the steepness and direction of a straight line graph. A horizontal line has slope of zero. If the right side tips up, the slope is positive and gets bigger (more positive) as the right side tips further up. If the left side tips up, the slope is negative and gets bigger (more negative) as the left side tips further up. From left to right, a line with negative
slopes drop and a line with positive slope rises. When units are involved, slopes show the constant rate of change between two variables. For more, see page 24.

**tangent line**

A tangent line is a straight line that passes through a point on the graph of a function such that its slope is equal to the instantaneous rate of change (value of the derivative) of the function at that point. For more, see page 35.

**velocity**

A vector that contains information about the direction and speed of an object. For the purposes of this book, direction is away from some fixed point if velocity is positive and toward that fixed point if velocity is negative. The absolute value of velocity in this case is speed.
Bibliography


**MID MICHIGAN COMMUNITY COLLEGE**  
*Board of Trustees Regular Meeting*  
*Harrison, MI 48625 and Mt. Pleasant, MI 48858*  
February 6, 2018

Houghton Room – Harrison Campus

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<thead>
<tr>
<th>Topic</th>
<th>Presenter</th>
<th>Action/Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Call to Order</td>
<td>Chair Jacobson</td>
<td>Action</td>
</tr>
<tr>
<td>A. Welcome</td>
<td>Chair Jacobson</td>
<td>Information</td>
</tr>
<tr>
<td>B. Public Comments</td>
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<td></td>
</tr>
<tr>
<td>II. Approval of Agenda</td>
<td>Chair Jacobson</td>
<td>Action</td>
</tr>
<tr>
<td>III. Approval of Consent Items</td>
<td>Chair Jacobson</td>
<td>Action</td>
</tr>
<tr>
<td>A. Minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Monthly Financial Report</td>
<td></td>
<td></td>
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<tr>
<td>C. Monthly Personnel Report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV. Old Business</td>
<td>Hammond and Mertes</td>
<td>Action</td>
</tr>
<tr>
<td>A. College Name</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V. New Business</td>
<td>Hammond</td>
<td>Information</td>
</tr>
<tr>
<td>A. Correspondence and Announcements</td>
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<td>Information</td>
</tr>
<tr>
<td>B. Enrollment Report</td>
<td>Hammond</td>
<td>Information</td>
</tr>
<tr>
<td>C. Meeting Date Change</td>
<td>Hammond</td>
<td>Action</td>
</tr>
<tr>
<td>D. Mt. Pleasant City Women’s Club Event</td>
<td>Hammond</td>
<td>Action</td>
</tr>
<tr>
<td>E. Administrative Sabbatical Request</td>
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<td>Action</td>
</tr>
<tr>
<td>F. Security Incident Update</td>
<td>Hammond</td>
<td>Information</td>
</tr>
<tr>
<td>G. USDA Resolution</td>
<td>Mertes</td>
<td>Action</td>
</tr>
<tr>
<td>VI. Board Comments</td>
<td>Chair Jacobson</td>
<td>Information</td>
</tr>
<tr>
<td>A. Calendar of Events</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Other Business</td>
<td>Chair Jacobson</td>
<td>Information</td>
</tr>
<tr>
<td>1. Comments by Trustees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Closed Session</td>
<td>Chair Jacobson</td>
<td>Information</td>
</tr>
<tr>
<td>VII. Adjournment</td>
<td></td>
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</tr>
</tbody>
</table>
Agenda Item: II, Approval of Agenda

Board Consideration: Action

Background:

Item II, Approval of Agenda.

Recommendation:

It is recommended the Board approve the agenda as presented.
Agenda Item: III, Approval of Consent Items

Board Consideration: Action

Background:

A. Minutes – January 2, 2018 Regular Minutes

B. Monthly Financial Report:

1. Financial Summary for the period ended December 31, 2017
2. General fund balance sheet as of December 31, 2017
3. General fund statement of revenues and expenses for six months ended December 31, 2017
4. Gifts and Donations: Donations totaling $142,578 were received for the Scholarship and Grant Fund in December 2017.
5. Donations were received in November for the Capital Campaign, Eckersley Foundation Scholarship, Scholarship and Grant, Gerstacker Fund, A Northern Tradition, Bicknell Scholarship, Foundation, Retirees Scholarship, Manning Ford Scholarship, VanDeventer Adult Incentive Award, Elizabeth J. Horrocks CNA Scholarship, Lakers Athletic Fund, Students of Promise Scholarship, Grabmeyer Scholarship, Lickly Chemistry Scholarship, Mark Wilson Scholarship, McDonald Scholarship, and Glenn Berry Scholarship.


Recommendation:

It is recommended the Board approve the consent items as described by the Board Chair.
The meeting took place in the Houghton Room, Harrison Campus.

Present: Betty M. Mussell, Vice Chair; Richard S. Allen, Jr., Secretary; Carolyn C. Bay, Trustee; Eric T. Kreckman, Trustee; Terry Petrongelli, Trustee; Tonya Clayton, Executive Assistant to the President and Board of Trustees; Jennifer Fager, Vice President of Academic Services; Lori Fassett, Executive Director of Personnel Services; Anthony Freds, Chief Information Officer; Lillian K. Frick, Vice President of Finance and Administrative Services; L. Scott Govitz, Executive Director of Economic and Workforce Development; Christine M. Hammond, Ph.D., President; Matt Miller, Ed.D., Vice President Student & Community Relations; Scott Mertes, Vice President for Community Outreach & Advancement

Absent: Douglas A. Jacobson, Board Chair; Thomas W. Metzger, Treasurer; Kim Barnes, Executive Dean of Student & Academic Support Services; Michael W. Jankoviak, Ph.D., Vice President of Accreditation, Quality Assurance, and Institutional Research; Bob Elmore, Faculty Senate President; Char Keel, ESPA President;

Guests:

Agenda Item I: CALL TO ORDER

The Board Vice-Chair called the meeting to order at 7:10 p.m. There were no public comments from the guests.

Agenda Item II: APPROVAL OF AGENDA

With no proposed changes, the Board Vice-Chair stated that the agenda stands as approved as reflected in the Board packet.

Agenda Item III: APPROVAL OF CONSENT ITEMS

With no changes noted, the Board Vice-Chair stated the consent items stand as approved.

Agenda Item IV-A: CORRESPONDENCE AND ANNOUNCEMENTS

President Hammond reviewed the correspondence items including the recent Michigan College Access Network presentation, Office of Civil Rights Complaint, and Ronnie Jankoviak’s thank you note.

Vice President Frick informed the Board that Michigan Community Colleges are working to understand the recent payment to community colleges from the State. A few years ago, there was a change in the Personal Property Tax making it no longer subject to millages. To offset the loss of revenue, the State sends a payment to compensate. The State paid $38 million to community colleges this year to compensate for the loss of revenue, which is an increase from last year. However, Mid and other community colleges received fewer funds than prior years and funding between community colleges varied widely.

Vice President Frick provided an update from a recent Michigan Supreme Court settlement. The Michigan Supreme Court declared it was unconstitutional for the State to impose a 3% contribution of MPSERS members’ salaries toward retirement healthcare in 2010 and ruled the funds must be returned to members. The State will return the funds to Colleges who will be responsible for distributing to the employees who were employed from July 2010 to September 2012. These are complicated calculations and the College will seek guidance from MPSERS and from Plante Moran to ensure compliance.
Agenda Item IV-B: ENROLLMENT REPORT

Vice President Miller provided an enrollment report for the 2018 winter semester. Enrollment is down 1% in billing hours. Classes start this Saturday, January 6, with registration open though Wednesday, January 10. LUCES classes begin January 15. The College expects de-matriculated students from CMU will be registering this week.

New financial aid regulations may be affecting returning student enrollment numbers. The political climate and troubles with obtaining student visas may be contributing factors in the decreased international student numbers.

Agenda Item IV-C: COLLEGE NAME

Vice President Mertes and Vice President Miller lead a discussion concerning changing the college’s name. Nine of the twenty-eight Michigan Community Colleges do not include the word community in their name. The reasons for the name changes include better positioning for graduates in the employment market, enhancing recruitment efforts, preparing for the possibility of offering bachelor’s degrees, and attracting international students.

Arguments against a name change include the cost (e.g., signage, website, letterhead, publications, diplomas, etc.) which is estimated at $50,000 the first year. Of these costs, new signage is the most significant. However, the College plans to invest in new signage based on the recommendations of the 2016 Master Plan and those costs would be the same regardless of the decision on the name. A further concern is the possibility of confusion and/or resentment among community members.

A lengthy discussion took place among Board members and others in attendance concerning the name change. Discussion included the suggestion that a totally different name might be considered. In addition, the importance of timing and sequencing was discussed as renovations to the Harrison campus will require new signage and the preferred name should be used.

A motion was made by Trustee Kreckman and seconded by Trustee Bay to place this item on the February 6, 2018 Board of Trustees meeting agenda. All ayes; motion carried.

Agenda Item IV-D: HARRISON CAMPUS CONSTRUCTION

President Hammond reviewed the Harrison Campus Construction request with the Board. At the December 5, Board of Trustees meeting the Board authorized negotiations with Hobbs + Black Architects at a cost not to exceed $200,000 for Phase I renovations.

President Hammond reported that negotiations for Phase I design were successful. However, the sequencing of project will require architectural and engineering design work beyond Phase I elements if the Chiller Project is to be accomplished in the winter of 2019. Approximately 70% of this design work will be the technical requirements as identified by the engineering firm Peter Basso & Associates. The design work will enable the College to launch a request for proposal (RFP) process by March 2018 so that the Board can consider awarding contracts at its April 2018 meeting. Planning to complete the chiller project during the winter months will enable contractors to provide preferential pricing options rather than completing work in the summer.

As stated before, these updates and renovations are a part of the Campus Master plan and will provide a more student friendly environment on the Harrison campus as well as the capacity of offer new programs to attract students.

A motion was made by Trustee Kreckman to authorize MMCC administration to work with Hobbs + Black Architects and Peter Basso Associates to complete design and specification work to prepare bid documents for construction
related to a new fitness center in the Goldberg wing and the relocation of the administrative offices in the East/West wing, improvement to lighting and controls throughout the main classroom building, acquisition and installation of a new chiller system; and design development work related to the renovation and reconfiguration of space in the East/West wing and the connection between the current Administration Wing and Goldberg Center. Seconded by Trustee Allen. All ayes; motion carried.

A second motion was made by Trustee Kreckman to authorize MMCC administration to continue the College's work with Rowe Engineering in the design and specification work needed to prepare bid documents for an additional entrance to the College from Clare Avenue to the east parking lots. Seconded by Trustee Allen. All ayes; motion carried.

**Agenda Item V-A: CALENDAR OF EVENTS**

The Board Vice-Chair reviewed the calendar of events for upcoming months, an informational item.

**Agenda Item V-B: OTHER BUSINESS**

Meeting adjourned at 8:18 p.m.

Recording Secretary,
Tonya Clayton
Executive Assistant to the President and Board of Trustees

____________________________  ______________________________
Douglas A. Jacobson, Board Chair  Richard S. Allen, Jr., Secretary
GENERAL FUND REVENUE:

- The 2017-18 tuition and fee revenue budget is based on a four (4) percent enrollment decrease from 2016-17 levels. The final Fall 2017 enrollment showed a 1% decline in billable tuition hours. This represents 49% of the total 2017-18 budgeted tuition and fees revenue. The 2018 Winter term registration began on October 16 and accounts for the balance of the tuition and fees revenue to date. As of December 31, 2017, Winter 2018 enrollment reflected a slight decrease from prior year levels.
- State appropriations revenue for 2017-18 increased 2.8% and was booked in September at $4,968,900. Additional state appropriations of $1,326,450 were allocated to MMCC for the UAAL funding and booked as receivable in November.
- Property tax revenue of $2,326,696 was levied and booked as revenue in December 2017.

GENERAL FUND EXPENSES:

- All departmental expenses are in line with 50% of the year elapsed with the exception of:
  - Informational Technology expended 68% due to the prepayment of several service contract agreements for 2017-18, including Ellucian.
  - Public Service, due to courses and workshops that were budgeted but haven’t yet taken place.

INTER FUND TRANSFERS:

- The Planned Savings transfer of $419,713 to Building & Site represents 50% of the annual budgeted amount.
- The transfers of $51,519 to the Restricted Grant Funds represents 41% of the annual budget for the College’s match on various federal grants.

GENERAL FUND REVENUE OVER EXPENSES:

- The total increase in net assets as of December 31, 2017 is $11.2 million. This includes $5.7 million in tuition for the 2018 Winter term that began on January 6, 2018. This excess will fund the operations for the balance of the 2017-18 fiscal year.

BALANCE SHEET:

- The cash balance increased roughly $425,000 from November 30, 2017 due to receipt of federal financial aid funds in December.
• The State appropriations receivable of $4,578,424 represents the remaining 8 monthly payments of 2017-2018 general and UAAL state appropriations.

• Student receivables increased $250,000 due to registration for the 2018 Winter term that began October 16.

• The prepaid expense balance of $56,554 represents the unearned employee balance of the college funded deductible for health insurance for calendar year 2017, plus several other prepaid items.

• The balance due to other funds of $9.2 million can be broken down as follows:
  o $578,000 due to the designated student activities fund
  o $1.9 million due to the auxiliary services for sales
  o $280,000 due from the scholarship and grant fund
  o $8.0 million due to building and site for current and future college needs
  o $1.1 million due from the federal restricted fund for student financial aid
  o $22,000 due to the restricted grant fund
  o $62,000 due to the Foundation

• The $1,730,293 in accrued payroll and other compensation includes expenses incurred but not paid as follows:
  o Accrued salary, wages and vacation of $205,000
  o FICA, Federal and State withholding of $66,000
  o MPSERS/ORP payable of $505,000
  o Employee health and dental insurances payable of $630,000
  o Less self-funded health insurance reserves of $234,846
  o Deferred faculty pay of $533,000
  o Unemployment and workers’ compensation insurances payable of $20,000
  o Miscellaneous payroll deductions

• A significant portion of the Unreserved Net Assets of $3 million represents funds set aside by the Board of Trustees to fund current and future college expansion needs.

AUXILIARY FUNDS:

• Total revenue is at 48% of the annual budget, which is 8% behind prior year due to a decline in bookstore sales.

• Total expenses is at 48% of the annual budget which corresponds with the sales volume.

• The excess expense over revenues to date is $285,415, which will fund bookstore operations for the balance of the 2017-18 year.
### Assets

**Current Assets:**
- Cash and cash equivalents: $12,157,125
- Short-term investments: $576,196
- Property taxes receivable: $2,303,826
- State appropriations receivable: $4,578,424
- Student receivables: $7,181,514
- Other receivables: $29,338
- Inventories: $-
- Prepaid expenses and other assets: $56,554
- Due from (due to) other funds: $(9,186,825)

Total current assets: $17,696,152

- Long-term investments: $1,081,392

**Total assets:** $18,777,545

### Liabilities and Net Assets

**Liabilities:**
- Accounts payable: $(111,490)
- Accrued payroll and other compensation: $1,730,293
- Other payables: $-
- Planned savings: $-
- Unearned revenue: $3,200

Total liabilities: $1,622,003

**Net assets:**
- Reserved for:
  - Technology: $527,345
  - Program development: $2,248,339
  - Retirement incentives: $200,000
  - Unreserved: $2,949,996
  - Current year excess revenue over/(under) expenditures: $11,229,862

Total net assets: $17,155,542

**Total liabilities and net assets:** $18,777,545
# MID MICHIGAN COMMUNITY COLLEGE
STATEMENT OF REVENUES, EXPENSES
For the six months ended December 31, 2017

<table>
<thead>
<tr>
<th>OPERATING REVENUES:</th>
<th>Current Fiscal Year</th>
<th>% of Budget</th>
<th>Prior Fiscal Year</th>
<th>% of Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition and fees</td>
<td>$15,381,589</td>
<td>85%</td>
<td>$14,588,303</td>
<td>81%</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>$61,798</td>
<td>28%</td>
<td>$110,501</td>
<td>51%</td>
</tr>
<tr>
<td>Total operating revenues</td>
<td>$15,443,387</td>
<td>84%</td>
<td>$14,698,804</td>
<td>81%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>EXPENSES:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating expenses:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instruction</td>
<td>$4,545,419</td>
<td>47%</td>
<td>$4,276,586</td>
<td>45%</td>
</tr>
<tr>
<td>Information technology</td>
<td>$1,063,007</td>
<td>68%</td>
<td>$821,554</td>
<td>51%</td>
</tr>
<tr>
<td>Public service</td>
<td>$224,436</td>
<td>38%</td>
<td>$185,355</td>
<td>38%</td>
</tr>
<tr>
<td>Instructional support</td>
<td>$1,417,076</td>
<td>56%</td>
<td>$1,263,347</td>
<td>54%</td>
</tr>
<tr>
<td>Student services</td>
<td>$1,742,756</td>
<td>56%</td>
<td>$1,557,148</td>
<td>50%</td>
</tr>
<tr>
<td>Institutional administration</td>
<td>$2,101,560</td>
<td>43%</td>
<td>$1,936,944</td>
<td>43%</td>
</tr>
<tr>
<td>Operation and maintenance of plant</td>
<td>$1,285,549</td>
<td>51%</td>
<td>$1,219,520</td>
<td>48%</td>
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<tr>
<td>MPSERS UAAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total operating expenses</td>
<td>$12,379,803</td>
<td>47%</td>
<td>$11,260,454</td>
<td>44%</td>
</tr>
</tbody>
</table>

| Operating income/(loss)                   | $3,063,584          |             | $3,438,351        |             |

<table>
<thead>
<tr>
<th>NON-OPERATING REVENUES:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>State appropriations</td>
<td>$6,292,150</td>
<td>99%</td>
<td>$6,270,297</td>
<td>102%</td>
</tr>
<tr>
<td>Property tax levy</td>
<td>$2,327,424</td>
<td>101%</td>
<td>$2,305,674</td>
<td>100%</td>
</tr>
<tr>
<td>Investment income</td>
<td>$12,694</td>
<td>25%</td>
<td>$13,853</td>
<td>28%</td>
</tr>
<tr>
<td>Unrealized gain (loss) on investments</td>
<td>$(1,934)</td>
<td></td>
<td>$(19,688)</td>
<td></td>
</tr>
<tr>
<td>Gifts</td>
<td>$-</td>
<td></td>
<td>$-</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>$7,177</td>
<td></td>
<td>$3,080</td>
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<tr>
<td>Transfers from other funds:</td>
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<td></td>
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<tr>
<td>Restricted grants</td>
<td>$-</td>
<td></td>
<td>$-</td>
<td></td>
</tr>
<tr>
<td>Auxiliary services</td>
<td>$-</td>
<td></td>
<td>$-</td>
<td></td>
</tr>
<tr>
<td>Foundation - Capital Campaign</td>
<td>$-</td>
<td></td>
<td>$388,125</td>
<td></td>
</tr>
<tr>
<td>Total Non-operating revenues</td>
<td>$8,637,510</td>
<td>99%</td>
<td>$8,961,341</td>
<td>105%</td>
</tr>
</tbody>
</table>

| Revenues over/(under) expenses            | $11,701,094         |             | $12,399,692       |             |

| Inter Funds Transfers                     |                     |             |                   |             |
| Planned Savings (Building & Site)         | $419,713            | 50%         | $522,518          | 50%         |
| Additional Savings (Building & Site)      | $-                  | 0%          | $-                |             |
| Bond Debt Service (Building & Site)       | $-                  | 0%          | $-                |             |
| Restricted Grant Match                    | $51,519             | 41%         | $54,859           | 15%         |

| Total Transfer to Building & Site         | $471,232            |             | $577,377          |             |

| Net increase (decrease) in Net Assets     | $11,229,862         |             | $11,822,315       |             |
## MID MICHIGAN COMMUNITY COLLEGE
### STATEMENT OF REVENUES, EXPENSES
#### For the six months ended December 31, 2017
#### AUXILIARY FUND

<table>
<thead>
<tr>
<th></th>
<th>Current Fiscal Year</th>
<th></th>
<th>Prior Fiscal Year</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REVENUE:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bookstore</td>
<td>$1,093,283</td>
<td>47%</td>
<td>$1,194,501</td>
<td>56%</td>
</tr>
<tr>
<td>Espresso Bar</td>
<td>$48,406</td>
<td>62%</td>
<td>$45,756</td>
<td>62%</td>
</tr>
<tr>
<td><strong>Total Revenue:</strong></td>
<td>$1,141,689</td>
<td>48%</td>
<td>$1,240,257</td>
<td>56%</td>
</tr>
<tr>
<td><strong>EXPENSES:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bookstore</td>
<td>$758,521</td>
<td>47%</td>
<td>$729,164</td>
<td>46%</td>
</tr>
<tr>
<td>Espresso Bar</td>
<td>$35,634</td>
<td>52%</td>
<td>$38,086</td>
<td>58%</td>
</tr>
<tr>
<td>Auxiliary Services</td>
<td>$62,120</td>
<td>55%</td>
<td>$61,128</td>
<td>54%</td>
</tr>
<tr>
<td><strong>Total Expenses:</strong></td>
<td>$856,275</td>
<td>48%</td>
<td>$828,379</td>
<td>47%</td>
</tr>
<tr>
<td><strong>EXCESS REVENUE OVER EXPENSES</strong></td>
<td>$285,415</td>
<td>25%</td>
<td>$411,879</td>
<td>33%</td>
</tr>
</tbody>
</table>
## Mid Michigan Community College Contributions

### December 2017

<table>
<thead>
<tr>
<th>Scholarship &amp; Grant</th>
<th>Current</th>
<th>2018 Year-to-Date</th>
<th>2017 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Campaign</td>
<td>$27,636</td>
<td>$195,839</td>
<td>$337,238</td>
</tr>
<tr>
<td>Eckersley Foundation Scholarship</td>
<td>$43,000</td>
<td>$43,000</td>
<td>$</td>
</tr>
<tr>
<td>Scholarship &amp; Grant</td>
<td>$21,227</td>
<td>$32,893</td>
<td>$33,290</td>
</tr>
<tr>
<td>Gerstacker Fund</td>
<td>$30,000</td>
<td>$30,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>A Northern Tradition</td>
<td>$9,950</td>
<td>$19,400</td>
<td>$67,732</td>
</tr>
<tr>
<td>Mussel Endowment Scholarship</td>
<td>$</td>
<td>$10,186</td>
<td>$</td>
</tr>
<tr>
<td>Harris Allied Health Scholarship</td>
<td>$</td>
<td>$5,500</td>
<td>$</td>
</tr>
<tr>
<td>Golf Outing</td>
<td>$</td>
<td>$5,230</td>
<td>$5,370</td>
</tr>
<tr>
<td>Bicknell Scholarship</td>
<td>$3,250</td>
<td>$3,250</td>
<td>$4,075</td>
</tr>
<tr>
<td>Jerry Freeland Scholarship</td>
<td>$</td>
<td>$3,075</td>
<td>$300</td>
</tr>
<tr>
<td>Foundation</td>
<td>$1,985</td>
<td>$2,980</td>
<td>$3,250</td>
</tr>
<tr>
<td>Isabella 8th Grade Girls Lunch</td>
<td>$</td>
<td>$2,813</td>
<td>$5,000</td>
</tr>
<tr>
<td>Retirees Scholarship</td>
<td>$2,250</td>
<td>$2,350</td>
<td>$1,950</td>
</tr>
<tr>
<td>Manning Ford Scholarship</td>
<td>$230</td>
<td>$1,330</td>
<td>$2,670</td>
</tr>
<tr>
<td>VanDeventer Adult Incentive Award</td>
<td>$1,200</td>
<td>$1,200</td>
<td>$</td>
</tr>
<tr>
<td>Campus Cupboard</td>
<td>$</td>
<td>$1,000</td>
<td>$</td>
</tr>
<tr>
<td>Student Showcase</td>
<td>$</td>
<td>$800</td>
<td>$800</td>
</tr>
<tr>
<td>Elizabeth J Horrocks CNA Scholarship</td>
<td>$100</td>
<td>$800</td>
<td>$908</td>
</tr>
<tr>
<td>Lakers Athletic Fund</td>
<td>$540</td>
<td>$720</td>
<td>$9,270</td>
</tr>
<tr>
<td>Cross Country</td>
<td>$</td>
<td>$700</td>
<td>$</td>
</tr>
<tr>
<td>Computer Info Systems Scholarship</td>
<td>$500</td>
<td>$500</td>
<td>$1,000</td>
</tr>
<tr>
<td>Students of Promise Scholarship</td>
<td>$500</td>
<td>$500</td>
<td>$1,000</td>
</tr>
<tr>
<td>Janice Langdon Scholarship</td>
<td>$</td>
<td>$500</td>
<td>$1,000</td>
</tr>
<tr>
<td>Grabmeyer Scholarship</td>
<td>$130</td>
<td>$325</td>
<td>$644</td>
</tr>
<tr>
<td>Myers Memorial Scholarship</td>
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<td>$250</td>
<td>$200</td>
</tr>
<tr>
<td>Misc Fundraisers</td>
<td>$</td>
<td>$250</td>
<td>$250</td>
</tr>
<tr>
<td>Licky Chemistry Scholarship</td>
<td>$250</td>
<td>$250</td>
<td>$500</td>
</tr>
<tr>
<td>Mark Wilson Scholarship</td>
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<td>$200</td>
<td>$200</td>
</tr>
<tr>
<td>McDonald Scholarship</td>
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<td>$130</td>
<td>$500</td>
</tr>
<tr>
<td>Glenn Berry Scholarship</td>
<td>$100</td>
<td>$100</td>
<td>$</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$142,578</td>
<td>$366,071</td>
<td>$506,646</td>
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</table>

<table>
<thead>
<tr>
<th>Additional Scholarships</th>
<th>Current</th>
<th>2018 Year-to-Date</th>
<th>2017 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBT Brownson Scholarship</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>Gladwin Automotive Scholarship</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>David Lang Memorial Fund</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>Catherine King Scholarship</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>MidMichigan Medical Center Scholarship</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>Kehoe's Fund</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>HRA Scholarship</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>Christopher &amp; Estelle Smith Scholarship</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>L U V Scholarship</td>
<td>$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$</td>
<td>$</td>
<td>$10,490</td>
</tr>
</tbody>
</table>

| Total                                | $142,578| $366,071          | $517,136   |

| Prior Year Contributions - current month | $60,159 | $288,355 |
| % Current Year to Prior Year            | 137.0%  | 27.0%    |

| Prior Year Contributions - current month (Same Contributors) | $59,534 | $286,965 |
| % Current Year to Prior Year               | 139.5%  | 27.6%    |
TO: Board of Trustees

FROM: Lori Fassett, Executive Director of Personnel Services

SUBJECT: MMCC Staffing Update February 6, 2018 Board Meeting

DATE: January 24, 2017

NEW HIRES:
Eric Wittig – Enrollment Clerk 
Effective: 12/18/2017
Eric continues his contributions with MMCC in a new capacity as an Enrollment Clerk. Eric has been an adjunct instructor with MMCC for over 10 years in the Math area. Eric holds a Bachelor of Science Degree from Central Michigan University majoring in math and statistics. We look forward to Eric joining the Enrollment Clerk team and using his knowledge as an instructor to continue successfully assisting our students. Welcome Eric!

NEW PART-TIME AND STUDENT EMPLOYEES:
Casey Batterson – Work Study Tech Center 
Effective: 01/03/2018
Serene Newby – Work Study Speech 
Effective: 01/08/2018
Allison Shoaf – Work Study Off Campus (Skeels Elementary) 
Effective: 01/02/2018
Kelly Bennett – Adjunct Allied Health (EDUStaff) 
Effective: 01/06/2018
Nathanael Farrell – Adjunct Mechanical Tech (EDUStaff) 
Effective: 01/06/2018
Jacob Gullick – Adjunct Criminal Justice (EDUStaff) 
Effective: 01/02/2018
Kerim Gulyuz – Adjunct Math & Science (EDUStaff) 
Effective: 01/02/2018
Lacey Johnson – Adjunct Speech (EDUStaff) 
Effective: 01/03/2018
Caitlin Lambert – Adjunct Nursing (EDUStaff) 
Effective: 01/06/2018
Kendra Overla – Adjunct Criminal Justice (EDUStaff) 
Effective: 01/12/2018
Shannon Sharrar – Adjunct Nursing (EDUStaff) 
Effective: 12/28/2017
Lisa Siler – Adjunct Nursing (EDUStaff) 
Effective: 01/06/2018
Steven Tyler – Adjunct Drafting (EDUStaff)  Effective: 01/06/2018
Wendy Webster – Adjunct Nursing (EDUStaff)  Effective: 01/06/2018
Vicki Wiltse – Adjunct Art/Religion (EDUStaff)  Effective: 01/06/2018
Connie Wolfe – Adjunct Math & Science (EDUStaff)  Effective: 01/06/2018
Jess King – Adjunct Mechanical Tech  Effective: 01/06/2018
Kaylee Ayris – SI Leader (EDUStaff)  Effective: 01/11/2018
Mary Beach – Adjunct Nursing (EDUStaff)  Effective: 01/06/2018
Joanna Crain – Math Tutor (EDUStaff)  Effective: 01/15/2018
Victor Giacoman – IT Tech Intern II (EDUStaff)  Effective: 01/15/2018
Eric Kamischke – Adjunct Math (EDUStaff)  Effective: 01/06/2018
Chana Laarman – LLS Tutor (EDUStaff)  Effective: 01/15/2018
Ethan Lee – SI Leader (EDUStaff)  Effective: 01/15/2018
Jacob McPhail – Adjunct History (EDUStaff)  Effective: 01/03/2018
Alexander VanBuren – Math Tutor (EDUStaff)  Effective: 01/16/2018
Gracia Agin – Work Study: Admissions  Effective: 01/09/2018
Alexus Lowe – Work Study: Personnel Services  Effective: 01/10/2018

INTERNAL TRANSFERS:
Jennifer Cooper  From: Assoc. Dir. Financial Aid  To: Dir. of Financial Aid  Effective: 01/01/2018
Scott Mertes  From: Dean of Liberal Arts  To: VP for Community Outreach & Advancement  Effective: 01/01/2018
Peter Velguth  From: Dean of Math & Science  To: Assistant VP for Institutional Research  Effective: 01/01/2018
Amy Dykhouse  From: Adjunct Psychology  To: PT Career Center Coach  Effective: 01/08/2018
Erin Suraweera  From: Supplemental Instructor  
To: PT TRiO Academic Support Coach  
Effective: 01/09/2018

Kati Sellers  From: Enrollment Management Specialist  
To: Academic Advisor  
Effective: 01/15/2018

SEPARATIONS:

Gale Crandell – Director of Financial Aid (Retired)  
Effective: 12/31/2017

Christy Gary – Nursing Clinical Coordinator (Retired)  
Effective: 12/31/2017

Ronnie Jankoviak – Library & Learning Services Assistant (Retired)  
Effective: 12/31/2017

Pineniece Joshua – Adjunct Arts  
Effective: 12/31/2017

Derrick Moorehead-English – Academic Advisor  
Effective: 12/18/2017

Monica Eagloski – Work Study  
Effective: 12/14/2017

Jewel Cooper – Work Study  
Effective: 12/23/2017

Richard Kennard – Work Study: IT  
Effective: 09/01/2017

Olivia Perry – Work Study: Financial Aid  
Effective: 12/23/2017

VACANCIES:

Academic Advisor (Full-time)  
Filled

Adjunct Allied Health – Medical Terminology  
Filled

Adjunct Anthropology  
Posted

Adjunct Biology  
Filled

Adjunct Biology/Anatomy & Physiology  
Posted

Adjunct Computer Aided Drafting (CAD)  
Filled

Adjunct Chemistry  
Posted

Adjunct Computer Tomography (CT)  
Filled
<table>
<thead>
<tr>
<th>Position</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjunct Computer Information Systems</td>
<td>Posted</td>
</tr>
<tr>
<td>Adjunct Economics</td>
<td>Posted</td>
</tr>
<tr>
<td>Adjunct History – Huron ISD</td>
<td>Filled</td>
</tr>
<tr>
<td>Adjunct Machine Tool/INDS</td>
<td>Filled</td>
</tr>
<tr>
<td>Adjunct Math</td>
<td>Posted</td>
</tr>
<tr>
<td>Adjunct Mathematics – Huron ISD</td>
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</tr>
<tr>
<td>Adjunct Nursing Adult Health</td>
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</tr>
<tr>
<td>Adjunct Nursing Family Centered</td>
<td>Posted</td>
</tr>
<tr>
<td>Adjunct Nursing Foundations</td>
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</tr>
<tr>
<td>Adjunct Nursing General</td>
<td>Posted</td>
</tr>
<tr>
<td>Adjunct Mental Health Nursing</td>
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</tr>
<tr>
<td>Adjunct Physical Therapist Assistant (PTA)</td>
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</tr>
<tr>
<td>Adjunct Physics &amp; Astronomy</td>
<td>Filled</td>
</tr>
<tr>
<td>Adjunct Political Science</td>
<td>Posted</td>
</tr>
<tr>
<td>Adjunct Radiography (RAD)</td>
<td>Posted</td>
</tr>
<tr>
<td>Adjunct Religion</td>
<td>Filled</td>
</tr>
<tr>
<td>Adjunct Speech – Farwell High School</td>
<td>Filled</td>
</tr>
<tr>
<td>Adjunct Welding</td>
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</tr>
<tr>
<td>Automotive Lab Technician</td>
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</tr>
<tr>
<td>Administrative Specialist – Tech Center (Full-time)</td>
<td>Posted</td>
</tr>
<tr>
<td>Custodian (Part-time)</td>
<td>Filled</td>
</tr>
<tr>
<td>Custodian (Full-time)</td>
<td>Posted</td>
</tr>
<tr>
<td>Certified Nursing Assistant (C.N.A.) Instructor (Part-Time)</td>
<td>Posted</td>
</tr>
<tr>
<td>Position</td>
<td>Status</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Dean of Business &amp; Professional Studies (Full-time)</td>
<td>Posted</td>
</tr>
<tr>
<td>Director of Learning Services (Full-time)</td>
<td>Posted</td>
</tr>
<tr>
<td>Enrollment Clerk (Full-time)</td>
<td>Filled</td>
</tr>
<tr>
<td>Hospitality Assistant (Part-time)</td>
<td>Filled</td>
</tr>
<tr>
<td>Library &amp; Learning Assistant (Full-time)</td>
<td>Posted</td>
</tr>
<tr>
<td>LLS Instructor Support – Math (Part-time)</td>
<td>Posted</td>
</tr>
<tr>
<td>Maintenance Specialist - Harrison (Full-time)</td>
<td>Filled</td>
</tr>
<tr>
<td>Nursing Clinical Coordinator – (Full-Time)</td>
<td>Offer Made</td>
</tr>
<tr>
<td>VP of Academic Affairs/Dean of Arts &amp; Science (Full-time)</td>
<td>Posted</td>
</tr>
<tr>
<td>Writing &amp; Reading Center (WRC) Consultant (Part-time)</td>
<td>Posted</td>
</tr>
</tbody>
</table>
Agenda Item IV-A: College Name

Board Consideration: Action

Background:

At the January 2, 2018 meeting, the Board discussed a name change for the College. The Board approved to bring this item back to the February meeting. Attached is the name change resolution. Below is an excerpt of the Community College Act of 1966.

COMMUNITY COLLEGE ACT OF 1966 (EXCERPT)
Act 331 of 1966

389.109 Community college district; legal name.

Sec. 109.

(1) Until changed by board resolution, every community college district shall have the legal name of “Community College District of .........................” (the name of the county or counties when organized under chapter 1, the names of the component school districts when organized under chapter 2, or the name of the intermediate school district or districts when the community college district is organized under chapter 3).

(2) The board of any community college district by resolution may adopt a distinctive name for the community college district, which name, after being approved by the state board of education, shall be the legal name of the district for all purposes. The board in like manner may change the name of the district. The adoption of a distinctive name or the change in name of any district shall have no effect upon existing obligations incurred in the former name of the district or upon the district ownership of any real or personal property.


Recommendation:

It is recommended that the name of the College become Mid Michigan College, effective June 30, 2018 and pursuant to the required approval from the State Board of Education for Michigan.
WHEREAS, the Board has determined that it is in the best interest of Mid Michigan Community College that the name of the College be changed to “Mid Michigan College”;

WHEREAS, doing so is consistent with and will foster the continuing evolution and growth of the College; will advance the College’s mission, vision and values while continuing its tradition of serving its students and communities; will support the development of new academic programs; and will attract students and position them for success;

NOW, THEREFORE, BE IT RESOLVED, by the Board of Trustees that subject to any approvals of or notifications to the State of Michigan, including its State Board of Education and the Higher Learning Commission which may be legally required or advisable, Mid Michigan Community College’s name is changed to Mid Michigan College, effective June 30, 2018.

YEAS:  

NAY:  

ABSTENTIONS:  

RESOLUTION DECLARED ADOPTED

I, the undersigned Secretary of the Board of Trustees of Mid Michigan Community College, hereby certify that the foregoing is a true and complete copy of a resolution duly adopted by the Board at a regular meeting held on the day of February 6, 2018, the original of which resolution is on file at the President’s office of the College. I further certify that notice of said meeting was given in accordance with the provisions of the open meetings act.

IN WITNESS WHEREOF, I have hereunto affixed my official signature this day of February, 2018.

Richard S. Allen, Jr.
Secretary, Board of Trustees
Mid Michigan Community College
Agenda Item V-A: Correspondence and Announcements

Board Consideration: Information

Background:

- Thomas Metzger will be honored for his 25 years of dedicated service to the Board of Trustees.

- The Officers and members of MMCC’s PTK chapter have nominated President Hammond for the Shirley B. Gordon Award of Distinction with Phi theta Kappa. She will be recognized this April at the national Catalyst Convention and 100th Anniversary Celebration of Phi Theta Kappa. MMCC’s chapter is so excited that President Hammond is receiving this honor named after a founding member, at the 100th Anniversary Celebration. Attached is the nomination that was submitted and the congratulation letter.

- The Clare-Gladwin Regional Education Service District was awarded $400,000 to purchase equipment for welding and advanced integrated manufacturing labs. The equipment will be housed by Mid Michigan Community College. Clare Gladwin RESD was one of 14 grant applicants to receive an award. Please see the attached press release from the Michigan Department of Education.

- President Hammond will provide an update concerning the Office Of Civil Rights Complaint concerning accessibility. Please see attached letter from the Office of Civil Rights.

- Announcements may be made at this time.

Recommendation:

None.
College President Dr. Christine Hammond has helped build a solid foundation for our chapter by providing us with access to the MMCC campus. Further, she has graciously provided our chapter with access to conference rooms for our weekly meetings in addition to open access to computers and printers. President Hammond allows and encourages our chapter to utilize certain lecture halls or meeting rooms for larger events, such as induction ceremonies and other various larger Phi Theta Kappa-related events, including our recent Hallmark Writing Day event that involved representatives from the Michigan Region. These allowances, in turn, have greatly promoted and advanced the productivity of our chapter. President Hammond shows further support and commitment to Phi Theta Kappa by making it a priority to attend these chapter meetings, induction ceremonies, and other Phi Theta Kappa events that have been held throughout the year so far. She will also travel with our chapter to Kansas City next April to attend the Catalyst 2018 Centennial Celebration.

Since assuming her role as College President, Dr. Hammond has been a tireless advocate for the success of all students in her purview. It is this passion that inspired her to aid in the development of scholarship opportunities for Phi Theta Kappa chapter members. Her coordinated efforts with the Board of Trustees led to the provision of a $250 scholarship award given to All-USA Academic Team Scholarship nominees from both of MMCC’s campuses. President Hammond invites these nominees and their families, as well as the Alpha Omicron Omicron officer team, to the Board of Trustees workshop and meeting held each June. While there, the nominees are then recognized and given their All-Michigan Scholarships in a professional frame provided by the President and board of Trustees. They also have their photo taken with the Board and President Hammond to be submitted to local newspapers for further honor and distinction. The officer team is provided with the opportunity to share their activities from the past year and ruminate on their goals for the upcoming year, as well. President Hammond further exemplifies her passion for student success by advocating for members as she works with colleges and universities in Michigan to build and maintain a strong network for transfer connections. One great example of this is a partnership she recently formed with Alma College, a private institution within a 20 minute drive from MMCC’s Mount Pleasant campus, to provide MMCC students an opportunity to “try out” Alma College as they look to continue their education. Beginning with the winter 2018 term, MMCC students who have an interest in transferring to Alma in the fall may enroll in one Alma College course at the MMCC tuition rate. She builds further networks by participating in a college president's job-shadow program through the Michigan Community College Association.

President Hammond’s dedication to the student body at Mid Michigan Community College is exemplified by her commitment to empowering students for academic success. An example of this can be found in her effort to aid the Alpha Omicron Omicron chapter financially by allowing incoming Phi Theta Kappa members to charge their membership dues to their financial aid, a change made earlier this year. We have observed that the cost of membership can prove to be a financial barrier to entry for many potential Alpha Omicron Omicron inductees. As many students already rely on financial aid to accomplish their academic endeavors, President Hammond found it only reasonable to enact this change, which will help further empower scholars in financial need by allowing them to join Phi Theta Kappa and grow as students and leaders in their community. In addition, President Hammond has also made it easier for chapter officers to attend Phi Theta Kappa’s annual Catalyst Convention each year by allowing the sales generated from our annual haunted forest event, Deadwood Grove, to be applied to the registration fees for each officer or member who attends.
During her tenure, President Hammond has been an avid supporter of Phi Theta Kappa programs at Mid Michigan Community College. In addition to attending the majority of our events both on and off campus, she was also a useful resource for both our College Project and Honors in Action project. President Hammond and her husband, Tom, graciously opened their home to our officer team and hosted us for a luncheon; it was during this time that we discussed the progress our team had made on our Honors in Action project. She was instrumental in providing the team with valuable guidance during these early, formative stages of both our College Project and Honors in Action project and endeavored to spread the word about our projects to other faculty members. It was due in part to President Hammond's motivation and confidence in our officer team that we were given the opportunity to present our Honors in Action project to college faculty at MMCC's Professional Development Day, which proved to be an overwhelming success. Further, President Hammond has long advocated for providing a more prominent place on campus for the voices of Alpha Omicron Omicron's chapter officers, which would help to ensure proper representation from student leaders on matters pertaining to the college. To this end, she encouraged chapter officers to seek active engagement with and participation in the college's shared governance committees. In addition to discussing college-related matters during these meetings, we are provided with the opportunity to share our chapter's successes as well as update the committees on various events we hold either on campus or in the community. President Hammond has exhibited great trust and confidence in the leadership of our officer team by not only allowing but encouraging our active involvement on these committees, for they have served the all-important purpose of helping to gradually shape MMCC into what it is today and they will continue to aid in guiding the college through the changes it will inevitably undergo as the institution progresses into the future.
January 20, 2018

Dear Dr. Hammond:

Congratulations on your selection of Phi Theta Kappa’s *Shirley B. Gordon Award of Distinction*, named in honor of Phi Theta Kappa’s longest serving Board Chair and a founder and long-time President of Highline Community College in Washington. College presidents and campus chief executive officers, nominated by their Phi Theta Kappa chapter, are selected for this award in recognition for their outstanding support of Phi Theta Kappa.

We know the depth of each member’s experience has a lot to do with the value placed on Phi Theta Kappa by college leaders. Your nomination and selection for this award is recognition that your Phi Theta Kappa students have your support—thank you!

We look forward to honoring you at Phi Theta Kappa’s Centennial Celebration, April 19-21, 2018, at Kansas City Convention Center in Kansas City, MO. You are invited to the Catalyst breakfast on Friday, April 20, 8:00 – 9:30 am, Room 2103 A-C in the Convention Center. Following the breakfast, you will be presented your award during the Second General Session (10:00 – 11:30am) on stage before an audience of nearly 5,000 students, alumni chapter advisors, and college presidents. VIP seating will be provided to you during this session.

As the recipient of the *Shirley B. Gordon Award of Distinction*, your Convention registration is waived. You may invite one guest to attend the breakfast and Second General Session with you at no charge. To participate in other Convention sessions and activities, your guests are asked to register for the conference. You may view the Convention fees on our registration website. Please email Fredrica Tyes at fredrica.tyles@ptk.org, by Friday, February 16, 2018 to confirm your attendance and your guest’s attendance and with any questions.

Phi Theta Kappa will reimburse you for one night’s accommodations (room and tax). Following the Convention, please submit your hotel receipt to Fredrica Tyes. Upon arrival at convention, registration materials may be picked up at the Phi Theta Kappa registration kiosk located at the Kansas City Convention Center or the Marriott Hotel lobby.

Please submit a professional head and shoulders color photograph to Fredrica Tyes by Friday, February 16, 2018. Digital photos are preferred, 3”x5”, at least 300DPI. You will be celebrated on the Phi Theta Kappa website and in several publications. A press release will also be forwarded to your school’s public relations office.
Congratulations and thank you for your support of the mission and members of Phi Theta Kappa. For more information on the exciting events of the 2018 Annual Convention, visit our Convention website.

Sincerely,

Lynn Tincher-Ladner
President and CEO
Phi Theta Kappa Honor Society
MDE awards $5 million to districts to expand CTE programs, opportunities

Contact: Martin Ackley, Director of Public and Governmental Affairs 517-241-4395
Agency: Education

January 24, 2018

LANSING – Students across Michigan will have more opportunities for in-demand career skills as 14 districts and intermediate districts are being awarded $5 million in grants to purchase specialized equipment and expand programs, the Michigan Department of Education (MDE) announced.

The Career and Technical Education (CTE) Innovation and Equipment Grants will allow districts to obtain equipment to expand career and technical education programs in manufacturing with an emphasis on mechatronics, computer numerical control machining, and welding.

“Schools need state-of-the-art equipment so students can get the training they need for great careers,” State Superintendent Brian Whiston said. “These grants will help schools modernize, with the guidance from local partners who know the skills – and equipment – needed to be successful today and moving forward. We appreciate the support from the Legislature to make this happen.”

Additional funding for career and technical education equipment was a recommendation from the Michigan Career Pathways Alliance, which was created by Gov. Rick Snyder and is headed by Whiston and Roger Curtis, director of the Michigan Department of Talent and Economic Development. The alliance includes more than 100 education, business, economic development and labor organizations from across the state.

Snyder reiterated his strong commitment to Michigan leading the world in the development of talent.

“A top priority I’ve had for years is career technical education,” Snyder said during his State of the State address Tuesday. “I’ve made it one of my missions. We need to do more to support them and get more young people interested in having these great, outstanding careers.”
The $5 million in competitive grants are part of an overall $12.5 million program, with $7 million distributed equally to Career Education Planning Districts across the state. MDE received 62 applications for the competitive grants, totaling $26.8 million in requested funds.

“We need to increase career and technical education classes so even more students can benefit from these opportunities,” Curtis said. “We also want to encourage partnerships with local employers. It is important for schools and employers to work closely together, which can lead to work-based learning for students; externships for teachers and counselors; and students graduating with skills that will help them find jobs and stay in their communities after graduation.”

Districts selected for the grants demonstrated that they could

- identify local high-wage, high-skill, and high-demand job opportunities using state and regional business, workforce, and labor market information;
- increase career option awareness of middle and high school students, adult learners, parents, teachers, and counselors;
- partner with employers to increase work-based learning, apprenticeships, and teacher and counselor externships;
- align high school, adult education, community college, and postsecondary curriculum to focus on attaining career goals;
- expand availability of career and technical education training for remote and other geographically disadvantaged students; and
- demonstrate a commitment of local or regional partners to assist in sustaining program beyond the initial grant funding.

Award Summaries:

- Alpena Public Schools’ grant of $400,000 will be used to purchase equipment for a mechatronics and design lab as well as a computer lab. As part of the proposal, Alpena plans to become the first school in Michigan to offer Algebra I with Manufacturing Processes, Entrepreneurship, and Design. Students will operate a business running an advanced fabrication lab customizing textile products and manufacturing items comprised of wood, metal, and plastic.
- Calhoun Intermediate School District’s equipment grant of $199,000 will focus on welding equipment. The district has a partnership with Kellogg Community College for a Welding Early/Middle College program.
- Center Line Public Schools was awarded $105,000 for a pre-apprenticeship sheet metal program in partnership with Sheet Metal Works’ Local 80. Students who successfully complete the program will be able to begin the apprenticeship program, allowing them to be paid, while training for various professional certifications and gaining a career track.
- Clare-Gladwin Regional Education Service District was awarded $400,000 to purchase equipment for welding and advanced integrated manufacturing labs. The equipment will be housed by Mid-Michigan Community College.
- Copper Country Intermediate School District was awarded $364,000 for welding and manufacturing equipment to benefit 13 school districts. Students will be able to earn
several industry-recognized certificates. Employer partners have agreed to in-kind donations and support for teacher and counselor externships. Articulation agreements are in place with Northern Michigan University and Gogebic Community College.

- Detroit Public Schools Community District is being awarded $800,000 to expand programs at the Detroit Randolph, Golightly and Breithaupt career and technical centers, with funds purchasing equipment for training in mechatronics, manufacturing, and welding. Students will have opportunities to earn college credit and certifications and job shadowing, internships, co-ops, mentoring and project based learning. The City of Detroit also is hiring an on-site career specialist who will be housed at the Randolph Center.

- Dickinson-Iron Intermediate School District was awarded $467,000 to purchase equipment to expand a mechatronics program. Planned purchases include FANUC robots. Students can pursue a certificate in mechatronics from Bay College, and will be able to earn college credit.

- Ingham Intermediate School District is awarded $253,000 to purchase equipment for construction technology. Programs will be offered at the Wilson Talent Center and students will earn an Introduction to Civil Technician certificate. Summer camps are planned for seventh- and eighth-grade students.

- Kalamazoo Regional Educational Services Agency is being awarded $199,000 to purchase industry standard equipment in manufacturing and construction trades. Students will be able to earn college credit and certificates, as well as have access to increased work-based learning opportunities.

- Kent Intermediate School District will be awarded $300,000 to create a welding program, with equipment used by the diesel, auto, auto collision, precision machining, mechatronics, and HAVC programs. Also planned are programs for middle school students, adult learners, and for summer camps.

- Saginaw Intermediate School District is awarded $230,000 to create a county-wide cybersecurity CTE program. Students will earn articulated credit with Delta College’s Cybersecurity Program. The proposal includes hosting career days and camps focused on computer science and the many career paths.

- Traverse Bay Intermediate School District equipment grant of $583,000 will be targeting precision machining technology, manufacturing technology and a new mechatronics program. Equipment purchases planned include CNC and robotics. Students trained on the equipment will be able to obtain industry-recognized certificates and credit with Baker College and Northwestern Michigan College.

- Utica Community Schools will use $400,000 to purchase advanced manufacturing equipment for the new Stevenson Center for Manufacturing, Automation, Design and Engineering, a STEM Academy, at Adlai Stevenson High School in Sterling Heights. Students will be able to earn college credit. Advanced manufacturing concepts will be integrated into all core academic classes. Students will graduate with industry recognized certifications.

- Van Dyke Public Schools will use $300,000 for manufacturing and computer assisted design equipment purchases for the Southwest Macomb Technical Education Consortium.
A new manufacturing alliance technical skills certificate will be offered. Students will have opportunities for job shadowing, field trips, and employment with local area manufacturers. The equipment also will allow for teacher training and a pilot program for adult learners.
January 19, 2018

Dr. Christine Hammond
President
Mid Michigan Community College
1375 South Clare Ave.
Harrison, Michigan 48625

Re: OCR Docket #15-18-2006

Dear Dr. Hammond:

This letter is to inform you of the disposition of the above-referenced complaint filed against Mid Michigan Community College (the College) with the U.S. Department of Education (Department), Office for Civil Rights (OCR), on October 2, 2017, alleging discrimination on the basis of disability. Specifically, the complaint alleged that certain of the College’s web pages have substantive accessibility issues. The alleged inaccessible pages include, but are not limited to, the following:

1. Homepage- https://www.midmich.edu/?bad_host=midmich.edu
2. Admissions & Aid- https://www.midmich.edu/admissions
3. Paying for College- https://www.midmich.edu/admissions/paying-for-college
4. Applying to Mid- https://www.midmich.edu/admissions/applying
5. Veterans- https://www.midmich.edu/admissions/applying/veterans
6. Adult Learners- https://www.midmich.edu/admissions/adult-learners
8. Types of Aid- https://www.midmich.edu/student-resources/financial-aid/applying-fin-aid
9. Library & Learning Services- https://www.midmich.edu/student-resources/lls

OCR is responsible for enforcing Section 504 of the Rehabilitation Act of 1973, 29 U.S.C. § 794, and its implementing regulation at 34 C.F.R. Part 104, which prohibit discrimination on the basis

The Department of Education’s mission is to promote student achievement and preparation for global competitiveness by fostering educational excellence and ensuring equal access.

www.ed.gov
of disability by recipients of Federal financial assistance. OCR is also responsible for enforcing Title II of the Americans with Disabilities Act of 1990, 42 U.S.C. § 12131 et seq., and its implementing regulation at 28 C.F.R. Part 35, which prohibit discrimination on the basis of disability by public entities. As a recipient of Federal financial assistance and as a public entity, the College is subject to these laws. Accordingly, OCR had jurisdiction to investigate this complaint.

Based on the complaint allegations, OCR opened an investigation of the following issues:

- whether the College, on the basis of disability, excluded qualified persons with disabilities from participation in, denied them the benefits of, or otherwise subjected them to discrimination in its programs and activities based on disability, in violation of the regulation implementing Section 504 at 34 C.F.R. § 104.4 and the regulation implementing Title II at 28 C.F.R. § 35.130; and

- whether the College failed to take appropriate steps to ensure that communications with applicants, participants, members of the public, and companions with disabilities are as effective as communications with others, in violation of 28 C.F.R. § 35.160(a).

Legal Authority:

Section 504 and Title II prohibit people, on the basis of disability, from being excluded from participation in, being denied the benefits of, or otherwise being subjected to discrimination by recipients of federal financial assistance or by public entities. 34 C.F.R. § 104.4 and 28 C.F.R. § 35.130. People with disabilities must have equal access to recipients’ programs, services, or activities unless doing so would fundamentally alter the nature of the programs, services, or activities, or would impose an undue burden. 28 C.F.R. § 35.164. Both Section 504 and Title II prohibit affording individuals with disabilities an opportunity to participate in or benefit from aids, benefits, and services that is unequal to the opportunity afforded others. 34 C.F.R. § 104.4(b)(1)(ii); 28 C.F.R. § 35.130(b)(1)(ii). Similarly, individuals with disabilities must be provided with aids, benefits, or services that provide an equal opportunity to achieve the same result or the same level of achievement as others. 34 C.F.R. § 104.4(b)(2); 28 C.F.R. § 35.130(b)(1)(iii). An individual with a disability, or a class of individuals with disabilities, may be provided with a different or separate aid, benefit, or service only if doing so is necessary to ensure that the aid, benefit, or service is as effective as that provided to others. 34 C.F.R. § 104.4(b)(1)(iv); 28 C.F.R. § 35.130(b)(1)(iv). Title II also requires public entities to take steps to ensure that communications with people with disabilities are as effective as communications with others, subject to the fundamental alteration and undue burden defenses. 28 C.F.R. § 35.160(a)(1). In sum, programs, services, and activities—whether in a “brick and mortar,” on-line, or other “virtual” context—must be operated in ways that comply with Section 504 and Title II.

Investigation to Date:
To date, OCR has investigated this complaint by reviewing information provided by the Complainant and conducting a preliminary assessment of the accessibility of several pages from the College’s website.

The complaint alleges that the College’s website is not in compliance with Section 504 and Title II because it is inaccessible to individuals with disabilities. The Complainant used website accessibility checkers (PowerMapper and WAVE) and reported to OCR that all of the pages of the College’s website have accessibility issues. She included examples cut and pasted from one of the online website accessibility tools (PowerMapper) onto the complaint form.

OCR conducted a preliminary examination of some of the web pages identified by the Complainant (e.g., the homepage and admissions page) and found possible compliance concerns as to whether the College’s website is accessible to individuals with disabilities. For example, numerous images and controls did not have appropriate alternative text, and the pages OCR reviewed had contrast issues.

Prior to the completion of OCR’s investigation, the College asked to resolve this complaint pursuant to Section 302 of OCR’s Case Processing Manual (CPM). On January 17, 2018, the College submitted the enclosed signed resolution agreement (the Agreement) to OCR. When fully implemented, the Agreement will resolve the allegations in the complaint. In light of the commitments the College has made in the Agreement, OCR finds that the complaint is resolved, and OCR is closing its investigation as of the date of this letter. OCR will monitor the College’s implementation of the Agreement to ensure that the commitments made are implemented timely and effectively. OCR may request additional information as necessary to determine whether the University has fulfilled the terms of the Agreement and is in compliance with Section 504 and Title II with regard to the issues raised.

If the College fails to implement the Agreement, OCR may initiate administrative enforcement or judicial proceedings to enforce the specific terms and obligations of the Agreement. Before initiating administrative enforcement (34 C.F.R. §§ 100.9, 100.10), or judicial proceedings to enforce the Agreement, OCR shall give the College written notice of the alleged breach and sixty (60) calendar days to cure the alleged breach.

This concludes OCR’s investigation of the complaint and should not be interpreted to address the College’s compliance with any other regulatory provision or to address any issues other than those addressed in this letter.

This letter sets forth OCR’s determination in an individual OCR case. This letter is not a formal statement of OCR policy and should not be relied upon, cited, or construed as such. OCR’s formal policy statements are approved by a duly authorized OCR official and made available to the public.

Please be advised that the College may not harass, coerce, intimidate, or discriminate against any individual because he or she has filed a complaint or participated in the complaint resolution process. If this happens, the harmed individual may file a complaint alleging such treatment.

The Complainant may file a private suit in federal court, whether or not OCR finds a violation.
Under the Freedom of Information Act, it may be necessary to release this letter and related correspondence and records upon request. In the event that OCR receives such a request, it will seek to protect, to the extent provided by law, personally identifiable information, which, if released, could reasonably be expected to constitute an unwarranted invasion of personal privacy.

OCR looks forward to receiving the College’s first monitoring report by February 28, 2018. For questions about implementation of the Agreement, please contact Mr. David Schwark, who will be monitoring the College’s implementation, by e-mail at David.Schwark@ed.gov or by telephone at (216) 522-7629.

For questions about this letter, please contact Ms. Brenda Redmond by telephone at (216) 522-2667.

Sincerely,

Meena Morey Chandra
Regional Director

Enclosure
Mid Michigan Community College
Resolution Agreement
OCR Docket #15-18-2006

Mid Michigan Community College (the College) voluntarily submits this Resolution Agreement (Agreement) to the U.S. Department of Education, Office for Civil Rights (OCR), for the purpose of resolving the above-referenced complaint alleging violation of Section 504 of the Rehabilitation Act of 1973 (Section 504), 29 U.S.C. § 794, and its implementing regulation at 34 C.F.R. Part 104.

"Accessible," as used in this Agreement, means a person with a disability is afforded the opportunity to acquire the same information, engage in the same interactions, and enjoy the same services as a person without a disability in an equally effective and equally integrated manner, with substantially equivalent ease of use. A person with a disability must be able to obtain the information as fully, equally, and independently as a person without a disability. Although this might not result in identical ease of use compared to that of persons without disabilities, it still must ensure equal opportunity to the educational benefits and opportunities afforded by the technology and equal treatment in the use of such technology.

The College agrees to take the following actions:

1. By February 28, 2018, the College will draft and submit to OCR for review and approval a policy and/or procedures to ensure information provided through the College’s website(s) (online content) is accessible to students, prospective students, employees, guests, and visitors with disabilities, particularly those with visual, hearing, or manual impairments or who otherwise require the use of assistive technology to access information (Web Accessibility Policy). The Web Accessibility Policy will, at minimum, accomplish the following:

   a. identify and adopt the specific technical standard(s) the College will use to determine whether online content is accessible (e.g., W3C's Web Content Accessibility Guidelines (WCAG), Web Accessibility Initiative - Accessible Rich Internet Applications Suite (WAI-ARIA) techniques for web content, or other standard or combination of standards that will render online content accessible);¹

   b. designate at least one individual (Web Accessibility Coordinator) and provide that individual with sufficient resources and authority to coordinate and implement the Web Accessibility Policy, and all other commitments relating to accessibility within this Agreement;

   c. provide a procedure to ensure that online content and information obtained through online content provided or developed by third parties is accessible. This procedure should direct administrators and staff to ensure that any College acquisition or use of

¹ This Agreement does not imply that conformity with WCAG, WAI-ARIA and/or other electronic and information technology standard is either required or sufficient to comply with the requirements of either Section 504 or Title II. The technical standard(s) serve only as guidance with respect to whether the online content is accessible.
online content provided or developed by third parties (e.g. vendors, video-sharing websites such as YouTube, other open sources) that the College chooses to make available on its website will provide equal opportunity to the educational benefits and opportunities afforded by the technology and equal treatment in the use of such technology;

d. annual training for any staff (e.g. administrators, faculty, support staff, student employees) responsible for creating or distributing information with online content to students, employees, guests, and visitors with disabilities, including, but not limited to, training on the Web Accessibility Policy and their roles and responsibilities to ensure that web design, documents, and multimedia content are accessible. The training will be facilitated, in whole or in part, by an individual with sufficient knowledge, skill, and experience to understand and employ the technical standard(s) adopted by the College;

e. an accessibility audit (Audit) to be completed at regular intervals under the direction of the Web Accessibility Coordinator, during which information provided by the College through its online content is measured against the technical standard(s) adopted in the Web Accessibility Policy. All problems identified through the Audit will be documented, evaluated, and, if necessary, remediated within a reasonable period of time; and

f. inform students, prospective students, employees, guests, and visitors that they may report violations of the technical standard(s) used by the College, file a formal complaint through its Section 504 and Title II grievance procedure, and/or contact the Web Accessibility Coordinator with any accessibility concerns. The Web Accessibility Policy will include the name and/or title, office address and telephone number, and email address of the Web Accessibility Coordinator.

Reporting Requirement: By February 28, 2018, the College will provide for OCR's review and approval the Web Accessibility Policy drafted consistent with Item 1.

2. Within 60 calendar days of OCR’s approval of the College’s Web Accessibility Policy, the College will post the Web Accessibility Policy in a logical and readily identifiable location on its website and will provide notification to students, prospective students, employees, guests, and visitors. The notification will occur by written correspondence, email, and/or website notification and will further provide information on where the Web Accessibility Policy is located on the College’s website and, alternatively, where individuals may request or obtain a copy of such document.

Reporting Requirement: Within 60 calendar days of OCR’s approval of the College’s Web Accessibility Policy, the College will provide documentation to OCR verifying its implementation of Item 2, including a copy of the notification(s) and the URL (web address(es)) for the location of its Web Accessibility Policy.

3. Within 180 calendar days of OCR’s approval of the College’s Web Accessibility Policy, the College will complete an initial Audit to examine whether information provided through online content is currently accessible, measured against the technical standard(s) adopted by
the Web Accessibility Policy. The College will document the results of the Audit and develop a corrective action strategy based on the audit findings that includes relevant timeframes for completion.

**Reporting Requirement:** Within 180 calendar days of OCR’s approval of the College’s Web Accessibility Policy, the College will provide to OCR for review and approval a copy of its Audit report and corrective action strategy, including the timeline for implementation of the corrective action strategy, and the credentials of a third party web accessibility consultant or employee of the College with sufficient knowledge, skill, and experience to understand and employ the technical standard(s) adopted by the College that will be certifying (pursuant to Item 4 below) that the College’s online content meets the technical requirements adopted in the Web Accessibility Policy.

4. Within 30 calendar days of OCR’s approval of the corrective action strategy, including the timeline for implementation of the corrective action strategy and the credentials of the College’s consultant or responsible employee described above, the College will begin implementation of the corrective action strategy to make its online content accessible to individuals with disabilities, particularly students with visual, hearing, or manual impairments or who otherwise require the use of assistive technology to access the online content.

**Reporting Requirements:** Within 180 calendar days of OCR’s approval of the corrective action strategy, the College will submit documentation to OCR confirming implementation of the corrective action strategy consistent with established timeframes, including certification to OCR that its online content meets the technical requirements adopted in the Web Accessibility Policy. The College will also provide to OCR the bases for this certification including copies of any accessibility evaluation or report, dates of correction actions, and copies of any reports from interim audits conducted pursuant to the Web Accessibility Policy.

5. Within 60 calendar days of OCR’s approval of the College’s Web Accessibility Policy, the College will develop and conduct training on how to ensure accessibility in web design and implementation. The training will be provided by qualified personnel, or through an online training program vetted by said qualified personnel, to all staff involved in web design and implementation, including but not limited to administrators, teachers, staff, and volunteers who develop content for online instruction and/or post material on College webpage(s)/portal(s). The training will include, at a minimum, training on the Web Accessibility Policy and the roles and responsibilities of College staff to ensure that web design, documents, course content, and multimedia videos or content are accessible.

**Reporting Requirement:** Within 60 calendar days of OCR’s approval of the College’s Web Accessibility Policy, the College will provide to OCR the name(s) and credentials of the individual(s) who conducted the training; a list of individuals, by name and title, who attended the training; and a copy of any training materials (e.g., pamphlets, presentation materials).
General Requirements

The College understands that by signing this Agreement, it agrees to provide the foregoing information in a timely manner in accordance with the reporting requirements of this Agreement. Further, the College understands that during the monitoring of this Agreement, if necessary, OCR may visit the College, interview staff, and request such additional reports or data as are necessary for OCR to determine whether the College has fulfilled the terms of this Agreement and is in compliance with Section 504 and its implementing regulation at 34 C.F.R. § 104.4. Upon completion of the obligations under this Agreement, OCR shall close this case.

The College understands and acknowledges that OCR may initiate administrative enforcement or judicial proceedings to enforce the specific terms and obligations of this Agreement. Before initiating administrative enforcement (34 C.F.R. §§ 100.9, 100.10) or judicial proceedings to enforce this Agreement, OCR shall give the College written notice of the alleged breach and sixty (60) calendar days to cure the alleged breach.

This Agreement will become effective immediately upon the signature of the College’s representative below.

[Signature]  
Superintendent or Designee  
1-17-2018  
Date
Agenda Item V-B: Enrollment Report

Board Consideration: Information

Background:

President Hammond will review the attached enrollment report for the winter 2018 semester.

Recommendation:

None.
## Winter 2018 Enrollment Report

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<tr>
<th></th>
<th>Winter 2017 as of 1/22/17</th>
<th>Winter 2018 as of 1/21/18</th>
<th>Change</th>
<th>% Change</th>
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### Credit Hours by Location

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<th>Winter 2018 as of 1/21/18</th>
<th>Change</th>
<th>% Change</th>
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<td>-11.0%</td>
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### In-District Credit Hours

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<th>% Change</th>
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<td>10694</td>
<td>10469</td>
<td>-225</td>
<td>-2.1%</td>
</tr>
</tbody>
</table>

### Out-District Credit Hours

<table>
<thead>
<tr>
<th></th>
<th>Winter 2017 as of 1/22/17</th>
<th>Winter 2018 as of 1/21/18</th>
<th>Change</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21994</td>
<td>21788</td>
<td>-206</td>
<td>-0.9%</td>
</tr>
</tbody>
</table>

### International Credit Hours

<table>
<thead>
<tr>
<th></th>
<th>Winter 2017 as of 1/22/17</th>
<th>Winter 2018 as of 1/21/18</th>
<th>Change</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1014</td>
<td>842</td>
<td>-172</td>
<td>-17.0%</td>
</tr>
</tbody>
</table>

### Dual Enrollment

<table>
<thead>
<tr>
<th></th>
<th>Winter 2017 as of 1/22/17</th>
<th>Winter 2018 as of 1/21/18</th>
<th>Winter 2017 as of 1/22/17</th>
<th>Winter 2018 as of 1/21/18</th>
<th>WI 2018 as % of Final WI 2017 Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual</td>
<td>5271</td>
<td>5456</td>
<td>5271</td>
<td>104%</td>
<td></td>
</tr>
<tr>
<td>First-Time Freshman</td>
<td>1834</td>
<td>1818</td>
<td>1834</td>
<td>99%</td>
<td></td>
</tr>
<tr>
<td>Guest</td>
<td>968</td>
<td>883</td>
<td>972</td>
<td>91%</td>
<td></td>
</tr>
<tr>
<td>Returning</td>
<td>23724</td>
<td>23178</td>
<td>23746</td>
<td>98%</td>
<td></td>
</tr>
<tr>
<td>Transfer</td>
<td>1905</td>
<td>1765</td>
<td>1905</td>
<td>93%</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>33702</td>
<td>33100</td>
<td>33728</td>
<td>98%</td>
<td></td>
</tr>
</tbody>
</table>

### Winter 2018 Credit Hours per Student

<table>
<thead>
<tr>
<th></th>
<th>Winter 2017 as of 1/22/17</th>
<th>Winter 2018 as of 1/21/18</th>
<th>Winter 2017 as of 1/22/17</th>
<th>Winter 2018 as of 1/21/18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual</td>
<td>991</td>
<td>1063</td>
<td>991</td>
<td>5.13</td>
</tr>
<tr>
<td>First-Time Freshman</td>
<td>193</td>
<td>190</td>
<td>193</td>
<td>9.57</td>
</tr>
<tr>
<td>Guest</td>
<td>149</td>
<td>150</td>
<td>150</td>
<td>5.89</td>
</tr>
<tr>
<td>Returning</td>
<td>2503</td>
<td>2362</td>
<td>2506</td>
<td>9.81</td>
</tr>
<tr>
<td>Transfer</td>
<td>190</td>
<td>180</td>
<td>190</td>
<td>9.81</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4026</td>
<td>3945</td>
<td>4030</td>
<td>8.39</td>
</tr>
<tr>
<td>Community College</td>
<td>Report Date</td>
<td>Percent change in Credit Hours</td>
<td>Percent change in Head Count</td>
<td>Credit Hours</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------</td>
<td>--------------------------------</td>
<td>-----------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>GLENOAKS</td>
<td>1/22/2018</td>
<td>7.4%</td>
<td>1.1%</td>
<td>9710</td>
</tr>
<tr>
<td>KIRTLAND</td>
<td>1/22/2018</td>
<td>5.3%</td>
<td>5.1%</td>
<td>15596</td>
</tr>
<tr>
<td>MUSKEGON</td>
<td>1/15/2018</td>
<td>0.7%</td>
<td>-3.1%</td>
<td>36769</td>
</tr>
<tr>
<td>GOGEBIC</td>
<td>1/22/2018</td>
<td>0.4%</td>
<td>-2.5%</td>
<td>10720</td>
</tr>
<tr>
<td>MONTCALM</td>
<td>1/22/2018</td>
<td>0.2%</td>
<td>0.7%</td>
<td>12497</td>
</tr>
<tr>
<td>KELLOGG</td>
<td>1/22/2018</td>
<td>-0.3%</td>
<td>5.9%</td>
<td>35990</td>
</tr>
<tr>
<td>WASHTENAW</td>
<td>1/22/2018</td>
<td>-0.9%</td>
<td>0.9%</td>
<td>95228</td>
</tr>
<tr>
<td>BAYDENOC</td>
<td>1/15/2018</td>
<td>-1.0%</td>
<td>1.0%</td>
<td>15578</td>
</tr>
<tr>
<td>SOUTHWESTERN</td>
<td>1/8/2018</td>
<td>-1.0%</td>
<td>-0.8%</td>
<td>19236</td>
</tr>
<tr>
<td>HFC</td>
<td>1/22/2018</td>
<td>-1.0%</td>
<td>-0.3%</td>
<td>115793</td>
</tr>
<tr>
<td>STCLAIR</td>
<td>1/22/2018</td>
<td>-1.1%</td>
<td>-0.7%</td>
<td>32098</td>
</tr>
<tr>
<td>MIDMICH</td>
<td>1/21/2018</td>
<td>-1.8%</td>
<td>-2.0%</td>
<td>33098</td>
</tr>
<tr>
<td>GRANDRAPIDS</td>
<td>1/18/2018</td>
<td>-2.1%</td>
<td>-1.8%</td>
<td>108582</td>
</tr>
<tr>
<td>LANSING</td>
<td>1/8/2018</td>
<td>-2.6%</td>
<td>-2.5%</td>
<td>108459</td>
</tr>
<tr>
<td>JACKSON</td>
<td>1/15/2018</td>
<td>-2.7%</td>
<td>-2.1%</td>
<td>45076</td>
</tr>
<tr>
<td>NORTHCENTRAL</td>
<td>1/15/2018</td>
<td>-3.3%</td>
<td>5.6%</td>
<td>18050</td>
</tr>
<tr>
<td>DELTA</td>
<td>1/8/2018</td>
<td>-3.5%</td>
<td>-4.5%</td>
<td>73194</td>
</tr>
<tr>
<td>KVCC</td>
<td>1/2/2018</td>
<td>-3.5%</td>
<td>-3.6%</td>
<td>58856</td>
</tr>
<tr>
<td>ALPENA</td>
<td>1/16/2018</td>
<td>-4.1%</td>
<td>-0.3%</td>
<td>13504</td>
</tr>
<tr>
<td>MACOMB</td>
<td>1/22/2018</td>
<td>-4.1%</td>
<td>-4.4%</td>
<td>167756</td>
</tr>
<tr>
<td>LAKEMICHIGAN</td>
<td>1/8/2018</td>
<td>-4.6%</td>
<td>-5.5%</td>
<td>22883</td>
</tr>
<tr>
<td>NORTHWESTERN</td>
<td>1/22/2018</td>
<td>-4.8%</td>
<td>-4.3%</td>
<td>33070</td>
</tr>
<tr>
<td>MONROE</td>
<td>1/12/2018</td>
<td>-5.1%</td>
<td>-3.3%</td>
<td>23022</td>
</tr>
<tr>
<td>MOTT</td>
<td>1/22/2018</td>
<td>-5.1%</td>
<td>-4.7%</td>
<td>61961</td>
</tr>
<tr>
<td>WESTSHORE</td>
<td>1/16/2018</td>
<td>-7.6%</td>
<td>-8.3%</td>
<td>9623</td>
</tr>
<tr>
<td>OAKLANDCC</td>
<td>1/8/2018</td>
<td>-8.7%</td>
<td>-8.9%</td>
<td>130059</td>
</tr>
<tr>
<td>SCHOOLCRFT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAYNECOUNTRY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVERAGE</td>
<td></td>
<td>-2.1%</td>
<td>-1.7%</td>
<td></td>
</tr>
</tbody>
</table>
## Interesting Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Winter 2017</th>
<th>Winter 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit hours per student for First-Time Freshman, Returning, and Transfer students:</td>
<td>9.52</td>
<td>9.80</td>
</tr>
<tr>
<td><strong>Student Count</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-District</td>
<td>1288</td>
<td>1297</td>
</tr>
<tr>
<td>Out-District</td>
<td>2639</td>
<td>2559</td>
</tr>
<tr>
<td>International</td>
<td>99</td>
<td>89</td>
</tr>
<tr>
<td><strong>Grade Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of Freshman</td>
<td>2341</td>
<td>2425</td>
</tr>
<tr>
<td># of Sophomores</td>
<td>1177</td>
<td>1077</td>
</tr>
<tr>
<td># of Other</td>
<td>508</td>
<td>443</td>
</tr>
<tr>
<td>Average Age (all students)</td>
<td>22.4</td>
<td>22.13</td>
</tr>
<tr>
<td>% Part-Time Students</td>
<td>70.27</td>
<td>70.74</td>
</tr>
<tr>
<td>% Full-Time Students</td>
<td>29.73</td>
<td>29.25</td>
</tr>
<tr>
<td>% Part-Time Men</td>
<td>27.4</td>
<td>27.6</td>
</tr>
<tr>
<td>% Full-Time Men</td>
<td>15.25</td>
<td>14.98</td>
</tr>
<tr>
<td><strong>Total % Men</strong></td>
<td><strong>42.65</strong></td>
<td><strong>42.58</strong></td>
</tr>
<tr>
<td>% Part-Time Women</td>
<td>42.87</td>
<td>43.14</td>
</tr>
<tr>
<td>% Full-Time Women</td>
<td>14.48</td>
<td>14.27</td>
</tr>
<tr>
<td><strong>Total % Women</strong></td>
<td><strong>57.35</strong></td>
<td><strong>57.41</strong></td>
</tr>
<tr>
<td><strong>% of Students from Counties</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isabellla</td>
<td>29.04</td>
<td>26.64</td>
</tr>
<tr>
<td>Clare</td>
<td>18.38</td>
<td>18.00</td>
</tr>
<tr>
<td>Gratiot</td>
<td>9.51</td>
<td>10.75</td>
</tr>
<tr>
<td>Gladwin</td>
<td>10.23</td>
<td>10.14</td>
</tr>
<tr>
<td>Mecosta</td>
<td>5.37</td>
<td>4.16</td>
</tr>
<tr>
<td>Midland</td>
<td>3.03</td>
<td>2.92</td>
</tr>
<tr>
<td>Huron</td>
<td>2.29</td>
<td>2.28</td>
</tr>
<tr>
<td>Oakland</td>
<td>1.89</td>
<td>2.28</td>
</tr>
<tr>
<td>Osceola</td>
<td>2.41</td>
<td>2.18</td>
</tr>
<tr>
<td><strong># of MI counties served</strong></td>
<td>75</td>
<td>73</td>
</tr>
</tbody>
</table>
Agenda Item V-C: Meeting Date Change

Board Consideration: Action

Background:

Due to the Business Innovation Factory meeting in Chicago on April 3, the Board is being asked to consider an alternate date for the April Board of Trustees Meeting.

Recommendation:

A recommendation will be provided at the meeting.
Agenda Item V-D: Mt. Pleasant City Women’s Club Event

Board Consideration: Action

Background:

The Mt. Pleasant City Women’s Club has requested the use of the Mt. Pleasant facilities for an event on April 24, 2018 for a "Fashion for Compassion" Style Show. Proceeds from the event will support the educational and nutritional needs of the children of Isabella County. They are requesting to serve wine at this event.

In accordance with Board Policy 304.01 Alcoholic Beverages – Alcoholic beverages may be allowed on campus with approval of the Board of Trustees.

Recommendation:

It is recommended the Board approve the request to allow the Mt. Pleasant City Women’s Club to have alcoholic beverages on the Mt. Pleasant Campus for their event on April 24, 2018.
Agenda Item V-E: Administrative Sabbatical Request

Board Consideration: Action

Background:

President Hammond will present the administrative sabbatical request from Brent Mishler, Director of Admissions. A request for an administrative sabbatical request has not been brought forward in quite some time. In addition to the items mentioned in Board Policy 406.06 Sabbatical Leave, President Hammond also considered the following items in her determination:

1. The individual must be in good standing with positive performance reviews on file.
2. The individual must have the support of his/her immediate supervisor along with an acceptable planning for covering the work while the individual is absent.
3. The individual must be willing to make a commitment to complete the proposed project within six months of the sabbatical and to remain with the College for one year after the sabbatical’s completion.
4. Preference would be given for projects that relate to further study and/or to projects that relate directly to the individual’s responsibilities at Mid.
5. The individual must have a plan to disseminate the results of the project upon return.

The request has been reviewed by President Hammond and the Vice Presidents and is attached for review. President Hammond feels the proposal satisfies the requirements in the Sabbatical Leave policy below and her additional items above and supports the request.

406.06 Sabbatical Leave

[LAST APPROVED November 3, 2009]

Administrative employees who have a minimum of five (5) years of full-time employment are eligible for a sabbatical leave upon written request and approval of the President and Board of Trustees. The duration, compensation and future employment and other considerations shall be determined at the time of the request.

Recommendation:

It is recommended the Board approve the Administrative Sabbatical request from Brent Mishler.
Pursuant to Board Policy 406.06 (Sabbatical Leave), I am humbly requesting Sabbatical Leave to complete my dissertation through Ferris State University’s Doctorate in Community College Leadership.

Background
In 2013, I began the doctoral program in Community College Leadership at Ferris State University. Ferris’ DCCL program results in a Doctorate in Education degree and includes a dissertation. Ferris’ program is a cohort model that spreads classes out over three continuous years. Most of the class is online, with one face-to-face weekend per course. Over the summer semester, we would have one week of face-to-face class. Our cohort of students began with around 24 and finished at nearly 20. Most of the students were from Michigan, with a handful from other Midwest states, including one from Arizona. Over the course of those three years, I took courses in:

- Community College Critical Issues
- New Leadership
- Leading Organizational Transformation
- Strategic Planning
- Qualitative Research
- Quantitative Research
- Managing Physical and Financial Resources
- Resource Development (Fundraising)
- Leveraging Human Resources
- Marketing and Community Engagement
- Policy and Governance
- Student Learning and Success

In addition to these courses, we began the program with a Prospectus course, had a mid-program course titled Practicum where we selected a topic of interest and explored it on more depth (I did mine on the differences between community college fundraising
and university fundraising), and our dissertation was embedded throughout the program by taking 1 or 2 credits of the dissertation class each semester.

The knowledge gained through this program has helped me tremendously in my position here at MMCC. Beyond the knowledge, the friendships (both professional and personal) that I gained from the cohort of students has been beneficial not only to me but the college as well.

Our formal classes ended in the spring 2015 semester, and I participated in commencement exercises in May 2015. All of my coursework has been completed, and I just need to complete and defend my dissertation.

**Dissertation Topic**

My dissertation is a project focused on creating an Office of Dual Enrollment at Mid Michigan Community College. I wanted my dissertation to be practical and to benefit the college. While not obligated to implement the dissertation or its recommendations, the growth of dual enrollment at MMCC has had its challenges. This dissertation would work to mitigate many of those challenges, as well as make recommendations for organizational structure, staffing, and budget, and strategy related to dual enrollment moving forward.

Because I wanted my dissertation to be as practical as possible, my committee consists of Dr. Matt Miller (chair), Dr. Richard Smith (MMCC), and Dr. Deedee Stakely (Ferris State). All of them have experience in dual enrollment and both Drs. Smith and Stakely are graduates of Ferris’ DCCL program.

My hope for this dissertation is continue to find best practices for working with high schools and their students to provide a great dual enrollment experience, while at the same time streamlining MMCC’s dual enrollment structure.

**Specifics About the Leave**

The Sabbatical Leave would include no more than three weeks, and would begin on Monday, February 12th and end on Friday, March 2nd. I propose that this time period is the maximum allowed, and the Leave would only include the amount necessary to complete my dissertation.

During this leave, I will be writing, editing, and finalizing the components of my dissertation. My current structure of the dissertation includes chapters on introducing the topic, a literature review, the methods, the actual product, and a conclusion chapter on implications and future research needed. By the conclusion of the Leave, I will have all five chapters written and edited. The last remaining aspects will be to format the chapters, ensure citations are correct, and prepare the defense.
Although not officially in the office, I commit to checking and responding to emails daily, and continuing to check in and monitor staff. If any meetings are scheduled where my attendance is necessary based upon the recommendation by my supervisor, I will attend those.

I specifically request February 12-March 2 as my Sabbatical Leave time due to the nature of my position within Admissions. February is generally a month that can accommodate me not being physically in the office. Planning is underway for many events in March and beyond, and those have been in the works for some time. Spring recruiting for the upcoming semester traditionally begins in April with another round of high school visits. I have complete confidence in my staff to handle any issue that may arise, while noting that I’m always a phone call away.

I propose to continue to receive full pay and benefits throughout the Leave and at the conclusion of the Leave, return to my position as Director of Admissions.

If you have any questions, please let me know.

Respectfully,

Brent Mishler
Agenda Item V-F: Security Incident Update

Board Consideration: Information

Background:

President Hammond will provide an update on the security incident that occurred on January 25, 2018.

Recommendation:

None.
Agenda Item V-G: USDA Resolution

Board Consideration: Action

Background:

Discussion has taken place with USDA Representative Jackie Morgan regarding the desire to build a pavilion at the Harrison Campus Trail Head. The Pavilion would provide the much needed accommodations for the hundreds of visitors that use both the bike and walking trails. Currently, visitors are using the parking lot to change their clothes, have a porta-john to use for a bathroom and lack running water. This project will provide a heated pavilion that will have private areas for changing, flush toilet bathrooms and drinking water.

The MMCC Foundation earmarked funds last year towards this project, additional funding is being sought through this grant. The grant application is due by February 28, 2018. Ms. Morgan has encouraged MMCC to seek funding through the USDA’s grant process.

Recommendation:

It is recommended that the Board approve the attached resolution.
At the meeting at the Board of Trustees for Mid Michigan Community College on February 6, 2018, the following resolution was presented and approved by the board:

Be it resolved:

That the Mid Michigan Community College Board of Trustees is in full support of a grant proposal to the United States Department of Agriculture, Rural Business Development Grant Program Construction Projects, for the Harrison Campus Trail Head Pavilion Project.

Signed:

____________________________________
Chairperson of the Board
Mid Michigan Community College Board of Trustees

Agenda Sheet
February 6, 2018

Agenda Item VI-A: Calendar of Events

Board Consideration: Information

Background:

Mar 3-9 Spring Break – No Classes
Mar 6 MMCC Board of Trustees Workshop – 6:00 p.m., Houghton Room, Harrison
Mar 6 MMCC Board of Trustees Regular Meeting – 7:00 p.m., Houghton Room, Harrison
Mar 28 Faculty Professional Development Day – No Classes
Mar 30 No Classes
Mar 14 Phi Theta Kappa Awards Luncheon – 10:00 a.m., Kellogg Center, Lansing
Apr 3 MMCC Board of Trustees Workshop – 6:00 p.m., Houghton Room, Harrison
Apr 3 MMCC Board of Trustees Regular Meeting – 7:00 p.m., Houghton Room, Harrison
Apr 6-10 Higher Learning Commission Annual Conference, TBA
Apr 19 MCCA Community College Day – 11:30 a.m., Lansing
Apr 22 A Northern Tradition Fundraiser – 6:00 p.m., Jay’s Sporting Goods, Clare
Apr 28 – May 1 AACC Annual Convention - Dallas, TX
May 1 MMCC Board of Trustees Workshop – 6:00 p.m., Houghton Room, Harrison
May 1 MMCC Board of Trustees Regular Meeting – 7:00 p.m., Houghton Room, Harrison
May 4 Winter 2018 Semester Ends
May 5 Winter 2018 Commencement
May 18 Spring 2018 Semester Begins
May 28 Memorial Day – College Closed
June 5 MMCC Board of Trustees Workshop – 6:00 p.m., Houghton Room, Harrison
June 5 MMCC Board of Trustees Regular Meeting – 7:00 p.m., Houghton Room, Harrison
June 22 Spring 2018 Six Week Semester Ends
July 4 Independence Day – College Closed
July 8 Spring 2018 Eight Week Semester Ends
July 24-27 MCCA Summer Conference – Grand Traverse Resort, Traverse City
Aug 3 Spring 2018 Twelve Week Semester Ends
Sept 27-28 MCCA Student Success Summit – 11:00 a.m., Lansing
Oct 24-27 ACCT Annual Leadership Congress – New York, New York
Nov 8-9 MCCA Trustee Leadership Institute – Lansing

Recommendation: None.
Agenda Item: VI-B: Board Comments-Other Business

Board Consideration: Information

Background:

1. Any comments may be offered by Trustees at this time.

2. Closed Session - Public Act No. 267 of 1976 permits the Board to meet in closed session for the purpose of conducting strategy sessions necessary in reaching a collective bargaining agreement and for other specified purposes relating to personnel, property and litigation. The Board will go into Closed Session for a litigation, personnel and property discussions. A two-thirds roll call vote of Board members is required to call a closed session.

Recommendation:

None.