Oregon Transfer Compass

Summary of CCN Math Subcommittee Report

The following provides a summary of the Recommendation Report from the CCN Math Subcommittee.

Recommendation	Vote
Course Number and Prefix: MTH or MATH 251Z	Yes 15 No 0 Abstain 0
Course Title: Differential Calculus	Yes 15 No 0 Abstain 0
Course Credits: 5 *Note: Transfer Council approved 4 credits 10/17/2024	Yes 10 No 5 Abstain 0
Course Description: This course explores limits, continuity, derivatives, and their applications for real-valued functions of a single variable. These topics will be explored graphically, numerically, and symbolically in real-life applications. This course emphasizes abstraction, problem-solving, modeling, reasoning, communication, connections with other disciplines, and the appropriate use of technology.	Yes 15 No 0 Abstain 0
Course Learning Outcomes: At the end of the course, students will be able to… 1. Calculate limits graphically, numerically, and symbolically; describe the behavior of functions using limits and continuity; and recognize indeterminate forms. 2. Apply the definition of the derivative and analyze average and instantaneous rates of change. 3. Interpret and apply the concepts of the first and second derivative to describe and illustrate function features including the slopes of tangent lines, locations of extrema and inflection points, and intervals of increase, decrease, and concavity. 4. Apply product, quotient, chain, and function-specific rules to differentiate combinations of power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions, as well as functions defined implicitly.	Yes 15 No 0 Abstain 0
5. Apply derivatives to a variety of problems in mathematics and other disciplines, including related rates, optimization, and L'Hôpital's rule.	Yes 15 No 0 Abstain 0
Required Course Content: At the end of the course, students will be able to…	

1. Calculate limits graphically, numerically, and symbolically; describe the behavior of functions using limits and continuity; and recognize indeterminate forms. a. Students will be able to calculate limits graphically, numerically, and algebraically. b. Students will be able describe the local and global behavior of functions using limits. c. Students will be able to describe the notion of continuity using limits and determine whether a function is continuous. d. Students will be able to recognize and evaluate indeterminate forms. 2. Apply the definition of the derivative and analyze average and instantaneous rates of change. a. Students will be able to state and use the definition of the derivative to calculate the derivatives of simple functions. b. Students will be able to determine whether a function is differentiable using limits. c. Students will be able to describe the connection between the definition of the derivative and the average and instantaneous rates of change of a function. d. Students will be able to use derivatives in applications using appropriate units. 3. Interpret and apply the concepts of the first and second derivative to describe and illustrate function features including the slopes of tangent lines, locations of extrema and inflection points, and intervals of increase, decrease, and concavity. a. Students will recognize and apply the concept of the derivative to describe and find the slopes of tangent lines.	

b. Students will be able to use the derivative to identify the intervals on which a function is increasing or decreasing, and the locations of extreme values. c. Students will be able to use the second derivative to identify intervals of concavity and the locations of inflection points. 4. Apply product, quotient, chain, and function-specific rules to differentiate combinations of power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions, as well as functions defined implicitly. a. Students will be able to differentiate power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions algebraically b. Students will be able to apply sum, constant multiple, product, quotient, and chain rules to differentiate combinations of functions listed above. c. Students will be able to differentiate functions defined implicitly. 5. Apply derivatives to a variety of problems in mathematics and other disciplines, including related rates, optimization, and L'Hôpital's rule. a. Students will be able to recognize when L'Hôpital's rule is appropriate and use it to calculate limits involving indeterminate forms. b. Students will be able to use the derivative to solve related rates problems. c. Students will be able to use the derivative to solve optimization problems. d. Students will be able to interpret and communicate the meaning of the derivative and its application in context, including using appropriate notation.	
Course Number and Prefix: MTH or MATH 252Z **Course Title:** Integral Calculus	Yes 15 No 0 Abstain 0 Yes 15 No 0 Abstain 0

Course Credits: 5 *Note: Transfer Council approved 4 credits 10/18/2024	Yes 10 No 5 Abstain 0
Course Description: This course explores Riemann sums, definite integrals, and indefinite integrals for real-valued functions of a single variable. These topics will be explored graphically, numerically, and symbolically in real-life applications. This course emphasizes abstraction, problem-solving, modeling, reasoning, communication, connections with other disciplines, and the appropriate use of technology.	Yes 15 No 0 Abstain 0
Course Learning Outcomes: At the end of the course, students will be able to… 1. Approximate definite integrals using Riemann sums and apply this to the concept of accumulation and the definition of the definite integral. 2. Explain and use both parts of the Fundamental Theorem of Calculus. 3. Choose and apply integration techniques including substitution, integration by parts, basic partial fraction decomposition, and numerical techniques to integrate combinations of power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions. 4. Use the integral to model and solve problems in mathematics involving area, volume, net change, average value, and improper integration. 5. Apply integration techniques to solve a variety of problems, such as work, force, center of mass, or probability.	Yes 15 No 0 Abstain 0
Required Course Content: At the end of the course, students will be able to… 1. Approximate definite integrals using Riemann sums and apply this to the concept of accumulation and the definition of the definite integral. a. Students will be able to express finite sums using sigma notation. b. Students will be able to use Riemann sums to describe the process of approximating the net signed area between a curve and an axis. c. Students will be able to relate the definite integral with the concept of accumulation of area or other	Yes 15 No 0 Abstain 0

infinitesimal quantities, including the use of appropriate units. 2. Explain and use both parts of the Fundamental Theorem of Calculus. a. Students will be able to recognize and express the definite integral as a limit of a Riemann sum. b. Students will use and compare different methods for calculating definite integrals, such as linear properties of integrals, net-signed area, and graphical approaches. c. Students will explain and apply the concept of indefinite integrals and its connection to antidifferentiation. d. Students will explain the connection between derivatives and integrals and apply their understanding using the Fundamental Theorem of Calculus. 3. Choose and apply integration techniques including substitution, integration by parts, basic partial fraction decomposition, and numerical techniques to integrate combinations of power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions. a. Students will be able to integrate power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions using basic rules. b. Students will be able to use substitution and integration by parts to algebraically integrate appropriate combinations of functions. c. Students will be able to use partial fraction decomposition to evaluate integrals of rational functions whose denominators may be expressed as products of distinct linear factors.	

d. Students will be able to use numerical techniques, such as Midpoint, Trapezoidal, and Simpson's rules, to approximate definite integrals. 4. Use the integral to model and solve problems in mathematics involving area, volume, net change, average value, and improper integration. a. Students will be able to use definite integrals to find the area between two curves. b. Students will be able to calculate volumes of solids, such as solids of revolution or prisms, using integrals. c. Students will be able to apply the integral to find the average value of a function over an interval. d. Students will be able to apply the integral to find the net change of a function over an interval. e. Students will be able to recognize, describe, and calculate improper integrals. 5. Apply integration techniques to solve a variety of problems, such as work, force, center of mass, or probability. a. Students will apply integration to problems in the instructor's choice of context, including but not limited to the possible options above. At least two distinct applications are recommended based on the population of students in the class.	
Course Number and Prefix: MTH or MATH 253Z **Course Title:** Calculus: Sequences and Series **Course Credits:** 4 **Course Description:** This course explores real-valued sequences and series, including power and Taylor series. Topics include convergence and divergence tests and applications. These topics will be explored graphically, numerically, and symbolically. This course emphasizes abstraction, problem-solving, reasoning, communication, connections with other disciplines, and the appropriate use of technology. **Course Learning Outcomes:** At the end of the course, students will be able to...	Yes 15 No 0 Abstain 0 Yes 15 No 0 Abstain 0 Yes 15 No 0 Abstain 0 Yes 15 No 0 Abstain 0 Yes 15 No 0 Abstain 0

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1. Recognize and define sequences in a variety of forms and describe their properties, including the concepts of convergence and divergence, boundedness, and monotonicity.
2. Recognize and define series in terms of a sequence of partial sums and describe their properties, including convergence and divergence.
3. Recognize series as harmonic, geometric, telescoping, alternating, or p-series, and demonstrate whether they are absolutely convergent, conditionally convergent, or divergent, and find their sum if applicable.
4. Choose and apply the divergence, integral, comparison, limit comparison, alternating series, and ratio tests to determine the convergence or divergence of a series.
5. Determine the radius and interval of convergence of power series, and use Taylor series to represent, differentiate, and integrate functions.
6. Use techniques and properties of Taylor polynomials to approximate functions and analyze error.

Required Course Content:
At the end of the course, students will be able to…
1. Recognize and define sequences in a variety of forms and describe their properties, including the concepts of convergence and divergence, boundedness, and monotonicity.
    a. define and recognize sequences given explicitly or recursively.
    b. determine whether a given sequence is convergent or divergent by appropriate use of the limit laws for sequences, the Squeeze Theorem, or L’Hôpital’s rule.
    c. determine the monotonicity and boundedness properties of a sequence, and use them to draw conclusions about convergence or divergence.
2. Recognize and define series in terms of a sequence of partial sums and describe their properties, including convergence and divergence.
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<td>Yes 15 No 0 Abstain 0</td>
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a. represent a series as a limit of a sequence of partial sums, and describe the notions of convergence or divergence of the series. b. algebraically manipulate series, and apply series laws to draw conclusions about divergence, convergence, and the value of the limit. 3. Recognize series as harmonic, geometric, telescoping, alternating, or p-series, and demonstrate whether they are absolutely convergent, conditionally convergent, or divergent, and find their sum if applicable. 4. Choose and apply the divergence, integral, comparison, limit comparison, alternating series, and ratio tests to determine the convergence or divergence of a series. a. recognize when the divergence, integral, comparison, and limit comparison tests apply to a particular series, and draw conclusions about the convergence or divergence of the series. b. recognize when the ratio and alternating series tests apply to a particular series, and draw conclusions about the absolute convergence, conditional convergence, or divergence of a series. 5. Determine the radius and interval of convergence of power series, and use Taylor series to represent, differentiate, and integrate functions. a. find the radius and interval of convergence of a given power series. b. use power series to represent functions, and determine the radius of convergence of the series. c. differentiate and integrate power series that represent functions. d. find the Taylor series centered at a point $x=c$ of a given function and determine its radius of convergence. 6. Use techniques and properties of Taylor polynomials to approximate functions and analyze error.	

a. approximate a function using a Taylor polynomial. b. estimate the error in a Taylor polynomial approximation using either Taylor's Inequality or the Alternating Series Estimation Theorem. c. approximate an alternating series to a desired error by a partial sum of the series.	

Chart approved by CCN Math Co-chairs Celeste Petersen and Leanne Merrill, November 6, 2023.

CCN Subcommittee Recommendation Report

Math

Subcommittee Members
Dr. Leanne Merrill, Western Oregon University
Celeste Petersen, Clatsop Community College

Celeste Petersen and Dr. Leanne Merrill, Co-chairs
November 6, 2023

Date of last meeting

November 3, 2023.

Plans for next meeting

This report contains the final recommendations issued by the Common Course Numbering (CCN) 2023 Mathematics Subcommittee. This subcommittee was tasked with recommending common course numbers, prefixes, credits, descriptions, and learning outcomes for four mathematics courses identified by the Transfer Council as commonly transferred between public institutions in the state of Oregon. We have completed this work for three of the four courses and have received approval from the Transfer Council to delay alignment of the fourth course (MTH 254) until a future year; therefore, our work is concluded until we are further tasked by the Transfer Council to continue. In the “Action items In-progress/pending” section below, we provide suggestions for future tasks that our subcommittee could complete in the case that it is reconvened. We acknowledge that we may be reconvened more quickly, depending upon the acceptance of recommendations in this report.

Overview

Our subcommittee convened in February 2023 to align four courses: MTH/MATH 251Z, MTH/MATH 252Z, MTH/MATH 253Z, and MTH/MATH 254Z. We met biweekly from February through April 2023, and then began meeting weekly in May and June 2023. We recessed for Summer term, and then resumed weekly meetings in October and November 2023. Prior to Fall 2023, each meeting was 90 minutes long, and beginning Fall 2023 we met for 2 hours each week.

Our goals in these meetings were to decide upon the common prefixes, course numbers, titles, credits, course description, and learning outcomes for each of the assigned courses. In addition to these goals, we opted to create additional “Required Course Content” language for the three courses upon whose learning outcomes we agreed. The idea for Required Course Content (originated in the 2022 Statistics Subcommittee) is to provide additional detail for instructors so they can more easily align their course to the common course outcomes. We include this additional content in the “Other Items” section below.

Our work in Winter 2023 began by compiling a spreadsheet that listed the prefix, course number, title, credits, description, outcomes, outline of major topics, and student audience for each assigned course from all 17 community colleges and 7 public universities in Oregon. This allowed us to see areas of agreement, such as prefixes and course numbers, as well as areas that were currently not aligned, such as some of the learning outcomes and numbers of credits. We then compiled lists of major topics for each course, and sorted them into "required" and "optional" categories. We gained consensus on those before beginning to write descriptions and outcomes. We chose to use this strategy because many of us had served on the 2022 CCN Math Subcommittee, and we realized that one of our challenges last year was that we moved too quickly to outcome writing before deciding upon content. The strategy we used this year seemed to be more effective in that it streamlined and focused our content discussions throughout the rest of the process.

In Spring 2023, we began writing outcomes for MTH 251Z and MTH 252Z. Working from the major topics list, we created five outcomes for each course. Our outcomes sufficiently describe what we would expect a student to be able to do after having completed one of the commonly numbered courses at any institution in the state. Nevertheless, the courses we were asked to align are sequential and serve many populations, and as faculty who teach these courses, we strongly feel that it is important to specify content to meet the spirit of transferability. Therefore, in addition to the outcomes, we created "Required Course Content" which details more specific content and skills that we hope instructors around the State will include in these courses. Indeed, we believe that this Required Course Content will be a boon to instructors as they design their courses to align with our common outcomes, and aid in our goal of transparency for students.

By the end of Spring 2023, we successfully agreed upon outcomes, content, and descriptions, as well as prefix, course number, and title for MTH 251Z and MTH 252Z. We also began to look towards MTH 253Z and MTH 254Z, and realized that it was not prudent for us to align MTH 254Z in this cycle. We submitted a memo to the Transfer Council and requested to postpone alignment of MTH 254Z, and they agreed with our recommendation. It should also be noted that during Spring 2023, Nikki Gavin had to step down as co-chair of the subcommittee, but we are deeply indebted to her work on the first part of this process.

In Fall 2023, we reconvened with the goal of aligning MTH 253Z and deciding on the number of credits for each course. MTH 253Z was more challenging to align than the previous two courses because it serves a significantly different population of students at each institution – in particular, schools that contain or feed engineering programs had many additional demands on their content – and as such the content was much more varied. Nevertheless, we agreed upon six learning outcomes and corresponding required course content for this course, as well as description, prefix, course number, and title.

After having agreed upon the prefix, course number, title, description, learning outcomes, and required course content, our final task was to agree on the number of credits for each course. It should be noted that while Senate Bill (SB) 233 itself does not require us to declare that each institution offers each commonly numbered course for the same number of credits, our Subcommittee Charge does include this mandate per the Transfer Council interpretation of this law. Prior to common course numbering, these courses did not have equal numbers of credits at each institution. In particular, at least 10 community colleges offered MTH 251Z and MTH 252Z at 5 credits, whereas all of the public universities offered these courses at 4 credits. Data for all colleges that offer any of the courses being aligned was included in the spreadsheet and considered in our decisions, though some community colleges do not offer all of these courses.

Our discussion of credits centered on what is best for students. Student success, particularly for historically underserved student populations, was at the heart of the argument for 5 credits in MTH 251Z and MTH 252Z. Many members of the subcommittee, particularly those who teach at community colleges, believe that more time in class, as well as more time devoted outside of class to studying, would increase the chances of success in these crucial gateway STEM courses. For institutions that already offer these courses at 5 credits, there was a sense that all of that time was necessary for students to grasp the material fully and feel confident in their mathematical skills to pass the classes and succeed in future situations where these mathematical skills were necessary.

On the other hand, more credits do cost students more money, which impacts equity in a different way. There was also concern about the amount of time students were being asked to spend outside of class. Per the federal definition, a credit hour means "two hours outside of class each week for each credit hour," which some faculty felt would be difficult for students to meet with other demands on their time. Last, there was concern expressed about the impact of credit hour increases on other programs at the public universities, as adding credits may force certain programs to exceed 180 hours or reduce upper-division, discipline-specific requirements. We also discussed the possibility of lecture/lab hours, which would increase the time spent in class, but not the expectations outside of the class, and to be true to the federal definition would cut down on the content delivery time, which is one of the main arguments for 5 credits.

In addition to consulting the federal definition of a credit hour, we obtained some sparse data from the HECC on degree completion information for Calculus courses (not D-F-W data as we had hoped). Additionally, we considered our own experience and the experience of our colleagues around the state whose institutions did not have representatives on the committee. Ultimately, we recommend that MTH 251Z be 5 credits, MTH 252Z be 5 credits, and MTH 253Z be 4 credits.

While we did reach the threshold for approving a number of credits for these courses, we wish to issue a recommendation to the Transfer Council that we not be required to decide upon a single number of credits; rather, we should be able to decide, as individual institutions, between either 4 or 5 credits for our commonly numbered Mathematics courses.

As math faculty, many of whom deal with transfer students who have varying numbers of credits, we are largely unaware of issues caused by 4 or 5 credit calculus classes transferring between Oregon public institutions. Additionally, we believe that forcing institutions to agree upon a number of credits may introduce additional inequities. In short, a one-size-fits-all requirement is not the correct solution for Oregon students. We therefore recommend that institutions be allowed to choose between 4 or 5 credits. We affirmed this with a unanimous straw poll with 15 in favor and 0 opposed.

Per the paragraphs above, we request that the Transfer Council reevaluate their interpretation of SB 233, concerning the alignment of credits.

The discussion around MTH 253Z was less heated; more faculty believed this course, particularly with the content specified in the required course content document, could be covered sufficiently with 4 credits and fewer schools offer this course at 5 credits prior to common course numbering.

Throughout our debates on content, learning outcomes, and credits, it should be noted that the subcommittee showed incredible integrity, collegiality, and a true interest in student success. We completed our task to the best of our ability given a relative dearth of historic or comparative data. Additionally, many faculty completed this work – over 40 hours worth of meeting time, plus additional time to seek information from our own institutions and other institutions that were not represented – with no compensation beyond our usual faculty pay. We are proud of our work and hope that as we revisit these questions in the future, the Transfer Council and the HECC are able to provide more resources and information to allow faculty to make better-informed decisions. We have included some suggested data collection actions in the “Questions for Transfer Council” section below.

Action Items Completed

RECOMMENDATION	STATUS (include the vote tally for each recommendation and whether the motion passed or failed)
MTH or MATH 251Z Decisions	
Course Number and Prefix: MTH or MATH 251Z **Rationale:** Following the pattern established for MATH (or MTH) 105Z, 111Z, and 112Z, we recommend continuing to use either MATH or MTH, as well as using the 'Z' to indicate the course complies with the final HECC recommendations. The number 251 is used without exception for a first course in calculus at public Community Colleges and Universities in Oregon.	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**
MTH or MTH 251Z Course Title: Differential Calculus **Rationale:** While we briefly considered variations on this title, as well as less descriptive titles like "Calculus 1," in the end we settled on the natural descriptive term "differential." This distinguishes the course from the material generally taught in a second term of calculus, which can be broadly described as "integral."	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**
MTH or MTH 251Z Course Credits: 5 **Rationale:** Over 60% of the subcommittee believed that 5 credits is necessary for student success in this course at their institutions.	**Vote:** Yes: 10 No: 5 Abstain: 0 **Passed**
MTH or MTH 251Z Course Description: This course explores limits, continuity, derivatives, and their applications for real-valued functions of a single variable. These topics will be explored graphically, numerically, and symbolically in real-life applications. This course emphasizes abstraction, problem-solving, modeling,	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**

reasoning, communication, connections with other disciplines, and the appropriate use of technology. **Rationale:** This is a very standard class, and while we discussed at length the importance of a few specific topics (discussed in the outcomes below), we all pretty much agreed on this broad overview.	
MTH or MTH 251Z Learning Outcomes: At the end of the course, students will be able to… 1. Calculate limits graphically, numerically, and symbolically; describe the behavior of functions using limits and continuity; and recognize indeterminate forms. 2. Apply the definition of the derivative and analyze average and instantaneous rates of change. 3. Interpret and apply the concepts of the first and second derivative to describe and illustrate function features including the slopes of tangent lines, locations of extrema and inflection points, and intervals of increase, decrease, and concavity. 4. Apply product, quotient, chain, and function-specific rules to differentiate combinations of power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions, as well as functions defined implicitly. 5. Apply derivatives to a variety of problems in mathematics and other disciplines, including related rates, optimization, and L'Hôpital's rule. **Rationale:** There was near unanimous agreement on the vast majority of these topics. There were a few topics that we did consider closely. We discussed the use of "indeterminate forms" as well as the related topic of "L'Hôpital's rule." The later topic is often postponed to a later course, most typically Math 252 or 253. However, many students don't take Math 253 (the typical engineering sequence at several member schools is Math 251, 252, and 254). We also thought it is	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**

just not a "good fit" for Math 252, which generally concerns integral calculus. Finally, we decided to include "improper integrals" in the topics covered in Math 252, and while not absolutely necessary, L'Hôpital's rule is used in many examples of improper integrals. Therefore we decided to include "L'Hôpital's rule" in Math 251Z. It was natural, then, to include a full discussion of "indeterminate forms" as this is important support material for L'Hôpital's rule, as well as being important in its own right. We also discussed which applications of the derivative should be required. While we all agreed on the importance of physics-themed applications such as velocity and acceleration, we decided in the end *not* to require these. It was thought that the instructor could better choose which applications are most relevant to their population of students. We did decide to require two applications that appear in any calculus course: Related Rates and Optimization.	
MTH or MATH 252Z Decisions	
Course Number and Prefix: MTH or MATH 252Z **Rationale:** Following the pattern established for MATH (or MTH) 105Z, 111Z, and 112Z, we recommend continuing to use either MATH or MTH, as well as using the 'Z' to indicate the course complies with the final HECC recommendations. The number 252 is used without exception for a second course in calculus at all public Community Colleges and Universities in Oregon.	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**
MTH or MTH 252Z Course Title: Integral Calculus **Rationale:** This continues the convention we are recommending for the MATH 251Z class by specifying general content material within the title rather than using a number (such as Calculus II).	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**
MTH or MTH 252Z Course Credits: 5 **Rationale:** Over 60% of the subcommittee believed that	**Vote:** Yes: 10 No: 5 Abstain: 0

5 credits is necessary for student success in this course at their institutions.	**Passed**
MTH or MTH 252Z Course Description: This course explores Riemann sums and definite and indefinite integrals for real-valued functions of a single variable. These topics will be explored graphically, numerically, and symbolically in real-life applications. This course emphasizes abstraction, problem-solving, modeling, reasoning, communication, connections with other disciplines, and the appropriate use of technology. **Rationale:** This description continues the pattern of our MATH 251Z recommendations, specifying content while emphasizing the importance of problem-solving, communication, and applications to other disciplines.	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**
MTH or MTH 252Z Learning Outcomes: At the end of the course, students will be able to… 1. Approximate definite integrals using Riemann sums and apply this to the concept of accumulation and the definition of the definite integral. 2. Explain and use both parts of the Fundamental Theorem of Calculus. 3. Choose and apply integration techniques including substitution, integration by parts, basic partial fraction decomposition, and numerical techniques to integrate combinations of power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions. 4. Use the integral to model and solve problems in mathematics involving area, volume, net change, average value, and improper integration. 5. Apply integration techniques to solve a variety of problems, such as work, force, center of mass, or probability. **Rationale:** Integrals are the fundamental topic in this course. The first learning outcome specifies that students will be able to define and interpret the meaning of the integral	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**

as well as to approximate integral values using Riemann sums. The second learning outcome connects derivatives (the main topic of MATH 251Z) to the concept of integral in MATH 252Z. The third outcome specifies a list of techniques for evaluating integrals. We had a long discussion about which techniques to include, and though there are many items we discussed that were not ultimately included on this list, the committee agrees that this is the minimum set needed to comfortably ensure transferability of fundamental skills. The fourth and fifth outcomes specify common applications of integrals, with the fourth outcome requiring applications within the field of mathematics and the fifth describing applications to other disciplines. The committee had a long discussion about how the audiences for calculus classes varied quite a bit among institutions. There was a particularly wide gap between the audience in schools that were preparing students for engineering programs and those that were not. As such the fifth learning outcome suggests many possible applications which could be used to assess the outcome. The array of applications should ensure that students will be well prepared to apply the concept of the integral regardless of which subsequent classes they may take, though it allows the flexibility for schools to focus on particular applications more than others.	
MTH or MATH 253Z Decisions	
Course Number and Prefix: MTH or MATH 253Z **Rationale:** These prefixes and number were already agreed upon across the state.	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**
MTH or MTH 253Z Course Title: Calculus: Sequences and Series **Rationale:** This continues the convention we are recommending for the MATH 251Z class by specifying general content material within the title rather than using a number (such as Calculus II).	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**

MTH or MTH 253Z Course Credits: 4 **Rationale:** Most schools that regularly offer this course have it at 4 credits, and we believe that outcomes we specified for this course constitute 4 credits worth of material.	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**
MTH or MTH 253Z Course Description: This course explores real-valued sequences and series, including power and Taylor series. Topics include convergence and divergence tests and applications. These topics will be explored graphically, numerically, and symbolically. This course emphasizes abstraction, problem-solving, reasoning, communication, connections with other disciplines, and the appropriate use of technology. **Rationale:** This description continues the pattern of our MATH 251Z recommendations, specifying content while emphasizing the importance of problem-solving, communication, and applications to other disciplines.	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**
MTH or MTH 253Z Learning Outcomes: At the end of the course, students will be able to... 1. Recognize and define sequences in a variety of forms and describe their properties, including the concepts of convergence and divergence, boundedness, and monotonicity. 2. Recognize and define series in terms of a sequence of partial sums and describe their properties, including convergence and divergence. 3. Recognize series as harmonic, geometric, telescoping, alternating, or p-series, and demonstrate whether they are absolutely convergent, conditionally convergent, or divergent, and find their sum if applicable. 4. Choose and apply the divergence, integral, comparison, limit comparison, alternating series, and ratio tests to determine the convergence or divergence of a series. 5. Determine the radius and interval of convergence of power series, and use Taylor series to represent, differentiate, and integrate functions.	**Vote:** Yes: 15 No: 0 Abstain: 0 **Passed**

6. Use techniques and properties of Taylor polynomials to approximate functions and analyze error. **Rationale:** The fundamental content of this course is the study of sequences and series, two distinct but interconnected concepts in a third calculus course. We discussed including other content, such as differential equations, an introduction to vectors, or polar/parametric equations, but we did not have sufficient consensus to decide which additional topics to include, and decided that additional topics could be covered in the 25% that instructors and institutions are free to add to their courses. The first outcome deals with sequences and their primary properties, which are a necessary starting point to understand series. The second outcome introduces series and their basic definition and properties, which are the primary object of study of the course. The third and fourth outcomes deal with types of series and common techniques used to analyze them. While this list of series types and techniques is not exhaustive, and certain institutions may choose to add to this list, we agreed that this is the minimal list required to ensure transferability. The fifth and sixth outcomes deal with a particular type of series known as power series (of which Taylor series are a particular example). These series connect the content of this course to the content of the previous two courses, MTH 251Z and MTH 252Z, and provide ways to answer questions that arise in those courses but that those courses did not provide sufficient techniques to answer. Additionally, the content specified in these outcomes is of use in areas outside of mathematics and contain the majority of the applied content in the course.	

Action Items In-progress/Pending

While we do not suggest beginning work on these items right away, we do see these as important future activities for this subcommittee to undertake at the specified time.

ACTIVITY	STATUS (include an estimate—hours/# of meetings—it will take to complete work)
Assessment Review Cycle: Annual meetings beginning in Winter 2026 and Triennial Workshops beginning in Winter 2027	Our annual meetings, likely 6 hours each (split over 2-3 weeks) would be dedicated to discussing faculty and student experience of commonly numbered courses, looking at data collected either by our local institutions or the HECC, and identify areas of improvement and suggested changes to the courses aligned above. Our triennial workshops, likely 12 hours (perhaps split into 6 weeks, or 2 long days) would be dedicated to more definitive problem-solving and recommendation-making based on the data and experiences referenced above. We believe that a three-year review cycle will be sufficient to keep these courses up-to-date and ensure continued transferability around the state.
Further alignment work: MTH 254Z and potentially MTH 255Z	We began to look at the content for MTH 254Z in Spring 2023 and realized there is significant variation around the state. Much of this variation is caused by the fact that some institutions have two courses (MTH 254Z and MTH 255Z) that cover multivariable calculus, whereas some institutions only have one. In fact, the course listed on the HECCs Commonly Transferred Courses is called "Multivariable Calculus" rather than referring to a specific course number, perhaps for this reason. The Transfer Council approved our recommendation to delay the review of these courses until a future cycle. It would likely take an entire review cycle (40 hours of meetings) for the subcommittee to discuss these two courses, find a solution that did not overburden

	schools with only one course, and decide on alignment for one or both courses. We recommend commencing this work **AFTER** the assessment of outcomes of the courses in the current cycle (MTH 251Z, 252Z, 253Z) as the content in MTH 254Z and MTH 255Z is highly dependent upon the courses aligned in this report. Therefore, we recommend starting this report in **Winter 2028 or later.**

Questions for Transfer Council

- We request that data collection mechanisms be put in place at the State level to track how common course numbering affects student success. For instance, we suggest tracking D-F-W-I rates in the courses above, as well as Associate's/Bachelor's degree completion rates. We request that these data be disaggregated by various demographic factors, including but not limited to first-generation student status, Pell eligibility status, race, and sex.
- We request clarity on the process by which community colleges who do not have members on the subcommittee are notified of our recommendations and the decisions of the Transfer Council. In conversations with our colleagues around the state at professional organization conferences such as Oregon Mathematics Association of Two Year Colleges, concern was expressed by non-represented institutions that they have not been told about current or previous changes (e.g. MTH 105Z, 111Z, 112Z) with sufficient time to update their courses to be aligned. We suggest not only contacting the Registrars of these institutions, but additionally the Department Head for Mathematics or similar mathematics representative.

Other Notes

For clarity, we are listing (again) the Learning Outcomes with the interwoven Required Course Content for each of the three courses below, and we request that this information be distributed directly to Mathematics Departments at every public institution in Oregon.

MTH/MATH 251Z Required Course Content

At the end of the course, students will be able to...

1. Calculate limits graphically, numerically, and symbolically; describe the behavior of functions using limits and continuity; and recognize indeterminate forms.
    a. Students will be able to calculate limits graphically, numerically, and algebraically.

    b. Students will be able describe the local and global behavior of functions using limits.
    c. Students will be able to describe the notion of continuity using limits and determine whether a function is continuous.
    d. Students will be able to recognize and evaluate indeterminate forms.
2. Apply the definition of the derivative and analyze average and instantaneous rates of change.
    a. Students will be able to state and use the definition of the derivative to calculate the derivatives of simple functions.
    b. Students will be able to determine whether a function is differentiable using limits.
    c. Students will be able to describe the connection between the definition of the derivative and the average and instantaneous rates of change of a function.
    d. Students will be able to use derivatives in applications using appropriate units.
3. Interpret and apply the concepts of the first and second derivative to describe and illustrate function features including the slopes of tangent lines, locations of extrema and inflection points, and intervals of increase, decrease, and concavity.
    a. Students will recognize and apply the concept of the derivative to describe and find the slopes of tangent lines.
    b. Students will be able to use the derivative to identify the intervals on which a function is increasing or decreasing, and the locations of extreme values.
    c. Students will be able to use the second derivative to identify intervals of concavity and the locations of inflection points.
4. Apply product, quotient, chain, and function-specific rules to differentiate combinations of power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions, as well as functions defined implicitly.
    a. Students will be able to differentiate power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions algebraically.
    b. Students will be able to apply sum, constant multiple, product, quotient, and chain rules to differentiate combinations of functions listed above.

    c. Students will be able to differentiate functions defined implicitly.

5. Apply derivatives to a variety of problems in mathematics and other disciplines, including related rates, optimization, and L'Hôpital's rule.
    a. Students will be able to recognize when L'Hôpital's rule is appropriate and use it to calculate limits involving indeterminate forms.
    b. Students will be able to use the derivative to solve related rates problems.
    c. Students will be able to use the derivative to solve optimization problems.
    d. Students will be able to interpret and communicate the meaning of the derivative and its application in context, including using appropriate notation.

MTH/MATH 252Z Required Course Content

At the end of the course, students will be able to...

1. Approximate definite integrals using Riemann sums and apply this to the concept of accumulation and the definition of the definite integral.
    a. Students will be able to express finite sums using sigma notation.
    b. Students will be able to use Riemann sums to describe the process of approximating the net signed area between a curve and an axis.
    c. Students will be able to relate the definite integral with the concept of accumulation of area or other infinitesimal quantities, including the use of appropriate units.
2. Explain and use both parts of the Fundamental Theorem of Calculus.
    a. Students will be able to recognize and express the definite integral as a limit of a Riemann sum.
    b. Students will use and compare different methods for calculating definite integrals, such as linear properties of integrals, net-signed area, and graphical approaches.
    c. Students will explain and apply the concept of indefinite integrals and its connection to antidifferentiation.
    d. Students will explain the connection between derivatives and integrals and apply their understanding using the Fundamental Theorem of Calculus.
3. Choose and apply integration techniques including substitution, integration by parts, basic partial fraction decomposition, and numerical techniques to

integrate combinations of power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions.

   a. Students will be able to integrate power, polynomial, rational, exponential, logarithmic, trigonometric, and inverse trigonometric functions using basic rules.
   b. Students will be able to use substitution and integration by parts to algebraically integrate appropriate combinations of functions.
   c. Students will be able to use partial fraction decomposition to evaluate integrals of rational functions whose denominators may be expressed as products of distinct linear factors.
   d. Students will be able to use numerical techniques, such as Midpoint, Trapezoidal, and Simpson's rules, to approximate definite integrals.

4. Use the integral to model and solve problems in mathematics involving area, volume, net change, average value, and improper integration.
   a. Students will be able to use definite integrals to find the area between two curves.
   b. Students will be able to calculate volumes of solids, such as solids of revolution or prisms, using integrals.
   c. Students will be able to apply the integral to find the average value of a function over an interval.
   d. Students will be able to apply the integral to find the net change of a function over an interval.
   e. Students will be able to recognize, describe, and calculate improper integrals.
5. Apply integration techniques to solve a variety of problems, such as work, force, center of mass, or probability.
   a. Students will apply integration to problems in the instructor's choice of context, including but not limited to the possible options above. At least two distinct applications are recommended based on the population of students in the class.

MTH/MATH 253Z Required Course Content

At the end of the course, students will be able to...

1. Recognize and define sequences in a variety of forms and describe their properties, including the concepts of convergence and divergence, boundedness, and monotonicity.
   a. define and recognize sequences given explicitly or recursively.

    b. determine whether a given sequence is convergent or divergent by appropriate use of the limit laws for sequences, the Squeeze Theorem, or L'Hôpital's rule.
    c. determine the monotonicity and boundedness properties of a sequence, and use them to draw conclusions about convergence or divergence.
2. Recognize and define series in terms of a sequence of partial sums and describe their properties, including convergence and divergence.
    a. represent a series as a limit of a sequence of partial sums, and describe the notions of convergence or divergence of the series.
    b. algebraically manipulate series, and apply series laws to draw conclusions about divergence, convergence, and the value of the limit.
3. Recognize series as harmonic, geometric, telescoping, alternating, or p-series, and demonstrate whether they are absolutely convergent, conditionally convergent, or divergent, and find their sum if applicable.
4. Choose and apply the divergence, integral, comparison, limit comparison, alternating series, and ratio tests to determine the convergence or divergence of a series.
    a. recognize when the divergence, integral, comparison, and limit comparison tests apply to a particular series, and draw conclusions about the convergence or divergence of the series.
    b. recognize when the ratio and alternating series tests apply to a particular series, and draw conclusions about the absolute convergence, conditional convergence, or divergence of a series.
5. Determine the radius and interval of convergence of power series, and use Taylor series to represent, differentiate, and integrate functions.
    a. find the radius and interval of convergence of a given power series.
    b. use power series to represent functions, and determine the radius of convergence of the series.
    c. differentiate and integrate power series that represent functions.
    d. find the Taylor series centered at a point $x=c$ of a given function and determine its radius of convergence.
6. Use techniques and properties of Taylor polynomials to approximate functions and analyze error.
    a. approximate a function using a Taylor polynomial.
    b. estimate the error in a Taylor polynomial approximation using either Taylor's Inequality or the Alternating Series Estimation Theorem.
    c. approximate an alternating series to a desired error by a partial sum of the series.

Signed by:

Name: Celeste Petersen — Signature *Celeste Petersen*

Name: Leanne Merrill — Signature *Leanne Merrill*

Date: November 6, 2023

Provide copies to:

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Transfer Council Co-chairs	Teresa Rivenes Jose Coll	
HECC	Donna Lewelling, Director of Community Colleges and Workforce Development, Higher Education Coordinating Commission Veronica Dujon, Director of Academic Policy and Authorization, Higher Education Coordinating Commission	

— END OF REPORT–