Indiana Mathematics

Calculus: Grades 9, 10, 11, 12

Adopted 2020

Process Standards For Mathematics

1. **Make sense of problems and persevere in solving them.** PS.1
2. **Reason abstractly and quantitatively.** PS.2
3. **Construct viable arguments and critique the reasoning of others.** PS.3
4. **Model with mathematics.** PS.4
5. **Use appropriate tools strategically.** PS.5
6. **Attend to precision.** PS.6
7. **Look for and make use of structure.** PS.7
8. **Look for and express regularity in repeated reasoning.** PS.8

Limits and Continuity

1. **Understand the concept of limit and estimate limits from graphs and tables of values.** C.LC.1
2. **Find limits by substitution.** C.LC.2
3. **Find limits of sums, differences, products, and quotients.** C.LC.3
4. **Find limits of rational functions that are undefined at a point.** C.LC.4
5. **Find limits at infinity.** C.LC.5
6. **Decide when a limit is infinite and use limits involving infinity to describe asymptotic behavior. Find special limits.** C.LC.6
7. **Find one-sided limits.** C.LC.7
8. **Understand continuity in terms of limits.** C.LC.8
9. **Decide if a function is continuous at a point.** C.LC.9
10. **Find the types of discontinuities of a function.** C.LC.10
11. **Understand and use the Intermediate Value Theorem on a function over a closed interval.** C.LC.11
12. **Understand and apply the Extreme Value Theorem: If f(x) is continuous over a closed interval, then f has a maximum and a minimum on the interval.** C.LC.12

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Differentiation	1. **Understand the concept of derivative geometrically, numerically, and analytically, and interpret the derivative as a rate of change.** C.D.1
	2. **State, understand, and apply the definition of derivative.** C.D.2
	3. **Find the derivatives of functions, including algebraic, trigonometric, logarithmic, and exponential functions.** C.D.3
	4. **Find the derivatives of sums, products, and quotients.** C.D.4
	5. **Find the derivatives of composite functions, using the chain rule.** C.D.5
	6. **Find the derivatives of implicitly-defined functions.** C.D.6
	7. **Find the derivatives of inverse functions.** C.D.7
	8. **Find second derivatives and derivatives of higher order.** C.D.8
	9. **Find derivatives using logarithmic differentiation.** C.D.9
	10. **Understand and apply the relationship between differentiability and continuity.** C.D.10
	11. **Understand and apply the Mean Value Theorem.** C.D.11
Applications of Derivatives	1. **Find the slope of a curve at a point, including points at which there are vertical tangents and no tangents.** C.AD.1
	2. **Find a tangent line to a curve at a point and a local linear approximation.** C.AD.2
	3. **Decide where functions are decreasing and increasing. Understand the relationship between the increasing and decreasing behavior of f and the sign of f'.** C.AD.3
	4. **Solve real-world and other mathematical problems finding local and absolute maximum and minimum points with and without technology.** C.AD.4
	5. **Analyze real-world problems modeled by curves, including the notions of monotonicity and concavity with and without technology.** C.AD.5
	6. **Find points of inflection of functions. Understand the relationship between the concavity of f and the sign of f''. Understand points of inflection as places where concavity changes.** C.AD.6
	7. **Use first and second derivatives to help sketch graphs modeling real-world and other mathematical problems with and without technology. Compare the corresponding characteristics of the graphs of f, f', and f''.** C.AD.7
	8. **Use implicit differentiation to find the derivative of an inverse function.** C.AD.8
	9. **Solve optimization real-world problems with and without technology.** C.AD.9
	10. **Find average and instantaneous rates of change. Understand the instantaneous rate of change as the limit of the average rate of change. Interpret a derivative as a rate of change in applications, including distance, velocity, and acceleration.** C.AD.10

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11. **Find the velocity and acceleration of a particle moving in a straight line.** C.AD.11

12. **Model rates of change, including related rates problems.** C.AD.12

Integrals

1. **Use rectangle approximations to find approximate values of integrals.** C.I.1

2. **Calculate the values of Riemann Sums over equal subdivisions using left, right, and midpoint evaluation points.** C.I.2

3. **Interpret a definite integral as a limit of Riemann Sums.** C.I.3

4. **Understand the Fundamental Theorem of Calculus: Interpret a definite integral of the rate of change of a quantity over an interval as the change of the quantity over the interval.** C.I.4

5. **Use the Fundamental Theorem of Calculus to evaluate definite and indefinite integrals and to represent particular antiderivatives. Perform analytical and graphical analysis of functions so defined.** C.I.5

6. **Understand and use these properties of definite integrals.** C.I.6

   a. <img src="http://purl.org/ASN/resources/images/D21094507/IN_Math_Calculus_C.I.6.a.gif" height="35" alt="IN_Math_Calculus_C.I.6.a.gif"> C.I.6.A

   b. <img src="http://purl.org/ASN/resources/images/D21094507/IN_Math_Calculus_C.I.6.b.gif" height="35" alt="IN_Math_Calculus_C.I.6.b.gif"> C.I.6.B

   c. <img src="http://purl.org/ASN/resources/images/D21094507/IN_Math_Calculus_C.I.6.c.gi height="35" alt="IN_Math_Calculus_C.I.6.c.gif"> C.I.6.C

   d. <img src="http://purl.org/ASN/resources/images/D21094507/IN_Math_Calculus_C.I.6.d.gif" height="35" alt="IN_Math_Calculus_C.I.6.d.gif"> C.I.6.D

   e. <img src="http://purl.org/ASN/resources/images/D21094507/IN_Math_Calculus_C.I.6.e.gi height="35" alt="IN_Math_Calculus_C.I.6.e.gif"> C.I.6.E

   f. If f(x) ≤ g(x) on [a,b], then <img src="http://purl.org/ASN/resources/images/D21094507/IN_Math_Calculus_C.I.6.f_part2.gi height="24" alt="IN_Math_Calculus_C.I.6.f_part2.gif"> C.I.6.F

7. **Understand and use integration by substitution (or change of variable) to find values of integrals.** C.I.7

8. **Understand and use Riemann Sums, the Trapezoidal Rule, and technology to approximate definite integrals of functions represented algebraically, geometrically, and by tables of values.** C.I.8

Applications of Integrals

1. **Find specific antiderivatives using initial conditions, including finding velocity functions from acceleration functions, finding position functions from velocity functions, and applications to motion along a line.** C.AI.1

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2. **Solve separable differential equations and use them in modeling real-world problems with and without technology.** C.AI.2

3. **Solve differential equations of the form y' = ky as applied to growth and decay problems.** C.AI.3

4. **Use definite integrals to find the area between a curve and the x-axis, or between two curves.** C.AI.4

5. **Use definite integrals to find the average value of a function over a closed interval.** C.AI.5

6. **Use definite integrals to find the volume of a solid with known cross-sectional area.** C.AI.6

7. **Apply integration to model and solve (with and without technology) real-world problems in physics, biology, economics, etc., using the integral as a rate of change to give accumulated change and using the method of setting up an approximating Riemann Sum and representing its limit as a definite integral.** C.AI.7