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Calculus Early Transcendentals

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Alta Calculus Early Transcendentals was developed to meet the scope and sequence of a typical three-semester calculus course. To develop the course, Knewton used three main sources of content: Openstax, videos created by a Math Professor we have partnered with, and a team of Subject Matter Experts (SMEs). The SMEs come from diverse backgrounds and are all accomplished academics in the field of mathematics.

Alta Calculus Early Transcendentals has two instructional sequences for every learning objective, giving students multiple opportunities to learn new concepts. Between our OpenStax text content, instructional videos, and Knewton SMEs, we were able to solicit ideas from math instructors and students. Alta Calculus Early Transcendentals covers the typical breadth of calculus topics, and also provides the necessary depth to ensure the course is manageable and engaging for instructors and students alike.

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Chapter 8: Introduction to Differential Equations

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11.1 Parametric Equations

- Write Parametric Equations
    - Parameterize a curve
    - Find the parametric equations for a line segment given an orientation
- Eliminate the Parameter
    - Eliminate the parameter in linear equations
    - Eliminate the parameter in polynomial and radical equations
    - Eliminate the parameter in exponential and logarithmic equations
    - Eliminate the parameter in trigonometric parametric equations
- Graph Parametric Equations
    - Graph parametric equations by plotting points
    - Graph trigonometric parametric equations by plotting points
    - Use parametric equations in applications
- Cycloids
    - Graph a cycloid defined by parametric equations
    - Determine the number of cusps on a hypocycloid

11.2 Calculus of Parametric Curves

- Derivatives of Parametric Equations
    - Find the derivative of a curve defined by polynomial parametric equations
    - Find the derivative of a curve defined by trigonometric parametric equations
    - Find the equation of a line tangent to a parametrically defined curve
    - Find the second derivative of curve defined by parametric equations
- Integrating Parametric Curves
    - Find the area under a curve defined by parametric equations
    - Find the arc length of a curve defined by trigonometric parametric equations

        - Find the surface area of a volume of revolution generated by revolving a parametrically defined curve

11.3 Polar Coordinates

- Defining Polar Coordinates
    - Locate points in a plane by using polar coordinates
    - Convert coordinates from polar form to rectangular form
    - Convert coordinates from rectangular form to polar form
- Converting Equations Between Rectangular and Polar Forms
    - Convert a cartesian equation to polar form
    - Convert a polar equation to cartesian form
- Graphs Using Polar Coordinates
    - Identify symmetry in polar equations and curves
    - Graph polar equations by plotting points and find zeros and maximum values for a polar equation

11.4 Calculus in Polar Coordinates

- Area and Arc Length in Polar Coordinates
    - Find the area of a region between two polar curves
    - Find the arc length of a polar curve
    - Find the area of a region bounded by a polar curve

Chapter 12: Vectors in Space

12.1 Vectors in the Plane

- Introduction to Plane Vectors
    - Describe a plane vector using correct notation
    - Perform the basic vector operations of scalar multiplication and vector addition and subtraction
    - Determine if vectors are equivalent
- Vectors in Component Form
    - Express a vector in component form
    - Find the magnitude of a vector and perform vector operations in component form
    - Find the component form of a vector using trigonometry
- Unit Vectors
    - Find a unit vector
    - Express a vector in terms of standard unit vectors
- Application of Vectors
    - Find a resultant force or velocity using vectors

12.2 Vectors in Three Dimensions

- Introduction to Three-Dimensional Coordinate Systems
    - Sketch a point in three-dimensional space
    - Find the distance between two points in space
- Graph Equations in Three Dimensions
    - Write the equation of a plane parallel to a coordinate plane
    - Find the equation of a sphere
    - Graph other equations in three dimensions

- Application of Vectors in Three Dimensions
    - Graph and find component forms for vectors in three dimensions
    - Perform vector operations in three dimensions
    - Applications of vectors in three dimensions

12.3 The Dot Product

- Properties of the Dot Product
    - Calculate a dot product
    - Use properties of the dot product
- Angles Between Vectors and Directional Angles
    - Find the angle between two vectors using dot products and magnitudes
    - Determine if vectors are orthogonal
    - Determine directional angles and directional cosines
- Projections of Vectors
    - Determine a vector projection
    - Resolve a vector into components
- Applications of Dot Products
    - Use a scalar projection to determine a velocity
    - Use a dot product to determine amount of work

12.4 The Cross Product

- Properties of the Cross Product
    - Find the cross product of two vectors
    - Find the cross product of standard unit vectors and use properties of the cross product
    - Find the magnitude of a cross product
    - Use a determinant to find a cross product
- Find Orthogonal Vectors and Areas with Cross Products
    - Find a unit vector orthogonal to two given vectors
    - Find the area of a parallelogram or triangle using a cross product
- Triple Scalar Products and Volumes of Parallelepipeds
    - Calculate a triple scalar product
    - Find the volume of a parallelepiped
- Applications of Cross Products
    - Determine if vectors are coplanar and find a vector orthogonal to a plane
    - Calculate torque

12.5 Equations of Lines and Planes in Space

- Vector and Parametric Equations of a Line
    - Find parametric and symmetric equations of a line passing through two points
    - Find parametric equations of a line segment
    - Calculate the distance from a point to a line
    - Determine if two lines are parallel, intersecting, or skew
- Equations for a Plane
    - Write the equation of a plane given points or lines
    - Find the distance between a plane and a point

- Parallel and Intersecting Planes
    - Find the line of intersection for two planes
    - Find the angle between two planes
    - Find the distance between two parallel planes

12.6 Quadric Surfaces

- Identifying Cylinders
    - Identify the graph of a cylindrical surface given an equation
- Identifying Quadric Surfaces
    - Recognize a quadric surface and sketch an ellipsoid
    - Identify the equation or traces of a hyperboloid of one or two sheets or an elliptic cone
    - Identify the equation or traces of an elliptic paraboloid or hyperbolic paraboloid

12.7 Cylindrical and Spherical Coordinates

- Cylindrical Coordinates
    - Convert between cylindrical and rectangular coordinates
    - Identify a surface in the cylindrical coordinate system
- Spherical Coordinates
    - Convert between spherical and rectangular coordinates
    - Identify a surface in the spherical coordinate system

Chapter 13: Vector-Valued Functions

13.1 Vector-Valued Functions and Space Curves

- Definition and Graphs of Vector-Valued Functions
    - Evaluate and determine the domain of a vector-valued function
    - Graph a vector-valued function
- Limits and Continuity of Vector-Valued Functions
    - Evaluate the limit of a vector-valued function
    - Determine if a vector-valued function is continuous at a point

13.2 Calculus of Vector-Valued Functions

- Derivatives of Vector-Valued Functions
    - Find the derivative of a vector-valued function
    - Use linear properties of derivatives of vector-valued functions
    - Use dot product, cross product, and chain rule properties of derivatives of vector-valued functions
- Tangent Vectors and Unit Tangent Vectors
    - Find the unit tangent vector to a vector-valued function
- Integrals of Vector-Valued Functions
    - Find the antiderivative of a vector-valued function
    - Find the definite integral of a vector-valued function

13.3 Arc Length and Curvature

- Arc Length and Arc-Length Parameterization
    - Find the arc length for a vector-valued function
    - Find an arc-length parameterization for a vector-valued function
- Curvature
    - Find the curvature of a curve

- Normal and Binormal Vectors
    - Find the principal unit normal vector and binormal vector of a curve
    - Find the equation of an osculating circle

13.4 Motion in Space

- Motion Vectors in the Plane and in Space and Components of the Acceleration Vector
    - Find the velocity, acceleration, and speed of a particle moving along a curve
    - Find the tangential and normal components of acceleration
- Projectile Motion
    - Solve problems involving projectile motion

Chapter 14: Differentiation of Functions of Several Variables

14.1 Functions of Several Variables

- Graphs of Functions of Two Variables
    - Find the domain and range of a function of two variables
    - Identify the graph of a two variable function
- Level Curves and Vertical Traces of Functions of Two Variables
    - Find the level curves of a function of two variables
    - Find the vertical traces of a function of two variables
- Graphs and Level Curves of Functions of Three Variables
    - Find the domain of a function of three variables
    - Find the level surfaces of a function of three variables

14.2 Limits and Continuity for Functions of Several Variables

- Limit of a Function of Two Variables
    - Find the limit of a function of two variables using direct substitution
    - Use paths to determine if the limit of a function of two variables exists
- Continuity of a Function of Two Variables
    - Understand the conditions for continuity of a function of two variables at a point
    - Determine the region of the coordinate plane where a function of two variables is continuous
- Limit of a Function of Three or More Variables
    - Find the limit of a function of three variables

14.3 Partial Derivatives

- Partial Derivatives of a Function of Two Variables
    - Find the partial derivative of a function of two variables
    - Estimate the partial derivative of a function at a point from a graph or contour map
- Partial Derivatives of a Function of Three or More Variables
    - Find the partial derivative of a function of three variables
- Higher Order Partial Derivatives
    - Find the higher order partial derivatives of a function of two variables
- Partial Differential Equations
    - Verify a solution to a partial differential equation

14.4 Tangent Planes and Linear Approximations

- Tangent Planes
    - Find the equation of the tangent plane to a surface at a point

- Linear Approximations of Functions of Several Variables
    - Approximate the value of a function of several variables using a linear approximation
- Differentiability of Functions of Several Variables
    - Understand differentiability for a function of several variables and the relationship between continuity of first partials and differentiability
- Differentials and Maximum Error
    - Use the differential to approximate the change in a function given the change in the inputs or to calculate maximum error

14.5 The Chain Rule

- The Chain Rule for Functions of Several Variables
    - Use the chain rule for one independent variable
    - Use the chain rule for two independent variables
    - Use the generalized chain rule
- Implicit Differentiation by Partial Derivatives
    - Use implicit differentiation to find partial derivatives

14.6 Directional Derivatives and the Gradient Vector

- Directional Derivatives and Gradients for Functions in Two Variables
    - Find the directional derivative of a function of two variables
    - Find the gradient of a function of two variables
- Applications of Directional Derivatives and Gradients
    - Find the maximum and minimum directional derivative of a function of two variables
    - Understand the relationship between the gradient and level curves of a two variable function
- Directional Derivatives and Gradients for Functions in Three Variables
    - Find the gradient of a function of three variables
    - Find the directional derivative of a function of three variables

14.7 Maximum and Minimum Values for Functions of Two Variables

- Critical Points and the Second Derivative Test for Functions of Two Variables
    - Find critical points of a function of two variables
    - Use the second derivative test to classify critical points of a function of two variables
- Absolute Extrema and Applications for Functions of Two Variables
    - Find the absolute extrema of a function of two variables on a closed region
    - Solve maximization and minimization word problems with multiple variables

14.8 Lagrange Multipliers

- Lagrange Multipliers with One Constraint
    - Use Lagrange multipliers to find maximum and minimum values of a function of two variables with a single constraint
    - Use Lagrange multipliers to find maximum and minimum values of a function of three variables with a single constraint
- Lagrange Multipliers with Two Constraints
    - Use Lagrange multipliers to find maximum and minimum values of a function with two constraints

Chapter 15: Multiple Integration

15.1 Double Integrals over Rectangular Regions

- Volume and Double Riemann Sums
  - Set up and approximate a double integral over a rectangular region
- Iterated Integrals and Properties of Double Integrals
  - Recognize and use some of the properties of double integrals
  - Evaluate a double integral over a rectangular region by writing it as an iterated integral
  - Evaluate a double integral over a rectangular region by reversing the order of integration
- Applications of Double Integrals Over Rectangular Regions
  - Find the volume under a surface
  - Find the average value of a function over a rectangular region

15.2 Double Integrals over General Regions

- Double Integrals Over Nonrectangular Regions
  - Recognize when a function of two variables is integrable over a general region
  - Evaluate a double integral by computing an iterated integral over a region bounded by two lines and two functions
- Double Integrals by Decomposing Regions or Changing the Order of Integration
  - Evaluate a double integral over a more complex region by decomposing the region
  - Simplify the calculation of an iterated integral by changing the order of integration
- Applications of Double Integrals Over General Regions
  - Use double integrals to calculate the area of a general plane region
  - Use double integrals to calculate the volume of a region between two surfaces over a general plane region
  - Find the average value of a function over a general region
- Improper Double Integrals
  - Evaluate a double improper integral
- The Joint Density Function with Double Integrals
  - Find the probability given a joint density function
  - Find the expected value given a joint density function

15.3 Double Integrals in Polar Coordinates

- Double Integrals Over a Polar Rectangular Region
  - Express a region of the plane in terms of polar coordinates
  - Evaluate a double integral in polar coordinates by using an iterated integral
  - Convert an integral from rectangular to polar coordinates and evaluate
- Double Integrals Over a General Polar Region
  - Evaluate a double integral over a general polar region
- Polar Areas and Volumes
  - Use double integrals in polar coordinates to compute areas
  - Use double integrals in polar coordinates to compute the area between polar curves
  - Use double integrals in polar coordinates to compute volume
- Improper Double Integrals in Polar Coordinates
  - Evaluate a double improper integral in polar coordinates

15.4 Triple Integrals

- Triple Integrals Over a Rectangular Box
  - Evaluate a triple integral over a box
- Triple Integrals Over a General Bounded Region
  - Evaluate a triple integral over a general bounded region
  - Simplify a calculation by changing the order of integration of a triple integral
- Volume and Average Value of a Function of Three Variables
  - Find the volume of a general bounded region using a triple integral
  - Calculate the average value of a function of three variables

15.5 Triple Integrals in Cylindrical and Spherical Coordinates

- Integration in Cylindrical Coordinates
  - Evaluate a triple integral over a cylindrical box
  - Convert a triple integral from rectangular to cylindrical coordinates and evaluate
- Integration in Spherical Coordinates
  - Evaluate a triple integral in spherical coordinates
  - Convert a triple integral from rectangular to spherical coordinates and evaluate
  - Change the order of integration in a spherical triple integral
- Volume in Spherical Coordinates
  - Compute the volume of a portion of a sphere using spherical coordinates
  - Compute the volume between two surfaces in spherical coordinates

15.6 Calculating Centers of Mass and Moments of Inertia

- Center of Mass in Two Dimensions
  - Use double integrals to find the total mass of a lamina given its density function
  - Use double integrals to find the moments and center of mass of a lamina
  - Use double integrals to locate the centroid of a two-dimensional region
- Moments of Inertia in Two Dimensions
  - Use double integrals to find the moments of inertia of a two-dimensional object
  - Use double integrals to find the radius of gyration of a two-dimensional object
- Center of Mass in Three Dimensions
  - Use triple integrals to find the mass of a three-dimensional object
  - Use triple integrals to locate the center of mass of a three-dimensional object
- Moments of Inertia in Three Dimensions
  - Use triple integrals to find the moments of inertia of a solid

15.7 Change of Variables in Multiple Integrals

- Planar Transformations and Jacobians
  - Determine the image of a region under a given transformation of variables
  - Compute the Jacobian of a given transformation
- Change of Variables for Double Integrals
  - Evaluate a double integral using a change of variables
- Change of Variables for Triple Integrals
  - Evaluate a triple integral using a change of variables

Chapter 16: Vector Calculus

16.1 Vector Fields

- Drawing a Vector Field
  - Find the vector associated with a given point in a vector field
  - Identify the plot of a two-dimensional vector field
  - Identify the plot of a three-dimensional vector field
- Gradient Fields
  - Plot the gradient vector field of a scalar function
  - Verify a potential function for a vector field
  - Use the cross-partial property to determine if a vector field is not conservative

16.2 Line Integrals

- Scalar Line Integrals
  - Calculate a scalar line integral along a general curve
  - Find the arc length of a curve using a line integral
- Vector Line Integrals
  - Calculate a vector line integral along an oriented curve in space
  - Calculate a vector line integral written in expanded notation
  - Use properties to compute a vector line integral
- Applications of Line Integrals
  - Calculate the mass of a wire
  - Use a line integral to compute the work done in moving an object along a curve in a vector field
- Flux and Circulation
  - Compute the flux of a vector field across a curve
  - Calculate the circulation of a vector field

16.3 Conservative Vector Fields

- Curves and Regions
  - Identify simple and closed curves
  - Identify connected and simply connected regions
- Fundamental Theorem for Line Integrals
  - Use the Fundamental Theorem for Line Integrals to compute line integrals
  - Understand the definition of path independence
  - Find the potential function for a vector field in two dimensions
  - Find the potential function for a vector field in three dimensions
- Potential Functions for Line Integrals
  - Use the cross-partial property to show that a vector field is conservative
  - Find the potential function and use it to compute a line integral

16.4 Green’s Theorem

- Circulation Form of Green's Theorem
  - Apply the circulation form of Green's theorem
  - Use Green's theorem to calculate work
  - Use Green's theorem to find the area of a region enclosed by a curve

- Flux Form of Green's Theorem
    - Apply the flux form of Green's theorem
    - Find the flux in a word problem context
- Source Free and Harmonic Functions
    - Determine if a vector field F is source free and find a stream function for F
    - Determine if a vector field satisfies Laplace's equation
- Green's Theorem on General Regions
    - Use Green's theorem on a region with holes

16.5 Divergence and Curl

- Divergence
    - Find the divergence of a vector field
    - Determine if a vector field is magnetic
- Divergence and Flow
    - Determine if a vector field is source free using the divergence test
    - Use divergence to determine flow of a fluid
- Curl
    - Compute the curl of a vector field
    - Show that a vector field is not the curl of another vector field
- Applications of Curl
    - Use curl to determine if a vector field is conservative
    - Use Laplace's equation to determine if a function can represent an electrostatic potential

16.6 Surface Integrals

- Parametric Surfaces
    - Identify the surface described by a parametrization
    - Find a parametrization for a surface
    - Identify a smooth, regular parametrization of a surface
- Scalar Surface Integrals
    - Find the surface area of a parametrized surface
    - Calculate the surface integral of a scalar valued function
    - Calculate the mass of a sheet described by a parametrized surface
- Surface Integrals of a Vector Field
    - Find an orientation for a surface
    - Calculate a surface integral of a vector field
- Applications of Surface Integrals
    - Calculate mass flow rate using a surface integral
    - Calculate heat flow using a surface integral

16.7 Stokes’ Theorem

- Understand and Apply Stokes' Theorem
    - Understand Stokes' theorem
    - Use Stokes' theorem to compute a surface integral
    - Use Stokes' theorem to compute a line integral
    - Use Faraday's law to compute the curl of an electric field

16.8 The Divergence Theorem

- Understand and Apply the Divergence Theorem
    - Understand the divergence theorem
    - Use the divergence theorem to compute the flux across a closed surface
- Divergence Theorem for Electrostatic Fields
    - Apply the divergence theorem to electrostatic fields

Chapter 17: Second-Order Differential Equations

17.1 Homogeneous Second-Order Linear Differential Equations

- Understanding and Classifying Linear Differential Equations
    - Identify linear and homogeneous differential equations
    - Verify a solution to a differential equation
- The Superposition Principle
    - Understand the superposition principle
    - Identify linearly dependent functions
    - Find the general solution to a differential equation
- Solving Homogeneous Second-Order Linear Differential Equations
    - Solve a second-order differential equation with constant coefficients, characteristic equation has distinct roots
    - Solve a second-order differential equation with constant coefficients, characteristic equation has a repeated root
    - Solve a second-order differential equation with constant coefficients, characteristic equation has complex roots
- Initial Value Problems for Second-Order Linear Differential Equations
    - Solve an initial value problem for a second-order differential equation
    - Solve a second-order differential equation representing a spring problem
    - Solve a boundary value problem for a second-order differential equation

17.2 Nonhomogeneous Linear Equations

- Finding Particular Solutions Using Undetermined Coefficients
    - Given a particular solution, find the general solution to a nonhomogeneous differential equation
    - Use the method of undetermined coefficients when r(x) is a polynomial or exponential
    - Use the method of undetermined coefficients when r(x) is a more complicated function
    - Use the method of undetermined coefficients when r(x) is a solution of the complementary equation
- Finding Particular Solutions Using Variation of Parameters
    - Use Cramer's rule to solve a system of equations with variable coefficients
    - Use the method of variation of parameters to find a particular solution to a differential equation

17.3 Applications of Second-Order Differential Equations

- Simple Harmonic Motion
    - Solve problems involving simple harmonic motion
    - Express a sum of trigonometric functions as a single trigonometric function

- Damped Spring-Mass Systems
    - Solve an overdamped spring-mass system
    - Solve a critically damped spring-mass system
    - Solve an underdamped spring-mass system
    - Find the transient and steady-state solution in an application problem
- RLC Series Circuits
    - Solve problems involving an RLC series circuit

17.4 Power Series Solutions

- Solve Differential Equations with Power Series
    - Find a power series solution to a differential equation