Stony Brook University
Mathematics Department
Julia Viro

MAT 203, Lec 01
Calculus III with Applications
Spring 2022

Syllabus

Course description (from Undergraduate Bulletin): Vector algebra in two and three dimensions, multivariate differential and integral calculus, optimization, vector calculus including the theorems of Green, Gauss, and Stokes. Applications to economics, engineering, and all sciences, with emphasis on numerical and graphical solutions; use of graphing calculators or computers. May not be taken for credit in addition to AMS 261.

Prerequisite: C or higher in MAT 127 or 132 or 142 or AMS 161 or level 9 on the mathematics placement examination

SBC: STEM+

Credits: 4

Instructors

• Julia Viro (lectures)
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MLC hours (online): Tuesday and Thursday at 10am-11am.
Office hours (online): Tuesday at 3pm-4pm.
Zoom personal meeting room:
https://stonybrook.zoom.us/j/9792031214

• Runjien Hu (recitation R01)
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MLC hours (online): Thursday and Friday at 9am-10am.
Office hours (online): Tuesday at 4pm-5pm.
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• Srijan Ghosh (recitations R02, R03)
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MLC hours (online): Monday at 6pm-8pm.
Online office hours (online): Wednesday at 5pm-6pm.
Zoom personal meeting room:
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Blackboard. All course documents (Syllabus, Lecture notes, Practice exams, etc.) will be posted on Blackboard MAT 203.01(R01-R03) in the section of Course Documents.

Textbook: Larson, Edwards *Multivariable Calculus*, 11th edition, Brooks/Cole. The cheapest way to get the book (as e-book) is thought WebAssign package (assignments and e-book).

WebAssign. WebAssign is the course online platform and you need to purchase an access code (the first two weeks are free).

Weekly assignments (due each Thursday 11:59 pm) will be given through WebAssign. You can access WebAssign through Blackboard of your recitation section.

Calculators. Calculators will NOT be allowed on the exams. Some homework problems may require use of calculator, though. Google calculator will serve all your needs.

You are encouraged to use any 2D and 3D graphing programs that will help you to visualize multivariable calculus events (but not on the exams!)

Homework. Homework will be assigned weekly in the form of WebAssign. Paper homeworks may be introduced depending on overall performance of the class.

Exams. Midterms dates are tentative. Always check Announcements on Blackboard for updated information.

Midterm 1	Tu 2/22	11:30am-12:50pm (in class)
Midterm 2	Tu 4/12	11:30am-12:50pm (in class)
Final	Tu 5/17	11:15am-1:45pm

Missing an exam without any serious and documented reason will result to failure in the course.

Make-up policy. Make-up examinations are given only for work missed due to unforeseen circumstances beyond the student's control. Late home work will not be accepted. Extra assignments to "boost" the grades will not be given.

Grading System. Your grade for the course will be based on: Homework (through WebAssign): 5%, Recitations: 5%, Midterm 1: 25%, Midterm 2: 25%, Final Exam: 40%.

Where to get help. If you have any mathematical questions or concerns, your instructors are ready to help you. Please address to your recitation instructor (during his/her office hours or by e-mail) or your lecturer (during office hours or by e-mail).

Also, you can get help in Math Learning Center (MLC). It is located in Math building S-235. No appointment is needed:

http://www.math.stonybrook.edu/mlc/center-hours.html

Student Accessibility Support Center (SASC) statement:

If you have a physical, psychological, medical or learning disability that may impact your course work, please contact Student Accessibility Support Center, ECC (Educational Communications Center) Building, Room 128, (631)632-6748. They will determine with you what accommodations, if any, are necessary and appropriate. All information and documentation is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and the Student Accessibility Support Center. For procedures and information go to the following website:

https://ehs.stonybrook.edu//programs/fire-safety/emergency-evacuation/evacuation-guide-disabilities and search Fire Safety and Evacuation and Disabilities.

Academic integrity statement:

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology and Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at:

http://www.stonybrook.edu/commcms/academic integrity/index.html

Critical Incident Management Statement:

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.

Weekly plan (tentative) is presented below.

Week 1 (January 24-28). Vectors and coordinate spaces.

Lectures: Lecture 1 (Vectors and coordinates), Lecture 2 (Dot product. Cross product).

Learning objectives. The subject of multivariable calculus. Scalars and vectors. Vector operations and their properties. Vectors ih Physics. Coordinate method. Coordinates of a vector. Coordinate form of vector operations. Magnitude and distance in coordinates. Coordinate space $\mathbb{R}^n$. Dot product: algebraic and geometric definitions, properties. Angle between vectors. Orthogonality and orthogonal projections. Physical applications of orthogonality. Cross product: algebraic and geometric definitions, properties. Orientation of the space. Applications to area calculations. Triple product: definition and geometric interpretation. Coplanar vectors.

Learning outcomes. A student should be able to
1. outline the scope of the course, distinguish different types of functions studied in multivariable calculus and use correct terminology
2. explain the difference between scalars and vectors and provide numerous examples of scalars and vectors in Physics
3. define a vector as a class of co-directed segments of the same length and use correct terminology and notations related to vectors
4. characterize a vector by its direction and magnitude, list properties of the magnitude
5. interpret a vector as a translation
6. define an opposite vector and interpret geometrically a vector subtraction
7. list properties of scalar multiplication and vector addition and provide geometric description of these operations
8. describe the idea of coordinate method and explain why it is used in mathematics
9. express vector operations in coordinate form

10. justify the distance formula in coordinate form
11. generalize the concept of coordinate plane $\mathbb{R}^2$ and coordinate 3-space $\mathbb{R}^3$ to a coordinate space $\mathbb{R}^n$ of arbitrary dimension n.
12. solve problems requiring using vector operations and give geometric interpretation of the problems.
13. define the dot product of vectors algebraically (in coordinate form) and geometrically
14. find the angle between two vectors given by their coordinates
15. relate the magnitude of a vector and the dot product of the vector by itself
16. define orthogonal vectors, relate orthogonality and properties of the dot product and use this for problem solving
17. express the idea of orthogonal decomposition of a vector, both algebraically and geometrically
18. prove the formula for orthogonal projection in terms of dot product and use this formula for calculations
19. interpret physical problems involving forces in terms of vector algebra
20. define the cross product of two vectors in $\mathbb{R}^3$ geometrically and algebraically (as a determinant), list properties of the cross product
21. express the concept of an orientation of the space
22. show proficiency in calculation of cross product of two vectors given by their coordinates
23. use cross product for area calculations
24. express the triple product of vectors algebraically (as a determinant) and geometrically
25. give necessary and sufficient condition for coplanar vectors.

Week 2 (January 31 - February 4). Lines and planes. Conics and quadrics.

Lectures: Lecture 3 (Lines and planes), Lecture 4 (Conics and quadrics)

Learning objectives. Parametric equation of a line. Normal equation of a line on a plane. Angle between lines. Normal equation of a plane in the space. Angle between two lines in the space. Parametric equation of a plane. Distance from a point to a plane. Parametric equation of a line in the space. The standard equation of a line. Distance from a point to a plane. Distance from a point to a line. Distance between two lines in the space. What conic and quadrics are. Ellipse, hyperbola and parabola by their canonical equations. Irreducible conics and their equations. Quadrics by their canonical equations.

Learning outcomes. A student should be able to
1. explain geometrical meaning of the parametric equation of a line, both in vector and coordinate form and solve related problems
2. interpret geometrically the normal equation of a line on a plane, both in vector and coordinate form and solve related problems
3. convert a parametric equation of a line into normal equation and vice versa
4. calculate the angle between two lines given by equations in any form
5. derive the normal equation of a plane in the space, both in vector and coordinate form and solve related problems
6. write down the equation of a plane passing through three non-collinear points
7. list all possible mutual positions of two plans in the space
8. calculate the angle between two planes in the space

9. draw a plane in the space using three-intercept form of the standard equation
10. derive the parametric equation of a plane in the space
11. apply the distance formula to problem solving
12. interpret geometrically the parametric equation of a line in the space, both in vector and coordinate form and solve related problems
13. interpret geometrically the standard equation of a line in the space and solve related problems
14. apply various distance formulas in the space
15. recognize a conic (both irreducible and reducible) by its canonical equation and draw the conic on the coordinate plane
16. recognize by equations and sketch the following quadrics: ellipsoid, hyperboloid of one sheet, hyperboloid of two sheets, elliptic cone, elliptic, parabolic and hyperbolic cylinders, elliptic paraboloid, hyperbolic paraboloid

Week 3 (February 7-11). Plane and spacial curves. Curvature, torsion and the Frenet frame

Lectures: Lecture 5 (Curves), Lecture 6 (Curvature, torsion and the Frenenet frame).

Learning objectives. Parametric curves on a plane and in the space. Parametric equations of a circle and ellipse. Helix. Curves as intersections of surfaces. Kinematic interpretation of a curve. Velocity, speed, acceleration. Arc length. Catenary. Arc length parametrization of a curve. The Frenet frame. Unit tangent vector. Curvature. Radius of curvature. Unit principal normal vector. Osculating circle. Unit binormal vector. Osculating, normal and rectifying planes. Torsion. The Frenet-Serret formulas. The Fundamental Theorem on space curves. The Frenet frame, curvature and torsion in arbitrary parametrization.

Learning outcomes. A student should be able to

3. explain what a parametric curve is
4. write down parametric equations of graphs of function
5. explain why a curve may be paramertized in infinitely may ways and give examples of different parametrizations of the same curve
6. provide various parametrizations of a circle, ellipse and their arcs
7. relate the equation and the shape of a helix
8. write down a parametric equation of a curve gives as the intersection of two surfaces
9. describe a parametric curve kinematically
10. calculate the arc length curves
11. write down the equation of catenary
12. characterize an arc-length paramertization in terms of the speed
13. calculate an arc-length paramertization for a line and a circle
14. give algebraic and geometric description for the Frenet triple $(\mathbf{T}, \mathbf{N}, \mathbf{B})$
15. define curvature in terms of arc-length parametrization
16. provide algebraic and geometric description of the radius of curvature
17. define unit principal normal vector in terms of arc-length parametrization
18. describe unit principal normal vector
19. explain what the osculating circle is
20. define unit binormal vector in terms of arc-length parametrization

21. explain geometrically what osculating, normal and rectifying planes are
22. provide algebraic and geometric description of the torsion
23. express the rate of change of the Frenet frame in matrix forms
24. formulate the Fundamental Theorem on space curves
25. explain what tangential and normal acceleration are
26. write down the Frenet frame in arbitrary parametrization and apply them to calculate the Frenet frame of curves
27. express curvature and torsion in terms of arbitrary parametrization
28. calculate the Frenet frame, curvature and torsion for a helix using a) arc-length parametrization b) using arbitrary parametrization

Week 4 (February 14-18). Functions of several variables. Partial derivatives and differentiability.

Lectures: Lecture 7 (Functions of several variables), Lecture 8 (Differentiability).

Learning objectives. Functions of several variables and their visualization by graphs and level curves. Level surfaces of functions of three variables. Limit of a function in several variables. Continuity. Partial derivatives. Higher-order partial derivatives. Laplace operator and harmonic functions. The gradient. Differentiability of a function of several variables and existence of the tangent plane. Linear approximations of functions. Approximate calculations. Relation between continuity, differentiability and existence of partial derivatives. Total differential.

Learning outcomes. A student should be able to
1. describe the graph of a function of two variables as a surface in $\mathbb{R}^3$
2. use the concept of level curves to describe a function
3. distinguish graphs and level surfaces
4. comprehend the idea of the limit of a function in several variables
5. calculate the limit of a function in several variables using the definition and properties of the limit
6. handle the situations when the limit does not exist
7. prove continuity of a function using the definition
8. give definition and geometric interpretation of partial derivatives
9. calculate partial derivatives using definition
10. demonstrate proficiency in calculation of partial derivatives of any order
11. understand what a harmonic function is and verify whether a given function is harmonic
12. define the gradient of a function and be fluent in calculation of the gradient
13. understand formula for the differentiability of a function is several variables and provide its geometric interpretation
14. write the equation of the tangent plane to a given function at a given point
15. find a linear approximation of a given function near a given point
16. apply the concept of linearization to approximate calculations
17. identify the situations when a function is not differentiable at a point
18. operate with the total differential of a function in error analysis.

Week 5 (February 21 - 25). Chain rule. Directional derivative. The implicit function theorem.

Lectures: Lecture 9 (The Chain rule), Lecture 10 (Implicit function theorem).

Learning objectives. Jacobian matrix and the differential of a function. The chain rule via matrix multiplication. Gradient and level curves and level surfaces. Application of gradient for finding tangent planes and tangent lines. Directional derivative. Functions defined implicitly. The implicit function theorem. Implicit differentiation.

Learning outcomes. A student should be able to
1. write down the Jacobian matrix of a function $f : \mathbb{R}^n \to \mathbb{R}^m$
2. express the chain rule in terms of matrix multiplication
3. express the chain rule in terms of the dependence chart for variables
4. implement the chain rule in various situations
5. use the chain rule to prove that the gradient of a function is orthogonal to the level curve or level surface
6. use the gradient for finding the tangent plane and the normal line to a surface
7. use the gradients for finding the tangent line to the intersection curve of two surfaces
8. use the gradients for finding the angle between two curves.
9. define the directional derivative, explain what for it is needed and how to calculate it
10. interpret directional derivative as the rate of growth
11. calculate fluently the directional derivative
12. explain what is a function defined implicitly by an equation
13. state the implicit function theorem for two and three variables and give their geometric interpretation
14. apply the implicit function theorem for functions of two and three variables
15. find the tangent line to a curve given by an implicit equation
16. find partial derivatives by implicit differentiation.

Week 6 (February 28 - March 4). Extreme values.

Lectures: Lecture 11 (Extreme value problems. Part 1).

Learning objectives. Various types of extreme value problems: local, global on a compact domain, with constraints. Local and global extrema of a function in several variables. Necessary condition for extremum. The Hessian matrix. Types of critical points (local maximum, local minimum, saddle point). Second derivative test for a function in two variables.

Learning outcomes. A student should be able to
1. describe local maximum and local minimum of a function algebraically and geometrically
2. describe global maximum and local minimum of a function algebraically and geometrically
3. define critical and singular points of a function
3. formulate a necessary condition for extremum
4. distinguish interior, exterior, and boundary points of a region
5. present examples of functions with non-degenerate critical points, degenerate critical points and singular points
6. write down the Hessian matrix of a function of two variables
7. formulate the second derivative test for a function in two variables
8. apply the second derivative test to classification of critical points.

Week 7 (March 7-11). Extreme value problems.

Lectures: Lecture 12 (Extreme value problems. Part 2), Lecture 13 (Extreme value problems. Part 3).

Learning objectives. Closed, bounded, and compact sets. Sufficient condition for extremum. Solving global extreme value problem on a compact domain. Extreme value problems with a constraint. Necessary conditions for conditional extremum. Lagrange multipliers. Linear dependence of gradients.

Learning outcomes. A student should be able to
1. identify whether a set is closed, bounded, compact
2. state the sufficient condition for extremum
3. present an algorithm for solving a global extreme value problem on a compact domain and apply this algorithm for problem solving
4. adopt the algorithm for functions in three variables
5. identify extreme value problems with a constraint and provide an algorithm for their solution and its geometric interpretation
6. formulate necessary conditions for conditional extremum
7. solve extreme value problems with constraints
8. apply method of Lagrange multipliers to solve EVP with one and two constraints
9. use methods of linear algebra to solve EVP with one and two constraints.

Week 8 (March 14-18. Spring recess, no classes).

Week 9 (March 21- 25). Non-Cartesian coordinates. Double integrals.

Lectures: Lecture 14 (Non-Cartesian coordinates), Lecture 15 (Double integrals).

Learning objectives. Polar coordinates. Polar equations of curves. Polar coordinates as a map. Cylindrical coordinates. Coordinate surfaces in cylindrical coordinates. Cylindrical coordinates as a map. Spherical coordinates. Coordinate surfaces in spherical coordinates. Axioms for double integral. Evaluation of double integral using the axioms. Fubini's theorem for iteration. Double integral for area and volume calculations.

Learning outcomes. A student should be able to
1. use polar and Cartesian coordinates interchangeably
2. work with polar equations of curves
3. explain how to construct Archimedes's spiral, cardioid, and polar rose by their polar equations
4. understand how polar, Cartesian and parametric equation of the same curve are related
5. comprehend polar coordinates as a map $\mathbb{R}^2 \to \mathbb{R}^2$
6. recalculate Cartesian coordinates via cylindrical coordinates
7. identify coordinate surfaces in cylindrical coordinates
8. recognize equations of cylinder, paraboloid and cone in cylindrical coordinates
9. comprehend cylindrical coordinates as a map $\mathbb{R}^3 \to \mathbb{R}^3$
10. recalculate Cartesian coordinates via spherical coordinates
11. identify coordinate surfaces in spherical l coordinates
12. comprehend spherical coordinates as a map $\mathbb{R}^3 \to \mathbb{R}^3$
13. understand latitude and longitude as coordinates on Earth's surface
14. list the axioms defining the double integral
15. analyze the similarity and differences between single definite integral and double integral
16. evaluate double integrals using the axioms

17. identify vertically simple and horizontally simple regions and iterate the double integral using Fubini's theorem
18. express the area of a region in terms of double integral and evaluate the integral
19. express the volume of a spatial region in terms of double integral and evaluate the integral.

Week 10 (March 28- April 1). Change of variables in double integrals.

Lectures: Lecture 16 (Change of variables in double integrals).

Learning objectives. Change of variables in double integral. Jacobian of the change of variables and its geometric interpretation. Area element in polar coordinates. Generalized polar change of coordinates. Calculation of areas enclosed by polar curves. Change of variables followed by iteration. Jacobian of the inverse map. Applying various integration techniques for calculation of double integrals.

Learning outcomes. A student should be able to
1. explain how the area changes under a linear map
2. understand the general formula for change of variables in double integral and its geometrical interpretation
3. relate Jacobian and the area element under change of variables
4. justify analytically and geometrically the area element in polar coordinates
5. calculate the area of a disk and the ares of elliptic disk using polar coordinates
6. extend the formulas of polar change to a generalized polar change
7. apply the generalized polar change of coordinates to evaluation of integrals
8. identify the Gaussian integral and calculate it
9. calculate the area of a region enclosed by polar curves using the iteration in polar coordinates
10. arrange a change of variables respecting the geometry of the integration region
11. calculate the Jacobian of the inverse map
12. sketch the dome of Viviani and calculate its volume using various integration techniques.

Week 11 (April 4-8)). Triple integrals.

Lectures: Lecture 17 (Triple integrals).

Learning objectives. Appearance and properties of the triple integral. Iterations of the triple integral. Integration along the stick and along the slices. Change of variables in the triple integral. Jacobian of change of variables. Cylindrical change of variables. Spherical change of variables. Iteration in cylindrical and spherical coordinates.

Learning outcomes. A student should be able to
1. recognize a triple integral by its appearance and list properties of the triple integral
2. present all possible ways of iteration of the triple integral
3. interpret geometrically various iteration techniques of the triple integral
4. use geometry of the region of integration to iterate appropriately the triple integral
5. set correctly the limits of integration for iterated integral
6. evaluate the iterated integral using various integration techniques
7. calculate the Jacobian of a change variables and use the formula for the change of variables in

triple integral
8. calculate the Jacobian of the cylindrical change and integrate in cylindrical coordinates
9. recalculate the region of integration in terms of cylindrical coordinates
10. interpret geometrically iterations in cylindrical coordinates
11. calculate the Jacobian of the spherical change and integrate in spherical coordinates
9. recalculate the region of integration in terms of spherical coordinates
10. interpret geometrically iterations in spherical coordinates
11. calculate the volume of a ball and the volume of solid ellipsoid using the spherical coordinates
12. calculate the volume of a cone using various integration techniques

Week 12 (April 11-15). Vector fields.

Lectures: Lecture 18 (Vector fields), Lecture 19 (Conservative vector fields).

Learning objectives. Definition of a vector field in $\mathbb{R}^n$. Field lines. Classical fields if physics. Gradient as a vector field. Differential equation for field lines. Conservative fields. Curl. Test for a conservative field. Applications to differential equations. Finding a potential for a conservative field.

Learning outcomes. A student should be able to
1. distinguish vector fields and scalar fields
2. provide graphical illustrations of a field given by a formula using vectors and field lines
3. describe standard vector fields originated in physics: magnetic field of a bar magnet, gravitational field of a point mass, electrostatic field of a point charge
4. treat the gradient as a vector field
5. demonstrate practical skills in drawing vector fields both by hand and using a software
6. write down the equations of field lines for a given field
7. give definition of a conservative vector field and describe its field lines
8. provide examples of conservative fields
9. define a curl of a vector field and provide a physical interpretation of it
10. formulate a test for a conservative field in terms of curl
11. apply the theory of conservative fields to solving exact differential equations
12. find a potential for a conservative field

Week 13 (April 18-22). Line integrals.

Lectures: Lecture 20 (Line integrals).

Learning objectives. Line integrals of a scalar field. Line integrals of a vector field. Work and circulation. Line integrals of a conservative fields. Independence on path in a conservative field.

Learning outcomes. A student should be able to
1. distinguish two types of line integrals
2. understand the definition of a line integral along a curve and integrate a function along a curve
3. apply the line integral concept for calculation of mass
4. understand the definition and various notations of a line integral of a vector field along a curve
5. interpret physical notions of work and circulation in terms of line integrals, calculate work and circulation along a given curve in a given field
6. formulate the theorem about independence on path in the case of a conservative field

7. formulate conditions when the circulation of a conservative field is zero

Week 14 (April 25 - 29). Parametric surfaces. Surface integrals. Divergence Theorem.

Lectures: Lecture 21 (Parametric surfaces), Lecture 22 (Surface integrals), Lecture 23 (Divergence theorem).

Learning objectives. Parametric surface a map. Parametizations inspired by Cartesian, polar, cylindrical and spherical coordinates. Area of a parametric surface. Surface integral of a scalar field. Orientation of a surface. The flux of a vector field across a surface and its physical interpretation. Divergence of a vector field. The Divergence theorem. Gauss's law of gravity. Gauss's law of electrostatic. Application of the Divergence theorem for calculation of flux.

Learning outcomes. A student should be able to
1. comprehend a parametric surface as a map
2. parametrize standard surfaces using Cartesian, polar, cylindrical and spherical coordinates
3. demonstrate proficiency in drawing parametric surfaces using software
4. understand how to calculate surface area element and calculate area of standard surfaces
5. distinguish two types of surface integrals
6. understand the definition of a surface integral of a scalar field and integrate a function over a surface
7. interpret physical notion of mass in terms of surface integrals and calculate the mass of given surface density
8. understand orientation of a surface in terms of normal vector fields
9. distinguish orientable and non-orientable surfaces
10. construct an induced orientation on the boundary of a surface
11. explain the flux of a field across a surface in physical terms
12. provide formal definition of the flux
13. calculate the flux integral given a field and a surface
14. define the divergence of a vector field and provide its physical interpretation as the flux density
15. be familiar with notions of a sink and source of a vector field
16. formulate the Divergence theorem and give its physical interpretation
17. derive Gauss's law of gravity from the Divergence theorem
18. apply the Divergence theorem to electrostatic to derive Gauss's law
19. apply the Divergence theorem to calculation of flux integrals over closed surfaces
20. make adjustments to treat the cases of non-closed surfaces

Week 15 (May 2-6). Stokes' theorem. Green's theorem.

Lectures: Lecture 24 (Stokes' theorem), Lecture 25 (Green's theorem).

Learning objectives. The curl and its physical interpretation. Stokes's theorem. Faraday's equation for electromagnetic induction. Green's theorem as a special case of Stokes's theorem. Applications of Green's formula to integral calculations.

Learning outcomes. A student should be able to
1. understand the notion of the boundary of a surface and induced orientation on the boundary
2. define the curl of a vector field and give its physical interpretation
3. state Stokes's theorem
4. derive Faraday's equation for electromagnetic induction from the Stokes's theorem and formulate it both in integral and differential form
5. apply Stokes's theorem for calculation of the circulation
6. derive Green's theorem from Stokes's theorem
7. understand Green's formula
8. use Green's formula for calculation of the circulation along a closed contour
9. apply Green's formula to integral calculations
10. recognize four Maxwell equations in both differential and integral form