Math 302 Outcome Statements
Winter 2006

1 Vectors in Two and Three Dimensions

A. Evaluate the distance between two points in 3-space.
B. Define vector and identify examples of vectors.
C. Be able to represent a vector in each of the following ways for \( n = 2, 3 \):
   (a) as a directed arrow in \( n \)-space
   (b) as an ordered \( n \)-tuple
   (c) as a linear combinations of unit coordinate vectors
D. Carry out the vector operations:
   (a) addition
   (b) scalar multiplication
   (c) magnitude (or norm or length)
   (d) normalize a vector (find the vector of unit length in the direction of a given vector)
E. Represent the operations of vector addition, scalar multiplication and norm geometrically.
F. Recall, apply and verify the basic properties of vector addition, scalar multiplication and norm.
G. Model and solve application problems using vectors.

Reading: Multivariable Calculus 1.1, Linear Algebra 1.1

Homework: MC 1.1: 1ac,2,4d,7,9ace,12df,13bg,14b,15b,17bc,A1 LA 1.1: 1c,3c,4c,5c,6,14

Outcome Mapping:
A. 1-6 (LA 1.2: 13-16)
B. A1,A2,7
C. 7,12,13,14 (LA 1.1 1,13)
D. 10,15 (LA 1.1 7-10,11-12)
E. 8,10 (LA 14,19,22)
F. 11,16-21,A3 (LA 1.1 18,23,24)
G. 6,7
2 Vector Products

A. Evaluate a dot product from the angle formula or the coordinate formula.
B. Interpret the dot product geometrically.
C. Evaluate the following using the dot product:
   i. the angle between two vectors.
   ii. the magnitude of a vector.
   iii. the projection of a vector onto another vector.
   iv. the component of a vector in the direction of another vector.
   v. the work done by a constant force on an object.
D. Evaluate a cross product from the angle formula or the coordinate formula.
E. Interpret the cross product geometrically.
F. Evaluate the following using the cross product:
   i. the area of a parallelogram.
   ii. the area or a triangle.
   iii. physical quantities such as moment of force and angular velocity.
G. Find the volume of a parallelepiped using the scalar triple product.
H. Recall, apply and derive the algebraic properties of the dot and cross products.

Reading: Multivariable Calculus 1.2-3, Linear Algebra 1.2

Homework: MC 1.2: 2adegj,3be,8a,13,B1 LA 1.2:17,18,19,32,35,41; MC 1.2: 2knop,4,5,6,7dfgh,8d,10,16,17,18,B2

Outcome Mapping:
A. 1,2,7 (LA 1.2: 1-6,17)
B. 3,9,19 (LA 1.2: 40,41)
C. 2,13,14,15 (LA 1.2: 7-12,18-29,30-32,34-39,42-45)
D. 1,2,7
E. 9,16
F. 5
G. 6,8

3 Planes in Space

A. Find the equation of a plane in 3-space given a point and a normal vector, three points, a sketch of a plane or a geometric description of the plane.
B. Determine a normal vector and the intercepts of a given plane.
C. Sketch the graph of a plane given its equation.
D. Determine the angle between two planes.

Reading: Multivariable Calculus 1.3, Linear Algebra 1.3

Homework: MC 1.3: 1bejln,2b,3abc,4abc LA 1.3: 25

Outcome Mapping:
A. 1,3,5 (LA 1.3: 7-10,24,25)
B. 2,4 (LA 1.3: 18,19)
C. 4
D. 2 (LA 1.3: 43,44)
4 Lines in Space

A. Represent a line in 3-space by a vector parameterization, a set of scalar parametric equations or using symmetric form.
B. Find a parameterization of a line given information about
   (a) a point of the line and the direction of the line or
   (b) two points contained in the line.
   (c) the direction cosines of the line.
C. Determine the direction of a line given its parameterization.
D. Find the angle between two lines.
E. Determine a point of intersection between a line and a surface.
F. Find the equation of a plane determined by lines.

Reading: Multivariable Calculus 1.5, Linear Algebra 1.3

Homework: MC 1.5: 1ac,2bd,3bfimps,4bde,8,10,16ab,20

Outcome Mapping:
A. 3,4 (LA 1.3: 1-6,16)
B. 3,4,5,6,7,8,9,12 (LA 1.3: 1-6,11-15,20-23)
C. 1,12 (LA 1.3: 17,23)
D. 2
E. 10,11,14 (LA 1.3: 45,46)
F. 9

5 Systems of Linear Equations

Outcomes:
A. Define linear equation and system of linear equations. Define solution and solution set for both a linear equation and a system of linear equations.
B. Relate the following types of solution sets of a system of two or three variables to the intersections of lines in a plane or the intersection of planes in three space:
   i. a unique solution.
   ii. infinitely many solutions.
   iii. no solution.
C. Represent a linear system as an augmented matrix and vice versa.
D. Transform a system to a triangular pattern and then apply back substitution to solve the linear system.
E. Represent the solution set to a linear system using parametric equations.

Reading: Linear Algebra 2.1

Homework: 2.1: 1,4,5,8,10,12,13,15,17,21,24,25,28,29,31,37,39

Outcome Mapping:
A. 1-6, 7-10
B. 15-18
C. 27-30, 31-32
D. 19-24, 25-26, 33-38
E. 11-14, 39-40
6 Direct Methods for Solving Linear Systems

Outcomes:
A. Identify matrices that are in row echelon form and reduced row echelon form.
B. Determine whether a system of linear equations has no solution, a unique solution or an infinite number of solutions from its echelon form.
C. Apply elementary row operations to transform systems of linear equations.
D. Solve systems of linear equations using Gaussian elimination.
E. Solve systems of linear equations using Gauss-Jordan elimination.
F. Define and evaluate the rank of a matrix.
G. Apply the Rank Theorem relate the rank of an augmented matrix to the solution set of a system in the case of homogeneous and nonhomogeneous systems.
H. Model and solve application problems using linear systems.

Reading: Linear Algebra 2.2

Homework: 2.2: 1,2,3,4,5,10,12,13,19,21,23,25,27,31,35,37,39,45,49; 2.4: 15

Outcome Mapping:
A. 1-8,24
B. 39-44
C. 9-14,15-16,17-18,19-22
D. 25-34
E. 23
F. 35-38
G. 45-52, (2.4: 1-47)

7 Spanning Sets and Linear Independence

Outcomes:
A. Explain what is meant by the span of a set of vectors both geometrically and algebraically.
B. Determine the span of a set of vectors. Determine if a given vector is in the span of a set of vectors.
C. Define linear independence.
D. Determine whether a set of vectors is linearly dependent or linearly independent. For sets that are linearly dependent, determine a dependence relation.
E. Prove theorems about span and linear independence.

Reading: Linear Algebra 2.3

Homework: 2.3: 2,4,7,11,14,15,24,26,34,36,44,46,Q1

Outcome Mapping:
A. 13-16,17
B. 1-6,7-12
C. Q1
D. 22-31
E. 18-21,42-48
8 Matrix Operations

Outcomes:
A. Perform the operations of matrix addition, scalar multiplication, transposition, and matrix multiplication.
B. Represent matrices in terms of double subscript notation.
C. Recall and demonstrate that the cancellation laws for scalar multiplication do not hold for matrix multiplication.
D. Use matrices and matrix operations to model application problems.
E. Represent matrix multiplication in terms of blocks.

Reading: Linear Algebra 3.1

Homework: 3.1: 2,4,6,8,16,17,18,19,22,32,36,39

Outcome Mapping:
A. 1-16,35-38
B. 39-40
C. 17-18
D. 19-20,21-22
E. 23-28,29-30,31-34,41

9 Matrix Algebra

Outcomes:
A. Recall and apply the algebraic properties for matrix addition, scalar multiplication, matrix multiplication, and transposition.
B. Prove algebraic properties for matrices.
C. Apply the concepts of span and linear independence to matrices.
D. Recall that matrix multiplication is not commutative in general. Determine conditions under which matrices do commute.

Reading: Linear Algebra 3.2

Homework: 3.2: 2,4,6,9,14,22,24,36a,37,39,42

Outcome Mapping:
A. 1-4
B. 17-22,29-36,37-43,44-47
C. 5-8,9-12,13-16
D. 23-28

10 The Inverse of a Matrix

Outcomes:
A. Define the inverse of a matrix.
B. Recall the Fundamental Theorem of Invertible Matrices and the properties of invertible matrices. Prove theorems involving matrix inverses.
C. Recall and apply the formula for the inverse of 2 \times 2 matrices.
D. Demonstrate the relationship between elementary matrices and row operations. Determine inverses of elementary matrices.
E. Compute the inverse of a matrix using the Gauss-Jordan method.
F. Solve a linear equation using matrix inverses.

Reading: Linear Algebra 3.3

Homework: 3.3: 2,10,11,17a,20,22,24,26,28,34,36,38,42,43,45,49,50,52

Outcome Mapping:
A. B1
B. 14-19,41-47
C. 1-10
D. 24-30,31-38,39-40
E. 48-63
F. 11-13,20-23
11 The LU Factorization

Outcomes:
A. Find the LU factorization of a matrix.
B. Use the LU factorization of a matrix to solve a system of linear equations.
*C. Find the $P^TLU$ factorization of a matrix.
*D. Use that $P^TLU$ factorization of a matrix to solve a system of linear equations.
*E. Find the inverse of a matrix using the LU factorization.

Reading: Linear Algebra 3.4

Homework: 3.4: 3,5,7,10,12,13,14

Outcome Mapping:
A. 7-12,13-14
B. 1-6
*C. 19-22,23-25
*D. 27-28
*E. 15-18,30

12 Subspaces, Basis, Dimension, and Rank

Outcomes:
A. Define subspace of $\mathbb{R}^n$. Determine whether or not a given set of vectors forms a subspace of $\mathbb{R}^n$.
B. Define row space, column space, and null space for a matrix. Determine whether or not a given vector is in one of these spaces.
C. Define basis and dimension. Given a subspace, determine its dimension and a basis. Verify whether or not a given set of vectors is a basis for the subspace.
D. Define rank and nullity. Determine the rank and nullity of a given matrix.
*E. Prove and recall theorems involving the rank, nullity, and invertibility of matrices.
*F. Find the coordinates of a vector with respect to a given basis.

Reading: Linear Algebra 3.5

Homework: 3.5: 1,2,3,5,10,11,12,15,17,20,28,30,35,38,41,42,46

Outcome Mapping:
A. 1-10
B. 11-16
C. 17-20,21-26,27-30,31-34,45-48
D. 35-42,43-44
*E. 55-64
*F. 49-50

13 Linear Transformations

Outcomes:
A. Define linear transformation. Determine whether or not a given transformation is linear.
B. Determine the matrix that represents a given linear transformation of vectors.
C. Prove and recall theorems involving linear transformations.
*D. Find compositions and inverses of linear transformations.

Reading: Linear Algebra 3.6

Homework: 3.6: 1,4,9,12,20,22,24,36,38,44

Outcome Mapping:
A. 1-10,46-51
B. 11-14,15-28
C. 29,40-45,52-55
*D. 30-35,36-39
14 Applications

Outcomes:
A. Model Markov processes. Determine the transition matrix, state vectors, probability vectors, and the steady state vectors.
*B. Model population growth using a Leslie matrix. Investigate the behavior of the growth.
*C. Relate adjacency matrices to graphs and digraphs. Investigate path lengths by taking powers of adjacency matrices.
*D. Solve problems involving error coding.

Reading: Linear Algebra 3.7

Homework: 3.7: 11,12,20,27,30,41

Outcome Mapping:
A. 1-18
B. 19-24
C. 25-60
*D. 61-75

15 Introduction to Eigenvalues and Eigenvectors

Outcomes:
A. Interpret the eigenvalue problem algebraically.
   i. Determine whether a given vector is an eigenvector.
   ii. Verify that a given value is an eigenvalue.
B. Interpret the eigenvalue problem geometrically. Determine eigenvalues and eigenvectors based on:
   i. an understanding of the linear transformation determined by the matrix
   ii. from the graph of the eigenspace.
C. Find the eigenvalues and eigenvectors of a general $2 \times 2$ matrix.

Reading: Linear Algebra 4.1

Homework: 4.1: 2,6,8,11,14,15,17,18,19,21,22,23,24,28

Outcome Mapping:
A. 1-6,7-12
B. 13-18,19-22
C. 23-26,27-30,31-34,35-38
16 Determinants

Outcomes:
A. Apply the Laplace Expansion to evaluate determinants of \( n \times n \) matrices.
B. Recall and apply the properties of determinants to evaluate determinants, including:
   i. \( \det(AB) = \det(A) \det(B) \)
   ii. \( \det(kA) = k^n \det(A) \)
   iii. \( \det(A^{-1}) = \frac{1}{\det(A)} \)
   iv. \( \det(A^T) = \det(A) \)
C. Recall the effects that row operations have on the determinants of matrices. Relate to the determinants of elementary matrices.
D. Prove theorems involving determinants.
E. Evaluate matrix inverses using the adjoint method. Determine whether or not a matrix has an inverse based on its determinant.
F. Use Cramer’s rule to solve a linear system.

Reading: Linear Algebra 4.2

Homework: 4.2: 5, 8, 13, 17, 24, 26, 27, 30, 32, 37, 39, 40, 46, 48, 49, 51, 53, 54, 60, 64

Outcome Mapping:
A. 1-6, 7-15, 16-20
B. 35-38, 47-52
C. 26-33, 35-40
D. 21, 41-44, 53-56, 66
E. 45-46, 61-64, 65
F. 57-60

17 Eigenvalues and Eigenvectors of \( n \times n \) Matrices

Outcomes:
A. Given an \( n \times n \) matrix, compute
   i. the characteristic polynomial
   ii. the eigenvalues
   iii. a basis for each eigenspace
   iv. the algebraic and geometric multiplicities of each eigenvalue
B. Solve application problems involving eigenvalues and eigenvectors.
C. Recall and prove theorems involving eigenvalues and eigenvectors.

Reading: Linear Algebra 4.3

Homework: 4.3: 4, 5, 9, 15, 16, 19, 20

Outcome Mapping:
A. 1-12
B. 15-22, 26-31, 33-38
C. 23-25, 32, 39-42
18  Similarity and Diagonalization

Outcomes:
A. Define similarity. Determine whether or not two matrices are similar.
B. Determine if a matrix is diagonalizable. Find the diagonalization of a matrix.
C. Find powers of a matrix using the diagonalization of a matrix.
D. Prove theorems involving the similarity and diagonalization of matrices.

Reading: Linear Algebra 4.4

Homework: 4.4: 1,3,6,8,11,15,16,40,41

Outcome Mapping:
A. 1-4,36-39
B. 5-7,8-15,24-29
C. 16-23
D. 30-35,40-50

19  Surfaces

A. Identify standard quadratic surfaces given their functions or graphs.
B. Sketch the graph of a quadratic surface by identifying the intercepts, traces, sections, symmetry and boundedness or unboundedness of the surface.

Reading: Multivariable Calculus 1.4

Homework: 1.4: 2,3bdgikm,4

Outcome Mapping:
A. 1,2,3
B. 3,4,6,7

20  Curves in Space

A. Identify the domain of a vector function.
B. Identify a curve given its parameterization.
C. Determine combinations of vector functions such as sums, vector products and scalar products.
D. Define limit, derivative and integral for vector functions.
E. Evaluate limits, derivatives and integrals of vector functions.
F. Find the line tangent to a curve at a given point.
G. Describe what is meant by arc length.
H. Evaluate the arc length of a curve.
I. Recall, derive and apply rules to combinations of vector functions for the following:
   (a) limits
   (b) differentiation
   (c) integration

 Reading: Multivariable Calculus 1.6

Homework: 1.6: 1ac,2bd,3b,4c,5bc,6bd,8cd,13,14,C1,C2,C3,C4,C5

Outcome Mapping:
A. 1
B. 2
C. 3,4
D. C1
E. C2,C3,C4,13
F. 5,16
G. C5
H. 6
I. 7-12,14,15
21 Curvilinear Motion

A. Sketch the curve determined by a vector function in 2-space or 3-space.
B. Parameterize a curve in 2-space or 3-space.
C. Given the position vector function of a moving object, calculate the velocity, speed, and acceleration of the object.
D. Model and analyze curvilinear motion in applications.

Reading: Multivariable Calculus 1.7

Homework: 1.7: 1be,5,7,13,20,D1,D2

Outcome Mapping:
A. D1
B. D2
C. 1
D. 2-22

22 Curvature

A. Recall the definitions of unit tangent, unit normal, binormal and osculating plane for a space curve. Illustrate each graphically.
B. Calculate the curvature, the radius of curvature, the center of curvature (*), and the osculating plane for a space curve.
C. Derive formulas for the curvature of a parameterized curve and the curvature of a plane curve given as a function.
D. Determine the tangential and normal components of acceleration for a given path.

Reading: Multivariable Calculus 1.8

Learning Module: Moving Trihedron

Homework: 1.8: 1ace,2bc,3,5bd,8,E1,E2

Outcome Mapping:
A. E1,E2,8
B. 1,5
C. 3,4,7
D. 2

23 Functions of Several Variables

A. Identify the domain and range of a function of several variables.
B. Represent a function of two variables by level curves or a function of three variables by level surfaces.
C. Identify the characteristics of a function from its graph or from a graph of its level curves (or level surfaces).
D. Represent combinations of multivariable functions algebraically.

Reading: Multivariable Calculus 2.1

Homework: 2.1: 1bdfhk,2,5,6bdfh,7aceh,8c,9bdfh

Outcome Mapping:
A. 1
B. 2,4,7,8
C. 3,5,6
D. 9
24 Limits and Continuity

A. Describe a delta neighborhood of a point in 2- or 3-space.
B. Evaluate the limit of a function of several variables for a given approach or show that it does not exists.
C. Determine whether a function is continuous at a given point. Interpret the definition of continuity of a function of several variables graphically.
D. Determine whether a set in 2- or 3-space is open, closed or neither. Determine whether a set is compact.
E. Recall and apply the Extreme Value Theorem.

Reading: Multivariable Calculus 2.2

Homework: 2.2: 1a, 2bdhj,3aceg,7,8ac,F1,F2,F3,F4

Outcome Mapping:
A. F1
B. 1-7
C. 8,F4
D. F3,10,11,12,13 (3.1:5)
E. F2,9

25 Partial Derivatives

A. Interpret the definition of a partial derivative of a function of two variables graphically.
B. Evaluate the partial derivatives of a function of several variables.
C. Describe the relationship between the existence of partial derivatives and the existence of a derivative for a function of several variables.
D. Evaluate the higher order partial derivatives of a function of several variables.
E. State the conditions under which mixed partial derivatives are equal.
F. Verify equations involving partial derivatives.
G. Evaluate the gradient of a function.
H. Prove identities involving the gradient.

Reading: Multivariable Calculus 2.3

Homework: 2.3: 1,4,5behk,6ac,7,9behk,10bc,15a,G1,G2,G3

Outcome Mapping:
A. G1,4,11,18
B. 2,3,5,6,19 (2.4:2)
C. G2
D. 5,7,8
E. G3
F. 12-17
G. 9
H. 10

26 Differentiability and the Chain Rule

A. Define differentiability for a function of several variables.
B. Evaluate partial derivatives from the definition. Describe the relationship between the derivative of a multivariable function and its partial derivatives.
C. Apply the chain rule to evaluate derivatives.
D. Solve related rates problems using the chain rule.

Reading: Multivariable Calculus 2.4

Homework: 2.4: H1,1,3b,5,6ac,8

Outcome Mapping:
A. H1
B. H1,1
C. 3,5,6
D. 4,7,8,9
27 Directional Derivative

A. Give a graphical interpretation of the gradient.
B. Evaluate the directional derivative of a function.
C. Give a graphical interpretation of directional derivative.
D. Prove that a differential function \( f \) increases most rapidly in the direction of the gradient (the rate of change is then \( \|f(\vec{x})\| \)) and it decreases most rapidly in the opposite direction (the rate of change is then \( -\|f(\vec{x})\| \)).
E. Find the path of a heat seeking or a heat repelling particle.

Reading: Multivariable Calculus 2.5

Homework: 2.5: 1,3,4bf,5,8,10c,H2,H3

Outcome Mapping:
A. 1,11,H2 (2.6:2)
B. 4,6,10
C. 2,3,H3 (2.6:2)
D. H4
E. 5,7,8,9

28 Normal Vectors and Tangent Planes

A. Interpret the gradient of a function as a normal to a level curve or a level surface.
B. Find the normal line and tangent plane to a smooth surface at a given point.
C. Find the angles between curves and surfaces.

Reading: Multivariable Calculus 2.6

Homework: 2.6: 1cg,3d,6,9,11,14,15b,16,17a,18b

Outcome Mapping:
A. 1,3,11,12,13
B. 4-11
C. 14,15,16,17

29 Extrema of Functions of Several Variables

A. Identify local extreme values graphically.
B. Determine the local extreme values and saddle points of a function of two variables. When possible, apply the second partial derivatives test.
C. Identify the extreme values of a function defined on a closed and bounded region.
D. Solve word problems involving maximum and minimum values.

Reading: Multivariable Calculus 2.7

Homework: 2.7: 1,3bgmo,4ad,7,12,14

Outcome Mapping:
A. 1,2
B. 3
C. 4,5
D. 6-25
30 Constrained Extrema

A. Graphically interpret the method of Lagrange.
B. Determine the extreme values of a function subject to a side constraints by applying the method of Lagrange.
C. Apply the method of Lagrange to solve word problems.

Reading: Multivariable Calculus 2.9

Homework: 2.9: 1,3aci,4,6,13

Outcome Mapping:
A. 1,2
B. 3
C. 4-20

31 Double Integrals

A. Compare the definition of the double integral to the method of repeated integration geometrically.
B. Evaluate double integrals over a rectangle by repeated integration.
C. Apply a double integral to calculate the volume or mass of a solid.

Reading: Multivariable Calculus 3.1

Homework: 3.1: 1bf,2abcdg,3c,4b,6,J1

Outcome Mapping:
A. J1
B. 1,2,6
C. 3,4

32 Double Integrals over General Regions

A. Evaluate double integrals over general regions.
B. Evaluate double integrals by interpreting them as known volumes.
C. Rewrite a double integral changing the order of integration.
D. Apply double integrals to calculate areas of planar regions and volumes of solids.
E. Evaluate the physical characteristics of a plate such as mass, centroid, center of mass and moment of inertia.

Reading: Multivariable Calculus 3.2

Homework: 3.2: 1bd,2bc,3ab,4be,5b,6b,7a,8

Outcome Mapping:
A. 1
B. 2
C. 3
D. 4,8
E. 5,6,7,8
33  Double Integrals in Polar Coordinates

A. Represent a region in both Cartesian and polar coordinates.
B. Evaluate double integrals in polar coordinates.
C. Convert a double integral in Cartesian coordinates to a double integral in polar coordinates and then evaluate.
D. Evaluate areas and volumes using polar coordinates.
E. Evaluate the physical characteristics of a plate such as centroid, mass, and center of mass using polar coordinates.
F. Make conversions of algebraic expressions between Cartesian coordinates and cylindrical coordinates.

**Reading:** Multivariable Calculus 3.3

**Homework:** 3.3: 2,3,5a(iii)b(i,iii,iv)c(ii),7a,8ac,9bd,10ad,11abce,12abf

**Outcome Mapping:**

A. 1,2,3,4
B. 5a
C. 8
D. 5b,6,7
E. 5c
F. 9,10,11,12

34  Triple Integrals

A. Find the volume of a solid using triple integration in Cartesian coordinates.
B. Evaluate the physical characteristics of a solid such as mass, centroid and center of mass using Cartesian coordinates.

**Reading:** Multivariable Calculus 3.4

**Homework:** 3.4: 1cei,3,7,9

**Outcome Mapping:**

A. 1,3,4,7,8,9
B. 2,3,4,5,6,7,8,9

35  Triple Integrals in Cylindrical Coordinates

A. Describe regions in both Cartesian coordinates and cylindrical coordinates.
B. Evaluate triple integrals using cylindrical coordinates.
C. Find volumes by applying triple integration in cylindrical coordinates.
D. Evaluate the physical characteristics of a solid such as mass, centroid and center of mass using cylindrical coordinates.

**Reading:** Multivariable Calculus 3.5

**Homework:** 3.5: 1,3,5b,6b,7a,8,11bd,12

**Outcome Mapping:**

A. 1,2,34
B. 5,11
C. 6,9,10,12
D. 7,8,12
36 Triple Integrals in Spherical Coordinates

A. Describe regions in both Cartesian coordinates and spherical coordinates.
B. Evaluate triple integrals using spherical coordinates.
C. Find volumes by applying triple integration in spherical coordinates.
D. Evaluate the physical characteristics of a solid such as mass, centroid and center of mass using spherical coordinates.
E. Convert a triple integral in Cartesian coordinates to cylindrical or spherical coordinates and then evaluate.
F. Make conversions of algebraic expressions between Cartesian coordinates and spherical coordinates.

Reading: Multivariable Calculus 3.6

Homework: 3.6: 1,3,5a,6ad,7a,10ab,11,12ad,13ad,14ad,15bce,16bde,19

Outcome Mapping:
A. 1,2,3,4
B. 5,10
C. 6,9,11
D. 7,8,11
E. 10
F. 12-19

37 The Jacobian

A. Find the Jacobian of a transformation.
B. Change variables in a multiple integration to obtain a more simple integral and then evaluate.

Reading: Multivariable Calculus 3.7

Homework: 3.7: 1aek,3a,4b,5

Outcome Mapping:
A. 1,2,7
B. 3,4,5,6,8,9

38 Recovering a Function from Its Gradient

A. Analyze the characteristics of a vector field. Sketch a vector field.
B. Determine whether or not a vector field is a gradient.
C. Determine whether or not a differential form is exact.
D. Recover a function from its gradient or differential form, if possible.

Reading: Multivariable Calculus 4.1

Homework: 4.1: 2,4achkl,5ag,7,8a

Outcome Mapping:
A. 1,2,3,7,8
B. 5,8,12
C. 4,6,7
D. 4,5,8,12-16
39 Line Integrals

A. Evaluate the work done by a varying force over a curved path.
B. Evaluate line integrals in general including line integrals with respect to arc length.
C. Evaluate the physical characteristics of a wire such as centroid, mass, and center of mass using line integrals.

Reading: Multivariable Calculus 4.2

Homework: 4.2: 1ach, 2ac, 3b, 4ab, 6, 8

Outcome Mapping:
A. 1, 8
B. 2, 3, 4, 7
C. 5, 6

40 Path Independent Line Integrals

A. Recall and apply the Fundamental Theorem for Line Integrals.
B. Determine whether or not a force field is conservative, and if so, find its potential.
C. Evaluate the circulation of a force field or the work done by a force field on an object moving along a given path.

Reading: Multivariable Calculus 4.3

Homework: 4.3: K1, 1bd, 2be, 3cg, 4ab, 7

Outcome Mapping:
A. K1, 1
B. 3, 5, 6, 7
C. 2, 4

41 Green’s Theorem

A. Recall and verify Green’s Theorem.
B. Apply Green’s Theorem to evaluate line integrals.
C. Apply Green’s Theorem to find the area of a region.

Reading: Multivariable Calculus 4.4

Homework: 4.4: L1, L2, 1adf, 2c, 3, 5

Outcome Mapping:
A. L1, L2, 3, 5, 6
B. 1, 7
C. 2, 4

42 Surface Integral

A. Determine the area of a given surface using integration.
B. Evaluate the physical characteristics of a surface such as centroid, mass, and center of mass using surface integrals.
C. Find the flux of a vector field through a surface.

Reading: Multivariable Calculus 4.5

Homework: 4.5: 1afi, 2d, 3a(ii), c(ii), d(iii)

Outcome Mapping:
A. 1, 5
B. 1, 2, 4, 6
C. 3
43 Parametric Surfaces

A. Write a parameterization for a given surface.
B. Identify a surface from its parameterization.
C. Describe a surface from its nets. Sketch a parametric surface.

Reading: Multivariable Calculus 4.6

Homework: 4.6: 1,3,4,5,6cd,7b,8

Outcome Mapping:
A. 3,5,8,9 (4.7: 7,9)
B. 1,2,4 (4.7:10)
C. 6,7

44 Integrals Over Parametric Surfaces

A. Graphically describe a surface in terms of its parameterization.
B. Determine a (unit) normal vector to a surface from a parameterization of the surface.
C. Determine the plane tangent to a surface at a given point.
D. Evaluate the physical characteristics of parameterized surfaces such as centroid, mass, and center of mass.
E. Find the flux of a flow through a parametric surface.

Reading: Multivariable Calculus 4.7

Homework: 4.7: 2,4

Outcome Mapping:
A. 1-6
B. 1-6
C. 1-6
D. 1-6,7,8,9
E. 1-6,7,9

45 Flux Density and Divergence

A. Explain what is meant by the flux density and divergence of a vector field.
B. Evaluate the divergence of a vector field.
C. Evaluate the Laplacian of a function.
D. Derive formulas involving divergence, gradient and Laplacian.

Reading: Multivariable Calculus 5.1

Homework: 5.1: M1,1abcdefj,2,3afg,4abc

Outcome Mapping:
A. M1
B. 1
C. 2,3
D. 4,5
46 The Divergence Theorem

A. Recall and verify the Divergence Theorem.
B. Apply the Divergence Theorem to evaluate the flux through a surface.
*C. Derive integration formulas using the Divergence Theorem.

Reading: Multivariable Calculus 5.2

Homework: 5.2: N1,N2,1ceh,2,4,5,8

Outcome Mapping:
A. N1,N2,4,8
B. 1,2,3
*C. 5,6,7

47 Circulation Density and Curl

A. Explain what is meant by the circulation density and curl of a vector field.
B. Evaluate the curl of a vector field
C. Derive and apply formulas involving divergence, gradient and curl.

Reading: Multivariable Calculus 5.3

Homework: 5.3: O1,1bej,2abcd,3,4,6

Outcome Mapping:
A. O1,3,7
B. 1,4,5,6
C. 2

48 Stoke’s Theorem

A. Recall and verify Stoke’s theorem.
B. Apply Stoke's theorem to calculate the circulation (or work) of a vector field around a simple closed curve.
C. Recall and apply the divergence and curl tests.

Reading: Multivariable Calculus 5.4

Homework: 5.4: P1,P2,abcd,2a,3a,4d,10,12dh

Outcome Mapping:
A. P1,1,6,11,12
B. 2,3,7,8,9,13
C. P2,4,5,10
49 Iterative Methods for Solving Linear Systems

Outcomes:
A. Apply Jacobi iteration to approximate a solution to a linear system of equations.
B. Apply Gauss-Seidel iteration to approximate a solution to a linear system of equations.
C. Analyze convergence and divergence in the application of the Jacobi and Gauss-Seidel methods. Use diagonal dominance to determine convergence.
D. Use iterative methods to solve application problems.

Reading: Linear Algebra 2.5

Homework: 2.5: 2,4,8,10,22

Outcome Mapping:
A. 1-6
B. 7-12
C. 13-14,15-17,18-21
D. 22-28

50 Numerical Methods for Solving the Eigenvalue Problem

Outcomes:
A. Use the power method to approximate the dominant eigenvalues and eigenvectors.
B. Identify conditions under which the power method applies.
*C. Use the Rayleigh quotient method to approximate dominant eigenvalues.
D. Use the shifted power method, the inverse power method and the shifted inverse power method to find the non-dominant eigenvalues and eigenvectors.
*E. Construct the Gershgorin disks for a matrix. Relate the Gershgorin disks to the eigenvalues of a matrix.

Reading: Linear Algebra 4.5

Homework: 4.5: 3,7,10,30,33,37

Outcome Mapping:
A. 1-4,5-8,9-14,15-16
B. 21-24,25-28
C. 17-20
D. 29-32,33-36,37-40,41-45
*E. 47-50,51