Syllabus Physics 221

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COURSE TITLE: PHY 221, University Physics I (Calculus base Physics I)

Prerequisite(s): MAT 140 or MAT 177 with a minimum grade of "C".

COURSE DESCRIPTION:

This is the first in a sequence of college transfer courses. The course includes a calculus-based treatment of the following topics: Vectors, laws of motion, rotation, vibratory and wave motion.

General Education Outcomes

Students who complete the general education core curriculum should be able to demonstrate

1. rationality, logic, and coherence, through critical thinking;
2. their ability to express themselves effectively in written and oral communication;
3. their ability to express themselves effectively in quantitative and qualitative terms;
4. their knowledge of the value and significance of diverse cultures;
5. the scientific method of inquiry;
6. their knowledge of global, political, social, economic, and historical perspectives; and
7. their ability to access, retrieve, synthesize, and evaluate information.

Course Outcomes

After completion of this course, students will

1) have an increased awareness of the physics behind phenomena observed in everyday life, including an understanding of our natural and technological environments.

2) be able to apply abstract mathematical and physical principles to specific problems such as those presented in the homework and on tests, and to reason both qualitatively and quantitatively.

3) be able to apply these same principles when confronted with similar situations in the real world, taking into account factors such as reasonable approximation and limitations due to uncertainty.

4) have strengthened mathematical skills due to the constant application of mathematics in physics.

5) be able to design experiments and acquire data with the goal of verification of physical principles.

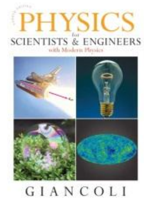
6) have the ability to communicate experimental procedures and results clearly and effectively through a written lab report.

7) have an appreciation for the historical advancement of physics, and its relation to other disciplines.

8) be prepared for future study in engineering, chemistry, advanced physics, or related fields.

CREDITS/CONTACT HOURS: 4 credit hour

Textbook: Giancoli, Douglas C., *Physics for scientists and engineers*, Englewood Clifts, NJ: Prentice Hall, Inc., 4th Ed.



References:

- Freedman, Roger A. & Young, Hugh D., University Physics with Modern Physics with Mastering Physics, 12th ed. Addison Wesley/Benjamin Cummings, 1991.
- Serway, Raymond A. & Jewitt, John, Physics for Scientists and Engineers, 6th ed. Thompson Brooks/Cole, 2006.
- Halliday& Resnick & Walker. Fundamental of Physics Extended, Prentice-Hall,2007

Recommended tools: Scientific, graphic calculator (TI series)
Method of Instruction: The class will be taught by lecture and class participation in problem sessions and laboratories.

Grading System:

90	-	100	=	A
80	-	89	=	B
70	-	79	=	C
60	-	69	=	D
Below	-	60	=	F

Methods of Evaluation for Student Performance:

- Weekly problems assigned as homework
- Written quizzes and tests (including a comprehensive final examination)
- In class exercise/practice and/or activities
- Term papers and oral presentation
- Lab reports for each lab

Grade Calculation Method:
There will be midterm and final tests given during the semester. A comprehensive examination will be available. The course grade percentage from midterm tests and final test is weighted by individual instructor.

Attendance Policy:
Students are responsible for punctual and regular attendance in all classes, laboratories, field trips, and other class activities. The college does not grant excused absences; therefore, students are urged to reserve their absences for emergencies. When illness or other emergencies occur, the student is responsible for notifying instructors and completing work missed.

Except in extenuating circumstances with approval by the division dean, instructors withdraw students from class when 80 percent attendance is not maintained. Some courses have more restrictive attendance policies as indicated in course syllabus. If a student exceeds the allowable attendance, the instructor will withdraw the student and award a grade of "W" or "WF" based upon the student's academic standing at the last date of attendance.

Students are tardy if not in class at the time the class is scheduled to begin. Tardy students are admitted to class at the discretion of the instructor. Course syllabi reflect attendance policies related to tardiness.

Withdrawl Policy: During the first 75% of the course, a student may initiate withdrawl and receive a grade of 'W'. A student cannot initiate withdrawl during the last 25% of the course. Extending circumstances require documentation and approval by the appropriate department head and academic dean.

<u>Absences for Religious Holidays</u>: Students who are absent from class in order to observe religious holidays are responsible for the content of any activities missed and for the completion of assignments occurring during the period of absence. Students who anticipate their observance of religious holidays will cause them to be absent from class and do not wish such absences to penalize their status in class should adhere to the following guidelines:

1. Observance of religious holidays resulting in three or fewer consecutive absences: Discuss the situation with the instructor and provide written notice at least one week prior to the absence(s). Develop (in writing) an instructor-approved plan which outlines the make up of activities and assignments.

Observances of religious holidays resulting in four or more consecutive absences: Discuss the situation with the instructor and provide the instructor with written notice within the first 10 days of the academic term. Develop an instructor-approved plan which outlines the make up of activities and assignments.

Classroom Conduct:
ACADEMIC DISHONESTY: Students are expected to uphold the integrity of the College's standard of conduct, specifically in regards to academic honesty. All forms of academic dishonesty including, but not limited to, cheating on assignments/tests, plagiarism, collusion, and falsification of information will call for disciplinary action. Disciplinary action imposed may include one or more of the following: written reprimand, loss of credit for assignment/test, termination from course, and probation, suspension, or expulsion from the College. For further explanation of this and other conduct codes, please refer to the Student Handbook.

CELLULAR PHONES AND PAGERS/BEEPERS: Cellular phones, pagers and beepers are not permitted to be turned on or used within the classroom. Use of these devices during classroom time will be considered a violation of the student code as it relates to "disruptive behavior."

Class/Lab Procedures:
The class is taught primarily by lecture. Questions from students are both expected and encouraged. Student participation is expected in problem sessions and laboratories. Problem sessions and laboratories are generally done in small groups.

Accommodations:
Students who need special accommodations in this class because of a documented disability should notify Student Disability Services by calling (864) 592-4818, toll-free 1-800-922-3679; via email through the SCC web site at www.sccsc.edu/resources/disabilities; or by visiting the office located in the East Building Room 30-B on the SCC Central campus. Contacting Student Disability Services early in the semester gives the College an opportunity to provide necessary support services and appropriate accommodations.

<u>Course Outcomes & Objectives:</u>
Upon satisfactory completion of this course, the student will be able to:

Chapter 1: Introduction

- What is **science** and how is it like **art** and **literature** and how is it different?

- I plan to pursue a **career**. How will physics help me?
- **Models**, **Theories**, **Laws** and **Principles:** What are they and how do they work together?
- How do you make **measurements** and how should they be reported?
- What is the **SI system** of units and how do they relate to everyday things like pound, foot, and hour?
- How can I use **estimates** to help me understand the world?

Chapter 2: Describing Motion: Kinematics in One Dimension

- What is **displacement** and how does it help me describe the world around me?
- What is the difference between **average speed** and **average velocity**? I thought they were the same.
- Speed and velocity can both change. How do I find **instantaneous speed** and **instantaneous velocity**?
- What is **acceleration** and how is it calculated?
- If **acceleration is constant** how can I describe motion?
- The mystery of **problem solving**-how do I do it?
- Up and down, **the rise and fall of bodies**뻡ow do I master this motion?
- How can **graphs** help me understand this chapter?

Chapter 3: Kinematics in Two Dimensions; Vectors

- What is the difference between a **vector** and a **number (scalar)**?
- How can I **add vectors**?
- How can **vectors be subtracted**?
- Can **vector components** help me use vectors?
- What is **projectile motion**?
- How do you **describe the motion** of a projectile?
- Around and around, how do you **describe circular motion**?
- What is **relative motion**?

Chapter 4: Motion and Force: Dynamics

- What is **Newton's First Law** and what does it tell us about why objects don't move?
- ..and what is the difference between **Mass** and **Inertia** anyway?
- To Move or Not To Move, that is the question. The answer is **Newton's Second Law**.
- How does **Newton's Third Law** help us understand "To Touch and Be Touched"?
- What are the **Important Forces** I will have to use?
- **Weight**: How does that differ from Mass?
- How do I **solve problems** using these forces?

Chapter 5: Further Applications of Newton's Laws

- Getting things going, what is **static friction**?
- Keeping them moving, what is **kinetic friction**?
- Around and around뻡ow do you describe **circular motion**?
- What is **centripedal acceleration** and how do I use it?
- How do **forces** produce circular motion?
- Why do different curves have different speed limits?
- Why does **'banking'** a curve help a car negotiate it?
- How does a **centrifuge** work?

Chapter 6: Gravitation and Newton's Synthesis

- **Universal Gravity**巽hat is it and why is it "Universal"?
- How does gravity vary near the surface of the earth and what does that tell us?
- All **satellites**, great and small巽hat do they have in common?
- What is special about **Geosynchronous Satellites**?
- Are astronauts really **weightless** and what does **weightlessness** mean?
- The **Gravitational Field**, what is it?
- **Kepler's Laws**巽hat do thet tell us about the motion of the planets?
- **Gravity** is a force in Nature. What are the other forces?
- The **Principle of Equivalence**, what does it tell about mass, gravity and acceleration?
- **Curved Space-Time**, **Black Holes** and **Gravitational Lenses**, how do they derive from the Principle of Equivalence?

Chapter 7: Work and Energy

- How do I find the **Work** I do
- ...with a **constant force**?
- ...with a **variable force**?

- What is **Kinetic Energy**, and how does it relate to **work**?
- What is the **Scalar Product** of two vectors?
- ...and how do I calculate it?

Chapter 8: Conservation of Energy

- **Conservative forces** and **Nonconservative forces** what are they are and how do they differ?
- I know that falling objects gain kinetic energy, is this from **Potential Energy**?
- ...and how do I calculate it?
- ... near the earth? ...far from the earth? ...for a spring?
- What is **Mechanical Energy**?
- Why is it important,
- and, how can I use it?
- What are other forms of energy and how do they combine with mechanical energy to form **Conservation of Energy**?
- Why can little engines do big things (what is the difference between **Energy** and **Power**)?

Chapter 9: Linear Momentum and Collision

- How are **Momentum** and force related?
- If there are no external forces, is the momentum of a system of (group of) particles **conserved**?
- How can I use this to solve one dimensional problems?
- Why are dashboards padded, why should I roll with the punch and what is **Impulse** anyway?
- What are **Elastic Collisions** and how can I use **Conservation of Momentum** and **Conservation of Energy** to solve these problems?
- How do **Inelastic Collisions** differ from elastic collisions and how do I solve these problems?
- I play pool how can I explain **Two Dimensional Collisions**?
- When is the **Center of Mass** of a body not at its center
- ...and how do I calculate it?

Chapter 10: Rotational Motion about a Fixed Axis

- "Degrees" signifies an arbitrary measure, so what is the **Absolute Measure of Angle**?
- What are the other basic **Angular Variables**?
- What are the tools I can use to describe the motion of **Rotating Bodies**?
- "**Rolling**", slipping, and sliding, what is the difference?
- How can I find the **Torque** if I know the force?
- How do I solve problems in **Rotational Dynamics**?
- What is **Rotational Inertia**, how do I calculate it and when should I use it?
- Why is rolling important in solving these problems?
- Does a rotating body have **Kinetic Energy**?
- How do I find the total **Kinetic Energy of a rolling ball**?
- ...and why does a rolling ball slow down?
- **Angular Momentum** - how do I calculate it?
- If angular momentum, like regular momentum, is a vector, how do I find its direction?

Chapter 11: General Rotation

- Vector Product! How do you multiply vectors?
- ...is it the same as the Cross Product?
- How can I use the vector product to define the Torque Vector and Angular Momentum Vector of a particle?
- ...a System of Particles?
  ...a Rigid Body?
- How are the Angular Momentum Vector and Torque Vector related?
- ...how does a TOP work?
- When and why is the Angular Momentum Vector Conserved?
- Inertial and Noninertial Reference Frames, how do they differ?
- ...and what is the Coriolis Force and why is it called 'fictitious'?

Chapter 12: Static Equilibrium: Elasticity and Fracture

- What keeps structures from collapsing? Is this the study of **Statics**?

- How do you achieve **Equilibrium**?
- How do I **Solve Problems** using statics and equilibrium?
- **Muscles, Joints, and Tendons** How do they 'hang together'?
- **Stability** and **Balance** that is the difference?
- **Stress** and **Strain** How do they relate to **Elasticity** and the integrity of structures?
- "All Fall Down": When does **Fracture** occur?
- **Building Bridges**, how do I do it?

Chapter 13: Fluids

- **Density** and **Specific Gravity** that are they and how do they differ?
- "The weight of the matter", **Pressure** that is it?
- **Atmospheric Pressure** and **Gauge Pressure** then do I use them?
- **Pascal and Arcimedes** both had **Principles** that are they and how are they related?
- How do they make **Barometers**? How do they work and what do they measure?
- How can I use **Archimedes Principle** as an investigative tool?
- What is the difference between **Turbulent Fluid Flow** and **Laminar Fluid Flow**?
- **Bernoulli's Equation** and **Conservation of Energy**, how are they related?
- How can Bernoulli's Equation be used to explain the lift of an **Airplane Wing**, the drive of a **Sail**, and similar phenomena?
- What is **Viscosiity** and how does it affect the real flow of liquids?
- What is **Surface Tension** and how can insects walk on water?
- What are **Pumps** and how do they work?
- Isn't my **Heart** a fluid pump?

Chapter 14: Oscillations

- What is Simple Harmonic Motion and why is it important?
- How can I use Conservation of Energy to study this motion?
- What is Periodic Motion and how do I find the Period and Frequency of this motion?
- How is a Simple Pendulum, a mass on a cord, like a mass on a spring?
- ...and how does it differ from a Physical Pendulum?
- What is Damped Harmonic Motion and Resonance and why did that Bridge fall down anyway?
- How can I describe complicated vibrations?

Chapter 15: Wave Motion

- Where do **Waves** come from and what are **Periodic Waves**?
- Are the major types of waves **Transverse** and **Longitudinal** and what are they?
- How do waves **Transmit Energy**?
- What is the **Wave Equation**?
- ...and what do I get when I solve it?
- In what ways do waves interfere with each other, what is the **Principle of Superposition** and how does it explain **Standing Waves**.
- I have heard of **Refraction** and **Diffraction**. What are they?

Chapter 16: Sound

- What are the Characteristics of Sound?
- What is...
- Infrasound?
Ultrasound?
Pitch?
Frequency?
Loudness?
Intensity?
- I have heard of Decibels. What are they and how are they related to Intensity?
- How is Wave Amplitude related to Intensity?
- How is the Ear constructed and how does it sense sound?
- What are the common sources of Musical Sounds?
- How do Vibrating Strings produce sounds of different frequencies?
- How do Vibrating Air Columns produce sounds of different frequencies?
- How does Quality effect how a particular instrument sounds?
- What are Beats and how do they arise from the Interference of sounds?

- We have all heard the train whistle change pitch as it passes us. Does the Doppler Effect explain this?
- What is a Sonic Boom and how is it produced?

Chapter 13: Temperature, Thermal Expansion, and the Ideal Gas Law

- Matter on a small scale that is its **Atomic Basis**?
- **Temperature** and **Thermometers** how do they work together?
- Why is there a **Zeroth Law of Thermodynamics** and what is it?
- What is **Thermal Expansion** and how is it measured?
- How does Thermal Expansion give rise to **Thermal Stress**?
- How do the **Gas Laws** allow us to predict **Absolute Zero** and establish the **Kelvin Temperature Scale**?
- What is **The Ideal Gas Law** and how can I use it?
- What is the **Standard Temperature Scale**?

Chapter 18: Kinetic Theory of Gases

- What is the **Kinetic Theory of Matter** and how will it help me understand the true nature of matter?
- How are the molecules in a gas distributed?
- ... and what is **Maxwell's Distribution**?
- ...the most probable speed
...the average speed
...the rms speed
What are they and why do they differ?

- I know about the Ideal Gas Law, what are the **Other Gas Laws**?
- How do **Real Gases** differ from an ideal gas?
- **Water Vapor**, **Humidity**,and **Relative Humidity**巽hat are they and how do they affect my comfort level?

Chapter 19: Heat and the First Law of Thermodynamics

- What is **Heat** and how is it related to **Temperature** and **Internal Energy**?
- How do I use **Specific Heat** to solve **Calorimetry** problems?
- **Latent Heat** and **Change of Phase**巽hat are they and how are they related?
- What is **Thermodynamics**?
- What is a ...
- **System**
Closed System
Open System
Isolated System
- The **First Law of Thermodynamics** and **Thermodynamic Processes**巽hat are they?
- What is a...
Isobaric process?
Isothermal process?
Isochoric process?
Adiabatic process?

Chapter 20: The Laws of Thermodynamics

- What is the **Second Law of Thermodynamics** and how does it affect my life?
- What is a **Heat Engine**?
- How does it work?
What is its **Efficiency**?
How about a **Steam Engine**?
...an **Internal Combustion Engine**?

- What is the **Otto Cycle**?
  The **Carnot Cycle**, why is it so important?
  BTW what is a **Cycle** anyway?
- What about **Refrigerators**?
  …**Heat Pumps**?
  …**Air Conditioners**?
- What is **Entropy** and how is it related to The Second Law?
- How is it related to **Order and Disorder**?
  How does it give **Direction to Time**?
  How is it related to **Probability**?

Course Content Outline:
The following is an outline of the material covered during the course. The study of nearly every topic involves the critical evaluation of the pertinent theories and concepts as well as the critical evaluation of data in sample problems concerning each of the following topics.

CHAPTER1: INTRODUCTION, MEASUREMENT, ESTIMATING
1–1 The Nature of Science
1–2 Models, Theories, and Laws
1–3 Measurement and Uncertainty; Significant Figures
1–4 Units, Standards, and the SI System
1–5 Converting Units
1–6 Order of Magnitude: Rapid Estimating
CHAPTER 2: DESCRIBING MOTION: KINEMATICS IN ONE DIMENSION
2–1 Reference Frames and Displacement
2–2 Average Velocity
2–3 Instantaneous Velocity
2–4 Acceleration
2–5 Motion at Constant Acceleration
2–6 Solving Problems
2–7 Freely Falling Objects
CHAPTER 3: KINEMATICS IN TWO OR THREE DIMENSIONS; VECTORS
3–1 Vectors and Scalars
3–2 Addition of Vectors—Graphical Methods
3–3 Subtraction of Vectors, and Multiplication of a Vector by a Scalar
3–4 Adding Vectors by Components
3–5 Unit Vectors
3–6 Vector Kinematics
3–7 Projectile Motion
3–8 Solving Problems Involving Projectile Motion
3–9 Relative Velocity
CHAPTER 4: DYNAMICS: NEWTON'S LAWS OF MOTION
4–1 Force
4–2 Newton's First Law of Motion
4–3 Mass
4–4 Newton's Second Law of Motion
4–5 Newton's Third Law of Motion
4–6 Weight—the Force of Gravity; and the Normal Force
4–7 Solving Problems with Newton's Laws: Free-Body Diagrams
4–8 Problem Solving—A General Approach
CHAPTER 5: USING NEWTON'S LAWS: FRICTION, CIRCULAR MOTION, DRAG FORCES
5–1 Applications of Newton's Laws Involving Friction
5–2 Uniform Circular Motion—Kinematics
5–3 Dynamics of Uniform Circular Motion
5–4 Highway Curves: Banked and Unbanked
CHAPTER 6: GRAVITATION AND NEWTON'S6 SYNTHESIS
6–1 Newton's Law of Universal Gravitation
6–2 Vector Form of Newton's Law of Universal Gravitation
6–3 Gravity Near the Earth's Surface; Geophysical Applications
6–4 Satellites and "Weightlessness"
6–5 Kepler's Laws and Newton's Synthesis
6–7 Types of Forces in Nature
CHAPTER 7: WORK AND ENERGY
7–1 Work Done by a Constant Force
7–2 Scalar Product of Two Vectors
7–3 Work Done by a Varying Force
7–4 Kinetic Energy and the Work-Energy Principle
CHAPTER 8: CONSERVATION OF ENERGY
8–1 Conservative and Nonconservative Forces
8–2 Potential Energy
8–3 Mechanical Energy and Its Conservation
8–4 Problem Solving Using Conservation of Mechanical Energy
8–5 The Law of Conservation of Energy

8–6 Energy Conservation with Dissipative Forces: Solving Problems
8–7 Gravitational Potential Energy and Escape Velocity
8–8 Power
CHAPTER 9: LINEAR MOMENTUM
9–1 Momentum and Its Relation to Force
9–2 Conservation of Momentum
9–3 Collisions and Impulse
9–4 Conservation of Energy and Momentum in Collisions
9–5 Elastic Collisions in One Dimension
9–6 Inelastic Collisions
9–7 Collisions in Two or Three Dimensions
9–8 Center of Mass (CM)
9–9 Center of Mass and Translational Motion
CHAPTER 10: ROTATIONAL MOTION
10–1 Angular Quantities
10–2 Vector Nature of Angular Quantities
10–3 Constant Angular Acceleration
10–4 Torque
10–5 Rotational Dynamics; Torque and Rotational Inertia
10–6 Solving Problems in Rotational Dynamics
10–7 Determining Moments of Inertia
10–8 Rotational Kinetic Energy
10–9 Rotational Plus Translational Motion; Rolling
10–10 Why Does a Rolling Sphere Slow Down?
CHAPTER 11: ANGULAR MOMENTUM; GENERAL ROTATION
11–1 Angular Momentum—Object Rotating About a Fixed Axis
11–2 Vector Cross Product; Torque as a Vector
11–3 Angular Momentum of a Particle
11–4 Angular Momentum and Torque for a System of Particles; General Motion
11–5 Angular Momentum and Torque for a Rigid Object
11–6 Conservation of Angular Momentum
CHAPTER 12: STATIC EQUILIBRIUM; ELASTICITY AND FRACTURE
12–1 The Conditions for Equilibrium
12–2 Solving Statics Problems
12–3 Stability and Balance
12–4 Elasticity; Stress and Strain
12–5 Fracture
CHAPTER 13: FLUIDS
13–1 Phases of Matter
13–2 Density and Specific Gravity
13–3 Pressure in Fluids
13–4 Atmospheric Pressure and Gauge Pressure
13–5 Pascal's Principle
13–6 Measurement of Pressure; Gauges and the Barometer
13–7 Buoyancy and Archimedes' Principle
13–8 Fluids in Motion; Flow Rate and the Equation of Continuity
13–9 Bernoulli's Equation
13–10 Applications of Bernoulli's Principle: Torricelli, Airplanes, Baseballs, TIA
CHAPTER 14: OSCILLATIONS
14–1 Oscillations of a Spring
14–2 Simple Harmonic Motion
14–3 Energy in the Simple Harmonic Oscillator
14–4 Simple Harmonic Motion Related to Uniform Circular Motion
14–5 The Simple Pendulum
14–7 Damped Harmonic Motion
14–8 Forced Oscillations; Resonance

CHAPTER 15: WAVE MOTION
15–1 Characteristics of Wave Motion
15–2 Types of Waves: Transverse and Longitudinal
15–3 Energy Transported by Waves
15–4 Mathematical Representation of a Traveling Wave
15–6 The Principle of Superposition
15–7 Reflection and Transmission
15–8 Interference
15–9 Standing Waves; Resonance
CHAPTER 16: SOUND
16–1 Characteristics of Sound
16–2 Mathematical Representation of Longitudinal Waves
16–3 Intensity of Sound: Decibels
16–4 Sources of Sound: Vibrating Strings and Air Columns
16–6 Interference of Sound Waves; Beats
16–7 Doppler Effect
CHAPTER 17: TEMPERATURE, THERMAL EXPANSION, AND THE IDEAL GAS LAW
17–1 Atomic Theory of Matter
17–2 Temperature and Thermometers
17–3 Thermal Equilibrium and the Zeroth Law of Thermodynamics
17–4 Thermal Expansion
*17–5 Thermal Stresses
17–6 The Gas Laws and Absolute Temperature
17–7 The Ideal Gas Law
17–8 Problem Solving with the Ideal Gas Law
17–9 Ideal Gas Law in Terms of Molecules: Avogadro's Number
CHAPTER 18: KINETIC THEORY OF GASES

18–1 The Ideal Gas Law and the Molecular Interpretation of Temperature
18–2 Distribution of Molecular Speeds
18–3 Real Gases and Changes of Phase
18–4 Vapor Pressure and Humidity

CHAPTER 19: HEAT AND THE FIRST LAW OF THERMODYNAMICS

19–1 Heat as Energy Transfer
19–2 Internal Energy
19–3 Specific Heat
19–4 Calorimetry—Solving Problems
19–5 Latent Heat
19–6 The First Law of Thermodynamics
19–7 Applying the First Law of Thermodynamics; Calculating the Work
19–8 Molar Specific Heats for Gases, and the Equipartition of Energy
19–9 Adiabatic Expansion of a Gas
19–10 Heat Transfer: Conduction, Convection, Radiation

CHAPTER 20: SECOND LAW OF THERMODYNAMICS

20–1 The Second Law of Thermodynamics—Introduction
20–2 Heat Engines
20–3 Reversible and Irreversible Processes; the Carnot Engine
20–4 Refrigerators, Air Conditioners, and Heat Pumps
20–5 Entropy
20–6 Entropy and the Second Law of Thermodynamics
20–7 Order to Disorder
20–8 Unavailability of Energy; Heat Death