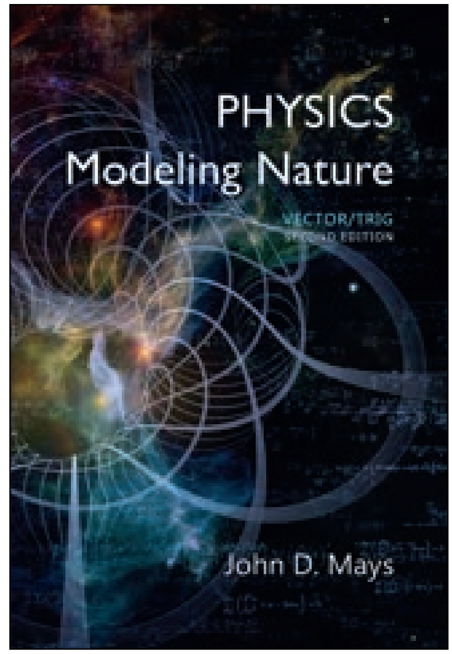
Physics: Modeling Nature

All Keys and Sample Answers



Thank you for using *Physics: Modeling Nature*. This supplementary document is being provided to aid in situations in which the adult teacher responsible for conducting the course does not possess a background in this subject, or in which a student is studying independently. The answers here are only samples and should not be considered the only correct response to the question.

In environments where there are multiple students in a class or group, it is the recommended method that the student should form their own answers in complete sentences as a homework assignment. These should be graded for completion only, not accuracy. Then in the group setting, students bring their preliminary answers to class where they collaborate with each other and the teacher and improve their answers. The final product will be a useful study tool developed by the group. In such an arrangement, there would be no need for this document, but it is provided for the many home study situations in which there is no collaborative group.

Additional information about how this course should be conducted is provided in the textbook introduction and other documents included in the Digital Resources. A full presentation of strategies and techniques for mastery-learning can be found in our book *From Wonder to Mastery*, available from our website.

Thank you!

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Physics: Modeling Nature

All Keys and Sample Answers

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Contents

NOTE: Full solutions to the computations in the chapter exercises are available in the *Solutions Manual to Accompany Physics: Modeling Nature*. To procure a copy, visit classicalsubjects.com.

Chapter Exercises

Chapter 1 Exercises

SECTION 1.1

1. Explain why measurement is such a central concern in science.

One of the things that distinguishes scientific research from other fields of study is the central role played in science by measurement. In every branch of science, researchers study the natural world, and they do it by making measurements. The measurements we make in science are the data we use to quantify the facts we have and to test new hypotheses. These data—our measurements—answer questions such as What is its volume? How fast is it moving? What is its mass? How much time did it take? What is its diameter? What was its frequency and wavelength? When do we expect it to occur again? and many others. Without measurements, modern science would not exist.

2. Distinguish between matter, inertia, and mass.

The term *matter* refers to anything composed of atoms or parts of atoms. All forms of matter may be described in terms of their physical and chemical properties, e.g., all matter takes up space and all matter has inertia.

All matter possesses the property of *inertia*. The effect of this property is that objects resist being accelerated. The more inertia an object has, the more difficult it is to accelerate the object.

As with the property of taking up space, we need a way to quantify the inertia of an object. The way we do this is with the variable we call mass. The mass of an object is a numerical measurement specifying the amount of inertia the object has.

3. Compare volume and mass.

All matter takes up space. Even individual atoms and protons inside of atoms take up space. We quantify the amount space occupied by an object by specifying its volume. As with the property of taking up space, we need a way to quantify the inertia of an object. The way we do this is with the variable we call mass. The mass of an object is a numerical measurement specifying the amount of inertia the object has.

5. Distinguish between base and derived units.

There are seven base units defined in the SI system. All other units of measure are derived by combinations of one or more of the base units.

6. Describe the origin of the SI system of units.

This system was published in 1960 but originated in France during the French Revolution. The original system included only the meter and the kilogram. Over the years, as measurement treaties were signed and scientific learning advanced, the system grew into the formal SI System that has now been in use since 1960. The SI System is administered by an organization in Sèvres, France (near Paris) known as the International Bureau of Weights and Measures. The SI System has been adopted almost globally. There are only three nations in the world that have not accepted the SI System as their official system of measurement: Myanmar, Liberia, and the United States. But even though our road sign markers still give distances in miles, in scientific work the SI System is the one we use.

SECTION 1.2

7. Describe the effect of uncertainty on scientific measurements.

All measurements contain error because there is no such thing as an exact measurement or a perfect measurement instrument. Any measurement, if made with a precise enough instrument, will exhibit variation. For this reason, good experimental practice consists of performing measurements repeatedly so that the value under study consists not only of a single measurement but of an entire set of data. Scientists then communicate a measurement by specifying (usually) the mean value and a quantitative description of the uncertainty in the measurement.

8. Write a paragraph distinguishing between accuracy and precision.

Accuracy relates to error—that is, to the lack of it—which is the difference between a measured value and the true value. The lower the error is in a measurement, the better the accuracy. Error can arise from many different sources including human mistakes, malfunctioning equipment, incorrectly calibrated instruments, vibrations, changes in temperature or humidity, or unknown causes that are influencing a measurement without the knowledge of the experimenter. Precision refers to the resolution or degree of "fine-ness" in a measurement. The limit to the precision that can be obtained in a measurement is ultimately dependent on the instrument being used to make the measurement. If you want greater precision, you must use a more precise instrument. The degree of precision in every measurement is signified by the measurement value itself because the precision is a built-in part of the measurement. The precision of a measurement is indicated by the number of significant digits (or significant figures) included in the measurement value when the measurement is written down.

9. Distinguish between random error and systematic error.

The two main types of error in experimental measurements are random error and systematic error. Random errors are caused by unknown and unpredictable fluctuations in the experimental setup. Examples of random error would be changes in the apparatus due to temperature fluctuations in the room, vibrations or wind that influence the measurement in a random fashion, or electronic noise that influences the readings in your instruments. When you calculate and discuss the uncertainty in your measurements, you are discussing the random error that caused your measurements to fluctuate randomly around the mean value.

Systematic errors are errors that bias the experimental results in one direction, and are usually caused by equipment defects, miscalibration of measurement instruments, or an experimenter who consistently misreads or misuses the instruments in the same way. Usually, when discussing systematic error, we are talking about problems that could be eliminated by proper use, calibration, and operation of the equipment.

10. Explain the meaning of the standard deviation of a data set and how the standard deviation relates to uncertainty in measurements.

The standard deviation of a data set is a statistical parameter that indicates the amount of "spread" in a data set. When taking measurements or performing calculations from repeated trials of an experiment, the values of the measurements—if there are enough of them—often form a also called a normal distribution. The standard deviation, s, of a data set is a measure of how spread out the data are. Larger values of s mean wider spread; smaller values of s mean a narrower spread. The more accurate your experimental methods, and the more precise your instruments, the narrower the spread in the data should be (all else being equal). Data that are very close together will have a very small value of s—exactly what you want. If all the data have exactly the same value, then $s = 0$.

The sample standard deviation is often used as a measure of uncertainty in a data set. All measurements made with enough precision will show variation, and together the values will form a distribution, indicating that there is uncertainty as to the true value of the parameter being measured. Quoting the value of s for a set of data is a very common way of indicating the uncertainty in the data.

SECTION 1.3

11. Explain why scientists should avoid terms such as "proven" and "true" when describing scientific knowledge.

The goal of science is to uncover the truth about how nature works, but scientific theories are always works in progress. Even our best theories are provisional and subject to change. For this reason, science is not in the business of making truth claims. It is in the business of modeling how nature works with theories based on research.

As our theories develop over time, our hope is that they get closer and closer to the truth. But the truth about nature is always out in front of us somewhere, always outside of our grasp. To know the truth about nature we would have to understand nature as God understands it. We are nowhere close to that.

For this reason, all scientific knowledge—facts and theories—is regarded as provisional. Facts may be regarded as correct, and theories may be regarded as our best approximation to the reality of nature, but all such knowledge is subject to change, to being replaced by more accurate facts or theories.

Facts can and do change as new scientific knowledge—new data—is acquired. Since facts are always subject to change, careful scientists will usually avoid terms such as *true* or *proven* to describe facts. Instead, we say a fact is correct as far as we know.

12. Describe the ways we apprehend truth and contrast these to the processes and goals of scientific inquiry.

One way we know truth is when it is evident or obvious to us. For example, it is evident or obvious to you that you are awake right now while you are reading this text. Thus, it is correct to say that it is true you are awake. Likewise, you probably know if you have eaten a meal within the past three days. If so, then it is obvious to you that if you said, "I have eaten a meal within the past three days" you would be speaking the truth.

The second way humans can know truth is by the use of valid logic, beginning with true premises. I do not develop this idea here, since the use of formal logic has little direct relation to our work in this text. The exception is the use of mathematical logic to discover new mathematical truth. This is, of course, at the core of what mathematicians do, and also plays a role in problem solving.

The third way for us to know truth is for God to *reveal* it to us. Much truth is knowledge that is revealed to us by God, either by Special Revelation or by General Revelation. Special Revelation is the term theologians use to describe truths God teaches us in the Bible, his Holy Word. General Revelation refers to truths God teaches us through the world he made. Sometimes people describe Special and General Revelation as the two "books" of God's revelation to us, the book of God's *Word* (the Bible) and the book of God's *Works* (nature).

The goal of scientific inquiry is to build reliable and successful mental models of nature through the cycle of fact, theory, hypothesis, and experiment. All scientific knowledge is provisional because it is always subject to change as new knowledge comes to light. Theories are provisional models that account for facts. Hypotheses are predictions, based on a theory, that be tested by experiment or observation, and the results of the experiments provide us with new facts.

13. Explain the difference between truth and scientific facts.

Truth is either obvious or revealed by God. This means that truth is not discovered the same way scientific facts are discovered. Facts are discovered by experiment, observation, and inferences from experiments and observations. They are not regarded as truth but as statements that are correct so far as we know. Facts can change when new information becomes know. Truth is the way things really are and does not change—it is the same for all people and all times.

14. Describe the role of theories in scientific research.

A theory is a mental model that accounts for the data (facts) in a certain field of research, and attempts to relate them, interpret them, and explain them. Scientific theories are successful if they repeatedly allow scientists to form new hypotheses that can be confirmed by experiment. Successful theories are the glory and goal of science. Nevertheless, theories, like facts, are provisional and subject to change. Indeed, theories are almost constantly evolving as research continues. And as with facts, when referring to theories, we avoid terms like true or proven. Instead, we speak in terms of how successful theories have been in generating hypotheses that are supported by experiments, that is, how accurately predictions derived from the theory match the results of experiments. A widely accepted scientific theory should be understood as our best explanation at present—our best model of how nature works.

There is no scientific knowledge that is not theoretical. That is, data or facts by themselves don't tell us anything apart from the theories we have to account for and explain the facts. It is also important to note that scientific theories need to be testable. A theory that does not lead to testable hypotheses has no chance of gaining credibility and remains at the level of conjecture. For a theory to be well established, it must lead to hypotheses that can be put to the test.

15. I once read the statement, "No theory is true until it is proven." Use our discussion of the nature and role of theories and scientific knowledge to respond to this claim.

This claim is full of category errors. First, no theory is ever known to be true. The best we can ever know is that a theory has never led to a hypothesis that wasn't supported by experimental results. A theory may be true, but if it is we have no way of knowing; only God can know that. Second, we don't speak of scientific things being proven for the simple reason that all scientific knowledge is provisional and subject to change when new knowledge becomes known.

Chapter 2 Exercises

SECTION 2.1

1. What is physics?

From Section 1.3.1, physics is all about the modeling of the fundamental interactions of matter and energy.

SECTION 2.2

6. Is it possible for an object to be accelerating and at rest simultaneously? Explain your response and give an example that demonstrates your point.

Yes. A ball thrown straight up will be at rest at the top of its trajectory when it changes direction. Since it is also being attracted by the earth's gravity, it is accelerating.

7. Distinguish between velocity and acceleration.

Velocity refers to the speed and direction in which an object is moving. Acceleration is the rate at which a velocity is changing.

Chapter 3 Exercises

SECTION 3.1

1. Why is it that the gravitational force, which is by far the weakest of all forces, is the only force that affects objects on a cosmic scale (i.e., at the scale of solar systems and galaxies)?

As with gravity, the range of the electromagnetic force extends to infinity. However, any large-scale object will have equal numbers of positive and negative changes (protons and electrons), so the attractions and repulsions between these particles essentially cancel out. Since both the strong and weak nuclear forces have ranges limited to the size of the atomic nucleus, only gravity can affect objects on a cosmic scale.

2. Compare the ranges of the weak and strong nuclear forces to the size of the atomic nucleus.

The range of the strong nuclear force is 10^{-15} m; that of the weak nuclear force is 10^{-15} m. The size of the atomic nucleus is about the same as the range of the strong nuclear force; the nucleus is 1,000 times the size of the range of the weak nuclear force.

3. Consider a force applied to an object from a source other than gravity, such as the force of the wind on a kite that keeps the kite aloft. Which of the four fundamental interactions is the fundamental force involved here?

The electromagnetic force. Even though we are not as aware of electrical and magnetic forces as we are of gravity, electrical forces play a much greater role in our lives. One way or another, electrical attraction is the force holding together the atoms in all different materials. Electrical forces also hold things apart from each other—when an object "touches" another object, what is really happening is that the objects are close enough together so that the electrons surrounding the atoms repel each other, and the objects cannot be forced any closer together against this electrical repulsion. In summary, electrical forces are responsible for holding all substances intact, and thus they are a dominating factor in our everyday world.

4. Describe a specific, actual situation in which a vector field is changing in time.

An example is the gravitational field around the earth-moon system. As the moon orbits the earth, the shape of the overall gravitational field is changing.

5. How does the fact that the diameter of an atom is about five orders of magnitude greater than the diameter of the atomic nucleus relate to the possibility of the strong nuclear force affecting objects outside the nucleus?

It means that although the strong nuclear force reaches throughout the nucleus, it has no chance of affecting anything outside the nucleus.

6. Do the humidity values in the air above a valley form a scalar field or a vector field? Explain.

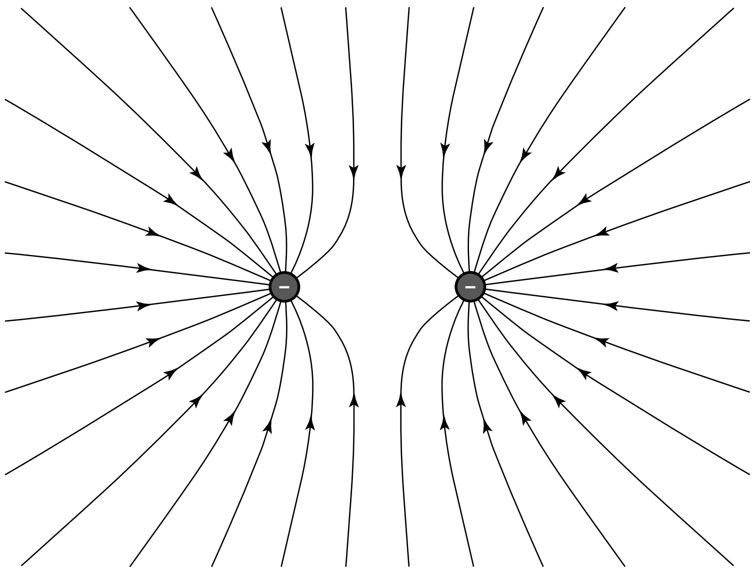
Humidity values are scalar values and together they form a scalar field.

7. Do the velocities of water molecules throughout the volume of water in a flowing stream constitute a scalar field or a vector field? Explain.

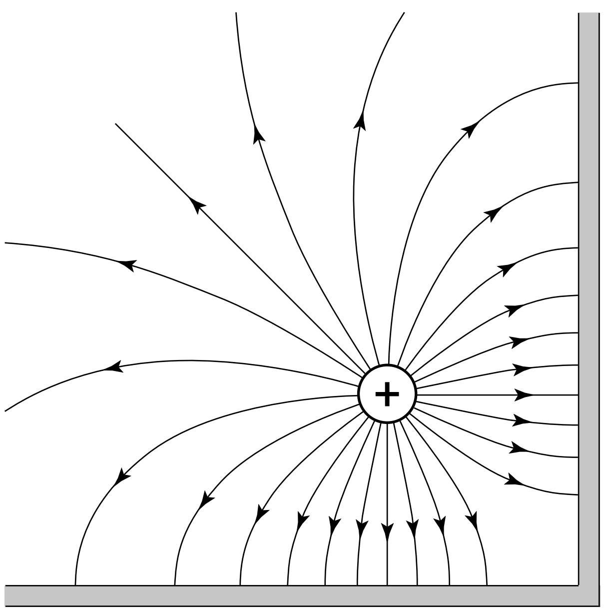
Velocities are vectors because they have both magnitude and direction. Together, the velocities of the molecules in flowing water form a vector field.

8. Draw sketches of the vector fields that would be present in the following scenarios:

a. Two negative charges near to each other.

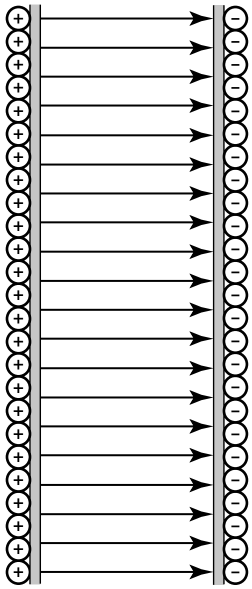


b. A positive charge near the corner of two large conducting sheets joined together, as shown in the sketch in Figure 3.38.



c. The electric field between and outside of two large metal sheets, placed close together and parallel, if one is positively charged and the other is negatively charged.

The fields from the two sheets cancel out, so there is no field outside the plates, only between them.



9. What evidence is there to indicate that fields are more than mathematical abstractions and may have actual physical existence?

Electric and magnetic fields possess energy. It is also the case that photons of light—which entail propagating fields—possess energy. Thus, fields can possess energy.

Now if we imagine that an electric charge is accelerated in the electric field produced by some confined charges, and thus moves to the left. The law of conservation of momentum requires that as the electron gains momentum in one direction, the system responsible for the accelerating electric field must gain an equal amount of momentum in the opposite direction. However, once the electron begins moving, the information about its motion—i.e., the disturbance in the field produced by its own changing electric field location—cannot be received by the accelerating charges at a speed faster than the speed of light. But the law of conservation of momentum is regarded as absolute: the momentum of the universe is always the same at all times. This raises the question of where the recoil momentum is prior to the system of positive charges "feeling" the electron's motion. The only answer physicists have to this question is that the momentum is in the field.

As it became clear during the 20th century that fields could possess energy and momentum, physicists became increasingly persuaded that fields were more than mere mathematical abstractions—they were real.

10. Describe the sources and effects of various types of fields.

Gravitational fields are the result of mass and result in an attractive force on all other masses. Gravitational fields also result in the bending of light rays as the rays pass near a massive object, such as the sun.

Electric fields are produced by charged particles and changing magnetic fields. They affect other charged particles.

Magnetic fields are produced by permanent magnets and by changing electric fields, such as those produced by the moving electric charges in an electric current. Changing magnetic fields produce electric fields and vice versa. Static electric and magnetic fields can exist apart from each other, but if any dynamics occur (changes with respect to time) in one of these types of fields, the other is produced as a result.

11. What large features on earth are clearly a result of the gravitational attraction of the moon?

The tides.

SECTION 3.2

13. Describe four major advances in motion theory proposed by Galileo.

1. Based on his own experiments with pendulums and falling objects, Galileo determined that all falling objects accelerate at the same rate, regardless of their weights.

Course Lesson Schedule Physics Fall Semester

Lesson Number	Topic	Text Key	Assignment	Notes
1	The Cycle of Scientific Enterprise; SI and MKS units; accuracy and precision; significant figures	1.1-1.3	p.34 1–15	Problem 4 practice conversions are optional, if students need practice.
2	Vector quantities; graphical vector addition	1.4	p. 35 Do graphically: 16–19	
3	Analytic vector addition	1.4	p. 36 Do analytically: 20–29 Read Gribbin ch 1. Submit 1 page summary notes.	
4	Displacement and velocity	2.1-2.2	p. 69 1–7	
5	Acceleration and rectilinear motion	2.2	p. 70 8–25	
6	Class work on problems	-	-	
7	Solutions review	-	-	
8	Class work on problems	-	-	
9	Gribbin discussion ch 1 Theories, hypotheses, etc	-	-	Gribbin Ch 1 provides a good opportunity to review the Cycle of Scientific Enterprise from text Ch 1.
10	Exam 1	-	Read Gribbin ch 2.	
11	Projectile motion	2.3	p. 71 26–40	
12	Projectile motion	2.3		
13	Class work on problems	-		
14	Relative velocity	2.4	p. 73 41–46	
15	Bull's Eye Lab	-	Lab Report	Bull's eye lab handout
16	Gribbin discussion ch 2.	-	-	
17	Exam 2	-	Read Gribbin ch 3.	
18	Forces, fields, historical review	3.1-3.2	p. 107 1–14	
19	Laws of Motion; weight	3.3	p. 108 15–23	
20	Newton's 2nd law applications	3.3	p. 108 24–29	
21	Friction	3.4	p. 110 30–46	Friction Lab Handout
22	Class work on problems	-	-	
23	Class work on problems	-	-	
24	Friction Lab Session 1	-	-	
25	Class work on problems	-	p. 111 47–48	
26	Gribbin discussion ch 3.	-	-	
27	Exam 3	-	Read Gribbin ch 4.	
28	Conditions for static equilibrium	4.1	p. 130 1–3	
29	Torque; Vector products	4.2	p. 37 #31–32; p. 130 2–7	
30	Statics applications	4.3	p. 130 8–30	
31	Class work on problems	-	-	
32	Friction Lab Session 2	-	-	
33	Gribbin discussion ch 4	-	-	
34	Exam 4		Read Gribbin ch 5	
35	Energy	5.1-5.2	p. 37 #30; p. 163 1–34	
36	Conservation of mass-energy	5.3	p. 165 35–53	
37	Conservation of mass-energy	5.3	-	
38	Class work on problems	-	-	
39	Friction Lab Session 3	-	-	
40	Discuss Gribbin ch 5	-	p. 167 54–58	
41	Exam 5		Read Gribbin ch 6	
42	Linear momentum and impulse, cons. of mom	6.1-6.2	p. 183 1–14	
43	Elastic and inelastic collisions; Cons of mom in 2 dims.	6.2	p. 184 15–21	
44	Combining momentum and energy	6.3	p. 185 22–26	
45	Class work on problems	-	-	
46	Class work on problems	-	-	
47	Discuss Gribbin ch 6	-	p. 27–30	
48	Exam 6	-	Read Gribbin ch 7.	
49	Angular quantities, moment of inertia	7.1-7.2	p. 208 1–23	
50	Class work on problems	-	-	
51	Centripetal and "centrifugal" force	7.3	p. 210 24–34	
52	Newton's Law of Grav	7.4	p. 211 35–39	
53	Class work on problems	-	-	
54	Class work on problems	-	p. 211 40–43	
55	Exam 7			

Course Lesson Schedule   Physics   Spring Semester

Lesson Number	Topic	Text Key	Assignment	Notes
1	Rotational energy and mom	8.1-8.2	p. 225 1–18	Rotational Conservation of Energy lab handout
2	Class work on problems	-	-	
3	Rotational Conservation of Energy lab	-	Lab report	
4	Cons of angular mom	8.3	p. 227 19–26	
5	Class work on problems	-	-	
6	Class work on problems	-	-	
7	Discuss Gribbin ch 7	-	p. 228 27–29	
8	Exam 8	-	Read Gribbin chapter 8	
9	Pressure, abs pressure, gauge pressure	9.1	p. 249 1–12	
10	Pascal’s principle, pressure examples, U-Tubes and hydraulics, Bernoulli’s principle	9.1	p. 250 13–28	
11	Classwork on problems	-	-	
12	Archimedes’ principle,	9.2	p. 252 29–40	
13	Classwork on problems	-	-	
14	Discuss Gribbin ch 8	-	p. 253 41–48	
15	Exam 9	-	Read Gribbin chapter 9	
16	Moles, Avogadro’s number, molar mass	10.1	p. 288 1–8	
17	Gas Laws	10.2	p. 288 9–20	
18	Kinetic-molecular theory and molecular velocities	10.3	p. 289 21–26	
19	Class work on problems	-	-	
20	Heat cap, heat of fusion/vap, calorimetry	10.4	p. 290 27–43	Calorimetry lab handout
21	Class work on problems and lab prep	-	-	
22	Calorimetry lab	-	Lab Report	
23	Discuss Gribbin ch 9	-	p. 291 44–47	
24	Exam 10	-	Read Gribbin chapter 10	
25	First Law of Thermodynamics; thermodynamic processes	11.1	p. 313 1–14	
26	Thermodynamic processes	11.2	p. 314 15–22	
27	Second Law of thermodynamics, entropy	11.3	p. 23–28	
28	Heat Engines, refrigeration	11.3	p. 29–37	
29	Class work on problems	-	-	
30	Discuss Gribbin ch 10	-	p. 315 38–42	
31	Exam 11	-	Read Gribbin chapter 11	
32	SHM	12.1	p. 351 1–11	
33	Pendulum, small angle approximation, modeling waves	12.1, 12.2	p. 352 12–20	
34	Wave interactions	12.2	p. 353 21–32	
35	Sound intensity and SPL	12.3	p. 354 33–42	Sound lab handout
36	Frequency response, Doppler effect	12.3	p. 355 46–50	
37	Class work on problems	-	-	
38	Sound Lab	-	Lab Report	
39	Discuss Copenhagen	-	p. 355 51–55	
40	Exam 12	-	-	
41	DC Circuits	13.5	p. 400 39–51 as needed	Placing this topic here with only one day of treatment assumes students previously mastered this topic as described in the teacher preface of the text and the recommendations document on the CD.
42	Electrostatics and Coulomb’s Law	13.1-13.2	p. 397 1–12	
43	Electric Fields and Charge Symmetries	13.3	p. 398 13–21	
44	Electric Fields, potential, work, charge, capacitors	13.4	p. 399 22–38	
45	Classwork on problems	-	-	
46	Classwork on problems	-	-	
47	Classwork on problems	-	p. 403 52–57	
48	Exam 13	-	-	
49	Forces Caused by Magnetic Fields	14.1	p. 443 1–15	
50	Torque on a current loop and motors	14.1	p. 444 16–21	
51	Faraday's Law, Generators	14.2	p. 445 22–26	
52	Transformers	14.2	p. 445 27–32	
53	Classwork on problems	-		
54	Inductance and Time-Varying Circuits	14.3	p. 446 33–41	
55	Inductance and Time-Varying Circuits	14.3	p. 446 42–49	
56	Lenz's Law	14.4	p. 447 50–52	
57	Class work on problems	-	-	
58	Class work on problems	-	p. 447 53–57	
59	Exam 14	-		

First and Last Name________________________________

Physics
Quiz 10: Section 7.3

A child is whirling a rock on a string in a vertical circle at a rate of 2.0 revolutions per second. The string is 32 inches long and the rock has a mass of 125 g. Determine the tension in the string when it is straight down, that is, when the rock is at the bottom of the circle.

First and Last Name________________________________

Physics
Quiz 12: Section 9.1

A standpipe is a tall, narrow, cylindrical water tank with an air space in the top. The air in the air space is trapped. If the standpipe is empty, the air inside is at atmospheric pressure. Then an electric pump pumps water from a well into the bottom of the standpipe. As the standpipe fills, the air in the space at the top is increasingly compressed and under increasing pressure. This trapped air pressure then provides the pressure necessary to make the water flow to nearby houses.

A certain standpipe is 95.00 ft tall. When it is empty, the pressure inside is atmospheric pressure. When it is filled to a depth of 65.60 ft with water (i.e., the air space is now 29.40 ft tall) the gauge pressure inside the air space is 223,775 Pa. Answer the following questions assuming the standpipe has 65.60 ft of water in it.

1. What is the gauge pressure at the bottom of the tank?

2. What is the absolute pressure at the bottom of the tank?

3. There is a small access plate at the bottom of the tank that can be removed for maintenance. This plate has a surface area of 0.785 m^2. What is the net force on this access plate?

4. If the well water pump is down at the bottom of the well 196.0 ft below the bottom of the tank, what is the gauge pressure in the water pipe where the pump is?

First and Last Name________________________________

Physics
Quiz 14: Sections 11.1-11.2

1. What are state variables?

2. State and explain the First Law of Thermodynamics.

3. Define these three processes: *adiabatic*, *isobaric*, and *isothermal*.

4. What is a thermodynamic state?

First and Last Name________________________________

Physics
Quiz 16: Section 13.2

1. Determine the Coulomb force acting on each of two sulfur ions, assuming the ions are held 0.0100 mm apart. (Note: $e = 1.602 \times 10^{-19}$ C)

2. Determine the force acting on a proton held 1.00 mm from a long, thin, straight wire carrying a charge of $\lambda = 0.15$ μC/m.