1 Physics, the Fundamental Science

1 What About Energy?
2 The Scientific Enterprise
3 The Scope of Physics
4 The Role of Measurement and Mathematics in Physics
5 Physics and Everyday Phenomena
Everyday Phenomenon: The Case of the Malfunctioning Coffeepot

The purpose of this introductory chapter is introduce the connections between physics and everyday phenomena, including current issues involving energy. The scientific method is introduced as well as an overview of what physics is about and its relation to other sciences. The experimental and quantitative aspects of physics are stressed. The chapter concludes with the philosophy of the text in relating physics to everyday phenomena.

Suggestions for Presentation

To begin the course using the approach relating physics with everyday phenomena, have a coffee pot (or other small appliance) that no longer works on the lecture table. Ideally, the presence of this unusual object will arouse student's interest and will be used later.

As you give your introductory lecture it is important to share the enthusiasm that you have for physics with your students. Think about your favorite aspect of physics that lends itself to demonstration, and provide a sort of “teaser” with it. Many students have the idea that physics is dry, boring, impossible, and utterly inapplicable to the average person’s life. You may feel that "Physics is Phun" but to all too many it is really "Physics is Phear". Let students know that they will be able to understand the essential physics and that basic mathematics is really all they need. In fact, many concepts can and should be initially grasped without mathematics. If students need a calculator to do everything, then the concept is being replaced by mathematics. However, it's important to not put down the course as an easy or low-level course. This will rob the students of a sense of achievement when they do master the concepts. After all, just because the course avoids advanced mathematics doesn't make the concepts any simpler. In fact this limitation actually makes for a more understanding-based course.

It could be very helpful for you to outline the goal of science; that is, to understand nature in terms of logical self-consistent sets of principles which apply to all observers.

As an example of how we can use the scientific method in everyday life turn to the broken coffee pot (or waffle iron or toaster or…). Going over the six steps presented in Everyday Phenomena box 1.1 is very illustrative. Plug it in, checking hypothesis No. 1. We can easily check No. 2 and 3 as well. With a continuity meter we can see if there is an open circuit or not, which leaves the remaining three hypotheses. Unless we are especially handy and have spare parts available, we may wish at this point to take the appliance to the repair shop.

Another example from everyday life: a car that has been running perfectly but was left outside overnight suddenly won't start the next morning after a sudden cold snap. The car will start if it gets the proper fuel mixture and the spark at the right time. One can go through the possibilities of a weak battery or other electrical problem, an empty tank, a frozen fuel line or a blocked fuel line. If we think the fuel line may be frozen we can get it indoors or wait for warmer temperatures to get it going again. We may end up calling the garage or the motor club but at least we have some idea of the problem and we are not totally at the mercy of our ignorance.

There are innumerable examples of such thinking from a typical day, so decide on something that your audience can relate to. For instance, in southern states, cold snaps that kill cars are extremely rare, so you might wish to draw on other experience.

Demonstrations that yield unexpected answers are also excellent class-starters. For instance, a simple demonstration of rolling two soda cans – one filled with liquid and the other frozen solid (make sure it stays frozen for the demonstration; you might also fill it with mortar instead) - down an inclined plane, eliciting predictions from the class about which one will win, is quite an eye-opener. If your institution has the equipment, dropping a penny and feather in an evacuated cylinder also defies intuition. Setting up rows of dominoes with different spacings and asking which row of dominoes will fall faster is also an attention-getter, and will become relevant when you discuss such things as wave propagation through a medium. By setting up such demonstrations that require students to *predict* an outcome, you also can get your students engaged in discussions with each other, which is a good start to a class that will employ some learner-centered pedagogical methods. For larger classes, you might find that the most vocal students ultimately dominate every discussion, so having students hold up a color-coded voting card or creating clicker questions around possible predicted outcomes of your demonstrations is often a great way to keep everyone engaged. You will also be showing how science is done, namely by making testable predictions about the Universe.

The relevance of physics to the other sciences and technology should also be stressed along with its many applications to other areas such as medicine, psychology, music, agriculture, etc. Students can be asked to think about applications in their own home, work, and school: television and stereo systems, cordless telephones, cell phones, WiFi, computers, fluorescent lights, xray machines, MRIs, dimmable lighting systems, electrical thermostats, photocopiers, automatic clothes dryers, and so on.

The "m" word (mathematics) cannot be avoided. It is the language of the sciences and so the laws of physics are most precisely and economically stated in mathematical terms. The text demonstrates how we make measurements and simple calculations in everyday life. In the example of stretching a recipe we are assuming a linear relationship between the quantity of ingredients and the number of servings. First verbalize this example, then sketch it so that they can visualize the relationship, and only then show that using simple mathematics makes the solution easy. Mathematics is, thus, a shorthand notation for things that can be described and drawn.

As a physics instructor, you might find it inconceivable that students could struggle with computations that have come naturally to you for years. For instance, you have likely had enough math that you can convert from one unit to another in your head, estimate an answer to within an order of magnitude using scientific notation, or have a physical intuition about what a particular equation describes. These abilities are mystifying to most students of conceptual physics, so you should take the time to present a few examples of unit conversion, the use of scientific notation, multiplying exponents, and whatever other mathematical tools your students will need to succeed in your version of the course. This is where it is vitally important to use familiar real world examples so that students can gauge the "rightness" of a computed answer. When they are more comfortable with "speaking math," they will be more confident in their answers for unfamiliar problems, like those involving atomic energy levels.

The authors presents their philosophy in section 1.5, which is to present physics by starting from observable phenomena in everyday life. The concepts often have a tremendous range of application. Study of angular motion has applications not only to the bicycle wheel and gyroscope but also to atomic phenomena and to the motion of galaxies (at the opposite extreme in size). This is where you can show that not only is physics interesting but it is also exciting and has universal application.

Debatable Issues

"*We are often told that there is a strong consensus among climate scientists that global warming and climate change are being caused by human activity that is producing growing amounts of greenhouse gases, particularly carbon dioxide, in the atmosphere. Does a strong consensus among scientists imply that this idea is correct? Why or why not?*"

The new Debatable Issues feature found throughout the textbook might be helpful when engaging students in debates or trying to get them to see the relevance of physics to everyday life. The comments in this Instructor's Manual, such as those below, might be helpful in guiding your class, but be ready for the students to take you to unexpected places!

Again, depending on your audience, there might be strong *emotions* about the validity of scientific data with little scientific evidence backing those emotions. In this internet age, it is difficult for the average person to ferret out the scientifically valid websites from the sites that simply wish to push an agenda while conveniently ignoring other data. Celebrities with great visibility and hideous science are often seen as experts, and make it even more difficult for today's generation to get the facts.

In order to give your students a bit of a primer on good science versus bad science, you might begin with what is probably a much less heated issue of whether humans have landed on the moon (you may provide your favorite pet pseudoscience example, such as the apocalypse of 2012, the health benefits of colloidal silver. The list goes on and on.). By providing both the good and bad scientific views, which are easily found with a good internet search, and demonstrating logically the holes in the moon-landing-hoax proposition, you then set your students up for a better appreciation for the arguments behind other issues. You can also introduce the argument of attacking an argument, rather than a person. While Person A might be an abominable human being, this has no bearing on his/her scientific results, assuming they are presented in the appropriate scientific manner. In this blogging on-line age where everyone's comment carries equal weight, it is often difficult for our students to realize that Person A's arguments are valid even if Person A happens to be unpleasant.

It might also be worth mentioning that scientists themselves are human and do sometimes follow the herd. A case where scientific consensus was erroneous was in determining the hydrogen content of the Sun, which was discovered in 1921 by Cecilia Payne to be quite large. The astronomical community scoffed at this conclusion for a few years, but because her science was sound and repeatable, the discovery was ultimately accepted. Thus there are cases where strong consensus does not mean that something is correct, but it is important to note that support for unconventional ideas grows with further testing.

Clicker Questions

Clicker questions are a great way to engage class and to make students aware of the most important concepts. These questions can be used in a variety of ways, from quizzes to taking attendance to simply assessing in real time the understanding level of your class (and where you might need to go back over something!). A wealth of research has been performed on the value of personal response questions within the classroom setting, and they don't necessarily require a hardware purchase. We have provided a PowerPoint file of suggested clicker questions for this chapter in the instructor resources at www.mhhe.com/griffith. .

Answers to Questions

Q1. Yes. Although there are large fluctuations in the average temperature from year to year, the overall trend has been upward.

Q2. Yes. Trees and other green plants absorb carbon dioxide from the atmosphere to produce wood and other plant parts. To the extent that some of the plant material is buried in the ground and not burned, the net effect of plant cover is to reduce the amount of carbon dioxide in the atmosphere.

Q3. No. The burning of wood represents the use of plants that have recently absorbed carbon from the atmosphere; the net effect of burning wood has little or no impact on carbon-dioxide levels.

Q4. Yes (with some reservations). Carbon dioxide in the atmosphere contributes to the greenhouse effect. Greenhouse gases allow the energy from sunlight to enter the atmosphere, but trap the re-radiated energy from escaping into space (which keeps the earth warm). However, the greenhouse effect is just one of many factors that affect earth's climate, so it is difficult to predict the impact accurately.

Q5. No. The burning of fossil fuels on a significant scale has only been occurring over the last 200 years or so, with the largest amount of use taking place in the last 100 years. (See figure 1.3.)

Q6. No. Nuclear power does not involve the burning of fossil fuels and does not release carbon dioxide to the atmosphere.

Q7 Testability. Both religion and science deal with truth, however subjective that might be. Explanations given by either may be simple or complex, but those provided by science can be reliably tested.

Q8 A test could be conducted with the individual isolated from both the cards and the person doing the shuffling as well as the reading. Even if the person claims to require the presence of the cards, it is possible. The important considerations will be many repetitions, with several decks, and no communication between the subject and the dealers.

Q9 Probably not. People's actions and reactions depend not on fundamental or universal physical laws, but on various cultural, instinctive, and emotional responses that have a variety of causes.

Q10 There seems to be no controlled manner or process to test any theories of the existence or properties of UFOs. Since sightings seem to be at random, preparing for the observation of a UFO must always be done on an ad hoc basis and therefore the data will always be suspect.

Q11 Assuming that there is no cranking of the engine at all, we could turn on the headlights to see if they shine brightly. If they do there may be a bad connection in the starter circuit. If not, you could remove the battery and replace it with one known to be good or get a "jump start" with cables attached to the battery in another car.

Q12 One hypothesis is that your telephone number has been inexplicably given to someone else (this has actually happened). A test would be to try to call your own number. In this cell phone era, this is often doable in the same room. Of course, if this was the case, it is possible that your friend's call was picked up at the other phone. This test may also confirm that your phone does not even work at all! Check your ringer, the loudness setting, and if it is plugged in. This scenario is rich with possibilities!

Q13 Arrange for a random selection of sock color and then track the sock color and the stock market. Also, one could pre-select the sock color pattern for a month and track the stock market. It is important that this study be done over a long time interval, say a month, so that the statistics are representative.

Q14 Since physics deals with the principles and laws that are used to explain fundamental processes in biology and chemistry, it is often considered the most fundamental (though not necessarily by biologists and chemists).

Q15 Rainbows can be explained by the laws of optics, the motion of an acorn by the laws of mechanics.

Q16 Thermodynamics is involved in explaining the melting of an ice cube. Both mechanics and thermodynamics could be used to discuss how an airplane flies.

Q17 Speed is the distance traversed divided by the time it takes.

Q18 No. The expression would be written: *I = F*t.*

Q19 $s = 1/2(at^2)$; ~ = 1/2 (ãβ^2)

Q20 The metric system is easier to use, especially because conversions between units are decimal based. The British system has the more complicated conversions between units such as miles, feet, yards, inches, etc.

Q21 The only advantage of continuing to use the British system is its familiarity. In our opinion that is not much of an advantage. The metric system is not difficult to master.

Q22 All major countries outside of the United States use the metric system. U.S. companies increasingly are using metric units to remain competitive in the marketplace.

Q23 An advantage is that it is always available. Disadvantages include (among others) the fact that the width of one man's hand is not the same size as the width of some other fellow's hand. I leave it to the instructor to be surprised by some of the things students can come up with.

Q24 Not exactly. The length of a pace depends upon the person doing the pacing. Your measurement is likely to be off by several feet.

Q25 Gallon, liter, quart, milliliter

Q26 Mile, kilometer, ft, in, cm

Answers to Exercises

E1 1000 ml

E2 600 ml

E3 8 pizzas

E4 126 cm = 1.26 m

E5 135 in = 11.25 ft

E6 240 mm = 24.0 cm = 0.240 m

E7 9.40 kg = 9.40×10^3 g = 9.4×10^6 mg

E8 3.25 kL = 3.25×10^3 L = 3.25×10^6 mL

E9 1 mi = 1610 m = 1.610 km

E10 1760 yd = 1 mi

E11 6.25 m^2 = 6.25×10^4 cm^2
1 m^2 = 1×10^4 cm^2

E12 Yes, you are speeding, 55 MPH is 88.5 km/hr.

$$55MPH \times \frac{1.609km/hr}{1MPH} = 88.5km/hr$$

E13 \$4.16/gal

$$\frac{\$1.10}{liter} \times \frac{1\ liter}{0.2643gal} = \$4.16/gal$$

E14 $2X10^6$ cm^3

$$2m^3 \times \left(\frac{100cm}{1m}\right) \times \left(\frac{100cm}{1m}\right) \times \left(\frac{100cm}{1m}\right) = 2 \times 10^6 cm^3$$

E15 $3 = \sqrt{9}$

E16 Eight times; volume=$(side)^3$, $2^3 = 8$.

Answers to Synthesis Problems

SP1.
a. Yes, but the significance of the test is controlled by the vagueness of the predictions.
b. Record the predictions for several months; rate each as true or false.
c. These predictions are printed more as entertainment than serious news. Throughout history people have searched for knowledge of the future

SP2. a. 0.7567 liters

$(\frac{1}{5} gallon \times \frac{1 liter}{0.2643 gal} = 0.7567 liters)$

b. 756.7 ml $(0.756.7 liter \times \frac{1000 ml}{liter} = 756.7 ml)$

c. A fifth of a gallon is larger, by 56.7 ml.

SP3.

a. 5 X 350 = 1750 hrs
b. 75W X 1750 hrs = 131,250 Wh=131.25 kWh
c. 15W X 1750 hrs = 26,250 Wh = 26.25 kWh
d. $0.15/kWh X 131.25 kWh =$19.69
e. $0.15/kWh X 26.25 kWh = $3.94
f. $19.69-$3.94 = $15.75 per year
g. $15.75 X 20 = $315 per year