Natural Science 280: Inventing Reality

Course Reader Supplement #1: Sample Problems from Hewitt

The Course Reader contains many pages of text from Paul Hewitt’s eminently readable book, Conceptual Physics. Unfortunately, some parts of the photocopied pages in the Reader (namely the Sample Questions sprinkled throughout the chapters) did not photocopy well, and hence are illegible. Since the Sample Questions serve a vital role in the understanding of the material, this supplement contains these Sample Questions, reproduced so that they are readable! Next to each question the Reader page is indicated, so that you may follow along using this supplement as you progress through the Reader. In addition, a useful section entitled “Working with Units in Physics” is included at the end of this supplement.

► Questions

1. a. With the speedometer on the dashboard of every car is an odometer, which records the distance traveled. If the initial reading is set at zero at the beginning of a trip and the reading is 35 km one-half hour later, what has been your average speed?

   b. Would it be possible to attain this average speed and never exceed a reading of 70 km/h on the speedometer?

2. If a cheetah can maintain a constant speed of 25 m/s, it will cover 25 meters every second. At this rate, how far will it travel in 10 seconds? In 1 minute?

► Question

The speedometer of a car moving northward reads 60 km/h. It passes another car that travels southward at 60 km/h. Do both cars have the same speed? Do they have the same velocity?

► Questions

1. Suppose a car moving in a straight line steadily increases its speed each second, first from 35 to 40 km/h, then from 40 to 45 km/h, then from 45 to 50 km/h. What is its acceleration?

2. In 5 seconds a car moving in a straight line increases its speed from 50 km/h to 65 km/h while a truck goes from rest to 15 km/h in a straight line. Which undergoes the greater acceleration? What is the acceleration of each vehicle?
Table 2-2: Free-Fall Speed of Objects Dropped From Rest

<table>
<thead>
<tr>
<th>Elapsed Time (seconds)</th>
<th>Instantaneous Speed (meters/second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td></td>
<td>101</td>
</tr>
</tbody>
</table>

**Question**
What would the speedometer reading on the falling rock shown in Figure 2-5 be 4.5 seconds after it drops from rest? How about 8 s after it is dropped? 100 s?

**Question**
A ball is rolled across the top of a pool table and slowly rolls to a stop. How would Aristotle interpret this behavior? How would Galileo interpret it? How would you interpret it?

**Questions**
1. If suddenly the force of gravity of the sun stopped acting on the planets, in what kind of path would the planets move?
2. Would it be correct to say that the reason an object resists change and persists in its state of motion is because of inertia?

**Questions**
1. Does a 2-kilogram iron block have twice as much inertia as a 1-kilogram block of iron? Twice as much mass? Twice as much volume? Twice as much weight (when weighed in the same location)?
2. Does a 2-kilogram bunch of bananas have twice as much inertia as a 1-kilogram loaf of bread? Twice as much mass? Twice as much volume? Twice as much weight (when weighed in the same location)?
Question
The text states that a 1-kg bag of nails weighs 9.8 N at the earth's surface. Does 1 kg of yogurt also weigh 9.8 N?

Questions
1. If a car is able to accelerate at 2 m/s², what acceleration can it attain if it is towing another car of equal mass?
2. What kind of motion does an unchanging force produce on an object of fixed mass?

Question
If you were on the moon and dropped a hammer and a feather from the same elevation at the same time, would they strike the surface of the moon together?

Question
Since the moon is gravitationally attracted to the earth, why does it not simply crash into the earth?

Question
If there is an attractive force between all objects, why do we not feel ourselves gravitating toward massive buildings in our vicinity?

Question
Suppose that an apple at the top of a tree is pulled by earth gravity with a force of 1 N. If the tree were twice as tall, would the force of gravity on the apple be only ½ as strong? Explain your answer.
**Question**
Light entered the eyepiece when Michelson's octagonal mirror made exactly one eighth of a rotation during the time light reflected to the distant mountain and back. Would light enter the eyepiece if the mirror turned one quarter of a rotation in this time?

**Questions**
1. What is the frequency in vibrations per second of a 100-herz wave?
2. The Scars Building in Chicago sways back and forth at a vibration frequency of about 0.1 Hz. What is its period of vibration?

**Questions**
1. If a water wave vibrates up and down 2 times each second and the distance between wave crests is 1.5 m, what is the frequency of the wave? What is its wavelength? What is its speed?
2. What is the wavelength of a 340-Hz sound wave when the speed of sound in air is 340 m/s?

**Question**
When a source moves toward you, do you measure an increase or decrease in wave speed?

**Question**
Why is blue light used to view tiny objects in an optical microscope?

**Questions**
1. Why is it important that monochromatic (single-frequency) light be used in Young's interference experiment?
2. If the double slits were illuminated with monochromatic blue light, would the fringes be closer together or farther apart than those produced when monochromatic red light is used?
Appendix B: Working with Units in Physics

A quantity in science is expressed by a number and a unit of measurement. Quantities may be actual measurements, or they may be obtained by performing calculations on measurements. Quantities may be added, subtracted, multiplied, or divided. There are rules for handling both the numbers and the units of measurement during these mathematical operations.

Addition
When you add quantities, all must have the same units. Add up the numbers. The sum has the same unit as well.

Example:
\[(4 \text{ m}) + (8 \text{ m}) + (3 \text{ m}) = 15 \text{ m}\]

Subtraction
When you subtract one quantity from another, both must have the same units. Subtract the numbers. The difference has the same unit.

Example:
\[(5.2 \text{ s}) - (3.8 \text{ s}) = 1.4 \text{ s}\]

Multiplication
Quantities that are multiplied together need not have the same units. Multiply the numbers. Multiply the units just as if they are algebraic variables.

When full names of units are used, use a hyphen between the units that are multiplied together.

Example:
\[(3 \text{ newtons}) \times (2 \text{ meters}) = 6 \text{ newton-meters}\]

When symbols are used, use a raised dot between the unit symbols that are multiplied together.

Example:
\[(3 \text{ N}) \times (2 \text{ m}) = 6 \text{ Nm}\]

When the units being multiplied are the same, the product is called the square (or cubic) unit. In symbols, a raised 2 after the unit symbol is used for the square. A raised 3 after the unit symbol is used for the cubic unit. These raised numerals are known as exponents.

Examples:
\[(3 \text{ meters}) \times (2 \text{ meters}) = 6 \text{ meter-meters} = 6 \text{ m}^2\]
\[(3 \text{ meters}) \times (2 \text{ meters}) \times (4 \text{ meters}) = 24 \text{ meter-meter-meters} = 24 \text{ cubic meters}\]
\[(3 \text{ m}) \times (2 \text{ m}) \times (4 \text{ m}) = 24 \text{ m} \times \text{m} = 24 \text{ m}^3\]

Division
Quantities that are divided by each other need not have the same units. Divide the numbers. Divide the units as though they are algebraic variables.

When the units are full names, use the word per after the unit that is being divided.

Example:
\[(100 \text{ kilometers}) \div (2 \text{ hours}) = \frac{100 \text{ kilometers}}{2 \text{ hours}} = 50 \text{ kilometers per hour}\]

When the units are symbols, use a slash after the unit symbol that is being divided.

Example:
\[(100 \text{ km}) \div (2 \text{ h}) = \frac{100 \text{ km}}{2 \text{ h}} = 50 \text{ km/h}\]

When both units are the same, they “cancel” out and do not appear in the quotient.

Example:
\[(6 \text{ m}) \div (3 \text{ m}) = \frac{6 \text{ m}}{3 \text{ m}} = 2\]
Complicated Multiplication and Division

In multiplication, when the quantities have units which are quotients of units, treat them as
algebraic variables. Identical units in the numerator and denominator may be “cancelled” out.

Example:

\[
(25 \text{ meters per second}) \times (6 \text{ seconds}) = \left( \frac{25 \text{ meters}}{\text{second}} \right) \times (6 \text{ s})
\]

\[
= 25 \times 6 \frac{\text{meters\cdotseconds}}{\text{second}}
\]

\[
= 150 \text{ meters}
\]

\[
\frac{25 \text{ m/s}}{(6 \text{ s})} = \left( \frac{25 \text{ m}}{\text{s}} \right) \times (6 \text{ s})
\]

\[
= 25 \times 6 \frac{\text{m}}{\text{s}}
\]

\[
= 150 \text{ m}
\]

In division, when the quantities have units which are quotients of units, it is easiest to express
the division in numerator and denominator form. That is, the number to be divided is the
numerator (top value) and the divisor is the denominator (bottom value). Divide the numbers.
Treat units as algebraic variables.

Examples:

\[
(8.2 \text{ meters per second}) \div (2.0 \text{ seconds})
\]

\[
= \frac{8.2 \text{ meters per second}}{2.0 \text{ seconds}}
\]

\[
= \frac{8.2 \text{ meters}}{2.0 \text{ second-second}}
\]

\[
= 4.1 \text{ meters per second squared}
\]

\[
\frac{(8.2 \text{ m/s})}{(2.0 \text{ s})} = \frac{8.2 \text{ m}}{2.0 \text{ s}}
\]

\[
= \frac{8.2 \text{ m}}{2.0 \text{ s/s}}
\]

\[
= 4.1 \text{ m/s}^2
\]

Note that when second is multiplied by itself in the denominator, it is changed to per second
squared (and not to per square second). Similarly, the symbols "m/s²" are read as "meters per
second squared."

Scientific Notation

It is convenient to use a mathematical abbreviation for large and small numbers. The number
40,000,000 can be obtained by multiplying 4 by 10, and again by 10, and again by 10, and so on
until 10 has been used as a multiplier seven times. The short way of showing this is to write
the number 40,000,000 as \(4 \times 10^7\).

The number 0.0004 can be obtained from 4 by using 10 as a divisor four times. The short way of
showing this is to write the number 0.0004 as \(4 \times 10^{-4}\). Thus,

\[
2 \times 10^3 = 2 \times 10 \times 10 \times 10 \times 10 \times 10 = 200,000
\]

\[
5 \times 10^{-3} = 5/(10 \times 10 \times 10) = 0.005
\]

Numbers expressed in this shorthand manner are said to be in scientific notation.

1,000,000 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 10^6

100,000 = 10 \times 10 \times 10 \times 10 \times 10 = 10^5

10,000 = 10 \times 10 \times 10 \times 10 = 10^4

1,000 = 10 \times 10 \times 10 = 10^3

100 = 10 \times 10 = 10^2

10 = 10^1

1 = 10^0

0.1 = \frac{1}{10} = 10^{-1}

0.01 = \frac{1}{100} = 10^{-2}

0.001 = \frac{1}{1000} = 10^{-3}

0.0001 = \frac{1}{10,000} = 10^{-4}

0.00001 = \frac{1}{100,000} = 10^{-5}

0.000001 = \frac{1}{1,000,000} = 10^{-6}

We can use scientific notation to express some of the physical data often used in physics.