حلول مسائل – الوحدة الأولى (Inspire)





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Module 1 Physics Problems

Lesson 1 Methods of Science

Mastering Concepts

1. Describe a scientific method.

Possible answer: Identify a problem; gather information about it by observing and experimenting; create a model or theory to explain the results; analyze the information to test the model; and use the model to predict new results.

2. Explain why scientists might use each of the models listed below.

a. physical model of the solar system

The solar system is very large.

b. computer model of airplane aerodynamics

Airplane aerodynamics are complex and dynamic.

c. mathematical model of the force of attraction between two objects

The mathematical model can quantify the force each object is exerting.

Lesson 2 Mathematics and Physics

Mastering Concepts

3. Why is mathematics important to science?

Mathematics allows scientists to be quantitative, to say "how fast," not just "fast."

4. What is the SI system?

The International System of Units, or SI, is a base-10 system of measurement that is the standard in science. The base units are the meter, kilogram, second, kelvin, mole, ampere, and candela.

5. How are base units and derived units related?

The derived units are combinations of the base units.

6. Suppose your lab partner recorded a measurement as 100 g.

a. Why is it difficult to tell the number of significant figures in this measurement?

Zeros are necessary to indicate the magnitude of the value, but there is no way of knowing whether or not the instrument used to measure the values actually measured the zeros. The zeros may serve only to locate the 1.

b. How can the number of significant figures in such a number be made clear?

Write the number in scientific notation, including only the significant figures.

7. Give the name for each of the following multiples of the meter.

a. $\frac{1}{100}$ m

centimeter

b. $\frac{1}{1000}$ m

millimeter

c. 1000 m

kilometer

8. To convert 1.8 h to minutes, by what conversion factor should you multiply?

$\frac{60\ \text{min}}{1\ \text{h}}$, because the units will cancel correctly.

9. Solve each problem. Give the correct number of significant figures in the answers.

a. $4.667\times10^4\ \text{g} + 3.02\times10^5\ \text{g}$

3.49×10^5 g

b. $(1.70\times10^2\ \text{J}) \div (5.922\times10^{-4}\ \text{cm}^3)$

2.87×10^5 J/cm^3

Mastering Problems

10. Convert each of the following measurements to meters**.** (Level 1)

a. 42.3 cm

0.423 m

b. 6.2 pm

6.2×10^{-12} m

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c. 21 km

2.1×10^{4} m

d. 0.023 mm

2.3×10^{-5} m

e. 214 μm

2.14×10^{-4} m

f. 57 nm

5.7×10^{-8} m

11. Add or subtract as indicated. (Level 1)

a. 5.80×10^{9} s $+ 3.20\times10^{8}$ s

6.12×10^{9} s

b. 4.87×10^{-6} m $- 1.93\times10^{-6}$ m

2.94×10^{-6} m

c. 3.14×10^{-5} kg $+ 9.36\times10^{-5}$ kg

1.250×10^{-4} kg

d. 8.12×10^{7} g $- 6.20\times10^{6}$ g

7.50×10^{7} g

12. **Ranking Task** Rank the following numbers according to the number of significant figures they have, from most to least: 1.234, 0.13, 0.250, 7.603, 0.08. Specifically indicate any ties. (Level 1)

1.234 and 7.603 are tied with 4, 0.250 has 3, 0.13 had 2, and 0.08 has 1

13. State the number of significant figures in each of the following measurements. (Level 1)

a. 0.00003 m

1

b. 64.01 fm

4

c. 80.001 m

5

d. 0.720 μg

3

e. 2.40×10^{6} kg

3

f. 6×10^{8} kg

1

g. 4.07×10^{16} m

3

14. Add or subtract as indicated. (Level 1)

a. 16.2 m + 5.008 m + 13.48 m

34.7 m

b. 5.006 m + 12.0077 m + 8.0084 m

25.022 m

c. 78.05 cm^2 – 32.046 cm^2

46.00 cm^2

d. 15.07 kg – 12.0 kg

3.1 kg

15. Multiply or divide as indicated. (Level 1)

a. $(6.2\times10^{18}\text{ m})(4.7\times10^{-10}\text{ m})$

2.9×10^{9} m^2

b. $(5.6\times10^{-7}\text{ m})/(2.8\times10^{-12}\text{ s})$

2.0×10^{5} m/s

c. $(8.1\times10^{-4}\text{ km})(1.6\times10^{-3}\text{ km})$

1.3×10^{-6} km^2

d. $(6.5\times10^{5}\text{ kg})/(3.4\times10^{3}\text{ m}^3)$

1.9×10^{2} kg/m^3

16. **Gravity** The force due to gravity on Earth's surface is $F = mg$, where g = 9.8 N/kg on average. (Level 1)

a. Find the force due to gravity on a 41.63-kg object.

408 N

b. The force due to gravity on an object is 632 N. What is its mass?

64.5 kg

17. **Dimensional Analysis** Pressure is measured in pascals, where 1 Pa = 1 kg/m•s^2. Will the following expression give a pressure in the correct units? (Level 2)

$$\frac{(0.55\text{ kg})(2.1\text{ m/s})}{9.8\text{ m/s}^2}$$

No; it is in kg·s.

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Lesson 3 Measurement

Mastering Concepts

18. What determines the precision of a measurement?

the precision of a measuring device, which is limited by the finest division on its scale

19. How does the last digit differ from the other digits in a measurement?

The final digit is estimated.

Mastering Problems

20. A water tank has a mass of 3.64 kg when it is empty and a mass of 51.8 kg when it is filled to a certain level. What is the mass of the water in the tank? (Level 1)

48.2 kg

21. The length of a room is 16.40 m, its width is 4.5 m, and its height is 3.26 m. What volume does the room enclose? (Level 1)

2.4×10^2 m^3

22. The sides of a quadrangular plot of land are 132.68 m, 48.3 m, 132.736 m, and 48.37 m. What is the perimeter of the plot? (Level 1)

362.1 m

23. How precise a measurement could you make with the scale shown in the image? (Level 1)



±0.5 g

24. Give the measure shown on the meter in the image as precisely as you can. Include the uncertainty in your answer. (Level 1)



3.6 ± 0.1 A

25. Estimate the height of the nearest door frame in centimeters. Then measure it. How accurate was your estimate? How precise was your estimate? How precise was your measurement? Why are the two precisions different? (Level 1)

A standard residential doorframe height is 80 inches, which is about 200 cm. The precision depends on the measurement instrument used.

26. **Temperature** The temperature drops linearly from 24°C to 10°C in 12 hours. (Level 1)

a. Find the average temperature change per hour.

1.2°C/h

b. Predict the temperature in 2 more hours if the trend continues.

about 8°C

c. Could you accurately predict the temperature in 24 hours? Explain why or why not.

No. Temperature is unlikely to continue falling sharply and steadily that long.

Lesson 4 Graphing Data

Mastering Concepts

27. How do you find the slope of a linear graph?

The slope of a linear graph is the ratio of the vertical change to the horizontal change, or rise over run.

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28. When driving, the distance traveled between seeing a stoplight and stepping on the brakes is called the reaction distance. Reaction distance for a given driver and vehicle depends linearly on speed.

a. Would the graph of reaction distance versus speed have a positive or a negative slope?

Positive. As speed increases, reaction distance increases.

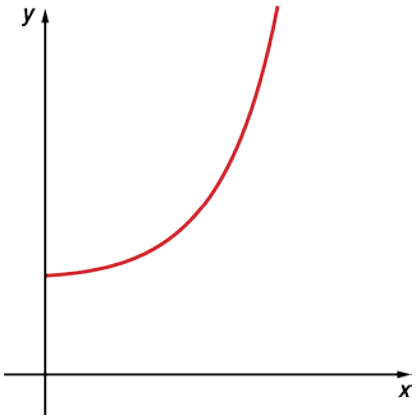
b. A driver who is distracted takes a longer time to step on the brake than a driver who is not. Would the graph of reaction distance versus speed for a distracted driver have a larger or smaller slope than for a normal driver? Explain.

Larger. The driver who was distracted would have a longer reaction time and thus a greater reaction distance at a given speed.

29. During a laboratory experiment, the temperature of the gas in a balloon is varied and the volume of the balloon is measured. Identify the independent variable and the dependent variable.

Temperature is the independent variable; volume is the dependent variable.

30. What type of relationship is shown in the graph? Give the general equation for this type of relation.



quadratic; $y = ax^2 + bx + c$

31. Given the equation $F = mv^2/R$, what relationship exists between each of the following?

a. F and R

inverse relationship

b. F and m

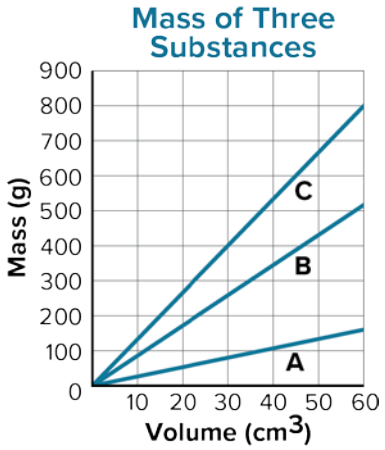
linear relationship

c. F and v

quadratic relationship

Mastering Problems

32. The graph shows the masses of three substances for volumes between 0 and 60 cm^3. (Level 1)



a. What is the mass of 30 cm^3 of each substance?

(A) 80 g; (B) 260 g; (C) 400 g

b. If you had 100 g of each substance, what would be its volume?

(A) 36 cm^3; (B) 12 cm^3; (C) 7 cm^3

c. In one or two sentences, describe the meaning of the slopes of the lines in this graph.

The slope represents the increased mass of each additional cubic centimeter of the substance.

d. Explain the meaning of each line's y-intercept.

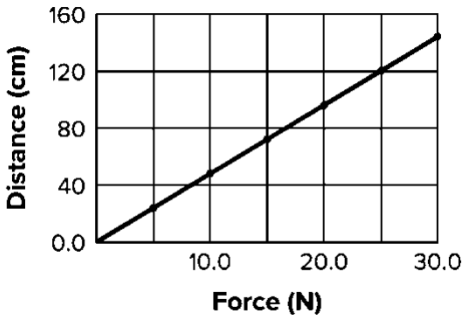
The y-intercept is (0,0). It means that when $V = 0$ cm^3, there is none of the substance present ($m = 0$ g).

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33. Suppose a mass is placed on a horizontal table that is nearly frictionless. Various horizontal forces are applied to the mass. The distance the mass traveled in 5 seconds for each force applied is measured. The results of the experiment are shown in **Table 1.** (Level 1)

Table 1	
Distance Traveled with Different Forces	
Force (N)	**Distance (cm)**
5.0	24
10.0	49
15.0	75
20.0	99
25.0	120
30.0	145

a. Plot the values given in the table and draw the curve that best fits all points.



b. Describe the resulting curve.

a straight line

c. Use the graph to write an equation relating the distance to the force.

$d = 4.9F$

d. What is the constant in the equation? Find its units.

The constant is 4.9 and has units cm/N.

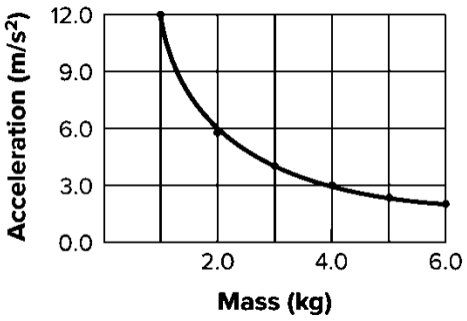
e. Predict the distance traveled when a 22.0-N force is exerted on the object for 5 *s*.

108 cm, or 110 cm using 2 significant figures

34. Suppose the procedure from the previous problem changed. The mass was varied while the force was kept constant. Time and distance were measured, and the acceleration of each mass was calculated. The results of the experiment are shown in **Table 2.** (Level 2)

Table 2	
Acceleration of Different Masses	
Mass (kg)	**Acceleration (m/s^2)**
1.0	12.0
2.0	5.9
3.0	4.1
4.0	3.0
5.0	2.5
6.0	2.0

a. Plot the values given in the table and draw the curve that best fits all points.



b. Describe the resulting curve.

a hyperbola

c. Write the equation relating acceleration to mass given by the data in the graph.

$$a = \frac{12}{m}$$

d. Find the units of the constant in the equation.

kg•m/s²

e. Predict the acceleration of an 8.0-kg mass.

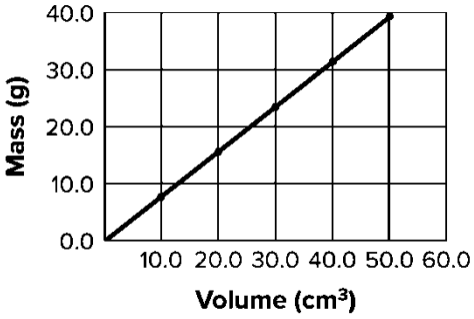
1.5 m/s²

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35. During an experiment, a student measured the mass of 10.0 cm^3 of alcohol. The student then measured the mass of 20.0 cm^3 of alcohol. In this way, the data in **Table 3** were collected. (Level 2)

Table 3	
The Mass Values of Specific Volumes of Alcohol	
Volume (cm^3)	**Mass (g)**
10.0	7.9
20.0	15.8
30.0	23.7
40.0	31.6
50.0	39.6

a. Plot the values given in the table and draw the curve that best fits all the points.



b. Describe the resulting curve.

a straight line

c. Use the graph to write an equation relating the volume to the mass of the alcohol.

m* = 0.79*V

d. Find the units of the slope of the graph. What is the name given to this quantity?

g/cm^3; density

e. What is the mass of 32.5 cm^3 of alcohol?

25.7 g

Applying Concepts

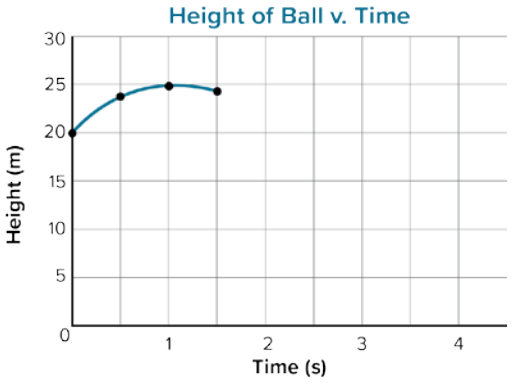
36. Is a scientific method one set of clearly defined steps? Support your answer.

There is no definite order of specific steps. However, whatever approach is used, it always includes close observation, controlled experimentation, summarizing, checking, and rechecking.

37. Explain the difference between a scientific theory and a scientific law.

A scientific law is a rule of nature, where a scientific theory is an explanation of the scientific law based on observation. A theory explains why something happens; a law describes what happens.

38. The graph shows the height above the ground of a ball that is thrown upward from the roof of a building, for the first 1.5 s of its trajectory. What is the ball's height at $t = 0$? Predict the ball's height at $t = 2$ s and at $t = 5$ s.



When $t = 0$ and $t = 2$, the ball's height will be about 20 m. When $t = 5$, the ball will have landed on the ground so the height will be 0 m.

39. **Density** The density of a substance is its mass divided by its volume.

a. Give the metric units for density.

possible answers include g/cm^3 or kg/m^3

b. Is the unit for density a base unit or a derived unit?

derived unit

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40. What metric unit would you use to measure each of the following?

a. the width of your hand

cm

b. the thickness of a book cover

mm

c. the height of your classroom

m

d. the distance from your home to your classroom

km

41. **Size** Make a chart of sizes of objects. Lengths should range from less than 1 mm to several kilometers. Samples might include the size of a cell, the distance light travels in 1 s, and the height of a room.

The chart might include: radius of an atom, 5×10^{-11} m; virus, 10^{-7} m; thickness of paper, 0.1 mm; width of paperback book, 10.7 cm; height of a door, 1.8 m; width of town, 7.8 km; radius of Earth, 6×10^{6} m; distance to the Moon, 4×10^{8} m

42. **Time** Make a chart of time intervals. Sample intervals might include the time between heartbeats, the time between presidential elections, the average lifetime of a human, and the age of the United States. In your chart, include several examples of very short and very long time intervals.

The chart might include: half-life of polonium-194, 0.7 s; time between heartbeats, 0.8 s; time to walk between physics class and math class, 2.4 min; length of school year, 180 days; time between elections for the U.S. House of Representatives, 2 years; time between U.S. presidential elections, 4 years; age of the United States, (about) 235 years

43. **Speed of Light** Two scientists measure the speed of light. One obtains $(3.001 \pm 0.001)\times10^{8}$ m/s; the other obtains $(2.999 \pm 0.006)\times10^{8}$ m/s.

a. Which is more precise?

$(3.001 \pm 0.001)\times10^{8}$ m/s

b. Which is more accurate?

$(2.999 \pm 0.006)\times10^{8}$ m/s

44. You measure the dimensions of a desk as 132 cm, 83 cm, and 76 cm. The sum of these measures is 291 cm, while the product is 8.3×10^{5} cm^3. Explain how the significant figures were determined in each case.

In addition and subtraction, you ask what place the least precise measure is known to: in this case, to the nearest cm. So the answer is rounded to the nearest cm. In multiplication and division, you look at the number of significant figures in the least precise answer: in this case, 2. So the answer is rounded to 2 significant digits.

45. **Money** Suppose you receive $15.00 at the beginning of a week and spend $2.50 each day for lunch. You prepare a graph of the amount you have left at the end of each day for one week. Would the slope of this graph be positive, zero, or negative? Why?

The slope would be negative, because the change in vertical distance is negative for a positive change in horizontal distance

46. Data are plotted on a graph, and the value on the *y*-axis is the same for each value of the independent variable. What is the slope? Why? How does *y* depend on *x*?

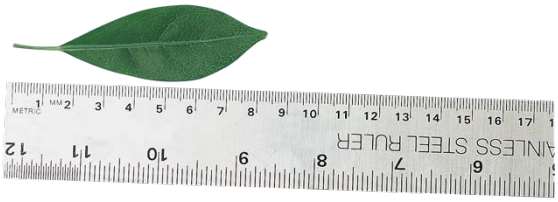
The slope is zero. The change in vertical distance is zero. *y* does not depend on *x*.

47. **Driving** The graph of braking distance versus car speed is part of a parabola. Thus, the equation is written $d = av^2 + bv + c$. The distance (d) has units in meters, and velocity (v) has units in meters/second. How could you find the units of a, b, and c? What would they be?

The units in each term of the equation must be in meters because distance (d) is measured in meters.
$av^2 = a(\text{m/s})^2$, so a is in s^2/m;
$bv = b(\text{m/s})$, so b is in s^{-1}.

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48. How long is the leaf in the image? Include the uncertainty in your measurement.



Laura Sifferlin

8.3 cm ± 0.05 cm, or 83 mm ± 0.5 mm

49. Explain the difference between a hypothesis and a scientific theory.

A scientific theory has been tested and supported many times before it becomes accepted. A hypothesis is an idea about how things might work; it has much less support than a theory.

50. Give an example of a scientific law.

Possible answers include Newton's laws of motion, law of conservation of energy, law of conservation of charge, law of reflection

51. What reason might the ancient Greeks have had not to question the hypothesis that heavier objects fall faster than lighter objects? *Hint: Did you ever question which falls faster?*

Air resistance affects many light objects. Without controlled experiments, everyday observations might have suggested to the ancient Greeks that heavier objects did fall faster.

52. A graduated cylinder is marked every mL. How precise a measurement can you make with this instrument?

±0.5 mL

53. **Reverse Problem** Write a problem with real-life objects for which the graph could be part of the solution.



Answers will vary, but a correct form of the answer is: "Every minute, three more people enter a room. If the room was initially empty at time = 0, how many people will be there after 8 minutes?"

Mixed Review

54. Arrange the following numbers from most precise to least precise

0.0034 m 45.6 m 1234 m

The numbers are in the correct order.

55. You are cracking a code and have discovered the following conversion factors: 1.23 longs = 23.0 mediums, and 74.5 mediums = 645 shorts. How many shorts are equal to one long?

$$1\ \text{long}\left(\frac{23.0\ \text{med}}{1.23\ \text{long}}\right)\left(\frac{645\ \text{short}}{74.5\ \text{med}}\right) = 162\ \text{shorts}$$

56. You are given the following measurements of a rectangular bar: length = 2.347 m, thickness = 3.452 cm, height = 2.31 mm, mass = 1659 g. Determine the volume, in cubic meters, and density, in g/cm^3, of the beam.

volume = 1.87×10^{-4} m^3, or 187 cm^3; density = 8.87 g/cm^3

57. A drop of water contains 1.7×10^{21} molecules. If the water evaporated at the rate of one million molecules per second, how many years would it take for the drop to completely evaporate?

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$$\frac{1.7\times10^{21}\ \text{molecules}}{\left(\frac{1{,}000{,}000\ \text{molecules}}{1\ \text{s}}\right)} = 1.7\times10^{15}\ \text{s}$$

$$(1.7\times10^{15}\ \text{s})\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)\left(\frac{1\ \text{day}}{24\ \text{h}}\right)\left(\frac{1\ \text{y}}{365\ \text{days}}\right)$$

$$= 5.4\times10^{7}\ \text{y}$$

58. A 17.6-gram sample of metal is placed in a graduated cylinder containing 10.0 cm^3 of water. If the water level rises to 12.20 cm^3, what is the density of the metal?

$$\text{density} = \frac{m}{v}$$

$$= \frac{17.6\ \text{g}}{12.20\ \text{cm}^3 - 10.0\ \text{cm}^3}$$

$$= 8.00\ \text{g/cm}^3$$

Thinking Critically

59. **Apply Concepts** It has been said that fools can ask more questions than the wise can answer. In science, it is frequently the case that one wise person is needed to ask the right question rather than to answer it. Explain.

The "right" question is one that points to fruitful research and to other questions that can be answered.

60. **Apply Concepts** Find the approximate mass of water in kilograms needed to fill a container that is 1.40 m long and 0.600 m wide to a depth of 34.0 cm. Report your result to one significant figure. (Use a reference source to find the density of water.)

V_w = (140 cm)(60.0 cm)(34.0 cm) = 285,600 cm^3. Because the density of water is 1.00 g/cm^3, the mass of water in kilograms is 286 kg.

61. **Analyze and Conclude** A container of gas with a pressure of 101 kPa has a volume of 324 cm^3 and a mass of 4.00 g. If the pressure is increased to 404 kPa, what is the density of the gas? Pressure and volume are inversely proportional.

Since the pressure is 4 times greater than the volume, the volume will be $\frac{1}{4}$ of the original volume.

$$\frac{324\ \text{cm}^3}{4} = 81.0\ \text{cm}^3$$

$$\frac{4.00\ \text{g}}{81.0\ \text{cm}^3} = 0.0494\ \text{g/cm}^3$$

62. **Design an Experiment** How high can you throw a ball? What variables might affect the answer to this question?

mass of ball, footing, practice, and conditioning

63. **Problem Posing** Complete this problem so that the final answer will have 3 significant digits: "A home remedy used to prevent swimmer's ear calls for equal parts vinegar and rubbing alcohol. You measure 45.62 mL of vinegar...."

Answers will vary. A possible form of the correct answer would be: "... You then add 46.3 mL of rubbing alcohol to it. How much total liquid do you have?"

Writing in Physics

64. Research and describe a topic in the history of physics. Explain how ideas about the topic changed over time. Be sure to include the contributions of scientists and to evaluate the impact of the contributions on scientific thought and the world outside the laboratory.

Answers will vary. Students might describe how scientists' views of the basic forces of nature have changed over time or how scientists' views of radiation have changed.

65. Explain how improved precision in measuring time would have led to more accurate predictions about how an object falls.

Answers will vary. For example, students might suggest that improved precision can lead to better observations.

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