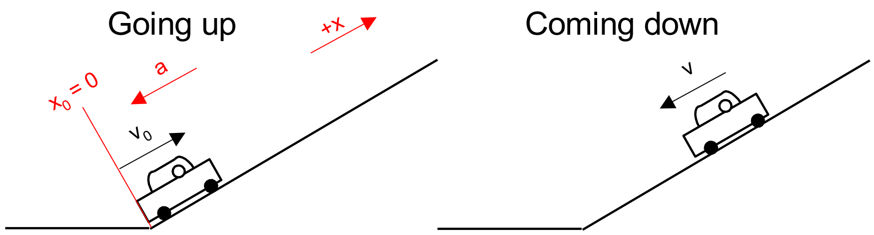


Practice Test Problem. (20 min, 2 pages) Refer to the diagram above. A car is initially traveling on a straight, level road. At the moment the car reaches the bottom of a hill, the engine dies. The car has a velocity of 20. m/s as it begins up the hill, and it loses velocity at a constant rate of 4.0 m/s each second. The car slows to a momentary stop and then coasts back down the hill with the same acceleration that it had going up the hill.

a. (8) Determine how far along the hill the car travels before coasting back down.

For the diagram, see above.

Given: $x_0 = 0$
$v_0 = 20.$ m/s
$v = 0$
$a = -4.0$ m/s²

Goal: x

$v^2 = v_0^2 + 2a(x - x_0)$

$0 = v_0^2 + 2a(x - 0)$

$x = - v_0^2/(2a)$

$= - (20.\text{ m/s})^2/(2*-4.0\text{ m/s}^2)$

$= 50.$ m (or 5.0×10^1)

b. (4) Determine how much time it takes the car to reach the highest point on the hill.

Given: x = 50. m
Goal: t

$v = v_0 + at$

$t = (v - v_0)/a$

$= (0 - 20.\text{ m/s})/(-4.0\text{ m/s}^2)$

$= 5.0$ s

Alternative solution

$x = x_0 + \frac{1}{2}(v_0 + v)t$

$= 0 + \frac{1}{2}(v_0 + 0)t$

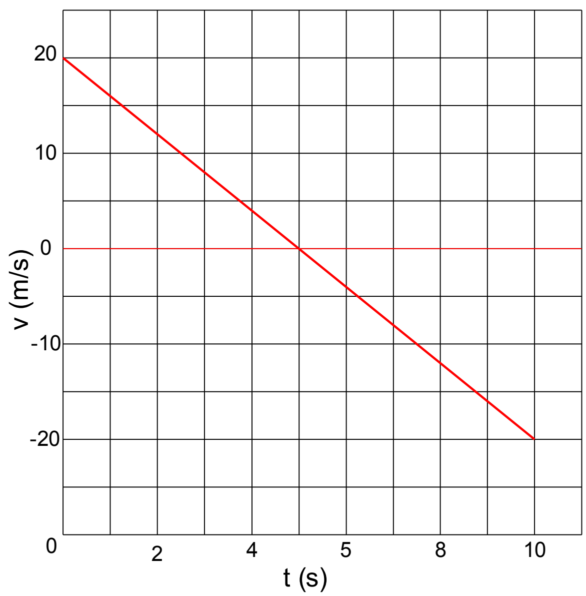
$t = 2x/v_0$

$= 2(50.\text{ m})/(20.\text{ m/s})$

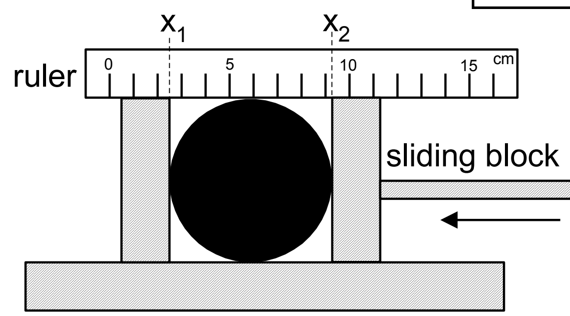
$= 5.0$ s

c. (6) Draw a velocity vs. time graph of the car's motion ***for the entire time that the car is on the hill.*** Number the axes.

Figure 1. Velocity vs. Time for a Car on a Hill



Practice Test Problem (lab type). (40 min, 3 pages)
A student carries out an experiment to determine the relationship between the diameter and volume of a collection of metal balls. The method of measuring the diameter is shown to the right. One of the balls is held between the jaws of an apparatus and the positions of the ends of the diameter measured on a ruler.



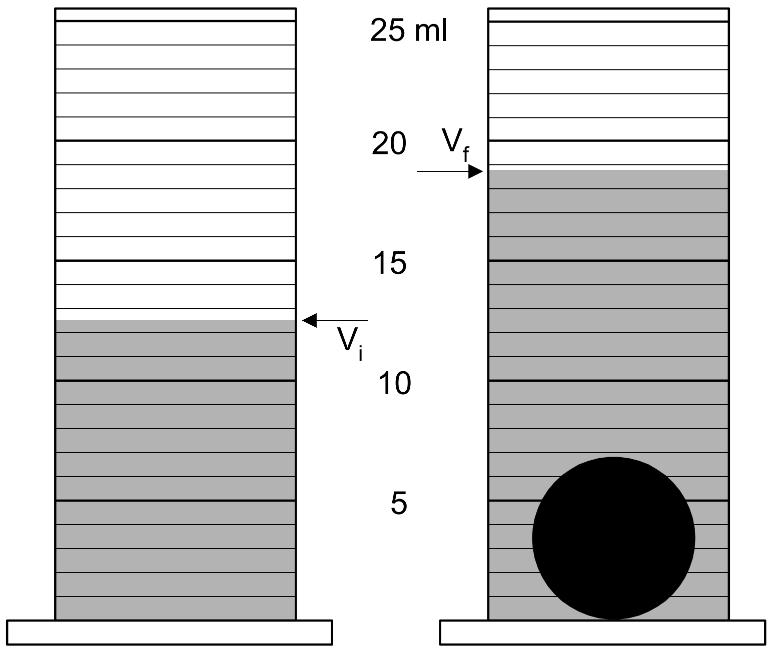
a. (3) Read the positions x_1 and x_2 to the appropriate precision. Then calculate the diameter, D.

x_1 = ___2.5_____ cm x_2 = ___9.2_____ cm D = __6.7__ cm

b. (4) Estimate the absolute uncertainty in the measurement of D. Then calculate the relative uncertainty.

Absolute uncertainty = __0.2_ cm Relative uncertainty = __3___ %

c. (3) The student measures the volume of a ball by first pouring some water into a graduated cylinder and taking the reading, V_1. The student then lowers the ball into the cylinder gently to avoid splashing and takes the new reading V_2. Give the volume readings to the appropriate precision. Then calculate the volume, V, of the ball.



V_1 = __12.5_ ml V_2 = __18.8_ ml

V = ___6.3___ ml

d. (4) Estimate the absolute uncertainty in the measurement of V. Then calculate the relative uncertainty.

Absolute uncertainty = __0.2_ ml Relative uncertainty = ___3__ %

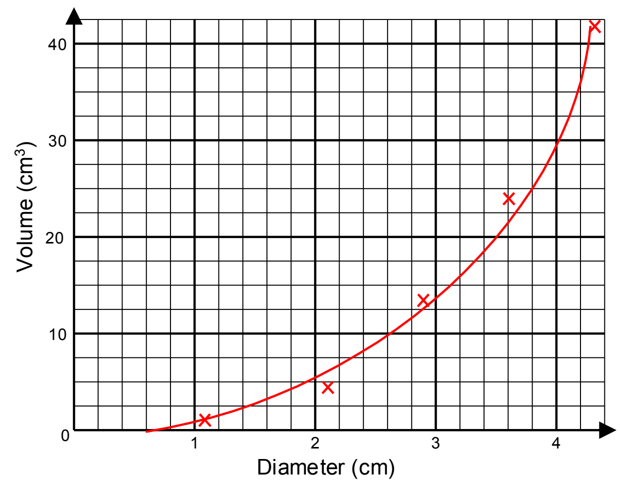
e. (4) In addition to the measurement uncertainties estimated above, there is potential error resulting from the possibility that the metal balls may not be perfectly spherical in shape. Describe a procedure to evaluate numerically the extent to which the balls deviate from perfect spheres. Be specific enough in your instructions that someone not in this class could follow them successfully.

i. Take 5 trials measuring D, each time removing the ball, rotating it randomly, and reinserting in the jaws for a new measurement.
ii. Calculate the mean of the 5 trials.
iii. Calculate deviations, mean deviation, and % mean deviation. The latter characterizes the reproducibility of the measurement.

f. (5) The student's data for a collection of 5 balls is given below. Note that the volume units are converted to cm^3 using the conversion factor, 1 ml = 1 cm^3. The empty column will be used in a later part. Plot a graph of Volume vs. Diameter.

Diameter (cm)	Dia^3 (cm^3)	Volume (cm^3)
1.1	1.3	0.8
2.1	9.3	4.7
2.9	24	13.0
3.6	47	24.1
4.3	80	41.9

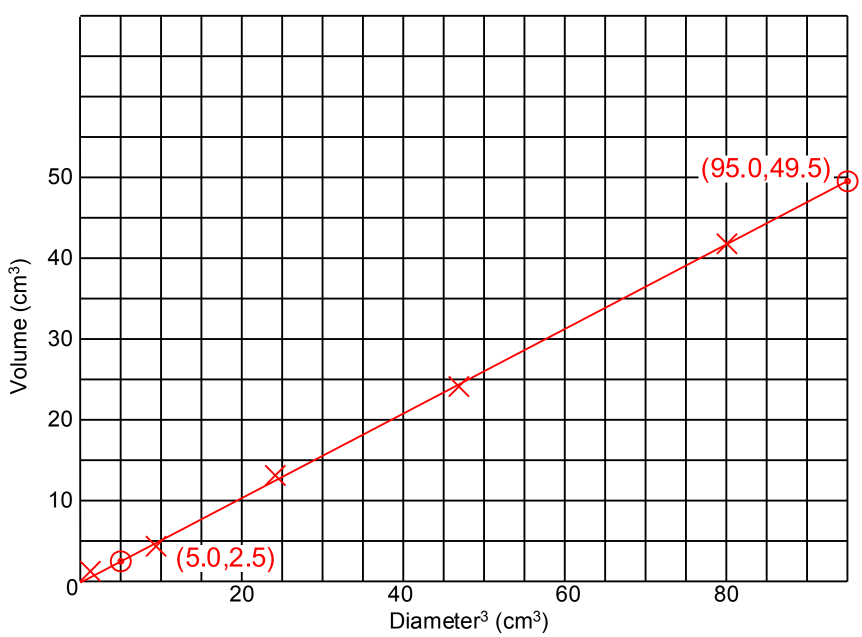
Figure 2. Volume vs. Diameter of Spheres



g. (1) Draw a smooth curve through your data points.

h. (4) In order to experimentally determine the relationship between the diameter and volume of the balls, the student must re-express the diameter in order to linearize the graph. In the heading of the empty column in the data table above, enter the functional form of the re-expressed variable. Include the units. Then complete the column by calculating the values of the re-expressed variable.

i. (4) On the grid below, plot a graph of the volume vs. the re-expressed variable. Label and number the scales appropriately. You need not title the graph.



j. (4) Using the side of a sheet of paper as a straight-edge, draw the best fit line through the data points. Indicate the two points on the line that you'll use to calculate the slope. Then show your calculation of the slope.

$$\text{slope} = (V_2 - V_1)/[(D^3)_2 - (D^3)_1] = (49.5 - 2.5)\text{cm}^3/(95.0 - 5.0)\text{cm}^3$$
$$= 0.522$$

k. (4) Complete the matching table for the fit. Note that the expected value for the slope is determined by the theoretical formula for the volume of a sphere, $V = (\pi/6)D^3$.

Math	Maps to	Physics	Value (fit)	Value (expected)	Units
y	→	V			cm^3
m		$\pi/6$	0.522	0.523	none
x		D^3			cm^3
b		0	0.0	0	cm^3

l. (2) Using Value (fit) for the slope, calculate an experimental value for π.

$\pi_{experimental}/6$ = slope = 0.522
$\pi_{experimental}$ = 6(slope) = 3.13

m. (2) Calculate the experimental error between the experimental value of π determined above and the theoretical value of 3.14.

Exp. Error = 100 |Exp.Value – Acc.Value| / Acc.Value

= ___0.3___%