DETERMINATION OF THE RATIO OF CIRCUMFERENCE TO DIAMETER FOR CIRCULAR OBJECTS

By: C. Gregory
Partners: S. Foster, M. Vural

Thursday, September 6, 2012

Purpose

The purpose of this experiment is to determine the ratio of the circumference (C) of a circle to its diameter (D).

Hypothesis

Since the ratio C/D is defined as pi, we expect the answer to be near 3.14.

Materials

- A variety of circular objects
- length of string (approximately one meter long)
- meter stick

Procedure

For each object, the string was wrapped once around the circumference and was marked where it touched itself again. The string was then straightened and held against the meter stick, and the distance between the end and the mark was recorded as the circumference. The meter stick was then placed across the width of the object to measure the object's diameter. This was repeated for ten different objects.

Procedure (Alternate Form)

1. Wrap the string around the outside of an object, marking it where it touches itself.
2. Straighten the string and use the meter stick to measure the distance between the end of the string and the mark.
3. Place the meter stick across the width of the object to measure its diameter.
4. Repeat this process for at least ten different objects.

Data

The data collected for each item is presented in Figure 1. The original data sheet is attached to the end of this report.

Item	Circ. (cm)	Dia. (cm)
White Softball	28.20	8.60
Blue Bucket	70.70	22.50
JIF Cap	23.50	7.80
Bucket Lid	45.50	14.20
MPH Bottle	22.90	6.40
Large Tin Can	32.80	10.60
Skippy Cap	23.40	7.80
Plastic Jar	23.40	6.90
Water Bottle Top	21.40	7.00
Yellow Softball	30.10	10.40

Figure 1

Analysis

The ratio of C/D was determined using two independent methods. The first, and simplest, was to calculate the ratio for each item and then calculate the average value of the ten data sets.

The ratio was determined using the following calculation:

White Softball: $\frac{C}{D} = \frac{28.20\,cm}{8.60\,cm} = 3.28$

The average value was calculated with the formula

$$x_{avg} = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{3.28 + 3.14 + ... + 2.89}{10} = 3.17$$

The results are summarized below in Figure 2.

Item	**Circ. (cm)**	**Dia. (cm)**	**Ratio of C/D**
White Softball	28.20	8.60	3.28
Blue Bucket	70.70	22.50	3.14
JIF Cap	23.50	7.80	3.01
Bucket Lid	45.50	14.20	3.20
MPH Bottle	22.90	6.40	3.58
Large Tin Can	32.80	10.60	3.09
Skippy Cap	23.40	7.80	3.00
Plastic Jar	23.40	6.90	3.39
Water Bottle Top	21.40	7.00	3.06
Yellow Softball	30.10	10.40	2.89
		Average	3.17

Figure 2

The second method to find the ratio C/D involved graphing the data, with the coordinates of circumference on the vertical axis and diameter on the horizontal axis. The resulting plot of the data sets was linear, and a line of best fit (calculated by the spreadsheet program OpenOffice Calc 3.2) resulted in a slope of 3.10. Because of the definition of slope (slope = $\Delta y/\Delta x$) this is also the value of C/D. The graph is shown on the next page in Figure 3.

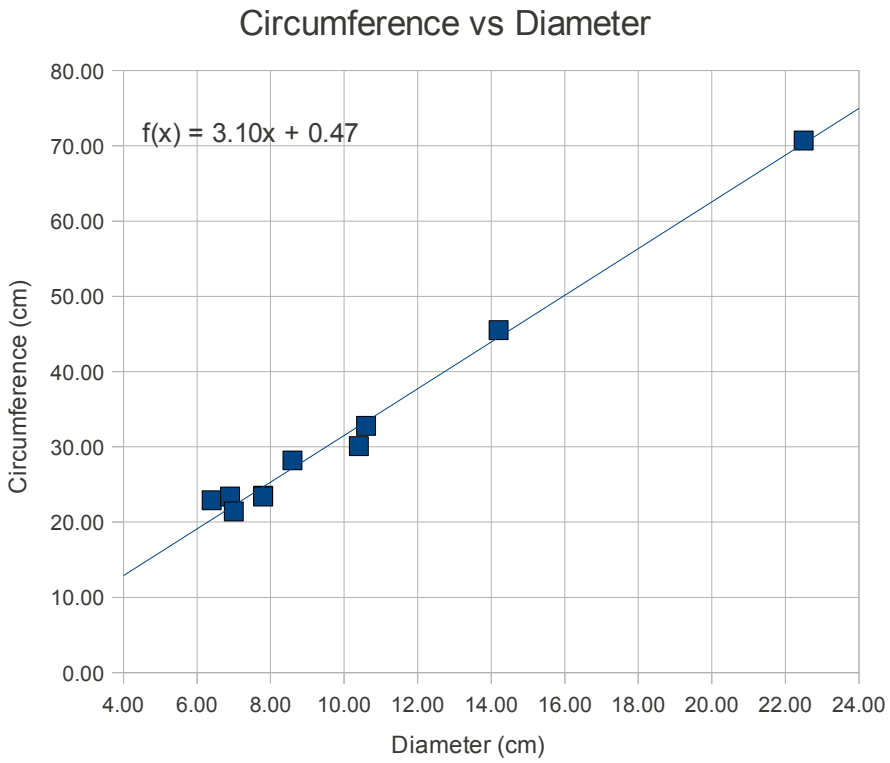

Figure 3

The relative percent error for each value was determined using the following formula:

$$Relative\ \%\ Error = \frac{Experimental\ Value - Accepted\ Value}{Accepted\ Value} x100\%$$

Taking the accepted ratio of C/D to be π = 3.14 and applying this formula to the average value calculated in Figure 1 yields a relative % error of 0.96%

$$\frac{3.17-3.14}{3.14} x100\% = 0.96\%$$

A similar calculation applied to the slope obtained in Figure 2 yields a relative error of -1.27%. An interesting exercise would be to see if combining the two techniques would give better results. In this case, the arithmetic mean of our two calculated results is:

$$\frac{3.17+2.10}{2} = \frac{6.27}{2} = 3.135$$

Consideration of significant figures requires that we round this value to 3.14, which, at least to the precision possible with this equipment, exactly matches the expected value of C/D.

Conclusion

The circumference and diameter was measured for a variety of circular objects, and two independent methods of calculating the ratio of circumference to diameter were used. The result of each method differed, but both methods resulted in values that were within ±2% of the expected value. Combining the individual results yielded perfect agreement with π to the first three digits.

Data Table

	Circum (cm)	Dia. (cm)
Softball (white)	28.2	8.60
Big Blue Bucket	70.7	22.5
PB (Jif?) Cap	23.5 cm	7.8 cm
Bucket lid	45.~~6~~5	14.2 cm
MPH Bottle ~~(illegible)~~	22.9	6.4
Big Tin can thing	32.8	10.6
~~Jif~~ Skippy lid	23.4	7.8
Plastic Jar	23.4	6.9
Water Bottle lid	21.4	7.00
Softball (yellow)	30.1	10.4