

SAMPLE LABORATORY REPORT

Measurement and Estimation

[Always state the purpose of the laboratory exercise or experiment]

Objectives:

- 1) To determine the width of a plat of grass between Barton and Shaffer Halls.
- 2) To determine the area of that plat .
- 3) To determine the number of blades of grass in that plat.
- 4) To determine “best” values for these parameters by including measurements from other groups

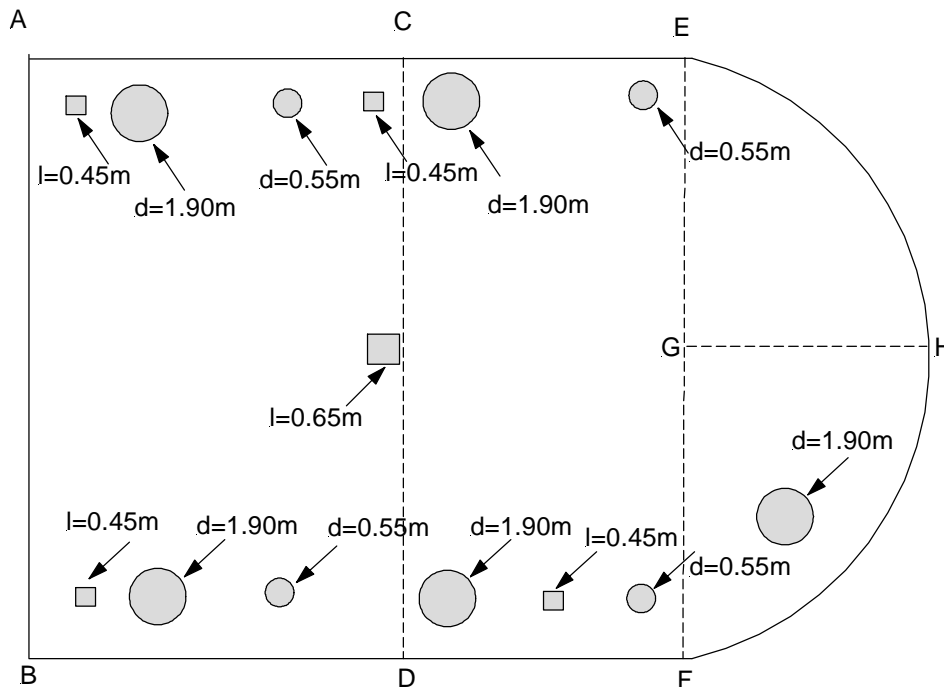
[For many laboratory exercises, listing the materials gives an idea of how the assignment is to be carried out.]

Materials:

The only materials provided was a meter stick.

[A picture or diagram can be much more enlightening than a verbal description.]

The plat of grass: See diagram below (not to scale). Cutouts are grassless areas associated with trees, lampposts, and gratings.



Measurements:

Width of plat:

[A description of how the measurements were taken will give insight into how errors might occur.]

Flipping the meter stick end over end and end, the following distances were measured:

A-B 34.05m
C-D 33.90m
E-F 34.05m

Preliminary values were obtained by counting the number of flips to obtain the integer number of meters and measuring the final fraction of a meter. Since each flip spanned one meter plus the thickness of the meter stick, the meter stick thickness times the number of flips minus one was added to the preliminary values to obtain the final values. Measurements were taken to the nearest centimeter.

Based on the three measurements, it would appear that the plat width is fairly uniform. Using the average value of our three measurements, we determine this width to be

[Clearly state any requested result. Results should be stated to the accuracy of the measurement. No more, no less. Don't forget to include the units of the measurement.]

Plat width = 34.00 m

Area of the plat:

Using the same measuring techniques as discussed in the previous sections, the distances A-E, B-F, G-H were measured. For these we obtained:

A-E 38.24 m
B-F 37.92 m
G-H 12.06 m

The exact positions where the perimeter changed from straight to curved was a bit difficult to determine (positions E and F), so the A-E and B-F measurements were not as good as recorded. Based on the measurements, the geometry of the plat was assumed to consist of two geometric elements: a rectangle, and a half ellipse. Using a rectangle length of the average of A-E and B-F and a width of 34.00m (from the previous section), we deduce the rectangle's area to be $38.08 \times 34.00 = 1295\text{m}^2$. For the half ellipse, we set $2a = 34.00\text{m}$, $b = G-H = 12.06\text{m}$. Then the area of the half ellipse is $A = \pi a b/2 = 322.0\text{m}^2$. So, the total area of the plat is

Area of plat = rectangle + half-ellipse = 1617 m²

Number of blades of grass:

[Whenever a method of measurement or approximation must be decided upon, state the reasons for making that decision.]

Counting the blades of grass in the plat was not practical. So we estimated their number using the method of sampling. A cursory examination of the area suggested that the grass density was fairly uniform over the entire plat—except for those areas taken by tree trunks, lampposts, and gratings. So our strategy was to count the blades of grass in ten 10cm x 10cm square subareas whose locations were randomly chosen over the complete plat. With these numbers we could estimate the grass density (blades per unit area) and apply the result to the whole plat.

[Whenever possible, try to comment on the accuracy of the measurement or result.]

Assumptions for counting: blades must be green and at least 1cm long. The data are tabulated in the table below. Note the significant variation of blade counts. In fact the standard deviation of the count 96 is 42% of the average value 231. So our blade estimate will be very crude.

Since each sample area is 0.01 m^2 , the average number of blades of grass per meter is 23100.

From the previous section, the total area of the plat is 1617 m^2 . From that total we must subtract the non-grassy areas associated with the trees, lampposts, and gratings. Identified in the schematic of the plat, these grassless areas can be computed as follows:

$$\begin{aligned} \text{Bare} &= 5\pi (0.9)^2 + 4\pi (0.27)^2 + 4(0.45)^2 + (0.65)^2 \\ &= 14.94 \text{ m}^2 \end{aligned}$$

So, the total grassy area is $1617\text{m}^2 - 15 \text{ m}^2 = 1602 \text{ m}^2$.

$$\text{Blades of grass} = 23100 \text{ B/m}^2 * 1602 \text{ m}^2 = 37006200$$

Grass blade data

Sub area	# blades
1	123
2	270
3	304
4	264
5	342
6	93
7	233
8	191
9	77
10	319
average	231
std dev.	96

[When multiple measurements are taken to determine an average value of a parameter, one should also calculate and report the standard deviation of the measurements. The standard deviation is a good measure of how accurate the sample average is compared to the real value. 66% of the time, the real value will lie within one standard deviation of the sample average.]

$$\text{Blades of grass} = 37*10^6 \quad +/- \quad 16*10^6$$

Results from all groups

Group #	Width (m)	Area (m²)	# Blades (*10⁶)
1	34.00	1589	56
2	34.60	1480	38
3	34.00	1462	31
4	33.60	1414	35
5	33.90	1440	17
6*	34.00	1617	37
7	34.00	1487	51
8	34.60	1414	22
9	37.04	1752	75
10	34.00	1474	13
average	34.37	1513	38
std dev	0.98	107	19
* We are group 6			

[Try to explain your results, especially if you can identify possible sources of error.]

The width measurements cluster around 34 m, except for group 9. It would appear that they miscounted the number of meter stick flips. Since we can't be sure, we will include their number in the final result. What is surprising is that the area measurements are quite different, given that, with the exception of group 9, the width measurements are closely clustered. We presume that the difficulty of determining points E and F (on the sketch) could account for the variation.

Finally, it is surprising that the standard deviation of the estimate of the number of blades of grass was not reduced by taking group averages. Our standard deviation, based on ten sample areas, was 16×10^6 whereas the group standard deviation was 19×10^6 . In principle, using data from all the groups should reduce the net standard deviation.

[Results, by themselves, are not very useful unless "error bars" are given. Error bars signify the probable range over which results might occur given a retaking of the same measurement or experiment. Error bars are usually plus or minus one standard deviation (sometimes two standard deviations, depending on the problem). The standard deviation is also called the "standard error".]

Group results:

plat width	= 34.37m +/- 0.98m
plat area	= 1513 m² +/- 107 m²
blades of grass	= 38*10⁶ +/- 19*10⁶