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Average Absorption Area

of a

Standing Person

For: Internal Only

Report No.: IR/ 57

Prepared By: P Edwards B.Sc.

1. Object

1.1. The object of this Report is to investigate the absorption characteristics of an average person.

2. Scope

2.1 The Scope of this document is limited to

a) Measurements
b) Results
c) Evaluation

3. Method

3.1. To measure reverberation time, an Omni-directional loudspeaker was set-up in the AMS reverberation chamber, using Pink noise band limited from 100Hz to 10kHz as the source input.

3.2. Octave Band reverberation times were captured on a B&K 2317 level recorder via a B&K 2231 sound level meter.

3.3. The Octave Band reverberation times of the empty chamber were measured.

3.4. The reverberation times were then measured again with 1 person standing in the chamber.

3.5. Section 3.4 was repeated with 2, 3, and 4 people in the chamber.

3.6. Using these results, the absorption area (in sabins) can be calculated using Sabines equation as follows:

$$RT = \frac{0.161V}{S\bar{a}}$$

$$S\bar{a} = \frac{0.161V}{RT}$$

where RT = Reverberation Time
V = Volume of chamber (38.4m^3)
S = Surface area of room
$\bar{a}$ = Average absorption coefficient
$S\bar{a}$ = Total absorption, sabins

4. Results

4.1. The average reverberation times are displayed in Table 1 below:

	RT@Octave Band (Hz)						
State	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Empty	6.30	7.00	8.20	7.50	5.20	3.50	1.60
1 Person	6.09	6.25	6.75	5.08	3.38	2.41	1.60
2 People	5.63	5.05	5.40	3.65	2.18	1.65	1.15
3 People	5.50	4.60	4.00	2.30	1.60	1.25	1.20

Table 1

4.2. Using the equation described in section 3.6, the total absorption areas in sabins were calculated and are displayed in table 2.

	Sabins / m^2 @Octave Band (Hz)						
State	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Empty	0.98	0.88	0.75	0.82	1.19	1.77	3.86
1 Person	1.03	1.03	0.99	1.45	2.24	3.02	5.38
2 People	1.10	1.23	1.14	1.69	2.84	3.75	6.69
3 People	1.12	1.34	1.55	2.69	3.86	4.95	7.73
Per Person	**0.05**	**0.16**	**0.25**	**0.58**	**0.86**	**1.03**	**1.29**
Standard Error	0.01	0.02	0.08	0.22	0.14	0.16	0.17
% error	26.91	15.57	30.72	37.99	15.92	15.20	13.07

Table 2

4.3. To estimate the total absorption area of a single person, a best-fit line was plotted on a chart of Absorption Area Vs No of people for each frequency. The Gradient of this best fit line is the absorption area per person and is displayed in table 2.

4.4. Graphs of this best fit line at each frequency are shown in Appendix A

4.5 Figure 1 overleaf shows the Absorption (in sabins) of a single person, compared with previous published data (see Appendix B for source reference)

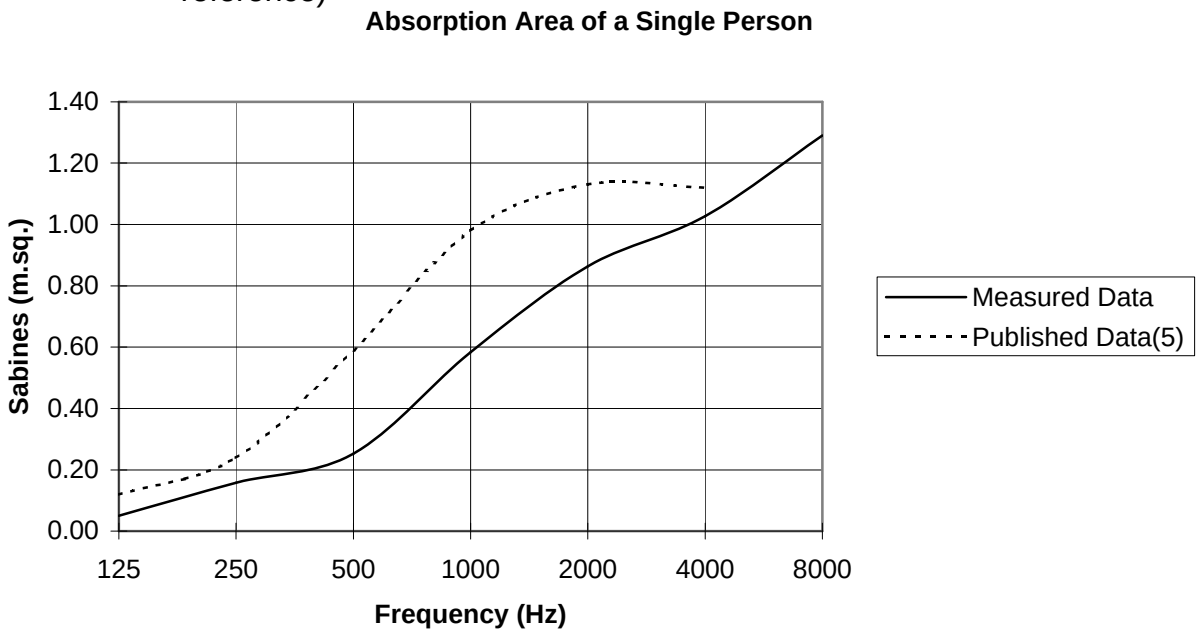


Figure 1

5. Observations

5.1 The majority of published data presenting the absorption area of a person includes the effects of seats or pews. This data is quite different from a solitary standing person (see Appendix B).

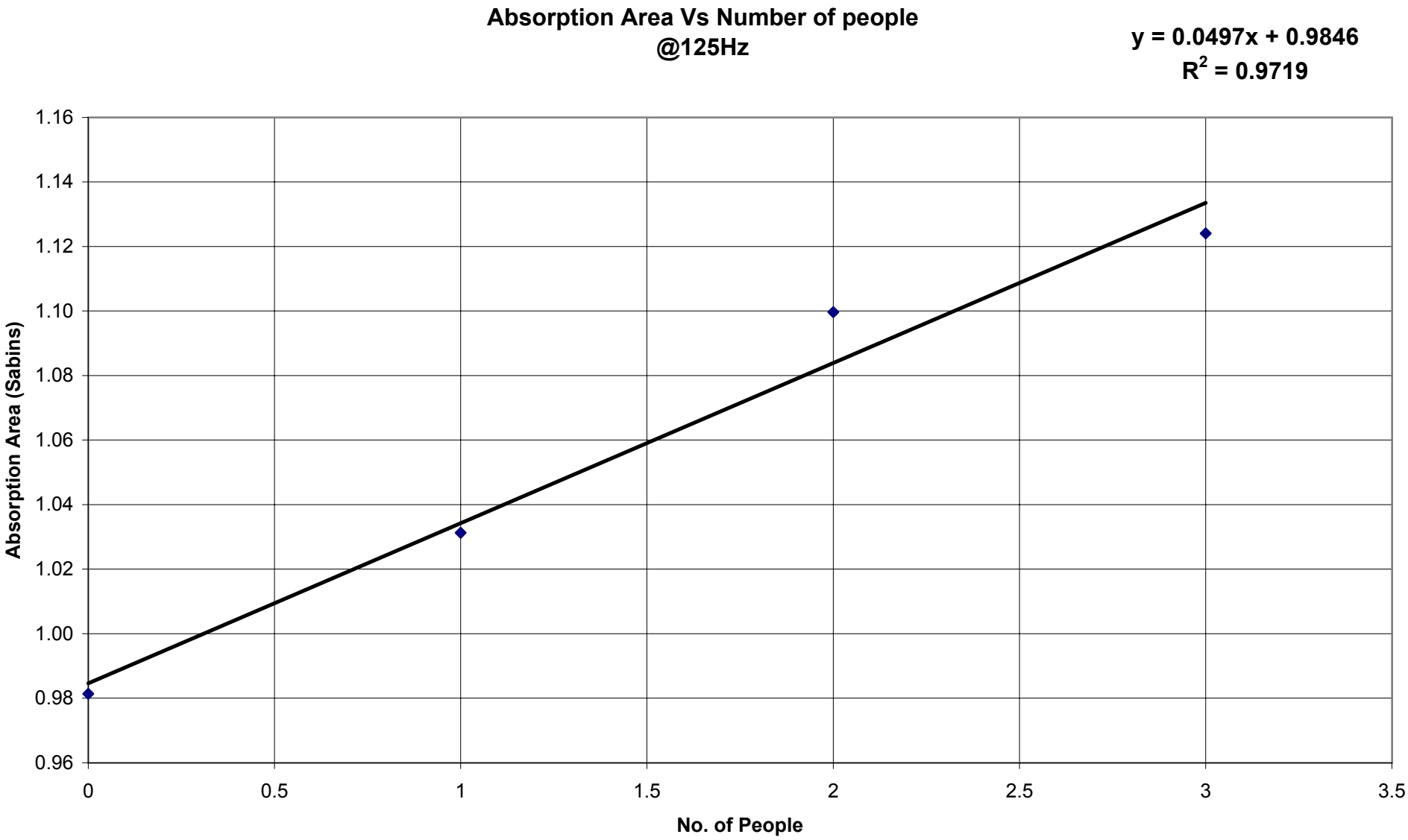
5.2 The difference is not only due to the characteristics of the seat, but because the area of the person exposed to incident sound when seated, especially within an audience, is reduced.

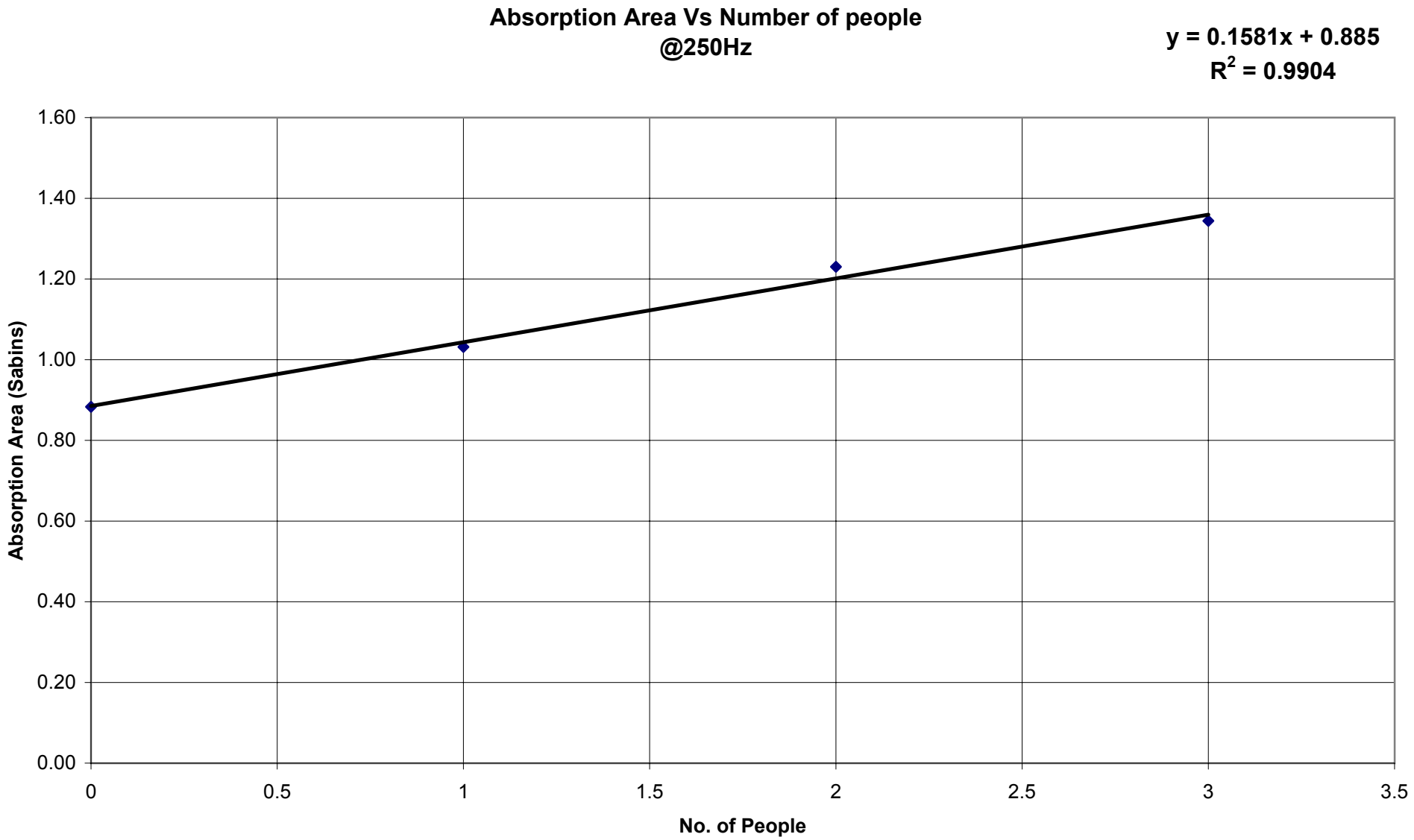
5.3 'Kuttfuff' quotes data for a standing person, which is shown in figure 1, and shows similar characteristics to the data measured.

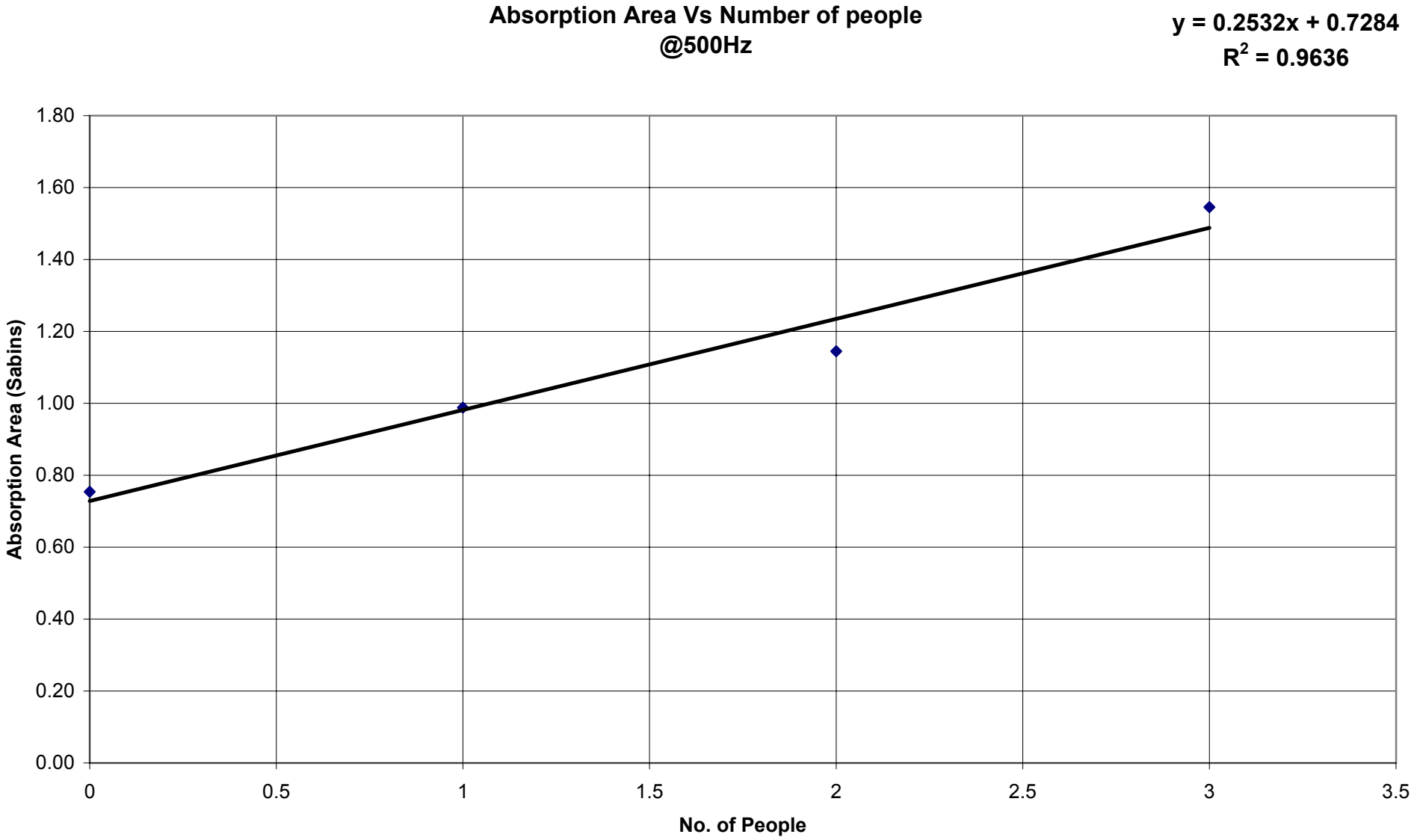
5.4 Different types of clothing can effect the absorption of a person, which could account for differences between the measured and published data of figure 1.

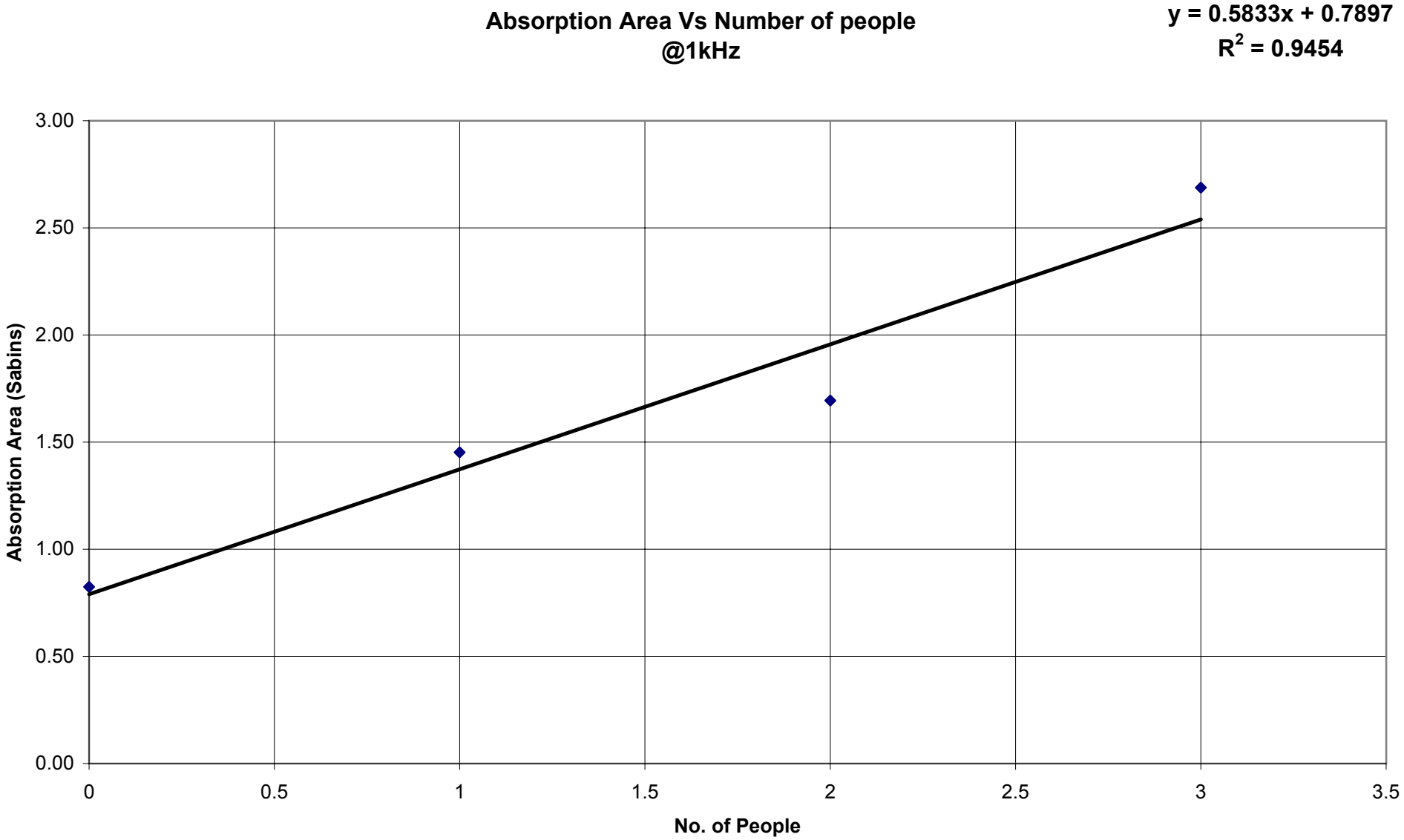
5.5 A large margin of error, as indicated in table 2 along with the wide range in values of published data limits the accuracy of any calculations using this information.

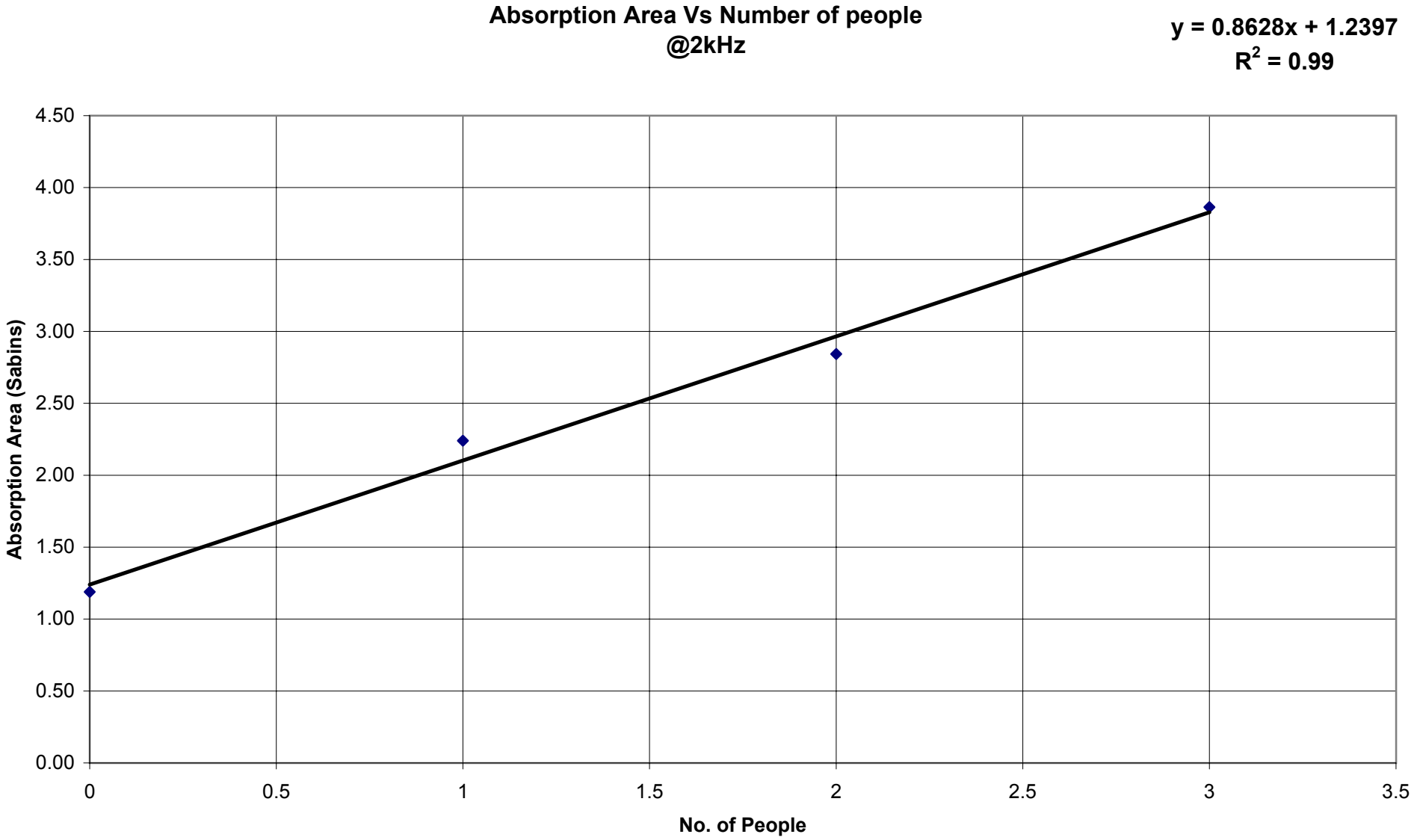
APPENDIX A

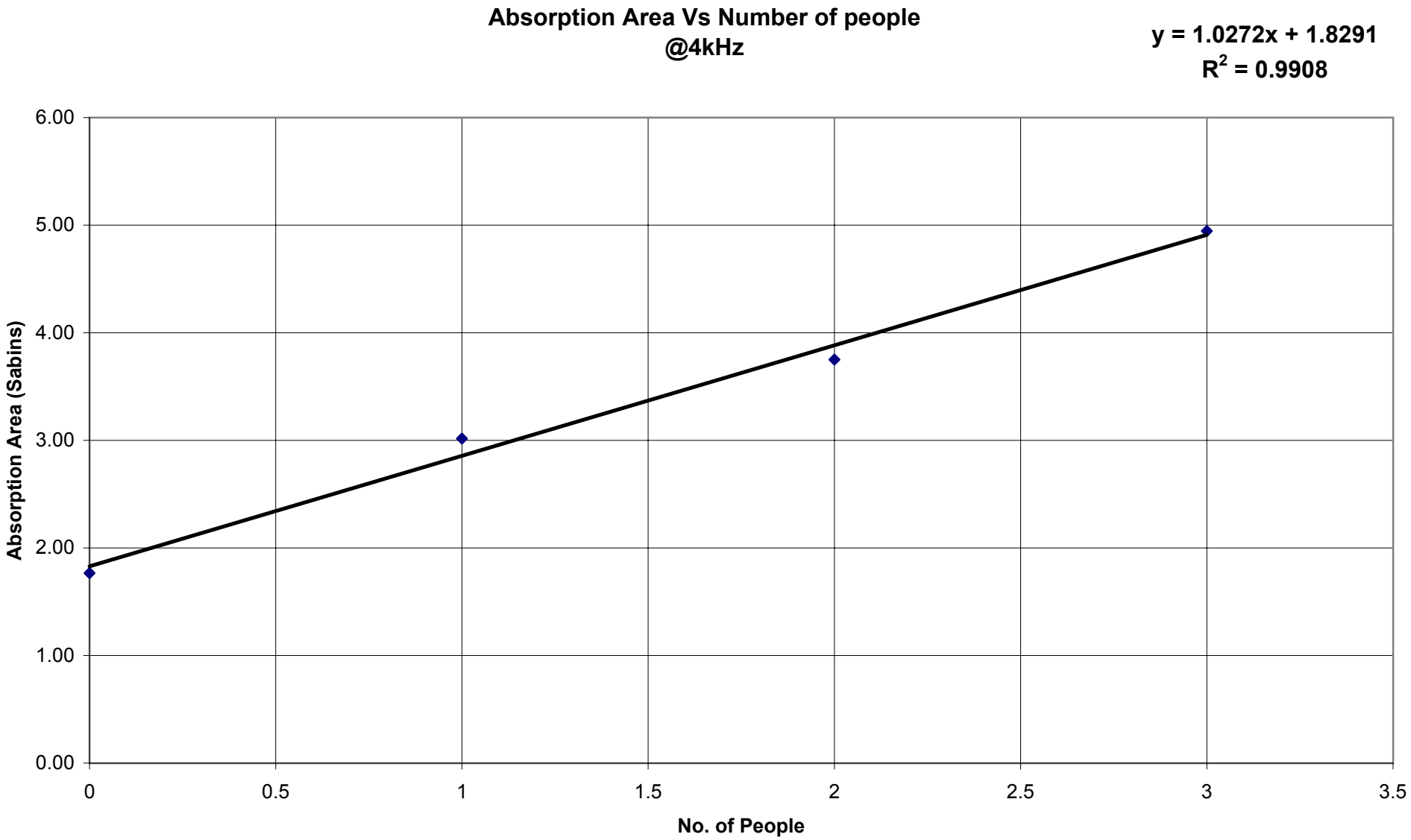

Absorption Area Vs Number of people
@125Hz
y = 0.0497x + 0.9846
R2 = 0.9719
Absorption Area (Sabins)
1.16
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0
0.5
1
1.5
2
2.5
3
3.5
No. of People

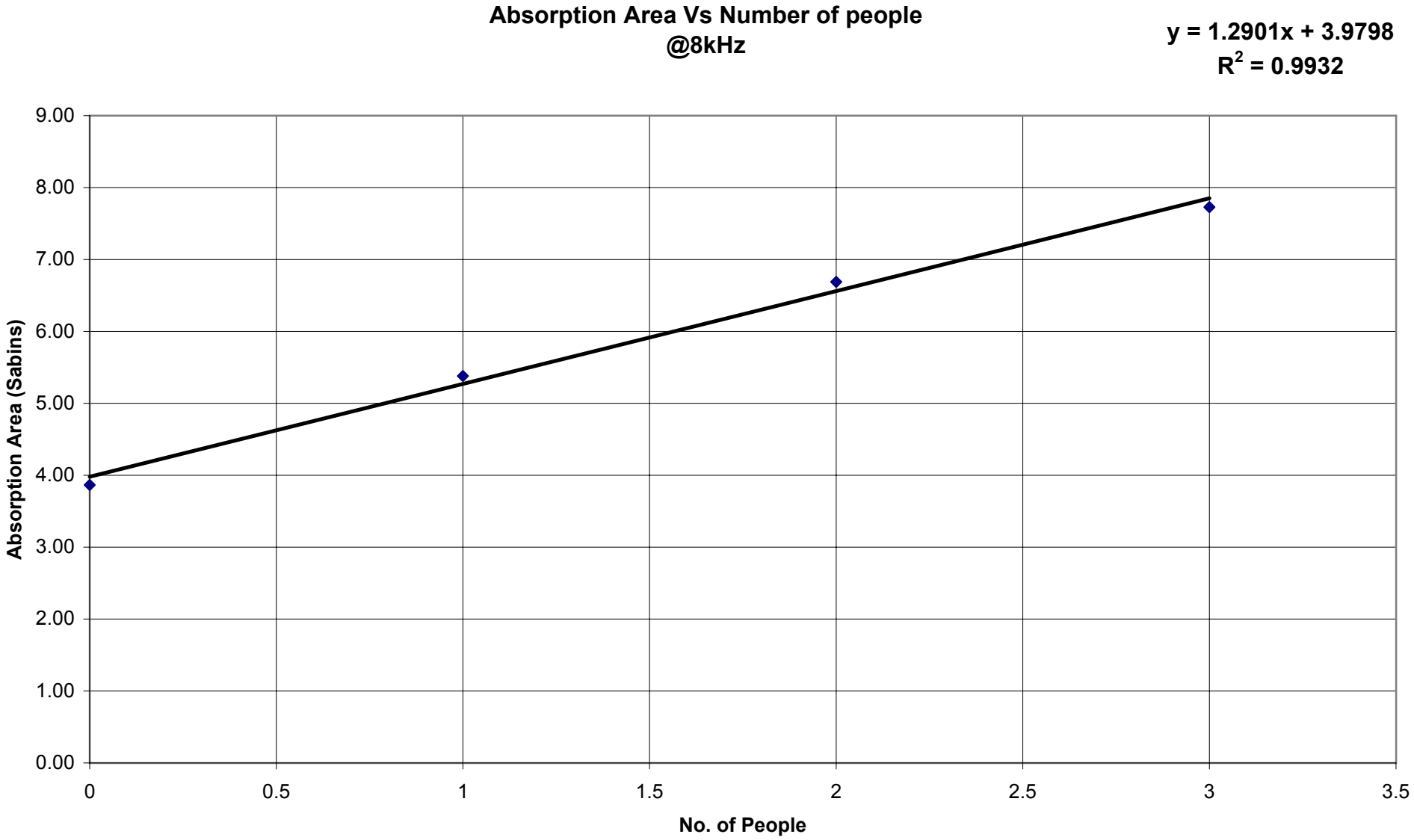

Absorption Area Vs Number of people
@250Hz
y = 0.1581x + 0.885
R2 = 0.9904
Absorption Area (Sabins)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
0.5
1
1.5
2
2.5
3
3.5
No. of People


Absorption Area Vs Number of people
@500Hz
y = 0.2532x + 0.7284
R2 = 0.9636
Absorption Area (Sabins)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
0.5
1
1.5
2
2.5
3
3.5
No. of People


Absorption Area Vs Number of people
@1kHz
y = 0.5833x + 0.7897
R2 = 0.9454
Absorption Area (Sabins)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
0.5
1
1.5
2
2.5
3
3.5
No. of People


Absorption Area Vs Number of people
@2kHz
y = 0.8628x + 1.2397
R2 = 0.99
Absorption Area (Sabins)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
0.5
1
1.5
2
2.5
3
3.5
No. of People


Absorption Area Vs Number of people
@4kHz
y = 1.0272x + 1.8291
R2 = 0.9908
Absorption Area (Sabins)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
0.5
1
1.5
2
2.5
3
3.5
No. of People


Absorption Area Vs Number of people
@8kHz
y = 1.2901x + 3.9798
R2 = 0.9932
Absorption Area (Sabins)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
0.5
1
1.5
2
2.5
3
3.5
No. of People

APPENDIX B

	Sabines @Octave Band (Hz)					
Type	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
People Standing[1]	0.19	0.33	0.44	0.42	0.46	0.37
Audience Seated(min)[2]	0.23	0.33	0.37	0.42	0.46	0.42
Audience Seated(max)[2]	0.37	0.46	0.51	0.60	0.65	0.65
Seated in arm chair[3]	-	0.23	0.27	0.46	0.48	0.46
Audience on wood seat[4]	0.15	0.30	0.30	0.55	0.60	0.50
Male Standing[5]	0.12	0.24	0.59	0.98	1.13	1.12

[1] *Acoustics* – Leo. L. Beranek
[2] *Sound System Engineering* – Don Davis
[3] *Master Handbook of Acoustics* – F. Alton Everest
[4] *Acoustics and Electroacoustics* – Mario Rossi
[5] *Room Acoustics* – Heinrich Kuttruff