To Study the random errors in determining the period of a simple pendulum.

DIAGRAM :

AIM: To study the random errors in determining the time period of a simple pendulum.

Apparatus required: A simple pendulum, a stand and a stop-watch.

Theory: The random errors in a large number of observations are distributed about the means of all the observations according to the Gaussian law of errors, i.e.,

$$f \propto Ae^{-Bx^2},$$

where A and B are constants,

x is the errors or the deviation of an observation from the mean of all observations, f is the frequency of the deviation.

Thus, if a graph is made between the deviations x and the frequencies, f, it will have the shape of curve.

Procedure: (i) Hang the pendulum from a stand and give it oscillations of small amplitude.

(ii) Find the time period $T = t/20$ for each observation and calculation the mean time period $\bar{T} = \Sigma T/100$.

(iii) Find the time t for 20 oscillations. Take 100 such readings.

(iv) Find the deviation in each reading from the mean as $x = T - \bar{T}$. x will either be zero or will have small positive or negative values. Also calculate the value of x^2 for each observation.

(v) Tabulate all the values of deviations, x, and their respective frequencies, f. The frequency of a deviation is the number of times it occurs in 100 observations taken.

(vi) Plot a graph between 'x' along x-axis and 'f' along y-axis. It will have a shape similar to the curved graph.

OBSERVATIONS: Least count of stop watch = 0.01 sec

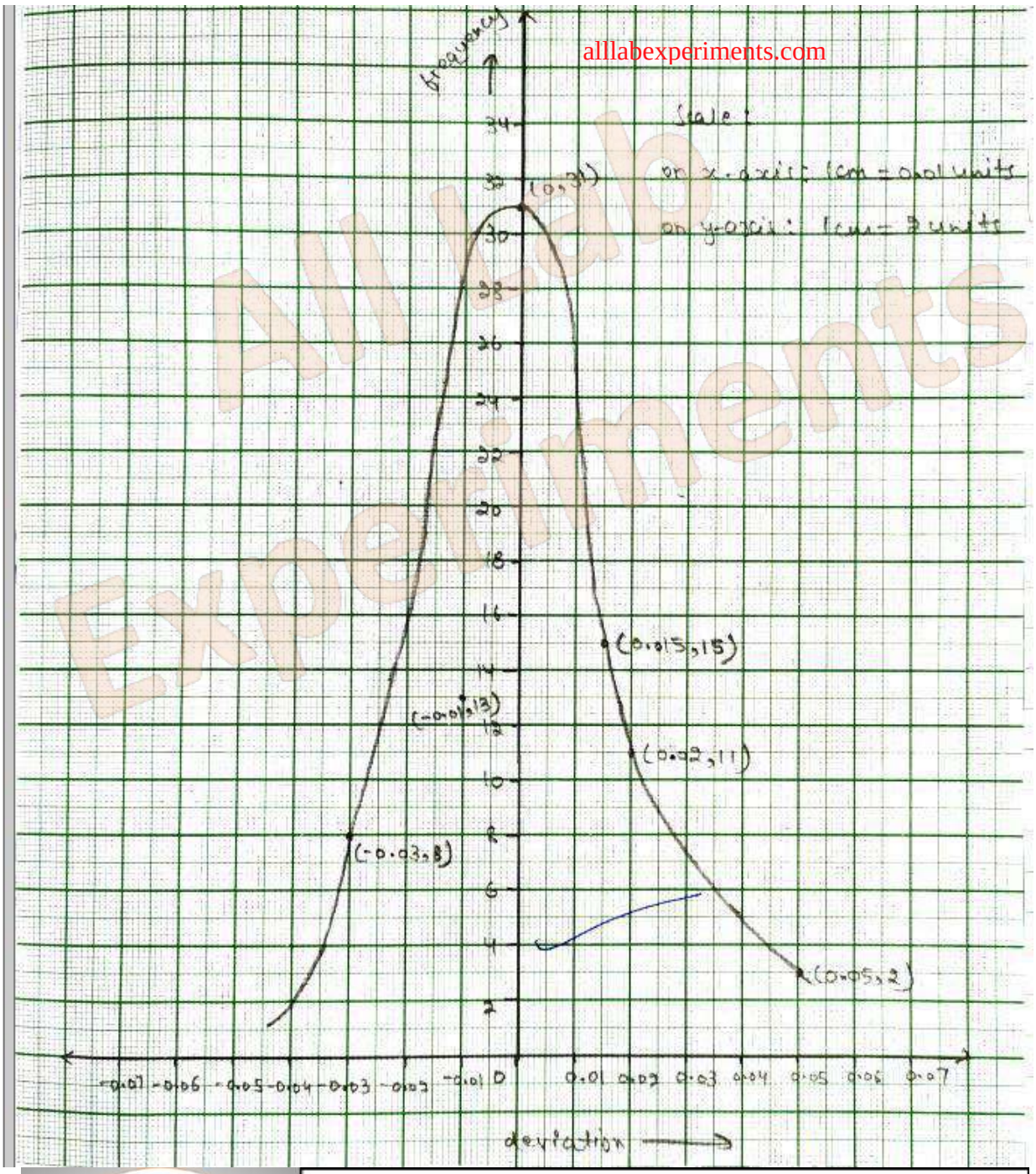
S.No	Time for 20 oscillations (±) (sec)	Time period T (sec) {±1/20}	$x = T - \bar{T}$ (sec)	x^2 (sec^2)
1.	34.40	1.72	0.02	0.0004
2.	34.28	1.714	0.014	0.000196
3.	34.72	1.736	0.036	0.001296
4.	35.22	1.761	0.061	0.003721
5.	34.31	1.715	0.015	0.000225
6.	34.00	1.7	0.0	0.0
7.	34.54	1.727	0.027	0.000729
8.	34.57	1.728	0.028	0.000784
9.	34.53	1.726	0.026	0.000676
10.	34.16	1.708	0.008	0.000064
11.	34.31	1.715	0.015	0.000225
12.	34.75	1.737	0.037	0.001369
13.	34.59	1.729	0.029	0.000841
14.	34.50	1.725	0.025	0.000625
15.	34.50	1.725	0.025	0.000625
16.	34.78	1.739	0.039	0.001521
17.	34.85	1.742	0.042	0.001764
18.	35.16	1.758	0.058	0.003364
19.	34.37	1.718	0.018	0.000324
20.	34.72	1.736	0.036	0.001296
21.	34.53	1.726	0.026	0.000676
22.	34.37	1.718	0.018	0.000324
23.	34.59	1.729	0.029	0.000841
24.	35.00	1.750	0.05	0.0025
25.	34.47	1.723	0.023	0.000529
26.	34.62	1.731	0.031	0.000961
27.	34.44	1.722	0.022	0.000484
28.	35.00	1.750	0.05	0.0025
29.	34.69	1.734	0.034	0.001156
30.	34.37	1.718	0.018	0.000324
31.	34.32	1.716	0.016	0.000256
32.	33.78	1.689	−0.011	0.000121
33.	34.44	1.722	0.022	0.000484

S.No	Time for 20 oscillations, t (sec)	Time period T = t/20 (sec)	$x = T - \bar{T}$ (sec)	x^2 (sec)^2
34.	34.46	1.723	0.023	0.000529
35.	33.00	1.65	−0.05	0.0025
36.	35.13	1.756	0.056	0.003136
37.	34.37	1.718	0.018	0.000324
38.	34.44	1.722	0.022	0.000484
39.	34.72	1.736	0.036	0.001296
40.	34.59	1.729	0.029	0.000841
41.	34.53	1.726	0.026	0.000676
42.	35.00	1.75	0.05	0.0025
43.	34.37	1.718	0.018	0.000324
44.	34.69	1.734	0.034	0.001156
45.	34.74	1.737	0.037	0.001369
46.	34.44	1.722	0.022	0.000484
47.	34.66	1.733	0.033	0.001089
48.	34.84	1.742	0.042	0.001764
49.	34.84	1.742	0.042	0.001764
50.	35.13	1.756	0.056	0.003136
51.	34.60	1.730	0.03	0.0009
52.	34.87	1.743	0.043	0.001849
53.	34.72	1.736	0.036	0.001296
54.	34.56	1.728	0.028	0.000784
56.	35.00	1.75	0.05	0.0025
57.	34.63	1.731	0.031	0.000961
58.	34.81	1.740	0.04	0.0016
59.	34.85	1.742	0.042	0.001764
60.	35.06	1.753	0.053	0.002809
61.	34.81	1.740	0.04	0.0016
62.	34.72	1.736	0.036	0.001296
63.	32.81	1.640	−0.06	0.0036
64.	34.81	1.740	0.04	0.0016
65.	34.62	1.731	0.031	0.000961
66.	34.47	1.723	0.023	0.000529
67.	34.54	1.727	0.027	0.000729
68.	34.50	1.725	0.025	0.000625
69.	34.43	1.721	0.021	0.000441
70.	34.50	1.725	0.025	0.000625
71.	34.72	1.736	0.036	0.001296
72.	34.59	1.729	0.029	0.000841
73.	34.37	1.718	0.018	0.000324
74.	34.69	1.734	0.034	0.001156
75.	34.72	1.736	0.036	0.001296
76.	35.13	1.756	0.056	0.003136
77.	34.81	1.740	0.04	0.0016
78.	34.72	1.736	0.036	0.001296
79.	34.44	1.722	0.022	0.000484
80.	34.86	1.743	0.043	0.001849

S.No	Time for 20 oscillations, t (sec)	Time period T (sec)	$x = T - \bar{T}$ (sec)	x^2 (sec^2)
81.	34.38	1.719	0.019	0.000361
82.	34.06	1.703	0.003	0.000009
83.	34.31	1.715	0.015	0.000225
84.	34.12	1.706	0.006	0.000036
85.	34.47	1.723	0.023	0.000529
86.	34.67	1.733	0.028	0.000784
87.	33.43	1.671	−0.029	0.000841
88.	34.37	1.718	0.018	0.000324
89.	34.31	1.715	0.015	0.000225
90.	34.56	1.728	0.028	0.000784
91.	34.88	1.744	0.044	0.001936
92.	33.75	1.687	−0.013	0.000169
93.	34.62	1.731	0.031	0.000961
94.	34.91	1.745	0.045	0.002025
95.	34.57	1.728	0.028	0.000784
96.	34.65	1.732	0.032	0.001034
97.	34.75	1.738	0.032	0.001024
98.	34.78	1.737	0.037	0.001369
99.	34.13	1.789	0.039	0.001521
100.	34.10	1.706	0.006	0.000036
		1.705	0.005	0.000025

- Frequency v/s Deviation :

S.NO	Deviation, x (sec)	frequency, f
1.	0.0	34
2.	0.01	3
3.	0.02	10
4.	0.03	8
5.	0.04	4
6.	0.05	2
7.	−0.01	13
8.	−0.02	17
9.	−0.03	8
10.	0.06	3



CALCULATIONS :

Summation of time period $= \Sigma T = 169.773$

Mean of time period $= \frac{\Sigma T}{n} = \frac{169.773}{100} = 1.70$ sec

Standard deviation $= \sigma$

$$\sigma = \sqrt{\frac{\Sigma x^2}{n}} = \sqrt{\frac{0.130554}{100}}$$

$\sigma = 0.0361$ sec

Probable error $= 0.6745 \times \sigma$

$= 0.6745 \times 0.0361$

$= 0.0243$ sec

Average error :- $\frac{\Sigma \bar{x}}{n} = \frac{1.8920}{100} = 0.01892$

Result : Random errors in the determination of the time-period of a simple pendulum are studied and it is found that :

(i) probability of 'no error' is maximum.

(ii) the positive and negative errors are equally probable.

(iii) the probability of large errors is very small.

(iv) small errors are more probable than large errors.

(v) Standard deviation, $\sigma = 0.0361$ sec

(vi) Probable error, $p = 0.0243$ sec