SOLUTION

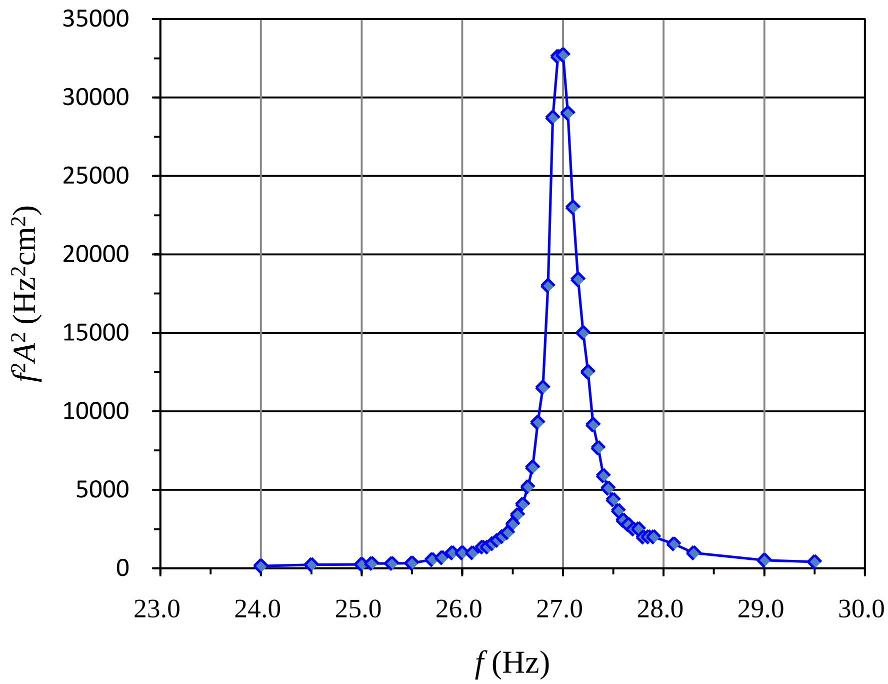
Exp. I-A、Measuring the resonance frequency

(1) Measure the amplitude A of the oscillating laser beam by tuning the frequency f of the sine wave generator. Record the measured data in the data table.

f(Hz)	A(cm)	f^2A^2(Hz^{2}cm^2)	f(Hz)	A(cm)	f^2A^2(Hz^{2}cm^2)
24.00	0.50	1.4×10^2	26.85	5.00	180×10^2
24.50	0.60	2.2×10^2	26.90	6.30	287×10^2
25.00	0.60	2.3×10^2	26.95	6.70	326×10^2
25.10	0.70	3.1×10^2	27.00	6.70	327×10^2
25.30	0.70	3.1×10^2	27.05	6.30	290×10^2
25.50	0.70	3.2×10^2	27.10	5.60	230×10^2
25.70	0.90	5.4×10^2	27.15	5.00	184×10^2
25.80	1.00	6.66×10^2	27.20	4.50	150×10^2
25.90	1.20	9.66×10^2	27.25	4.10	125×10^2
26.00	1.20	9.73×10^2	27.30	3.50	91.3×10^2
26.10	1.20	9.81×10^2	27.35	3.20	76.6×10^2
26.20	1.40	13.5×10^2	27.40	2.80	58.9×10^2
26.25	1.40	13.5×10^2	27.45	2.60	50.9×10^2
26.30	1.50	15.6×10^2	27.50	2.40	43.6×10^2
26.35	1.60	17.8×10^2	27.55	2.20	36.7×10^2
26.40	1.70	20.1×10^2	27.60	2.00	30.5×10^2
26.45	1.80	22.7×10^2	27.65	1.90	27.6×10^2
26.50	2.00	28.1×10^2	27.70	1.80	24.9×10^2
26.55	2.20	34.1×10^2	27.75	1.80	25.0×10^2
26.60	2.40	40.8×10^2	27.80	1.60	19.8×10^2
26.65	2.70	51.8×10^2	27.85	1.60	19.9×10^2
26.70	3.00	64.2×10^2	27.90	1.60	19.9×10^2
26.75	3.60	92.7×10^2	28.10	1.40	15.5×10^2
26.80	4.00	115×10^2	28.30	1.10	9.69×10^2

SOLUTION

(2) Plot a proper data in the graph paper to determine the resonance frequency f_{RO} and the quality factor Q. Record f_{RO} and Q in the following blank.



$$Q = \frac{f_{RO}}{f_2 - f_1} = \frac{27.0}{27.17 - 26.84} = 81.8$$

f_{RO} = 27.0 Hz	Q = 81.8

SOLUTION

Exp. I-B、Resonance frequency versus the external force.

(1) Measure and record the measured data z_0 in the data table.

z_0 = 6.40 cm

(2) Determine the position z of the top plane of the N-pole of M_C. Calculate the nominal distance d by defining $d = z_0 - z$. Record z and d in the data table.

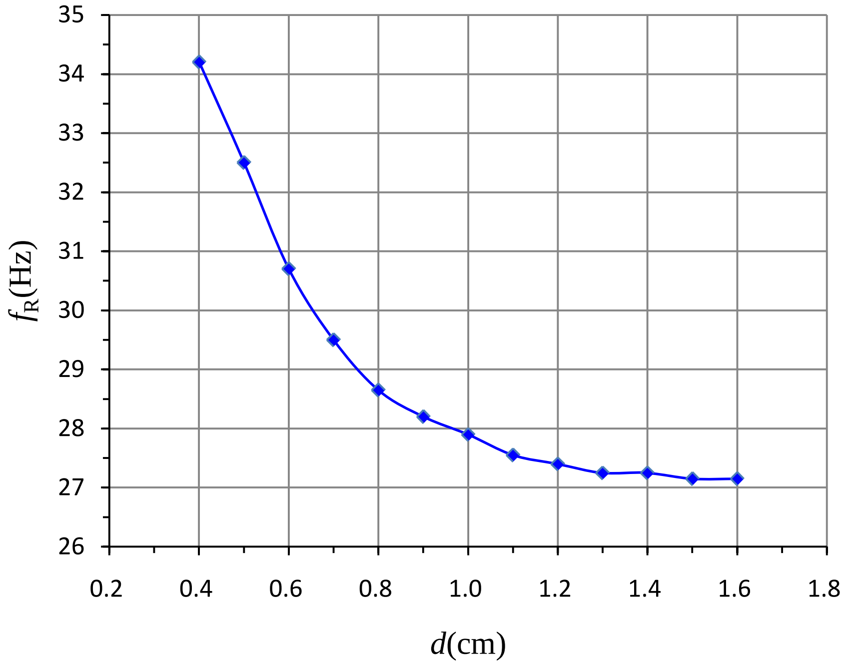
(3) Determine the resonance frequency f_R for the distance d by tuning the frequency of the sine wave generator until the maximum amplitude is reached. Record the determined resonance frequency f_R in the data table.

(4) Change the vertical position of the magnet M_C and repeat the steps (2) and (3) for a number of measurements of different distance d and the corresponding resonance frequency f_R.

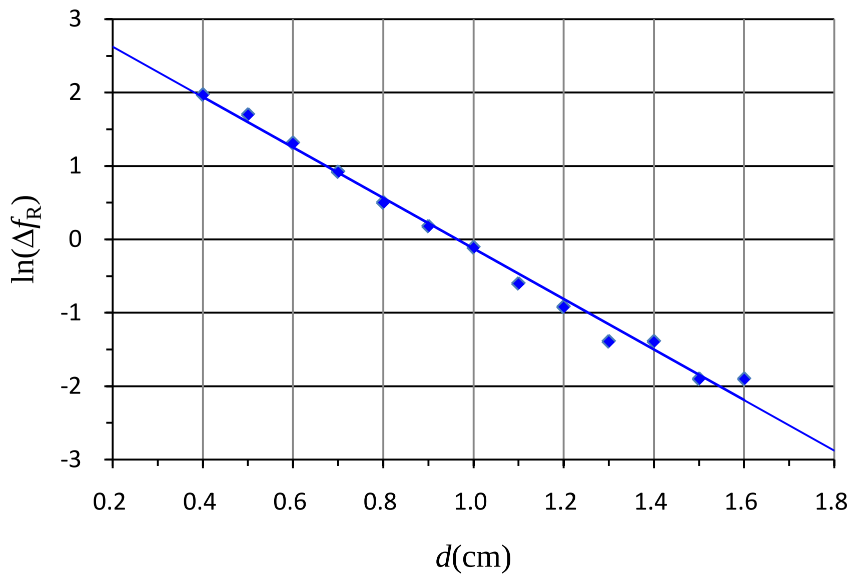
z(cm)	d (cm)	f_R(Hz)	Δf_R(Hz)	$\ln(\Delta f_R)$
4.80	1.60	27.15	0.15	-1.90
4.90	1.50	27.15	0.15	-1.90
5.00	1.40	27.25	0.25	-1.39
5.10	1.30	27.25	0.25	-1.39
5.20	1.20	27.40	0.40	-0.92
5.30	1.10	27.55	0.55	-0.60
5.40	1.00	27.90	0.90	-0.11
5.50	0.90	28.20	1.20	0.18
5.60	0.80	28.65	1.65	0.50
5.70	0.70	29.50	2.50	0.92
5.80	0.60	30.70	3.70	1.31
5.90	0.50	32.50	5.50	1.70
6.00	0.40	34.20	7.20	1.97

SOLUTION

(5) Plot a graph of f_R as a function of distance d using a graph paper.



(6) Define $\Delta f_R = f_R - f_{RO}$, and plot $\ln(\Delta f_R)$ as a function of d using another graph paper.



SOLUTION

Exp. I-C、Find the positions and depths of magnets in a black box.

(1) Record z_0 and z_{box} on the answer sheet.

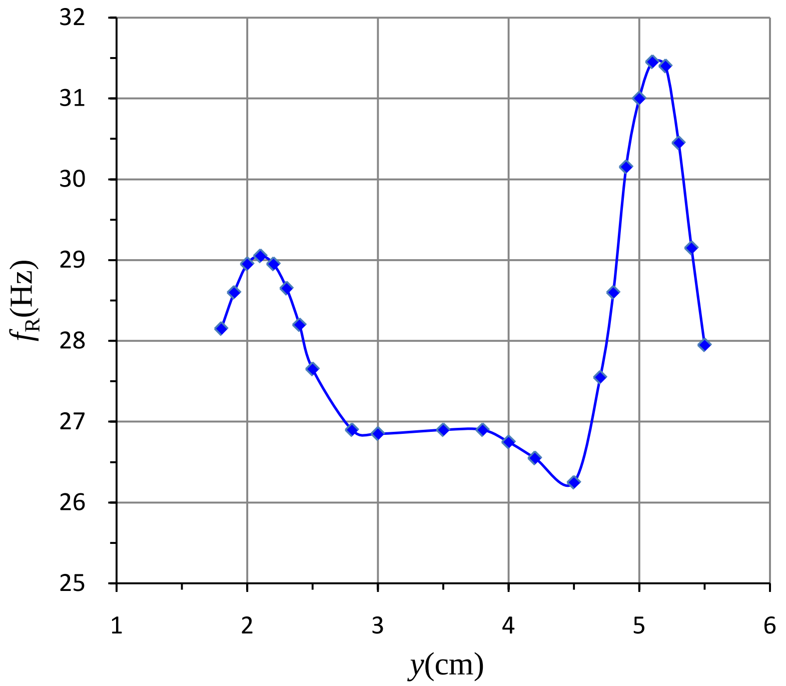
z_0 = 5.37 cm z_{box} = 4.97 cm

(2) Move the black box along the longer line and observe the variation in resonance frequency f_R of the reed to find the position of M_B. Record the measured distances y and their corresponding resonance frequencies f_R in the data table.

y(cm)	f_R(Hz)	y(cm)	f_R(Hz)
5.50	27.95	2.80	26.90
5.40	29.15	2.50	27.65
5.30	30.45	2.40	28.20
5.20	31.40	2.30	28.65
5.10	31.45	2.20	28.95
5.00	31.00	2.10	29.05
4.90	30.15	2.00	28.95
4.80	28.60	1.90	28.60
4.70	27.55	1.80	28.15
4.50	26.25		
4.20	26.55		
4.00	26.75		
3.80	26.90		
3.50	26.90		
3.00	26.85		

SOLUTION

(3) Plot f_R as a function of y on a graph paper to determine the position of magnet M_B. Mark the positions of magnets M_A and M_B on the y-axis of your graph, and write down the value of $\overline{AB}$ on the answer sheet.

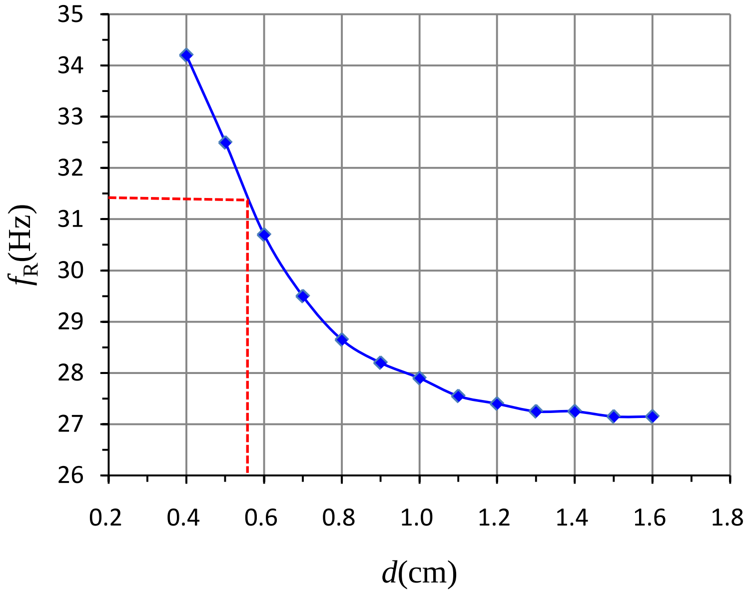


The distance between the two maximum points is 5.1-2.1=3.0 cm.

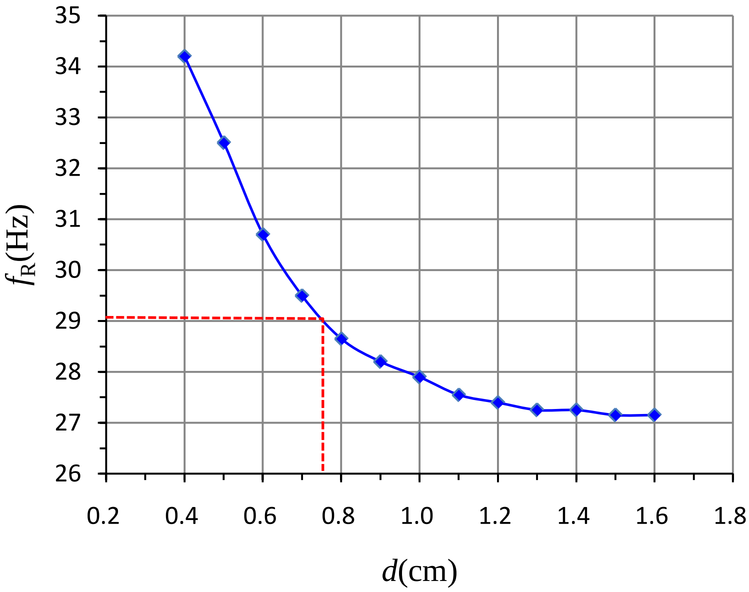
$\overline{AB}$ = 3.0 cm

SOLUTION

(4) Determine the depths d_A and d_B of the magnets M_A and M_B from the top surface of the black box using the results in Exp. I-B. Write down the values of d_A and d_B on the answer sheet.



$$
\begin{aligned}
d_A &= d-(z_0-z_{box}) \\
&= 0.56-0.40 \\
&= 0.16 \text{ cm}
\end{aligned}
$$

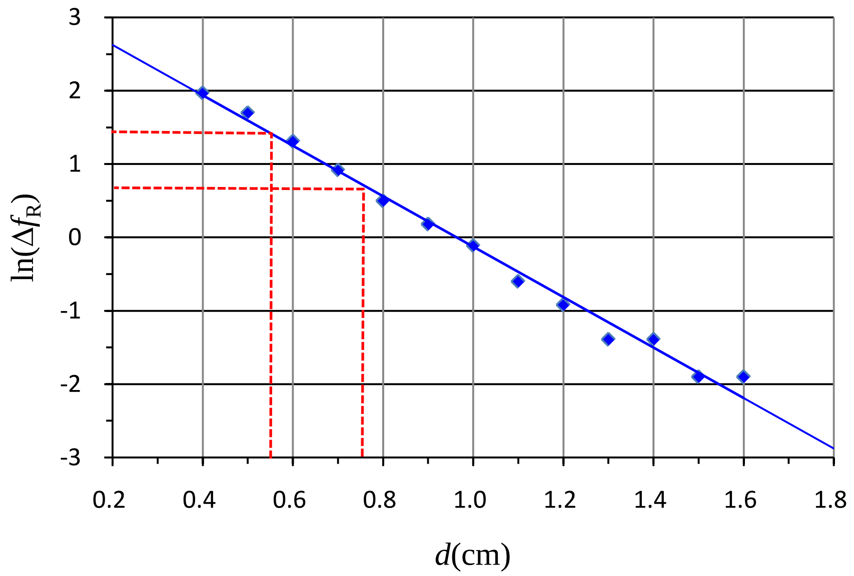


$$
\begin{aligned}
d_B &= d-(z_0-z_{box}) \\
&= 0.75-0.40 \\
&= 0.35 \text{ cm}
\end{aligned}
$$

d_A = 0.16 cm	d_B = 0.35 cm

SOLUTION

Alternatively,



M_A :

$$\ln(\Delta f_R) = \ln(31.4 - 27.0) = 1.48$$
$$\Rightarrow \; d = 0.56 \text{ cm}$$
$$\Rightarrow \; d_A = d - (z_0 - z_{box}) = 0.56 - 0.40 = 0.16 \text{ cm}$$

M_B :

$$\ln(\Delta f_R) = \ln(29.1 - 27.0) = 0.74$$
$$\Rightarrow \; d = 0.75 \text{ cm}$$
$$\Rightarrow \; d_A = d - (z_0 - z_{box}) = 0.75 - 0.40 = 0.35 \text{ cm}$$