APL103(Experimental Methods)
LAB REPORT
Exp no:- 7 (Cantilever Vibration)

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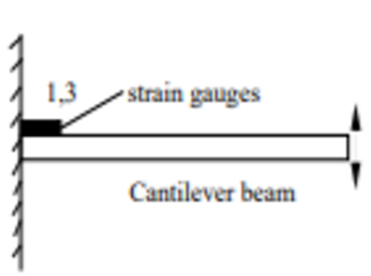
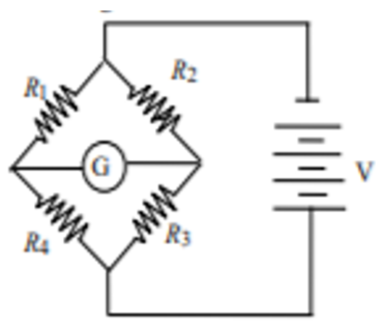
Objective:
1. To study damped vibrations of a cantilever beam.
2. To determine the damping ratio and un-damped natural frequency to the above system.

Apparatus:
i) A cantilever beam on which a resistance-type strain gauge has been mounted near the clamped end.
ii) A signal conditioner/strain meter and data acquisition system.
iii) Computer for data storage and analysis.

Theory:
When a metal cantilever, as shown in the figure below, is given an initial displacement and released, it exhibits damped oscillations. The damping is usually very small, so the oscillations persist for a long time and can be easily recorded. In the set-up two gauges have been used, both on the top surface of the cantilever, and they are to be connected on opposite sides of the Wheatstone bridge for measuring the bending strain.





Procedure:

i) Start up the software and set the sampling frequency to 10 kHz.
ii) Begin acquisition and set the cantilever in vibration by giving it an initial displacement and releasing it.
iii) Observe the damped oscillations on the screen and stop acquiring data after the amplitude falls to less than one-tenth of the initial value.
iv) Select the required range of data and store it in a file for analysis.
v) Repeat the above steps four more times --- i.e., take 5 data sets in all.

Analysis:

Using a spreadsheet such as Excel or your own software, determine the following:
i. The time taken for 10 oscillations. Using this, determine the time period, T, and the damped frequency:

$\boldsymbol{\omega_d = 2\pi/T}$ which is related to the undamped natural frequency, $\boldsymbol{\omega_n}$, by $\boldsymbol{\omega_d = \omega_n\sqrt{(1- \xi^2)}}$
Where $\boldsymbol{\xi}$ is the damping ratio.

ii. Pick any convenient cycle for the initial amplitude. Measure this amplitude and the amplitude after 10 cycles. Take the natural logarithm of the amplitude ratio and obtain another relation between the natural frequency and damping ratio as follows:

$\boldsymbol{- \xi\omega_n \times 10T = \ln(A_{10} / A_0)}$

iii. Hence, determine the un-damped natural frequency and the damping ratio.
iv. Repeat the above steps for the other 4 data sets.

Readings:

T_0	A_0	T_{10}	A_{10}	$T_{10} - T_0$
14.0675	**0.1945**	**14.186**	**0.194**	**0.1185**
18.9334	**0.1945**	**19.0519**	**0.01939**	**0.1185**
24.5552	**0.1951**	**24.6746**	**0.1944**	**0.1194**
30.4122	**0.1944**	**30.5309**	**0.1939**	**0.1187**
36.4445	**0.1948**	**36.5633**	**0.1942**	**0.1188**

Using the formula: $\boldsymbol{\omega_d = 2\pi/T}$

$T_{10} - T_0$	ω_d
0.1185	53.02266
0.1185	53.02266
0.1194	52.62299
0.1187	52.93332
0.1188	52.88877

Now using the formula: $\boldsymbol{\log(A_0 / A_{10}) = 2\pi\xi / \sqrt{(1 - \xi^2)}}$

A_0	A_{10}	ξ
0.1945	0.194	0.000409665425
0.1945	0.1939	0.000491725182
0.1951	0.1944	0.000572059368
0.1944	0.1939	0.000409876430
0.1948	0.1942	0.000490966736

Now to calculate $\boldsymbol{\omega_n}$ we have: $\boldsymbol{\omega_d = \omega_n\sqrt{(1- \xi^2)}}$

ω_d	ω_n
53.0226608	53.0226653
53.0226608	53.0226672
52.6229925	52.6230011
52.9333219	52.9333263
52.8887652	52.8887716

Discussion:

1. If we take the ratio to be very small then,

$$\log \left(A_0 / A_{10} \right) = 2\pi\xi$$

A_0	A_{10}	ω_n	ξ
0.1945	**0.194**	**53.0226608**	**0.000409665459**
0.1945	**0.1939**	**53.0226608**	**0.000491725241**
0.1951	**0.1944**	**52.6229925**	**0.000572059461**
0.1944	**0.1939**	**52.9333219**	**0.000409876464**
0.1948	**0.1942**	**52.8887652**	**0.000490966795**

We can see that the error in damping ratio $\boldsymbol{\xi}$ and undamped natural frequency is negligible, i.e., the error in the average of $\boldsymbol{\xi}$ is 5.6 x 10^{-11}, and the error in the average of undamped natural frequency is 6.06 x 10^{-6}.

2. Because strain is measured along the longitudinal axis of the strip, it cannot quantify multidirectional loads. They are susceptible to overload and as a result, may be damaged. Performance is affected by humidity, temperature, hysteresis, and repeatability, and accuracy decreases with extended use.