# AE 314 Lab Report
# Laser Doppler Vibrometry

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## Aim

To determine the natural frequency of the given composite sample

## Objectives

1. To understand the underlying principle and working of a Laser doppler vibrometer.

2. To understand the concept of natural frequencies.

3. To determine the natural frequency of a composite beam.

## Materials Required

1. Composite Beam

2. Clamps

3. Laser Doppler vibrometer machine

## Theory

A vibrometer is generally a two-beam laser interferometer that measures the frequency (or phase) difference between an internal reference beam and a test beam. The test beam is directed to the target. and scattered light from the target is collected and interfered with the reference beam on a photodetector. Vibrometers work in a heterodyne regime by adding a known frequency shift (typically 30-40 MHz) to one of the beams which are generated by a Bragg cell/ acousto-optic mod ulator. The beam splitter divides the incident beam of frequency f0 into a reference beam and test beam. Test beam passes through Bragg cell. which adds frequency shift fb and is then directed to the moving target which further adds a Doppler shift. The Doppler shift is given by the expression –

$$f_d = \frac{2 * v(t) * cos(\alpha)}{\lambda}$$

where, v(t) is the velocity of the target as a function of time. α is the angle between the laser beam and the velocity vector. λ is the wavelength of the light.

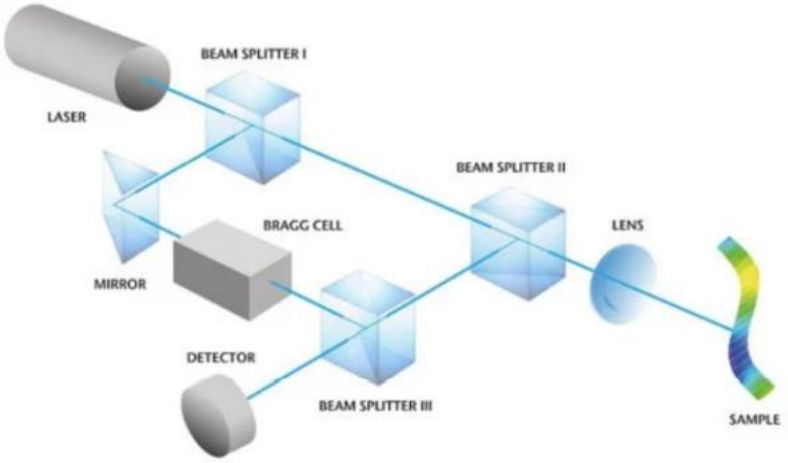



Fig : Experimental setup

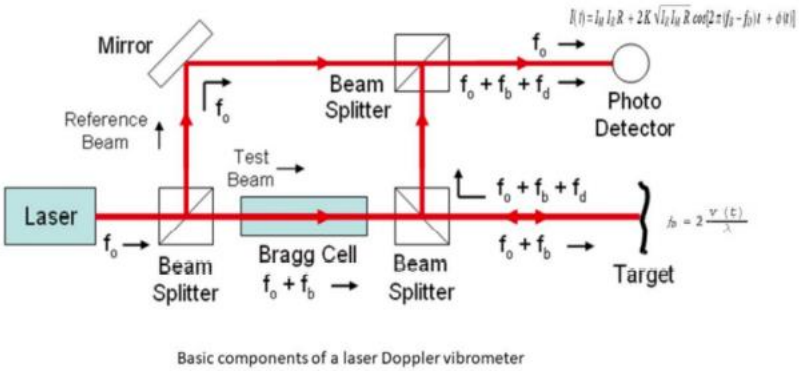
The scattered light from the target is collected by LDV and reflected to the photo detector. This scattered light (fd+f0+fb is combined with reference beam at photo detector output of which is frequency modulated which is demodulated to derive the velocity vs time of the vibrating target.

# Observations

The natural frequency of the beam is 18.8 Hz

# Exercise Questions

**1). Layout of LDV**




Basic components of a laser Doppler vibrometer

The laser beam from the LDV is directed at the surface of interest, and the vibration amplitude and frequency are extracted from the Doppler shift of the reflected laser beam frequency due to the motion of the surface. The output of an LDV is generally a continuous analog voltage that is directly proportional to the target velocity component along the direction of the laser beam.

**2). Explain interference pattern and reason**

The laser Doppler vibrometer works on the basis of optical interference, whereby essen tially two coherent light beams, with their respective light intensities I1 and I2 are required to overlap. The total intensity of both beams is not just the sum of the single intensities, but is modulated according to the formula:

$$I_{tot} = I_1 + I_2 + 2\sqrt{(I_1 I_2)}cos[\frac{2\pi(r_1 - r_2)}{\lambda}]$$

This interference term related to the path length difference between both the beams. If this difference is an integer multiple of the light wavelength, the total intensity is four times a single intensity.

**3). Explain the principle of LDV**

A vibrometer is generally a two beam laser interferometer that measures the frequency (or phase) difference between an internal reference beam and a test beam. The test beam is directed to the target, and scattered light from the target is collected and interferes with the reference beam on a photodetector. Most commercial vibrometers work by adding a known frequency shift (typically 30-40 Hz) to one of the beams. This frequency shift is usually generated by a Bragg cell.

**4). How does a Bragg cell work and state its application in the LDV**

A Bragg cell or an acousto-optic deflector (AOD) uses sound waves to shift the frequency of light, usually at radio frequency. It is used to provide a frequency shift to the laser which after reflecting from the target is collected in the photo detector with a doppler shift frequency. The frequency obtained by the photodetector is used to derive the velocity vs time of the target.

**5). Explain FFT in the context of vibration.**

Fast Fourier Transform or FFT transforms a function from time domain to frequency domain. It provides the frequencies that is contained within the vibrtaions