School of Mechanical and Manufacturing Engineering

MMAN2300 Engineering Mechanics 2

Lab 1 Rotating Mass Unbalance

Location: Undergraduate Teaching Laboratory, Room 116, Willis Annex

Due date: One week from your lab time slot (Moodle online submission)

Aim: To investigate the dynamics of a lightly damped single degree-of-freedom system under free and forced vibration

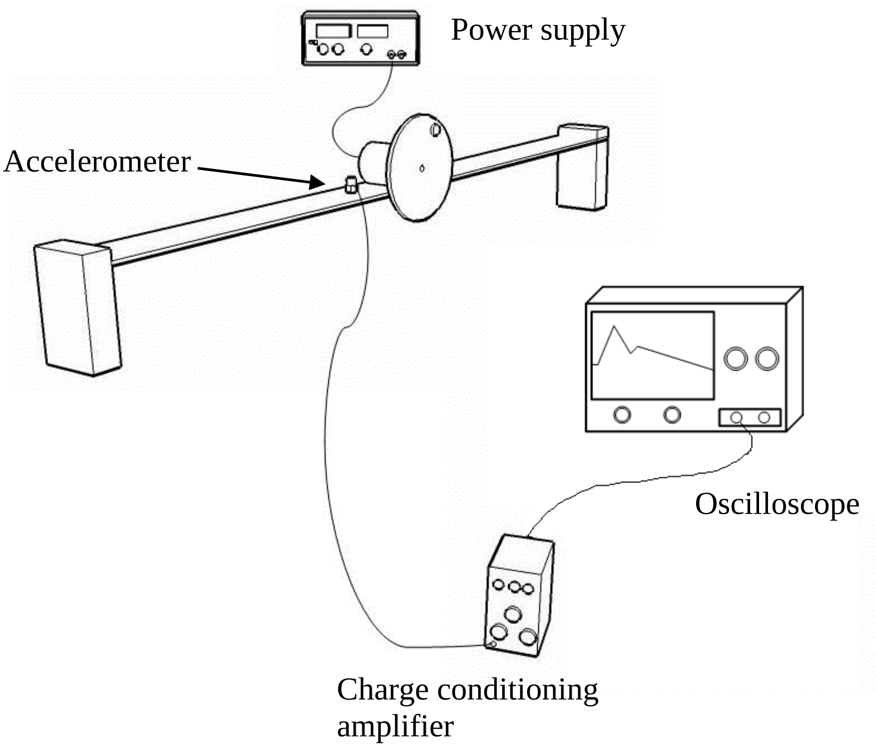

Figure 1. Schematic diagram of the rotating out-of-balance test rig and instrumentation

Procedure

1. Use the signal analyser (frequency analyser) to capture the free response of the vibrating beam. From the time domain response, use the logarithmic decrement to determine the damping ratio. Compare your results for 1 cycle and *N* cycles. From the frequency spectrum, obtain the natural frequency of the system.
2. Compare the damped and undamped natural frequencies found in (1) with those obtained analytically. The dimensions of the aluminium beam are $3\,\text{mm} \times 40\,\text{mm} \times 570\,\text{mm}$. The combined mass of the motor, disk, and out-of-balance weight is $M = 248\,\text{g}$.
3. Measure the amplitude of vibration generated by the rotating out-of-balance mass for a number of frequencies below and above the natural frequency of the beam.
4. Theoretically calculate the amplitude of vibration due to the rotating out-of-balance mass. The mass of the out-of-balance is 4 g, and the radius is 30 mm. Plot the vibration amplitude against frequency.
5. Compare the trend of your measured results in 3 with the analytical results in 4.
6. Discuss your results and observations. Discuss any discrepancies between the theoretical and experimental results, and the possible sources of error. Where possible, show sketches of the free and forced responses in both the time domain and frequency spectrum.

The material properties of aluminium are density $\rho = 2750\,\text{kg/m}^3$ and Young's modulus $E = 7.1 \times 10^{10}\,\text{N/m}^2$. The equivalent spring stiffness for a beam fixed at both ends in transverse vibration is $k = 192EI/l^3$, where $I = bh^3/12$ is the second moment of inertia of the beam cross-section, b is the width of the beam and h is the height of the beam. The effective combined mass of the motor, out-of-balance weight and the beam (for a beam fixed at both ends and carrying a central mass M) is: $m_{eq} = M + \frac{13}{35} m_{beam}$.