

UNIVERSITY OF NOTRE DAME
DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING

Professor H.M. Atassi
113 Hessert Center
Tel: 631-5736
Email: atassi.1@nd.edu

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Mathematical Methods II

Homework 8

1. Acoustic Waves in a Circular Duct

Consider a circular duct of radius $a = 1m$. Noise is produced in the duct by a fan of N blades. It is proposed to study noise propagation in the duct for different fan rotations per minutes (rpm). Consider the following rpm s: $\{1000, 5000, 10, 000, 15, 000\}$.

- (a) Determine the propagating acoustic modes for every one of these rpm s .
- (b) The acoustic pressure measured at $x = 0$, is given by

$$p(0, r, \theta, t) = NA(a^2 - r^2 \cos^3 \theta) \cos \omega t, \quad (1)$$

where $A = 0.2Pa$ and $N = 4$.

- i. Calculate the pressure associated with each mode for the different rpm s.
- ii. The human ear is sensitive to the logarithm of acoustic intensity. Acousticians measure the noise level using the Decibel scale defined as $dB = 20 \log_{10}(\bar{p}/\bar{p}_{reference})$, where \bar{p} is the pressure rms and $\bar{p}_{reference} = 20\mu Pa$. Calculate the noise level associated with each mode for the different rpm s.
- iii. Calculate the noise level for the different rpm s.

HINT: Details of the theory are given in the note: "Acoustic Waves in Ducts."

- 2. Problem 7; page 422.
- 3. Problems 60, 61; page 437.
- 4. Problems 62 and 64; page 428.