#### CHITKARA UNIVERSITY, HIMACHAL PRADESH

### **DECLARATION BY THE STUDENT**

I Jai Chand (PHDASM19063) hereby certify that the work which is being presented in this thesis entitled "Analysis of Vibrations of Electro-Magneto Transversely Isotropic Thermoelastic Materials with Voids" is for the fulfillment of the requirement for the award of Degree of Doctor of Philosophy submitted in the Department of Applied Sciences (Mathematics), Chitkara University, Himachal Pradesh is an authentic record of my own work carried out under the supervision of Dr Sita Ram.

The work has not formed the basis for the award of any other degree or diploma, in this or any other Institution or University. In keeping with the ethical practice in reporting scientific information, due acknowledgements have been made wherever the findings of others have been cited.

Jai Chand

#### **CERTIFICATE BY THE SUPERVISOR**

This is to certify that the thesis entitled "Analysis of Vibrations of Electro-Magneto Transversely Isotropic Thermoelastic Materials with Voids" submitted by Mr Jai Chand with Regd. No. PHDASM19063 to the Chitkara University, Himachal Pradesh in fulfillment for the award of the degree of Doctor of Philosophy is a bonafide record of research work carried out by him under my supervision. The contents of this thesis, in full or in parts, have not been submitted to any other Institution or University for the award of any degree or diploma.

> Dr. Sita Ram Professor, Department of Applied Sciences, Chitkara University, Himachal Pradesh

#### ACKNOWLEDGMENTS

It is my privilege to thanks my research supervisor Prof.(Dr.) Sita Ram, Department of Applied Sciences, Chitkara University, Himachal Pradesh, who encouraged, paved the way and guided me time to time during the present research work. My heartfelt thanks to Dr. Dinesh Kumar Sharma, Associate Professor, Department of Mathematics, Maharaja Agrasen University, Himachal Pradesh for his indebted guidance during the course of research work. I also extend my sincere thanks to one and all faculty members of Department of Applied Sciences, Dean R & D and other authorities of Chitkara University for their kind cooperation and guidance.

I am indebted especially to my beloved father Late Shri Sunder Ram Mehalwal whose dream comes true to see me as a doctor of philosophy. It will be my immense pleasure to share here that I am highly indebted to the person whose care, help, every type of support and blessings are always with me right from my birth to till date, my loving mother Smt. Kamla Devi. Without her endless love, I will never achieve this level of education. I express my gratitude to all my Mehalwal family members for their blessings and encouragements.

My efforts will remain incomplete if I do not articulate my recognition to my loving wife Santosh Mehalwal for her patience, endurance, solidarity and unconditional support.

I would like to put on record my sincere appreciation to my naughty children Shanvi and Rishit Mehalwal for their interest towards computer due to which I learn a lot of tricks and gain more knowledge of computer. They undoubtedly deserve my thanks.

In the last but not the least, I am highly thankful to almighty God, who made all things so easier to me in my whole life.

Jai Chand

# DEDICATED

# TO

## MEHALWAL FAMILY

### LIST OF TABLE

Table No.	. Title	Page No.
6.1	Natural frequencies $(\Omega_R)$ versus mode	124
	number(m)	
	LIST OF FIGURES	
Figure No.	Title	Page No.
2.1	Geometry of the problem (Vibration analysis of electro-magneto transversely isotropic non-local thermoelastic cylinder with voids)	28
2.2(a)	Natural frequencies $(\Omega_R)$ versus mode number $(m)$ for different models of thermoelasticity at $\eta = 1.5$ in nonlocal elastic cylinder with voids with magnetic field.	39
2.2(b)	Natural frequencies $(\Omega_R)$ versus mode number $(m)$ for different models of thermoelasticity at $\eta = 1.5$ in nonlocal elastic cylinder with voids without magnetic field	40
2.3(a)	Natural frequencies $(\Omega_R)$ versus mode number $(m)$ for different models of thermoelasticity at $\eta = 1.5$ in local elastic cylinder with voids and magnetic field	40
2.3(b)	Natural frequencies $(\Omega_R)$ versus mode number $(m)$ for different models of thermoelasticity at $\eta = 1.5$ in local elastic cylinder with voids and without magnetic field	41
2.3(c)	Natural frequencies $(\Omega_R)$ versus mode number $(m)$ for different models of thermoelasticity at $\eta = 1.5$ in local elastic cylinder without nonlocality, viods and magnetic fields	41
2.4(a)	Frequency shift $(\Omega_{Shift})$ versus mode number $(m)$ for different models of thermoelasticity at $\eta = 1.5$ in nonlocal elastic cylinder with voids with magnetic field.	42
2.4(b)	Frequency shift $(\Omega_{Shift})$ versus mode number $(m)$ for different models of thermoelasticity at $\eta = 1.5$ in nonlocal elastic cylinder with voids and without magnetic field.	42

2.5(a) 43 Frequency shift  $(\Omega_{\text{shift}})$  versus mode number (m) for different models of thermoelasticity at n = 1.5 in local elastic cylinder with voids with magnetic field. 2.5(b) 43 Frequency shift  $(\Omega_{Shift})$  versus mode number (m) for different models of thermoelasticity at n = 1.5 in local elastic cylinder with voids and without magnetic field. 44 2.6(a) Frequency shift  $(\Omega_{Shift})$  versus mode number (m) for different models of thermoelasticity at  $\eta = 2.0$  in nonlocal elastic cylinder with voids with magnetic field. Frequency shift  $(\Omega_{Shift})$  versus mode number (m) for different models of 44 2.6(b) thermoelasticity at  $\eta = 2.0$  in nonlocal elastic cylinder with voids without magnetic field. 45 2.7(a) Frequency shift  $(\Omega_{Shift})$  versus mode number (m) for different models of thermoelasticity at  $\eta = 2.0$  in local elastic cylinder with voids with magnetic field 2.7(b) 45 Frequency shift  $(\Omega_{Shift})$  versus mode number (m) for different models of thermoelasticity at n = 2.0 in local elastic cylinder with voids without magnetic field. 46 2.8(a) Thermoelastic damping  $(D_F)$  versus mode number (m) for different models of thermoelasticity at  $\eta = 1.5$  in nonlocal elastic cylinder with voids with magnetic field. Thermoelastic damping  $(D_F)$  versus mode number (m) for different 2.8(b) 46 models of thermoelasticity at  $\eta = 1.5$  in nonlocal elastic cylinder with voids without magnetic field. 47 2.9(a) Thermoelastic damping  $(D_F)$  versus mode number (m) for different models of thermoelasticity at  $\eta = 1.5$  in local elastic cylinder with voids with magnetic field 47 2.9(b) Thermoelastic damping  $(D_F)$  versus mode number (m) for different models of thermoelasticity at  $\eta = 1.5$  in local elastic cylinder with voids without magnetic field. 48 2.10(a) Thermoelastic damping  $(D_F)$  versus mode number (m) for different models of thermoelasticity at  $\eta = 2.0$  in nonlocal elastic cylinder with voids with magnetic field.

2.10(b)	Thermoelastic damping $(D_F)$ versus mode number $(m)$ for different	48
	models of thermoelasticity at $\eta = 2.0$ in nonlocal elastic cylinder with	
	voids without magnetic field	
2.11(a)	Thermoelastic damping $(D_F)$ versus mode number $(m)$ for different	49
	models of thermoelasticity at $\eta = 2.0$ in transversely isotropic local	
	elastic cylinder with voids with magnetic field.	
2.11(b)	Thermoelastic damping $(D_F)$ versus mode number $(m)$ for different	49
	models of thermoelasticity at $\eta = 2.0$ in transversely isotropic local	
	elastic cylinder with voids without magnetic field.	
3.1	Geometry of the problem (Vibration analysis of transversely isotropic electro-magneto generalized thermoelastic sphere with voids and dual- phase-lag effect)	55
3.2(a)	Variation of natural frequencies $(\Omega_{R})$ against mode number (m) for	67
	thermoelastic models at $\eta = 1.5$ in nonlocal case with magnetic field.	
3.2(b)	Variation of natural frequencies $(\Omega_p)$ against mode number $(m)$ for	67
	thermoelastic models at $\eta = 1.5$ in nonlocal case without magnetic field.	
3.3(a)	Variation of natural frequencies $(\Omega_R)$ against modenumber $(m)$ for	68
	thermoelastic models at $\eta = 1.5$ in local case with magnetic field.	
3.3(b)	Variation of natural frequencies $(\Omega_R)$ against mode number (m)	68
	for thermoelastic models $\eta = 1.5$ in local case without magnetic	
	field.	
3.4(a)	Variation of frequency shift $(\Omega_{Shift})$ against mode number $(m)$ for	69
	thermoelastic models at $\eta = 1.5$ in nonlocal case with magnetic field.	
3.4(b)	Variation of frequency shift $(\Omega_{Shift})$ against mode number ( <i>m</i> ) for	69
	thermoelastic models at $\eta = 1.5$ in nonlocal case without magnetic	
	field.	
3.5(a)	Variation of frequency shift $(\Omega_{Shift})$ against mode number ( <i>m</i> ) for	70
	thermoelastic models at $\eta = 1.5$ in local case with magnetic field.	
3.5(b)	Variation of frequency shift $(\Omega_{Shift})$ against mode number (m) for	70
	thermoelastic models at $\eta = 1.5$ in local case without magnetic field.	

3.6(a)	Variation of frequency shift $(\Omega_{Shift})$ against mode number ( <i>m</i> ) for	71
	thermoelastic models at $\eta = 2.0$ in nonlocal case with magnetic field.	
3.6(b)	Variation of frequency shift $(\Omega_{Shift})$ against mode number ( <i>m</i> ) for thermoelastic models at $n = 2.0$ in nonlocal case without magnetic field.	71
3.7(a)	Variation of frequency shift $(\Omega_{Shift})$ against mode number (m) for	72
	thermoelastic models at $\eta = 2.0$ in local case with magnetic field.	
3.7(b)	Variation of frequency shift $(\Omega_{Shift})$ against mode number (m) for	72
	thermoelastic models at $\eta = 2.0$ in local case without magnetic field.	
3.8(a)	Variation of thermoelastic damping $(D_F)$ against mode number	73
	( <i>m</i> ) for thermoelastic models at $\eta = 1.5$ in nonlocal case with magnetic field.	
3.8(b)	Variation of thermoelastic damping $(D_F)$ against mode number $(m)$ for thermoelastic models at $\eta = 1.5$ in nonlocal case without	73
3.9(a)	magnetic field. $(D)$	74
5.7(u)	Variation of thermoelastic damping $(D_F)$ against mode number	, ,
3.9(h)	( <i>m</i> ) for thermoetastic models at $\eta = 1.5$ in local case with magnetic field.	74
5.9(0)	Variation of thermoelastic damping $(D_F)$ against mode number ( <i>m</i> ) for thermoelastic models at $\eta = 1.5$ in local case without magnetic field.	7.7
3.10(a)	Variation of thermoelastic damping $(D_r)$ against mode number	75
	( <i>m</i> ) for thermoelastic models at $\eta = 2.0$ in nonlocal case with magnetic field.	
3.10(b)	Variation of thermoelastic damping $(D_F)$ against mode number	75
	( <i>m</i> ) for thermoelastic models at $\eta = 2.0$ in nonlocal case without magnetic field.	
3.11(a)	Variation of thermoelastic damping $(D_F)$ against mode number	76
3.11(b)	( <i>m</i> ) for mermoerasult models at $\eta = 2.0$ in local case with magnetic field.	76
5.11(0)	Variation of thermoelastic damping $(D_F)$ against modenumber $(m)$ for thermoelastic models at $\eta = 2.0$ in local case without magnetic field.	70
4.1	Geometry of the problem (Vibrations of phase-lags on electro-magneto	81

nonlocal elastic solid with voids in generalized thermoelastic cylinder/disk)

- 4.1(a) Natural frequencies  $(\Omega_n)$  against mode number (m) for TPL, DPL, LS and 92 CTE models at  $\eta = 1.5$  in nonlocal thermoelastic cylinder with voids with magnetic field.
- 4.1(b) Natural frequencies  $(\Omega_R)$  against mode number (m) for TPL, DPL, LS and 92 CTE models at  $\eta = 1.5$  in nonlocal thermoelastic cylinder with voids without magnetic field.
- 4.2(a) Natural frequencies  $(\Omega_{\kappa})$  against mode number (m) for TPL, DPL, LS and 93 CTE models at  $\eta = 1.5$  in local thermoelastic cylinder with voids with magnetic field.
- 4.2(b) Natural frequencies  $(\Omega_{R})$  against mode number (m) for TPL, DPL, LS and 93 CTE models at  $\eta = 1.5$  in local thermoelastic cylinder with voids without magnetic field.
- 4.3(a) Frequency shift  $(\Omega_{Shift})$  against mode number (m) for TPL, DPL and LS 94 models at  $\eta = 1.5$  in nonlocal thermoelastic cylinder with voids with magnetic field.
- 4.3(b) Frequency shift  $(\Omega_{shift})$  against mode number (m) for TPL, DPL and LS 94 models at  $\eta = 1.5$  in nonlocal thermoelastic cylinder with voids without magnetic field.
- 4.4(a) Frequency shift  $(\Omega_{Shift})$  against mode number (m) for TPL, DPL and LS 95 models at  $\eta = 1.5$  in local thermoelastic cylinder with voids with magnetic field.
- 4.4(b) Frequency shift  $(\Omega_{Shift})$  against mode number (m) for TPL, DPL and LS 95 models at  $\eta = 1.5$  in local thermoelastic cylinder with voids without magnetic field.
- 4.5(a) Frequency shift  $(\Omega_{shift})$  against mode number (m) for TPL, DPL and LS 96 models at  $\eta = 2.0$  in nonlocal thermoelastic hollow cylinder with voids with magnetic field.
- 4.5(b) Frequency shift  $(\Omega_{shift})$  against mode number (m) for TPL, DPL and LS 96 models at  $\eta = 2.0$  in nonlocal thermoelastic hollow cylinder with voids without magnetic field.
- 4.6(a) Frequency shift  $(\Omega_{Shift})$  against mode number (m) for TPL, DPL 97 and LS models at  $\eta = 2.0$  in local thermoelastic hollow cylinder

with voids with magnetic field.

4.6(b)	Frequency shift $(\Omega_{Shift})$ against mode number (m) for TPL, DPL	97
	and LS models at $\eta = 2.0$ in local thermoelastic hollow cylinder	
	with voids without magnetic field.	
4.7(a)	Thermoelastic damping $(D_F)$ against mode number $(m)$ for TPL,	98
	DPL, LS and CTE models at $\eta = 1.5$ in nonlocal thermo-elastic	
	hollow cylinder with voids with magnetic field.	
4.7(b)	Thermoelastic damping $(D_F)$ against mode number $(m)$ for TPL,	98
	DPL, LS and CTE models at $\eta = 1.5$ in nonlocal thermo-elastic	
	hollow cylinder with voids without magnetic field.	
4.8(a)	Thermoelastic damping $(D_F)$ against mode number $(m)$ for TPL,	99
	DPL, LS and CTE models at $\eta = 1.5$ in local thermo-elastic hollow	
	cylinder with voids with magnetic field.	
4.8(b)	Thermoelastic damping $(D_{F})$ against mode number $(m)$ for TPL,	99
	DPL, LS and CTE models at $\eta = 1.5$ in local thermo-elastic hollow	
	cylinder with voids without magnetic field.	
4.9(a)	Thermoelastic damping $(D_{F})$ against mode number $(m)$ for TPL,	100
	DPL, LS and CTE models at $\eta = 2.0$ in nonlocal elastic hollow	
	cylinder with voids with magnetic field.	
4.9(b)	Thermoelastic damping $(D_{F})$ against mode number (m) for TPL,	100
	DPL, LS and CTE models at $\eta = 2.0$ in nonlocal elastic hollow	
	cylinder with voids without magnetic field	
4.10(a)	Thermoelastic damping $(D_{F})$ against mode number $(m)$ for TPL,	101
	DPL, LS and CTE models at $\eta = 2.0$ in local thermo-elastic hollow	
	cylinder with voids with magnetic field	
4.10(b)	Thermoelastic damping $(D_F)$ against mode number $(m)$ for TPL,	101
	DPL, LS and CTE models at $\eta = 2.0$ in local thermo-elastic hollow	
	cylinder with voids without magnetic field.	
5.1(a)	Natural frequency $(\Omega_R)$ against mode number (m) for TPL, DPL, LS and	113
	CTE models of nonlocal thermoelastic sphere with voids with magnetic	
	field	
5.1(b)	Natural frequency $(\Omega_R)$ against mode number (m) for TPL, DPL, LS and	113
	CTE models of nonlocal thermoelastic sphere with voids	
	without magnetic field.	
5.2(a)	Dissipation $(\Omega_i)$ versus mode number (m) for TPL, DPL, LS and	114

	CTE models of nonlocal thermoelastic sphere with voids with magnetic field.	
5.2(b)	Dissipation $(\Omega_l)$ versus mode number ( <i>m</i> ) for TPL, DPL, LS and	114
	CTE models of nonlocal thermoelastic sphere with voids without magnetic field.	
5.3(a)	Frequency shift $(\Omega_{shift})$ versus mode number ( <i>m</i> ) for TPL, DPL, LS	115
	and CTE models of nonlocal thermoelastic sphere with voids with magnetic field.	
5.3(b)	Frequency shift $(\Omega_{shift})$ versus mode number ( <i>m</i> ) for TPL, DPL, LS	115
	and CTE models of nonlocal thermoelastic sphere with voids without magnetic field.	
6.1(a)	Frequency shift $(\Omega_{Shift})$ versus mode number (m) a $\eta = 2.0$ for	125
	nonlocal case.	
6.1(b)	Frequency shift $(\Omega_{Shift})$ versus mode number (m) at $\eta = 2.0$ for	125
	local case.	
6.2(a)	Thermoelastic damping $(Q^{-1})$ versus mode number (m) at $\eta = 2.0$ for (a)	126
	nonlocal case.	
6.2(b)	Thermoelastic damping $(Q^{-1})$ versus mode number ( <i>m</i> ) at $\eta = 2.0$ for local case.	126