

**THE  $L_m^k$  OPERATOR RELATED TO THE GENERALIZED  
HEAT EQUATION AND WAVE EQUATION**

**TAWATCHAI PANYATIP**

**DOCTOR OF PHILOSOPHY  
IN MATHEMATICS**

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่  
Copyright © Chiang Mai University  
All rights reserved  
THE GRADUATE SCHOOL  
CHIANG MAI UNIVERSITY  
FEBRUARY 2011

**THE  $L_m^k$  OPERATOR RELATED TO THE GENERALIZED  
HEAT EQUATION AND WAVE EQUATION**

**TAWATCHAI PANYATIP**

**A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN  
PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF  
DOCTOR OF PHILOSOPHY  
IN MATHEMATICS**

**THE GRADUATE SCHOOL  
CHIANG MAI UNIVERSITY  
FEBRUARY 2011**

**THE  $L_m^k$  OPERATOR RELATED TO THE GENERALIZED  
HEAT EQUATION AND WAVE EQUATION**

**TAWATCHAI PANYATIP**

THIS THESIS HAS BEEN APPROVED  
TO BE A PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY  
IN MATHEMATICS

**EXAMINING COMMITTEE**

Gumpon Sritanratana.....CHAIRPERSON

Asst. Prof. Dr. Gumpon Sritanratana

Suthep Suantai.....MEMBER

Prof. Dr. Suthep Suantai

Amnuay Kananthai.....MEMBER

Prof. Amnuay Kananthai

Vited Longani.....MEMBER

Assoc. Prof. Dr. Vited Longani

Jessada Tariboon.....MEMBER

Lect. Dr. Jessada Tariboon

**THESIS ADVISORY COMMITTEE**

Suthep Suantai.....ADVISOR

Prof. Dr. Suthep Suantai

Amnuay Kananthai.....CO-ADVISOR

Prof. Amnuay Kananthai

Vited Longani.....CO-ADVISOR

Assoc. Prof. Dr. Vited Longani

25 February 2011

© Copyright by Chiang Mai University

## ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor, Prof. Amnuay Kananthai, for his initial idea, guidance and encouragement which enable me to carry out my study successfully.

This work contains a number of improvement based on comments and suggestions provided by Prof. Amnuay Kananthai, Prof. Dr. Suthep Suantai, Assoc. Prof. Dr. Vited Longani, Asst. Prof. Dr. Gumpon Sritanratana and Lecturer Dr. Jessada Tariboon. It is my pleasure to express my sincere thanks to them for their generous assistance.

I would like to thank my friends in Department of Mathematics at Chiang Mai University for their help, friendship, and moral support.

Moreover, I gratefully appreciate my beloved parents for their love and encouragement.

Finally, I extend my sincere thanks to the Office of the Higher Education Commission, Thailand for supporting by grant fund under the program Strategic Scholarships for Frontier Research Network for the Join Ph.D. Program Thai Doctoral degree.

Tawatchai Panyatip