MODELLING THE RADIATION FIELD IN MACROALGAE AQUACULTURE

A Thesis

Presented to

The Graduate Faculty of The University of Akron

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Oliver Graham Evans

May, 2018

MODELLING THE RADIATION FIELD IN MACROALGAE AQUACULTURE

Oliver Graham Evans

Thesis

Approved:	Accepted:
Advisor Dr. Kevin Kreider	Dean of the College Dr. John Green
Co-Advisor Dr. Curtis Clemons	Dean of the Graduate School Dr. Chand Midha
Department Chair Dr. Kevin Kreider	Date

ABSTRACT

An abstract...

Thanks...

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The wave equation can be used to describe many physical phenomena. Challenging topics in meteorology, acoustics, electro-magnetics, and others involve solving the time-dependent wave equation. Many of these problems are described in an unbounded domain (i.e. there is no boundary to reflect the outward traveling waves). When an exact, theoretical solution is unavailable, the lack of a boundary prescription of accurate radiation conditions creates a problem for numerical solutions. The difficulty lies in is finding a way to do calculations on an infinite domain using a computer with finite memory in a finite amount of time and within a finite region.

CHAPTER II

THE TWO DIMENSIONAL WAVE EQUATION

Here is an example of a 'section' and a few equations.

2.1 Recurrence Relation

A series solution for the two-dimensional wave equation

$$\frac{1}{c^2}\frac{\partial^2 u}{\partial t^2} = \frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r} + \frac{1}{r^2}\frac{\partial^2 u}{\partial \theta^2} \tag{2.1}$$

for outgoing waves is

$$u = \sum_{n=0}^{\infty} a_n(\theta) f^n(r,t), \tag{2.2}$$

where

$$f^n = \sum_{k=0}^{\infty} r^{-k-\frac{1}{2}} f_k^n(ct-r). \tag{2.3}$$

You can reference a labeled equation by using the *ref* command. For example, you can show that equations (2.2) and (2.3) are a solution to equation (2.1). (see the file chap2.tex for the commands).

2.2 Second Section Long Subtitle Second Section Long Subtitle Second Section Long Subtitle

The text for the second section. The text for the second section. The text for the second section. The text for the second section. The text for the second section. The text for the second section. The text for the second section. The text for the second section.

2.2.1 First Subsection

The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section.

2.3 Third Section

The text for the third section. The text for the third section. The text for the third section. The text for the third section. The text for the third section. The text for the third section. The text for the third section. The text for the third section.

CHAPTER III

YOU NAME ANY CHAPTER HERE. MAKE SURE THEY'RE IN ALL CAPS

This text is from the file chap4.tex. Look at this file to see the[1] format of this text. A bibliography file will be need as well. The bibliography file used here is bio.bib. Not this file as many entries but not all are used. To reference a paper use \citelabel. Here is a reference for a paper [1]. The book ASM Handbook[2] Volume 15, [2].

When running Latex you need two run the folling commands:

latex main.tex

latex main.tex

bibtex main

latex main.tex

latex main.tex

dvips -o main.ps main.dvi

Then you should have a postscript file you can read using ghost view (gv main.ps).

You will have problems, when you do look in a book, the web or ask someone.

---

[1]Footnote text. Footnote text. Footnote text. Footnote text. Footnote text. Footnote text. Footnote text. Footnote text. Footnote text. Footnote text. Footnote text.

[2]Footnote text. Footnote text. Footnote text. Footnote text.

CHAPTER IV

EXAMPLE OF A TABLE AND A FIGURE

Table 4.1: Table captions belong above the table. Just some text to lengthen the title of the table beyond a single line.

Name	**Variable**	**Discretization**	**Step**
Radius	$r \in [a, R]$	$r_k = a + kdr, \quad k = 0, 1, 2, \ldots, K$	$dr = (R - a)/K$
Angle	$\theta \in [0, 2\pi)$	$\theta_l = ld\theta, \quad l = 0, 1, 2, \ldots, L - 1$	$d\theta = 2\pi/L$
Time	$t \in [0, T]$	$t_p = pdt, \quad p = 0, 1, 2, \ldots, P$	$dt = T/P$

To include figures side-by-side use the minipage environment.

See chap4.tex for the commands used to build the table and figure. As you add chapters, figures, and tables, the table of contents and lists will automatically be updated.

Figure 4.2 is an example of figures side-by-side, with Figure 4.2A to the left of 4.2B.

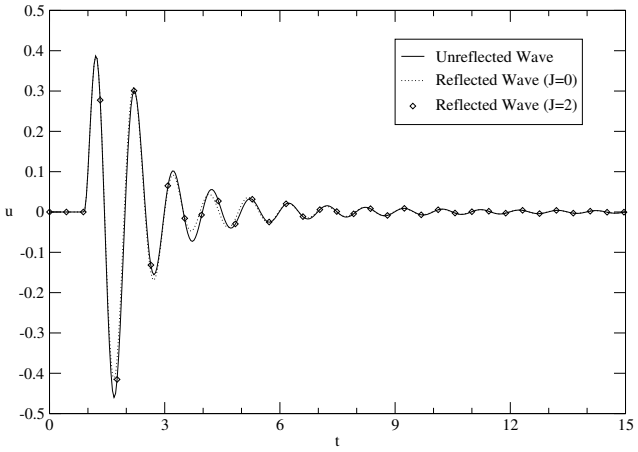


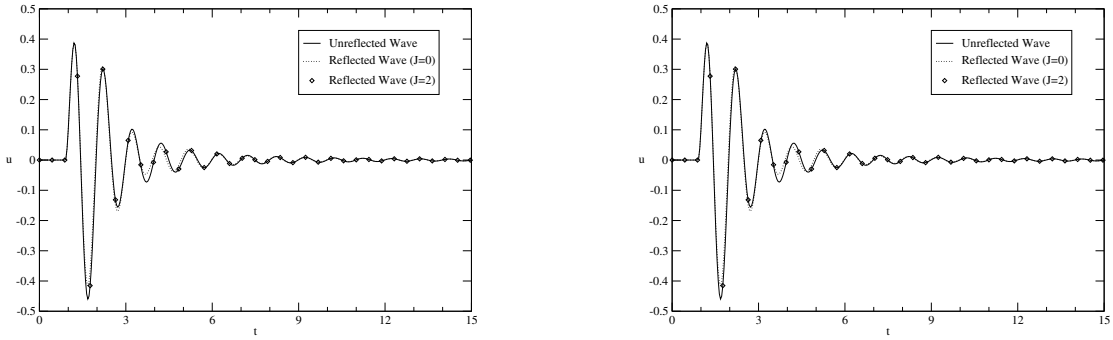
Figure 4.1: Figure labels go below the figure. Just some text to lengthen the title of the figure beyond a single line. Just some text to lengthen the title of the figure beyond a single line.

4.1 First Section

The text for the first section. The text for the first section. The text for the first section. The text for the first section. The text for the first section. The text for the first section. The text for the first section. The text for the first section.

4.2 Second Section

The text for the second section. The text for the second section. The text for the second section. The text for the second section. The text for the second section. The text for the second section. The text for the second section. The text for the second section.



4.2A: 4.2B:

Figure 4.2: Figures side-by side(a) part a (b) part b

4.2.1 First Subsection

The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section. The text for the first subsection of the second section.

4.3 Third Section

The text for the third section. The text for the third section. The text for the third section. The text for the third section. The text for the third section. The text for the third section. The text for the third section. The text for the third section.

4.4 Forth Section

The text for the forth section.

BIBLIOGRAPHY

[1] T. Hagstrom and S.I. Hariharan. A formulation of asymptotic and exact boundary conditions using local operators. *Applied Numerical Mathematics*, 27:403–416, 1998.

[2] ASM Handbook Committee. *Casting, ASM Handbook Volume 15*. ASM International, USA, 1988.

APPENDICES

APPENDIX A

APPENDIX TITLE GOES HERE

DO NOT SECTION OR SUBSECTION AN APPENDIX OR APPENDICS

We will recylcle Chapters 2 and 4 to make the following two appendices.

APPENDIX B

SECOND APPENDIX: THE TWO DIMENSIONAL WAVE EQUATION

DO NOT SECTION OR SUBSECTION AN APPENDIX OR APPENDICES

A series solution for the two-dimensional wave equation

$$\frac{1}{c^2}\frac{\partial^2 u}{\partial t^2} = \frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r} + \frac{1}{r^2}\frac{\partial^2 u}{\partial \theta^2} \tag{B.1}$$

for outgoing waves is

$$u = \sum_{n=0}^{\infty} a_n(\theta) f^n(r,t), \tag{B.2}$$

where

$$f^n = \sum_{k=0}^{\infty} r^{-k-\frac{1}{2}} f_k^n(ct-r). \tag{B.3}$$

You can reference a labeled equation by using the *ref* command. For example, you can show that equations (B.2) and (B.3) are a solution to equation (B.1). (see the file chap2.tex for the commands).

APPENDIX C

EXAMPLE OF A TABLE AND A FIGURE

DO NOT SECTION OR SUBSECTION AN APPENDIX OR APPENDICES

Table C.1: Table captions belong above the table

Name	**Variable**	**Discretization**	**Step**
Radius	$r \in [a, R]$	$r_k = a + kdr, \quad k = 0, 1, 2, \ldots, K$	$dr = (R - a)/K$
Angle	$\theta \in [0, 2\pi)$	$\theta_l = ld\theta, \quad l = 0, 1, 2, \ldots, L - 1$	$d\theta = 2\pi/L$
Time	$t \in [0, T]$	$t_p = pdt, \quad p = 0, 1, 2, \ldots, P$	$dt = T/P$

To include figures side-by-side use the minipage environment.

See chap4.tex for the commands used to build the table and figure. As you add chapters, figures, and tables, the table of contents and lists will automatically be updated.

Figure C.2 is an example of figures side-by-side, with Figure C.2A to the left of C.2B.

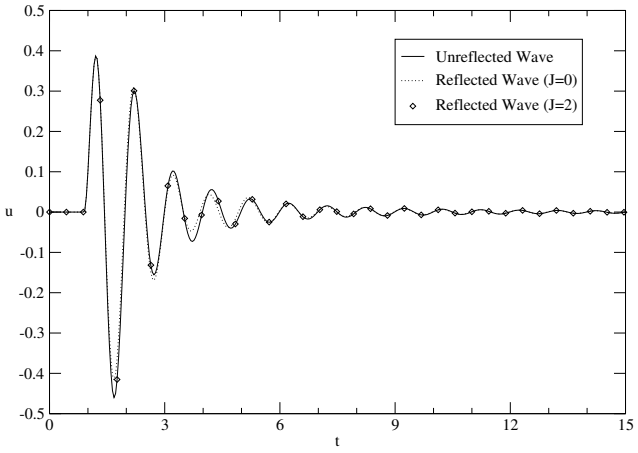
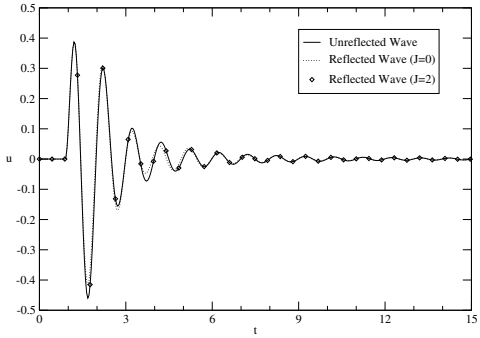
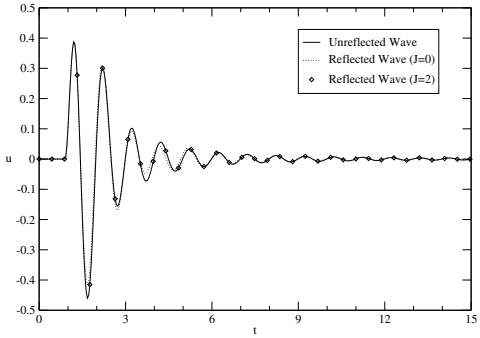


Figure C.1: Figure labels go below the figure



C.2A:



C.2B:

Figure C.2: Figures side-by side