THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

DYNAMICS OF FISH

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A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Mechanical Engineering
with honors in Mechanical Engineering

Reviewed and approved* by the following:

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Abstract

Some nonsense goes here.

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Acknowledgments

Chapter 1
Literature Review

1.1 Homogeneous Equilibrium Model

1.1.1 Brief outline of two-phase flows

Refer readers to Appendix A if they need it

1.1.2 Talk about HEM at length

1.2 Typical two-phase flow situations

Compare and contrast each application type in a clever way. For example, nuclear reactors and electronics are both expensive, but only electronics are feasible to change current cooling techniques. HVAC and Electronics are both feasible to change, but only advanced electronics justify the costs of optimizing and additively manufacturing designs. Possibly make a Venn diagram in which one side is "Feasible to Change" (politics) and the other side is "Justifiable Cost of Change" (economics)

1.2.1 Nuclear Reactors

1.2.2 Heating and Ventilation Systems

1.2.3 Advanced Electronics

Make it clear that electronics are the most suitable application for design tools, this necessitates some understanding of what I am trying to do (which I have not yet covered in this outline

1.3 Current optimization methods

1.3.1 Overview of engineering design tools

Advantages and disadvantages

1.3.2 Heat Sinks

Reference the Dede Paper(s)

1.3.3 Single-phase flows

Turbomachinery (Kirsch and Thole Paper)

1.3.4 Genetic Algorithms for other applications

1.3.5 Nick Larimer's and my previous work

Stress the simplicity of these models, show a figure and some results

1.4 Thesis goals and outlines

1. Genetic Algorithms
2. Make an actual design tool
3. Applied to advanced electronics
4. One dimensional single channel design optimization
5. Simple test cases representative of what might be seen and what might be useful in the cooling of advanced electronics
6. Water cooled (maybe try to use other coolants if possible)

Appendix A
Detailed Discussion of Two-Phase Flows

A.1 Introduction

When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

A.2 More Declaration

We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. –That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed, –That whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall seem most likely to effect their Safety and Happiness.

A.2.1 Some Subsection Title Here

Prudence, indeed, will dictate that Governments long established should not be changed for light and transient causes; and accordingly all experience hath shewn, that mankind

are more disposed to suffer, while evils are sufferable, than to right themselves by abolishing the forms to which they are accustomed. But when a long train of abuses and usurpations, pursuing invariably the same Object evinces a design to reduce them under absolute Despotism, it is their right, it is their duty, to throw off such Government, and to provide new Guards for their future security. –Such has been the patient sufferance of these Colonies; and such is now the necessity which constrains them to alter their former Systems of Government. The history of the present King of Great Britain [George III] is a history of repeated injuries and usurpations, all having in direct object the establishment of an absolute Tyranny over these States. To prove this, let Facts be submitted to a candid world.

Appendix B
Title of the Second Appendix

B.1 Introduction

When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

B.2 More Declaration

We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. –That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed, –That whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall seem most likely to effect their Safety and Happiness. Prudence, indeed, will dictate that Governments long established should not be changed for light and transient causes; and accordingly all experience hath shewn, that mankind are more disposed to suffer, while evils are sufferable, than to right themselves by abolishing the forms to which they are accustomed. But when a long train of abuses and usurpations, pursuing invariably the same Object evinces a design to reduce them under absolute Despotism, it is their right, it is their duty, to throw off such Government, and to provide new Guards for their

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Appendix C
Title of the Third Appendix

C.1 Introduction

When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

C.2 More Declaration

We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. –That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed, –That whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall seem most likely to effect their Safety and Happiness. Prudence, indeed, will dictate that Governments long established should not be changed for light and transient causes; and accordingly all experience hath shewn, that mankind are more disposed to suffer, while evils are sufferable, than to right themselves by abolishing the forms to which they are accustomed. But when a long train of abuses and usurpations, pursuing invariably the same Object evinces a design to reduce them under absolute Despotism, it is their right, it is their duty, to throw off such Government, and to provide new Guards for their

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Appendix D
Title of the Fourth Appendix

D.1 Introduction

When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

D.2 More Declaration

We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. –That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed, –That whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall seem most likely to effect their Safety and Happiness. Prudence, indeed, will dictate that Governments long established should not be changed for light and transient causes; and accordingly all experience hath shewn, that mankind are more disposed to suffer, while evils are sufferable, than to right themselves by abolishing the forms to which they are accustomed. But when a long train of abuses and usurpations, pursuing invariably the same Object evinces a design to reduce them under absolute Despotism, it is their right, it is their duty, to throw off such Government, and to provide new Guards for their

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Appendix E
Title of the Fifth Appendix

E.1 Introduction

When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

Some text.

```
      program chaos
c When a LS Fortran program has been compiled and linked into Mac
c application, all information written to the screen WRITE(6,...) or
c WRITE(*,...) appears in a standard Mac window, complete with basic
c menus.
      external fex, jac
      double precision atol, rtol, rwork, t, tout, h
      double precision ttotal, dtout
      dimension h(3), atol(3), rwork(70), iwork(23)
          character*8 tstart, tend
      neq = 3

          call time(tstart)
          write(6,*) "begin integration at  ", tstart
      write(6,*)

c --- Read in the total initial angular momentum.  The total angular
c     momentum H is always unity due to normalization.
          open(unit = 2, file = 'chaos.data', status = 'unknown')
      read(2,*) h(1), h(2), h(3)

c --- The integration begins at t = 0 and the values are printed at
c     every tout.  tout is incremented below.  ttotal is the length
c     of the entire integration.  The number of recorded values of
c     the integration is given by npoints.
      t = 0.0d0
      tout = 0.0d0
      write(6,*) 'Duration of integration interval, i.e., tfinal?'
      read(6,*) ttotal
      write(6,*)
      write(6,*) 'Number of points for trajectory plot?'
      read(6,*) npoints
      write(6,*)
      dtout = ttotal/dfloat(npoints)
      tout = tout + dtout

c --- Tolerance parameters used by lsoda.
      itol = 2
      rtol = 1.0d-9
      atol(1) = 1.0d-9
      atol(2) = 1.0d-9
```

```
      atol(3) = 1.0d-9

c --- Other parameters used by lsoda.  See below.
      itask = 1
      istate = 1
      iopt = 1
      lrw = 70
      liw = 23
      jt = 1

      do 11 kount = 5,10
         rwork(kount) = 0.0d0
         iwork(kount) = 0
  11  continue
      iwork(6) = 100000

          open(unit = 3, file = 'traj.dat', disp = 'keep',
     &      status = 'unknown')

c --- The actual integration begins here.  Loop on the value of iout.
      do 40 iout = 1, npoints

         call lsoda(fex,neq,h,t,tout,itol,rtol,atol,itask,istate,
     &              iopt,rwork,lrw,iwork,liw,jdum,jt)

c ------ Write the output to the file traj.dat.
         write(3,20) t, h(1), h(2), h(3)
  20     format(f9.1, 3e15.6)

         if (mod(tout,5000.0d0) .eq. 0.0d0) then
            write(6,*) tout
         end if

c ------ Check to see that things are going OK.
         if (istate .lt. 0) go to 80

c ------ Set the time at which the integration is next recorded and
c        continue the do-loop.
  40     tout = tout + dtout

      write(6,*) 'number of steps taken: ', iwork(11)
      write(6,*) 'number of f evaluations: ', iwork(12)
```

```
      write(6,*) 'number of Jacobian evaluations: ', iwork(13)
      write(6,*) 'method order last used: ', iwork(14)
      write(6,*) 'method last used (2 = stiff): ', iwork(19)
      write(6,*) 'value of t at last method switch: ', rwork(15)
      write(6,*)

          call time(tend)
          write(6,*) "end integration at  ", tend
      stop

c --- If there is an error, given by istate < 0, write the following.
   80 write(6,90) istate
   90 format(///22h error halt.. istate =,i3)

      stop
      end
```

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Vita

Nicholas A. Evich

The details of my childhood are inconsequential.