McKibben Webster Chapter 9 – Partial Solutions and Hints

MatLab – Exercise 9.1.1

i) Everything seems to be running properly. However, the help button doesn't seem to be working

ii) Still seems to be running fine.

iii) Comparing the two figures, it looks like i is faster than ii

iv) It seem that the larger k^2 is, the easier it is for the heat to disperse

v) My conjecture seems to be correct.

vi) Nuemann boundary conditions

   a. Runs fine
   b. Still runs fine
   c. Comparing the two figures, they look like they are similar in speed
   d. The troughs in the waves seem shallower when k^2 is larger
   e. My conjecture seems to be correct

vii) Summary the equation seems to depend on k^2, because the larger k^2 is, the more diluted the equation will be.

viii) Periodic boundary conditions

   a. Runs fine
   b. Still runs fine
   c. Comparing the two figures, they look like they are similar in speed
   d. The troughs in the waves seem shallower when k^2 is larger
   e. My conjecture seems to be correct

Matlab-Exercise 9.1.2

i) Runs fine, converges

ii) Runs fine, less convergence than k^2=.1

iii) Cos initial condition

   a. Converges to an arc
   b. Less convergence than k^2=.25
   c. Convergence seems to depend on k^2

iv) Step functions K^2 = .25 converges when k^2 is larger, does seem to depend on k^2

v) The larger the value of k^2, the greater the convergence

Matlab-Exercise 9.1.3

i) sin
   a. 0.5- Norm Difference vs. Time, Difference in parameters = 0
      Norm Difference between Initial Conditions = 0.4994
   b. Repeat (a)
      i. .25- Norm Difference vs. Time, Difference in parameters = 0
         Norm Difference between Initial Conditions = 0.2497
      ii. 0.1- Norm Difference vs. Time, Difference in parameters = 0
         Norm Difference between Initial Conditions = 0.9988
      iii. 0.01- Norm Difference vs. Time, Difference in parameters = 0
         Norm Difference between Initial Conditions = 0.009988
      iv. 0.005- Norm Difference vs. Time, Difference in parameters = 0
         Norm Difference between Initial Conditions = 0.004994
   c. Doesn't seem to depend on the initial condition
   d. Exp and step function
      i. Exp
         1. .5- Norm Difference vs. Time, Difference in parameters = 0
            Norm Difference between Initial Conditions = 0.48794
         2. Repeat (1)
            a. .25- Norm Difference vs. Time, Difference in parameters = 0
               Norm Difference between Initial Conditions = 0.24397
            b. 0.1- Norm Difference vs. Time, Difference in parameters = 0
               Norm Difference between Initial Conditions = 0.097588
            c. 0.01- Norm Difference vs. Time, Difference in parameters = 0
               Norm Difference between Initial Conditions = 0.0097588
            d. 0.005- Norm Difference vs. Time, Difference in parameters = 0
               Norm Difference between Initial Conditions = 0.0048794
         3. Doesn't seem to depend on initial conditions
      ii. Step
         1. .5- Norm Difference vs. Time, Difference in parameters = 0
            Norm Difference between Initial Conditions = 0.5
         2. Repeat (1)
            a. .25- Norm Difference vs. Time, Difference in parameters = 0
               Norm Difference between Initial Conditions = 0.25
            b. 0.1- Norm Difference vs. Time, Difference in parameters = 0
               Norm Difference between Initial Conditions = 0.1
            c. 0.01- Norm Difference vs. Time, Difference in parameters = 0
               Norm Difference between Initial Conditions = 0.01
            d. 0.005- Norm Difference vs. Time, Difference in parameters = 0
               Norm Difference between Initial Conditions = 0.005
         3. Doesn't seem to depend on initial conditions

Note: for this part I am using perturbation size .5

ii) Cos
   a. 0.4- Norm Difference vs. Time, Difference in parameters = 0.1
      Norm Difference between Initial Conditions = 0.99039
   b. Repeat (a)

i. .45- Norm Difference vs. Time, Difference in parameters = 0.05
Norm Difference between Initial Conditions = 0.99039
ii. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
Norm Difference between Initial Conditions = 0.99039
iii. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
Norm Difference between Initial Conditions = 0.99039
iv. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
Norm Difference between Initial Conditions = 0.99093

c. Doesn't seem to depend on initial conditions
d. Exp and step function
   i. Exp
      1. .4- Norm Difference vs. Time, Difference in parameters = 0.1
         Norm Difference between Initial Conditions = 0.48794
      2. Repeat (1)
         a. .45- Norm Difference vs. Time, Difference in parameters = 0.05
            Norm Difference between Initial Conditions = 0. 48794
         b. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
            Norm Difference between Initial Conditions = 0. 48794
         c. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
            Norm Difference between Initial Conditions = 0. 48794
         d. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
            Norm Difference between Initial Conditions = 0.48794
      3. Doesn't seem to depend on initial conditions
   ii. Step
      1. .4- Norm Difference vs. Time, Difference in parameters = 0.1
         Norm Difference between Initial Conditions = 0.5
      2. Repeat (1)
         a. .45- Norm Difference vs. Time, Difference in parameters = 0.05
            Norm Difference between Initial Conditions = 0.25
         b. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
            Norm Difference between Initial Conditions = 0.1
         c. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
            Norm Difference between Initial Conditions = 0.01
         d. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
            Norm Difference between Initial Conditions = 0.005
e. Doesn't seem to depend on initial conditions

iii) Exp
a. Diffusivity constant: 0.4- Norm Difference vs. Time, Difference in parameters = 0.1
   Perturbation size: 0.3- Norm Difference between Initial Conditions = 0.29276
b. Repeat (a)
   i. .45- Norm Difference vs. Time, Difference in parameters = 0.05
      .15- Norm Difference between Initial Conditions = 0.14638
   ii. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
      0.1- Norm Difference between Initial Conditions = 0.097588
   iii. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
      0.01- Norm Difference between Initial Conditions = 0.0097588
   iv. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
      0.005- Norm Difference between Initial Conditions = 0.0048794

c. Doesn't seem to depend on initial conditions
d. Cos and step function
    i. Cos
        1. .4- Norm Difference vs. Time, Difference in parameters = 0.1
           .3- Norm Difference between Initial Conditions = 0.59424
        2. Repeat (1)
            a. .45- Norm Difference vs. Time, Difference in parameters = 0.05
               .15- Norm Difference between Initial Conditions = 0. 29712
            b. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
               0.1- Norm Difference between Initial Conditions = 0.19808
            c. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
               0.01- Norm Difference between Initial Conditions = 0. 019808
            d. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
               0.005-Norm Difference between Initial Conditions = 0.0099039
        3. Doesn't seem to depend on initial conditions
    ii. Step
        1. .4- Norm Difference vs. Time, Difference in parameters = 0.1
           .3- Norm Difference between Initial Conditions = 0.3
        2. Repeat (1)
            a. .45- Norm Difference vs. Time, Difference in parameters = 0.05
               .15- Norm Difference between Initial Conditions = 0.15
            b. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
               0.1- Norm Difference between Initial Conditions = 0.1
            c. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
               0.01- Norm Difference between Initial Conditions = 0.01
            d. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
               0.005-Norm Difference between Initial Conditions = 0.005
e. Doesn't seem to depend on initial conditions

iv) Not the case

Matlab-Exercise 9.1.4

Note: L^2 button is actually L2

i) sin
    a. 0.5- Norm Difference vs. Time, Difference in parameters = 0
       Norm Difference between Initial Conditions = 0.5
    b. Repeat (a)
        i. .25- Norm Difference vs. Time, Difference in parameters = 0
           Norm Difference between Initial Conditions = 0.25
        ii. 0.1- Norm Difference vs. Time, Difference in parameters = 0
           Norm Difference between Initial Conditions = 0.1
        iii. 0.01- Norm Difference vs. Time, Difference in parameters = 0
           Norm Difference between Initial Conditions = 0.01
        iv. 0.005- Norm Difference vs. Time, Difference in parameters = 0
           Norm Difference between Initial Conditions = 0.005
    c. Doesn't seem to depend on the initial condition
    d. Exp and step function
        i. Exp

1. .5- Norm Difference vs. Time, Difference in parameters = 0
   Norm Difference between Initial Conditions = 0.17701
2. Repeat (1)
   a. .25- Norm Difference vs. Time, Difference in parameters = 0
      Norm Difference between Initial Conditions = 0.088505
   b. 0.1- Norm Difference vs. Time, Difference in parameters = 0
      Norm Difference between Initial Conditions = 0.035402
   c. 0.01- Norm Difference vs. Time, Difference in parameters = 0
      Norm Difference between Initial Conditions = 0.0035402
   d. 0.005- Norm Difference vs. Time, Difference in parameters = 0
      Norm Difference between Initial Conditions = 0.0017701
3. Doesn't seem to depend on initial conditions

ii. Step

1. .5- Norm Difference vs. Time, Difference in parameters = 0
   Norm Difference between Initial Conditions = 0.5
2. Repeat (1)
   a. .25- Norm Difference vs. Time, Difference in parameters = 0
      Norm Difference between Initial Conditions = 0.25
   b. 0.1- Norm Difference vs. Time, Difference in parameters = 0
      Norm Difference between Initial Conditions = 0.1
   c. 0.01- Norm Difference vs. Time, Difference in parameters = 0
      Norm Difference between Initial Conditions = 0.01
   d. 0.005- Norm Difference vs. Time, Difference in parameters = 0
      Norm Difference between Initial Conditions = 0.005
3. Doesn't seem to depend on initial conditions

Note: for this part I am using perturbation size .5

v) Cos

a. 0.4- Norm Difference vs. Time, Difference in parameters = 0.1
   Norm Difference between Initial Conditions = 0.86603
b. Repeat (a)
   i. .45- Norm Difference vs. Time, Difference in parameters = 0.05
      Norm Difference between Initial Conditions = 0. 86603
   ii. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
      Norm Difference between Initial Conditions = 0. 86603
   iii. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
      Norm Difference between Initial Conditions = 0. 86603
   iv. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
      Norm Difference between Initial Conditions = 0. 86603
c. Doesn't seem to depend on initial conditions
d. Exp and step function
   i. Exp
      1. .4- Norm Difference vs. Time, Difference in parameters = 0.1
         Norm Difference between Initial Conditions = 0.17701
      2. Repeat (1)
         a. .45- Norm Difference vs. Time, Difference in parameters = 0.05
            Norm Difference between Initial Conditions = 0. 17701
         b. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
            Norm Difference between Initial Conditions = 0. 17701

c. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
Norm Difference between Initial Conditions = 0. 17701
d. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
Norm Difference between Initial Conditions = 0. 17701

3. Doesn't seem to depend on initial conditions

ii. Step

1. .4- Norm Difference vs. Time, Difference in parameters = 0.1
Norm Difference between Initial Conditions = 0.5
2. Repeat (1)
a. .45- Norm Difference vs. Time, Difference in parameters = 0.05
Norm Difference between Initial Conditions = 0.5
b. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
Norm Difference between Initial Conditions = 0.5
c. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
Norm Difference between Initial Conditions = 0.5
d. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
Norm Difference between Initial Conditions = 0.5

e. Doesn't seem to depend on initial conditions

vi) Exp

a. Diffusivity constant: 0.4- Norm Difference vs. Time, Difference in parameters = 0.1
Perturbation size: 0.3- Norm Difference between Initial Conditions = 0.10621
b. Repeat (a)
i. .45- Norm Difference vs. Time, Difference in parameters = 0.05
.15- Norm Difference between Initial Conditions = 0.053103
ii. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
0.1- Norm Difference between Initial Conditions = 0.035402
iii. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
0.01- Norm Difference between Initial Conditions = 0.0035402
iv. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
0.005- Norm Difference between Initial Conditions = 0.0017701
c. Doesn't seem to depend on initial conditions
d. Cos and step function
i. Cos
1. .4- Norm Difference vs. Time, Difference in parameters = 0.1
.3- Norm Difference between Initial Conditions = 0.51926
2. Repeat (1)
a. .45- Norm Difference vs. Time, Difference in parameters = 0.05
.15- Norm Difference between Initial Conditions = 0. 25981
b. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
0.1- Norm Difference between Initial Conditions = 0.17321
c. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
0.01- Norm Difference between Initial Conditions = 0.017321
d. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
0.005-Norm Difference between Initial Conditions = 0.0086603
3. Doesn't seem to depend on initial conditions
ii. Step
1. .4- Norm Difference vs. Time, Difference in parameters = 0.1
.3- Norm Difference between Initial Conditions = 0.3

2. Repeat (1)
    a. .45- Norm Difference vs. Time, Difference in parameters = 0.05
       .15- Norm Difference between Initial Conditions = 0.15
    b. 0.55- Norm Difference vs. Time, Difference in parameters = 0.05
       0.1- Norm Difference between Initial Conditions = 0.1
    c. 0.48- Norm Difference vs. Time, Difference in parameters = 0.02
       0.01- Norm Difference between Initial Conditions = 0.01
    d. 0.51- Norm Difference vs. Time, Difference in parameters = 0.01
       0.005-Norm Difference between Initial Conditions = 0.005
    e. Doesn't seem to depend on initial conditions

ii. There is continuous dependence.

Matlab-Exercise 9.1.5

Note: Boundary Condition set to Dirichlet

i. Sin
    a. It seems lopsided at the beginning this could be because the nonhomogeneous part off sets things to one side
    b. Nonhomogeneousness flattens out on a higher plane
    c. $T_1 = .5$, $T_2 = 2$
        i. It just seems to converge to a convex line
        ii. Homogeneousness flattens out, but nonhomogeneousness just seems to slope up

ii. Exp
    a. Nonhomogeneousness arks upward
    b. Homogeneousness has a spike that flattens out, while nonhomogeneousness has a spike that flattens into a prabolla in the opposite direction
    c. $T_1 = .5$, $T_2 = 2$
        i. T_1 off sets the left side down and T_2 off sets the right side up
        ii. Homogeneousness flattens out while nonhomogeneousness slopes up

iii.
    a. Yes, it does seem that (i) tends to a steady-state temperature for large times
    b. Homogeneousness seems to tend to a stedy-state temperature much earlier than nonhomogeneousness
    c. Yes, it does seem that (ii) tends to a steady-state temperature for large times

d. Homogeneousness seems to tend to a stedy-state temperature earlier than nonhomogeneousness

MatLab-Exercise 9.1.6

i) Dirichlet

a. Runs fine

b. Runs fine

c. The heat seems to disperse much more slowly

d. It seems that the lower k^2 is, the slower the dispersion is. Which is the same as 9.1

e. The speed of the dispersion seems to be positively correlated to k^2

ii) Periodic

a. Runs fine

b. Runs fine

c. Seems to run faster with higher k^2

d. The higher k^2 is, the faster the heat dispersion, the same as 9.1

e. The higher k^2 is the faster the heat dispersion

iii) Neumann

a. Runs fine

b. Runs fine

c. Seems to run faster with higher k^2

d. The higher k^2 is, the faster the heat dispersion, the same as 9.1

e. The higher k^2 is the faster the heat dispersion

iv) The higher k^2 is, the faster the heat dispersion regardless of the boundary condition

MatLab-Exercise 9.1.7

i) Runs fine

a. Converges to the same function

ii) Runs fine

a. Yes the solution with BC periodic converged to the same function as (i)

iii) The bottom rises as the top falls

iv) They all converged to the same function. However, they all converged differently

MatLab-Exercise 9.1.8

Note: Perturb Parameters & Solve is actually Modify parameters & solve

i) Note: BC is Dirichet and k^2 = .5

   a. 0.5 - Norm Difference vs. Time Difference in Parameters = 0
      Norm Difference between Initial Conditions = 0.5
   b. Repeat
      i. 0.25 - Norm Difference vs. Time Difference in Parameters = 0
         Norm Difference between Initial Conditions = 0.25
      ii. 0.1 - Norm Difference vs. Time Difference in Parameters = 0
         Norm Difference between Initial Conditions = 0.1
      iii. 0.01 - Norm Difference vs. Time Difference in Parameters = 0
         Norm Difference between Initial Conditions = 0.01
      iv. 0.005 - Norm Difference vs. Time Difference in Parameters = 0
         Norm Difference between Initial Conditions = 0.005
   c. It doesn't seem to depend on the diffusivity constant
   d. Expo and step
      i. Expo
         1. 0.5 - Norm Difference vs. Time Difference in Parameters = 0
            Norm Difference between Initial Conditions = 0.099083
         2. Repeat
            a. 0.25 - Norm Difference vs. Time Difference in Parameters = 0
               Norm Difference between Initial Conditions = 0.049542
            b. 0.1 - Norm Difference vs. Time Difference in Parameters = 0
               Norm Difference between Initial Conditions = 0.019817
            c. 0.01 - Norm Difference vs. Time Difference in Parameters = 0
               Norm Difference between Initial Conditions = 0.0019817
            d. 0.005 - Norm Difference vs. Time Difference in Parameters = 0
               Norm Difference between Initial Conditions = 0.00099086
         3. It seems to depend on the diffusivity constant
      ii. Step
         1. 0.5 - Norm Difference vs. Time Difference in Parameters = 0
            Norm Difference between Initial Conditions = 0.5
         2. Repeat
            a. 0.25 - Norm Difference vs. Time Difference in Parameters = 0
               Norm Difference between Initial Conditions = 0.25
            b. 0.1 - Norm Difference vs. Time Difference in Parameters = 0
               Norm Difference between Initial Conditions = 0.1
            c. 0.01 - Norm Difference vs. Time Difference in Parameters = 0
               Norm Difference between Initial Conditions = 0.01
            d. 0.005 - Norm Difference vs. Time Difference in Parameters = 0
               Norm Difference between Initial Conditions = 0.005
         3. It seems to depend on the diffusivity constant

ii) BC Neumann, initial condition Cos

a. 0.5 - Norm Difference vs. Time Difference in Parameters = 0.1
   Norm Difference between Initial Conditions = 1.4142
b. Repeat
   i. 0.45 - Norm Difference vs. Time Difference in Parameters = 0.05
      Norm Difference between Initial Conditions = 1.4142
   ii. 0.55 - Norm Difference vs. Time Difference in Parameters = 0.05
      Norm Difference between Initial Conditions = 1.4142
   iii. 0.48 - Norm Difference vs. Time Difference in Parameters = 0.02
      Norm Difference between Initial Conditions = 1.4142
   iv. 0.51 - Norm Difference vs. Time Difference in Parameters = 0.01
      Norm Difference between Initial Conditions = 1.4142
c. It seems to depend on the diffusivity constant
d. Expo and step
   i. Expo
      1. 0.4 - Norm Difference vs. Time Difference in Parameters = 0.1
         Norm Difference between Initial Conditions = 0.099083
      2. Repeat
         a. 0.45 - Norm Difference vs. Time Difference in Parameters = 0.05
            Norm Difference between Initial Conditions = 0.099083
         b. 0.55 - Norm Difference vs. Time Difference in Parameters = 0.05
            Norm Difference between Initial Conditions = 0.099086
         c. 0.48 - Norm Difference vs. Time Difference in Parameters = 0.02
            Norm Difference between Initial Conditions = 0.099086
         d. 0.51 - Norm Difference vs. Time Difference in Parameters = 0.01
            Norm Difference between Initial Conditions = 0.099083
      3. It seems to depend entirely on the diffusivity constant
   ii. Step
      1. 0.4 - Norm Difference vs. Time Difference in Parameters = 0.1
         Norm Difference between Initial Conditions = 0.5
      2. Repeat
         a. 0.45 - Norm Difference vs. Time Difference in Parameters = 0.05
            Norm Difference between Initial Conditions = 0.25
         b. 0.55 - Norm Difference vs. Time Difference in Parameters = 0.05
            Norm Difference between Initial Conditions = 0.1
         c. 0.48 - Norm Difference vs. Time Difference in Parameters = 0.02
            Norm Difference between Initial Conditions = 0.01
         d. 0.51 - Norm Difference vs. Time Difference in Parameters = 0.01
            Norm Difference between Initial Conditions = 0.005
      3. It seems to depend on the diffusivity constant

iii) BC Periodic, initial condition expo
a. 0.4 - Norm Difference vs. Time Difference in Parameters = 0.1
   0.3 - Norm Difference between Initial Conditions = 3.8048
b. Repeat
   i. 0.45 - Norm Difference vs. Time Difference in Parameters = 0.05
      0.25 - Norm Difference between Initial Conditions = 3.1707
   ii. 0.55 - Norm Difference vs. Time Difference in Parameters = 0.05
      0.1 - Norm Difference between Initial Conditions = 1.2683
   iii. 0.48 - Norm Difference vs. Time Difference in Parameters = 0.02

0.01 - Norm Difference between Initial Conditions = 0.1283

iv. 0.51 - Norm Difference vs. Time Difference in Parameters = 0.01
0.005 - Norm Difference between Initial Conditions = 0.063413

c. It doesn't seem to depend on the diffusivity constant

d. Cos and step

i. Cos

1. 0.4 - Norm Difference vs. Time Difference in Parameters = 0.1
0.3 - Norm Difference between Initial Conditions = 54.3058

2. Repeat

a. 0.45 - Norm Difference vs. Time Difference in Parameters = 0.05
0.25 - Norm Difference between Initial Conditions = 45.2548

b. 0.55 - Norm Difference vs. Time Difference in Parameters = 0.05
0.1 - Norm Difference between Initial Conditions = 18.1019

c. 0.48 - Norm Difference vs. Time Difference in Parameters = 0.02
0.01 - Norm Difference between Initial Conditions = 1.8102

d. 0.51 - Norm Difference vs. Time Difference in Parameters = 0.01
0.005 - Norm Difference between Initial Conditions = 0.9051

3. It seems to depend heavily on the perturbation size

ii. Step

1. 0.4 - Norm Difference vs. Time Difference in Parameters = 0.1
0.3 - Norm Difference between Initial Conditions = 18.6

2. Repeat

a. 0.45 - Norm Difference vs. Time Difference in Parameters = 0.05
0.25 - Norm Difference between Initial Conditions = 15.5

b. 0.55 - Norm Difference vs. Time Difference in Parameters = 0.05
0.1 - Norm Difference between Initial Conditions = 6.2

c. 0.48 - Norm Difference vs. Time Difference in Parameters = 0.02
0.01 - Norm Difference between Initial Conditions = 0.62

d. 0.51 - Norm Difference vs. Time Difference in Parameters = 0.01
0.005 - Norm Difference between Initial Conditions = 0.31

3. It seems to depend on the perturbation size

iv) In 2d the difference between the initial conditions, and the perturbations is much greater than in 1d

MatLab-Exercise 9.2.1

i) Heat was less wavy

a. Convergence happens much faster

b. The smaller α is, the slower the convergence seems to be

c. No convergence, possible stability

d. The lower β is, the slower convergence seems to be

e. Expo

i. Convergence happens much faster
ii. The smaller α is, the slower the convergence seems to be
iii. No convergence, possible stability
iv. The lower β is, the slower convergence seems to be

ii) Nuemann, slower convergence
   a. Convergence happens much faster
   b. The smaller α is, the slower the convergence seems to be
   c. No convergence, possible stability
   d. The lower β is, the slower convergence seems to be
   e. Expo
      i. Convergence happens much faster
      ii. The smaller α is, the slower the convergence seems to be
      iii. No convergence, possible stability
      iv. The lower β is, the slower convergence seems to be

iii) Periodic, less wavy
   a. Convergence happens much faster
   b. The smaller α is, the slower the convergence seems to be
   c. No convergence, possible stability
   d. The lower β is, the slower convergence seems to be
   e. Expo
      i. Convergence happens much faster
      ii. The smaller α is, the slower the convergence seems to be
      iii. No convergence, possible stability
      iv. The lower β is, the slower convergence seems to be

iv) The α and β seems to be able to tweak the speed of conversion

v) (i) the observations didn't differ
   a. Convergence happens much faster
   b. The smaller α is, the slower the convergence seems to be
   c. No convergence, possible stability

d. The lower β is, the slower convergence seems to be

MatLab – Exercise 9.2.2

i) Heat disperses more quickly, sine, Dirichlet
   a. Now long-term behavior is similar to the heat equation
   b. There is almost no convergence, this happens with very small k^2 in the heat equation
   c. Expo, Dirichlet
      i. Long=term behavior is the similar as the heat equation when α = 0
      ii. There is almost no convergence, with β = 0, this happens in the heat equation when k^2 is very small

ii) Fluid seepage converges slower than the heat equation under these conditions, Cos, Nuemann
   a. Now long-term behavior is similar to the heat equation
   b. There is almost no convergence, this happens with very small k^2 in the heat equation
   c. Expo, Nuemann
      i. Long=term behavior is the similar as the heat equation when α = 0
      ii. There is almost no convergence, with β = 0, this happens in the heat equation when k^2 is very small

iii) Periodic, Cos, Fluid seepage converges slower than the heat equation
   a. Now long-term behavior is similar to the heat equation
   b. There is almost no convergence, this happens with very small k^2 in the heat equation
   c. Expo, Periodic
      i. Long=term behavior is the similar as the heat equation when α = 0
      ii. There is almost no convergence, with β = 0, this happens in the heat equation when k^2 is very small

iv) With α very small or 0, and/or β very large, the fluid seepage equation can converge similarly as the heat equation, with (k^2) = 1. With k^2 very small in the heat equation convergence is similar to β very small or 0 in the fluid seepage equation.

v) Periodic, step, heat equation disperses more quickly
   a. Now long-term behavior is similar to the heat equation
   b. There is almost no convergence, this happens with very small k^2 in the heat equation
   c. Expo, Periodic
      i. Long=term behavior is the similar as the heat equation when α = 0
      ii. There is almost no convergence, with β = 0, this happens in the heat equation when k^2 is very small
      iii. This is the same as the other condition and compare to the heat equation.

MatLab – Exercise 9.2.3

i) Sine

a. 0.5 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.5
b. Repeat
   i. 0.25 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 0.25
   ii. 0.1 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 0.1
   iii. 0.01 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 0.01
   iv. 0.005 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 0.005
c. Seems to be dependent on initial conditions
d. Expo, step
   i. Expo
      1. 0.5 - Norm Different vs. Time, Different Parameters = 0
         Norm Different between Initial Conditions = 0.11129
      2. Repeat
         a. 0.25 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.055645
         b. 0.1 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.022258
         c. 0.01 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.0022258
         d. 0.005 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.0011129
      3. Seems to be dependent on initial conditions
   ii. Step
      1. 0.5 - Norm Different vs. Time, Different Parameters = 0
         Norm Different between Initial Conditions = 0.5
      2. Repeat
         e. 0.25 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.25
         f. 0.1 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.1
         g. 0.01 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.01
         h. 0.005 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.005
      3. Seems to be dependent on initial conditions
e. The fluid seepage equation seems to correspond with the heat equation

ii) Cos
a. 1.1 - Norm Different vs. Time, Different Parameters = 0.1

Norm Different between Initial Conditions = 0

b. Repeat with α values
    v. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
        Norm Different between Initial Conditions = 0
    vi. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
        Norm Different between Initial Conditions = 0.
    vii. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
        Norm Different between Initial Conditions = 0
c. Seems to be dependent on initial conditions
d. Repeat with β values
    i. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
        Norm Different between Initial Conditions = 0
    ii. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
        Norm Different between Initial Conditions = 0.
    iii. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
        Norm Different between Initial Conditions = 0
    iv. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
        Norm Different between Initial Conditions = 0
e. Expo and step
    i. Expo
        1. 1.1 - Norm Different vs. Time, Different Parameters = 0.1
            Norm Different between Initial Conditions = 0
        2. Repeat for α values
            a. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
                Norm Different between Initial Conditions = 0
            b. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
                Norm Different between Initial Conditions = 0
            c. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
                Norm Different between Initial Conditions = 0
        3. Seems to be dependent on initial conditions
        4. Repeat for β values
            a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
                Norm Different between Initial Conditions = 0
            d. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
                Norm Different between Initial Conditions = 0
            e. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
                Norm Different between Initial Conditions = 0
            f. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
                Norm Different between Initial Conditions = 0
        5. Seems to be dependent on initial conditions
    ii. Step
        1. 1.1 - Norm Different vs. Time, Different Parameters = 0.1

Norm Different between Initial Conditions = 0

2. Repeat for α values
    a. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    b. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
       Norm Different between Initial Conditions = 0
    c. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
3. Seems to be dependent on initial conditions
4. Repeat for β values
    a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    b. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    c. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
    d. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
5. Seems to be dependent on initial conditions

f. Still seems to depend on the initial conditions

iii) Cos
- a. Yes difference is small
- b. Repeat for values of α
    - i. α = .9 the difference seems small
    - ii. α = .98 the difference seems small
    - iii. α = 1.01 the difference seems small
- c. changing α does not seem to change the dependence on the initial conditions
- d. Repeat for values of β
    - i. β = 2.1 the difference seems small
    - ii. β = 1.9 the difference seems small
    - iii. β = 1.99 the difference seems small
    - iv. β = 2.01 the difference seems small
- e. Still seems to depend on initial conditions
- f. Still seems to depend on initial conditions with different perturbation sizes.

iv) In 9.3, there was a dependence on 2 variables, the initial conditions and k^2. While here, the dependence seems to be on initial conditions, initial conditions, α, and β.

v) Expo and step
- a. Expo
    - i. 0.01 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0.0011129
    - ii. 0.001 - Norm Different vs. Time, Different Parameters = 0.001
      Norm Different between Initial Conditions = 0.0011129

iii. There seems to be a sensitivity to α being very small

b. Step

i. There seems to be no difference

ii. There seems to be no difference

iii. There seems to be a sensitivity to α being very small

MatLab – Exercise 9.2.4

i. BC Dirichlet, converges slower than the Heat Equation
   a. Similar convergence to Heat Equation with α = 0
   b. The smaller α, the faster convergence is
   c. Little or no convergence with β = 0
   d. The smaller β, the slower convergence
   e. Expo convergens is slower than the Heat Equation
      1. Similar convergence to Heat Equation with α = 0
      2. The smaller α, the faster convergence is
      3. Little or no convergence with β = 0
      4. The smaller β, the slower convergence

ii. BC Nuemann, converges slower than the Heat Equation
   a. Similar convergence to Heat Equation with α = 0
   b. The smaller α, the faster convergence is, same as (i)(b)
   c. Little or no convergence with β = 0, same as (i)(c)
   d. The smaller β, the slower convergence, same as (i)(d)
   e. Expo convergence is slower than the Heat Equation
      1. Similar convergence to Heat Equation with α = 0
      2. The smaller α, the faster convergence is, same as (i)(b)
      3. Little or no convergence with β = 0, same as (i)(c)
      4. The smaller β, the slower convergence, same as (i)(d)

iii. BC Periodic, converges slower than the Heat Equation
   a. Similar convergence to Heat Equation with α = 0
   b. The smaller α, the faster convergence is
   c. Little or no convergence with β = 0
   d. The smaller β, the slower convergence
   e. Expo convergens is slower than the Heat Equation
      1. Similar convergence to Heat Equation with α = 0
      2. The smaller α, the faster convergence is
      3. Little or no convergence with β = 0
      4. The smaller β, the slower convergence

iv. The evolution model seems to be similar to Explore 9.9

v. Step, no changes converges slower than the Heat Equation
   a. Similar convergence to Heat Equation with α = 0

b. The smaller α, the faster convergence is
c. Little or no convergence with β = 0
d. The smaller β, the slower convergence

MatLab – Exercise 9.2.5

i. BC Dirichlet, fluid disperses moderately
    a. When α = 0, convergence is the same as the Heat Equation
    b. Seems a little slower
    c. Converges faster than (b), and is similar to the Heat Equation
    d. Expo, fluid disperses moderately
        1. When α = 0, convergence is the same as the Heat Equation
        2. Seems a little slower
        3. Converges faster than (2), and is similar to the Heat Equation
ii. BC Nuemann, fluid disperses moderately
    a. When α = 0, convergence is the same as the Heat Equation
    b. Seems a little slower
    c. Converges faster than (b), and is similar to the Heat Equation
    e. Expo, fluid disperses moderately
        1. When α = 0, convergence is the same as the Heat Equation
        2. Seems a little slower
        3. Converges faster than (2), and is similar to the Heat Equation
ii. BC Periodic, fluid disperses moderately
    a. When α = 0, convergence is the same as the Heat Equation
    b. Seems a little slower
    c. Converges faster than (b), and is similar to the Heat Equation
    d. Expo, fluid disperses moderately
        1. When α = 0, convergence is the same as the Heat Equation
        2. Seems a little slower
        3. Converges faster than (2), and is similar to the Heat Equation
iii. B seems to be the dominant variable, over α
iv. Step, fluid disperses moderately
    e. When α = 0, convergence is the same as the Heat Equation
    f. Seems a little slower
    g. Converges faster than (b), and is similar to the Heat Equation

MatLab – Exercise 9.2.6

vi) Sine

a. 0.5 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.5
b. Repeat
   viii. 0.25 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 0.25
   ix. 0.1 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 0.1
   x. 0.01 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 0.01
   xi. 0.005 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 0.005
c. Seems to be dependent on initial conditions
d. Expo, step
   i. Expo
      1. 0.5 - Norm Different vs. Time, Different Parameters = 0
         Norm Different between Initial Conditions = 0.099083
      2. Repeat
         a. 0.25 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.049542
         b. 0.1 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.019817
         c. 0.01 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.0019817
         d. 0.005 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.00099083
      3. Seems to be dependent on initial conditions
   ii. Step
      1. 0.5 - Norm Different vs. Time, Different Parameters = 0
         Norm Different between Initial Conditions = 0.5
      2. Repeat
         e. 0.25 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.25
         f. 0.1 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.1
         g. 0.01 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.01
         h. 0.005 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.005
      3. Seems to be dependent on initial conditions
e. The fluid seepage equation seems to correspond with the heat equation

vii) Cos

a. 1.1 - Norm Different vs. Time, Different Parameters = 0.1

Norm Different between Initial Conditions = 0

b. Repeat with α values
    xii. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
        Norm Different between Initial Conditions = 0
    xiii. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
        Norm Different between Initial Conditions = 0.
    xiv. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
        Norm Different between Initial Conditions = 0
c. Seems to be dependent on initial conditions
d. Repeat with β values
    i. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
        Norm Different between Initial Conditions = 0
    ii. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
        Norm Different between Initial Conditions = 0.
    iii. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
        Norm Different between Initial Conditions = 0
    iv. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
        Norm Different between Initial Conditions = 0
e. Expo and step
    i. Expo
        1. 1.1 - Norm Different vs. Time, Different Parameters = 0.1
            Norm Different between Initial Conditions = 0
        2. Repeat for α values
            a. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
                Norm Different between Initial Conditions = 0
            b. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
                Norm Different between Initial Conditions = 0
            c. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
                Norm Different between Initial Conditions = 0
        3. Seems to be dependent on initial conditions
        4. Repeat for β values
            a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
                Norm Different between Initial Conditions = 0
            d. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
                Norm Different between Initial Conditions = 0
            e. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
                Norm Different between Initial Conditions = 0
            f. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
                Norm Different between Initial Conditions = 0
        5. Seems to be dependent on initial conditions
    ii. Step
        1. 1.1 - Norm Different vs. Time, Different Parameters = 0.1

Norm Different between Initial Conditions = 0

2. Repeat for α values
    a. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    b. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
       Norm Different between Initial Conditions = 0
    c. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
3. Seems to be dependent on initial conditions
4. Repeat for β values
    a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    b. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    c. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
    d. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
5. Seems to be dependent on initial conditions

f. Still seems to depend on the initial conditions

viii) Cos

a. Yes difference is small
b. Repeat for values of α
    i. α = .9 the difference seems small
    ii. α = .98 the difference seems small
    iii. α = 1.01 the difference seems small
c. changing α does not seem to change the dependence on the initial conditions
d. Repeat for values of β
    i. β = 2.1 the difference seems small
    ii. β = 1.9 the difference seems small
    iii. β = 1.99 the difference seems small
    iv. β = 2.01 the difference seems small
e. Still seems to depend on initial conditions
f. Still seems to depend on initial conditions with different perturbation sizes.

ix) In 9.3, there was a dependence on 2 variables, the initial conditions and k^2. While here, the dependence seems to be on initial conditions, initial conditions, α, and β.

x) Expo and step

a. Expo
    i. 0.01 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0.0011129
    ii. 0.001 - Norm Different vs. Time, Different Parameters = 0.001
       Norm Different between Initial Conditions = 0.0011129

iii. There seems to be a sensitivity to α being very small

b. Step
   i. There seems to be no difference
   ii. There seems to be no difference
   iii. There seems to be a sensitivity to α being very small

MatLab – Exercise 9.2.7

i. Nuemann, cos. Convergence seems similar to the fluid seepage equation, may be a little slower.
   a. Glitch
   b. The smaller α, the less the equation converges
   c. Little or no convergence
   d. The smaller β, the slower convergence
   e. Expo, convergence seems similar to the fluid seepage equation, may be a little slower
      i. Glitch
      ii. The smaller α, the less the equation converges
      iii. Little or no convergence
      iv. The smaller β, the slower convergence

ii. Periodic, cos. Convergence seems similar to the fluid seepage equation, may be a little slower.
   a. Glitch
   b. The smaller α, the less the equation converges
   c. Little or no convergence
   d. The smaller β, the slower convergence
   e. Expo, convergence seems similar to the fluid seepage equation, may be a little slower
      i. Glitch
      ii. The smaller α, the less the equation converges
      iii. Little or no convergence
      iv. The smaller β, the slower convergence

iii. B seems to be the dominant variable, and it seems to be similar to the fluid seepage equation.

iv. Step, convergence seems similar to the fluid seepage equation, may be a little slower.
   a. Glitch
   b. The smaller α, the less the equation converges
   c. Little or no convergence
   d. The smaller β, the slower convergence

MatLab – Exercise 9.2.8

1. Nuemann, cos, relatively slow convergence, slower than fluid seepage equation
    a. Glitch
    b. Little or no convergence
    c. Expo , relatively slow convergence, slower than fluid seepage equation
        i. Glitch
        ii. Little or no convergence
2. Periodic, cos , relatively slow convergence, slower than fluid seepage equation
    a. Glitch
    b. Little or no convergence
    c. Expo , relatively slow convergence, slower than fluid seepage equation
        i. Glitch
        ii. Little or no convergence
3. The smaller α, the faster convergence, and the smaller β, the slower convergence. With β being the dominant variable. Similar to Explore! 9.9.
4. Periodic, step, relatively slow convergence, slower than fluid seepage equation
    a. Glitch
    b. Little or no convergence
    c. No changes need to be made to (3)

MatLab – Exercise 9.2.9

xi) Neumann, cos
    a. 0.5 - Norm Different vs. Time, Different Parameters = 0
        Norm Different between Initial Conditions = 0.5
    b. Repeat
        xv. 0.25 - Norm Different vs. Time, Different Parameters = 0
            Norm Different between Initial Conditions = 0.25

xvi. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.1

xvii. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.01

xviii. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.005

c. Seems to be dependent on initial conditions

d. Expo, step

i. Expo

1. 0.5 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.099083

2. Repeat

a. 0.25 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.049542

b. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.019817

c. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.0019817

d. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.00099083

3. Seems to be dependent on initial conditions

ii. Step

1. 0.5 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.5

2. Repeat

e. 0.25 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.25

f. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.1

g. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.01

h. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.005

3. Seems to be dependent on initial conditions

e. The fluid seepage equation seems to correspond with the heat equation

xii) Cos

a. 1.1 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0

b. Repeat with α values

xix. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0

xx. 0.98 - Norm Different vs. Time, Different Parameters = 0.02

Norm Different between Initial Conditions = 0.

xxi. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
Norm Different between Initial Conditions = 0

c. Seems to be dependent on initial conditions
d. Repeat with β values
    i. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
    Norm Different between Initial Conditions = 0
    ii. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
    Norm Different between Initial Conditions = 0.
    iii. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
    Norm Different between Initial Conditions = 0
    iv. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
    Norm Different between Initial Conditions = 0
e. Expo and step
    i. Expo
        1. 1.1 - Norm Different vs. Time, Different Parameters = 0.1
        Norm Different between Initial Conditions = 0
        2. Repeat for α values
            a. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
            Norm Different between Initial Conditions = 0
            b. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
            Norm Different between Initial Conditions = 0
            c. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
            Norm Different between Initial Conditions = 0
        3. Seems to be dependent on initial conditions
        4. Repeat for β values
            a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
            Norm Different between Initial Conditions = 0
            d. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
            Norm Different between Initial Conditions = 0
            e. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
            Norm Different between Initial Conditions = 0
            f. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
            Norm Different between Initial Conditions = 0
        5. Seems to be dependent on initial conditions
    ii. Step
        1. 1.1 - Norm Different vs. Time, Different Parameters = 0.1
        Norm Different between Initial Conditions = 0
        2. Repeat for α values
            a. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
            Norm Different between Initial Conditions = 0
            b. 0.98 - Norm Different vs. Time, Different Parameters = 0.02

Norm Different between Initial Conditions = 0

c. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
Norm Different between Initial Conditions = 0

3. Seems to be dependent on initial conditions
4. Repeat for β values
    a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
    Norm Different between Initial Conditions = 0
    b. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
    Norm Different between Initial Conditions = 0
    c. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
    Norm Different between Initial Conditions = 0
    d. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
    Norm Different between Initial Conditions = 0
5. Seems to be dependent on initial conditions

f. Still seems to depend on the initial conditions

xiii) Cos

a. Yes difference is small
b. Repeat for values of α
    i. α = .9 the difference seems small
    ii. α = .98 the difference seems small
    iii. α = 1.01 the difference seems small
c. changing α does not seem to change the dependence on the initial conditions
d. Repeat for values of β
    i. β = 2.1 the difference seems small
    ii. β = 1.9 the difference seems small
    iii. β = 1.99 the difference seems small
    iv. β = 2.01 the difference seems small
e. Still seems to depend on initial conditions
f. Still seems to depend on initial conditions with different perturbation sizes.

MatLab – Exercise 9.2.10

i. Nuemann, cos, convergence is similar to the 2D fluid seepage equation, maybe a little slower
    a. Glitch
    b. The smaller α is, the faster convergence seems to be
    c. Little or no convergence
    d. The smaller β is, the slower convergence
    e. Expo
        i. Glitch
        ii. The smaller α is, the faster convergence seems to be

iii. Little or no convergence
iv. The smaller β is, the slower convergence

ii. Periodic, cos, cos, convergence is similar to the 2D fluid seepage equation, maybe a little slower
    a. Glitch
    b. The smaller α is, the faster convergence seems to be
    c. Little or no convergence
    d. The smaller β is, the slower convergence
    e. Expo
        i. Glitch
        ii. The smaller α is, the faster convergence seems to be
        iii. Little or no convergence
        iv. The smaller β is, the slower convergence
iii. B is the dominant variable, similar to Explore! 9.9
iv. Step, convergence is similar to the 2D fluid seepage equation, maybe a little slower
    a. Glitch
    b. The smaller α is, the faster convergence seems to be
    c. Little or no convergence
    d. The smaller β is, the slower convergence
    e. No changes to (iii) are needed

MatLab – Exercise 9.2.11

i. No sine initial condition option
    a. No sine initial condition option
    b. No sine initial condition option
    c. Expo, convergence is similar to the heat equation, but much slower
        i. Glitch
        ii. Little or no convergence
ii. Periodic, cos convergence is similar to the heat equation, but slower
    a. Glitch
    b. Little or no convergence
    c. Expo, convergence is similar to the heat equation, but much slower
        i. Glitch
        ii. Little or no convergence
iii. Summary is the same as Explore! 9.15
iv. Step, convergence is similar to the heat equation, but much slower
    a. Glitch

b. Little or no convergence
c. No difference in observations

MatLab – Exercise 9.2.12

xiv) Cos

a. 0.5 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 1.4142
b. Repeat
   xxii. 0.25 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.70711
   xxiii. 0.1 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.28284
   xxiv. 0.01 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.028284
   xxv. 0.005 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.014142
c. Seems to be dependent on initial conditions
d. Expo, step
   i. Expo
      1. 0.5 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 0.099083
      2. Repeat
         a. 0.25 - Norm Different vs. Time, Different Parameters = 0
         Norm Different between Initial Conditions = 0.049542
         b. 0.1 - Norm Different vs. Time, Different Parameters = 0
         Norm Different between Initial Conditions = 0.019817
         c. 0.01 - Norm Different vs. Time, Different Parameters = 0
         Norm Different between Initial Conditions = 0.0019817
         d. 0.005 - Norm Different vs. Time, Different Parameters = 0
         Norm Different between Initial Conditions = 0.00099083
      3. Seems to be dependent on initial conditions
   ii. Step
      1. 0.5 - Norm Different vs. Time, Different Parameters = 0
      Norm Different between Initial Conditions = 31
      2. Repeat

e. 0.25 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 15.5
f. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 6.2
g. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.62
h. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.31
3. Seems to be dependent on initial conditions

e. The fluid seepage equation seems to correspond with the heat equation

xv) Cos

a. 1.1 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0
b. Repeat with α values
xxvi. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0
xxvii. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
Norm Different between Initial Conditions = 0.
xxviii. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
Norm Different between Initial Conditions = 0
c. Seems to be dependent on initial conditions
d. Repeat with β values
i. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0
ii. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0.
iii. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
Norm Different between Initial Conditions = 0
iv. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
Norm Different between Initial Conditions = 0
e. Expo and step
i. Expo
1. 1.1 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0
2. Repeat for α values
a. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0
b. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
Norm Different between Initial Conditions = 0
c. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
Norm Different between Initial Conditions = 0
3. Seems to be dependent on initial conditions

4. Repeat for β values
    a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    d. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    e. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
    f. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
5. Seems to be dependent on initial conditions

ii. Step

1. 1.1 - Norm Different vs. Time, Different Parameters = 0.1
   Norm Different between Initial Conditions = 0
2. Repeat for α values
    a. 0.9 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    b. 0.98 - Norm Different vs. Time, Different Parameters = 0.02
       Norm Different between Initial Conditions = 0
    c. 1.01 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
3. Seems to be dependent on initial conditions
4. Repeat for β values
    a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    b. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
       Norm Different between Initial Conditions = 0
    c. 1.99 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
    d. 2.01 - Norm Different vs. Time, Different Parameters = 0.01
       Norm Different between Initial Conditions = 0
5. Seems to be dependent on initial conditions

f. Still seems to depend on the initial conditions

xvi) Cos

a. Yes difference is small
b. Repeat for values of α
    i. α = .9 the difference seems small
    ii. α = .98 the difference seems small
    iii. α = 1.01 the difference seems small
c. changing α does not seem to change the dependence on the initial conditions
d. Repeat for values of β
    i. β = 2.1 the difference seems small
    ii. β = 1.9 the difference seems small

iii. β = 1.99 the difference seems small
iv. β = 2.01 the difference seems small

e. Still seems to depend on initial conditions
f. Still seems to depend on initial conditions with different perturbation sizes.

xvii) Can't do this exercise

MatLab – Exercise 9.3.1

i) Dirichlet sine, runs
   a. Runs
   b. Motion is slower
   c. Runs
   d. The smaller c^2, the slower the motion
   e. The larger c^2, the faster motion is

ii) Runs
   a. Runs
   b. Motion is slower
   c. Runs
   d. The smaller c^2, the slower the motion
   e. The larger c^2, the faster motion is

iii) Runs
   a. Runs
   b. Motion is slower
   c. Runs
   d. The smaller c^2, the slower the motion
   e. The larger c^2, the faster motion is

iv) The Heat equation would converge to zero relatively quickly, but the wave equation does not

MatLab – Exercise 9.3.2

i. There's a series of ripples
    a. Less time between waves
    b. There's a series of peaks and troughs
        i. Not much change
ii. Repeat
    a. Cos, no pattern
        i. Smaller waves, still no pattern
    b. Step, argil pattern
        i. Denser pattern
iii. C^2 = 3
    a. Cos
        i. no pattern
        ii. No difference
    b. Sine
        i. Series of ripples
        ii. Less time between waves
    c. Expo
        i. X patterns of peaks and troughs
        ii. No difference
    d. Step
        i. Argil pattern
        ii. Denser pattern
iv. The heat equation dissipates and stops. While the wave equation continues on much longer
v. Dirichlet is more fluid, while the other 2 are more ridged

Matlab – Exercise 9.3.3

i. Sin, 0

    a. 0.5 - Norm Different vs. Time, Different Parameters = 0
       Norm Different between Initial Conditions = 0.5
    b. Repeat
        xxix. 0.25 - Norm Different vs. Time, Different Parameters = 0
              Norm Different between Initial Conditions = 0.25

xxx. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.1

xxxi. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.01

xxxii. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.005

xxxiii. Wave equation seems to depend on initial conditions

c. Non-zero, and expo
   i. Sine, 1
      1. 0.5 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.5
      2. Repeat
         a. 0.25 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.25
         b. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.1
         c. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.01
         d. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.005
   ii. Expo, 0
      1. 0.5 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.22258
      2. Repeat
         e. 0.25 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.11129
         f. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.044516
         g. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.0044516
         h. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.022258
   iii. Expo, 1
      1. 0.5 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.2258
      2. Repeat
         i. 0.25 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.11129
         j. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.044516
         k. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.0044516

l. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.0022258

a. No change to conjecture

d. Perturbing c^2, d and e
   i. Cos, 0
      1. 3.1 - Norm Different vs. Time, Different Parameters = 0.1
         Norm Different between Initial Conditions = 0
      2. Repeat
         m. 2.9 - Norm Different vs. Time, Different Parameters = 0.1
            Norm Different between Initial Conditions = 0
         n. 2.95 - Norm Different vs. Time, Different Parameters = 0.05
            Norm Different between Initial Conditions = 0
         o. 2.99 - Norm Different vs. Time, Different Parameters = 0.01
            Norm Different between Initial Conditions = 0
         p. 3.1 - Norm Different vs. Time, Different Parameters = 0.01
            Norm Different between Initial Conditions = 0

e. Repeat d with non-zero and expo, this is f
   i. Cos,1
      1. 3.1 - Norm Different vs. Time, Different Parameters = 0.1
         Norm Different between Initial Conditions = 0
      2. Repeat
         q. 2.9 - Norm Different vs. Time, Different Parameters = 0.1
            Norm Different between Initial Conditions = 0
         r. 2.95 - Norm Different vs. Time, Different Parameters = 0.05
            Norm Different between Initial Conditions = 0
         s. 2.99 - Norm Different vs. Time, Different Parameters = 0.01
            Norm Different between Initial Conditions = 0
         t. 3.1 - Norm Different vs. Time, Different Parameters = 0.01
            Norm Different between Initial Conditions = 0
   ii. Expo, 0
      1. 3.1 - Norm Different vs. Time, Different Parameters = 0.1
         Norm Different between Initial Conditions = 0
      2. Repeat
         u. 2.9 - Norm Different vs. Time, Different Parameters = 0.1
            Norm Different between Initial Conditions = 0
         v. 2.95 - Norm Different vs. Time, Different Parameters = 0.05
            Norm Different between Initial Conditions = 0
         w. 2.99 - Norm Different vs. Time, Different Parameters = 0.01
            Norm Different between Initial Conditions = 0
         x. 3.1 - Norm Different vs. Time, Different Parameters = 0.01
            Norm Different between Initial Conditions = 0
   iii. Expo, 1

1. 3.1 - Norm Different vs. Time, Different Parameters = 0.1
   Norm Different between Initial Conditions = 0
2. Repeat
   y. 2.9 - Norm Different vs. Time, Different Parameters = 0.1
      Norm Different between Initial Conditions = 0
   z. 2.95 - Norm Different vs. Time, Different Parameters = 0.05
      Norm Different between Initial Conditions = 0
   aa. 2.99 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0
   bb. 3.1 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0

f. This is really g and h
   i. Cos, 0
      1. 3.1 - Norm Difference vs. Time Difference in Parameters = 0.1
         0.5 - Norm Difference between Initial Conditions = 0.70711
      2. Repeat
         a. 2.95 - Norm Difference vs. Time Difference in Parameters = 0.05
            0.1 - Norm Difference between Initial Conditions = 0.14142
         b. 2.99 - Norm Difference vs. Time Difference in Parameters = 0.01
            0.051 - Norm Difference between Initial Conditions = 0.070711
         c. 3.01 - Norm Difference vs. Time Difference in Parameters = 0.01
            0.01 - Norm Difference between Initial Conditions = 0.014142
   ii. Cos, 1
      1. 3.1 - Norm Difference vs. Time Difference in Parameters = 0.1
         0.5 - Norm Difference between Initial Conditions = 0.70711
      2. Repeat
         a. 2.95 - Norm Difference vs. Time Difference in Parameters = 0.05
            0.1 - Norm Difference between Initial Conditions = 0.14142
         b. 2.99 - Norm Difference vs. Time Difference in Parameters = 0.01
            0.051 - Norm Difference between Initial Conditions = 0.070711
         c. 3.01 - Norm Difference vs. Time Difference in Parameters = 0.01
            0.01 - Norm Difference between Initial Conditions = 0.014142
   iii. Expo, 0
      1. 3.1 - Norm Difference vs. Time Difference in Parameters = 0.1
         0.5 - Norm Difference between Initial Conditions = 0.22258
      2. Repeat
         a. 2.95 - Norm Difference vs. Time Difference in Parameters = 0.05
            0.1 - Norm Difference between Initial Conditions = 0.022258
         b. 2.99 - Norm Difference vs. Time Difference in Parameters = 0.01
            0.01 - Norm Difference between Initial Conditions = 0.0044516
         c. 3.01 - Norm Difference vs. Time Difference in Parameters = 0.01
            0.01 - Norm Difference between Initial Conditions = 0.0044516
   iv. Expo, 1
      1. 3.1 - Norm Difference vs. Time Difference in Parameters = 0.1
         0.5 - Norm Difference between Initial Conditions = 0.22258

2. Repeat
    a. 2.95 - Norm Difference vs. Time Difference in Parameters = 0.05
       0.1 - Norm Difference between Initial Conditions = 0.022258
    b. 2.99 - Norm Difference vs. Time Difference in Parameters = 0.01
       0.051 - Norm Difference between Initial Conditions = 0.0044516
    c. 3.01 - Norm Difference vs. Time Difference in Parameters = 0.01
       0.01 - Norm Difference between Initial Conditions = 0.004451

ii. Skip

iii. Skip

iv. Repeat (i) with H^1, perturbation size

a. Sin, 0

v. 0.5 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 1.6485

vi. Repeat

1. 0.25 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.824223
2. 0.1 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.32969
3. 0.01 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.032969
4. 0.005 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.016485

b. Sin, 1

vii. 0.5 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 1.6485

viii. Repeat

1. 0.25 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.824223
2. 0.1 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.32969
3. 0.01 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.032969
4. 0.005 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.016485

c. Expo, 0

ix. 0.5 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 1.4252

x. Repeat

1. 0.25 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.7126
2. 0.1 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.28504

3. 0.01 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.028504
4. 0.005 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.014252

d. Expo, 1

xi. 0.5 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 1.4252

xii. Repeat

1. 0.25 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.7126
2. 0.1 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.28504
3. 0.01 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.028504
4. 0.005 - Norm Different vs. Time, Different Parameters = 0
   Norm Different between Initial Conditions = 0.014252

e. C^2 changes

i. Cos, 0

1. 0.5 - Norm Different vs. Time, Different Parameters = 0.1
   Norm Different between Initial Conditions = 0
2. Repeat
   a. 0.25 - Norm Different vs. Time, Different Parameters = 0.1
      Norm Different between Initial Conditions = 0
   b. 0.1 - Norm Different vs. Time, Different Parameters = 0.05
      Norm Different between Initial Conditions = 0
   c. 0.01 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0
   d. 0.005 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0

ii. Cos, 1

3. 0.5 - Norm Different vs. Time, Different Parameters = 0.1
   Norm Different between Initial Conditions = 0
4. Repeat
   a. 0.25 - Norm Different vs. Time, Different Parameters = 0.1
      Norm Different between Initial Conditions = 0
   b. 0.1 - Norm Different vs. Time, Different Parameters = 0.05
      Norm Different between Initial Conditions = 0
   c. 0.01 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0
   d. 0.005 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0

iii. Expo, 0

5. 0.5 - Norm Different vs. Time, Different Parameters = 0.1
   Norm Different between Initial Conditions = 0
6. Repeat
   a. 0.25 - Norm Different vs. Time, Different Parameters = 0.1
      Norm Different between Initial Conditions = 0
   b. 0.1 - Norm Different vs. Time, Different Parameters = 0.05
      Norm Different between Initial Conditions = 0
   c. 0.01 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0
   d. 0.005 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0

iv. Expo, 1

7. 0.5 - Norm Different vs. Time, Different Parameters = 0.1
   Norm Different between Initial Conditions = 0
8. Repeat
   a. 0.25 - Norm Different vs. Time, Different Parameters = 0.1
      Norm Different between Initial Conditions = 0
   b. 0.1 - Norm Different vs. Time, Different Parameters = 0.05
      Norm Different between Initial Conditions = 0
   c. 0.01 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0
   d. 0.005 - Norm Different vs. Time, Different Parameters = 0.01
      Norm Different between Initial Conditions = 0

f. This is g and h

i. Cos, 0

1. 3.1 - Norm Difference vs. Time Difference in Parameters = 0.1
   0.5 - Norm Difference between Initial Conditions = 6.5155
2. Repeat
   a. 2.95 - Norm Difference vs. Time Difference in Parameters = 0.05
      0.1 - Norm Difference between Initial Conditions = 1.3031
   b. 2.99 - Norm Difference vs. Time Difference in Parameters = 0.01
      0.01 - Norm Difference between Initial Conditions = 0.65155
   c. 3.01 - Norm Difference vs. Time Difference in Parameters = 0.01
      0.01 - Norm Difference between Initial Conditions = 0.13031

ii. Cos, 1

1. 3.1 - Norm Difference vs. Time Difference in Parameters = 0.1
   0.5 - Norm Difference between Initial Conditions = 6.5155
2. Repeat
   a. 2.95 - Norm Difference vs. Time Difference in Parameters = 0.05
      0.1 - Norm Difference between Initial Conditions = 1.3031
   b. 2.99 - Norm Difference vs. Time Difference in Parameters = 0.01
      0.01 - Norm Difference between Initial Conditions = 0.65155
   c. 3.01 - Norm Difference vs. Time Difference in Parameters = 0.01
      0.01 - Norm Difference between Initial Conditions = 0.13031

iii. Expo, 0
    1. 3.1 - Norm Difference vs. Time Difference in Parameters = 0.1
       0.5 - Norm Difference between Initial Conditions = 1.4252
    2. Repeat
        a. 2.95 - Norm Difference vs. Time Difference in Parameters = 0.05
           0.1 - Norm Difference between Initial Conditions =0.28504
        b. 2.99 - Norm Difference vs. Time Difference in Parameters = 0.01
           0.01 - Norm Difference between Initial Conditions = 0.14252
        c. 3.01 - Norm Difference vs. Time Difference in Parameters = 0.01
           0.01 - Norm Difference between Initial Conditions = 0.028504

iv. Expo, 1
    1. 3.1 - Norm Difference vs. Time Difference in Parameters = 0.1
       0.5 - Norm Difference between Initial Conditions = 1.4252
    2. Repeat
        a. 2.95 - Norm Difference vs. Time Difference in Parameters = 0.05
           0.1 - Norm Difference between Initial Conditions =0.28504
        b. 2.99 - Norm Difference vs. Time Difference in Parameters = 0.01
           0.01 - Norm Difference between Initial Conditions = 0.14252
        c. 3.01 - Norm Difference vs. Time Difference in Parameters = 0.01
           0.01 - Norm Difference between Initial Conditions = 0.028504

v. skip

MatLab – Exercise 9.3.4

i. Runs
    a. Runs
    b. They seem relatively similar
    c. They seem relatively similar
    d. A larger α yields less fluctuation
    e. The larger α, the larger the wave fluctuation

ii. Runs
    a. Runs
    b. They seem relatively similar
    c. They seem relatively similar
    d. A larger α yields less fluctuation
    e. The larger α, the larger the wave fluctuation

iii. Runs

a. Runs
b. They seem relatively similar
c. They seem relatively similar
d. A larger α yields less fluctuation
e. The larger α, the larger the wave fluctuation

MatLab – Exercise 9.3.5

i. They get smaller as time goes by
    a. Slower decline in wave fluctuation
    b. Slower decline in wave fluctuation
ii. Damped slows rapidly
    a. Damped slows rapidly
    b. Damped slows rapidly
iii. Damped slows rapidly
    a. Damped slows rapidly
    b. Damped slows rapidly
iv. The smaller α, the smaller the dampening effects are
v. The conjecture from (iv) holds
vi. The lower c^2, the greater the difference between damped and undamped.

Matlab – Exercise 9.3.6

ii. Sin, 0

g. 0.5 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.5

h. Repeat

i. 0.25 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.25

ii. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.1

iii. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.01

iv. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.005

v. Seems

i. Conjecture holds for non-zero initial velocity

iii. Cos, 0

j. P.p.c - 3.1 - Norm Different vs. Time, Different Parameters = 0.14142
p.d.c. - 4.9 - Norm Different between Initial Conditions = 0

k. Repeat

i. P.p.c - 2.9 - Norm Different vs. Time, Different Parameters = 0.14142
p.d.c. - 5.1 - Norm Different between Initial Conditions = 0

ii. P.p.c – 2.95 - Norm Different vs. Time, Different Parameters = 0.070711
p.d.c. – 4.95 - Norm Different between Initial Conditions = 0

iii. P.p.c – 2.99 - Norm Different vs. Time, Different Parameters = 0.05099
p.d.c. – 5.05 - Norm Different between Initial Conditions = 0

iv. P.p.c – 3.01 - Norm Different vs. Time, Different Parameters = 0.014142
p.d.c. - 4.99 - Norm Different between Initial Conditions = 0

v. Purterbing α and c^2, seems to change the model a bit

l. Conjecture holds for non-zero initial velocity

iv. 9.2.3 had no dampening effects, it was fluid

MatLab – Exercise 9.3.7

vi. Runs
    a. Runs
    b. Slower, same as EXPLORE! 9.21
    c. Slower, same as EXPLORE! 9.21
    d. The c^2 the less damping affects there are with non-zero initial velocity, the waves seem to mesh together and then reform
    e. A larger c^2 seems to accelerate the wave

vii. Runs
    a. Runs
    b. Slower, same as EXPLORE! 9.21
    c. Slower, same as EXPLORE! 9.21
    d. The c^2 the less damping affects there are with non-zero initial velocity, the waves seem to mesh together and then reform

viii. Runs
    a. Runs
    b. Slower, same as EXPLORE! 9.21
    c. Slower, same as EXPLORE! 9.21
    d. The c^2 the less damping affects there are with non-zero initial velocity, the waves seem to mesh together and then reform
    e.

MatLab – Exercise 9.3.8

i. 2 rows of waves
    a. No change, 2 rows of waves
    b. A spike that turns into a star pattern
        i. No change, a spike that turns into a star pattern

ii. Repeat
    a. Cos, one row of waves that breaks down with no change

iii. repeat
    a. 2 rows of waves

i. No change, 2 rows of waves

ii. A spike that turns into a star pattern

1. No change, a spike that turns into a star pattern

b. Repeat

i. Cos, one row of waves that breaks down with no change as initial velocity exponential

iv. 1D patterns did not present themselves in 2D equation

v. Step pillar that turns into a star pattern with no change as initial velocity exponential

MatLab – Exercise 9.3.9

vi. $C^2 = 3$, ant t = 0.5 (sin, 0), H_1

a. 0.25 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 1.7739

b. Repeat

i. 0.1 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.70956

ii. 0.01 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.070956

iii. 0.005 - Norm Different vs. Time, Different Parameters = 0
Norm Different between Initial Conditions = 0.035478

iv. Seems to depend on initial conditions

c. No change in conjecture

vii. (Cos, 0), with perturbation size = 0

a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0
The perturbed solution is less wavy

b. Repeat

i. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0
The perturbed solution is less wavy

ii. 1.95 - Norm Different vs. Time, Different Parameters = 0.05
Norm Different between Initial Conditions = 0
The perturbed solution is less wavy

iii. 2.005 - Norm Different vs. Time, Different Parameters = 0.005
Norm Different between Initial Conditions = 0
The perturbed solution is less wavy

c. No change in conjecture

viii. (Cos, 0) periodic boundary conditions with perturbation size = 0

a. 2.1 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0
The perturbed solution is less wavy

b. Repeat

i. 1.9 - Norm Different vs. Time, Different Parameters = 0.1
Norm Different between Initial Conditions = 0
The perturbed solution is less wavy

ii. 1.95 - Norm Different vs. Time, Different Parameters = 0.05
Norm Different between Initial Conditions = 0
The perturbed solution is less wavy

iii. 2.005 - Norm Different vs. Time, Different Parameters = 0.005
Norm Different between Initial Conditions = 0
The perturbed solution is less wavy

c. No change in conjecture

ix. 2D seems to depend on initial conditions, over boundary conditions and initial velocity, similar to the 1D wave equation.