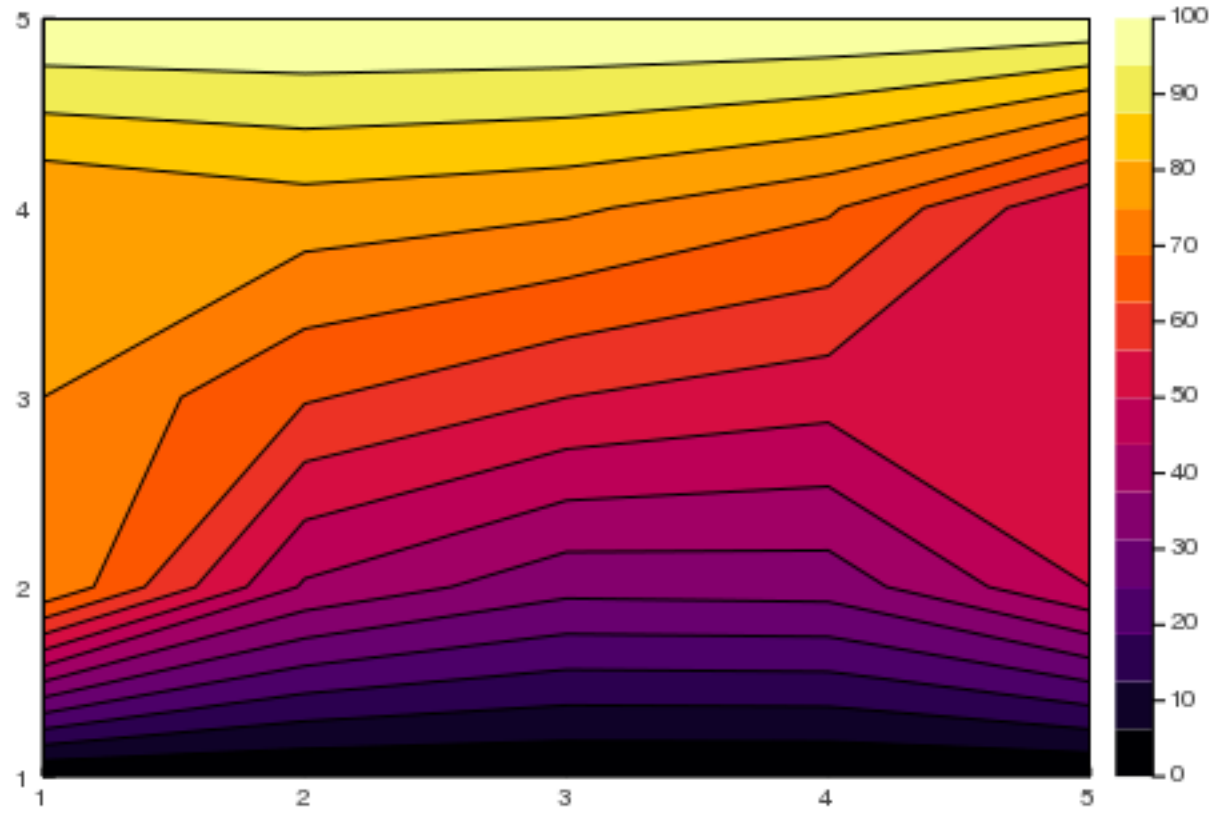
3.1.1

```
using LinearAlgebra
using Plots
using Printf


#### NOTE 3.1.1
# T = (A^-1)*B
A1 = [4 -1 0 -1 0 0 0 0 0;
-1 4 -1 0 -1 0 0 0 0;
0 -1 4 0 0 -1 0 0 0;
-1 0 0 4 -1 0 -1 0 0;
0 -1 0 -1 4 -1 0 -1 0;
0 0 -1 0 -1 4 0 0 -1;
0 0 0 -1 0 0 4 -1 0;
0 0 0 0 -1 0 -1 4 -1;
0 0 0 0 0 -1 0 -1 4]

B1 = [75; 0; 50; 75; 0; 50; 175; 100; 150]

T1 = A1\B1
Z1 = fill(NaN, (5,5))
for i = 1:3
   for j = 1:3
      Z1[i+1,j+1] = T1[3*(i-1)+j]
   end
end
Z1[:,1] = fill(75, (1,5))
Z1[:,5] = fill(50, (1,5))
Z1[5,:] = fill(100, (1,5))
Z1[1,:] = fill(0, (1,5))

contour(Z1,fill=true)
```



cond(A1)
λ = eigvals(A1)

k = maximum(λ)/minimum(λ)

both condition numbers were 5.83

x0 is initial guess: r0 = b - A*x0

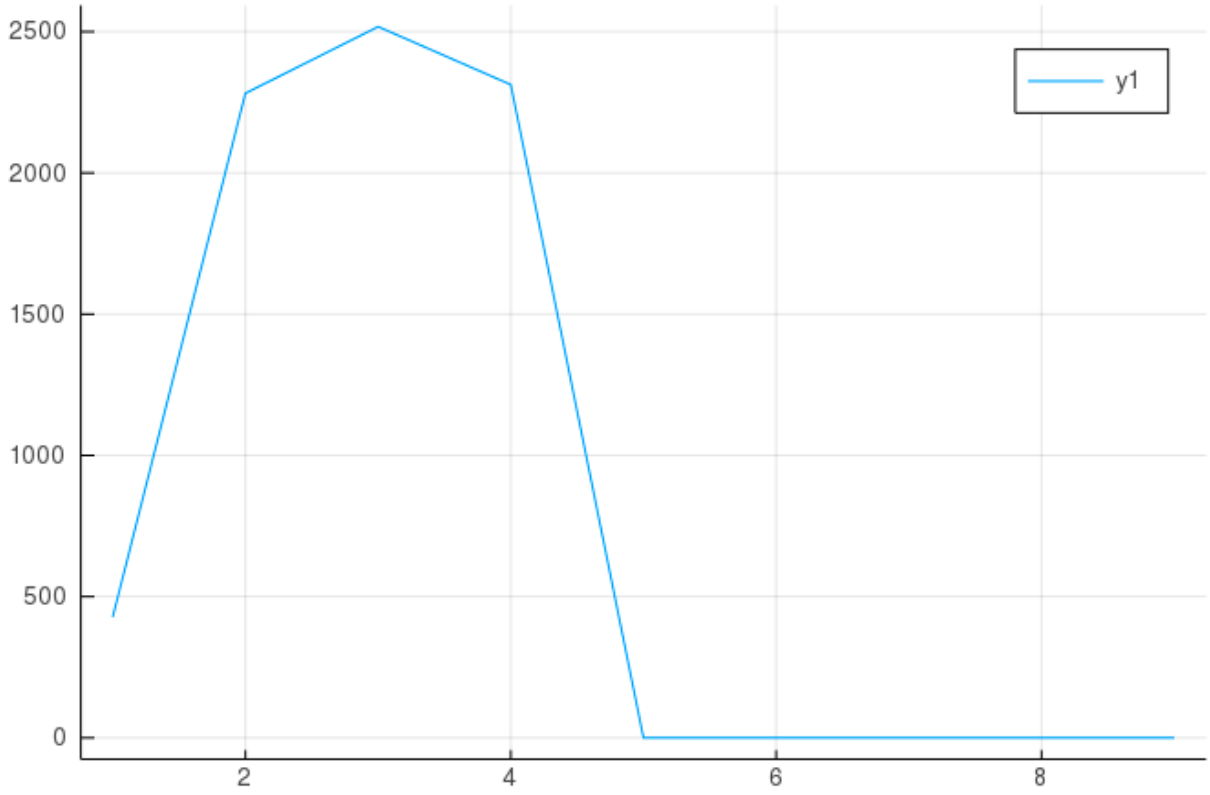
x0size = size(A1,2)
α = 1
ρ = α
ω = α

x0 = fill(5., (x0size,1)) |> vec

r0 = B1 - A1*x0

```
r0hat = r0
check = dot(r0hat,r0)

v = fill(0, (x0size,1)) |> vec
P = fill(0, (x0size,1)) |> vec
flag = 0

i = 1
num_iter = 10
res = fill(NaN , (1,num_iter-1)) |> vec
hfhdfhk = 1

while true
   global (r0,r0hat,α,ρ,ω,x0,v,p,flag)


   global ρnew = dot(r0hat,r0)
   global β = (ρnew/ρ)*(α/ω)
   global P = r0 + β*(P-(ω*v))
   global v = A1*P
   global α = ρnew/dot(r0hat,v)
   global h = x0 + α*P

   global s = r0 - α*v
   global t = A1*s
   global ω = dot(t,t)/dot(t,t)
   global xnew = h + ω*s
   global r0 = s - ω*t
   global tol = norm(r0)
   global x0 = xnew
   global ρ = ρnew
   global res[i] = tol
   global i += 1

   if tol < 1e-10
      global flag = 1
      break
   end


   if i >= num_iter
      global flag = -1
      break
```

```
    end
    end
#### When wiki says "i" I am going to say "i+1"
 #go to x0size+1

# also, r(i-1) is always going to be r0 in my code. I will update it at the end of the script

# If h is accurate enough, then set xi = h and quit

x = LinRange(1, 9, 9)
plot(x, res)
```

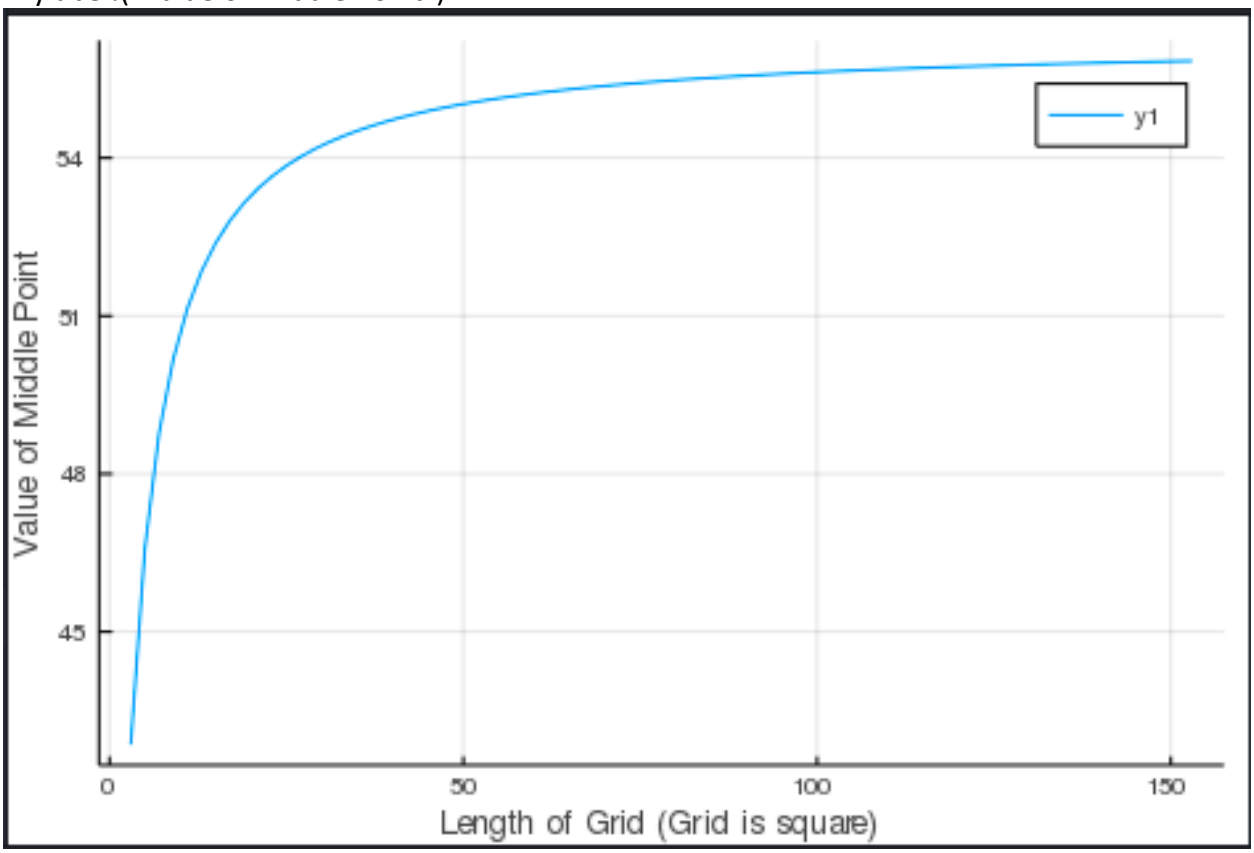


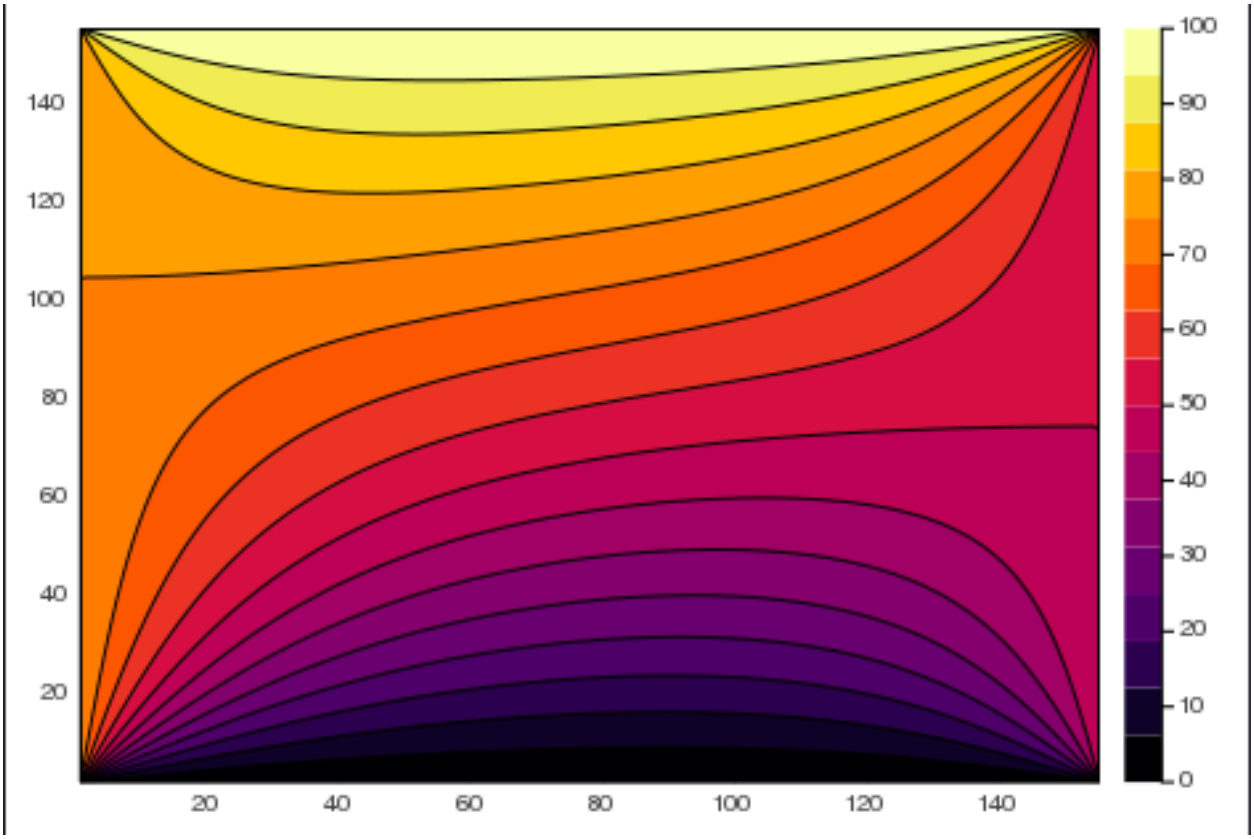

```
# NOTHING IS A MATRIX EXCEPT FOR A1
# also nothing needs to be kept two of except ρ

# compute norm of r
# r is the residual, so if the norm is small then we are good

#### NOTE 3.1.2
# n is going to change each iteration - for now, lets do n = 3
```

```
function InitializeArray(n)
   prev_middle = 500
   outer_counter = 1
   iter = 0
   tol = 1e-6
   T = zeros(n+2, n+2)


# Apply the boundary conditions
   T_south =   0.
   T_east  =  75.
   T_north = 100.
   T_west  =  50.

   T[:,1]   .= T_east
   T[end,:] .= T_north
   T[:,end] .= T_west
   T[1,:]   .= T_south
   # Note: I may want to fix the corners for plotting, but it's not needed for the solve.

   # Loop until convergence

   return T
end

T = InitializeArray(3)
contour(T,fill=true)
stop
# since variables inside a loop are local, then we need to use this 'let' stuff to pass in the stuff from before.
function GetContour(tol,iterMax,n)
   T = InitializeArray(n)
   flag = 0
   ωopt = 2/(1+sin(π/n+1))
   iter = 0
   while flag == 0
   # iter is 'global' since I want to reference it after the while loop ends.  This is *not* needed if this while loop was inside a function.
      iter += 1

      for i = 2:n+1
         for j = 2:n+1
            T[i,j] = (1-ωopt)*(T[i,j]) + ωopt*(1/4*(T[i-1,j] + T[i+1,j] + T[i,j-1] + T[i,j+1]))
         end
```

```
        end

    # Compute R = Ax - b
        resid = zeros(n+2,n+2)
        for i = 2:n+1
            for j = 2:n+1
                resid[i,j] = -T[i,j] + 1/4*(T[i-1,j] + T[i+1,j] + T[i,j-1] + T[i,j+1])
            end
        end

    # Since resid is a matrix, I'll use a norm
        if norm(resid) <= tol
            flag = 1
            break
            elseif iter >= iterMax
            flag = -1
            error("Failed to converge")
            break
        end

        end
        return(T)
    end
stop
T = GetContour(1e-5,1000,7)

contour(T,fill=true)


stop
function GetAccurateContour()
    tol=1e-5
    itermax=50000
    Tmiddle=500
    counter=0
    MiddleTemp=fill(NaN,(1,100))
    SizeOfMesh = fill(NaN,(1,100))
    while true
        counter += 1
        n = counter*2+1
        T = GetContour(tol,itermax,n)
        Tmiddlenew = T[counter+1,counter+1]
        change = abs(Tmiddlenew - Tmiddle)
        Tmiddle = Tmiddlenew
```

```
        MiddleTemp[counter] = Tmiddle
        SizeOfMesh[counter] = n
        if counter > 75
           return(T,MiddleTemp,counter,change,SizeOfMesh)
        elseif change < tol
           return(T,MiddleTemp,counter,change,SizeOfMesh)
        end

    end


end

T = GetAccurateContour()
contourf(T[1])
x = T[5] |> vec
y = T[2] |> vec
plot(x,y)
   xlabel!("Length of Grid (Grid is square)")
   ylabel!("Value of Middle Point")
```





3.2

```
using LinearAlgebra
function f(x,a)
   # where x is a row of data points
   # and a is a row vector of the coefficients
   # such that y = a[1]x^n + a[2]x^n-1 + ... + a[n]
   p = size(x,1)
   n = size(a,1)
   y = fill(0,(p,1))
   for j = 1:p
      for i = 1:n+1
         y[j] += a[i]*x[j]^(i-1)
      end
   end
   return(y)
end
stop = 0

start = 0
function buildX( x, f, n)
   # where x is a row of data points
   # f is funtion handle of the funtion we want to curve fit
   # n is the power of the last term we want the approximation of y to have
```

```
    p = size(x,1)
    X = fill(NaN,(p,n+1))
    for j = 1:p
        for i = 0:n
            X[j,i+1] = x[j]^i
        end
    end
    return(X)
end
stop = 0

n = 3
num_data_points = 5
x = LinRange(1,num_data_points,num_data_points) |> vec
check = buildX(x,f,n)

a = [2 -1]
check2 = f(x,a)
check3 = 2*x
check4 =

for x = linspace()

### I did not finish this problem
```