

# Programmierblatt 2

## Finite Differenzen, Laplace und Poisson Gleichung

Bearbeitende Studierende:

Jonathan Schnitzler Matr. - Nr: 3465192

Matthias Gültig Matr. - Nr: 3469020

Anmerkungen: Alle Aufgaben wurden bereits mit der freiwilligen aber sinnvollen Forderung nach Erweiterung bzw. Generalisierbarkeit implementiert

### Aufgabe 1 (FD-Gitter)

In dieser Aufgabe wird das Gitter  $\Omega = ((0, 3)^2 \setminus ([2, 3] \times (0, 1])) \setminus ((0, 1] \times [2, 3])$

Die Grundlegende Idee ist die kleinstmögliche Basis  $\Omega_R$  zu schaffen, sodass  $\overline{\Omega}_h \subset \Omega_R$  und ein rechteckiges Würfelgitter ist. Dann reicht es aus diesem allgemeinen Gitter kleinere Rechtecke "auszuschneiden", und man kann jedes beliebige gewünschte Gebiet erhalten.

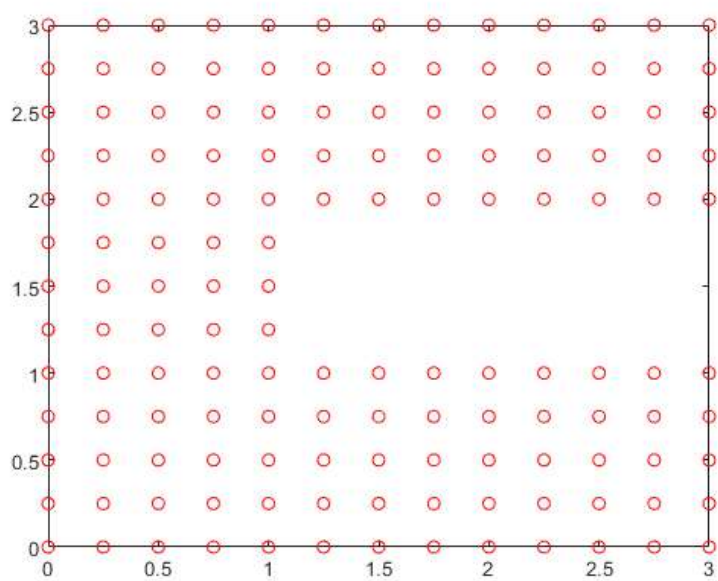
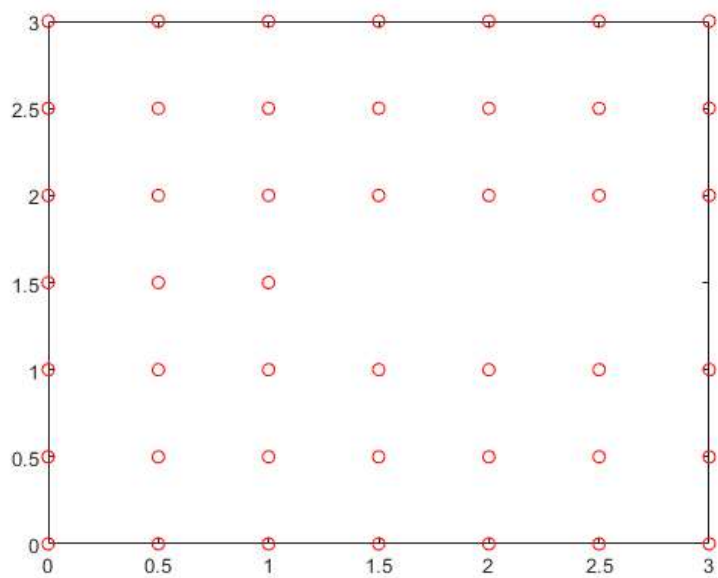
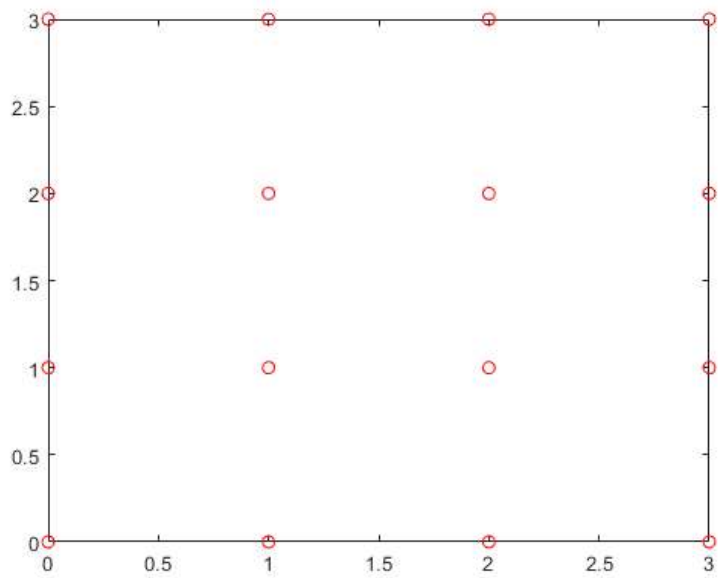
```
% omeg.o = [0,0]
% omeg.x = 3;
% omeg.y = 3;
% omeg.h = 1.5;
%
% Omega = genRectMesh2D(omeg);
% Omega = Omega.pointMat;
% plot(Omega(:,1), Omega(:,2), 'ro');
%
%
%
% figure;
% plot(omeg.o(1),omeg.o(2), 'ro');
% axis = [omeg.o(1),omeg.o(1)+omeg.x, omeg.o(2), omeg.o(2)+omeg.y];
% hold on
% nOmega = size(Omega,1);
% for k=1:nOmega
%     color = ones(3,1)*(k/nOmega);
%     plot(Omega(k,1),Omega(k,2), 'Color',color,"Marker",'o')
%
%     drawnow
%     pause(0.025)
% end
% hold off
```

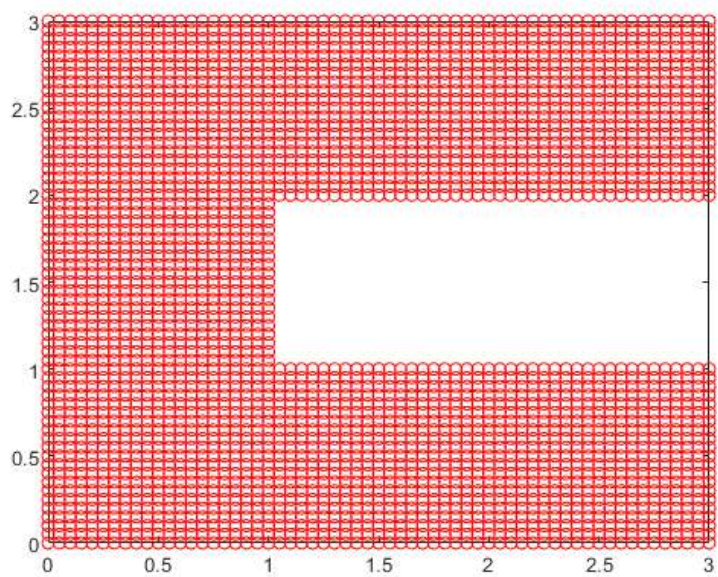
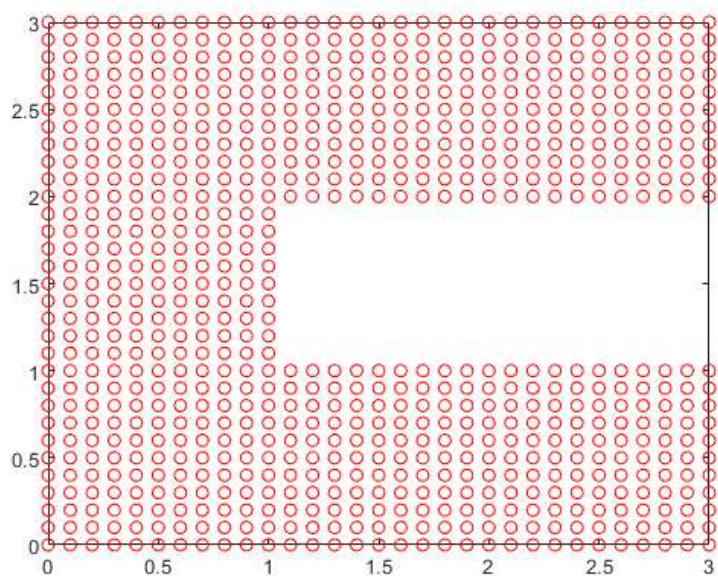
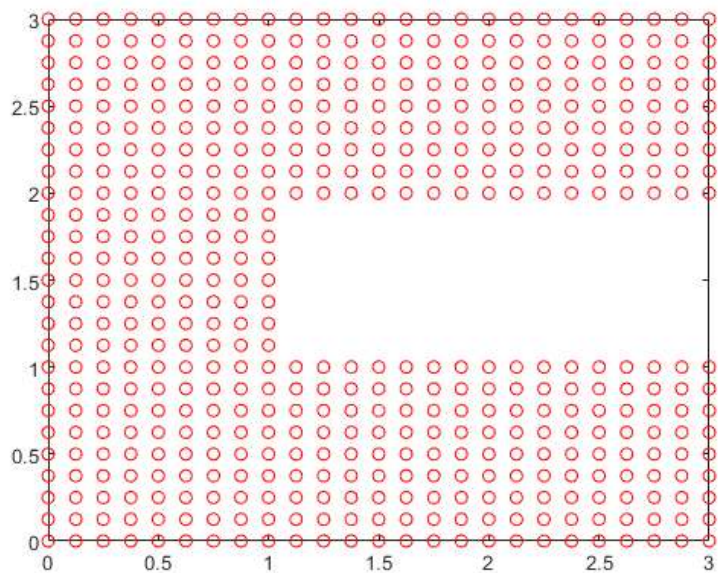
```
%Testing some shit
h = [1, 0.5, 0.25, 0.125, 0.1, 0.05, 0.02]
```

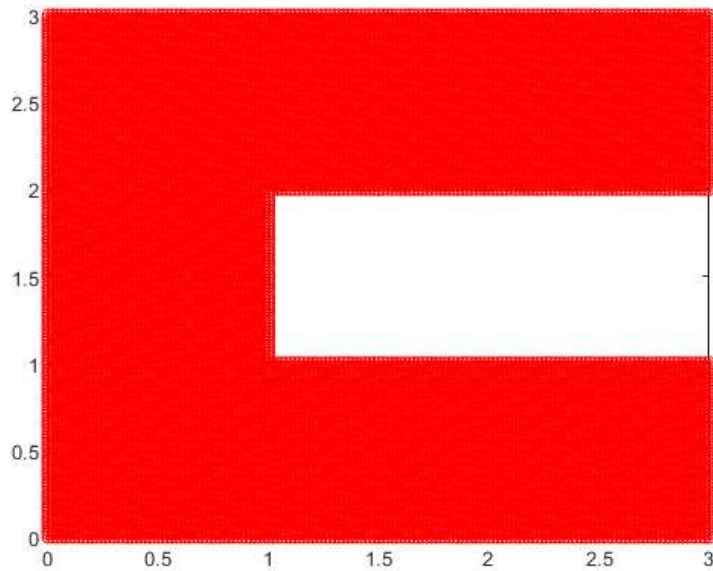
```
h = 1×7
    1.0000    0.5000    0.2500    0.1250    0.1000    0.0500    0.0200
```

```
t = zeros(numel(h),1);
for k = 1:numel(h)
    tic
    omeg.o = [0,0];
    omeg.x = 3;
    omeg.y = 3;
    omeg.h = h(k);
    O1 = genRectMesh2D(omeg);
    omeg.x = 2;
    omeg.y = 1;
    omeg.o = [1, 1];
    O2 = genRectMesh2D(omeg);

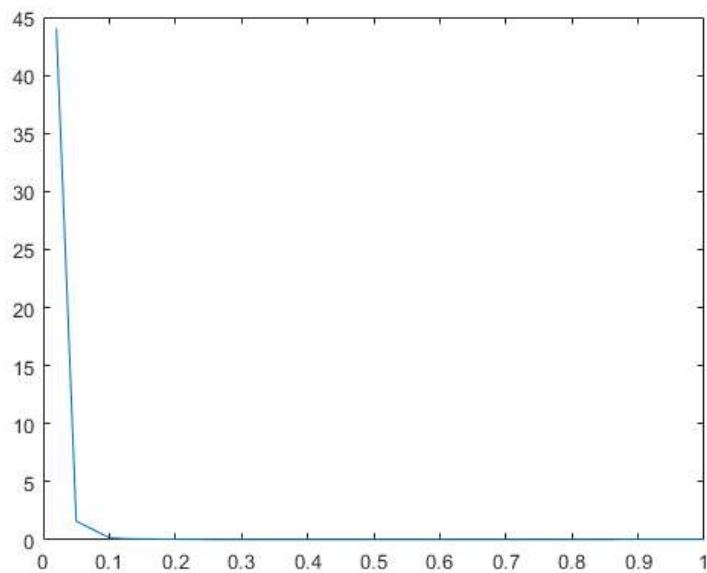
    O = meshSubtract(O1,O2);
    O = O.pointMat;
    figure
    plot(O(:,1), O(:,2), 'ro');
    t(k) = toc;
end
```







```
plot(h,t)
```



```
function OmegaHBar = genRectMesh2D(omeg)
%Input is a struct specifying the origin the X-Length, the Y-Length and the
%Meshsize h
if mod(omeg.x,omeg.h) ~= 0 || mod(omeg.y,omeg.h) ~= 0
    error("X-Length or Y-Length are not applicable with the Meshsize of h");
end

nX = round(omeg.x/omeg.h);
nY = round(omeg.y/omeg.h);
N = (nX+1).*(nY+1);
OmegaHBar = ome;
OmegaHBar.pointMat = zeros(N,2);
for kY = 0:nY
    for kX = 0:nX
        OmegaHBar.pointMat(kY*(nX+1) + (kX + 1),:) = [omeg.o(1) + kX *omeg.h, ome.o(2) + ome.y - kY * ome.h];
    end
end
end
```

```
function OmegaHBar = meshSubtract(Omega, subOmega)
%Subtracts a rectangular mesh from an arbitrary cubic Mesh while keeping the
%edges
if subOmega.h ~= Omega.h
    error("Meshsizes h are different");
end
```

```

h = subOmega.h;

if mod(subOmega.o(1)-Omega.o(1), h) ~= 0 || mod(subOmega.o(2)-Omega.o(2), h) ~= 0
    error("Origins are not a multiple of h appart from each other")
end

%Subtracting inner rectangle without the border
innerPoints.x = subOmega.x - 2*h;
innerPoints.y = subOmega.y - 2*h;
innerPoints.o = subOmega.o + [h, h];
innerPoints.h = h;

innerPoints = genRectMesh2D(innerPoints);
Omega.pointMat = meshSubtractWithEdge(Omega.pointMat, innerPoints.pointMat);
border = meshSubtractWithEdge(subOmega.pointMat, innerPoints.pointMat);
pM = Omega.pointMat;

%For every Element on the border check, if it is isolated or not - if remove
for k = 1:2
    idx = zeros(size(border,1));
    keep = true(size(pM,1),1);
    for k1 = 1:size(border,1)
        bP = border(k1,:);
        %Search index of borderPoint bP in pM
        %and if there is a
        neighX = false; %neighbour
        neighY = false;
        for k2 = 1:size(pM)
            if equalEps(bP, pM(k2,:))
                idx(k1) = k2;
            elseif equalEps(bP + [0 h], pM(k2,:))
                neighY = true;
            elseif equalEps(bP + [0 -h], pM(k2,:))
                neighY = true;
            end
        end
        end
        if (idx(k1) > 2) && (idx(k1) < size(pM,1))

            if equalEps((bP + [-h 0]), pM(idx(k1)-1,:)) || equalEps((bP + [h 0]), pM(idx(k1)+1,:)) %lexikografisch
                neighX = true;
            end

            if ~neighX || ~neighY
                keep(idx(k1)) = false;
            end
        end
    end
    pM = pM(keep,:);
end
Omega.pointMat = pM;
OmegaHBar = Omega;

end

```

```

function Omega = meshSubtractWithEdge(pM, pMSub)
%Input is the point Matrix of a area and an area you want to subtract it
%from - output is the point Matrix of pM without pMSub
%Could be implemented faster
isIn = zeros(size(pM,1),1);
for k1 = 1:size(pM,1)
    for k2 = 1:size(pMSub,1)
        if equalEps(pM(k1,:), pMSub(k2,:))
            isIn(k1) = 1;
            break;
        end
    end
end
Omega = pM(~logical(isIn),:);
end

```

```

function equalEps = equalEps(x, y)
if norm(x-y) < 1e4*eps(min(norm(x),norm(y)))

```

```
        equalEps = true;
    else
        equalEps = false;
    end
end

% function findNeighbor
```