**Vy Bui**

**Homework 3**

**ENGR652**

**Problem 1**

clear,clc,close all;

[X,Y] = meshgrid(-10:.05:10);

% R = sqrt(X.^2 + Y.^2) + eps;

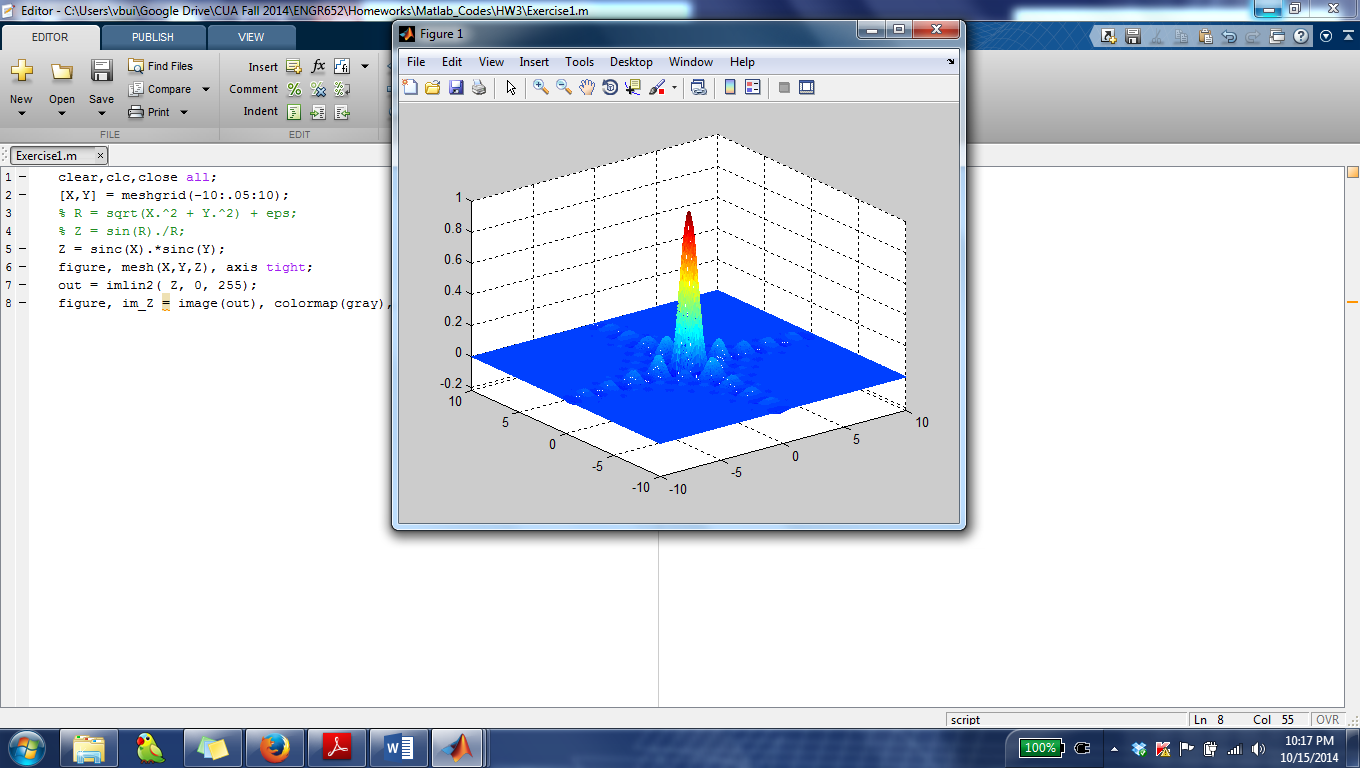
% Z = sin(R)./R;

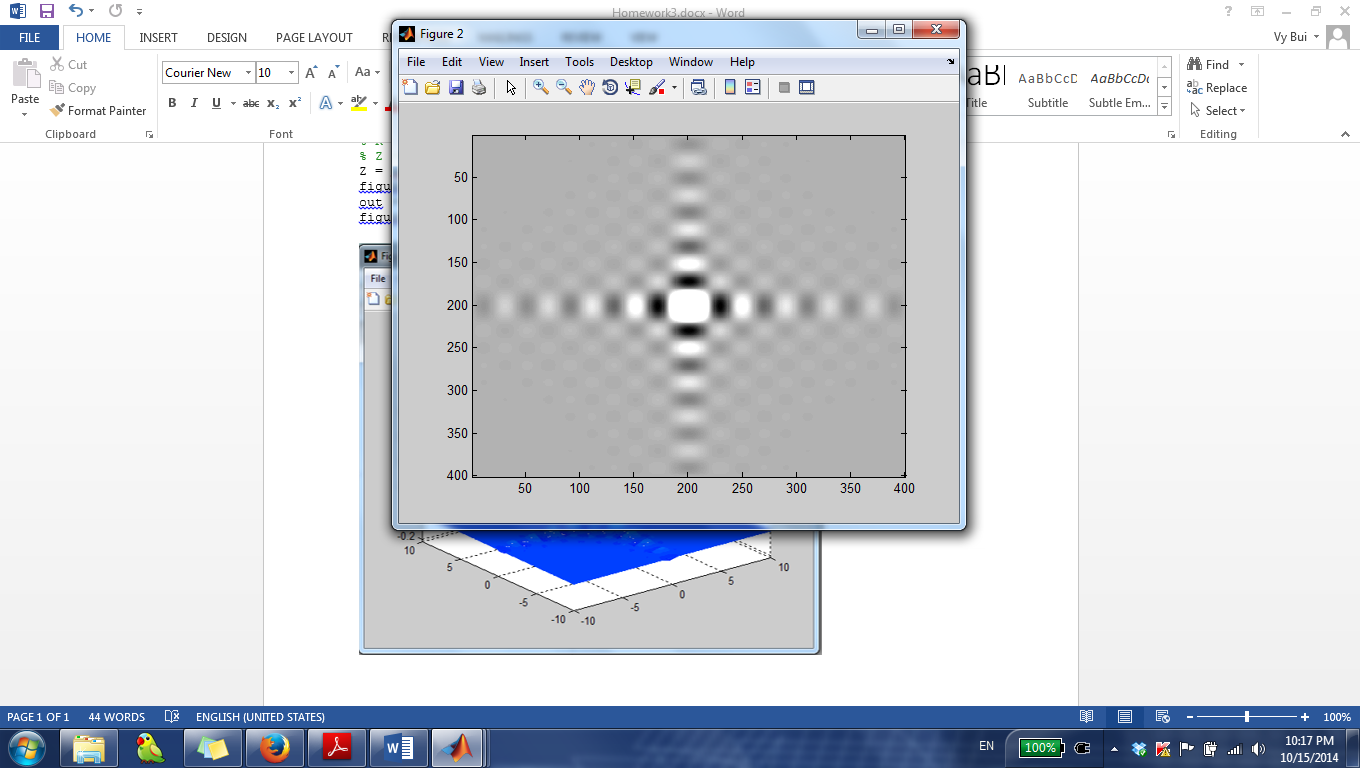
Z = sinc(X).\*sinc(Y);

figure, mesh(X,Y,Z), axis tight;

out = imlin2( Z, 0, 255);

figure, im\_Z = image(out), colormap(gray), axis tight;





**Problem 2**

%% Rect case

clear, clc, close all;

% [X,Y] = meshgrid(-5:.01:5);

% widthA = 1;

% widthB = 2;

% rectA = 0.5\*(sign(X/widthA + 0.5) - sign(X/widthA - 0.5));

% rectB = 0.5\*(sign(Y/widthB + 0.5) - sign(Y/widthB - 0.5));

% Z = rectA.\*rectB;

% figure, mesh(X,Y,Z);

[X,Y] = meshgrid(-3:.01:3);

widthA = 1;

rectA = rectpuls(X,widthA).\*rectpuls(Y,widthA);

figure, mesh(X,Y,rectA); title('rectA'), axis tight;

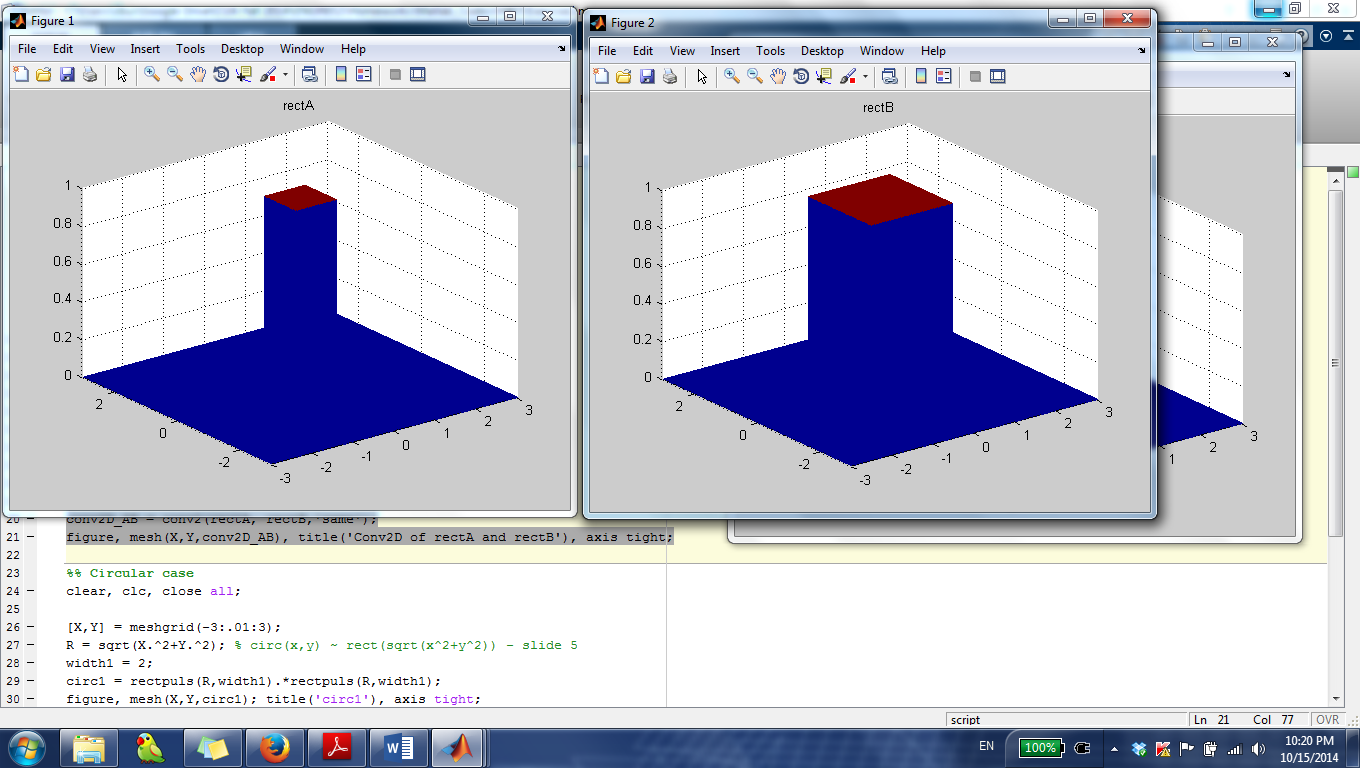
widthB = 2;

rectB = rectpuls(X,widthB).\*rectpuls(Y,widthB);

figure, mesh(X,Y,rectB); title('rectB'), axis tight;

conv2D\_AB = conv2(rectA, rectB,'same');

figure, mesh(X,Y,conv2D\_AB), title('Conv2D of rectA and rectB'), axis tight;





%% Circular case

clear, clc, close all;

[X,Y] = meshgrid(-3:.01:3);

R = sqrt(X.^2+Y.^2); % circ(x,y) ~ rect(sqrt(x^2+y^2)) - slide 5

width1 = 2;

circ1 = rectpuls(R,width1).\*rectpuls(R,width1);

figure, mesh(X,Y,circ1); title('circ1'), axis tight;

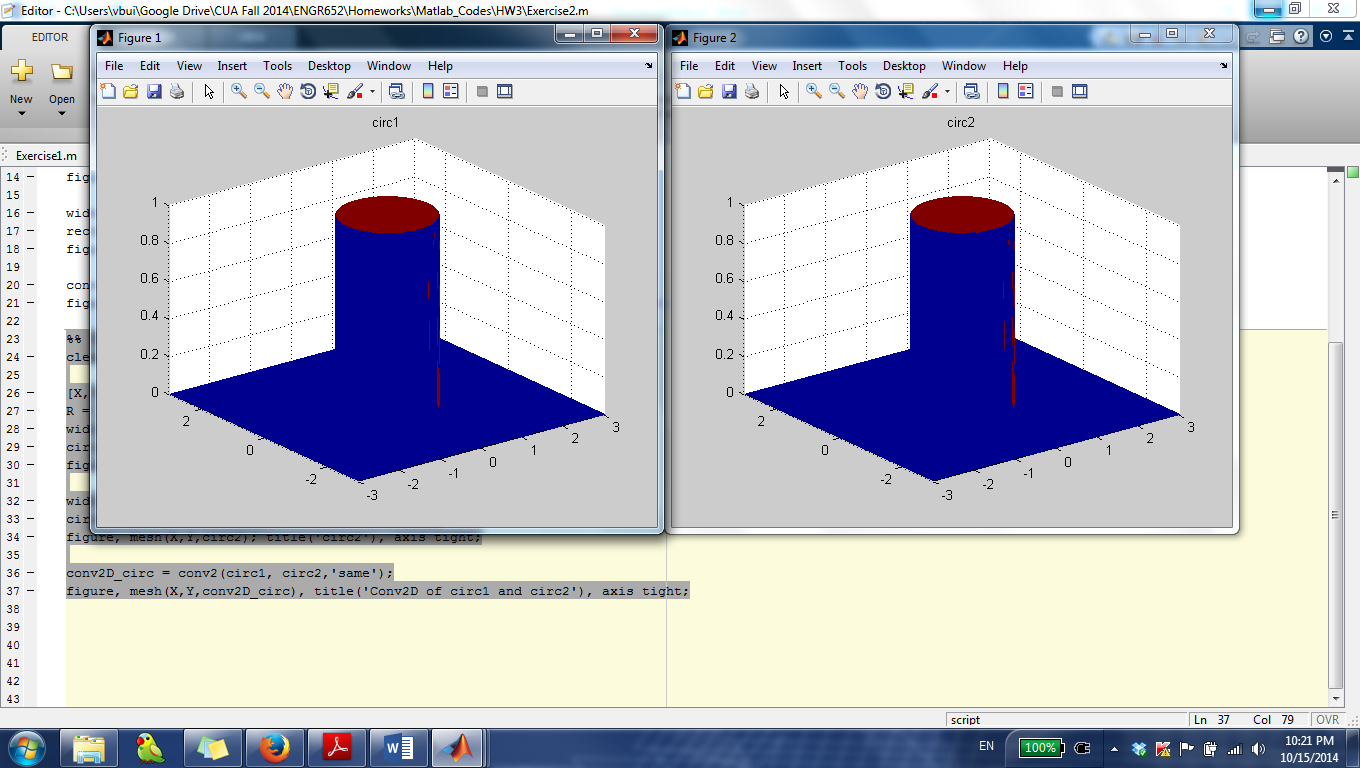
width2 = 2;

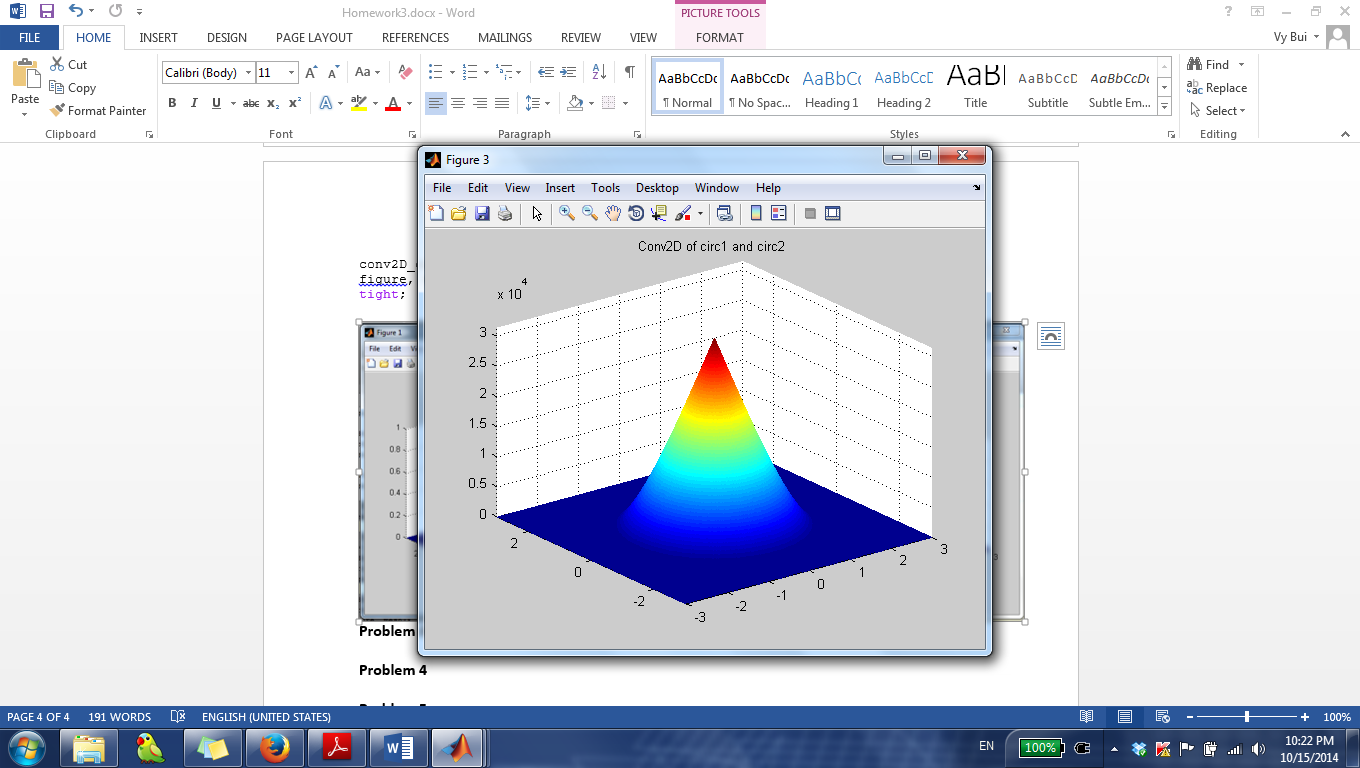
circ2 = rectpuls(R,width2).\*rectpuls(R,width2);

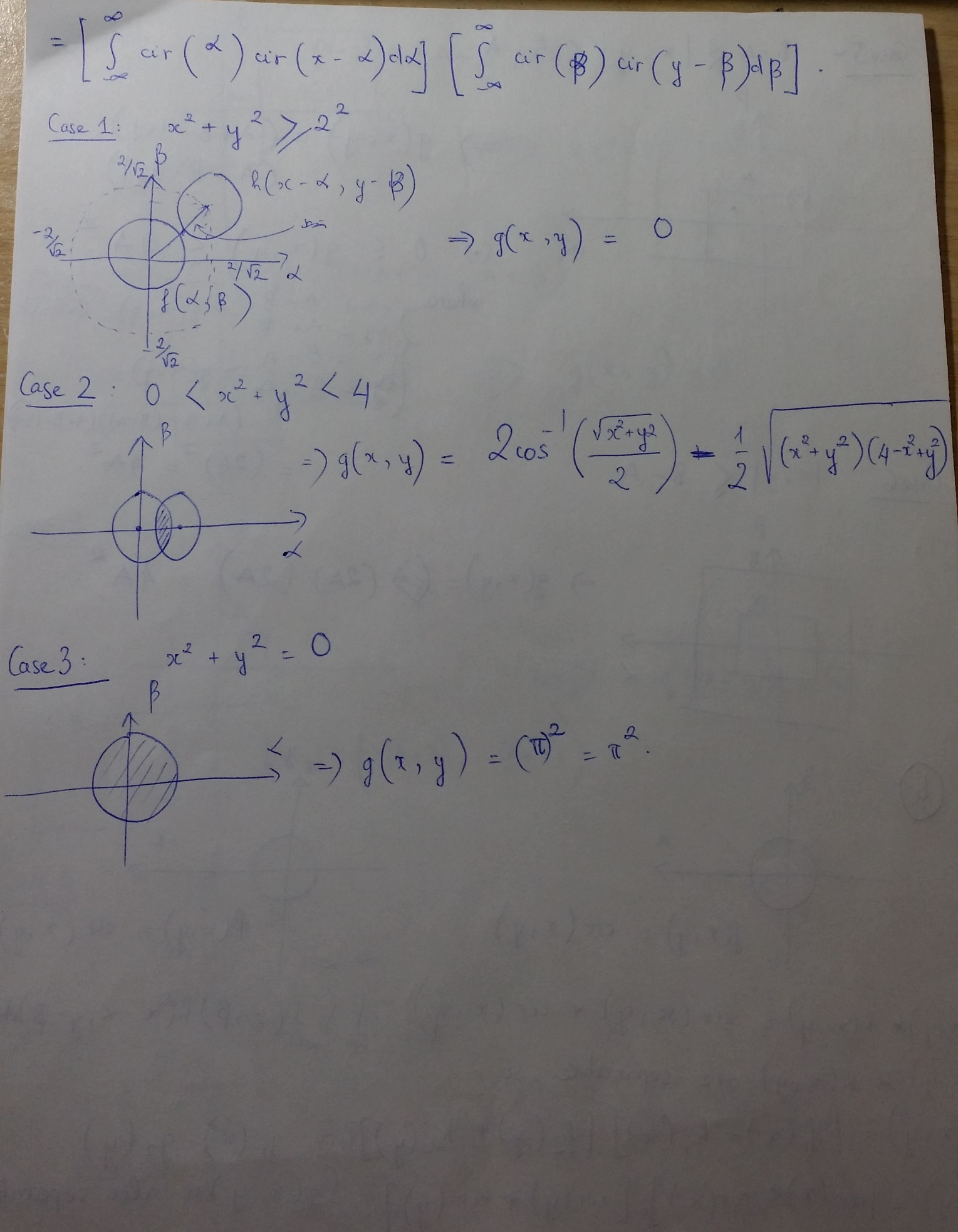
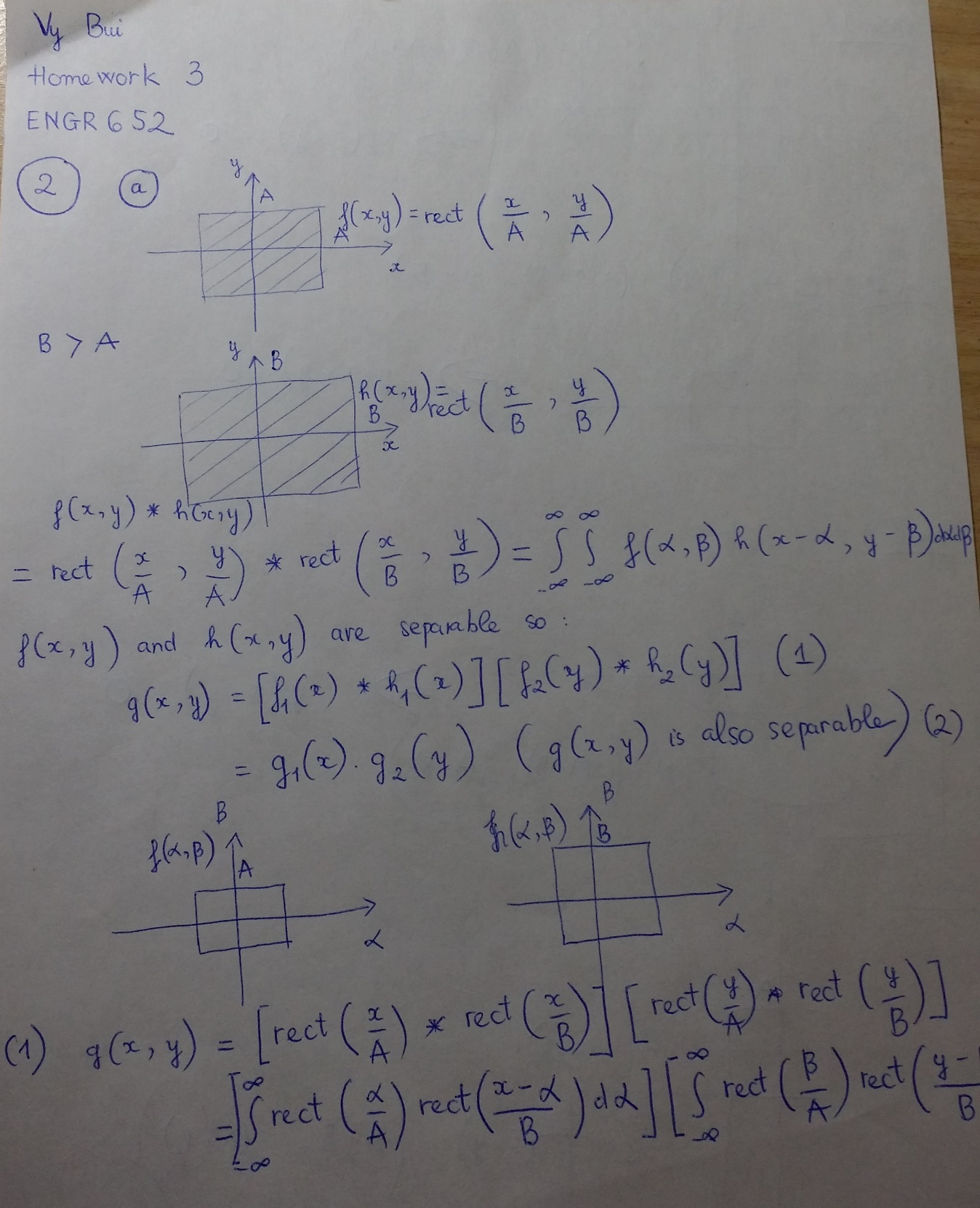
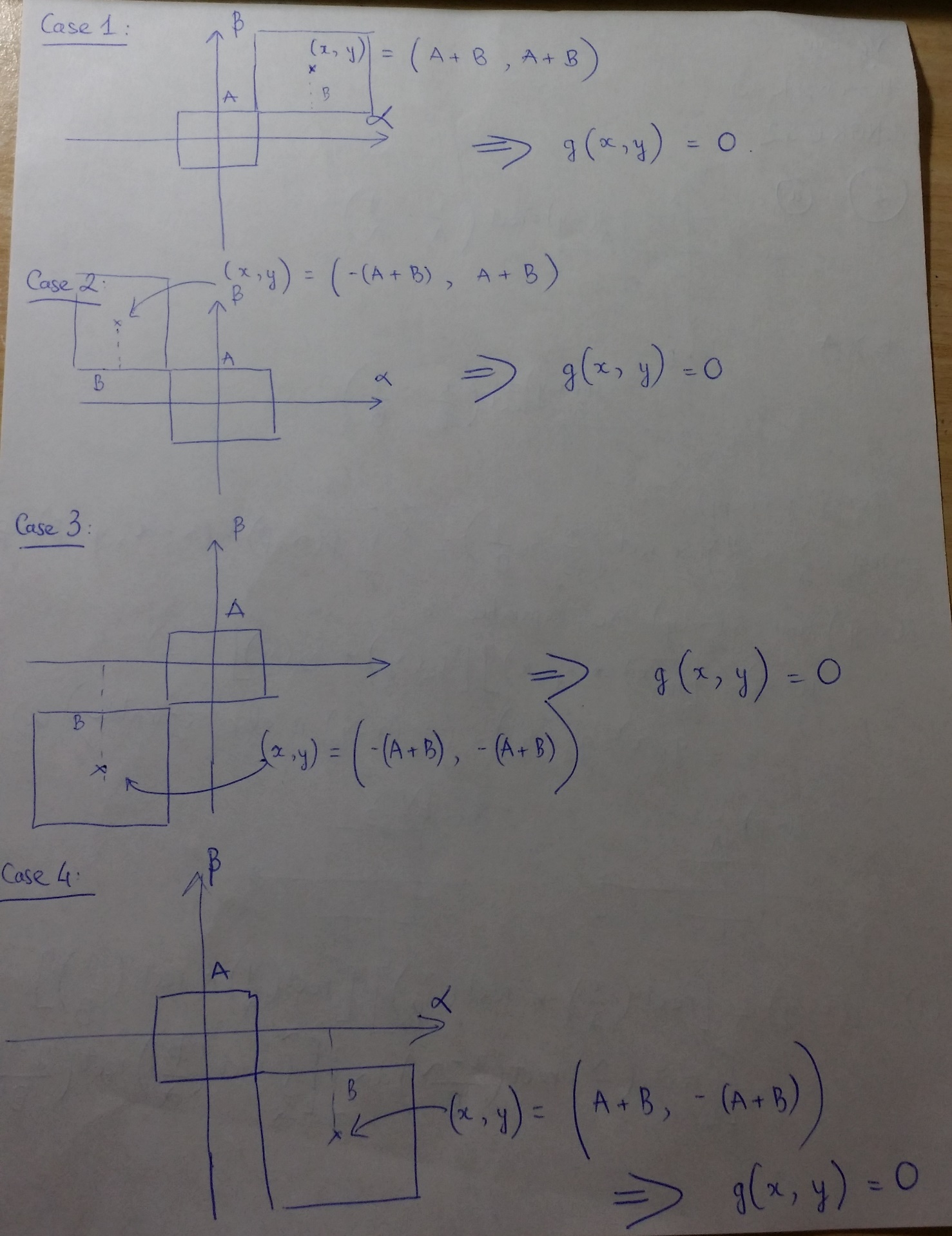
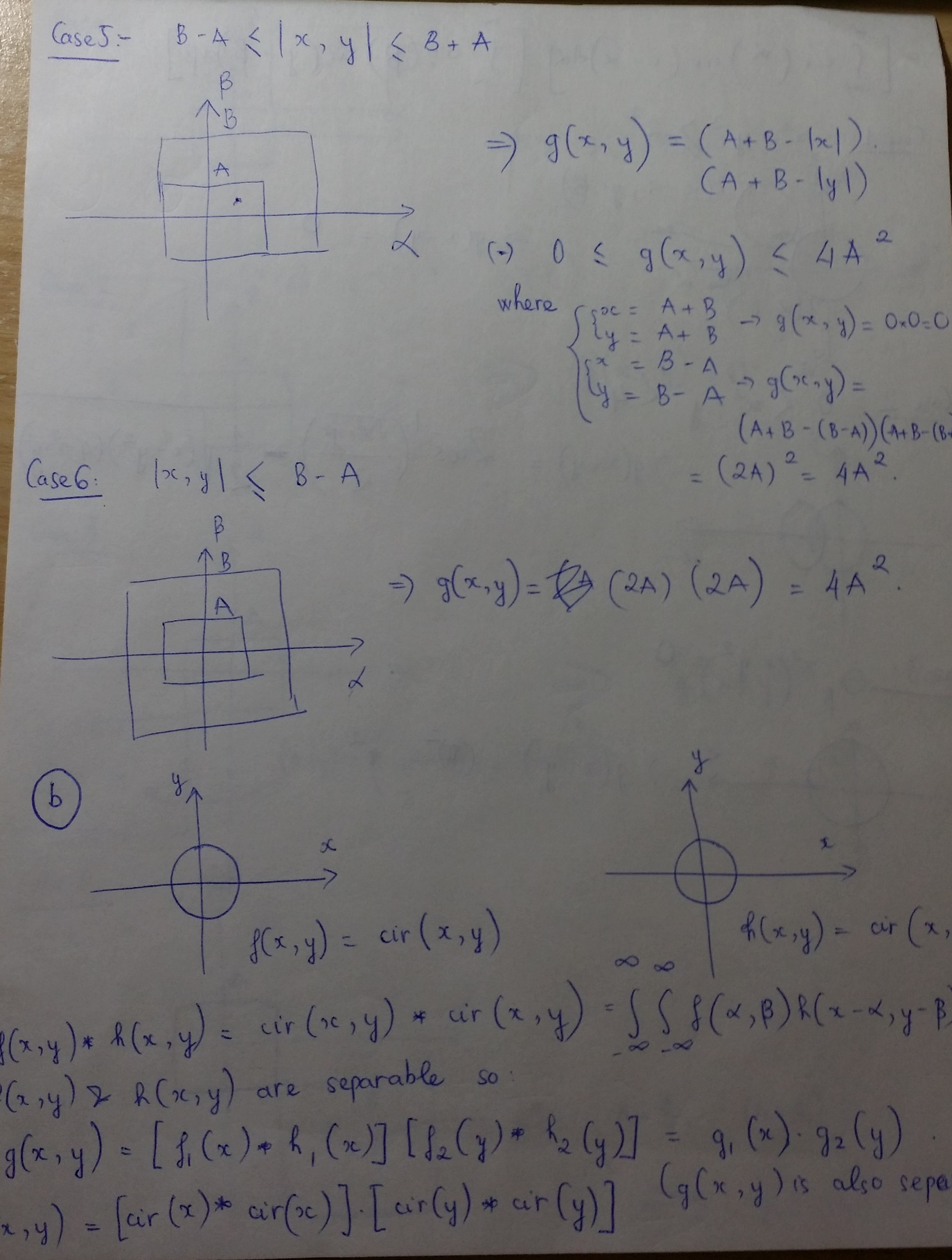
figure, mesh(X,Y,circ2); title('circ2'), axis tight;

conv2D\_circ = conv2(circ1, circ2,'same');

figure, mesh(X,Y,conv2D\_circ), title('Conv2D of circ1 and circ2'), axis tight;





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**Problem 3**

%% a

clc, clear, close all;

delta\_x=0.01;

delta\_y=0.01;

x=-5:delta\_x:5;

y=-5:delta\_y:5;

N=length(x);

[X,Y] = meshgrid(x,y);

f = cos(pi\*X);

figure, mesh(X,Y,f), colormap(gray(256)), view(0,90), title('f(x,y) = cos(\pix)'), xlabel('x'), ylabel('y'), zlabel('f(x,y)');

F = fft2(f);

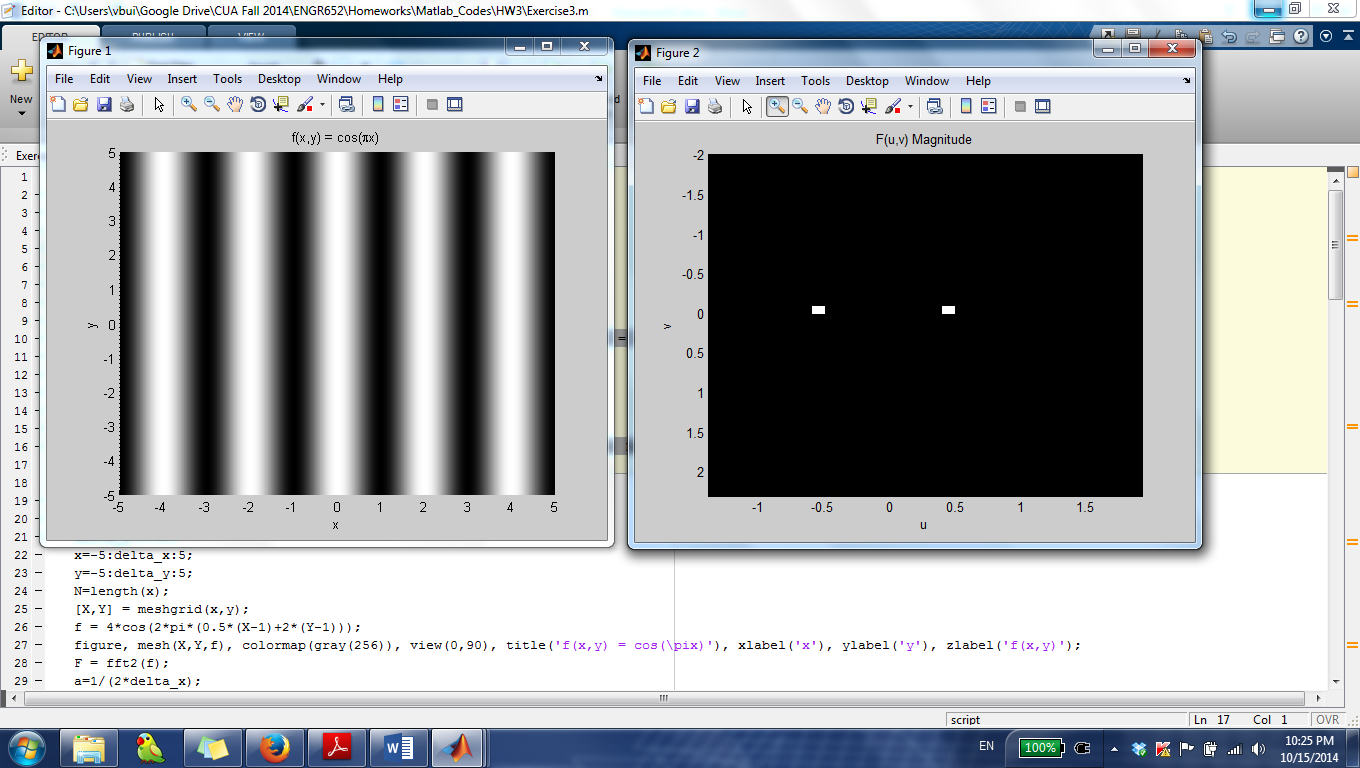
a=1/(2\*delta\_x);

b=1/(2\*delta\_y);

u=[-a:2\*a/N:a-2\*a/N]';

v=[-b:2\*b/N:b-2\*b/N]';

figure, imagesc(u,v,fftshift(abs(F))), colormap(gray), title('F(u,v) Magnitude'), xlabel('u'), ylabel('v'), axis tight;



%% b

clc, clear, close all;

delta\_x=0.01;

delta\_y=0.01;

x=-5:delta\_x:5;

y=-5:delta\_y:5;

N=length(x);

[X,Y] = meshgrid(x,y);

f = 4\*cos(2\*pi\*(0.5\*(X-1)+2\*(Y-1)));

figure, mesh(X,Y,f), colormap(gray(256)), view(0,90), title('f(x,y) = cos(\pix)'), xlabel('x'), ylabel('y'), zlabel('f(x,y)');

F = fft2(f);

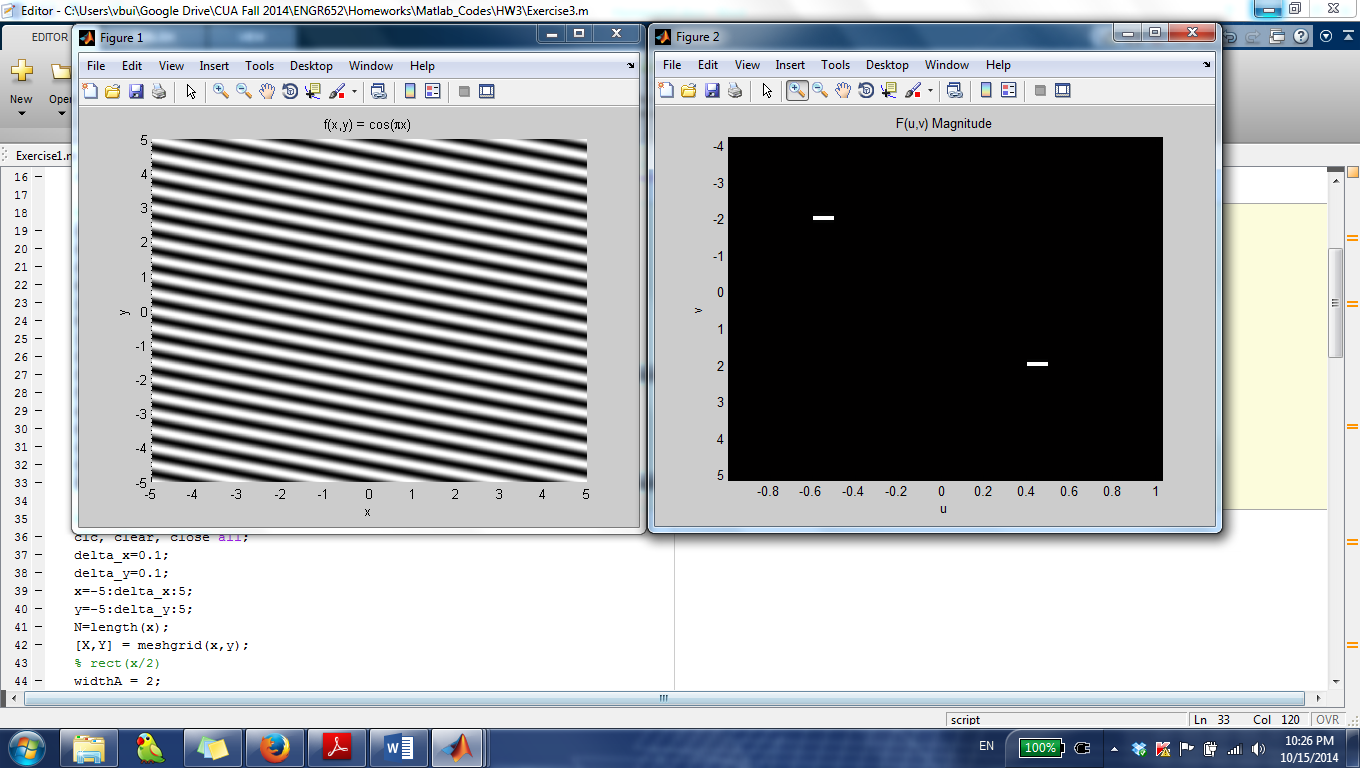
a=1/(2\*delta\_x);

b=1/(2\*delta\_y);

u=[-a:2\*a/N:a-2\*a/N]';

v=[-b:2\*b/N:b-2\*b/N]';

figure, imagesc(u,v,fftshift(abs(F))), colormap(gray), title('F(u,v) Magnitude'), xlabel('u'), ylabel('v'), axis tight;



%% c

clc, clear, close all;

delta\_x=0.1;

delta\_y=0.1;

x=-5:delta\_x:5;

y=-5:delta\_y:5;

N=length(x);

[X,Y] = meshgrid(x,y);

% rect(x/2)

widthA = 2;

rect = rectpuls(X,widthA);

figure, mesh(X,Y,rect); title('rect'), axis tight;

figure, imagesc(x,y,rect); title('rect - top view'), axis tight;

% comb4(x)\*impulse(y)

comb4 = zeros(length(x));

% from middle impulse, calculate the index of the impulses in front and

% after the middle impulse.

row\_index\_middle\_impulse = floor(length(x)/2);

col\_index\_middle\_impulse = floor(length(x)/2);

DELTA = 4/delta\_x;

comb4(row\_index\_middle\_impulse,col\_index\_middle\_impulse-DELTA:DELTA:col\_index\_middle\_impulse+DELTA) = 1;

figure, imagesc(x,y,comb4), colormap(gray), title('comb4(x)\*impulse(y) - top view'), axis tight;

% f = rect(x/2)\*comb4(x).impulse(y)

f = conv2(rect,comb4,'same');

figure, imagesc(x,y,f), colormap(gray(256)), title('f(x,y) = rect(x/2)\*comb4(x).dirac(y)'), xlabel('x'), ylabel('y');

F = fft2(f);

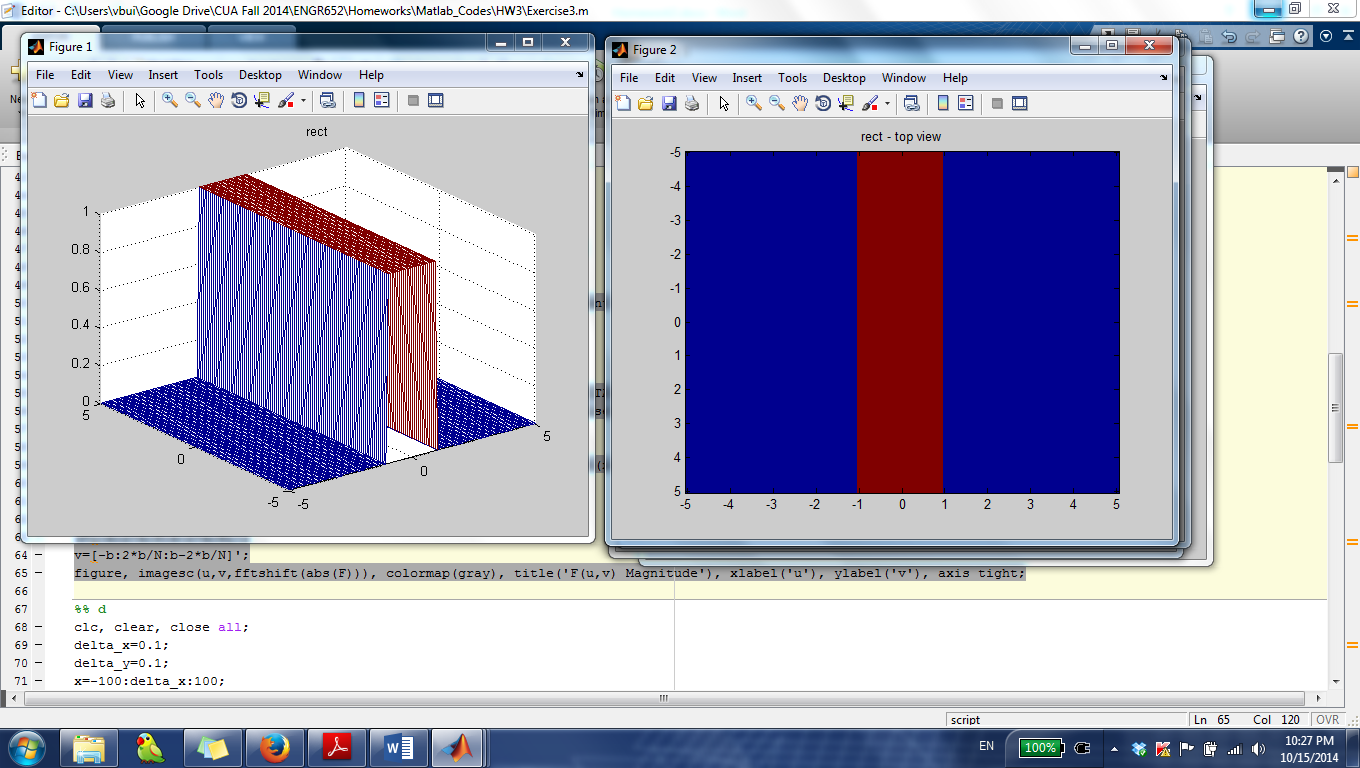
a=1/(2\*delta\_x);

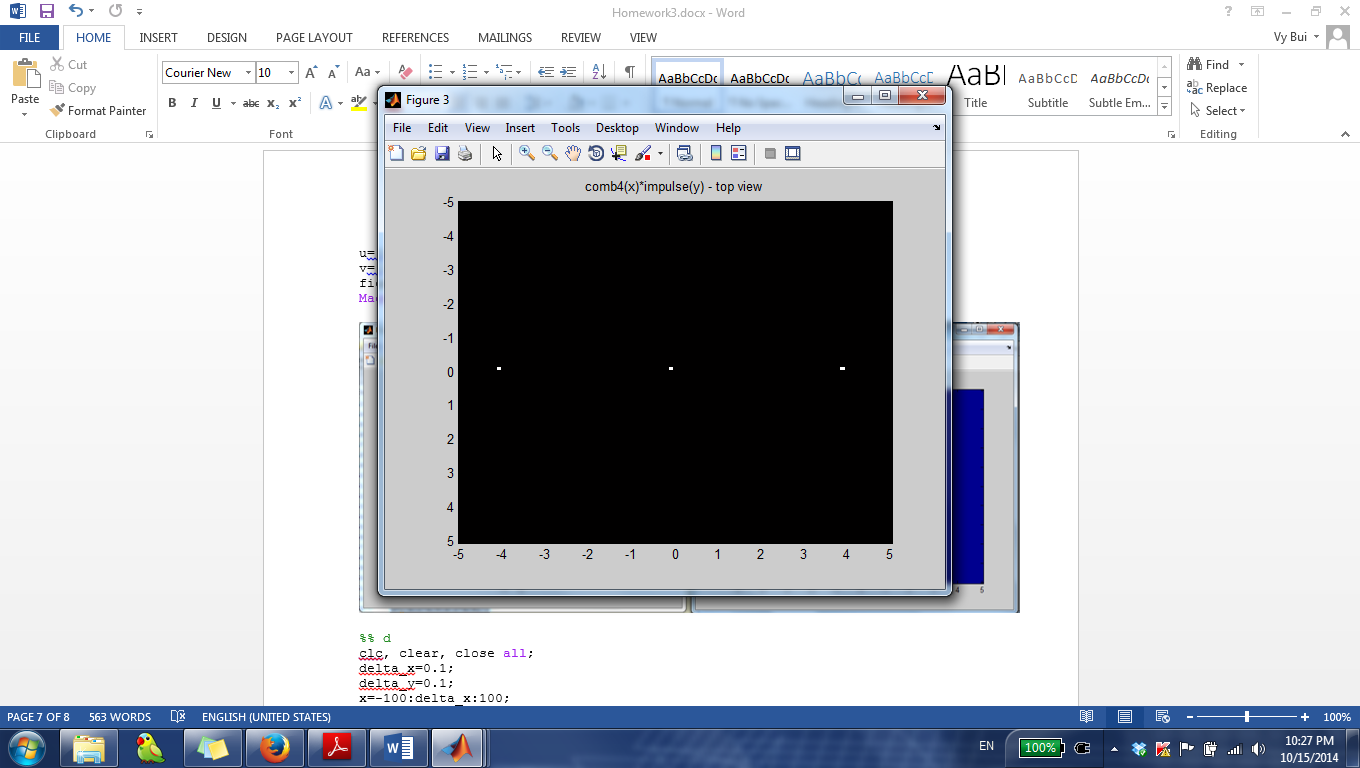
b=1/(2\*delta\_y);

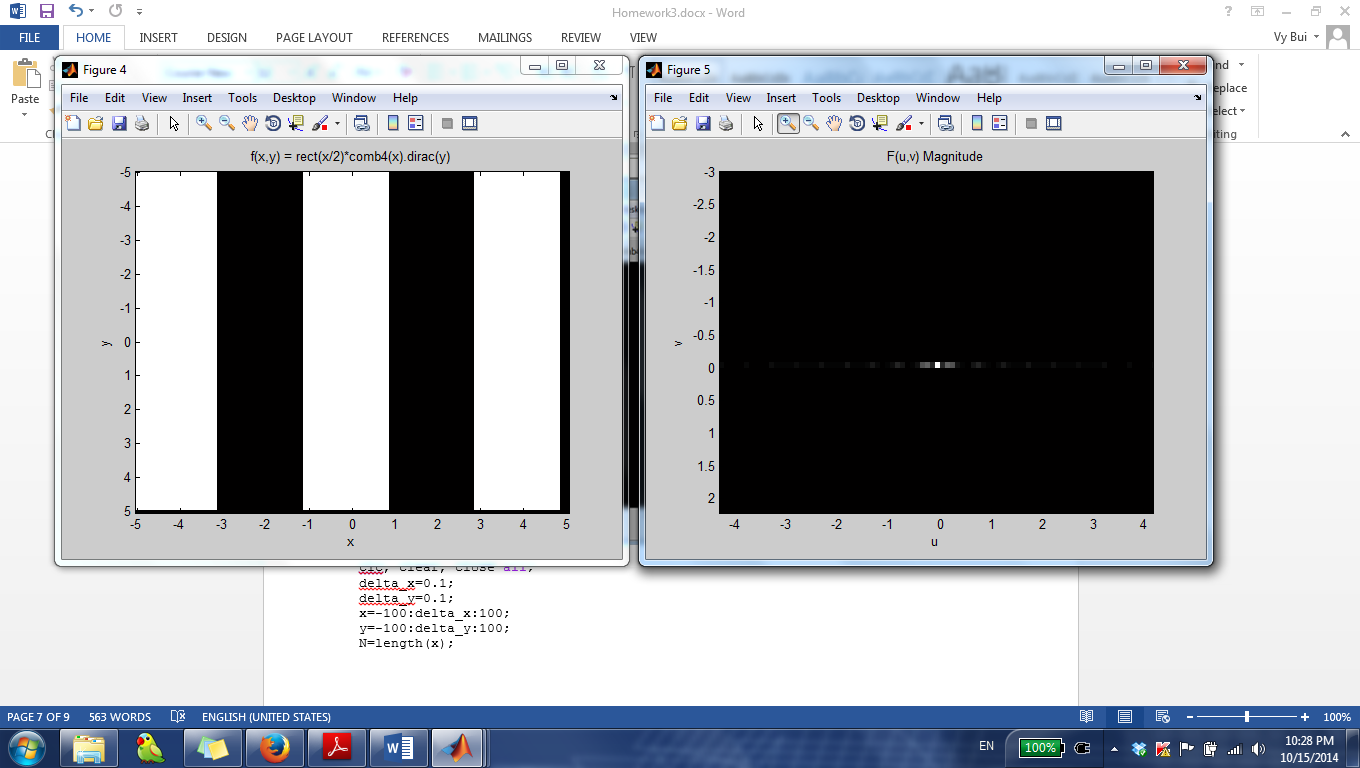
u=[-a:2\*a/N:a-2\*a/N]';

v=[-b:2\*b/N:b-2\*b/N]';

figure, imagesc(u,v,fftshift(abs(F))), colormap(gray), title('F(u,v) Magnitude'), xlabel('u'), ylabel('v'), axis tight;







%% d

clc, clear, close all;

delta\_x=0.1;

delta\_y=0.1;

x=-100:delta\_x:100;

y=-100:delta\_y:100;

N=length(x);

[X,Y] = meshgrid(x,y);

% rect(x/4-y\*sqrt(3)/4)

widthA = 1;

rect = rectpuls(X/4-Y\*sqrt(3)/4,widthA).\*rectpuls(X/4-Y\*sqrt(3)/4,widthA);

figure, mesh(X,Y,rect); title('rect'), axis tight;

figure, imagesc(x,y,rect); title('rect - top view'), axis tight;

% comb8(x)\*impulse(y)

comb8 = zeros(length(x));

row\_index\_middle\_impulse = floor(length(x)/2);

col\_index\_middle\_impulse = floor(length(x)/2);

DELTA = 8/delta\_x;

comb8(row\_index\_middle\_impulse,col\_index\_middle\_impulse-10\*DELTA:DELTA:col\_index\_middle\_impulse+10\*DELTA) = 1;

figure, imagesc(x,y,comb8), colormap(gray), title('comb8(x)\*impulse(y) - top view'), axis tight;

% f = rect(x/4-y\*sqrt(3)/4)\*comb8(x)\*impulse(y)

f = conv2(rect,comb8,'same');

figure, imagesc(x,y,f), colormap(gray(256)), title('f(x,y) = rect(x/2)\*comb8(x).dirac(y)'), xlabel('x'), ylabel('y');

F = fft2(f);

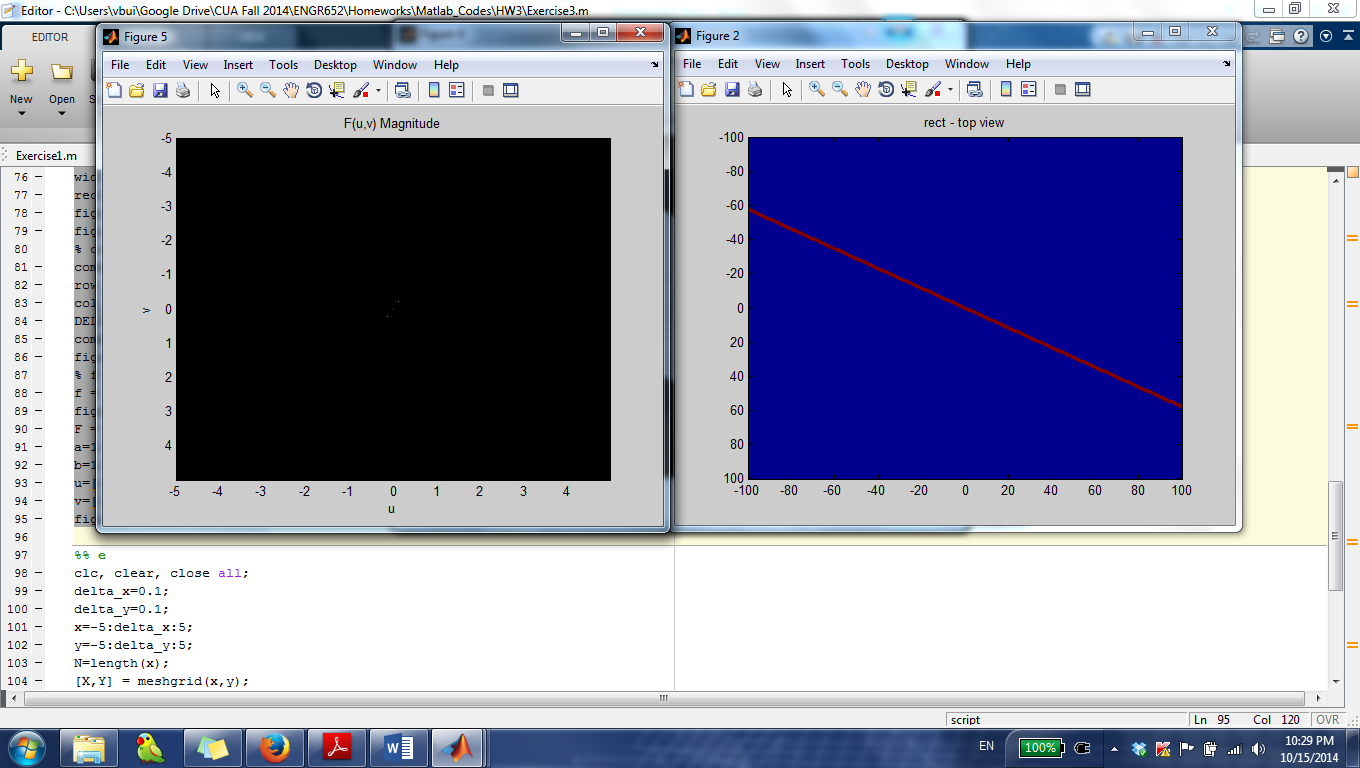
a=1/(2\*delta\_x);

b=1/(2\*delta\_y);

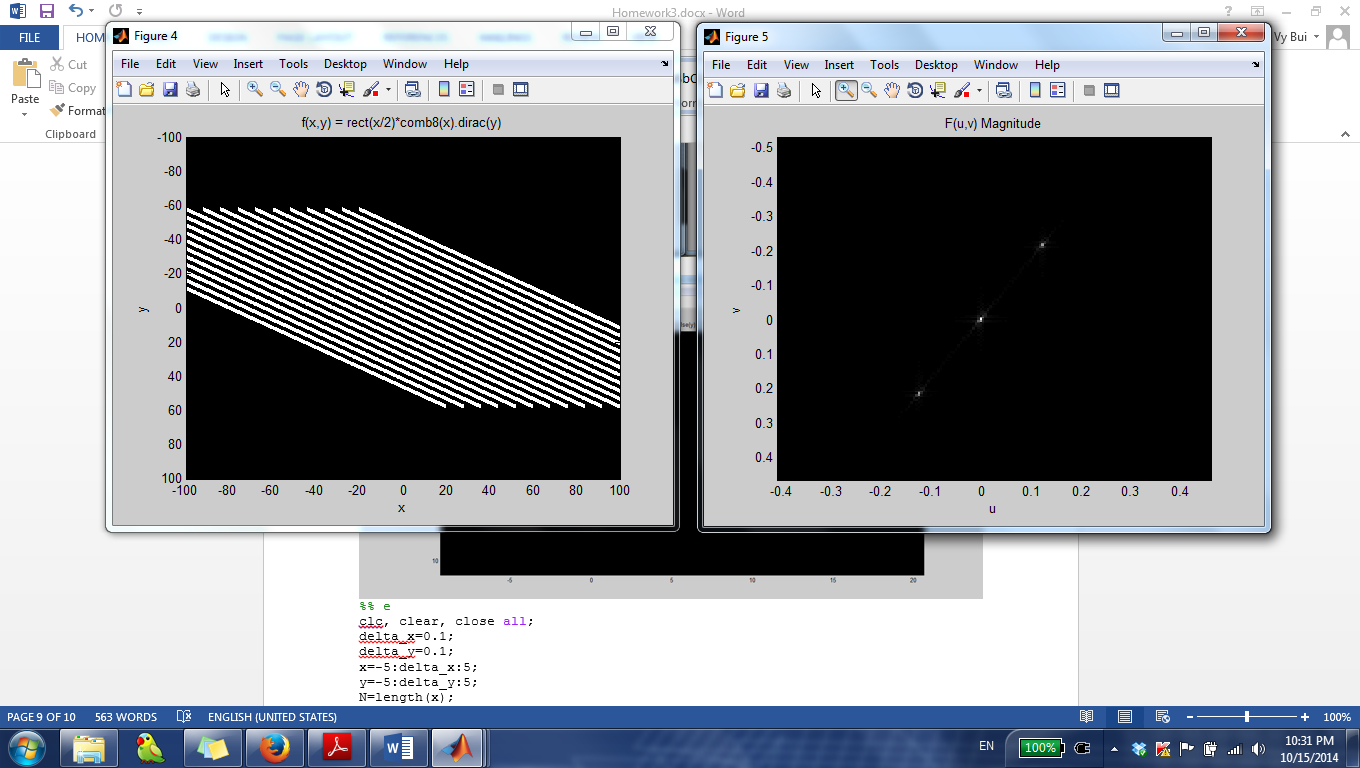
u=[-a:2\*a/N:a-2\*a/N]';

v=[-b:2\*b/N:b-2\*b/N]';

figure, imagesc(u,v,fftshift(abs(F))), colormap(gray), title('F(u,v) Magnitude'), xlabel('u'), ylabel('v'), axis tight;







%% e

clc, clear, close all;

delta\_x=0.1;

delta\_y=0.1;

x=-5:delta\_x:5;

y=-5:delta\_y:5;

N=length(x);

[X,Y] = meshgrid(x,y);

widthA = 1;

rect = rectpuls(X,widthA).\*rectpuls(Y,widthA);

figure, mesh(X,Y,rect); title('rect'), axis tight;

figure, imagesc(x,y,rect); title('rect - top view'), axis tight;

comb22 = zeros(length(x));

row\_index\_middle\_impulse = floor(length(x)/2);

col\_index\_middle\_impulse = floor(length(x)/2);

DELTA = 2/delta\_x;

comb22(col\_index\_middle\_impulse-2\*DELTA:DELTA:col\_index\_middle\_impulse+2\*DELTA,col\_index\_middle\_impulse-2\*DELTA:DELTA:col\_index\_middle\_impulse+2\*DELTA) = 1;

figure, imagesc(x,y,comb22), colormap(gray), title('comb8(x)\*impulse(y) - top view'), axis tight;

f = conv2(rect,comb22,'same');

figure, imagesc(x,y,f), colormap(gray(256)), title('f(x,y) = rect(x/2)\*comb8(x).dirac(y)'), xlabel('x'), ylabel('y');

F = fft2(f);

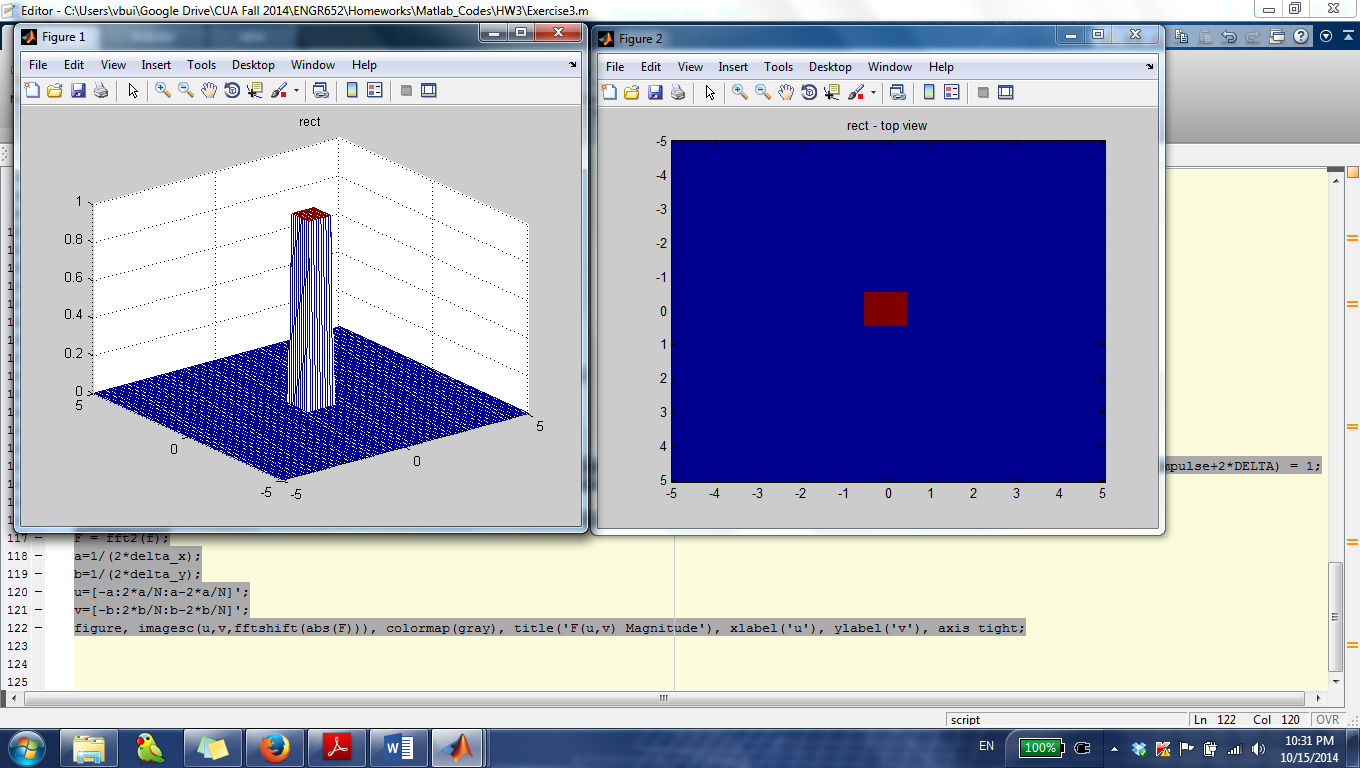
a=1/(2\*delta\_x);

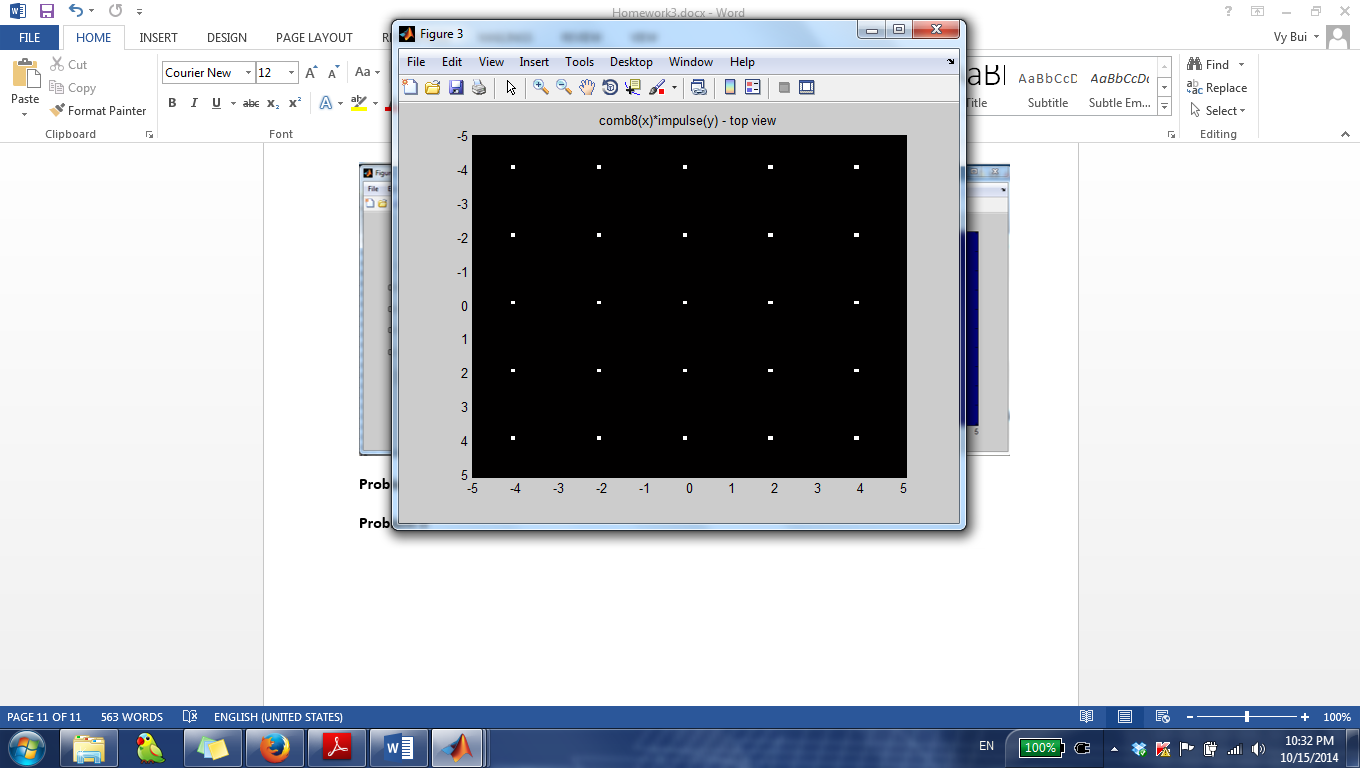
b=1/(2\*delta\_y);

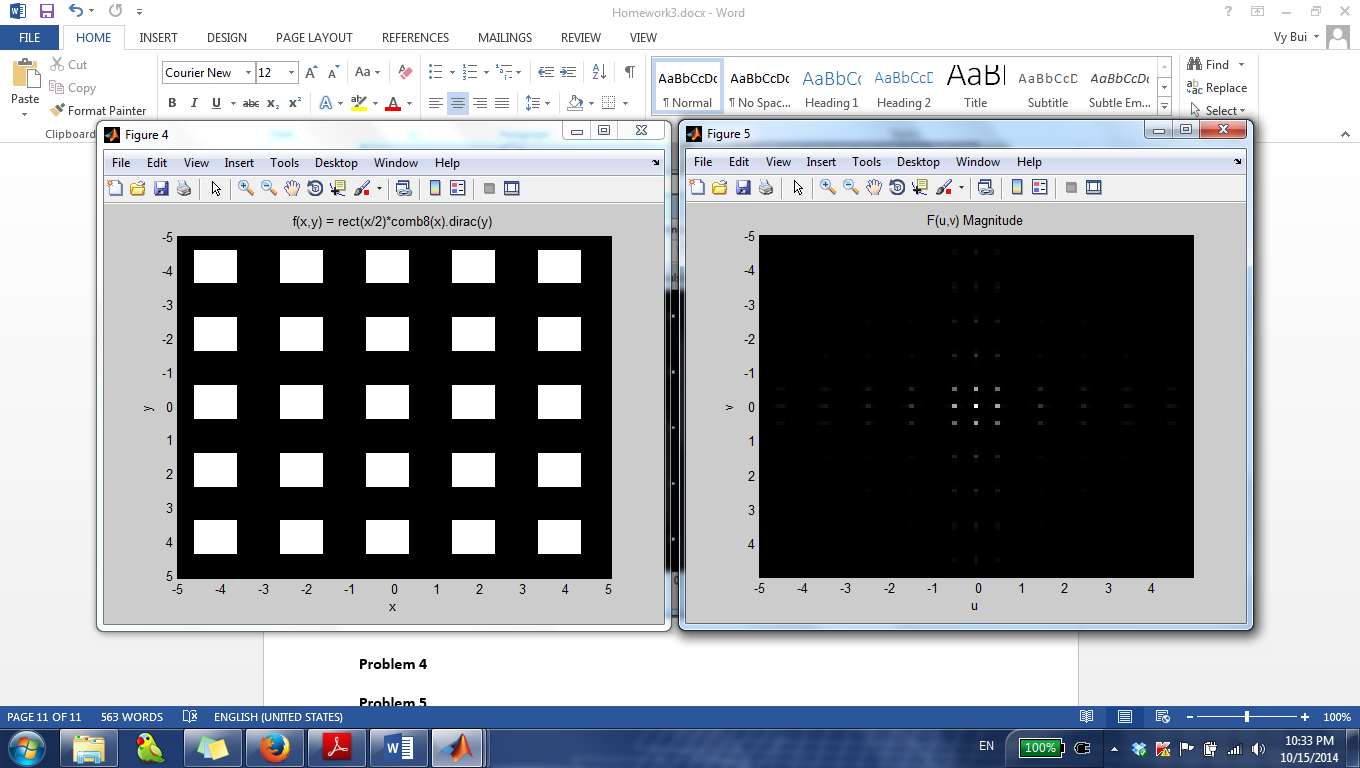
u=[-a:2\*a/N:a-2\*a/N]';

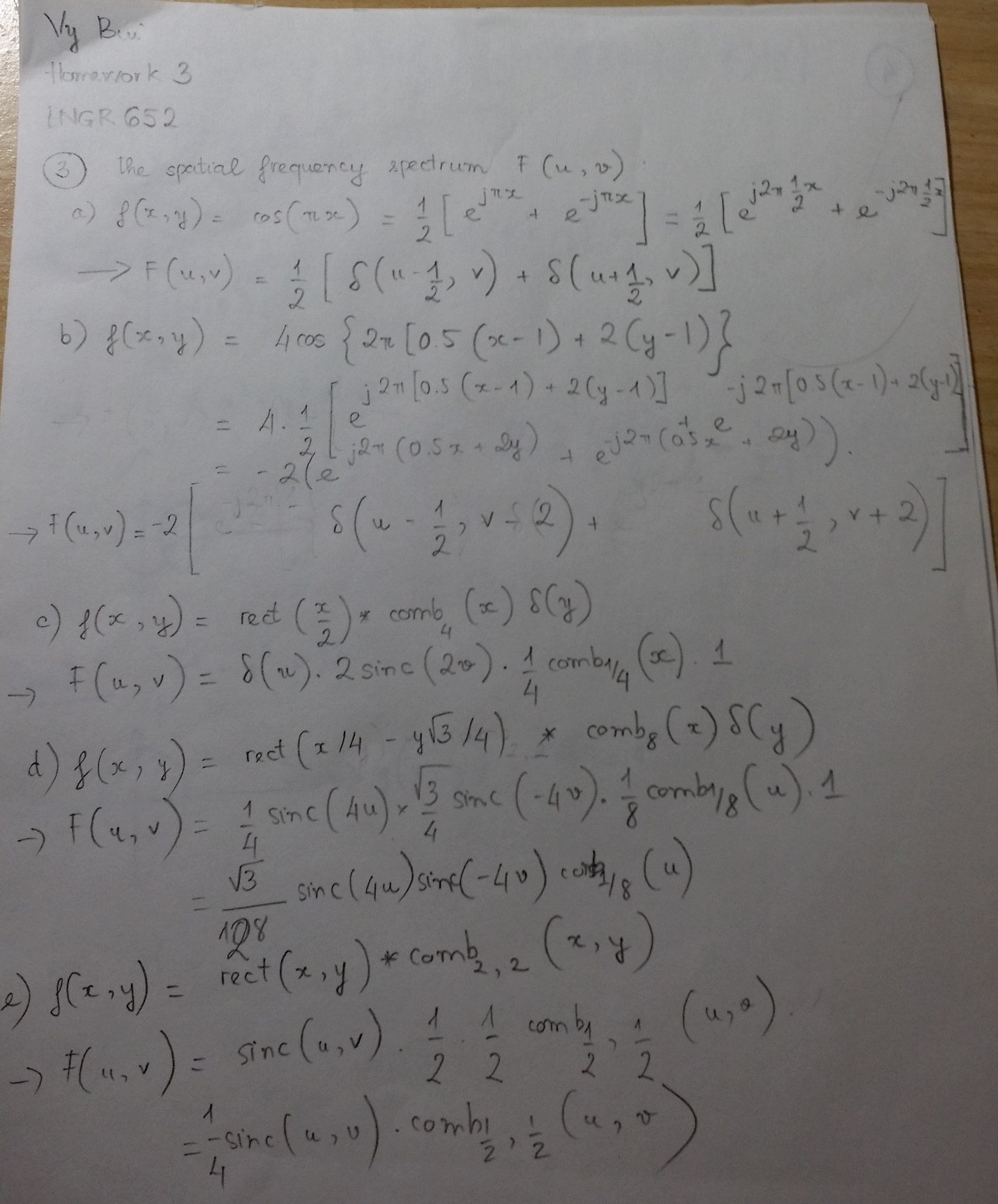
v=[-b:2\*b/N:b-2\*b/N]';

figure, imagesc(u,v,fftshift(abs(F))), colormap(gray), title('F(u,v) Magnitude'), xlabel('u'), ylabel('v'), axis tight;

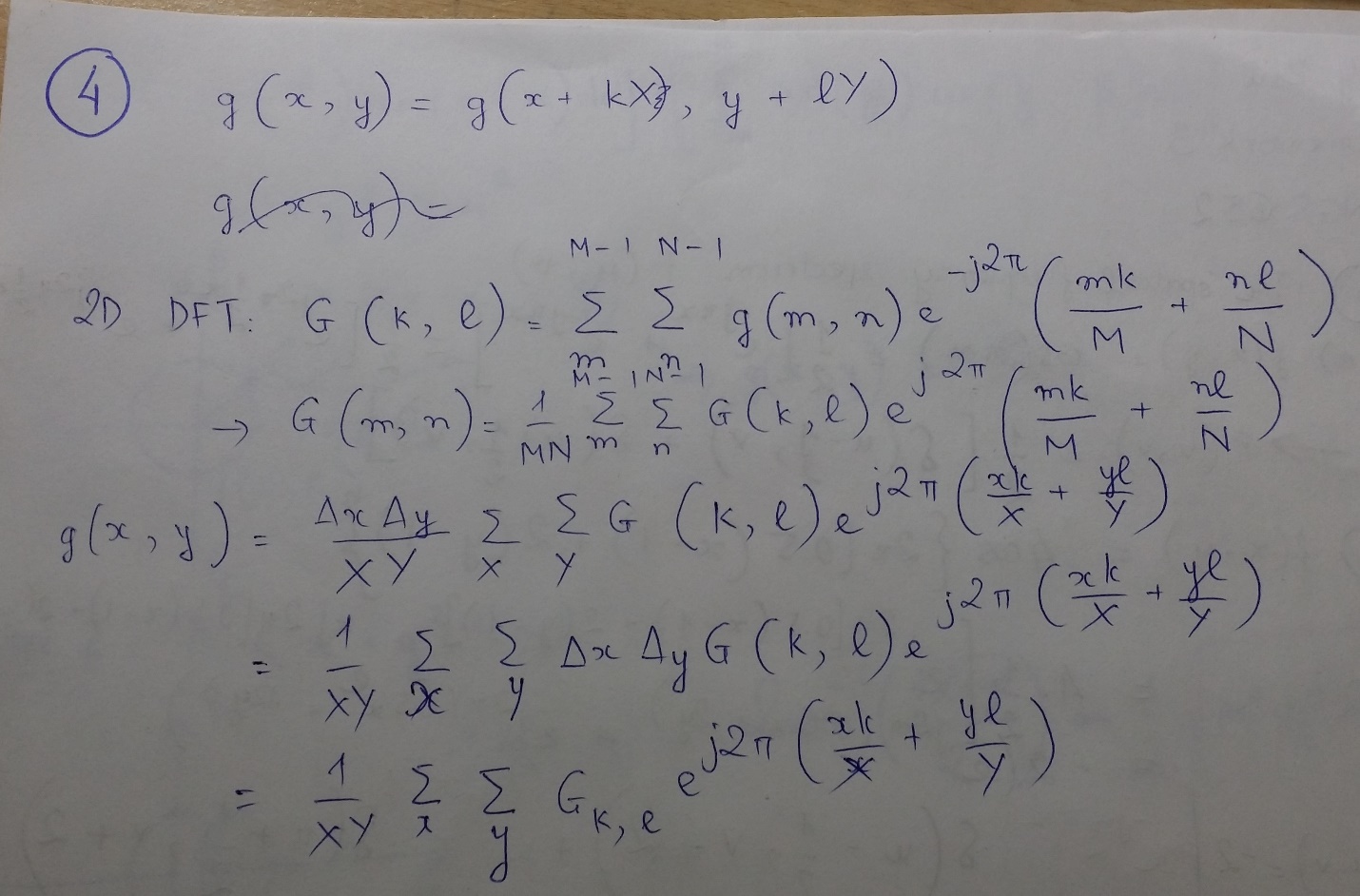








**Problem 4**

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**Problem 5**

%% Exercise 5a

clear, clc, close all;

delta\_x=0.1;

delta\_y=0.1;

x=-8:delta\_x:8;

y=-8:delta\_y:8;

N=length(x);

f = (checkerboard(8, 4, 8) > 0.5);

f = double(f);

figure, imagesc(x, y, f), colormap(gray(256));

% Find u,v coordinates

a=1/(2\*delta\_x);

b=1/(2\*delta\_y);

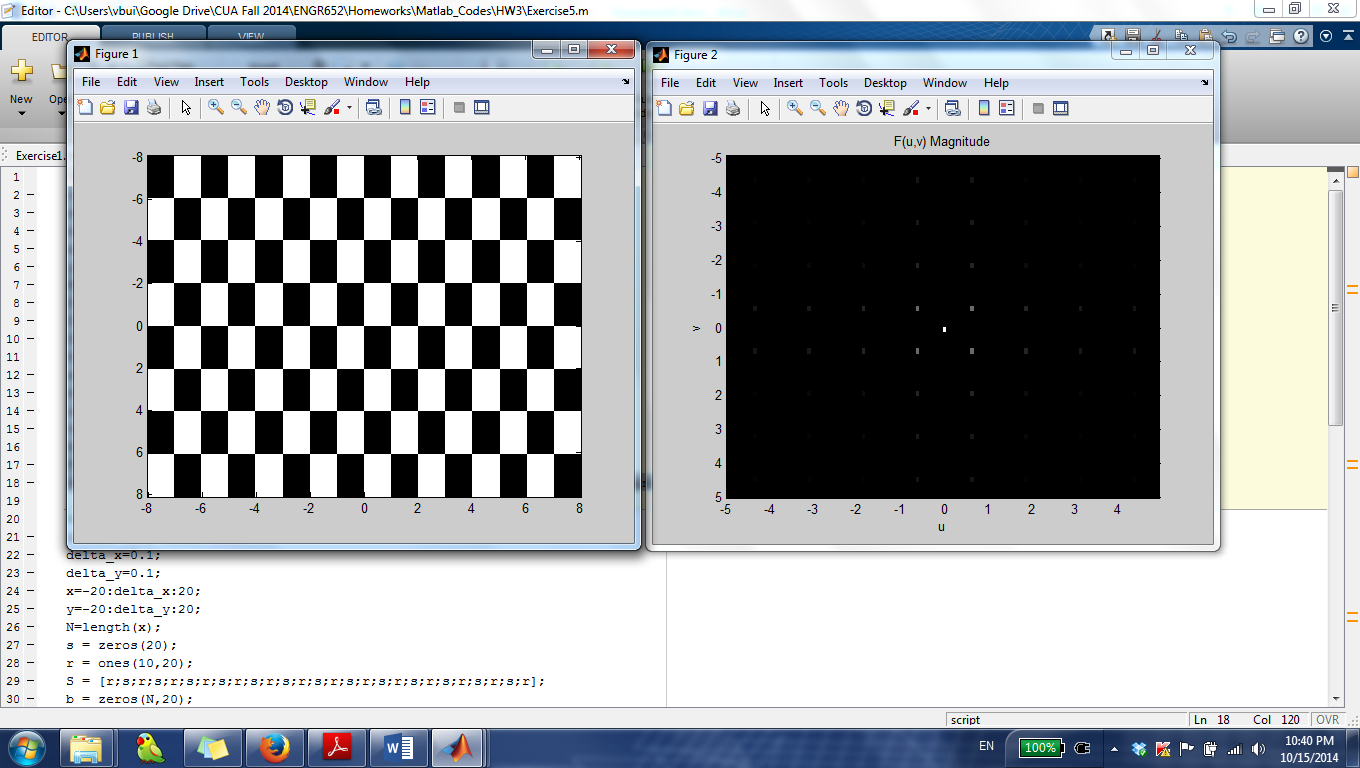
u=[-a:2\*a/N:a-2\*a/N]';

v=[-b:2\*b/N:b-2\*b/N]';

% fft

F = fft2(f);

figure, imagesc(u,v,fftshift(abs(F))), colormap(gray), title('F(u,v) Magnitude'), xlabel('u'), ylabel('v'), axis tight;



%% Exercise 5b

clear, clc, close all;

delta\_x=0.1;

delta\_y=0.1;

x=-20:delta\_x:20;

y=-20:delta\_y:20;

N=length(x);

s = zeros(20);

r = ones(10,20);

S = [r;s;r;s;r;s;r;s;r;s;r;s;r;s;r;s;r;s;r;s;r;s;r;s;r;s;r];

b = zeros(N,20);

w = ones(N,10);

Signal = [b w S w b w S w b w S w b w S w b w S w b w S w b w S w];

imagesc(x,y,Signal);

% Find u,v coordinates

a=1/(2\*delta\_x);

b=1/(2\*delta\_y);

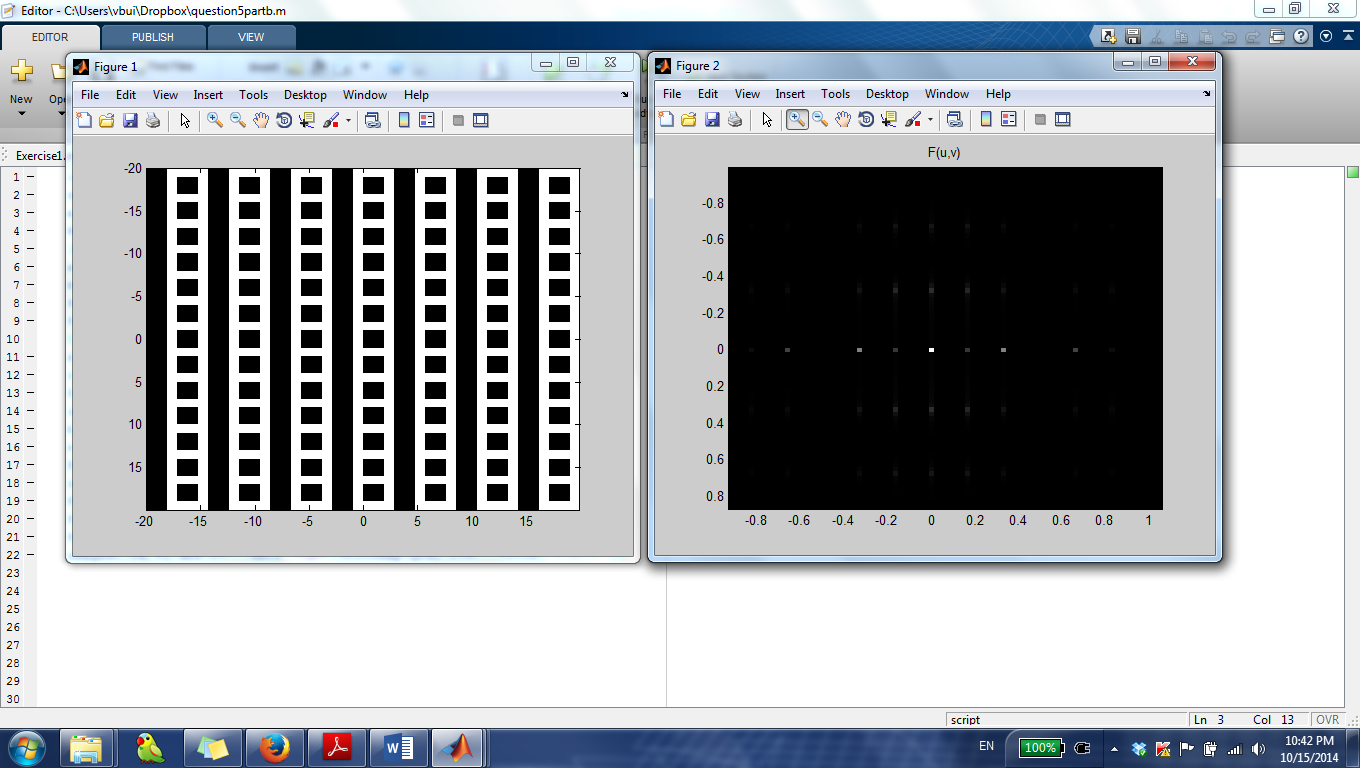
u=[-a:2\*a/N:a-2\*a/N]';

v=[-b:2\*b/N:b-2\*b/N]';

% fft

F = fft2(Signal);

figure, imagesc(u,v,fftshift(abs(F))), colormap(gray), title('F(u,v) Magnitude'), xlabel('u'), ylabel('v'), axis tight;



%% Exercise 5c

clear, clc, close all;

delta\_x=0.1;

delta\_y=0.1;

x=-6:delta\_x:6;

y=-6:delta\_y:6;

N=length(x);

[X,Y]=meshgrid(x,y);

rect = rectpuls(-X+Y+0.5,1)+rectpuls(-X+Y-4+0.5,1)+rectpuls(-X+Y+4+0.5,1)+rectpuls(-X+Y-8+0.5,1)+rectpuls(-X+Y+8+0.5,1)+rectpuls(-X+Y-12+0.5,1);

figure, mesh(X,Y,rect); title('rect'), axis tight;

figure, imagesc(x,y,rect); title('rect - top view'), axis tight;

% Find u,v coordinates

a=1/(2\*delta\_x);

b=1/(2\*delta\_y);

u=[-a:2\*a/N:a-2\*a/N]';

v=[-b:2\*b/N:b-2\*b/N]';

% fft

F = fft2(rect);

figure, imagesc(u,v,fftshift(abs(F))), colormap(gray), title('F(u,v) Magnitude'), xlabel('u'), ylabel('v'), axis tight;

