Problem 1

```
clc;clear;

%2D FFT
N=16;
L=2.*pi;
f=zeros(N,N);
x=zeros(1,N);
y=zeros(1,N);

%Exact Fuctional Values
 for j = 1:N
    for p=1:N
      x(j)=(L/N).*(j-1);
      y(p)=(L/N).*(p-1);
      f(j,p)= cos(3.*x(j)).*sin(5.*y(p))+sin(6.*x(j)).*cos(4.*y(p));
    end
 end

%Continuous Fourier Transform for exact coefficients
f_kc=zeros(N,N);
m=-(N/2):1:((N/2)-1);
for j = 1:N
    for p=1:N
      f_kc(j,p)= (1/(2.*pi.*2.*pi)).*(integral2(@(x,y)
(((cos(3.*x).*sin(5.*y)+sin(6.*x).*cos(4.*y))).*exp(-1i.*2.*pi.*((m(j).*x/
L)+(m(p).*y/L)))),0,L,0,L));
    end
 end

 %2D FFT
 for p=1:N
     f_x=myFFT_tocall(f);
 end
 f_x=f_x.';

 for m=1:N
         f_y=myFFT_tocall(f_x);
 end
 f_xy=f_y.';                     %2D FFT transform coefficients



%2D inverse FFT
for i =1:N
    f_y(1:N,i)=fftshift(f_y(1:N,i));
end

 %inverse in x dir:
 for p=1:N
          funcy(p,1:N)=ifft(f_y(1:N,p).*N);
 end

for i= 1:N
      funcy(1:N,i)=fftshift(funcy(1:N,i));
  end

 %in y-direction
 for m=1:N
     funcx=ifft(funcy.*N);        %2D FFT functional values
 end
```

My FFT Routine: Problem 1

```
function output=myFFT_tocall(f)

N=16;
M = log2(N);

% bitreversing

f1 = bitrevorder(f(1:N,1));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out1 = f1/N;
out1=fftshift(out1);

 % bitreversing

f1 = bitrevorder(f(1:N,2));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out2 = f1/N;
out2=fftshift(out2);

 f1 = bitrevorder(f(1:N,3));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out3 = f1/N;
out3=fftshift(out3);

 f1 = bitrevorder(f(1:N,4));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out4 = f1/N;
out4=fftshift(out4);

 f1 = bitrevorder(f(1:N,5));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out5 = f1/N;
out5=fftshift(out5);
```

```
 f1 = bitrevorder(f(1:N,6));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out6 = f1/N;
 out6=fftshift(out6);

 f1 = bitrevorder(f(1:N,7));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp= 0;
   end
 out7 = f1/N;
 out7=fftshift(out7);

 f1 = bitrevorder(f(1:N,8));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out8 = f1/N;
 out8=fftshift(out8);

f1 = bitrevorder(f(1:N,9));

%fft algorithm
```

```
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out9 = f1/N;
 out9=fftshift(out9);

 f1 = bitrevorder(f(1:N,10));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out10 = f1/N;
 out10=fftshift(out10);

f1 = bitrevorder(f(1:N,11));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out11 = f1/N;
 out11=fftshift(out11);

 f1 = bitrevorder(f(1:N,12));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out12 = f1/N;
 out12=fftshift(out12);


 f1 = bitrevorder(f(1:N,13));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out13 = f1/N;
 out13=fftshift(out13);


 f1 = bitrevorder(f(1:N,14));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out14 = f1/N;
 out14=fftshift(out14);


 f1 = bitrevorder(f(1:N,15));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out15 = f1/N;
 out15=fftshift(out15);


 f1 = bitrevorder(f(1:N,16));

%fft algorithm
%for x=1:N
   for l =1:M
    k = 2^l;
    w = exp((-1i.*2.*pi.*(0:k-1))./(k));
         for t=0:k:N-1
             temp(t+1:t+k) = [f1(t+1:t+k/2)+f1(t+k/2+1:t+k).*w(1:k/2), f1(t
+1:t+k/2)+f1(t+k/2+1:t+k).*w(k/2+1:k)] ;
         end
         f1=temp;
         temp = 0;
   end
 out16 = f1/N;
 out16=fftshift(out16);



 output=[out1.' out2.' out3.' out4.' out5.' out6.' out7.' out8.' out9.'
 out10.' out11.' out12.' out13.' out14.' out15.' out16.'];
end
```

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