PH170: Waves and Electromagnetics

LAB 1

Visualizations and plotting's of Vector fields, divergence and curl.

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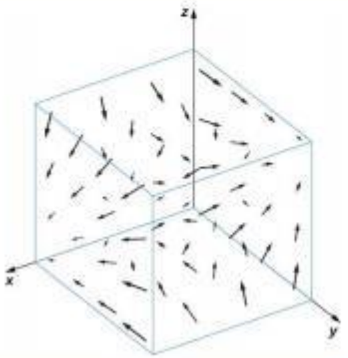
Theory

Vector Fields :

- Assignment of a vector at each point in subset of space.
- It represents the fluid flow.
- It is a way to visualize functions



Divergence :

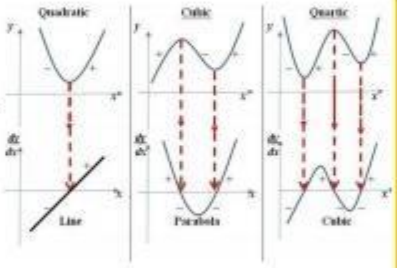
- Divergence of any vector (A) is $\nabla . A$
- It gives the volume density of the outward flux of a vector field.

Gradient :

- Gradient of any function is given by

$$\nabla f(x,y) = \frac{\partial f}{\partial x}\hat{\imath} + \frac{\partial f}{\partial y}\hat{\jmath}$$

- Gradient of any function is zero at local maxima and minima.



Curl :

- It represents the infinitesimal circulation of a vector field in 3-D Euclidean space.
- A vector with curl zero is called irrotational.

$$\nabla \times \mathbf{F} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ F_x & F_y & F_z \end{vmatrix}$$

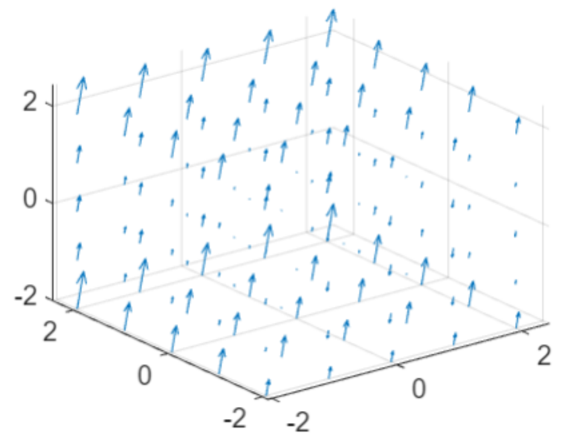
Q1)

Q11]

70lab1.asv ph170lab1que1a.m

```
clc
syms X Y Z
[X,Y,Z]=meshgrid(-2:2)
U = X.^2 + Y.^3 + Z.^4;
V = X.^2 + Y.^3 + Z.^4;
W = X.^2 + Y.^3 + Z.^4;
figure;
quiver3(X,Y,Z,U,V,W)
```

Figure 1



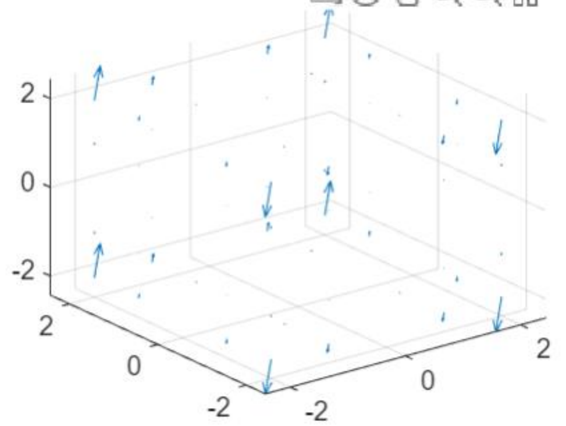
Command Window

```
     0     0     0     0     0
     0     0     0     0     0


Z(:,:,4) =

     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1


Z(:,:,5) =

     2     2     2     2     2
     2     2     2     2     2
     2     2     2     2     2
     2     2     2     2     2
     2     2     2     2     2

>>
```

70lab1.asv | ph170lab1que1a.m

```
syms X Y Z
[X,Y,Z]=meshgrid(-2:2)
U = X.^2.*Y.^3.*Z.^4;
V = X.^2.*Y.^3.*Z.^4;
W = X.^2.*Y.^3.*Z.^4;
figure;
quiver3(X,Y,Z,U,V,W)
```

Figure 2



Command Window

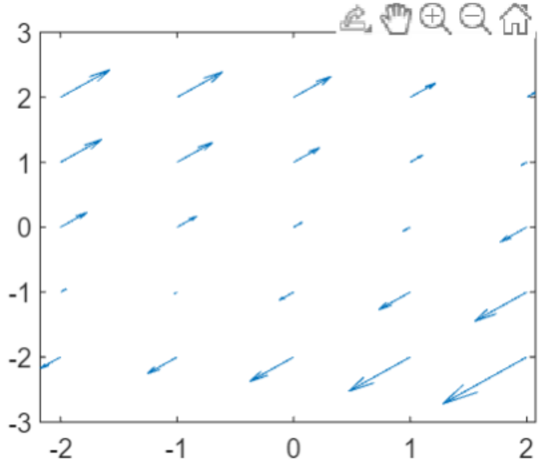
```
     0     0     0     0     0
     0     0     0     0     0


Z(:,:,4) =

     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1


Z(:,:,5) =

     2     2     2     2     2
     2     2     2     2     2
     2     2     2     2     2
     2     2     2     2     2
     2     2     2     2     2

>>
```

Q12]

ph170lab1.asv untitled2.m

```
clc
syms x y
[x, y]=meshgrid(-2:2)
U = 10*(2*x.*y-3*x.^2-4*y.^2
V = 10*(2*x.*y-3*x.^2-4*y.^2
figure;
quiver(x,y,U,V)
```

Figure 1



Command Window

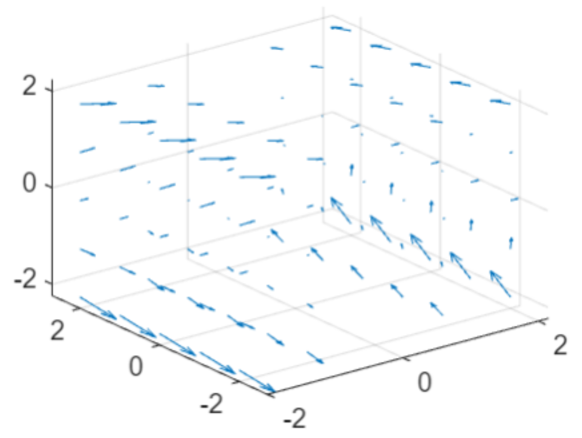
```
x =

    -2    -1     0     1     2
    -2    -1     0     1     2
    -2    -1     0     1     2
    -2    -1     0     1     2
    -2    -1     0     1     2


y =

    -2    -2    -2    -2    -2
    -1    -1    -1    -1    -1
     0     0     0     0     0
     1     1     1     1     1
     2     2     2     2     2

>>
```

Q15]

ph170lab1.asv | untitled2.m

```
clc
syms X Y Z
[X,Y,Z]=meshgrid(-2:2);
U = X.^2;
V = 3*X.*Z.^2;
W = -2*X.*Z;
figure;
quiver3(X,Y,Z,U,V,W)
```

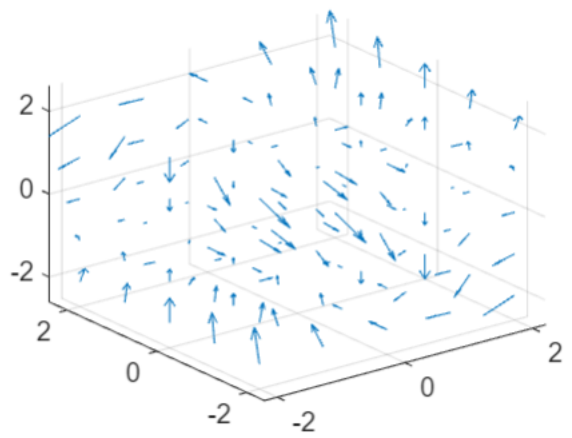
Figure 1



ph170lab1.asv untitled2.m

```
clc
syms X Y Z
[X,Y,Z]=meshgrid(-2:2);
U = X.*Y;
V = 2*Y.*Z;
W = 3*Z.*X;
figure;
quiver3(X,Y,Z,U,V,W)
```

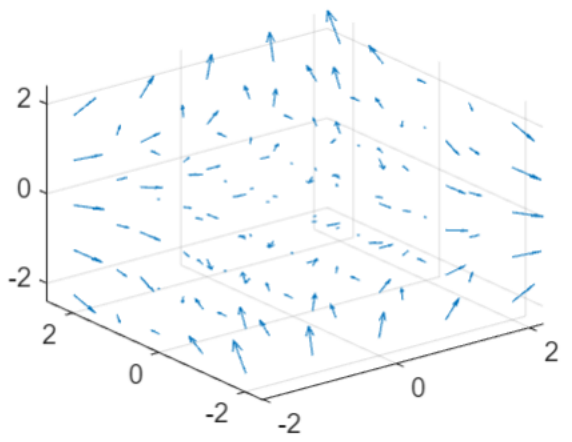
Figure 1



ph170lab1.asv untitled2.m

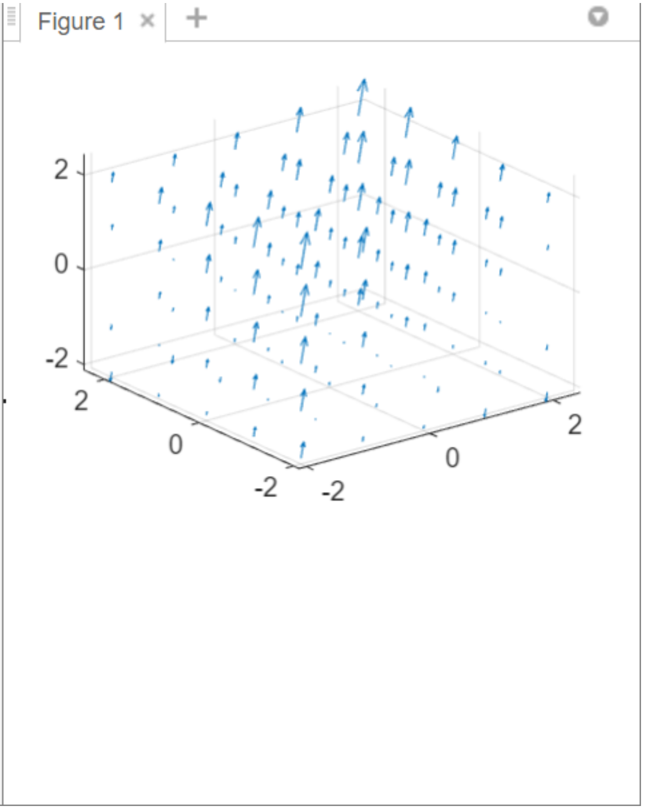
```
clc
syms X Y Z
[X,Y,Z]=meshgrid(-2:2);
U = Y.^2;
V = 2*X.*Y+Z.^2;
W = 2*Y.*Z;
figure;
quiver3(X,Y,Z,U,V,W)
```

Figure 1



Q26]

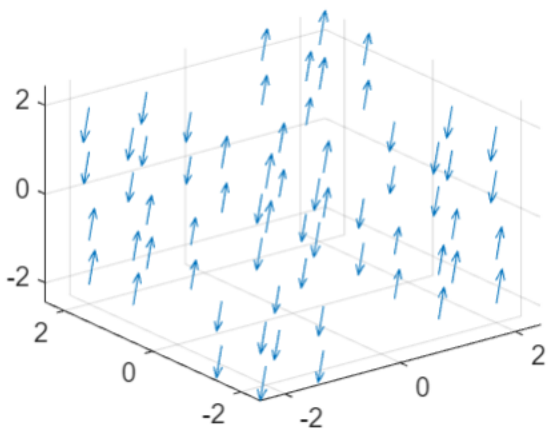
```
clc
syms X Y Z
[X,Y,Z]=meshgrid(-2:2);
U = X.^2+2*X.*Y+3*Z+4 ;
V = X.^2+2*X.*Y+3*Z+4 ;
W = X.^2+2*X.*Y+3*Z+4 ;
figure;
quiver3(X,Y,Z,U,V,W)
```



ph170lab1.asv untitled2.m

```
clc
syms X Y Z
[X,Y,Z]=meshgrid(-2:2);
U = sin(X).*sin(Y).*sin(Z) ;
V = sin(X).*sin(Y).*sin(Z) ;
W = sin(X).*sin(Y).*sin(Z) ;
figure;
quiver3(X,Y,Z,U,V,W)
```

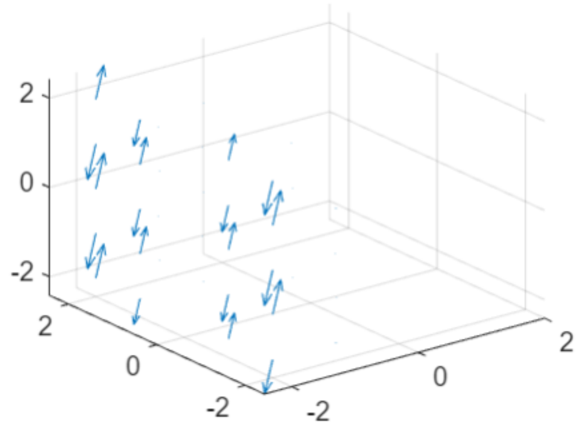
Figure 1



ph170lab1.asv   untitled2.m

```
clc
syms X Y Z
[X,Y,Z]=meshgrid(-2:2);
U = (exp(-5*X)).*sin(4*Y).*c
V = (exp(-5*X)).*sin(4*Y).*c
W = (exp(-5*X)).*sin(4*Y).*c
figure;
quiver3(X,Y,Z,U,V,W)
```

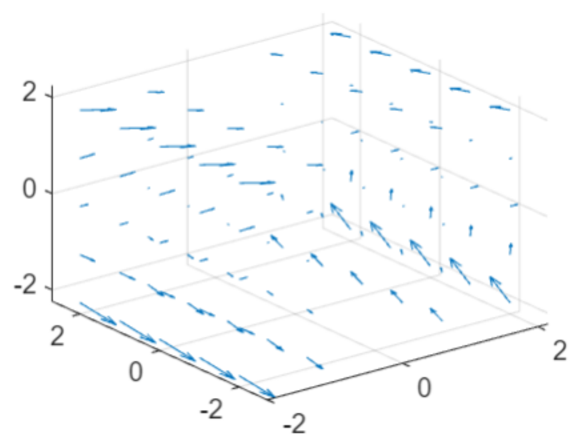
Figure 1



ph170lab1.asv untitled2.m

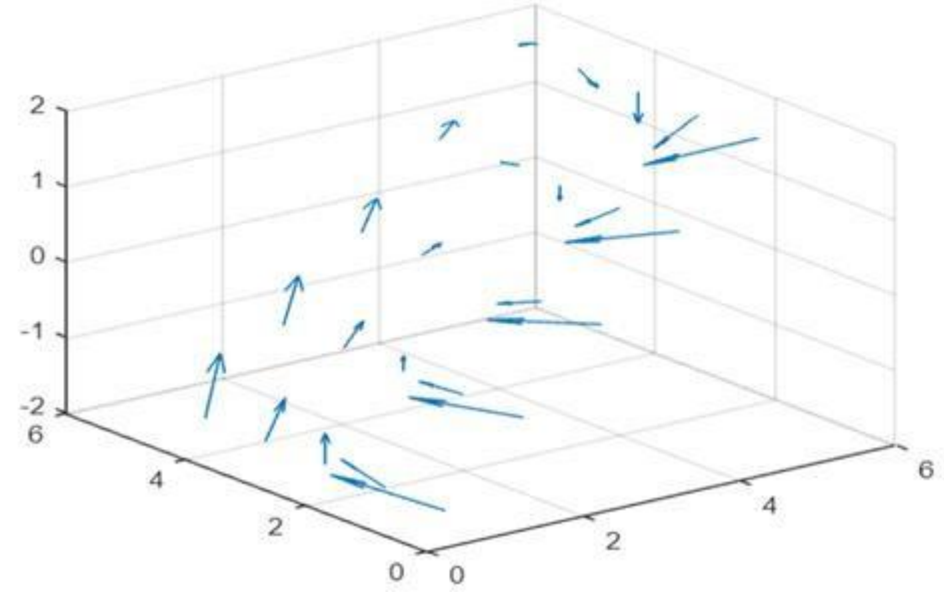
```
clc
syms X Y Z
[X,Y,Z]=meshgrid(-2:2);
U = X.^2;
V = 3*X.*Z.^2;
W = -2*X.*Z;
figure;
quiver3(X,Y,Z,U,V,W)
```

Figure 1



Q2

```
[X,Y] = meshgrid(-
2:2); U = Y.^2;
V = -X;
scale_factor=0.5;
figure;quiver3(X,Y,U*scale_factor,V*scale_factor)
%figure;quiver3(X,Y,U*scale_factor,V*scale_factor,'AutoScale',
X = 3;
Y = 2;
U =
Y.^2; V
= -X;
val = sqrt(U.^2 + V.^2)
```

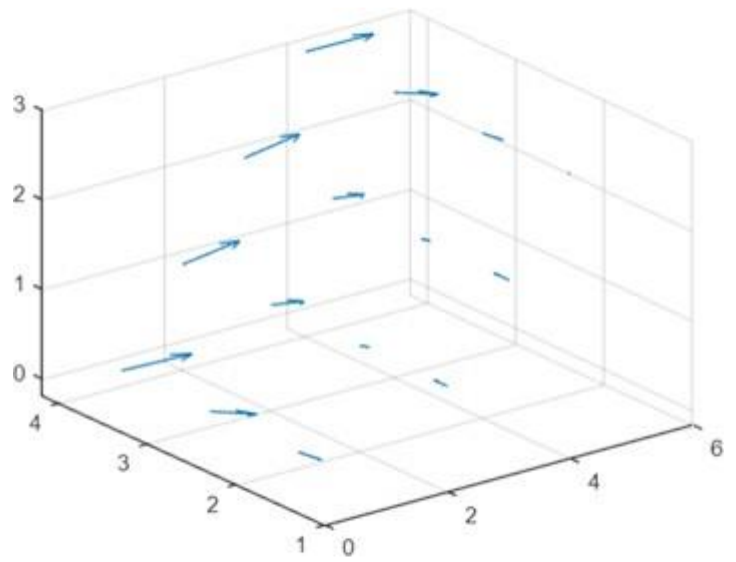


Output

Val = 5

Q3

```
[X,Y] =
meshgrid(0:pi); U =
sin(X);
V = -sin(Y);
%scale_factor = 1;
figure;quiver3(X,Y,U*scale_factor,V*scale_factor)
%figure;quiver3(X,Y,U*scale_factor,V*scale_factor,'AutoScale','off’)
X =
pi/2; Y
= pi/2;
U = sin(X);
V = -sin(Y);
val = sqrt(U.^2 + V.^2)
```

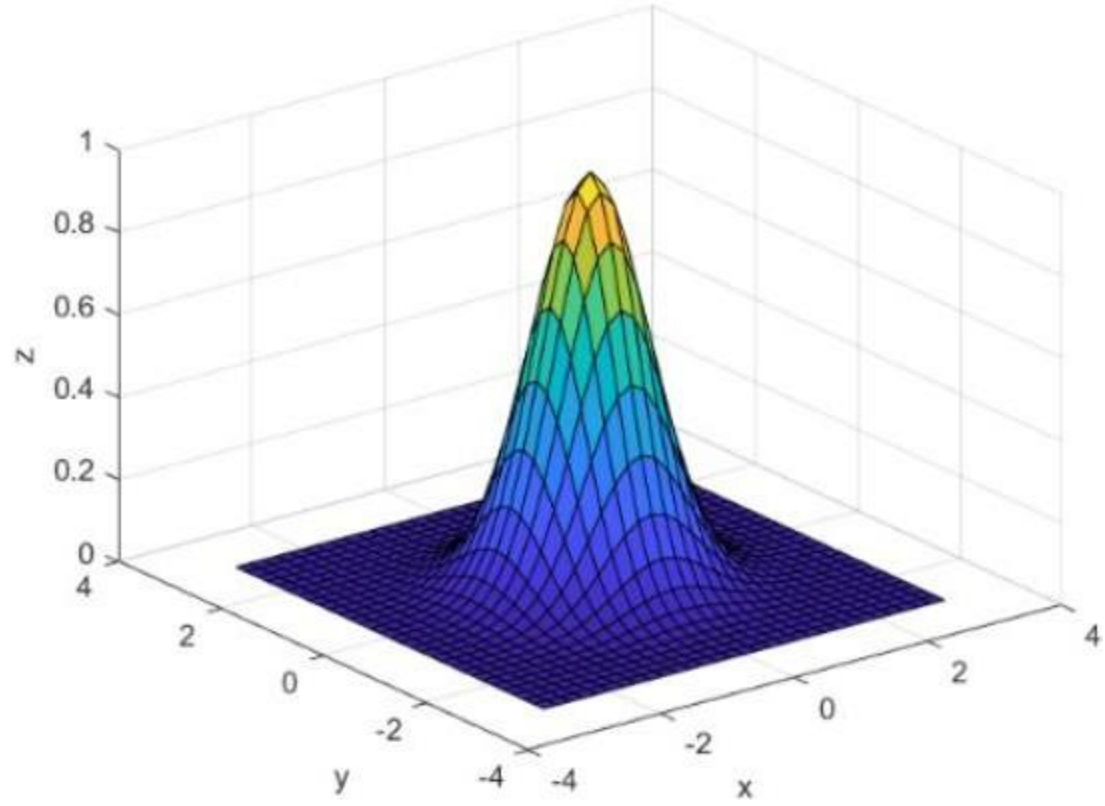


Output

Val = 1.4142

Q4

```
clear
x = -3:0.2:3;
y = x';
f = exp(-x.^2 -
y.^2); surf(x,y,f)
xlabel('x')
ylabel('y')
zlabel('z')
[fx,fy] =
gradient(f,0.2); x0 =
0;
y0 =0;
t = (x == x0) & (y ==
y0); indt = find(t);
gradient = [fx(indt),fy(indt)]
```

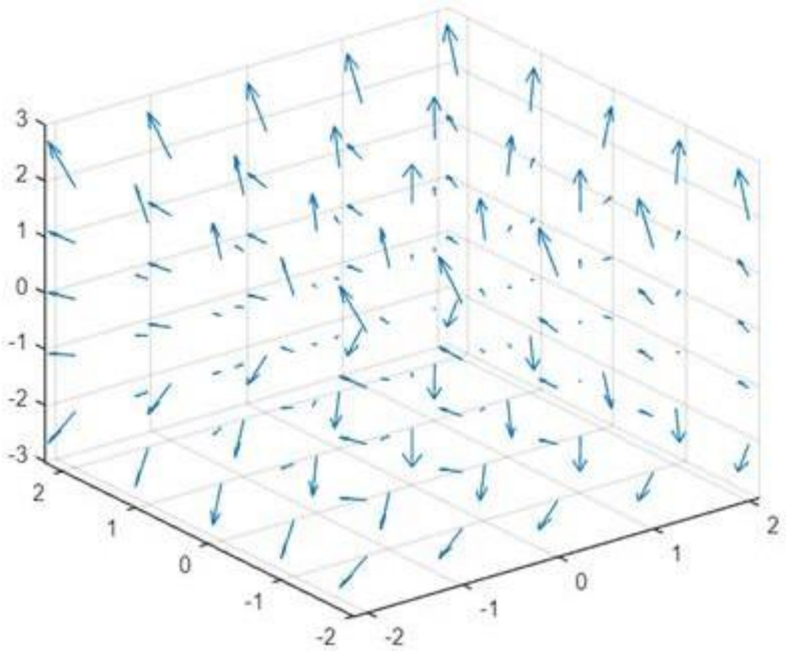


Output

```
gradient =

     0     0
```

Q4 a)

```
syms x y z;
F = x.^2 + y.^3 +
z.^4; G =
gradient(F)
[x,y,z] = meshgrid(-2:2);


U = 2*x;
V = 3*(y.^2);
W = 4*(z.^3);
figure;
scale_factor = 1;
quiver3(x,y,z,U*scale_factor,V*scale_factor,W*scale_fa
ctor);
```



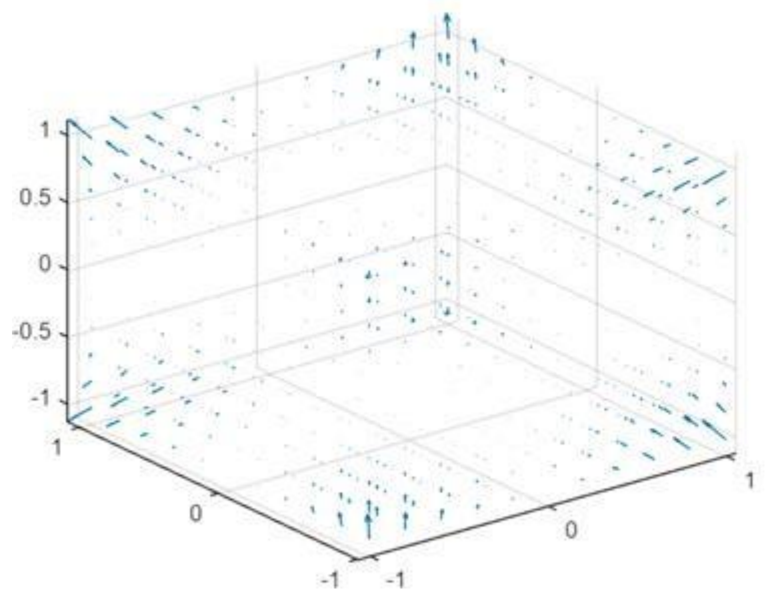
Output

G =

2*x
3*y^2
4*z^3

Q4 b)

```
syms x y z;
F = x.^2 * y.^3 *
z.^4;
G = gradient(F)
[x,y,z] = meshgrid(-1:0.2:1);


U = 2*x .* y.^3 .* z.^4;
V = 3*x.^2 .* y.^2 .* z.^4;
W = 4*x.^2 .* y.^3 .*
z.^3; figure;
scale_factor = 1;
quiver3(x,y,z,U*scale_factor,V*scale_factor,W*scale_factor);
```



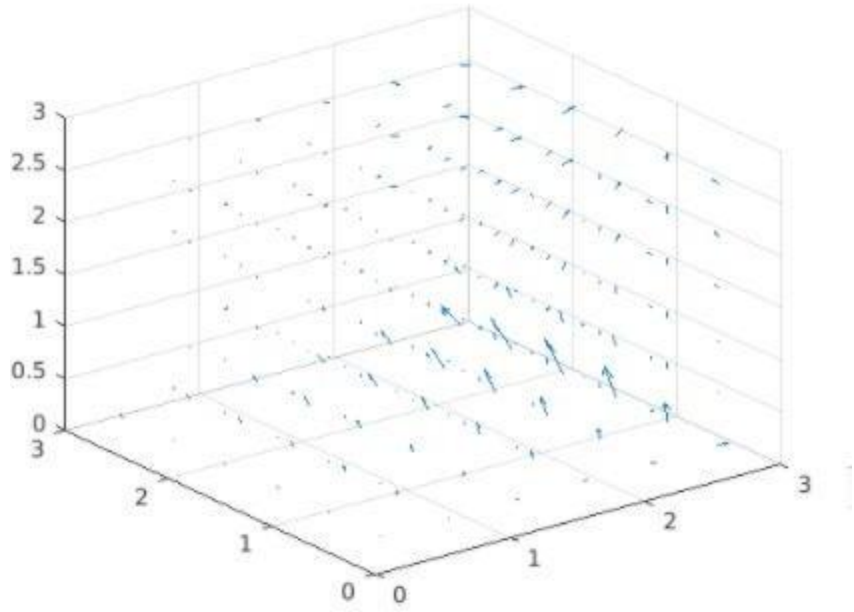
Output

G=

2*x*y^3*z^4
3*x^2*y^2*z^4
4*x^2*y^3*z^3

Q4 C)

```
syms x y z;
F = exp(x)*sin(y)*log(z);
G = gradient
(F)[x,y,z] = meshgrid(0:0.5:pi);
U = exp(x).*sin(y).*log(z);
V = exp(x).*cos(y).*log(z);
W = exp(x).*sin(y)./z;
figure;scale_factor = 1;
quiver3(x,y,z,U*scale_factor,V*scale_factor,W*scale_factor);
```



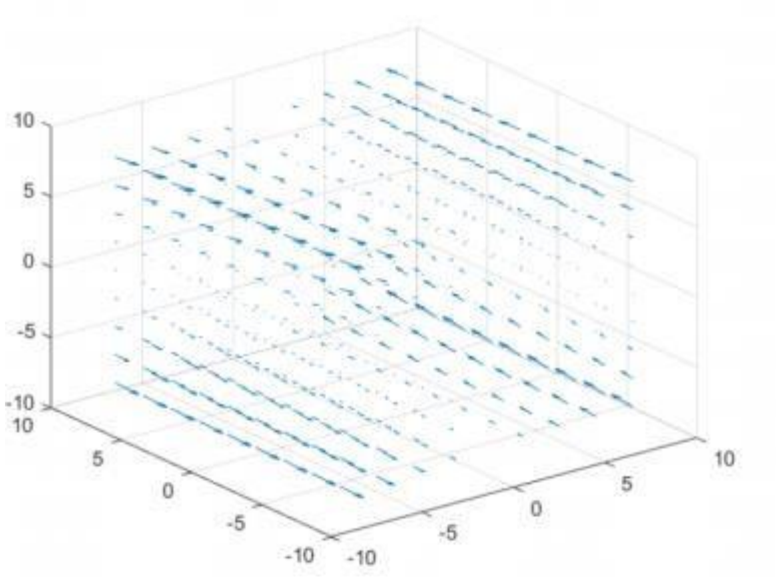
Output

G =

e^x
log(z)sin(y)
e^x
cos(y)log(z)
e^x sin(y)/z

Q5 a)

```
[x,y,z] = meshgrid(-
2:2); U = x.^2;
V = 3.x.(z.^2);
W = -2.*x.*z;
figure;
scale_factor = 1;
quiver3(x,y,z,U*scale_factor,V*scale_factor,W*scale_factor)
%quiver3(x,y,z,U*scale_factor,V*scale_factor,W*scale_factor,'AutoScale','off’);
syms x y z;field = [ x.^2 3.x.(z.^2) -2.*x.*z];
vars = [x y z];
D =
divergence(field,vars) C
= curl(field,vars);
```

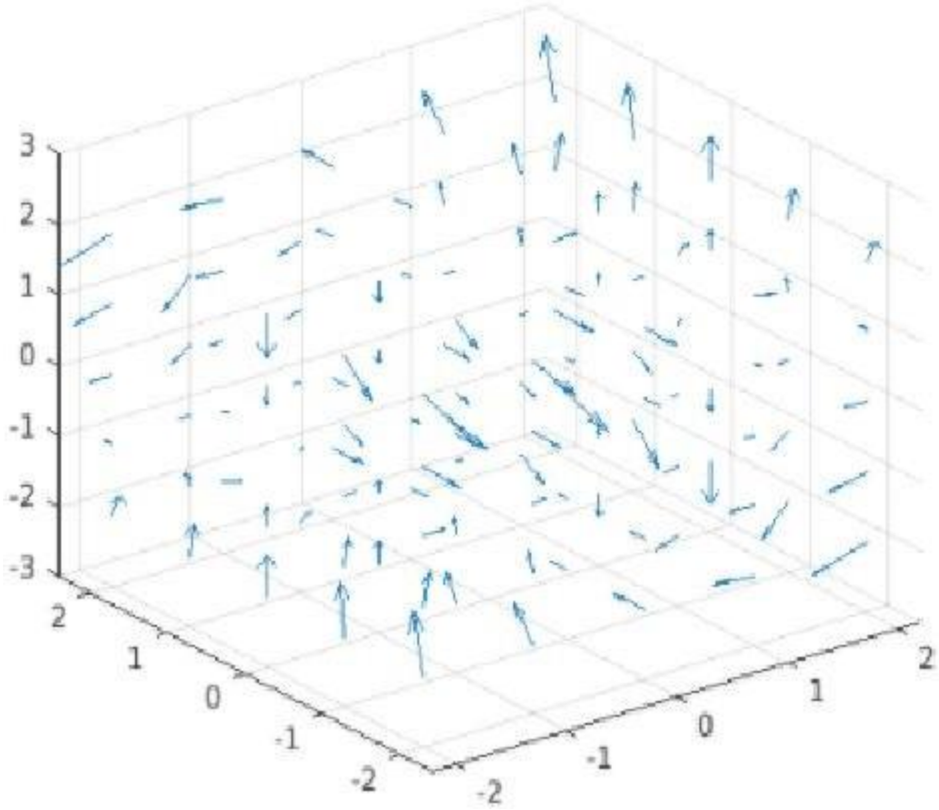


Output

D = 0

Q5 b)

```
syms x y z
 field = [x.*y 2.*y.*z 3.*z.*x];
vars = [x y z];
divergence(field,vars)
 [x,y,z] = meshgrid(-8:2:8, -8:2:8, -8:2:8);
Fx = x.*y;
 Fy = 2.*y.*z;
Fz = 3.*z.*x;
quiver3(x,y,z,Fx,Fy,Fz)
D = divergence(x,y,z,Fx,Fy,Fz);
```

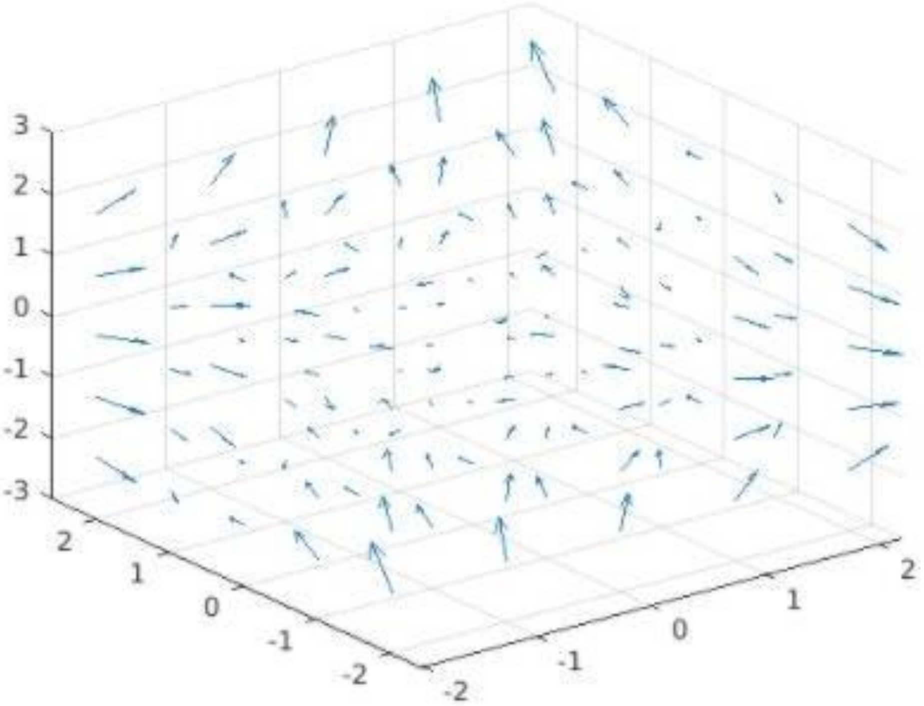


Output

D = 3x + y + 2z

Q5 C)

```
syms x y z
 field = [y.^2 2.*x.*y+z.^2 2.*y.*z];
vars = [x y z];
divergence(field,vars)
[x,y,z] = meshgrid(-8:2:8, -8:2:8, -8:2:8);
 Fx = y.^2;
 Fy = 2.*x.*y +
 z.^2; Fz =
 2.*y.*z;
quiver3(x,y,z,Fx,Fy,Fz);
D = divergence(x,y,z,Fx,Fy,Fz);
```

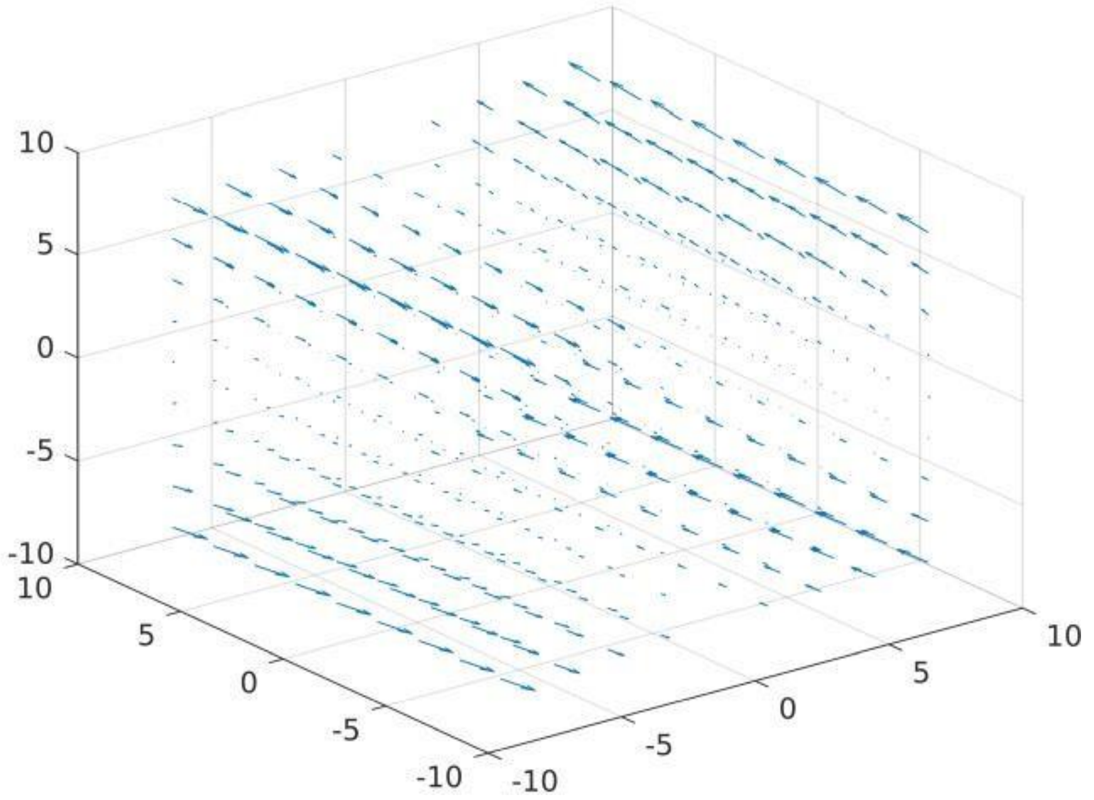


Output

D = 2x + 2y

Q6 a)

```
syms x y z
 a = [x.^2 3*x*z.^2 -2*x*z];
 b = [x y z];
 curl(a,b)
 [x,y,z] = meshgrid(-8:2:8, -8:2:8, -8:2:8);
Fx = x.^2;
 Fy = 3.*x.*z.^2;
 Fz = 2.*x.*z;
 quiver3(x,y,z,Fx,Fy,Fz
 );
 D = curl(x,y,z,Fx,Fy,Fz);
```

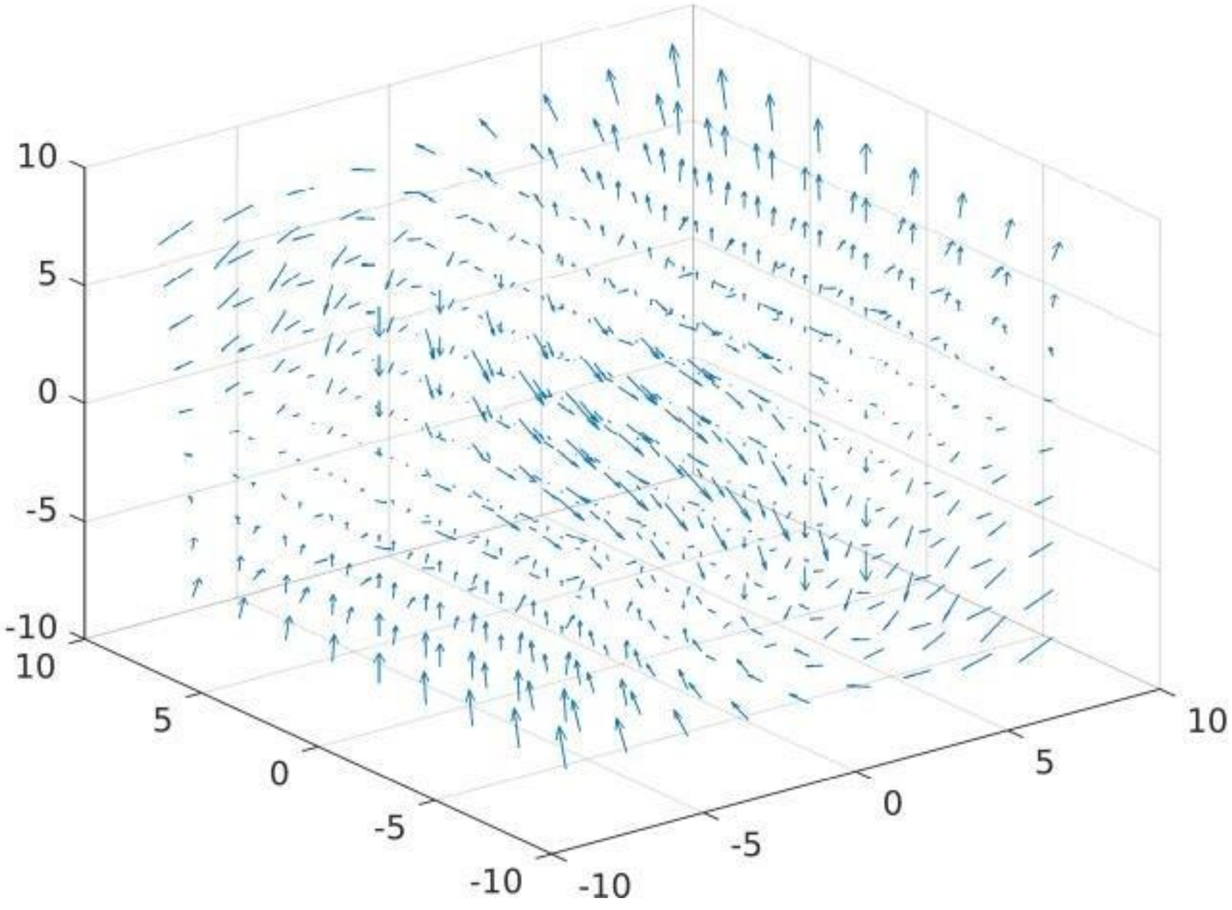


Output

Curl = $\begin{pmatrix} -6\,x\,z \\ 2\,z \\ 3\,z^2 \end{pmatrix}$

Q6 b)

```
syms x y z
 field = [x.*y 2.*y.*z
 3.*z.*x]; vars = [x y z];
curl(field,vars)
  [x,y,z] = meshgrid(-8:2:8, -8:2:8, -8:2:8);
 Fx = x.*y;
 Fy = 2.*y.*z;
 Fz = 3.*z.*x;
quiver3(x,y,z,Fx,Fy,Fz)
D = curl(x,y,z,Fx,Fy,Fz);
```

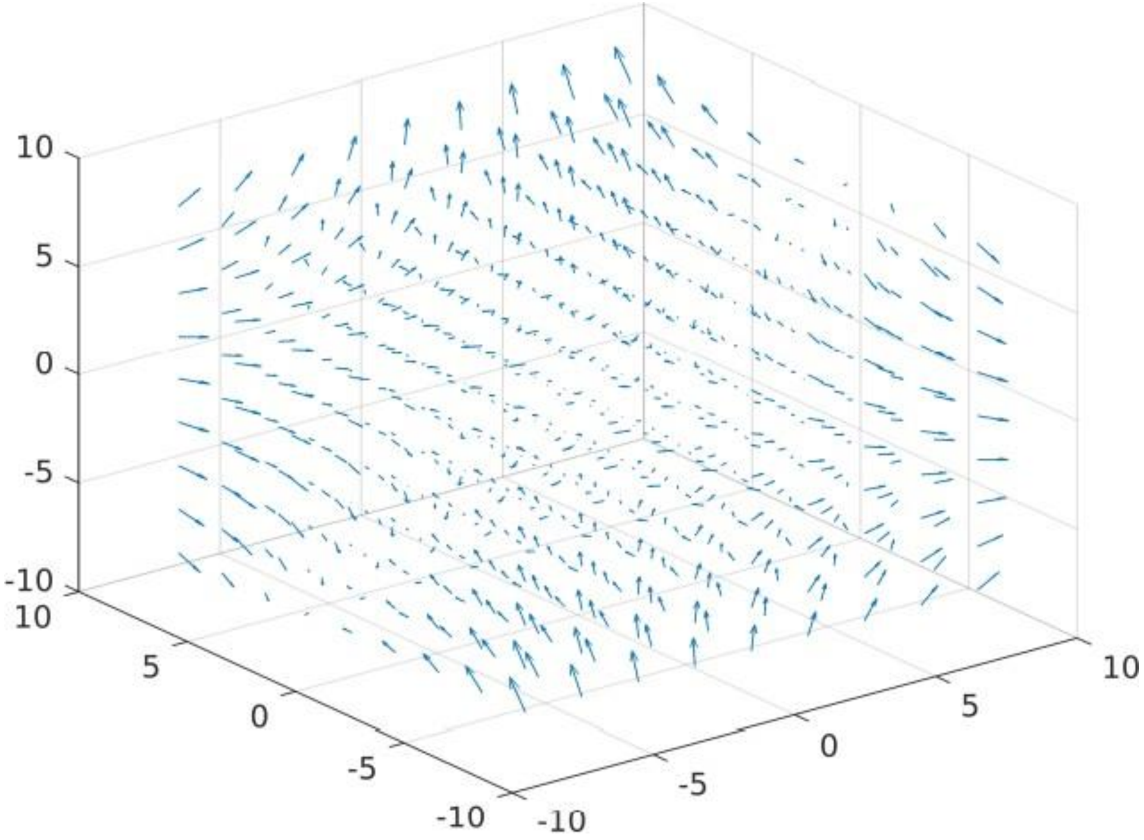


Output

Curl = $\begin{pmatrix} -2\,y \\ -3\,z \\ -x \end{pmatrix}$

Q6 c)

```
syms x y z
field = [y.^2 2.*x.*y+z.^2 2.*y.*z];
 vars = [x y z];
 curl(field,vars)
[x,y,z] = meshgrid(-8:2:8,-8:2:8,-8:2:8);
Fx = y.^2;
Fy = 2.*x.*y + z.^2;
Fz = 2.*y.*z;
quiver3(x,y,z,Fx,Fy,
Fz)
D = curl(x,y,z,Fx,Fy,Fz);
```

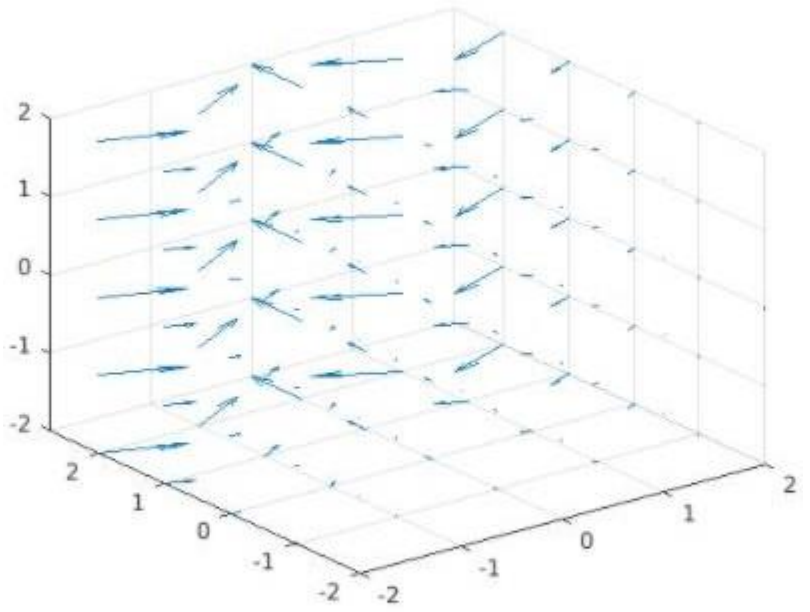


Output

Curl = $\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$

Q7

```
syms x y z
field = [(-exp(y)*sin(x)) (exp(y)*cos(x))
0]; vars = [x y z];
D =
divergence(field,vars) C
= curl(field,vars)
disp("plotting vector field")
[x,y,z] = meshgrid(-2:2);
U = (-exp(y).*sin(x));
V =
(exp(y).*cos(x)); W
= z*0;
figure;
scale_factor = 1;
quiver3(x,y,z,U*scale_factor,V*scale_factor,W*scale_factor);
%quiver3(x,y,z,U*scale_factor,V*scale_factor,W*scale_factor,'AutoScale','off');
```



$D = 0$

***F =** (-exp(y)*sin(x))(x^) + (exp(y)*cos(x))(y^) + 0 (z^)*

$C = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$

Thank You