```
syms theta phi psi rho X Y Z
%rotation matrix x
r_x = [1 0 0 0;0 cos(theta) -sin(theta) 0; 0 sin(theta) cos(theta) 0; 0 0 0 1]
```

```
r_x =
```

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(\theta) & -\sin(\theta) & 0 \\ 0 & \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
r_y = [cos(phi) 0 sin(phi) 0; 0 1 0 0; -sin(phi) 0 cos(phi) 0; 0 0 0 1]
```

```
r_y =
```

$$\begin{pmatrix} \cos(\phi) & 0 & \sin(\phi) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin(\phi) & 0 & \cos(\phi) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
r_z = [cos(psi) -sin(psi) 0 0; sin(psi) cos(psi) 0 0;0 0 1 0; 0 0 0 1]
```

```
r_z =
```

$$\begin{pmatrix} \cos(\psi) & -\sin(\psi) & 0 & 0 \\ \sin(\psi) & \cos(\psi) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
oraxis = [0; 0; 100; 1]
```

```
oraxis = 4×1
     0
     0
   100
     1
```

```
vector1 = r_z*r_y*r_x*oraxis
```

```
vector1 =
```

$$\begin{pmatrix} 100\sin(\psi)\sin(\theta) + 100\cos(\psi)\cos(\theta)\sin(\phi) \\ 100\cos(\theta)\sin(\phi)\sin(\psi) - 100\cos(\psi)\sin(\theta) \\ 100\cos(\phi)\cos(\theta) \\ 1 \end{pmatrix}$$

```
%find axis deflection vector first and into transformation vector

trans = [1 0 0 vector1(1,1); 0 1 0 vector1(2,1); 0 0 1 vector1(3,1); 0 0 0 1]
```

trans =

$$\begin{pmatrix} 1 & 0 & 0 & 100\sin(\psi)\sin(\theta) + 100\cos(\psi)\cos(\theta)\sin(\phi) \\ 0 & 1 & 0 & 100\cos(\theta)\sin(\phi)\sin(\psi) - 100\cos(\psi)\sin(\theta) \\ 0 & 0 & 1 & 100\cos(\phi)\cos(\theta) \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
%find transformation of joint j2 with respect to j1 axis,
% j1 considered to be orgin an at zero distance from j2
rotmat_check = r_z*r_y*r_x
```

rotmat_check =

$$\begin{pmatrix} \cos(\phi)\cos(\psi) & \cos(\psi)\sin(\phi)\sin(\theta) - \cos(\theta)\sin(\psi) & \sin(\psi)\sin(\theta) + \cos(\psi)\cos(\theta)\sin(\phi) & 0 \\ \cos(\phi)\sin(\psi) & \cos(\psi)\cos(\theta) + \sin(\phi)\sin(\psi)\sin(\theta) & \cos(\theta)\sin(\phi)\sin(\psi) - \cos(\psi)\sin(\theta) & 0 \\ -\sin(\phi) & \cos(\phi)\sin(\theta) & \cos(\phi)\cos(\theta) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
rotmat = trans*r_z*r_y*r_x
```

rotmat =

$$\begin{pmatrix} \cos(\phi)\cos(\psi) & \cos(\psi)\sin(\phi)\sin(\theta) - \cos(\theta)\sin(\psi) & \sin(\psi)\sin(\theta) + \cos(\psi)\cos(\theta)\sin(\phi) & 100\sin(\psi)\sin(\theta) + 100\cos(\psi)\cos(\theta)\sin(\phi) \\ \cos(\phi)\sin(\psi) & \cos(\psi)\cos(\theta) + \sin(\phi)\sin(\psi)\sin(\theta) & \cos(\theta)\sin(\phi)\sin(\psi) - \cos(\psi)\sin(\theta) & 100\cos(\theta)\sin(\phi)\sin(\psi) - 100\cos(\psi)\sin(\theta) \\ -\sin(\phi) & \cos(\phi)\sin(\theta) & \cos(\phi)\cos(\theta) & 100\cos(\phi)\cos(\theta) \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
% cordinate of j2 with respect to j1

%vector of eoat arm with respect to j2
vector2 = [0; 555; 0; 1]
```

```
vector2 = 4×1
     0
   555
     0
     1
```

```
%rotation of to eoat with respect to j2
r_z1= [cos(rho) -sin(rho) 0 0; sin(rho) cos(rho) 0 0;0 0 1 0; 0 0 0 1]
```

r_z1 =

$$\begin{pmatrix} \cos(\rho) & -\sin(\rho) & 0 & 0 \\ \sin(\rho) & \cos(\rho) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
rotmat_j2eoat = r_z1*vector2
```

rotmat_j2eoat =

$$\begin{pmatrix} -555\sin(\rho) \\ 555\cos(\rho) \\ 0 \\ 1 \end{pmatrix}$$

```
%rotation of eoat with respect to j1
rotmat_j1eoat= rotmat*rotmat_j2eoat
```

rotmat_j1eoat =

$$\begin{pmatrix} 100\sin(\psi)\sin(\theta) - 555\cos(\rho)\ (\cos(\theta)\sin(\psi) - \cos(\psi)\sin(\phi)\sin(\theta)) - 555\cos(\phi)\cos(\psi)\sin(\rho) + 100\cos(\psi)\cos(\theta)\sin(\phi) \\ 555\cos(\rho)\ (\cos(\psi)\cos(\theta) + \sin(\phi)\sin(\psi)\sin(\theta)) - 100\cos(\psi)\sin(\theta) - 555\cos(\phi)\sin(\psi)\sin(\rho) + 100\cos(\theta)\sin(\phi)\sin(\psi) \\ 100\cos(\phi)\cos(\theta) + 555\sin(\phi)\sin(\rho) + 555\cos(\phi)\cos(\rho)\sin(\theta) \\ 1 \end{pmatrix}$$