In[158]:=
```
homoT =
 {{      Cos[theta]             -Sin[theta]            0             a          },
  {Sin[theta] * Cos[alpha]  Cos[theta] * Cos[alpha]  -Sin[alpha]  -Sin[alpha] * d},
  {Sin[theta] * Sin[alpha]  Cos[theta] * Sin[alpha]   Cos[alpha]   Cos[alpha] * d},
  {           0                      0                  0             1          }};

T[α_, aa_, dd_, θ_] := homoT /. {theta → θ, alpha → α, a → aa, d → dd};
```

In[235]:=
```
T0to1 = T[0, 0, 0, θ1];
T1to2 = T[90 Degree, L1, 0, θ2];
            度
T2to3 = T[0, L2, 0, θ3];
T3toE = T[0, L3, 0, 0];
```

In[239]:=
```
T0to2 = T0to1.T1to2;
T0to3 = T0to2.T2to3;
T0toE = T0to3.T3toE;
T2toE = T2to3.T3toE;
T1toE = T1to2.T2toE;
```

In[244]:=
```
z1 = T0to1[[ ;; 3, 3]];
z2 = T0to2[[ ;; 3, 3]];
z3 = T0to3[[ ;; 3, 3]];
```

In[220]:=
```
p1E = T0to1.T1toE[[ ;; , 4]];
p1E = p1E[[ ;; 3]]
p2E = T0to2.T2toE[[ ;; , 4]];
p2E = p2E[[ ;; 3]]
p3E = T0to3.T3toE[[ ;; , 4]];
p3E = p3E[[ ;; 3]]
```

Out[221]=
$$\{\cos(\theta1)\,(L1 + \cos(\theta2)\,(L2 + L3\cos(\theta3)) - L3\sin(\theta2)\sin(\theta3)),\\ \sin(\theta1)\,(L1 + \cos(\theta2)\,(L2 + L3\cos(\theta3)) - L3\sin(\theta2)\sin(\theta3)),\ \sin(\theta2)\,(L2 + L3\cos(\theta3)) + L3\cos(\theta2)\sin(\theta3)\}$$

Out[223]=
$$\{L1\cos(\theta1) + \cos(\theta1)\cos(\theta2)\,(L2 + L3\cos(\theta3)) - L3\cos(\theta1)\sin(\theta2)\sin(\theta3),\\ L1\sin(\theta1) + \sin(\theta1)\cos(\theta2)\,(L2 + L3\cos(\theta3)) - L3\sin(\theta1)\sin(\theta2)\sin(\theta3),\\ \sin(\theta2)\,(L2 + L3\cos(\theta3)) + L3\cos(\theta2)\sin(\theta3)\}$$

Out[225]=
$$\{L1\cos(\theta1) + L2\cos(\theta1)\cos(\theta2) + L3\,(\cos(\theta1)\cos(\theta2)\cos(\theta3) - \cos(\theta1)\sin(\theta2)\sin(\theta3)),\\ L1\sin(\theta1) + L2\sin(\theta1)\cos(\theta2) + L3\,(\sin(\theta1)\cos(\theta2)\cos(\theta3) - \sin(\theta1)\sin(\theta2)\sin(\theta3)),\\ L2\sin(\theta2) + L3\,(\sin(\theta2)\cos(\theta3) + \cos(\theta2)\sin(\theta3))\}$$

In[251]:=
```
J = {Cross[z1, p1E],
       叉积
     Cross[z2, p2E],
     叉积
     Cross[z3, p3E]};
     叉积
J = Transpose[J];
    转置
```

In[250]:=
```
Insert[Grid[J], {Dividers → All, Spacings → 1.5 {1, 1}}, 2]
```
插入 格子 分隔线 全部 间隔

Out[250]=

$-L1\sin(\theta1) - L2\sin(\theta1)\cos(\theta2) + L3\sin(\theta1)\sin(\theta2)\sin(\theta3) - L3\sin(\theta1)\cos(\theta2)\cos(\theta3)$	$-L2\cos(\theta1)\sin(\theta2) - L3\cos(\theta1)\sin(\theta2)\cos(\theta3) - L3\cos(\theta1)\cos(\theta2)\sin(\theta3)$	$-L2\cos(\theta1)\sin(\theta2) - L3\cos(\theta1)\sin(\theta2)\cos(\theta3) - L3\cos(\theta1)\cos(\theta2)\sin(\theta3)$
$L1\cos(\theta1) + L2\cos(\theta1)\cos(\theta2) + L3\cos(\theta1)\cos(\theta2)\cos(\theta3) - L3\cos(\theta1)\sin(\theta2)\sin(\theta3)$	$-L2\sin(\theta1)\sin(\theta2) - L3\sin(\theta1)\sin(\theta2)\cos(\theta3) - L3\sin(\theta1)\cos(\theta2)\sin(\theta3)$	$-L2\sin(\theta1)\sin(\theta2) - L3\sin(\theta1)\sin(\theta2)\cos(\theta3) - L3\sin(\theta1)\cos(\theta2)\sin(\theta3)$
0	$L1\sin^2(\theta1) + L1\cos^2(\theta1) + L2\cos^2(\theta1)\cos(\theta2) + L2\sin^2(\theta1)\cos(\theta2) - L3\sin^2(\theta1)\sin(\theta2)\sin(\theta3) + L3\cos^2(\theta1)\cos(\theta2)\cos(\theta3) - L3\cos^2(\theta1)\sin(\theta2)\sin(\theta3) + L3\sin^2(\theta1)\cos(\theta2)\cos(\theta3)$	$L1\sin^2(\theta1) + L1\cos^2(\theta1) + L2\cos^2(\theta1)\cos(\theta2) + L2\sin^2(\theta1)\cos(\theta2) - L3\sin^2(\theta1)\sin(\theta2)\sin(\theta3) + L3\cos^2(\theta1)\cos(\theta2)\cos(\theta3) - L3\cos^2(\theta1)\sin(\theta2)\sin(\theta3) + L3\sin^2(\theta1)\cos(\theta2)\cos(\theta3)$

In[247]:=
```
Det[J]
```
行列式

Out[247]= 0