HOMEWORK 5 ECE 4560

1. a) $g_{ab} = \left(d_1 + R(\theta_1)\, d_2,\ R(\theta_1)R(\theta_2)\right)$

b) $\begin{bmatrix} R(\theta) & \vec{d} \\ 0 & 1 \end{bmatrix}$

c) $g^{-1} = \left(-R^T d_1,\ R^T\right) = \begin{bmatrix} R^T & -R^T d \\ 0 & 1 \end{bmatrix}$

d) $R(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$

e) $\hat{\xi}_s = g_{sb}\, g_{sb}^{-1}$
$\hat{\xi}_b = g_{sb}^{-1}\, g_{sb}$

2) a) $g_e(\vec{\alpha}) = g_{wa}\, g_{ab}\, g_{bc}\, g_{ce}$

$= \begin{bmatrix} R(\alpha_1) & 0 \\ 0 & 0 \\ \hline 0\ 0 & 1 \end{bmatrix} \begin{bmatrix} R(\theta) & \alpha_2 \\ 0 & 0 \\ \hline 0\ 0 & 1 \end{bmatrix} \begin{bmatrix} R(\alpha_3) & l_1 \\ 0 & 0 \\ \hline 0\ 0 & 1 \end{bmatrix} \begin{bmatrix} R(\alpha_4) & l_2 \\ 0 & 0 \\ \hline 0\ 0 & 1 \end{bmatrix}$ WHERE $R(\theta) = \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix}$

c) $g_e(\vec{\alpha}_1)^{-1}\, g_e(\vec{\alpha}_2)$

d) $h^{-1}\, g_e(\vec{\alpha}_1)^{-1}\, g_e(\vec{\alpha}_2)\, h$

3) a) TO SIMPLIFY, TAKING $-\hat{z}_c \to -\hat{y}_{LEG}$ & $\hat{y}_c \to \hat{x}_c$

$\Rightarrow g_f = \left[\begin{array}{c|c} R(\theta_1) & \begin{matrix} 0 \\ -L \end{matrix} \\ \hline 0 & 1 \end{array}\right] \left[\begin{array}{c|c} R\theta_2 & \begin{matrix} 0 \\ -L \end{matrix} \\ \hline 0 & 1 \end{array}\right] \left[\begin{array}{c|c} R(\theta_3) & \begin{matrix} w \\ 0 \end{matrix} \\ \hline 0 & 1 \end{array}\right]$

4) a)

2b)

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function outMat = homogeneousMatrix(x,y,theta)
    outMat = [cos(theta) -sin(theta) x; sin(theta) cos(theta) y; 0 0 1];
end

function outMat = homogeneousInverse(outMat)
    rotation_transpose = transpose(outMat(1:2,1:2));
    outMat = [rotation_transpose, -rotation_transpose*outMat(1:2,3); 0 0 1];
end
l1 = 3/4;
l2 = 1/2;
alpha = NaN([1,4]);
g_we = @(alpha)
homogeneousMatrix(0,0,alpha(1))*homogeneousMatrix(alpha(2),0,0)*homogeneousMatrix(l1
,0,alpha(3))*homogeneousMatrix(l2,0,alpha(4))
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g_we = function_handle with value:
    @(alpha)homogeneousMatrix(0,0,alpha(1))*homogeneousMatrix(alpha(2),0,0)*homogeneousMatrix(l1,0,alpha(3))*homoger
```

```
alpha = [pi/4, 3/4, pi/4, pi/3];
g_we1 = g_we(alpha);
fprintf("Transform g_we1 = ([%.2f, %.2f], R(%.2f
rad)",g_we1(1,3),g_we1(2,3),atan2(g_we1(2,1),g_we1(1,1)));
```

```
Transform g_we1' = ([1.06, 1.56], R(2.62 rad)
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```
alpha = [-pi/3, 1, -pi/6, pi/4];
g_we2 = g_we(alpha);
fprintf("Transform g_we2 = ([%.2f, %.2f], R(%.2f
rad)",g_we2(1,3),g_we2(2,3),atan2(g_we2(2,1),g_we2(1,1)));
```

```
Transform g_we2' = ([0.88, -2.02], R(-0.79 rad)
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