HW 5

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Ethan Foss, A16129635

5.8:

```
syms L;
S = [0 1 0 0 0 0; 0 0 0 0 1 0; 0 0 1 2*L 0 0]'; % Screw axes

Js = jacobiansym(S)
```

```
Js =

[0, 0,                         sin(theta1)]
[1, 0,                                   0]
[0, 0,                         cos(theta1)]
[0, 0,  cos(theta1)*(theta2 + 2*conj(L))]
[0, 1,                                   0]
[0, 0, -sin(theta1)*(theta2 + 2*conj(L))]
```

5.19:

```
S = [0 0 0 0 0 1;1 0 0 0 0 0;0 0 1 1 0 0;0 0 1 1/sqrt(2) 1/sqrt(2)
 0;1/sqrt(2) -1/sqrt(2) 0 0 0 -1/sqrt(2);0 0 0 0 1 0]'; % Screw Axes

Js = jacobiansym(S);
Js1to4 = Js(:,1:4) % Part a

singular = rank(S) == length(S) % Part b

ci = S'*[0;1;-1;1;0;0] % Part Ci
cii = S'*[1;-1;0;1;0;-1] % Part Cii
```

```
Js1to4 =

[0,      1,                      0,
                                                  0]
[0,      0,           -sin(theta2),
                                       -sin(theta2)]
```

```
[0,      0,            cos(theta2),
                                                cos(theta2)]
[0,      0, theta1*sin(theta2) + 1, (2^(1/2)*cos(theta3))/2 -
 cos(theta3) - (2^(1/2)*sin(theta3))/2 + theta1*sin(theta2) + 1]
[0, theta1,                         0,
 (cos(theta2)*(2^(1/2)*cos(theta3) - 2*sin(theta3) +
 2^(1/2)*sin(theta3)))/2]
[1,      0,                         0,
 (sin(theta2)*(2^(1/2)*cos(theta3) - 2*sin(theta3) +
 2^(1/2)*sin(theta3)))/2]


singular =

  logical

   1


ci =

         0
         0
         0
   -0.2929
   -0.7071
         0


cii =

   -1.0000
    1.0000
    1.0000
    0.7071
    2.1213
         0
```

5.25:

```
W1 = 109; W2 = 82; L1 = 425; L2 = 392; H1 = 89; H2 = 95; % lengths
S = [0 0 1 0 0 0;0 1 0 -H1 0 0;0 1 0 -H1 0 L1;0 1 0 -H1 0 L1+L2;0 0 -1
 -W1 L1+L2 0;0 1 0 H2-H1 0 L1+L2]'; % Screw Axes
J = jacobiansym(S);
theta1 = pi/2;theta2 = pi/2;theta3 = pi/2;theta4 = pi/2;theta5 =
 pi/2;theta6 = pi/2;
J = subs(J); % substitute thetas

Jw = J(1:3,:) % part a
Jv = J(4:6,:) % part a

Aw = Jw*Jw';
```

```
Av = Jv*Jv';

[Sw,Ew] = eig(Aw);
[Sv,Ev] = eig(Av);
Sv = double([Sv(:,1)/sqrt(sum(Sv(:,1).^2)),Sv(:,2)/
sqrt(sum(Sv(:,2).^2)),Sv(:,3)/sqrt(sum(Sv(:,3).^2))]);

PrincipleAxesJw = real(double([sqrt(Ew) Sw]))
PrincipleAxesJv = real(double([sqrt(Ev) Sv]))

[St,Et] = eig(Aw^-1);
[Sf,Ef] = eig(Av^-1);
Sf = double([Sf(:,1)/sqrt(sum(Sf(:,1).^2)),Sf(:,2)/
sqrt(sum(Sf(:,2).^2)),Sf(:,3)/sqrt(sum(Sf(:,3).^2))]);

PrincipleAxesJt = real(double([sqrt(Et) St]))
PrincipleAxesJf = real(double([sqrt(Ef) Sf]))


Jw =

[0, -1, -1, -1, 0, 0]
[0,  0,  0,  0, 1, 0]
[1,  0,  0,  0, 0, 1]


Jv =

[0,   0,   0,    0,  336, -297]
[0, -89, 336,  336,    0,  109]
[0,   0,   0, -392, -109,    0]


PrincipleAxesJw =

    1.7321         0         0    1.0000         0         0
         0    1.0000         0         0    1.0000         0
         0         0    1.4142         0         0    1.0000


PrincipleAxesJv =

  585.9696         0         0    0.0314    0.3106   -0.9500
         0  228.0305         0   -0.8062    0.5696    0.1596
         0         0  465.7099    0.5907    0.7609    0.2683


PrincipleAxesJt =

    1.0000         0         0         0    1.0000         0
         0    0.5774         0    1.0000         0         0
         0         0    0.7071         0         0    1.0000
```

```
PrincipleAxesJf =

    0.0044         0         0    0.3106    0.0314   -0.9500
         0    0.0017         0    0.5696   -0.8062    0.1596
         0         0    0.0021    0.7609    0.5907    0.2683
```

6.9

```
B = [0 0 1 0 2 0;0 0 1 0 1 0]';
M = [1 0 0 2;0 1 0 0;0 0 1 0;0 0 0 1];
Tsd = [-.5 -.866 0 .366;.866 -.5 0 1.366; 0 0 1 0;0 0 0 1];
thetaguess = [0 30]'*pi/180;
ew = .001; ev = 10^-4;

[thetalist, success] = IKinBodyIterations(B, M, Tsd, thetaguess, ew,
 ev);

| i: 0 | thetas: [0;30] | Tsb: [0.866 -0.5 0 1.866;0.5 0.866 0 0.5;0
 0 1 0;0 0 0 1] | Vb: [0;0;1.571;0.4979;1.858;0] | wbmag: 1.5708 |
 vbmag: 1.9238
| i: 1 | thetas: [34.23;79.18] | Tsb: [-0.3973 -0.9177 0 0.4294;0.9177
 -0.3973 0 1.48;0 0 1 0;0 0 0 1] | Vb: [0;0;0.115;-0.0736;0.108;0] |
 wbmag: 0.115 | vbmag: 0.13073
| i: 2 | thetas: [29.98;90.22] | Tsb: [-0.503 -0.8643
 0 0.3632;0.8643 -0.503 0 1.364;0 0 1 0;0 0 0 1] | Vb:
 [0;0;-0.003495;0.000348;-0.003474;0] | wbmag: 0.0034953 | vbmag:
 0.0034914
| i: 3 | thetas: [30;90] | Tsb: [-0.5 -0.866 0 0.366;0.866 -0.5 0
 1.366;0 0 1 0;0 0 0 1] | Vb: [0;0;-1.136e-05;3.359e-09;1.064e-05;0] |
 wbmag: 1.136e-05 | vbmag: 1.064e-05
```

Part 2:

```
W1 = 109; W2 = 82; L1 = 425; L2 = 392; H1 = 89; H2 = 95; % Lengths(mm)
M = [-1 0 0 L1+L2;0 0 1 W1+W2; 0 1 0 H1-H2; 0 0 0 1]; % Zero Position
 M matrix
S = [0 0 1 0 0 0;0 1 0 -H1 0 0;0 1 0 -H1 0 L1;0 1 0 -H1 0 L1+L2;0 0 -1
 -W1 L1+L2 0;0 1 0 H2-H1 0 L1+L2]'; % Screw axes

for i = 1:6
    B(:,i) = Adjoint(M^-1)*S(:,i); % Body Screw Axes
end

Tsd = [0 1 0 -500;0 0 -1 100;-1 0 0 100;0 0 0 1]; % Desired End
 effector position
ew = .001; %rad
ev = .001*1000; % mm
thetaguess = [3,-1,2,-1,-.5,-1.5]'; % Theta Guess

[theta,success] = IKinBodyIterations(B, M, Tsd, thetaguess, ew, ev); %
 Determine thetas, create report
```

```
| i: 0 | thetas: [171.9;-57.3;114.6;-57.3;-28.65;-85.94]
 | Tsb: [0.06624 0.9341 0.3508 -423.6;0.02481 0.3499
 -0.9365 -122.4;-0.9975 0.07074 0 21.77;0 0 0 1] | Vb:
 [0.3583;-0.01269;-0.07004;-78.97;-32.93;-234] | wbmag: 0.36526 |
 vbmag: 249.1847
| i: 1 | thetas: [145.8;-61.52;102.4;-42.43;-34.22;-88.63]
 | Tsb: [0.002099 1 -1.246e-05 -476;0.01488 -4.369e-05
 -0.9999 109.8;-0.9999 0.002098 -0.01488 109.7;0 0 0 1] | Vb:
 [-2.808e-05;-0.01488;-0.002099;9.553;-24.02;9.85] | wbmag: 0.015027 |
 vbmag: 27.6665
| i: 2 | thetas: [148.2;-58.29;99.11;-40.91;-31.74;-89.88]
 | Tsb: [0.0006004 1 -0.000164 -499.7;0.0008823 -0.0001645
 -1 99.05;-1 0.0006002 -0.0008824 99.27;0 0 0 1] | Vb:
 [-0.0001643;-0.0008824;-0.0006003;-0.7247;-0.2752;-0.9502] | wbmag:
 0.0010798 | vbmag: 1.2263
| i: 3 | thetas: [148.2;-58.27;98.95;-40.67;-31.82;-90] |
 Tsb: [-1.187e-06 1 -8.962e-07 -500;-2.084e-06 -8.962e-07
 -1 100;-1 -1.187e-06 2.084e-06 100;0 0 0 1] | Vb:
 [-8.962e-07;2.084e-06;1.187e-06;0.001399;-0.001397;-0.0002457] |
 wbmag: 2.5602e-06 | vbmag: 0.0019922
```

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