Homework 1

Problem 2.3

(a) ${}^C_D T = {}^C_A T \, {}^A_B T \, {}^B_D T \qquad {}^A_B T = ({}^B_A T)^{-1} \qquad {}^B_D T = ({}^D_B T)^{-1}$

${}^C_D T = {}^C_A T \, ({}^B_A T)^{-1} \, ({}^D_B T)^{-1}$

(b) ${}^A P_1 = {}^A_D T \, {}^D P_1 \qquad {}^B P_1 = {}^B_D T \, {}^D P_1 \qquad {}^C P_1 = {}^C_D T \, {}^D P_1$

Calculations shown in MATLAB code:

```
%% problem 2.3
T1 = [sqrt(3)/2, 0, 0.5, 20; 0, -1, 0, 0; 0.5, 0, -sqrt(3)/2, 0; 0, 0, 0, 1]; %A to B
T2 = [sqrt(2)/2, sqrt(2)/2, 0, 0; sqrt(2)/2, -sqrt(2)/2, 0, 0; 0, 0, -1, 10; 0, 0, 0, 1]; %A to C
T3 = [1, 0, 0, 0; 0, sqrt(3)/2, 0.5, 10; 0, -0.5, sqrt(3)/2, 0; 0, 0, 0, 1]; %B to D
T4 = T2*inv(T1)*inv(T3); %D to C
disp('the Transform Matrix is:')
disp(T4)

P1D = [20,-30,5,1]'; %this point is defined in the D corrodinate system
P1A = inv(T1)*inv(T3)*P1D; %Transformation needs to be from D to A
disp('the P1 in A is:')
disp(P1A)
P1B = inv(T3)*P1D; %Transformation needs to be from D to B
disp('the P1 in B is:')
disp(P1B)
P1C = T4*P1D; %Transformation needs to be from D to C
disp('the P1 in C is:')
disp(P1C)
```

Outputs:

```
the Transformation Matrix is:
    0.6124   -0.4356    0.6597   -7.8915
    0.6124    0.7891   -0.0474  -20.1389
   -0.5000    0.4330    0.7500   15.6699
         0         0         0    1.0000

the P1 in A is:
   -7.8349
   37.1410
   13.5705
    1.0000

the P1 in B is:
   20.0000
  -37.1410
  -15.6699
    1.0000

the P1 in C is:
   20.7225
  -31.8028
   -3.5705
    1.0000
```

Problem 2.4

$${}^{A}_{B}T = {}^{A}_{C}T\ {}^{C}_{D}T\ {}^{D}_{B}T$$

Calculation shown in MATLAB:

```
%% problem 2.4
mag1 = sqrt(2^2+4^2+7^2); %magnitude of the vector, used for calculating unit vector
m1 = [2/mag1, 4/mag1, 7/mag1, 1]'; %unit vector
v1 = 1 - cos(60/180*pi);
s1 = sin(60/180*pi);
c1 = cos(60/180*pi);
P2 = [3, 4, -2, 1]'; %point passed through
T5 = [1, 0, 0, P2(1); 0, 1, 0, P2(2); 0, 0, 1, P2(3); 0, 0, 0, 1]; %Translation from C to A
T6 = [m1(1)^2*v1+c1, m1(1)*m1(2)*v1-m1(3)*s1, m1(1)*m1(3)*v1+m1(2)*s1, 0;
      m1(1)*m1(2)*v1+m1(3)*s1, m1(2)^2*v1+c1, m1(2)*m1(3)*v1-m1(1)*s1, 0;
      m1(1)*m1(3)*v1-m1(2)*s1, m1(2)*m1(3)*v1+m1(1)*s1, m1(3)^2*v1+c1, 0;
      0, 0, 0, 1]; %Rotation from D to C
T7 = [1, 0, 0, -P2(1); 0, 1, 0, -P2(2); 0, 0, 1, -P2(3); 0, 0, 0, 1]; %Translation from to B to D
T8 = T5*T6*T7; %Resultatnt Transfomration Matrix from B to A
disp('the Transformation Matrix is:')
disp(T8)
```

Output:

```
the Transformation Matrix is:
    0.5290   -0.6718    0.5185    5.1373
    0.7878    0.6159   -0.0056   -0.8383
   -0.3156    0.4114    0.8551   -0.9888
         0         0         0    1.0000
```

Problem 2.8

$${}^{A}_{B}T = {}^{A}_{D}T\ {}^{D}_{E}T\ {}^{E}_{B}T$$

$${}^{B}_{A}T = ({}^{A}_{B}T)^{-1}$$

$${}^{B}_{C}T = ({}^{A}_{B}T)^{-1}\ {}^{A}_{C}T$$

Calculation shown in MATLAB:

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```
%% problem 2.8
P3 = [10, 20, 10, 1]'; %point passes thorugh
mag2 = sqrt(2^2+4^2+6^2);
m2 = [2/mag2, 4/mag2, 6/mag2, 1]'; %unit vector
v2 = 1 - cos(60/180*pi);
s2 = sin(60/180*pi);
c2 = cos(60/180*pi);
T9 = [1, 0, 0, P3(1); 0, 1, 0, P3(2); 0, 0, 1, P3(3); 0, 0, 0, 1]; %Translation from D to A
T10 = [1, 0, 0, 0; 0, cos(30/180*pi), -sin(30/180*pi), 0;
       0, sin(30/180*pi), cos(30/180*pi), 0; 0, 0, 0, 1]; %Rotation from E to D
T11 = [1, 0, 0, -P3(1); 0, 1, 0, -P3(2); 0, 0, 1, -P3(3); 0, 0, 0, 1]; %Translation from B to E
T12 = T9*T10*T11; %B to A
T13 = [m2(1)^2*v2+c2, m2(1)*m2(2)*v2-m2(3)*s2, m2(1)*m2(3)*v2+m2(2)*s2, 0;
      m2(1)*m2(2)*v2+m2(3)*s2, m2(2)^2*v2+c2, m2(2)*m2(3)*v2-m2(1)*s2, 0;
      m2(1)*m2(3)*v2-m2(2)*s2, m2(2)*m2(3)*v2+m2(1)*s2, m2(3)^2*v2+c2, 0;
      0, 0, 0, 1]; %C to A
T14 = inv(T12)*T13; %C to B

disp('the Transformation Matrix is:')
disp(T14)
```

Output:

```
the Transformation Matrix is:
    0.5357   -0.6229    0.5701         0
    0.4853    0.7796    0.3958   -2.3205
   -0.6910    0.0646    0.7200   11.3397
         0         0         0    1.0000
```