

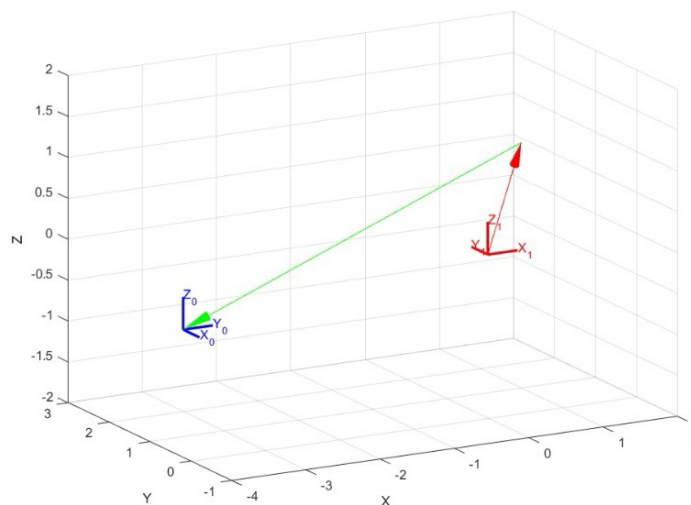
1. Homogeneous transformation matrix  $H_1^0$  for 3.4.

$$\begin{bmatrix} 0 & -1 & 0 & 2 \\ 1 & 0 & 0 & 3 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. MATLAB code for 3.1 ~ 3.6.

```
figure;
trplot(eye(4), 'color', 'b', 'frame', '0', 'length', 0.4, 'thick', 2); % Default frame {0}
xlabel('X'); ylabel('Y'); zlabel('Z');
axis([0 4 0 4 0 3]);
grid on;
hold on;
R_10 = rotz(90, 'deg'); % Rotation matrix for 90° about Z axis
t_10 = [2; 3; 1]; % Translation vector for position
q0 = [2; 3; 1];
plot_arrow([0,0,0], [q0(1),q0(2),q0(3)], 'b');
H_10 = rt2tr(R_10, t_10); % Combine rotation and translation
disp("H_10");
disp(H_10);
trplot(H_10, 'color', 'r', 'frame', '1', 'length', 0.4, 'thick', 2); % Frame {1} in red
p1 = [1; 1; 1];
p0 = H_10 * [p1; 1]; % Transform p1 to frame {0}
p0 = p0(1:3); % Extract position part
disp('p0');
disp(p0);
plot_arrow([0,0,0], [p0(1),p0(2),p0(3)], 'g');
plot_arrow([t_10(1),t_10(2),t_10(3)], [p0(1),p0(2),p0(3)], 'r');
```

3. Final output MATLAB figure for the operations in 3.1 ~ 3.6.



4. Homogeneous transformation matrix  $H_0^1$  for 3.8.

$$\begin{bmatrix} 0 & 1 & 0 & -3 \\ -1 & 0 & 0 & 2 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

5.  $t_0^1$  for 3.10.

$$\begin{bmatrix} -3 \\ 2 \\ -1 \end{bmatrix}$$

6. MATLAB code for 3.7 ~ 3.11.

```
figure;
trplot(eye(4), 'color', 'r', 'frame', '1', 'length', 0.4, 'thick', 2); % Default frame {1}
hold on;
grid on;
axis([-4 2 -1 3 -2 2]);

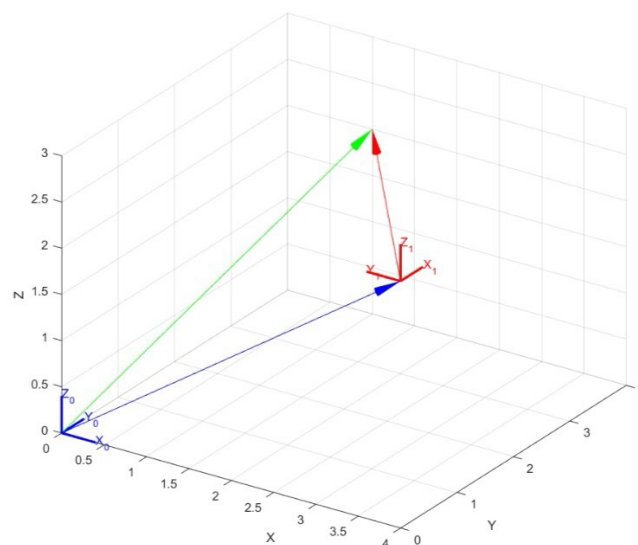
plot_arrow ([0,0,0], [p1(1),p1(2),p1(3)], 'r');

H_01 = inv(H_10);
trplot(H_01, 'color', 'b', 'frame', '0', 'length', 0.4, 'thick', 2); % Frame {0} in blue

t_01 = H_01(1:3, end);
disp('H_01');
disp(H_01);
disp('t_01');
disp(t_01);

plot_arrow ([p1(1),p1(2),p1(3)], [t_01(1),t_01(2),t_01(3)], 'g');
```

7. Final output MATLAB figure for the operations in 3.7 ~ 3.11.



8. Homogeneous transformation table.

| Requirement                         | MATLAB script to satisfy the requirement   | Homogeneous transformation matrix result   |
|-------------------------------------|--|--|
| $O_0X_0Y_0Z_0$ to<br>$O_1X_1Y_1Z_1$ | <pre> R_10 = eye(3); t_10 = [0; 1; 1]; H_10 = rt2tr(R_10, t_10); disp("H_10"); disp(H_10); trplot(H_10, 'color', 'b', 'frame', '1', 'length', 0.4, 'thick', 2); </pre>   | $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$       |
| $O_0X_0Y_0Z_0$ to<br>$O_2X_2Y_2Z_2$ | <pre> R_21 = eye(3); t_21 = [-0.5; 0.5; 0]; H_21 = rt2tr(R_21, t_21); H_20 = H_10 * H_21; disp("H_20"); disp(H_20); trplot(H_20, 'color', 'b', 'frame', '2', 'length', 0.4, 'thick', 2); </pre>                          | $\begin{bmatrix} 1 & 0 & 0 & -0.5 \\ 0 & 1 & 0 & 1.5 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$  |
| $O_0X_0Y_0Z_0$ to<br>$O_3X_3Y_3Z_3$ | <pre> R_32 = [     0 1 0;     1 0 0;     0 0 -1 ]; t_32 = [0; 0; 2]; H_32 = rt2tr(R_32, t_32); H_30 = H_20 * H_32; disp("H_30"); disp(H_30); trplot(H_30, 'color', 'b', 'frame', '3', 'length', 0.4, 'thick', 2); </pre> | $\begin{bmatrix} 0 & 1 & 0 & -0.5 \\ 1 & 0 & 0 & 1.5 \\ 0 & 0 & -1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ |

