

Exercises#5

KINEMATICS AND DYNAMICS Course ID: 01416308

65011428@kmitl.ac.th Switch account

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* Indicates required question

Sec No.? *

Your answer

Student ID (Member No.1) *

Your answer

Fullname (Member No.1) *

Your answer

1. Pls select the correct answer. *

Exercise A frame {A} is rotated 90° about x, and then it is translated a vector (6,-2,10) with respect to the fixed (initial) frame. Find the homogenous transformation matrix that describes {B} respect to {A}

- a) $\begin{bmatrix} 1 & 0 & 0 & 6 \\ 0 & 0 & -1 & -2 \\ 0 & 1 & 0 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ c) $\begin{bmatrix} 1 & 0 & 0 & 6 \\ 0 & 0 & 1 & -2 \\ 0 & 1 & 0 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
- b) $\begin{bmatrix} 1 & 0 & 0 & 6 \\ 0 & 0 & 1 & -2 \\ 0 & -1 & 0 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ d) $\begin{bmatrix} -1 & 0 & 0 & 6 \\ 0 & 0 & 1 & -2 \\ 0 & 1 & 0 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

- ☒ a)
- ☐ b)
- ☐ c)
- ☐ d)

2. Pls select the correct answer. *

Exercise Rotation about and translation along a global axis.

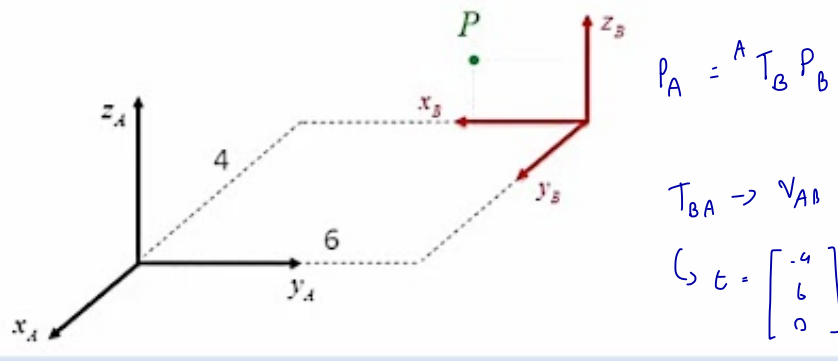
A point P is located at (0,0,200) in a body coordinate frame. If the rigid body rotates 30 deg. About the global X-axis and the origin of the body frame translates to (X,Y,Z) = (500, 0, 600), then the coordinates of the point in the global frame are :

- a) $\begin{bmatrix} 500 \\ -100 \\ 773.2 \\ 0 \end{bmatrix}$ c) $\begin{bmatrix} 500 \\ 100 \\ 773.2 \\ 1 \end{bmatrix}$
- b) $\begin{bmatrix} 500 \\ -100 \\ 773.2 \\ 1 \end{bmatrix}$ d) $\begin{bmatrix} 500 \\ -100 \\ 773.2 \end{bmatrix}$

- ☐ a)
- ☐ b)
- ☐ c)
- ☒ d)

3. Pls select the correct answer. *

Exercise Consider frame {A} and {B}. Point P in frame {B} is given by (5, 6, 7) find its coordinates with respect to frame {A} using a homogeneous transformation matrix



- a) $\begin{bmatrix} 2 \\ -1 \\ 7 \\ 0 \end{bmatrix}$ b) $\begin{bmatrix} 2 \\ 1 \\ 7 \\ 1 \end{bmatrix}$ c) $\begin{bmatrix} 2 \\ 1 \\ 7 \end{bmatrix}$ d) $\begin{bmatrix} 2 \\ -1 \\ 7 \end{bmatrix}$

- ☐ a)
- ☐ b)
- ☒ c)
- ☐ d)

4. Pls select the correct answer. *

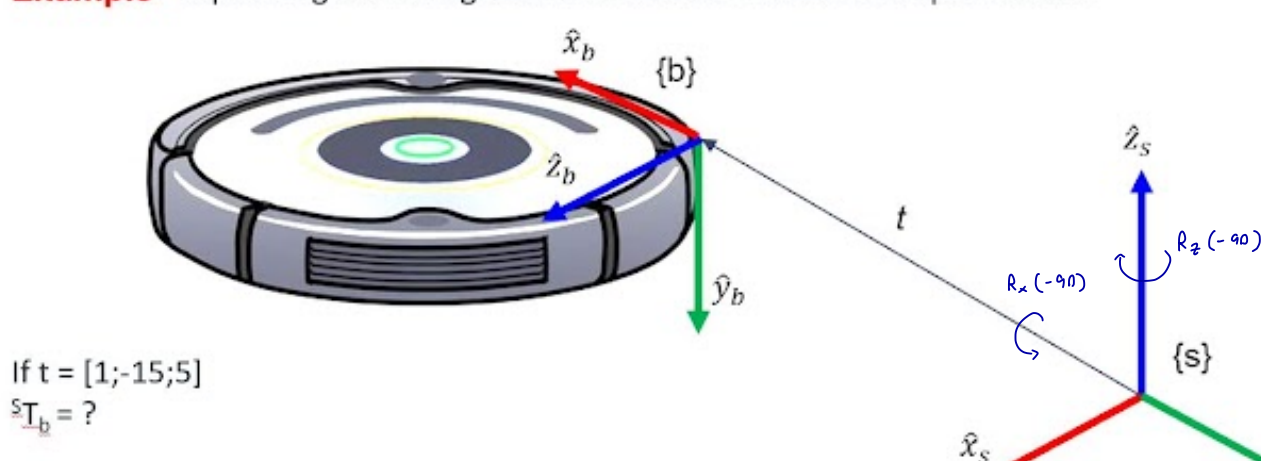
Exercise A frame {A} is rotated 90° about x, and then it is translated a vector (6,-2,10) with respect to the fixed (initial) frame. Consider a point p = (-5, 2, -12) with respect to the new frame {B}. Determine the coordinates of that point with respect to the initial frame

- a) $\begin{bmatrix} 1 \\ 10 \\ 12 \\ 0 \end{bmatrix}$ b) $\begin{bmatrix} 1 \\ 10 \\ 12 \\ 12 \end{bmatrix}$ c) $\begin{bmatrix} 1 \\ 10 \\ 12 \\ 1 \end{bmatrix}$ d) $\begin{bmatrix} 1 \\ 0 \\ 12 \end{bmatrix}$

- ☐ a)
- ☒ b)
- ☐ c)
- ☐ d)

5. Pls upload the solution. *

Example Expressing the configuration of a frame relative to a space frame



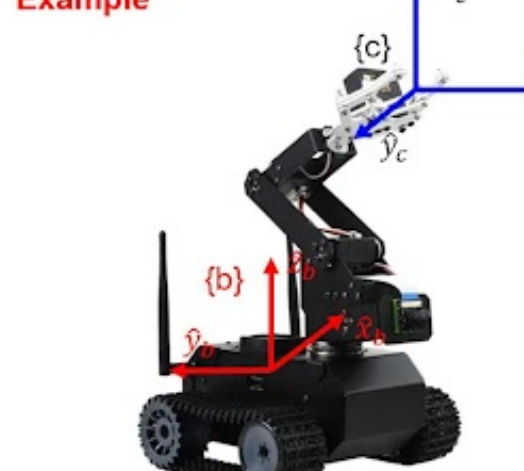
If t = [1;-15;5]
S T_B = ?

$$T_B^S = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(45^\circ) & \sin(45^\circ) & 0 \\ 0 & -\sin(45^\circ) & \cos(45^\circ) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

6. Pls upload the solution. *

Homogenous Transformation Matrix

Example



$$T_{ab} = \begin{bmatrix} 0 & 0 & -1 & 250 \\ 0 & -1 & 0 & -150 \\ -1 & 0 & 0 & 200 \\ 0 & 0 & 0 & 1 \end{bmatrix}, T_{de} = \begin{bmatrix} 0 & 0 & -1 & 300 \\ 0 & -1 & 0 & 100 \\ -1 & 0 & 0 & 120 \\ 0 & 0 & 0 & 1 \end{bmatrix}, T_{bc} = \begin{bmatrix} 0 & -\frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 30 \\ 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & -40 \\ 1 & 0 & 0 & 25 \\ 0 & 0 & 0 & 1 \end{bmatrix}, T_{ad} = \begin{bmatrix} 0 & 0 & -1 & 400 \\ 0 & -1 & 0 & 50 \\ -1 & 0 & 0 & 300 \\ 0 & 0 & 0 & 1 \end{bmatrix}, T_{ee} = ?$$

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7. Pls upload the solution. *

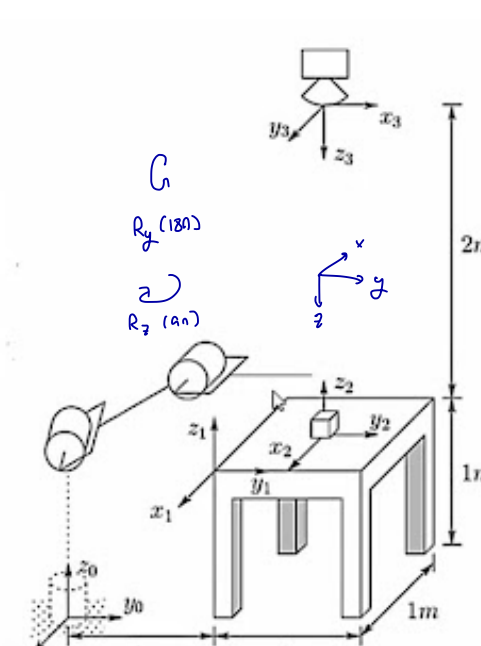
Homogenous Transformation Matrix

Example

The figure shows a robot whose base is 1m away from the base of the table. The table is 1m height and its surface is a square. Frame (1) is fixed on a corner of the table. A 20 cm cube is located on the middle of the table, and it has frame (2) attached to its center. A camera is located 2m above the table, just over the cube, and it has frame (3) attached to it.

a) Find the homogenous transformations that relate each of these frames with the base system (0).

b) Find the homogenous transformation that relates the cube frame (2) with respect to the camera frame (3).



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Your answer

1. Pls select the correct answer. *

Exercise A frame {A} is rotated 90° about y and then it is translated a vector (6,-2,10) with respect to the fixed (initial) frame. Find the homogenous transformation matrix that describes {B} respect to {A}

$\sqrt{A \rightarrow B}$

$A \rightarrow B$

a) $\begin{bmatrix} 1 & 0 & 0 & 6 \\ 0 & 0 & -1 & -2 \\ 0 & 1 & 0 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ c) $\begin{bmatrix} 1 & 0 & 0 & 6 \\ 0 & 0 & 1 & -2 \\ 0 & 1 & 0 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

b) $\begin{bmatrix} 1 & 0 & 0 & 6 \\ 0 & 0 & -1 & -2 \\ 0 & -1 & 0 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ d) $\begin{bmatrix} -1 & 0 & 0 & 6 \\ 0 & 0 & 1 & -2 \\ 0 & 1 & 0 & 10 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

- ☒ a)
☐ b)
☐ c)
☐ d)

2. Pls select the correct answer. *

Exercise Rotation about and translation along a global axis.

$R_x(30^\circ)$

A point P is located at (0,0,200) in a body coordinate frame. If the rigid body rotates 30 deg. About the global X-axis and the origin of the body frame translates to (X,Y,Z) = (500, 0, 600), then the coordinates of the point in the global frame are :

$P_b = R_x^{-1} P_g$

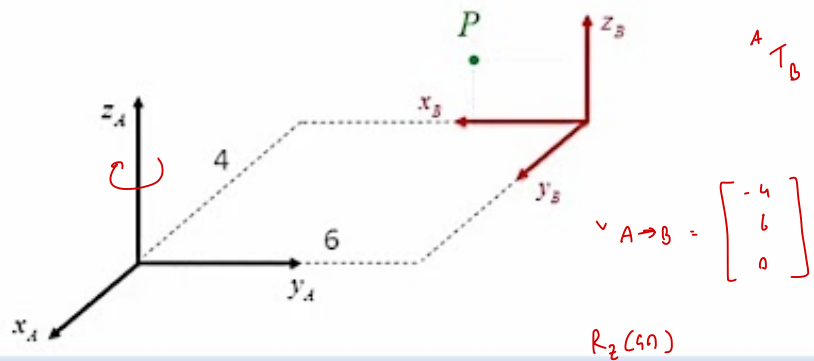
a) $\begin{bmatrix} 500 \\ -100 \\ 773.2 \\ 0 \end{bmatrix}$ c) $\begin{bmatrix} 500 \\ 100 \\ 773.2 \\ 1 \end{bmatrix}$

b) $\begin{bmatrix} 500 \\ 100 \\ 773.2 \\ 1 \end{bmatrix}$ d) $\begin{bmatrix} 500 \\ -100 \\ 773.2 \end{bmatrix}$

- ☐ a)
☒ b)
☐ c)
☐ d)

3. Pls select the correct answer. *

Exercise Consider frame {A} and {B}. Point P in frame {B} is given by (5, 6, 7) find its coordinates with respect to frame {A} using a homogeneous transformation matrix



a) $\begin{bmatrix} 2 \\ -1 \\ 7 \\ 0 \end{bmatrix}$ b) $\begin{bmatrix} 2 \\ 1 \\ 7 \\ 1 \end{bmatrix}$ c) $\begin{bmatrix} 2 \\ 1 \\ 7 \\ 1 \end{bmatrix}$ d) $\begin{bmatrix} 2 \\ -1 \\ 7 \end{bmatrix}$

- ☐ a)
☐ b)
☒ c)
☐ d)

4. Pls select the correct answer. *

$R_x(90^\circ)$

Exercise A frame {A} is rotated 90° about x, and then it is translated a vector (6, -2, 10) with respect to the fixed (initial) frame. Consider a point p = (-5, 2, -12) with respect to the new frame {B}. Determine the coordinates of that point with respect to the initial frame

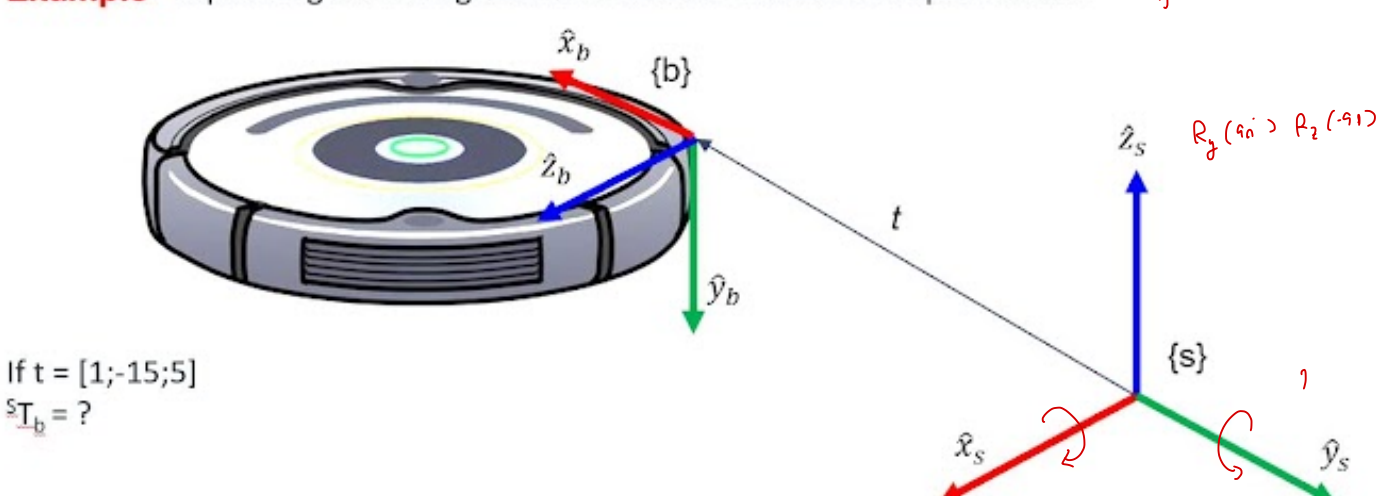
$P_A = R_x^{-1} P_B$

a) $\begin{bmatrix} 1 \\ 10 \\ 12 \\ 0 \end{bmatrix}$ b) $\begin{bmatrix} 1 \\ 10 \\ 12 \\ 1 \end{bmatrix}$ c) $\begin{bmatrix} 1 \\ 10 \\ 12 \\ 1 \end{bmatrix}$ d) $\begin{bmatrix} 1 \\ 0 \\ 12 \end{bmatrix}$

- ☐ a)
☒ b)
☐ c)
☐ d)

5. Pls upload the solution. *

Example Expressing the configuration of a frame relative to a space frame ${}^S T_b$



If t = [1;-15;5]
 ${}^S T_b = ?$

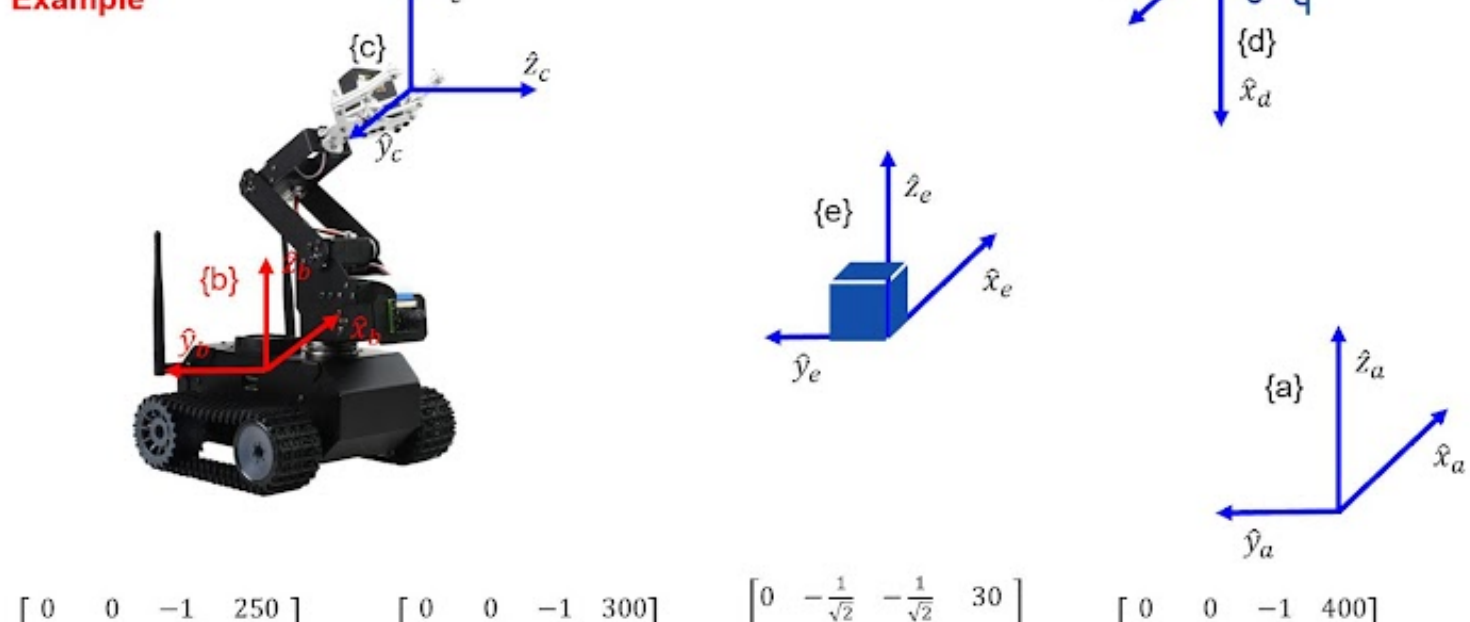
$\begin{bmatrix} 0 & 0 & 1 & 1 \\ -1 & 0 & 0 & -15 \\ 0 & -1 & 0 & 5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

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6. Pls upload the solution. *

Homogenous Transformation Matrix

Example



$T_{ab} = \begin{bmatrix} 0 & 0 & -1 & 250 \\ 0 & -1 & 0 & -150 \\ -1 & 0 & 0 & 200 \\ 0 & 0 & 0 & 1 \end{bmatrix}$, $T_{de} = \begin{bmatrix} 0 & 0 & -1 & 300 \\ 0 & -1 & 0 & 100 \\ -1 & 0 & 0 & 120 \\ 0 & 0 & 0 & 1 \end{bmatrix}$, $T_{bc} = \begin{bmatrix} 0 & -\frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 30 \\ 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & -40 \\ 1 & 0 & 0 & 25 \\ 0 & 0 & 0 & 1 \end{bmatrix}$, $T_{ad} = \begin{bmatrix} 0 & 0 & -1 & 400 \\ 0 & -1 & 0 & 50 \\ -1 & 0 & 0 & 300 \\ 0 & 0 & 0 & 1 \end{bmatrix}$, $T_{ce} = ?$

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${}^c T_b = {}^c T_d {}^d T_c$
 ${}^b T_c = {}^b T_d {}^d T_c$

7. Pls upload the solution. *

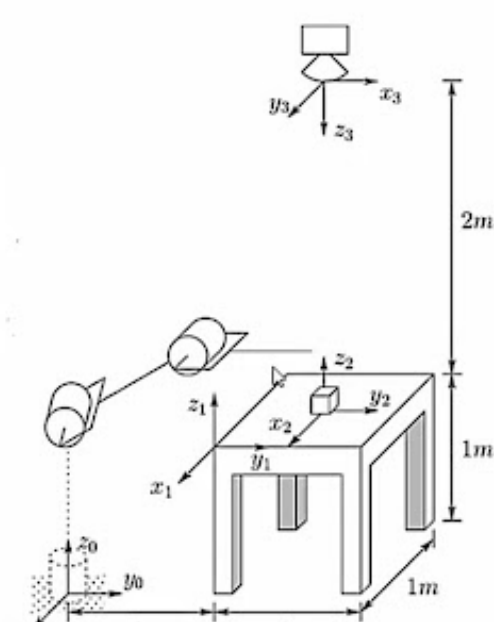
Homogenous Transformation Matrix

Example

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a) Find the homogeneous transformations that relate each of these frames with the base system (0).

b) Find the homogenous transformation that relates the cube frame (2) with respect to the camera frame (3).



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$$1) {}^0T_1 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^0T_2 = \begin{bmatrix} 1 & 0 & 0 & -0.5 \\ 0 & 1 & 0 & 1.5 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$${}^0T_3 = R_x(180) R_z(90) \begin{bmatrix} -0.5 \\ 1.5 \\ 3 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 1 & 0 & -0.5 \\ 1 & 0 & 0 & 1.5 \\ 0 & 0 & -1 & 3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$2) {}^3T_2 = {}^0T_2 {}^3T_0$$

$$= {}^0T_2 \cdot {}^0T_3^{-1}$$

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