Matrix Multiplication

\[
\begin{bmatrix}
  a & b \\
  c & d \\
\end{bmatrix}
\begin{bmatrix}
  e & f \\
  g & h \\
\end{bmatrix}
=
\begin{bmatrix}
  ae+bg & af+bh \\
  ce+dg & cf+dh \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
  ax_1 & ax_2 & ax_3 & ax_4 \\
  ay_1 & ay_2 & ay_3 & ay_4 \\
  az_1 & az_2 & az_3 & az_4 \\
  aw_1 & aw_2 & aw_3 & aw_4 \\
\end{bmatrix}
\begin{bmatrix}
  bx_1 & bx_2 & bx_3 & bx_4 \\
  by_1 & by_2 & by_3 & by_4 \\
  bz_1 & bz_2 & bz_3 & bz_4 \\
  bw_1 & bw_2 & bw_3 & bw_4 \\
\end{bmatrix}
=
\begin{bmatrix}
  ax_1*bx_1 + ax_2*by_1 + ax_3*bz_1 + ax_4*bw_1 & ax_1*bx_2 + ax_2*by_3 + ax_3*bz_2 + ax_4*bw_2 \\
  ay_1*bx_1 + ay_2*by_1 + ay_3*bz_1 + ay_4*bw_1 & ay_1*bx_2 + ay_2*by_3 + ay_3*bz_2 + ay_4*bw_2 \\
  az_1*bx_1 + az_2*by_1 + az_3*bz_1 + az_4*bw_1 & az_1*bx_2 + az_2*by_3 + az_3*bz_2 + az_4*bw_2 \\
  aw_1*bx_1 + aw_2*by_1 + aw_3*bz_1 + aw_4*bw_1 & aw_1*bx_2 + aw_2*by_3 + aw_3*bz_2 + aw_4*bw_2 \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
  ax_1*bx_3 + ax_2*by_3 + ax_3*bz_3 + ax_4*bw_3 \\
  ay_1*bx_3 + ay_2*by_3 + ay_3*bz_3 + ay_4*bw_3 \\
  az_1*bx_3 + az_2*by_3 + az_3*bz_3 + az_4*bw_3 \\
  aw_1*bx_3 + aw_2*by_3 + aw_3*bz_3 + aw_4*bw_3 \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
  ax_1*bx_4 + ax_2*by_4 + ax_3*bz_4 + ax_4*bw_4 \\
  ay_1*bx_4 + ay_2*by_4 + ay_3*bz_4 + ay_4*bw_4 \\
  az_1*bx_4 + az_2*by_4 + az_3*bz_4 + az_4*bw_4 \\
  aw_1*bx_4 + aw_2*by_4 + aw_3*bz_4 + aw_4*bw_4 \\
\end{bmatrix}
\]

SAYEF REYADH
Quiz Solution

Q1: A frame Fnoa is located in the position P. After the following transformation the frame position has changed to Q[2,5,7]T. A rotation along Z axis by anti-clock 45 degree but before that a translation along all axis by [2,3,5]. After those two, another rotation along Y axis by 60 degree followed by a translation along all axis by [3,-5,3]. Find the position P with respect to Q.

Solution: \[ T(3,-5,3) \ast \text{RotY}(60) \ast \text{RotZ}(45) \ast T(2,3,5) \ast -1 \ast Q[2,5,7] = P \]

Q2: A frame Fnoa is located in the position P. After the following transformation the frame position has changed to Q[2,5,7]T. A rotation along X axis by 60 degree but before that a translation along all axis by [2,3,5]. After those two, another rotation along Y axis by 45 degree followed by a translation along all axis by [3,-5,3]. Find the position P with respect to Q.

Solution: \[ T(3,-5,3) \ast \text{RotY}(45) \ast \text{RotX}(60) \ast T(2,3,5) \ast -1 \ast Q[2,5,7] = P \]

Q3: A frame Fnoa is located in the position P. After the following transformation the frame position has changed to Q[2,5,7]T. A rotation along Z axis by anti-clock 30 degree but before that a translation along all axis by [2,3,5]. After those two, another rotation along Y axis by 45 degree followed by a translation along all axis by [3,-5,3]. Find the position P with respect to Q.

Solution: \[ T(3,-5,3) \ast \text{RotY}(45) \ast \text{RotZ}(30) \ast T(2,3,5) \ast -1 \ast Q[2,5,7] = P \]

Q4: A frame Fnoa is located in the position P. After the following transformation the frame position has changed to Q[2,5,7]T. A rotation along X axis by 45 degree but before that a translation along all axis by [2,3,5]. After those two, another rotation along Y axis by 30 degree followed by a translation along all axis by [3,-5,3]. Find the position P with respect to Q.

Solution: \[ T(3,-5,3) \ast \text{RotY}(30) \ast \text{RotX}(45) \ast T(2,3,5) \ast -1 \ast Q[2,5,7] = P \]
Q1: A frame Fnoa is located in the position P. After the following transformation the frame position has changed to Q[2,5,7]T. A rotation along Z axis by anti-clock 45 degree but before that a translation along all axis by [2,3,5]. After those two, another rotation along Y axis by 60 degree followed by a translation along all axis by [3,-5,3]. Find the position P with respect to Q.

Solution : \[ T(3,-5,3) \times \text{RotY(60)} \times \text{RotZ(45)} \times T(2,3,5) \times T^{-1} \times Q[2,5,7] = P \]

\[
\text{RotZ(45)} \times T(2,3,5) = \begin{bmatrix}
\cos(45) & -\sin(45) & 0 & 0 \\
\sin(45) & \cos(45) & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
1 & 0 & 0 & 2 \\
0 & 1 & 0 & 3 \\
0 & 0 & 1 & 5 \\
0 & 0 & 0 & 1
\end{bmatrix} = \begin{bmatrix}
0.707 & -0.707 & 0 & 0 \\
0.707 & 0.707 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
1 & 0 & 0 & 2 \\
0 & 1 & 0 & 3 \\
0 & 0 & 1 & 5 \\
0 & 0 & 0 & 1
\end{bmatrix} = \begin{bmatrix}
0.707 \times 1 + -0.707 \times 0 + 0 \times 0 + 0 \times 0 & 0.707 \times 0 + -0.707 \times 1 + 0 \times 0 + 0 \times 0 & 0.707 \times 0 + -0.707 \times 0 + 0 \times 1 + 0 \times 0 & 0.707 \times 0 + -0.707 \times 0 + 0 \times 1 + 0 \times 1 \\
0.707 \times 1 + 0.707 \times 0 + 0 \times 0 + 0 \times 0 & 0.707 \times 0 + 0.707 \times 1 + 0 \times 0 + 0 \times 0 & 0.707 \times 0 + 0.707 \times 0 + 0 \times 1 + 0 \times 0 & 0.707 \times 0 + 0.707 \times 0 + 0 \times 1 + 0 \times 1 \\
0 \times 1 + 0 \times 0 + 0 \times 0 + 0 \times 0 & 0 \times 0 + 0 \times 1 + 1 \times 0 + 0 \times 0 & 0 \times 0 + 0 \times 0 + 1 \times 1 + 0 \times 0 & 0 \times 0 + 0 \times 0 + 1 \times 1 + 1 \times 0 \\
0 \times 1 + 0 \times 0 + 0 \times 0 + 0 \times 1 & 0 \times 0 + 0 \times 1 + 1 \times 0 + 0 \times 0 & 0 \times 0 + 0 \times 0 + 0 \times 1 + 1 \times 0 & 0 \times 0 + 0 \times 0 + 0 \times 1 + 1 \times 1
\end{bmatrix} = \begin{bmatrix}
0.707 & -0.707 & 0 & -0.707 \\
0.707 & 0.707 & 0 & 3.535 \\
0 & 0 & 1 & 5 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

SAYEF REYADH
Quiz Solution

Q1: A frame Fnoa is located in the position P. After the following transformation the frame position has changed to Q[2,5,7]T. A rotation along Z axis by anti-clock 45 degree but before that a translation along all axis by [2,3,5]. After those two, another rotation along Y axis by 60 degree followed by a translation along all axis by [3,-5,3]. Find the position P with respect to Q.

Solution: \[ \begin{bmatrix} T(3,-5,3) \ast \text{RotY}(60) \ast \text{RotZ}(45) \ast T(2,3,5) \ast -1 \ast Q[2,5,7] \ast P \end{bmatrix} \]

\[
\begin{bmatrix}
1 & 0 & 0 & 3 \\
0 & 1 & 0 & -5 \\
0 & 0 & 1 & 3 \\
0 & 0 & 0 & 1
\end{bmatrix}
\times
\begin{bmatrix}
\cos(60) & 0 & \sin(60) & 0 \\
0 & 1 & 0 & 0 \\
-\sin(60) & 0 & \cos(60) & 0 \\
0 & 0 & 1 & 3
\end{bmatrix}
\times
\begin{bmatrix}
1 & 0 & 0 & 3 \\
0 & 1 & 0 & -5 \\
0 & 0 & 1 & 3 \\
-0.866 & 0 & 0.5 & 0
\end{bmatrix}
\times
\begin{bmatrix}
0.5 & 0 & 0.866 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0
\end{bmatrix}
\]

\[
\begin{bmatrix}
1 \times 0.5 + 0 \times 0 + 0 \times -0.866 + 3 \times 0 \\
0 \times 0.5 + 1 \times 0 + 0 \times -0.866 + -5 \times 0 \\
0 \times 0.5 + 0 \times 0 + 1 \times -0.866 + 3 \times 0 \\
0 \times 0.5 + 0 \times 0 + 0 \times -0.866 + 1 \times 0
\end{bmatrix}
\]

\[
\begin{bmatrix}
0.5 & 0 & 0.866 & 3 \\
0 & 1 & 0 & -5 \\
-0.866 & 0 & 0.5 & 3 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

SAYEF REYADH
**Quiz Solution**

Q1: A frame Fnoa is located in the position P. After the following transformation the frame position has changed to Q[2,5,7]T. A rotation along Z axis by anti-clock 45 degree but before that a translation along all axis by [2,3,5]. After those two, another rotation along Y axis by 60 degree followed by a translation along all axis by [3,-5,3]. Find the position P with respect to Q.

**Solution :** 
\[ [T(3,-5,3) \times \text{RotY}(60) \times \text{RotZ}(45) \times T(2,3,5)]^{-1} \times Q[2,5,7] = P \]

\[ T(3,-5,3) \times \text{RotY}(60) \times \text{RotZ}(45) \times T(2,3,5) = \]

\[
\begin{bmatrix}
0.5 & 0 & 0.866 & 3 \\
0 & 1 & 0 & -5 \\
-0.866 & 0 & 0.5 & 3 \\
0 & 0 & 0 & 1
\end{bmatrix}
\times
\begin{bmatrix}
0.707 & -0.707 & 0 & -0.707 \\
0.707 & 0.707 & 0 & 3.535 \\
0 & 0 & 1 & 5 \\
0 & 0 & 0 & 1
\end{bmatrix}
= \\
\begin{bmatrix}
0.5 \times 0.707 + 0 \times 0.707 + 0.866 \times 0 + 3 \times 0 & 0.5 \times -0.707 + 0 \times 0.707 + 0.866 \times 0 + 3 \times 0 \\
0 \times 0.707 + 1 \times 0.707 + 0 \times 0 + -5 \times 0 & 0 \times -0.707 + 1 \times 0.707 + 0 \times 0 + -5 \times 0 \\
-0.866 \times 0.707 + 0 \times 0.707 + 0.5 \times 0 + 3 \times 0 & -0.866 \times -0.707 + 0 \times 0.707 + 0.5 \times 0 + 3 \times 0 \\
0 \times 0.707 + 0 \times 0.707 + 0 \times 0 + 1 \times 0 & 0 \times -0.707 + 0 \times 0.707 + 0 \times 0 + 1 \times 0
\end{bmatrix}
\]

\[
\begin{bmatrix}
0.5 \times 0 + 0 \times 0 + 0.866 \times 1 + 3 \times 0 & 0.5 \times -0.707 + 0 \times 3.535 + 0.866 \times 5 + 3 \times 1 \\
0 \times 0 + 1 \times 0 + 0 \times 1 + -5 \times 0 & 0 \times -0.707 + 1 \times 3.535 + 0 \times 5 + -5 \times 1 \\
-0.866 \times 0 + 0 \times 0 + 0.5 \times 1 + 3 \times 0 & -0.866 \times -0.707 + 0 \times 3.535 + 0 \times 5 + 3 \times 1 \\
0 \times 0 + 0 \times 0 + 0 \times 1 + 1 \times 0 & 0 \times -0.707 + 0 \times 3.535 + 0 \times 5 + 1 \times 1
\end{bmatrix}
\]

\[
= \begin{bmatrix}
0.3535 & -0.3535 & 0.866 & 6.9765 \\
0.707 & 0.707 & 0 & -1.465 \\
-0.612262 & 0.612262 & 0.5 & 6.112262 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

**SAYEF REYADH**
Quiz Solution

Q1: A frame Fnoa is located in the position P. After the following transformation the frame position has changed to Q[2,5,7]T. A rotation along Z axis by anti-clock 45 degree but before that a translation along all axis by [2,3,5]. After those two, another rotation along Y axis by 60 degree followed by a translation along all axis by [3,-5,3]. Find the position P with respect to Q.

Solution: \[ [T(3,-5,3) * \text{RotY}(60) * \text{RotZ}(45) * T(2,3,5)]^{-1} * Q[2,5,7] = P \]

\[ [T(3,-5,3) * \text{RotY}(60) * \text{RotZ}(45) * T(2,3,5)]^{-1} = \begin{bmatrix}
0.3535 & -0.3535 & 0.866 & 6.9765 \\
0.707 & 0.707 & 0 & -1.465 \\
-0.612262 & 0.612262 & 0.5 & 6.112262 \\
0 & 0 & 0 & 1
\end{bmatrix}^{-1} \]

\[ \begin{bmatrix}
0.35 & 0.707 & -0.61 & - (6.98 \times 0.35 + -1.465 \times (-0.35) + 6.11 \times 0.866) \\
-0.35 & 0.707 & 0.61 & - (6.98 \times (-0.35) + -1.465 \times 0.707 + 6.11 \times 0.61) \\
0.866 & 0 & 0.5 & - (6.98 \times 0.866 + -1.465 \times 0 + 6.11 \times 0.5) \\
0 & 0 & 0 & 1
\end{bmatrix} = \begin{bmatrix}
0.35 & 0.707 & -0.61 & -8.24701 \\
-0.35 & 0.707 & 0.61 & -0.248345 \\
0.866 & 0 & 0.5 & -9.09968 \\
0 & 0 & 0 & 1
\end{bmatrix} \]

Sayef Reyadh
Quiz Solution

Q1: A frame Fnoa is located in the position P. After the following transformation the frame position has changed to Q[2,5,7]T. A rotation along Z axis by anti-clock 45 degree but before that a translation along all axis by [2,3,5]. After those two, another rotation along Y axis by 60 degree followed by a translation along all axis by [3,-5,3]. Find the position P with respect to Q.

Solution : [T(3,-5,3) * RotY(60) * RotZ(45) * T(2,3,5 )-1 * Q[2,5,7] = P

\[
\begin{bmatrix}
0.35 & 0.707 & -0.61 & -8.25 \\
-0.35 & 0.707 & 0.61 & -0.25 \\
0.866 & 0 & 0.5 & -0.91 \\
0 & 0 & 0 & 1
\end{bmatrix}
\times
\begin{bmatrix}
2 \\
5 \\
7 \\
1
\end{bmatrix}
= \begin{bmatrix}
0.35 \times 2 + 0.707 \times 5 + -0.61 \times 7 + -8.25 \times 1 \\
-0.35 \times 2 + 0.707 \times 5 + 0.61 \times 7 + -0.25 \times 1 \\
0.866 \times 2 + 0 \times 5 + 0.5 \times 7 + -0.91 \times 1 \\
0 \times 2 + 0 \times 5 + 0 \times 7 + 1 \times 1
\end{bmatrix}
= \begin{bmatrix}
-8.285 \\
6.855 \\
4.322 \\
1
\end{bmatrix}

Answer: P [ -8.3 , 6.86 , 4.3 ]T
Quiz Solution

Q5: A frame Fnoa is located in the position P[1,1,1]T. After the following transformation the frame position has changed to Q. A rotation along Z axis by anti-clock 45 degree followed by a translation along all axis by [2,3,5], after those two, another rotation along Y axis by 45 degree followed by a translation along all axis by [3,3,3]. Find the position Q with respect to P.

Solution: \( T(3,3,3) \times \text{RotY}(45) \times T(2,3,5) \times \text{RotZ}(45) \times P[1,1,1] = Q \)

\[
T(2,3,5) \times \text{RotZ}(45) = \begin{bmatrix}
1 & 0 & 0 & 2 \\
0 & 1 & 0 & 3 \\
0 & 0 & 1 & 5 \\
0 & 0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
\cos(45) & -\sin(45) & 0 & 0 \\
\sin(45) & \cos(45) & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix} = \begin{bmatrix}
1 & 0 & 0 & 3 \\
0 & 1 & 0 & 3 \\
0 & 0 & 1 & 3 \\
0 & 0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
0.707 & -0.707 & 0 & 0 \\
0.707 & 0.707 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix} = \\
\begin{bmatrix}
1 \times 0.707 + 0 \times 0.707 + 0 \times 0 + 2 \times 0 & 1 \times -0.707 + 0 \times 0.707 + 0 \times 0 + 2 \times 0 & 1 \times 0 + 0 \times 0 + 0 \times 1 + 2 \times 0 & 1 \times 0 + 0 \times 0 + 0 \times 0 + 0 \times 2 + 1 \\
0 \times 0.707 + 1 \times 0.707 + 0 \times 0 + 3 \times 0 & 0 \times -0.707 + 1 \times 0.707 + 0 \times 0 + 3 \times 0 & 0 \times 0 + 1 \times 0 + 0 \times 1 + 3 \times 0 & 0 \times 0 + 1 \times 0 + 0 \times 0 + 0 \times 3 + 1 \\
0 \times 0.707 + 0 \times 0.707 + 1 \times 0 + 5 \times 0 & 0 \times -0.707 + 0 \times 0.707 + 1 \times 0 + 5 \times 0 & 0 \times 0 + 0 \times 0 + 1 \times 1 + 5 \times 0 & 0 \times 0 + 0 \times 0 + 1 \times 0 + 0 \times 5 + 1 \\
0 \times 0.707 + 0 \times 0.707 + 0 \times 0 + 1 \times 0 & 0 \times -0.707 + 0 \times 0.707 + 0 \times 0 + 1 \times 0 & 0 \times 0 + 0 \times 0 + 0 \times 1 + 1 \times 0 & 0 \times 0 + 0 \times 0 + 0 \times 0 + 0 \times 1 + 1 \\
\end{bmatrix}
\]

\[
= \begin{bmatrix}
0.707 & -0.707 & 0 & 2 \\
0.707 & 0.707 & 0 & 3 \\
0 & 0 & 1 & 5 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

SAYEF REYADH
Quiz Solution

Q5: A frame Fnoa is located in the position P[1,1,1]T. After the following transformation the frame position has changed to Q. A rotation along Z axis by anti-clock 45 degree followed by a translation along all axis by [2,3,5], after those two, another rotation along Y axis by 45 degree followed by a translation along all axis by [3,3,3]. Find the position Q with respect to P.

Solution: \( T(3,3,3) \times \text{RotY}(45) \times T(2,3,5) \times \text{RotZ}(45) \times P[1,1,1] = Q \)

\[
T(3,3,3) \times \text{RotY}(45) = \begin{bmatrix}
1 & 0 & 0 & 3 \\
0 & 1 & 0 & 3 \\
0 & 0 & 1 & 3 \\
0 & 0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
\cos(45) & 0 & \sin(45) & 0 \\
0 & 1 & 0 & 0 \\
-\sin(45) & 0 & \cos(45) & 0 \\
0 & 0 & 0 & 1
\end{bmatrix} = \begin{bmatrix}
1 & 0 & 0 & 3 \\
0 & 1 & 0 & 3 \\
0 & 0 & 1 & 3 \\
0 & 0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
0.707 & 0 & 0.707 & 0 \\
0 & 1 & 0 & 0 \\
-0.707 & 0 & 0.707 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix} =
\begin{bmatrix}
1 \times 0.707 + 0 \times 0 + 0 \times -0.707 + 3 \times 0 & 1 \times 0 + 0 \times 1 + 0 \times 0 + 3 \times 0 & 1 \times 0.707 + 0 \times 0 + 0 \times 0.707 + 3 \times 0 & 1 \times 0 + 0 \times 0 + 0 \times 0 + 0 \times 3 \times 1 \\
0 \times 0.707 + 1 \times 0 + 0 \times -0.707 + 3 \times 0 & 0 \times 0 + 1 \times 1 + 0 \times 0 + 3 \times 0 & 0 \times 0.707 + 1 \times 0 + 0 \times 0.707 + 3 \times 0 & 0 \times 0 + 1 \times 0 + 0 \times 0 + 3 \times 1 \\
0 \times 0.707 + 0 \times 0 + 1 \times -0.707 + 3 \times 0 & 0 \times 0 + 0 \times 1 + 1 \times 0 + 3 \times 0 & 0 \times 0.707 + 0 \times 0 + 1 \times 0.707 + 3 \times 0 & 0 \times 0 + 0 \times 0 + 1 \times 0 + 3 \times 1 \\
0 \times 0.707 + 0 \times 0 + 0 \times -0.707 + 1 \times 0 & 0 \times 0 + 0 \times 0 + 1 \times 0 + 1 \times 0 & 0 \times 0.707 + 0 \times 0 + 0 \times 0.707 + 1 \times 0 & 0 \times 0 + 0 \times 0 + 0 \times 0 + 1 \times 1 \\
\end{bmatrix}
\]

\[
= \begin{bmatrix}
0.707 & 0.707 & 3 \\
0 & 1 & 0 & 3 \\
-0.707 & 0.707 & 3 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

**SAYEF REYADH**
Solution: $T(3,3,3) \ast \text{RotY}(45) \ast T(2,3,5) \ast \text{RotZ}(45) \ast P[1,1,1] = Q$

$T(3,3,3) \ast \text{RotY}(45) \ast T(2,3,5) \ast \text{RotZ}(45) = \begin{bmatrix}
0.707 & 0 & 0.707 & 3 \\
0 & 1 & 0 & 3 \\
0 & 0 & 0 & 1 \\
-0.707 & 0 & 0.707 & 3
\end{bmatrix} \times \begin{bmatrix}
0.707 & -0.707 & 0 & 2 \\
0.707 & 0.707 & 0 & 3 \\
0 & 0 & 1 & 5 \\
0 & 0 & 0 & 1
\end{bmatrix} = \begin{bmatrix}
0.707 \times 0 + 0 \times 0.707 + 0 \times 0.707 + 0 + 3 \times 0 & -0.707 \times 0 + 0 \times 0.707 + 0 \times 0.707 + 0 + 3 \times 0 & 0 \times 0.707 + 0 \times 0.707 + 0 \times 0 + 1 \times 0 \\
0 \times 0.707 + 1 \times 0.707 + 0 \times 0 + 3 \times 0 & 0 \times -0.707 + 1 \times 0.707 + 0 \times 0 + 3 \times 0 & 0 \times -0.707 + 0 \times 0.707 + 0 \times 0 + 1 \times 0 \\
-0.707 \times 0.707 + 0 \times 0.707 + 0.707 \times 0 + 3 \times 0 & -0.707 \times -0.707 + 0 \times 0.707 + 0.707 \times 0 + 3 \times 0 & 0 \times 0.707 + 0 \times 0.707 + 0 \times 0 + 1 \times 0 \\
0 \times 0.707 + 0 \times 0.707 + 0 \times 0 + 3 \times 0 & 0 \times -0.707 + 0 \times 0.707 + 0 \times 0 + 1 \times 0 & 0 \times 0.707 + 0 \times 0.707 + 0 \times 0 + 1 \times 0
\end{bmatrix}$

$= \begin{bmatrix}
0.707 \times 0 + 0 \times 0 + 0 \times 0.707 + 1 + 3 \times 0 & 0 \times 0 + 1 \times 0 + 0 \times 1 + 3 \times 0 & 0 \times 0 + 0 \times 0 + 0 \times 1 + 1 \times 0 \\
0 \times 0 + 1 \times 0 + 0 \times 1 + 3 \times 0 & 0 \times 2 + 1 \times 3 + 0 \times 5 + 3 \times 1 & 0 \times 2 + 0 \times 3 + 0 \times 5 + 1 \times 1 \\
-0.707 \times 0 + 0 \times 0 + 0 \times 0.707 + 1 + 3 \times 0 & 0 \times 0 + 0 \times 0 + 0 \times 1 + 1 \times 0 & 0 \times 2 + 0 \times 3 + 0 \times 5 + 1 \times 1
\end{bmatrix}$

$= \begin{bmatrix}
0.499849 & -0.499849 & 0.707 & 7.949 \\
0.707 & 0.707 & 0 & 6 \\
-0.499849 & 0.499849 & 0.707 & 5.121 \\
0 & 0 & 0 & 1
\end{bmatrix}$
Q5: A frame Fnoa is located in the position P[1,1,1]T. After the following transformation the frame position has changed to Q. A rotation along Z axis by anti-clock 45 degree followed by a translation along all axis by [2,3,5], after those two, another rotation along Y axis by 45 degree followed by a translation along all axis by [3,3,3]. Find the position Q with respect to P.

Solution: \( T(3,3,3) \times \text{RotY}(45) \times T(2,3,5) \times \text{RotZ}(45) \times P[1,1,1] = Q \)

\[
\begin{bmatrix}
0.5 & -0.5 & 0.707 & 7.95 \\
0.707 & 0.707 & 0 & 6 \\
-0.5 & 0.5 & 0.707 & 5.12 \\
0 & 0 & 0 & 1
\end{bmatrix} \times \begin{bmatrix}
1 \\
1 \\
1 \\
1
\end{bmatrix} = \begin{bmatrix}
0.5 \times 1 + -0.5 \times 1 + 0.707 \times 1 + 7.95 \times 1 \\
0.707 \times 1 + 0.707 \times 1 + 0 \times 1 + 6 \times 1 \\
-0.5 \times 1 + 0.5 \times 1 + 0.707 \times 1 + 5.12 \times 1 \\
0 \times 1 + 0 \times 1 + 0 \times 1 + 1 \times 1
\end{bmatrix} = \begin{bmatrix}
8.657 \\
7.414 \\
5.827 \\
1
\end{bmatrix}
\]

Answer: Q [ 8.657 , 7.414 , 5.827 ]T
Mid Examination Discussion

SAYEF REYADH