Week 2 - Assignment 2

The due date for submitting this assignment has passed. Due on 2021-02-07, 23:59 IST.

As per our records you have not submitted this assignment.

Instructions:
- If not explained all symbols have same meaning as in the lectures.
- Use the D-H convention followed in the course wherever mentioned.
- In some options to the MCQ/MSQ the text may not be adjacent to checkbox (circle or square). Consider the text just below it for such cases.

1) For the following rotation matrix

\[
\frac{A[R]}{B} = \begin{bmatrix}
\frac{2}{3} & -\frac{1}{3} & \frac{2}{3} \\
\frac{2}{3} & 2/3 & -1/3 \\
-1/3 & 2/3 & 2/3
\end{bmatrix}
\]

The angle of rotation (in degrees) about the axis vector is  

Note: provide angle in between 0 and 360 degrees only

No, the answer is incorrect.
Score: 0
Accepted Answers:
(Type: Range) 59,61

2) For Z-Y-X Euler rotations with \(\theta_1\), \(\theta_2\) and \(\theta_3\) being rotation angles about \(X\), \(Y\) and \(Z\) axis respectively and \(r_{i,j}\), \(i, j = 1, 2, 3\) denoting the elements of resultant rotation matrix
Examples of D-H parameters and Link transformation matrices (unit? unit=20&lesson=23)

Lecture Slides (unit? unit=20&lesson=81)

Quiz : Week 2 - Assignment 2 (assessment? name=79)

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No, the answer is incorrect.
Score: 0
Accepted Answers:

No, the answer is incorrect.
Score: 0
Accepted Answers:

2 points

3) If $[A_B^B R]$ denotes a rotation matrix with $\hat{k}$ denoting it's axis, $[K]$ is the skew symmetric matrix formed by the elements of $\hat{k}$, and $\phi$ the corresponding angle of rotation, then

$$e^{[K] \phi} = [A_B^B R]$$

$$[A_B^B R] (u \times v) = ([A_B^B R] u) \times ([A_B^B R] v) \quad \forall \; u, v \in \mathbb{R}^3$$

$$[A_B^B R] = I + [K] \sin \phi + (1 - \cos \phi) [K]^2, \text{ where } I \text{ is the identity matrix.}$$

$$[A_B^B R] = I + [K]^2 \sin \phi + (1 - \cos \phi) [K], \text{ where } I \text{ is the identity matrix.}$$

No, the answer is incorrect.
Score: 0
Accepted Answers:

$$e^{[K] \phi} = [A_B^B R]$$

$$[A_B^B R] = I + [K] \sin \phi + (1 - \cos \phi) [K]^2, \text{ where } I \text{ is the identity matrix.}$$

2 points

4) Which of the following representation of orientation suffer from Gimbal Lock

- Rotation matrix.
- Quaternions.
- Euler parameters.
- Euler angles.
No, the answer is incorrect.
Score: 0
Accepted Answers:

Euler angles.

5) Two successive transformations are applied to a rigid body:
1. Rotation about vector \([1,2,3]^T\) by \(\pi/3\) rads, followed by a translation by \([1,1,0]^T\) and,
2. Rotation about vector \([1,1,1]^T\) by \(\pi/4\) rads, followed by a translation by \([1,2,3]^T\).

(Note the order of transformation is 1 before 2)
Which of the following represents the final homogeneous transformation matrix of the resultant motion

- \[
\begin{bmatrix}
-0.0611 & -0.3793 & 0.9232 & 2.0000 \\
0.9468 & 0.2708 & 0.1739 & 3.0000 \\
-0.3160 & 0.8848 & 0.3426 & 3.0000 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

- \[
\begin{bmatrix}
0.0133 & -0.4755 & 0.8796 & 1.4941 \\
0.9978 & 0.0637 & 0.0194 & 3.3106 \\
-0.0653 & 0.8774 & 0.4753 & 3.1953 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

- \[
\begin{bmatrix}
-0.0116 & -0.2989 & 0.9542 & 2.0000 \\
0.9542 & 0.2820 & 0.1000 & 3.0000 \\
-0.2989 & 0.9117 & 0.2820 & 3.0000 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

- \[
\begin{bmatrix}
0.0723 & -0.4040 & 0.9119 & 1.3333 \\
0.9963 & 0.0723 & -0.0470 & 3.3333 \\
-0.0470 & 0.9119 & 0.4077 & 3.3333 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

No, the answer is incorrect.
Score: 0
Accepted Answers:

\[
\begin{bmatrix}
-0.0611 & -0.3793 & 0.9232 & 2.0000 \\
0.9468 & 0.2708 & 0.1739 & 3.0000 \\
-0.3160 & 0.8848 & 0.3426 & 3.0000 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

6) For the consecutive rotations first about global X-axis by \(\pi/3\) rads, and then about global Y-axis by \(\pi/4\) rads and finally about global Z-axis by \(\pi/6\) rads, the \(r_{21}\) term of the resultant rotation matrix is
7) A rotary joint connects two rigid bodies in 3D space. Which of the following is true

- The rotary joint allows one relative degree of freedom between the two connected rigid bodies.
- The system of two rigid bodies have 1 degree of freedom.
- The system of two rigid bodies have 6 degrees of freedom.
- The system of two rigid bodies have 7 degrees of freedom.

No, the answer is incorrect.
Score: 0
Accepted Answers:
*The rotary joint allows one relative degree of freedom between the two connected rigid bodies.*
*The system of two rigid bodies have 7 degrees of freedom.*

8) An S-S pair in a loop gives rise to

- One constraint equation.
- Three constraint equations.
- Five constraint equations.
- No constraint equations.

No, the answer is incorrect.
Score: 0
Accepted Answers:
*One constraint equation.*

9) In the Denavit-Hartenberg convention used in this course

- Coordinate system \(i\) is attached to the link \(i\).
- Coordinate system \(i\) is attached to the link \(i-1\).
- Origin of \(i\) lies on the joint axis \(i\).
- Origin of \(i\) lies on the joint axis \(i-1\).

No, the answer is incorrect.
Score: 0
Accepted Answers:
*Coordinate system \(i\) is attached to the link \(i\).*
*Origin of \(i\) lies on the joint axis \(i\).*

10) In the Denavit-Hartenberg convention used in this course, link offset \(d_i\)

- is measured along joint \(\mathbf{Z}_i\) from \(\mathbf{X}_{i-1}\) to \(\mathbf{X}_i\).
- is always positive.
- is always constant if joint \(i\) is rotary.
- is always constant if joint \(i\) is prismatic.

No, the answer is incorrect.
Score: 0
Accepted Answers:
is measured along joint $\hat{Z}_i$ from $\hat{X}_{i-1}$ to $\hat{X}_i$.

is always constant if joint $i$ is rotary.

11) For the RRR serial manipulator shown in figure below, the Denavit-Hartenberg (D-H) table will contain $l_1$ will contain $l_5$.

is given by

<table>
<thead>
<tr>
<th>$i$</th>
<th>$\alpha_{i-1}$ (rad)</th>
<th>$a_{i-1}$</th>
<th>$d_i$</th>
<th>$\theta_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$\theta_1$</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>$l_2$</td>
<td>0</td>
<td>$\theta_2$</td>
</tr>
<tr>
<td>3</td>
<td>$\pi/2$</td>
<td>$l_3$</td>
<td>$l_4$</td>
<td>$\theta_3$</td>
</tr>
</tbody>
</table>
No, the answer is incorrect.
Score: 0
Accepted Answers:

is given by

<table>
<thead>
<tr>
<th>$i$</th>
<th>$\alpha_{i-1}$ (rad)</th>
<th>$a_{i-1}$</th>
<th>$d_i$</th>
<th>$\theta_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>$l_1$</td>
<td>0</td>
<td>$\theta_1$</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>$l_2$</td>
<td>0</td>
<td>$\theta_2$</td>
</tr>
<tr>
<td>3</td>
<td>$\pi/2$</td>
<td>$l_3$</td>
<td>$l_4$</td>
<td>$\theta_3$</td>
</tr>
</tbody>
</table>

12) Figure 2 shows the 3-RPS parallel manipulator discussed in lectures. The location **3 points** of the R joint is $b$ units from the origin of the $\{Base\}$ along the $\hat{X}$ as shown in the figure below.
The transformation matrix $^{Base}_{S_1}[T]$ is given by

$$^{Base}_{S_1}[T] = \begin{bmatrix}
\cos \theta_1 & 0 & -\sin \theta_1 & b - l_1 \sin \theta_1 \\
\sin \theta_1 & 1 & \cos \theta_1 & l_1 \cos \theta_1 \\
0 & -1 & 0 & 0 \\
0 & 0 & 0 & 1 
\end{bmatrix}$$
The given answer is incorrect.

Score: 0

Accepted Answers:

$$\begin{bmatrix}
\cos \theta_1 & 0 & -\sin \theta_1 & b - l_1 \sin \theta_1 \\
0 & 1 & 0 & 0 \\
\sin \theta_1 & 0 & \cos \theta_1 & l_1 \cos \theta_1 \\
0 & 0 & 0 & 1
\end{bmatrix}$$