## Chapter 3 through 3.2, Rigid-Body Motions

Latest Submission Grade 100%

1. In terms of the  $\hat{x}_s$ ,  $\hat{y}_s$ ,  $\hat{z}_s$  coordinates of a fixed space frame {s}, the frame {a} has its  $\hat{x}_a$ -axis pointing in the direction (0,0,1) and its  $\hat{y}_a$ -axis pointing in the direction (1,0,0), and the frame {b} has its  $\hat{x}_b$ -axis pointing in the direction (1,0,0) and its  $\hat{y}_b$ -axis pointing in the direction (0,0,-1). Draw the {s}, {a}, and {b} frames, similar to examples in the book and videos (e.g., Figure 3.7 in the book), for easy reference in this question and later questions.

1/1 point

Write the rotation matrix  $R_{
m sa}$ . All elements of this matrix should be integers.

If your answer is

[1	2	3
4	5	6
7	8	9

for example, you should just type

[[1,2,3],[4,5,6],[7,8,9]]

in the answer box below. (You can just modify the matrix that is currently written there.) Then click "Run." You will not get any immediate feedback; the grade will be given when you submit the whole quiz.

1 [[0,1,0],[0,0,1],[1,0,0]]

Run

Reset



2. Referring to your drawing from Question 1, write  $R_{sb}^{-1}$ . All elements of this matrix should be integers.

1/1 point

If your answer is

$$\left[\begin{array}{ccc} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{array}\right]$$

you should just type

[[1,2,3],[4,5,6],[7,8,9]]

in the answer box below. (You can just modify the matrix that is currently written there.) Then click "Run." You will not get any immediate feedback; the grade will be given when you submit the whole quiz.

1 [[1,8,8],[8,8,-1],[8,1,8]]

Run

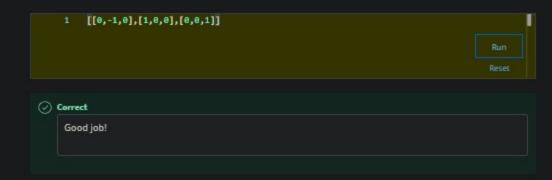
Reset



3. Referring to your drawing from Question 1, write  $R_{ab}$ . All elements of this matrix should be integers.

1/1 point

Write your matrix in the answer box below, using the format mentioned in questions 1 and 2, and click "Run."



**4.** Referring back to Question 1, let  $R=R_{\rm sb}$  be considered as a transformation operator consisting of a rotation about  $\hat{x}$  by  $-90^\circ$ . Calculate  $R_1=R_{\rm so}R$ , and think of  $R_{\rm so}$  as the representation of the initial orientation of {a} relative to {s}, R as a rotation operation, and  $R_1$  as the new orientation of {a} after performing the rotation. The new orientation  $R_1$  corresponds to the orientation of the new {a} frame relative to {s} after rotating the original {a} frame by  $-90^\circ$  about which axis?

1/1 point

igodeligap The  $\hat{x}_{\mathrm{a}}$ -axis of the {a} frame.

 $\bigcap$  The  $\hat{x}_s$ -axis of the {s} frame.

**⊘** Correct

5. Referring back to Question 1, use  $R_{sb}$  to change the representation of the point  $p_b = (1, 2, 3)^T$  (in  $\{b\}$  coordinates) to  $\{s\}$  coordinates. All elements of this vector should be integers.

1/1 point

If your answer is

 $\left[\begin{array}{c}1\\2\\3\end{array}\right]$ 

you should enter

[1,2,3]

in the text box below and click "Run."



**⊘** Correct

Good job!

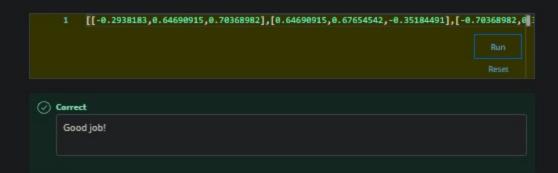
Referring back to Question 1, choose a point p represented by $p_s=(1,2,3)^\intercal$ in {s} coordinates. Calculate $q=R_{sb}^\intercal p_s$ . Is $q$ a representation of p in {b} coordinates?	1/1 point
Yes.	
○ No.	
⊙ Correct	
Referring back to Question 1, an angular velocity $w$ is represented in {s} as $\omega_s=(3,2,1)^\intercal$ . What is its representation $\omega_a$ ? All elements of this vector should be integers.	1/1 point
If your answer is	
$\left[\begin{array}{c}1\\2\\3\end{array}\right]$	
you should enter	
[1,2,3]	
in the text box below and click "Run."	
1 [1,3,2]	
Run	
⊘ Correct	
Good job!	
Referring back to Question 1, calculate the matrix logarithm $[\hat{\omega}] heta$ of $R_{ m sa}$ by hand. (You may verify your answer with software.) Extract and enter the rotation amount $ heta$ in radians with at least two decimal places.	1/1 point
1 2.0944	
Run	
⊘ Correct	

Good job!

**9.** Calculate the matrix exponential corresponding to the exponential coordinates of rotation  $\hat{\omega}\theta=(1,2,0)^\intercal$ . The maximum allowable error for any matrix element is 0.01, so give enough decimal places where necessary.

1/1 point

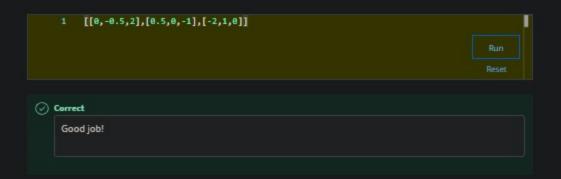
Write your matrix in the answer box below, using the format mentioned in questions 1 and 2, and click "Run."



10. Write the  $3 \times 3$  skew-symmetric matrix corresponding to  $\omega = (1,2,0.5)^{\rm T}$ . Confirm your answer using the function VecToBo3 in the given software.

1/1 point

Write your matrix in the answer box below, using the format mentioned in questions 1 and 2, and click "Run."



11. Use the function  ${\tt MatrixExp3}$  in the given software to calculate the rotation matrix  $R \in SO(3)$  corresponding to the matrix exponential of

1/1 point

$$\hat{\omega}] heta = \left[egin{array}{ccc} 0 & 0.5 & -1 \ -0.5 & 0 & 2 \ 1 & -2 & 0 \end{array}
ight].$$

The maximum allowable error for any matrix element is 0.01, so give enough decimal places where necessary.

Write your matrix in the answer box below, using the format mentioned in questions 1 and 2, and click "Run."

1 [[0.60482045,0.796274,-0.01182979],[0.46830057,-0.34361048,0.81401868],[0.64411707, -0]4
Run
Reset

**⊘** Correct

Good job!

**12.** Use the function MatrixLog3 in the given software to calculate the matrix logarithm  $[\hat{\omega}]\theta \in so(3)$  of rotation matrix

$$R = \left[ \begin{array}{ccc} 0 & 0 & 1 \\ -1 & 0 & 0 \\ 0 & -1 & 0 \end{array} \right]$$

The maximum allowable error for any matrix element is 0.01, so give enough decimal places where necessary.

Write your matrix in the answer box below, using the format mentioned in questions 1 and 2, and click "Run."

1 [[0,1.20919958,1.20919958],[-1.20919958,0,1.20919958],[-1.20919958,-1.20919958,0]]

Run

Reset



1/1 point