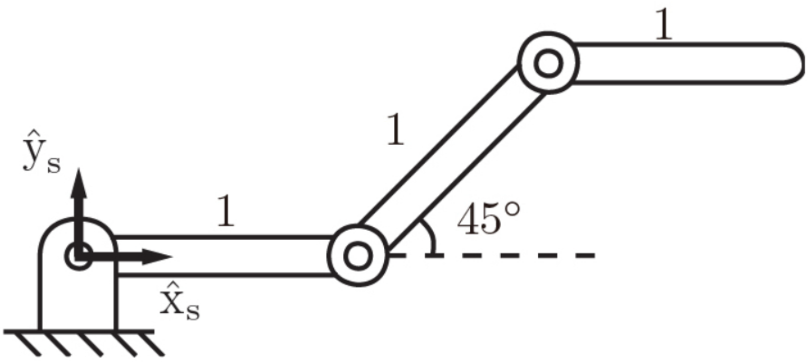
Congratulations! You passed!

Grade received 100% Latest Submission Grade 100% To pass 80% or higher

Go to next item

1. A 3R planar open-chain robot is shown below. 1 / 1 point



Suppose the tip generates a wrench that can be expressed in the space frame {s} as a force of 2 N in the $\hat{x}_s$ direction, with no component in the $\hat{y}_s$ direction and zero moment in the {s} frame. What torques must be applied at each of the joints? Positive torque is counterclockwise (the joint axes are out of the screen, so positive rotation about the joints is counterclockwise). Give the torque values in the form (τ_1, τ_2, τ_3). The maximum allowable error for any number is 0.01, so give enough decimal places where necessary.

Important: Remember that the wrench applied by the robot end-effector has zero moment in the {s} frame. **No other frame is defined in the problem. In particular, no frame is defined at the tip of the robot.**

Write the vector in the answer box and click "Run":

[1.11,2.22,3.33] for $\begin{bmatrix} 1.11 \\ 2.22 \\ 3.33 \end{bmatrix}$.

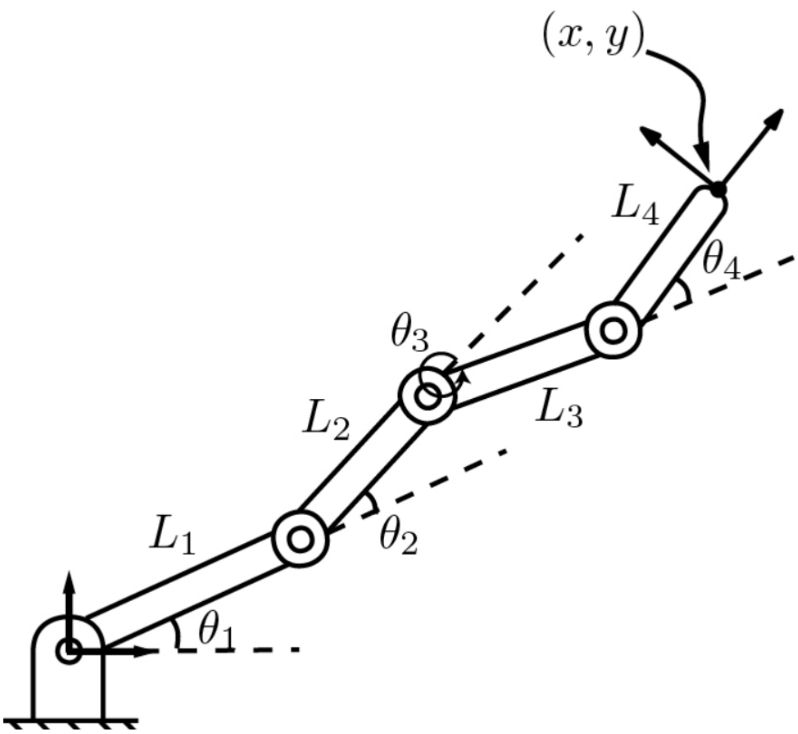
```
[0,0,1.414]
# Edit the answer above this line!  Do not edit below this line!
print 'Your answer has been recorded as', Your_Answer()
```

Run
Reset

Correct

Good job!

2. The 4R planar open-chain robot below has an end-effector frame {b} at its tip. 1 / 1 point



Considering only the planar twist components $(\omega_{bz}, v_{bx}, v_{by})$ of the body twist $\mathcal{V}_b$, the body Jacobian is

$$J_b(\theta) = \begin{bmatrix} 1 & 1 & 1 & 1 \\ L_3 s_4 + L_2 s_{34} + L_1 s_{234} & L_3 s_4 + L_2 s_{34} & L_3 s_4 & 0 \\ L_4 + L_3 c_4 + L_2 c_{34} + L_1 c_{234} & L_4 + L_3 c_4 + L_2 c_{34} & L_4 + L_3 c_4 & L_4 \end{bmatrix}$$

where $s_{23} = \sin(\theta_2 + \theta_3)$, etc.

Suppose $L_1 = L_2 = L_3 = L_4 = 1$ and the chain is at the configuration $\theta_1 = \theta_2 = 0, \theta_3 = \pi/2, \theta_4 = -\pi/2$. The joints generate torques to create the wrench $\mathcal{F}_b = (0, 0, 10, 10, 10, 0)$ at the last link. What are the torques at each of the joints? Give the torque values in the form $(\tau_1, \tau_2, \tau_3, \tau_4)$. The maximum allowable error for any number is 0.01, so give enough decimal places where necessary.

Write the vector in the answer box and click "Run":

[1.11,2.22,3.33,4.44] for $\begin{bmatrix} 1.11 \\ 2.22 \\ 3.33 \\ 4.44 \end{bmatrix}$.

```
[30,20,10,20]
```

Run

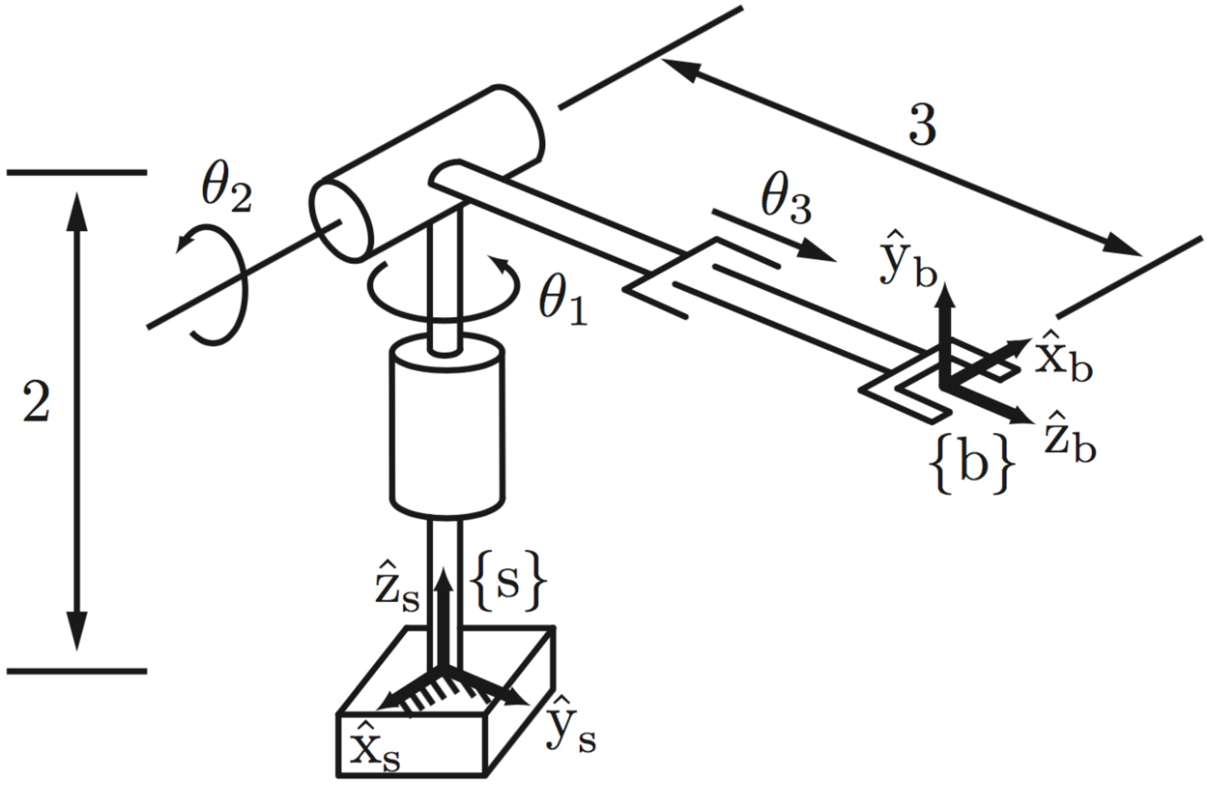
Reset

Correct

Good job!

3. The RRP robot is shown below in its zero position.

1 / 1 point



Its screw axes in the space frame are

$$\mathcal{S}_1 = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \mathcal{S}_2 = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 2 \\ 0 \end{bmatrix}, \mathcal{S}_3 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}.$$

Use the function `JacobianSpace` in the given software to calculate the 6x3 space Jacobian J_s when $\theta = (90^\circ, 90^\circ, 1)$. The maximum allowable error for any number is 0.01, so give enough decimal places where necessary.

Write the matrix in the answer box and click "Run":

[[1.11,2.22,3.33],[4.44,5.55,6.66],[7.77,8.88,9.99]] for $\begin{bmatrix} 1.11 & 2.22 & 3.33 \\ 4.44 & 5.55 & 6.66 \\ 7.77 & 8.88 & 9.99 \end{bmatrix}$.

```
[[0,0,0],[0,1,0],[1,0,0],[0,-2,0],[0,0,0],[0,0,1]]
```

Run

Reset

Correct

Good job!

4. Referring back to Question 3, the screw axes in the body frame are

1 / 1 point

$$\mathcal{B}_1 = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 3 \\ 0 \\ 0 \end{bmatrix}, \mathcal{B}_2 = \begin{bmatrix} -1 \\ 0 \\ 0 \\ 0 \\ 3 \\ 0 \end{bmatrix}, \mathcal{B}_3 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}.$$

Use the function `JacobianBody` in the given software to calculate the 6x3 body Jacobian J_b when $\theta = (90°, 90°, 1)$. The maximum allowable error for any number is 0.01, so give enough decimal places where necessary.

Write the matrix in the answer box and click "Run":

[[1.11,2.22,3.33],[4.44,5.55,6.66],[7.77,8.88,9.99]] for $\begin{bmatrix} 1.11 & 2.22 & 3.33 \\ 4.44 & 5.55 & 6.66 \\ 7.77 & 8.88 & 9.99 \end{bmatrix}$.

```
[[0,-1,0],[0,0,0],[1,0,0],[0,0,0],[0,4,0],[0,0,1]]
```

Run

Reset

Correct

Good job!

5. The kinematics of the 7R WAM robot are given in Section 4.1.3 in the textbook. The numerical body Jacobian J_b when all joint angles are $\pi/2$ is

1 / 1 point

$$J_b = \begin{bmatrix} 0 & -1 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 & 0 & 1 \\ -0.105 & 0 & 0.006 & -0.045 & 0 & 0.006 & 0 \\ -0.889 & 0.006 & 0 & -0.844 & 0.006 & 0 & 0 \\ 0 & -0.105 & 0.889 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Extract the linear velocity portion J_v (joint rates act on linear velocity). Calculate the directions and lengths of the principal semi-axes of the three-dimensional linear velocity manipulability ellipsoid based on J_v. Give a unit vector, with at least 2 decimal places for each element in this vector, to represent the direction of the longest principal semi-axis.

Write the vector in the answer box and click "Run":

[1.11,2.22,3.33] for $\begin{bmatrix} 1.11 \\ 2.22 \\ 3.33 \end{bmatrix}$.

```
[-0.0872,-0.9962,0.0002]
```

Run

Reset

Correct

Good job!

6. Referring back to Question 5 and its result, give the length, with at least 2 decimal places, of the longest principal semi-axis of that three-dimensional linear velocity manipulability ellipsoid.

1 / 1 point

1.2305

Correct