Course 2 Graded Assignment 2

**Problem 1:**

Chat GPT Answer (Wrong): <https://chatgpt.com/share/679c4b30-d0a4-8000-802c-5d86beabc3a8>

Relevant lecture: <https://modernrobotics.northwestern.edu/nu-gm-book-resource/5-1-1-space-jacobian/>

First construct the wrench [0,0,0,2,0,0]T

Then you need to construct the jacobian. The jacobian is constructed from the twists that result when the velocity of each joint is one and the velocities of all other joints are zero. You need to use adjoint transformation matrices to express all of these in the space frame.

There is a function that does this called JacobianSpace. The input to this function is Slist - a matrix of joint screw axis in the space frame when the manipulator is at its home position, and also thetalist, a list of the current joint coordinates. If you define the current configuration of the model as the home position, then the thetalist is all zero as it is in its home position.

How do I define the screw axis correctly? The rotation axis is simple – just the rotation axis of the joint, in this case 0,0,1 for all joints. The velocity component is determined by finding the velocity of the origin of the space frame when the velocity of the joint is at 1. Calculate the radius between the two positions and consider the joint to be rotating about this. The velocity is then just the angular velocity times the radius. As the angular velocity is 1, it is just the same magnitude as the radius and split between whatever vector directions have components.

Then with the Jacobian from this you multiply the Jacobian Transpose by the Wrench to get the vector of joint torques.

**Answer:**

[0,0,1.414]

**Problem 2:**

Here we are given the 2D / Planar version of the jacobian transpose in a round about way where we plug in the parameter values and have it be calculated. This results in a 3x4 matrix rather than a 6x4 matrix that we are given in the wrench. How do you convert from the wrench in 3D to a wrench in 2D? It is simply the torque followed by the xy force components in a 3 vector.

**Answer:**

[30,20,10,20]

**Problem 3:**

Here we are given the screw axis and need to compute the 6x3 space jacobian Js when theta ia 90, 90, 1. The theta list is [pi/2,pi/2,1] and the S list is the matrix of the screw axes given.  
  
**Answer:**

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

**Problem 4:**

Use the BodyJacobian function with the Screw Axes in the body frame given.

**Answer:**

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

**Problem 5:**

The Jv matrix is the linear component of the jacobian (the bottom rows). The mobility matrix is the Jv matrix multiplied by its transpose. Now that the mobility matrix is generated we need to determine the principle semi axis. To do so you need to find the eigenvalues. The square root of the eigen values represent the lengths of the principal semi axes (See question 6).  
The eig function in matlab can take the mobility matrix and return the eigenvalues and eigenvectors given the right context [V,D]=eig(MobilityMatrix). V is three columns of eigenvectors and D is a diagonal matrix of eigenvalues.

**Answer:**

The third eigenvalue is largest so it will be the principle axis. The eigenvector corresponding to this eigenvalue is then:

[-0.0872,-0.9962,0.0002]

**Problem 6:**

This is the square root of the largest eigenvalue of the mobility matrix.

**Answer:**

1.23