Let $S_1, S_2, S_3$ be the (unit) screw axes (relative to $\{s\}$ frame) for the three joints of the HRR robot when the robot is at the home position. Let $M$ be the end-effector frame matrix when the robot is at home position.

1) Find the space Jacobian when the robot is at home position, i.e., $J_S(0)$

   For $\theta = 0$, \[ J_S(\theta) = [S_1 \ S_2 \ S_3] \]

2) Find the space Jacobian $J_S(\hat{\theta})$, where $\hat{\theta} = \left(0, \frac{\pi}{4}, 0\right)$

   \[ J_{S_1} = S_1 \], \[ J_{S_2} = \left[Ad_{\hat{\theta}_2}^{\{s\}}\right] S_2 = S_2 \], \[ J_{S_3} = \left[Ad_{\hat{\theta}_3}^{\{s\}}\right] S_3 \]

   \[ J_S(\theta) = \begin{bmatrix} J_{S_1} & J_{S_2} & J_{S_3} \end{bmatrix} = \left[Ad_{\hat{\theta}_2}^{\{s\}}\hat{\theta}_2\right] S_3 \]

3) What is the spatial twist when the robot is at home position, and $\dot{\theta}_1 = 0$, $\dot{\theta}_2 = \dot{\theta}_3 = 2$

   \[ \nu_S = J_S(0) \dot{\theta} = \begin{bmatrix} S_1 & S_2 & S_3 \end{bmatrix} \begin{bmatrix} 0 \\ \dot{\theta}_2 \\ \dot{\theta}_3 \end{bmatrix} = 2S_2 + 2S_3 \]