Problem 1

The manipulator shown above is a six-DOF manipulator with five revolute joints and one prismatic joint. The link lengths are \( H_1 = H_2 = H_6 = 1 \text{ m} \). The Denavit-Hartenberg coordinate axes are given and assume the manipulator position is given by:

\[
\begin{align*}
\theta_1 &= 10^\circ, \quad \theta_2 = 20^\circ, \quad d_3 = 1 \text{ m}, \quad \theta_4 = 0, \quad \theta_5 = 0, \quad \theta_6 = 0
\end{align*}
\]

1) Write out the Denavit-Hartenberg parameters for each link and compute numerically each DH matrix as well as the global homogeneous 4x4 transformation matrix (from Frame 0 to Frame 6) for the given configuration.

2) Find the angular velocity \( ^0\omega \) and the linear velocity \( ^0V \) of point \( P \) if the joints have the following velocities:
\[ \dot{\theta}_1 = 0.1 \text{ rad/sec} \]
\[ \dot{\theta}_2 = 0.2 \text{ rad/sec} \]
\[ \dot{d}_3 = 0.1 \text{ m/sec} \]
\[ \dot{\theta}_4 = \dot{\theta}_5 = \dot{\theta}_6 = 0.0 \]

3) Model this robot manipulator with Working Model 3D. Use the given configuration in 1) as a starting configuration \((t=0)\) and apply the joint velocities given in 2) to the manipulator for a simulation time of 1 second.

Using Working Model-3D graphics, print out some graphical results showing:

- The model in the starting configuration and its bodies/connections list
- The plotted curves of velocities \(\omega, \omega_p\) versus time
- The final configuration of the manipulator and the trajectory of \(P\) from \(t=0\) to \(t=1\) (in the 0 frame)

The number (and the organization) of pictures you will choose to include in the homework is left to your discretion, but try to be concise and precise.