An-Najah National University  
Faculty of Engineering  
Mechanical Engineering Department  
Robotics (67682)  
Second Exam

Instructor Name: Dr. Nidal Farhat  
Academic Year: Fall 2013/2014  
Credit Hours: 3  
Date: Thursday, November 14, 2013  
Exam Duration: 50 min

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<td>Q2</td>
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Student Grade

Exam Notes:
1. Solve all the problems.
2. Closed books and notes.
3. Read each problem carefully before attempting to solve it.
4. Write all work on this exam paper.
Q1. Given the position \((x, y, z)\) of the end effector of the following manipulator, find solution of the inverse kinematics \((\theta_1, d_2, d_3)\).

Consider \(d_3 \geq 0\).

\[
\begin{align*}
\theta_1 &= \arctan 2(y, x) \\
\theta_2 &= \pi \\
\theta_3 &= \sqrt{x^2 + y^2}
\end{align*}
\]
Q2. Sketch the finger-tip workspace of the following manipulators:

\[ L_1 = 5, \quad 0 \leq \theta_1 \leq 90 \]
\[ 5 \leq L_2 \leq 10 \]
Q2. For the following manipulator determine the absolute linear and angular velocities of frame \( \{3\} \), expressed in the same frame \( \{3\} \), i.e. \( ^3\dot{\omega}_3 \) and \( ^3\dot{v}_3 \).