Computer Vision **Name:** _____
Prof. Bolton **Net ID:** _____
Assignment 1

This assignment contains 2 pages (including this cover page) and 6 questions. Total of points is 100.

Conditions: All work must be completed individually.

Write your answers neatly and clearly on standard paper. Include your name and Net ID. Follow submission instructions as indicated on Canvas.

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1. (10 points) Denote the following homogeneous points in non-homogeneous form: $\tilde{x_1} = (2, 4, 2)$ and $\tilde{x_2} = (2, 4, 1, 3)$

2. (30 points) Consider two homogenous lines $\tilde{l_1} = (3, 1, 1)$ and $\tilde{l_2} = (-1, 0, 1)$.
    A. Plot these lines on a Cartesian plane.
    B. Write the equations for these lines using standard equation form using x for horizontal and y for vertical axes.
    C. Find the point where these lines intersect.
    D. For both lines, find the unit normal components $\hat{n}$ such that line equation vector $l = (\hat{n_x}, \hat{n_y}, d)$ where $||\hat{n}|| = 1$

3. (20 points) Prove that affine transformations preserve parallelism. That is, if an affine transformation is applied to two lines, the resulting curves are lines and are parallel.

4. (20 points) Camera Geometry.
    A. Illustrate and describe the virtual image plane and the actual image plane. Identify the focal length.
    B. Illustrate the projection of a non-homogenous point $x = (u, v, w)$ from 3-d space to the virtual and actual image planes. Denote the coordinates of the projected points within the image planes in terms of u, v, and w.

5. (10 points) Rotation. Assume you have an image (collection of 2-d points) which you wish to rotate $-65°$.
    A. Construct the rotation matrix R.
    B. Consider a pixel located at image coordinates $x = (4, 5)$. Apply the aforementioned rotation to the image. What is the new location of pixel x?

6. (10 points) Camera Intrinsics and Extrinsics. Mapping a 3-d scene to a 2-d image using a camera is analogous to applying a transformation to each point in the scene. This transformation is often viewed as the applications of two sequential transformations.

One transformation characterized by parameters intrinsic to the camera and one transformation characterized by parameters extrinsic to the camera. These transformations are characterized by the so-called camera matrix $P = K[R|t]$, where K is the so-called calibration matrix (characterized by intrinsics) and $[R|t]$ is characterized by extrinsics.

A. Each matrix entry is a parameter which affects the overall transformation. Identify the parameters intrinsic to the camera and parameters extrinsic to the camera (entries in the Matrices). Using matrix and homogeneous point notation, write out this transformation from 3-d to 2-d as a sequence of matrix multiplications. Define and describe each of the parameters and how it affects the overall transformation.