Name: _____   Signature: _____

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1. The human eye is an imaging device with a focal length of about $17\,\text{mm}$, the retina on the back of the eye contains thousands of optical receptors called rods and cones. In a region called fovea in the retina there is a great concentration of cones. This region is mostly responsible for the spatial accuracy of vision. The fovea has a diameter of about $1.5\,\text{mm}$. Each cone in the fovea has a diameter of approximately $0.003\,\text{mm}$.

   (a) Based on these data, what is the theoretical field of view in degrees of spatially accurate human vision?

   (b) What is the field of view in degrees for one cone in the optical axis?

   (c) If we assume that the image of an object has to cover at least one cone receptor to be seen by the human visual system, what is the smallest object you can see at a distance of $30\,\text{m}$?

2. A CCD camera has a focal length of $24\,$mm, its CCD sensor array has dimensions $16 \times 12\,$mm (width $\times$ height) and it has a resolution of 500×500 pixels. Assume that the origin of the image buffer is at top-left and y_{im} axis is pointing down.

    (a) Give the intrinsic parameters of the camera.

    (b) Give the expression relating a 3D point in the world reference frame to the image buffer as a function of the intrinsic and extrinsic parameters (for the rotation matrix $\mathbf{R}$ give the expression as a function of its rows $\mathbf{r}_1$, $\mathbf{r}_2$ and $\mathbf{r}_3$).

    (c) Suppose that the camera reference frame coincides with the world reference frame. Give the expression relating a 3D point in the world reference frame to the image buffer.

    (d) Assuming that the camera reference frame coincides with the world frame, what are the image buffer pixel coordinates of a 3D point with coordinates $x = 12\,$m, $y = 7\,$m and $z = -103\,$m (coordinates in world reference frame) imaged by this camera?

    (e) If the camera generates images in RGB, with each color channel quantized in 256 levels. How many different digital images can be generated by this camera?