# Congratulations! You passed!

| Grade received | Latest Submission Grade | To pass |
|---|---|---|
| 100% | 100% | 70% or higher |

**Go to next item**

**1.** How many dimensions are there in the homogenous representation of a 4D point? **1 / 1 point**

- 3
- 4
- 5 (selected)
- 6

**Correct**
The homogenous representation of a 4D point is a 5D point where the last coordinate is nonzero.

**2.** Convert the following homogenous coordinate representation back into image coordinates $(u, v)$ : $\begin{bmatrix} 14 \\ 7.5 \\ 0.5 \end{bmatrix}$ **2 / 2 points**

- $(7, 3.25)$
- $(14, 7.5)$
- $(28, 15)$ (selected)
- Cannot be calculated without additional information

**Correct**
The conversion from $\begin{bmatrix} \tilde{u} \\ \tilde{v} \\ \tilde{w} \end{bmatrix}$ to $(u, v)$ is defined as $u = \frac{\tilde{u}}{\tilde{w}}$ and $v = \frac{\tilde{v}}{\tilde{w}}$

respectively, which in this case results in $(28, 15)$.

**3.** Which of the following can NOT be a calibration matrix? **2 / 2 points**

- ○ $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$
- ◉ $\begin{bmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \\ 1 & 2 & 3 \end{bmatrix}$
- ○ $\begin{bmatrix} 1 & 2 & 3 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix}$
- ○ $\begin{bmatrix} 1 & 2 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix}$

✓ **Correct**
A calibration matrix must be an upper triangular matrix. Thus the second answer option is NOT a calibration matrix.

**4.** If the calibration matrix of a camera is an identity matrix, which of the following could be the full projection matrix from world to image coordinates? **3 / 3 points**

- ○ $\begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
- ◉ $\begin{bmatrix} -0.8 & 0.6 & 0 & 0 \\ -0.6 & 0.8 & 0 & 1 \\ -0 & 0 & 1 & 1 \end{bmatrix}$
- ○ $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & 5 & 0 \end{bmatrix}$
- ○ $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$

**Correct**

Since the calibration matrix is identity, the intrinsic matrix is $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$.

The projection matrix is simply $\begin{bmatrix} R_{3\times 3} & \mathbf{t} \end{bmatrix}$, where $R_{3\times 3}$ is orthonormal matrix. Therefore, the second answer choice is correct.

**5.** Which of the following is true regarding the setup of the camera calibration procedure? **1 / 1 point**

- The 3D world coordinates of each point are known while its 2D image plane coordinates are not
- The 2D image plane coordinates of each point are known while its 3D world coordinates are not
- The projection matrix is known; the extrinsic and intrinsic matrices are not
- **The projection, extrinsic, and intrinsic matrices are unknown**

**Correct**

In a camera calibration procedure, we know the 2D image plane coordinates of points in the image and their corresponding 3D world coordinates from the calibration object. However, our goal is to calculate the best-fit projection matrix to decompose into the extrinsic and intrinsic matrices, meaning all 3 are unknown to begin with.

**6.** The Projection matrix acts on homogenous coordinates. Therefore, any scalar multiple of a solution will also be a solution. To isolate to a single solution, we need to add the normalization constraint. Which of the following statements is correct regarding the importance of the normalization constraint? **1 / 1 point**

- This constraint makes the optimization easier
- **$A\mathbf{p} = \mathbf{0}$ is not sufficient to produce a unique $\mathbf{p}$**
- The flattened projection matrix $\mathbf{p}$ is only valid when $\|\mathbf{p}\|^2 = 1$
- The correspondences to form $A$ are noisy

**Correct**

Projection matrix acts on homogenous coordinates. Therefore, any $kp$ ( $k$ is an arbitrary constant) is a solution. To get a unique solution, we need to add such constraint.

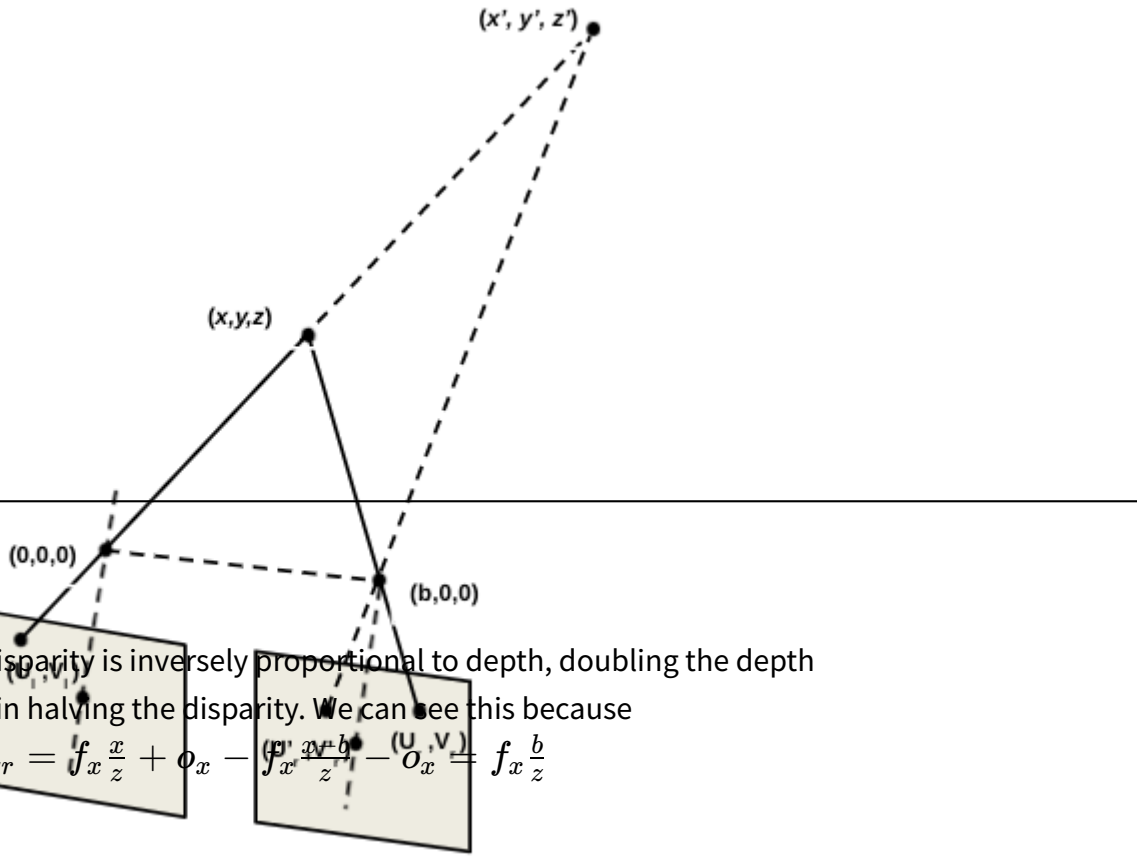
**7.** Which of the following parameters could NOT be included in an expanded intrinsic model? **1 / 1 point**

- Radial distortions
- Exposure time
- Tangential distortions
- Focal length

**Correct**

Intrinsic parameters affect how 3D world points map to 2D points in the image. Exposure time does not affect this; it only affects the image point intensity.

**8.** Consider the simple stereo system shown below. If, if we move the scene point $(x, y, z)$ to $(x', y', z')$ such that $z' = 2z$, what will be the new disparity $b'$ in terms of the previous disparity $b = u_l - u_r$ ? **2 / 2 points**




- $b$
- $2b$
- $b/2$
- $\sqrt{b}$

**Correct**

Since disparity is inversely proportional to depth, doubling the depth results in halving the disparity. We can see this because $u_l - u_r = f_x \frac{x}{z} + o_x - f_x \frac{x-b}{z} - o_x = f_x \frac{b}{z}$

**9.** In a simple stereo system, which of the following statements is true? **1 / 1 point**

- Scene depth is proportional to focal lengths of both cameras.
- Baseline is proportional to scene depth.
- Disparity is inversely proportional to scene depth.
- Disparity is inversely proportional to baseline.

**Correct**

The formula of scene depth $z$ is:

$z = \frac{bf_x}{(u_l - u_r)}$

Therefore, the third answer choice is correct.

**10.** Suppose there is a simple stereo system of two cameras with the same intrinsic parameters without distortion. The two cameras are placed distance $b$ apart with parallel optical axes. In the 3D world, there is a perfect 2D circle parallel to the image planes of both cameras and centered in front of the left camera. What is the shape of the circle projected on the left and right image planes, respectively? **2 / 2 points**

- ○ Perfect Circle on the left image plane; Non-circle ellipse on the right image plane
- ○ Non-circle Ellipse on the left image plane; Perfect circle on the right image plane
- ◉ Perfect circle on both image planes
- ○ Non-circle ellipse on both image planes

**Correct**

Since two cameras have no distortion and have parallel optical axes, a 2D circle parallel to their image planes remains a circle after projected onto their image planes.