

CSE 152A Midterm Exam Example  
Fall 2023  
Time limit: 30 minutes

**Instructions :**

- Attempt all questions.
- Show intermediate steps to receive partial credit.
- All the best!

**Problem 1      (15 points)**

Consider a road, which is given by a flat plane. The edges of the road and the center divider are parallel straight lines drawn on the road surface. Each edge is 3 meters from the center divider along the road surface. A car is driving on the road, perfectly aligned with the center divider. A camera is mounted on the car, 2 meters above the surface of the road. The camera is situated above the center divider, parallel to the surface of the road and facing along the direction of motion of the car. The focal length of the camera is 200 pixels, with aspect ratio equal to 1, zero pixel skew and principal point at  $(100 \text{ pixels}, 100 \text{ pixels})^\top$  on the image plane.

**(a)** Draw the geometry of the above scenario showing the road, lanes and the car, along with various distances and directions of the camera axes. **[3 points]**

**(b)** Determine the intrinsic parameter matrix of the camera. **[2 points]**

(c) Pick two points on the left edge that are 10m and 20m along the direction of the camera's principal axis. Similarly pick two points that are on the center divider and the right edge that are, respectively, 10m and 20m along the direction of the camera's principal axis. State the image coordinates of the points. [5 points]

(d) The car turns by an angle of  $90^\circ$  to the right (assume it can turn in-place with a zero radius) and then moves directly forward by a distance of 1m. Derive the essential matrix induced between the two views. [5 points]

## Problem 2 (10 points)

You want to re-tile your floor with a perfectly Lambertian material, so you go to the store to get a sample tile. You bring with you a camera and a flashlight, which you can consider as distant directional light source of intensity 1. You have the ability to measurably control the direction of the light source.

(a) Consider a point  $X$  on the tile with a constant albedo of 0.5, which is illuminated by your light source at an angle of  $45^\circ$  with respect to the surface normal at  $X$ . What is the intensity of light reflected by  $X$  towards a camera placed exactly overhead with respect to it? [3 points]

**(b)** You want to verify the salesperson's assertion that the tile is indeed Lambertian. Suggest a procedure to do it. **[3 points]**

**(c)** You are now satisfied that the tile is Lambertian, but want to verify the salesperson's assertion that the tile is indeed flat, which can be achieved by measuring surface normals across the tile. Suggest a method to do it. **[4 points]**