University of California San Diego
Department of Computer Science
CSE190: Virtual Reality
Spring Quarter 2017
Midterm Examination
Thursday, May 25th, 2017

Name:_____

This is closed book exam. You may not use electronic devices, notes, books or other written materials.

Good luck!

Do not write below this line

Exercise	Max.	Points
1	10	
2	10	
3	10	
4	10	
5	10	
6	10	
7	10	
8	10	
Total	80	

1. Head-Mounted Displays (10 Points)

a) Below are two options for each specifications category for the **VPL EyePhone**. Check the correct one. (7 points)

VR Display Type:
o CAVE
o Head-mounted display

Display:
o Black and white
o Color

Tracking:
o Electromagnetic
o Optical

Field of View:
o 30x17 degrees
o 90x60 degrees

Weight:
o 1.0 lbs
o 2.4 kg

Release date:
o June 7, 1989
o June 7, 1998

Price:
o $94,000
o $9,400

b) For the following categories, describe which technological advancements contributed substantially to the rise of **modern consumer VR** since 2012. (3 points)

Display Technology:

6 DOF Tracking Technology:

Rendering:

2. Depth Cues (10 Points)

a) Name and briefly describe three monocular depth cues – these are cues which help us judge the distance of objects from our eyes, even if we're only using one eye. (6 points)

b) Describe the difference between accommodation and convergence. (2 points)

c) Describe what is meant by the "accommodation-convergence mismatch" in the context of most of today's VR displays. (2 points)

3. Human Color Vision (10 Points)

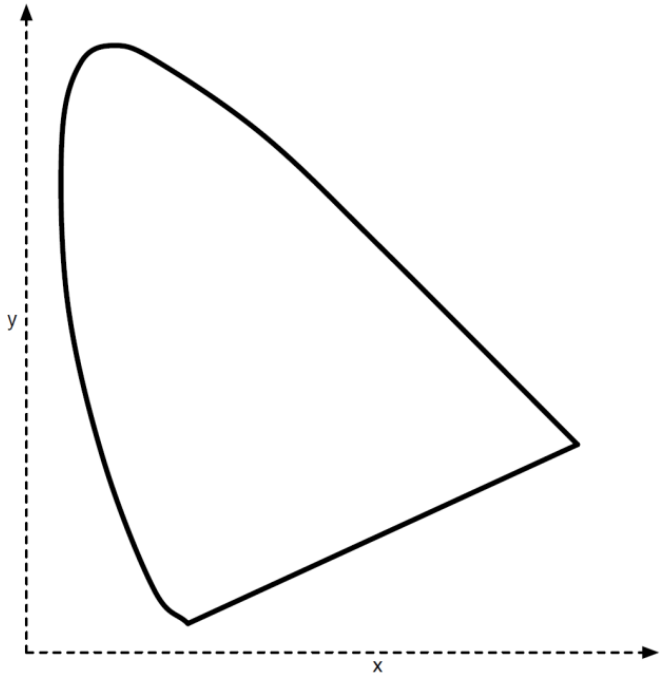
a) How many different types of rods and cones are there in the retina? (2 points)

b) Describe one difference between rods and cones (besides that there are different amounts of types). (2 points)

c) What is the tristimulus theory, and how does it help us in Computer Graphics? (2 points)

d) Can a computer monitor produce all the colors our eyes can distinguish? Why/why not? (2 points)

e) The diagram below shows the the x-y plane of the CIE color space. Mark and label one plausible location each for the red, green, and blue basis colors. Indicate the color gamut for the color basis you have shown. (2 points)



4. Stereo Imaging Techniques (10 Points)

a) The owner of a movie theater wants to start showing 3D movies and is torn between anaglyphic, active and passive stereo. Name one advantage and one disadvantage for each of them which it has compared to the other two. (6 points)

b) Briefly describe how an autostereoscopic display with a barrier screen works. Draw a sketch with a few light paths from screen pixels to right and left eyes, and where they pass through the barrier screen. (2 points)

c) Many stereo imaging techniques suffer from ghosting. Briefly describe what ghosting is. (1 point)

d) Name an example for a 3D display which completely avoids ghosting? (1 point)

5. VR Displays (10 Points)

a) What is the difference between Field of View and Field of Regard? (2 points)

b) Compare front projected to rear projected screens: describe one advantage of each of them which it has over the other. (2 points)

c) Compare CAVE-type VR displays with head-mounted displays. Name three advantages of each of them which it has over the other. (6 points)

CAVE

-
-
-

HMD

-
-
-

6. The Oculus Rift (10 Points)

a) Describe the Asynchronous Time Warp (ATW) by answering the following questions.

Why is it done? (1 point)

When is it done? (1 point)

How does it work? (4 points)

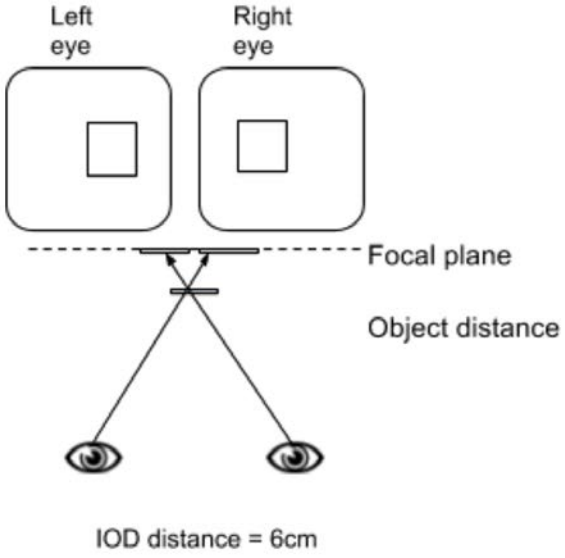
b) Name and describe two ways in which the Asynchronous Space Warp (ASW) differs from ATW. (4 points)

7. Rendering to an HMD (10 Points)

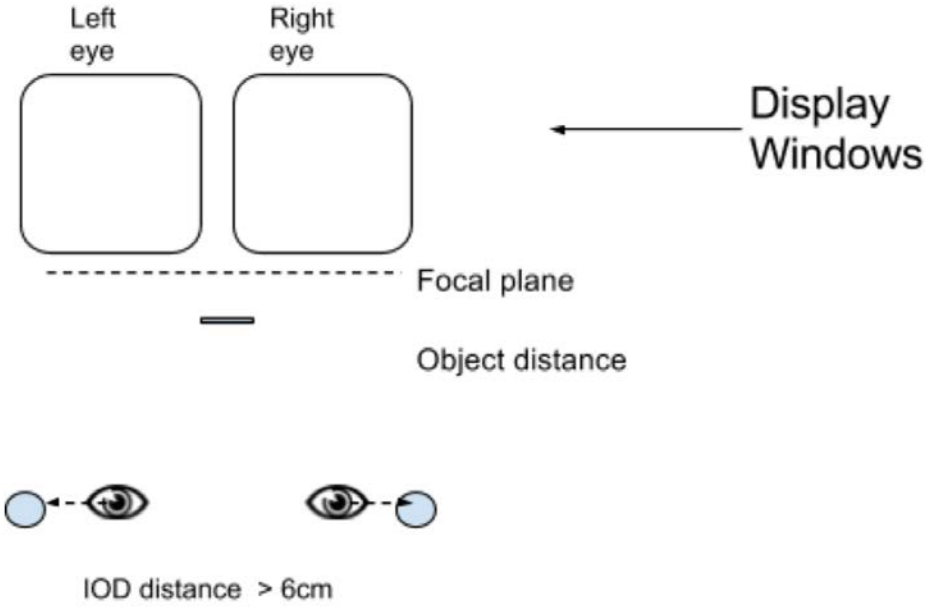
Assuming that you are rendering a square in the middle of the scene and that HMD has a focal distance of 5 feet.

Note: For all of the following questions, please draw the images in the left/right eye display windows, and indicate the direction that the squares have moved relatively to the display windows for IOD = 6cm. Add eye projection lines, projected square position on the focal plane and notes to justify your final images.

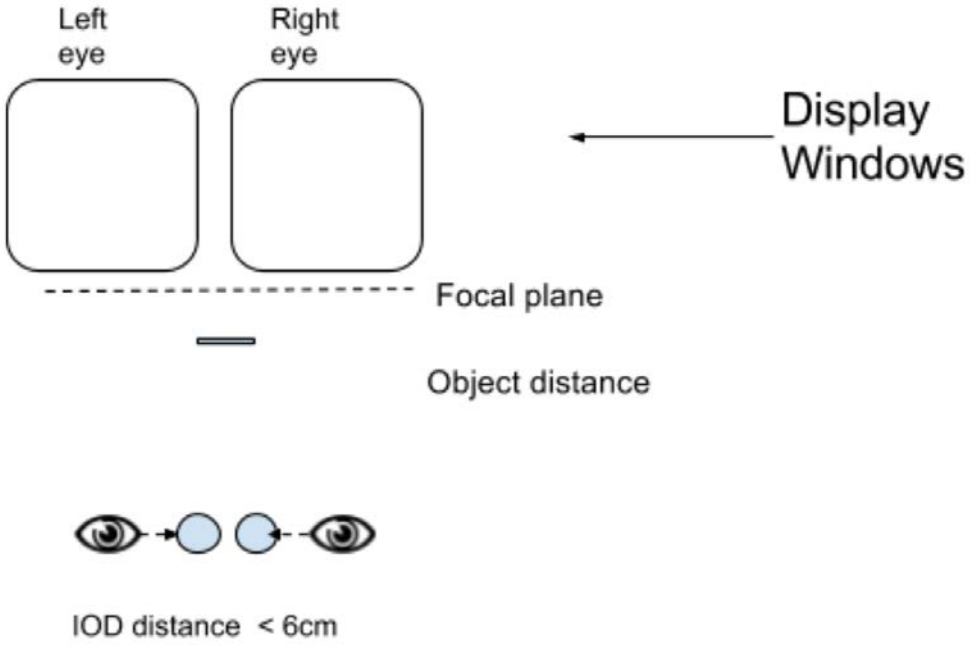
a) If the object is rendered in front of the focal plane, how does the IOD affect the rendered images? For example, if the IOD=6cm looks like the images below:



What should the images look like if IOD > 6cm? (2 points)

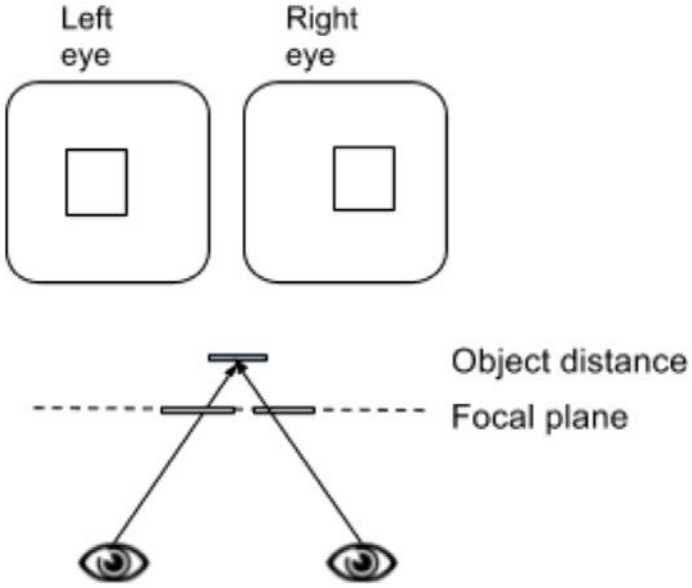


What should the images look like if IOD < 6cm? (2 points)



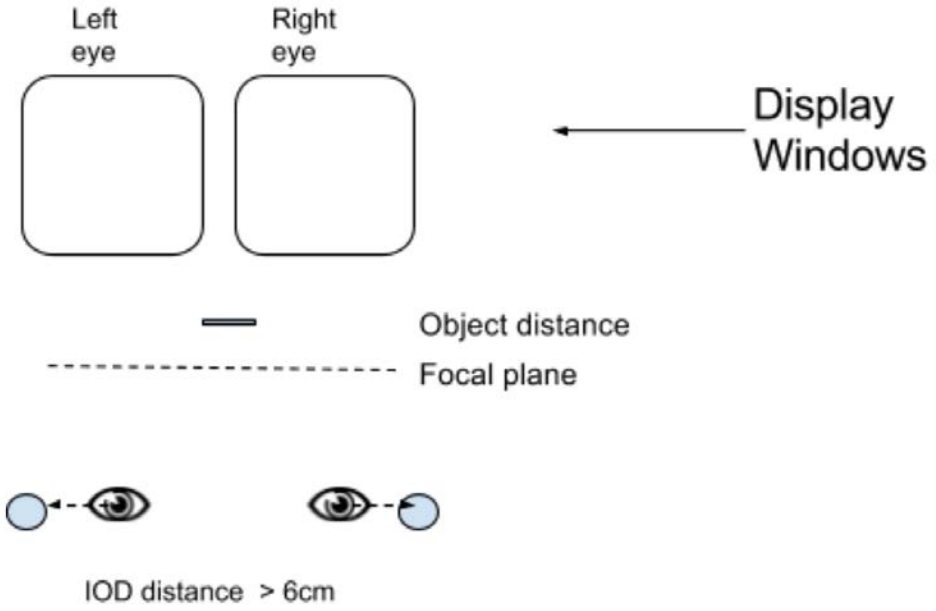
IOD distance < 6cm

b) If the object is rendered beyond the focal plane, how does the IOD affect the rendered images?

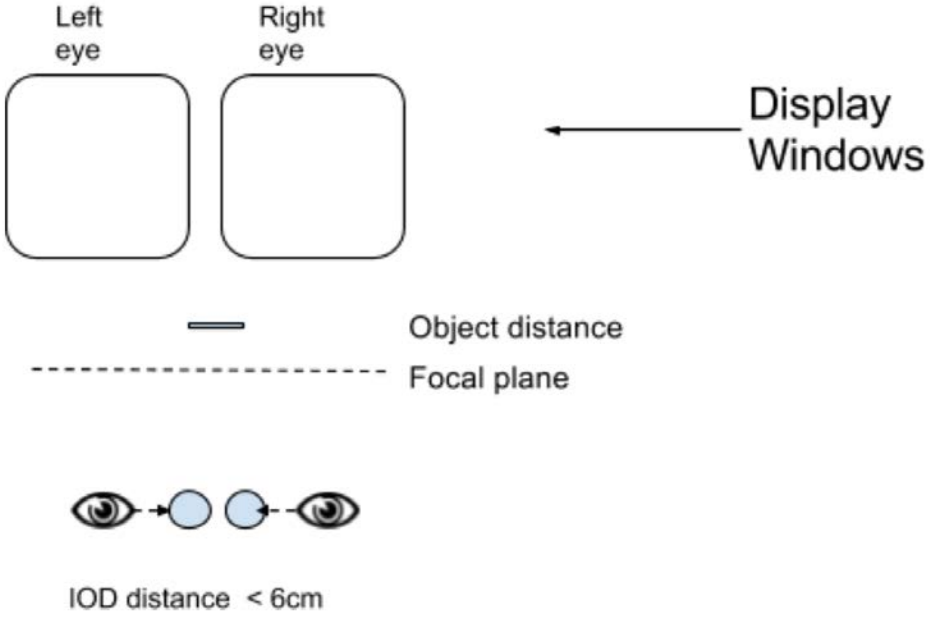


IOD distance = 6cm

What should the images look like if IOD > 6cm? (2 points)



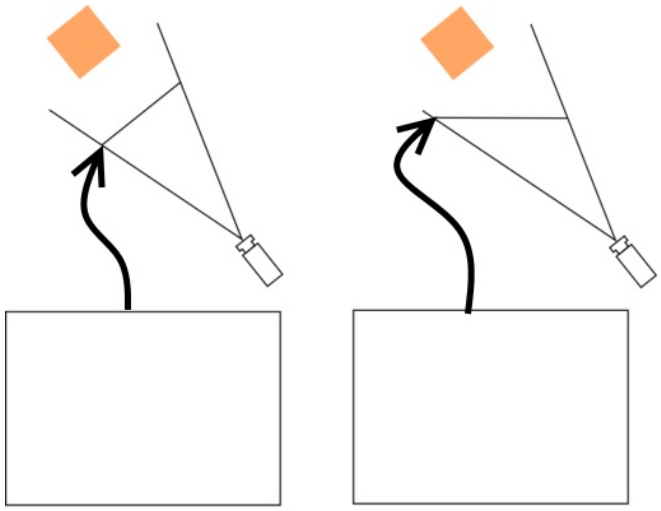
What should the images look like if IOD < 6cm? (2 points)



c) If the square is rendered in the focal plane, would IOD affect the rendered images? If yes, how would the IOD affect the rendered squares. If no, why not? (2 points)

8. Off-Center Viewing (10 Points)

a) In the section below, draw how the cube should be rendered on the screen. Additionally, explain your drawings. (4 points)



Explanations:

b) Why do we need an off-center projection matrix for rendering to a CAVE? (1 point)

c) How does head tracking affect the images on CAVE screens -- what happens when you only change head position or orientation?
Changing only head position: (1 point)

Changing only head orientation: (1 point)

d) The off-axis perspective matrix is constructed from $P * M^T * T$. What does each matrix represent? Also, give a high-level explanation of how each one is generated. (3 points)