CS3388 FINAL EXAMINATION MASTER

Monday April 6 2020 9:00 am to Tuesday April 7 9:00 pm

NAME:	Not Required
STUDENT NUMBER:	Not Required

- This examination counts for 20% towards your final mark
- This examination has 10 questions
- All questions are multiple choice
- Choose only one answer per question
- You are allowed all printed materials, your own Python programs, and web resources that you see fit
- Submit your answers as a text file in OWL: The file should contain only one line with your 10 answers, and nothing else

Question 1 (2 marks): Suppose a generic sphere is placed into a scene by the following homogeneous transformation matrix:

$$M = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

and a ray $r(t) = e + \vec{d}\,t$, where $e = (5,5,5,1)^T$ and $\vec{d} = (-1,-1,-1,0)^T$. What is the ray in homogeneous notation once it is transformed with matrix M^{-1} ?

A) $e = (4,4,5,1)^T$ and $\vec{d} = (-1,-1,-1,0)^T$

B) $e = (6,6,5,1)^T$ and $\vec{d} = (0,0,-1,0)^T$

C) $e = (5,5,5,1)^T$ and $\vec{d} = (0,0,-1,0)^T$

D) $e = (6,6,5,1)^T$ and $\vec{d} = (-1,-1,-1,0)^T$

E) $e = (4,4,5,1)^T$ and $\vec{d} = (0,0,-1,0)^T$

Question 2 (2 marks): Following your answer to Question 1, what is the smallest *t*-value at which the transformed ray intersects the generic sphere?

A) 5.3333

B) 6.0

C) 3.0

D) 4.0

E) 4.6667

Question 3 (2 marks): Following your answer to Question 2, what are the 3D coordinates in homogeneous notation of the intersection point that the transformed ray makes with the generic sphere?

A) $(-1.3333,-1.3333,-0.3333,1)^T$

B) $(-2,-2,-1,1)^T$

C) $(1,1,2,1)^T$

D) $(0,0,1,1)^T$

E) $(-0.6666,-0.6666,0.3333,1)^T$

Question 4 (2 marks): In which coordinate system the intersection point from the previous question was obtained?

A) World coordinates
B) Camera coordinates
C) Image coordinates
D) Pixel coordinates
E) Generic coordinates

Question 5 (2 marks): The implicit equation for the hyperboloid of one sheet is given by $x^2+y^2-z^2-1=0$. Given a ray $r(t)=e+\vec{d}\,t$, what are the coefficients a, b, c in the polynomial $at^2+2bt+c=0$ which yields the *t*-values of the ray-hyperboloid intersections?

A) $a=d_x^2+d_y^2+d_z^2 \quad b=e_x d_x+e_y d_y+e_z d_z \quad c=e_x^2+e_y^2+e_z^2$

B) $a=d_x^2+d_y^2+d_z^2 \quad b=e_x d_x+e_y d_y+e_z d_z \quad c=e_x^2+e_y^2+e_z^2-1$

C) $a=d_x^2+d_y^2-d_z^2 \quad b=e_x d_x+e_y d_y-e_z d_z \quad c=e_x^2+e_y^2-e_z^2-1$

D) $a=d_x^2+d_y^2 \quad b=e_x d_x+e_y d_y \quad c=e_x^2+e_y^2-1$

E) $a=d_y^2+d_z^2 \quad b=e_y d_y+e_z d_z \quad c=e_y^2+e_z^2-1$

Question 6 (2 marks): What is a normal vector in homogeneous notation at any given point on the surface of the hyperboloid of one sheet from the preceding question?

A) $(x, 2y, -z, 0)^T$

B) $(x, y, -z, 0)^T$

C) $(2x, 2y, 2z, 0)^T$

D) $(x, y, z, 0)^T$

E) $(-2x, -2y, z, 0)^T$

Question 7 (2 marks): Suppose a generic sphere is placed in world coordinates in a scene by the following transformation matrix:

$$M = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 2 & 0 & 1 \\ 0 & 0 & 3 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

where is the centre of the sphere in world coordinates (expressed non-homogeneously) once it is placed in the scene by matrix M ?

A) $(0,0,0)^T$

B) $(1,2,3)^T$

C) $(3,2,1)^T$

D) $(2,1,1)^T$

E) $(1,1,2)^T$

Question 8 (2 marks): Suppose we have a light located at $(5,5,10,1)^T$ in world coordinates. Also suppose we have a generic sphere placed and scaled in the world coordinate system by matrix

$$M=\begin{bmatrix}1&0&0&1\\0&2&0&1\\0&0&3&2\\0&0&0&1\end{bmatrix}$$

with its inverse is given by

$$M^{-1}=\begin{bmatrix}1&0&0&-1\\0&1/2&0&-1/2\\0&0&1/3&-2/3\\0&0&0&1\end{bmatrix}$$

Given the ray $r(t)=e+\vec{d}\,t$ where $e=(11,21,32,1)^T$ and $\vec{d}=(-1,-2,-3,0)^T$, what is the normal vector in generic coordinates at the closest ray-sphere intersection in homogeneous notation?

A) $(0.5774,0.5774,0.5774,0)^T$

B) $(0.4082,0.4082,0.4082,0.7071)^T$

C) $(1,1,2,0)^T$

D) $(1,2,3,0)^T$

E) $(-0.5774,0.5774,-0.5774,0)^T$

Question 9 (2 marks): From Question 8, what is the normalized vector in generic coordinates from the intersection point to the light source in homogeneous notation?

A) $(0.3911,0.3911,0.8316,0)^T$

B) $(0.8044,0.3344,0.4910,0)^T$

C) $(0.5774,0.5774,0.5774,0)^T$

D) $(0.4082,0.4082,0.4082,0.7071)^T$

E) $(1,1,2,0)^T$

Question 10 (2 marks): From Question 8, what is the normalized vector in generic coordinates from the intersection point to the centre of the camera in homogeneous notation?

A) $(0.5774, 0.5774, 0.5774, 0)^T$

B) $(0.4082, 0.4082, 0.4082, 0.7071)^T$

C) $(1,1,2,0)^T$

D) $(1,2,3,0)^T$

E) $(-0.5774, 0.5774, -0.5774, 0)^T$