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Middle East Technical University
Department of Computer Engineering

CENG 477

Fall '19

Midterm Exam #1

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- **Duration: 120** minutes.
- **Grading:**
  - Each of the **15** TRUE-FALSE questions is worth **2** points.
  - Each of the **10** Multiple-choice questions is worth **5** points.
  - Each of the **2** Classical-type questions is worth **10** points.
  - For TRUE-FALSE and multiple-choice questions **4** wrong points cancel out **1** correct point.
- **Asking questions:** is not allowed. If you decide that a question is wrong:
  - DO NOT ask the proctor about a clarification.
  - Indicate clearly your objection and your proposed answer on the **first page of the question booklet**.
  - For all transformation questions, assume that points are multiplied from the right with the matrix (as in $p' = Mp$)
- **Mark** your group ID (as A or B) on your answer sheet.
- **Turn in** your question booklet (this booklet) together with the answer sheet. Otherwise your answer sheet will not be evaluated, and you will receive a zero from this exam.
- GOOD LUCK !

We start with TRUE-FALSE questions, mark $\boxed{\text{A}}$ box for TRUE, $\boxed{\text{B}}$ box for FALSE on your answer sheet

F $\boxed{\textbf{1}}$ The barycentric coordinates of a point inside a triangle will add up to 1 even if some of them may be negative. They cannot be negative

F $\boxed{\textbf{2}}$ In bilinear interpolation for texture mapping, the nearest two pixels' colors are interpolated to find the final color. four

T $\boxed{\textbf{3}}$ In ray tracing, the color of a pixel is computed independently from the colors of neighboring pixels.

F $\boxed{\textbf{4}}$ The dot product of any two vectors gives the cosine of the angle between them. only unit

F $\boxed{\textbf{5}}$ The running-time complexity of ray tracing grows quadratically with the number of pixels. linearly

F $\boxed{\textbf{6}}$ In Blinn-Phong shading of a shiny sphere, when we increase the specular exponent (shininess), the specular highlight on the sphere will get larger.

T $\boxed{\textbf{7}}$ Diffuse shading components of a surface point are the same for cameras located at different points.

F $\boxed{\textbf{8}}$ Vectors remain unchanged by all modeling transformations.

T $\boxed{\textbf{9}}$ In a k-D tree used to partition a 3D scene, each interior node has $k = 3$ children.

F $\boxed{\textbf{10}}$ No objects will be in shadow if there are three or more light sources that are separated by 120° in a scene.

T $\boxed{\textbf{11}}$ In ray tracing, with everything else being constant, the image size of the objects become smaller if the image plane is brought closer to the camera.

F $\boxed{\textbf{12}}$ The specular (Blinn-Phong shading) component of the ray tracing illumination model depends on the viewer's position and the light position, but it does not depend on the normal vector of the surface. (n.h)^p

T $\boxed{\textbf{13}}$ The surface color obtained by texture mapping can be used as an object's reflectance coefficient in ray tracing computations. diffuse reflectance coef

F $\boxed{\textbf{14}}$ A rectangular image cannot be used for texture mapping of a triangle.

T $\boxed{\textbf{15}}$ The surface of a unit sphere can be modeled by a parametric equation with only two parameters. cos(u,v) sin(u,v)

The TRUE-FALSE questions END here.

Wr = -Wo + 2n.cosQ = -Wo + 2n.(n.Wo)

16 Find the reflection of the vector $\vec{w}_i = [1/\sqrt{14} \quad 2/\sqrt{14} \quad 3/\sqrt{14}]$ along the surface normal $\vec{n} = [0 \quad 1/\sqrt{2} \quad 1/\sqrt{2}]$.

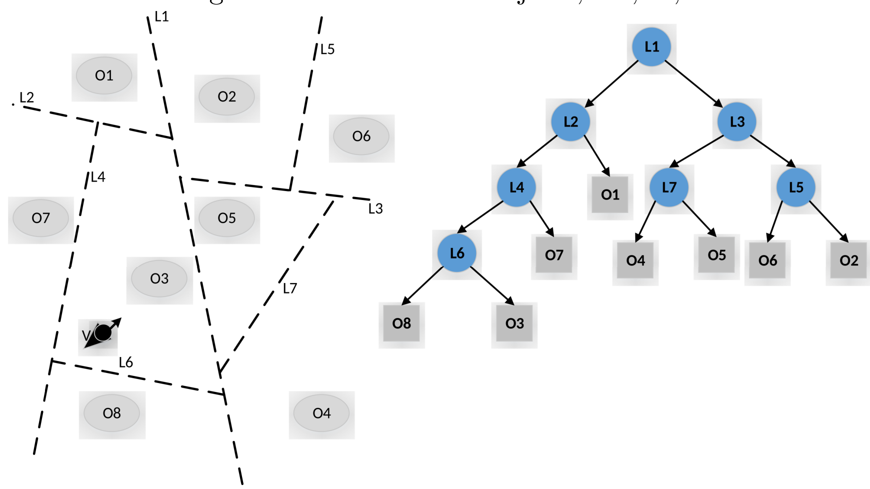
A) $[2/\sqrt{56} \quad -6/\sqrt{56} \quad 4/\sqrt{56}]$
B) $[2/\sqrt{56} \quad 4/\sqrt{56} \quad -6/\sqrt{56}]$
C) $[-2/\sqrt{56} \quad 4/\sqrt{56} \quad 6/\sqrt{56}]$
D) $[-2/\sqrt{56} \quad 6/\sqrt{56} \quad 4/\sqrt{56}]$
E) $[2/\sqrt{56} \quad 6/\sqrt{56} \quad -4/\sqrt{56}]$

17 Assume that we want to store 8 different vertices and a closed-mesh made up of 12 triangles to represent a shape. Each vertex is made up of 3 floating point numbers (assume one float occupies 4 bytes). Each index is represented using an integer value (assume one integer also occupies 4 bytes). If the only extra information that the file contains is the number of vertices (one integer) and number of triangular faces (another integer), how many total bytes will be used to represent this mesh using an Indexed-Face-Set representation that only supports triangles?

A) 216
B) 232
C) 248
D) 256
E) 282

(#vertices) 4bytes + (#triangles) 4bytes + (triangles indexes) 12*3*4 bytes+ (vertices) 8*3*4 bytes = 248

18 Consider the BSP Tree given below for the 8 objects, O1, ...,O8.



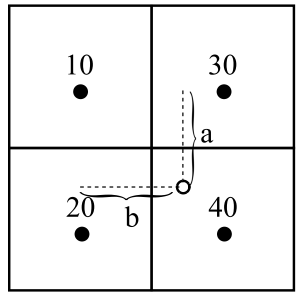
If the camera is in the same sub-space as in O3 as shown in the figure above, which of the following correctly list the leaf nodes in a back-to-front ordering with respect to the camera?

A) O8, O7, O3, O1, O4, O5, O6, O2
B) O6, O2, O4, O5, O1, O7, O8, O3
C) O4, O5, O6, O2, O8, O7, O1, O3
D) O6, O2, O5, O4, O7, O1, O8, O3
E) O2, O6, O5, O4, O7, O1, O3, O8

19 Assume that the uv coordinates of a texture point is indicated by the empty circle in the diagram below. Its distance to the top pixel is given by $a = 0.75$ and the left pixel by $b = 0.60$. The numbers above filled circles indicate the intensities of different pixels. Compute the final color that should be used for this texture point assuming bilinear interpolation.

A) 28.5
B) 29.0
C) 29.5
D) 28.0
E) 30.0

10*(1-b).(1-a) + 20*(1-b).(a) + 30*(b).(1-a) + 40*(b).(a)
10*(0.4).(0.25) + 20*(0.4).(0.75) + 30*(0.6).(0.25) + 40*(0.60).(0.75) = 29.5



$\boxed{20}$ Given a 2D square defined by its top-left $(10, 10)$ and bottom-right $(20, 20)$ coordinates. What is the correct combined 2D transformation matrix to scale this square around its center by a factor of 3 along x-axis and 2 along y-axis?

A)
$$\begin{bmatrix} 3 & 0 & -15 \\ 0 & 2 & -15 \\ 0 & 0 & 1 \end{bmatrix}$$

B)
$$\begin{bmatrix} 3 & 0 & 15 \\ 0 & 2 & 15 \\ 0 & 0 & 1 \end{bmatrix}$$

C)
$$\begin{bmatrix} 3 & 0 & -45 \\ 0 & 2 & -30 \\ 0 & 0 & 1 \end{bmatrix}$$

D)
$$\begin{bmatrix} 3 & 0 & 45 \\ 0 & 2 & 30 \\ 0 & 0 & 1 \end{bmatrix}$$

E)
$$\begin{bmatrix} 3 & 0 & -30 \\ 0 & 2 & -15 \\ 0 & 0 & 1 \end{bmatrix}$$

$\boxed{21}$ Assume that a display device has a gamma (γ) value of 2.5. What is the most appropriate gamma-correction value that you should use to prepare an image for this display device?

A) 0.2
B) 0.3
C) 0.4
D) 1.5
E) 2.5

gamma correction = 1/gamma

$\boxed{22}$ Given the following transformation definitions:

- $R(\theta)$: Rotate a point around origin counter-clockwise by θ degrees
- $T(\Delta x, \Delta y)$: Translate a point by the $(\Delta x, \Delta y)$ vector
- $S(s_x, s_y)$: Scale the x-component of a point by s_x and y-component by s_y

Which of the following transformations will take the reflection of any given point along the line passing through $P_1 = (5, 4)$ and $P_2 = (6, 5)$?

I $T(1,0)R(-45^o)S(-1,1)R(45^o)T(-1,0)$

II $T(1,0)R(45^o)S(1,-1)R(-45^o)T(-1,0)$

III $T(1,0)R(-315^o)S(1,-1)R(315^o)T(-1,0)$

A) I
B) I and II
C) II and III
D) All of the above
E) None of the above

alfa + beta + gamma =1

u(beta, gamma) = ua + beta(ub – ua) + gamma(uc – ua)
v(beta, gamma) = va + beta(vb – va) + gamma(vc – va)

23 Consider a triangle with the following texture coordinates at its vertices: $(u_1, v_1) = (0.4, 0.6)$, $(u_2, v_2) = (0.8, 0.8)$, and $(u_3, v_3) = (0.2, 0.3)$. What will be the texture coordinates of the point on the triangle identified by the following Barycentric coordinates: $\alpha = 0.2$, $\beta = 0.3$, associated with vertices 1 and 2 respectively.

A) (0.36,0.36)
B) (0.42,0.36)
C) (0.36,0.51)
D) (0.42,0.51)
E) none of the above

u = 0.4 + (0.3).(0.4) + 0.5 (-0.2) = 0.42
v= 0.6 + (0.3).(0.2) + 0.5 (-0.3) = 0.51

24 Find the intersection point of a ray with origin $o = [3 \quad 2 \quad 1]$ and direction $\vec{d} = [5 \quad 2 \quad 8]$ with a plane with surface normal $\vec{n} = [1/\sqrt{2} \quad 0 \quad -1/\sqrt{2}]$ and passing through the point $a = [6 \quad 4 \quad 7]$.

p = o + td

A) $[6 \quad 7 \quad 2]$
B) $[8 \quad 4 \quad 9]$
C) $[6 \quad 2 \quad 8]$
D) $[1/\sqrt{2} \quad 2 \quad -1/\sqrt{2}]$
E) $[-1/\sqrt{2} \quad 3 \quad -2/\sqrt{2}]$

t = (a-o).n / (d.n)
= (3,2,6).n / (5,2,8).n = 1

25 Which of the following matrices can be used to draw the reflection of a 2D object from a mirror with line equation **y=5**?

A)
$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 10 \\ 0 & 0 & 1 \end{bmatrix}$$

B)
$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & -5 \\ 0 & 0 & 1 \end{bmatrix}$$

C)
$$\begin{bmatrix} 1 & 0 & 5 \\ 0 & -1 & -5 \\ 0 & 0 & 1 \end{bmatrix}$$

D)
$$\begin{bmatrix} 1 & 0 & -5 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

E)
$$\begin{bmatrix} -1 & 0 & 10 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

The Multiple-choice questions END here.

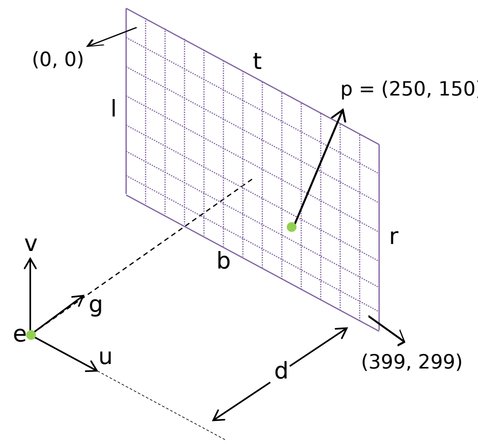
Classical questions BEGIN here. You must show your work with a clear writing. You can use the back of the page if needed.

$\boxed{\textbf{26}}$ Derive the composite transformation matrix as a multiplication of basic transformation matrices to rotate a 2-dimensional triangle with vertices (v_1, v_2, v_3), 30 degrees around v_1, counter-clockwise and then making it 70% smaller without moving v_1. Here, $v_1 = (2, 4)$, $v_1 = (7, 5)$, and $v_1 = (3, 9)$. Write your solution as a sequence of basic transformations. In other words, you do **not** need to write or multiply any 3×3 matrices. You may indicate basic transformations as: $R(\alpha)$: rotate around origin α degrees, $T(t_x, t_y)$: translate t_x and t_y along the $x-$ and $y - axes$, and $S(s_x, s_y)$: scale with scaling ratios s_x and s_y in x and y coordinates.

T(2,4).S(0.7,0.7).R(30).T(-2,-4)

27 Assume that you are given the following configuration for ray tracing defined in a right-handed world coordinate system:

Eye position (e):	$[3, 4, 5]$
View direction (g):	$[0, 0, -1]$
Up vector (v):	$[0, -1, 0]$
Near plane (NP) distance (d):	10
NP left coordinate (l):	-10
NP right coordinate (r):	10
NP bottom coordinate (b):	-7.5
NP top coordinate (t):	7.5
Image width (pixels):	400
Image height (pixels):	300
Image origin:	top-left



(8 pts) Given the configuration above, find the world coordinate of pixel $p(x = 250, y = 150)$.

u = g x v = (-1,0,0)
su = (i+0.5) * (r-l) / nx = 250.5 * 20 / 400 = 12.525
sv = (j+0.5) * (t-b) / ny = 150.5 * 15 / 300 = 7.525
m = (3,4,-5)
q = (13, -3.5,-5)
s = q + su.u - sv.v = (13-12.525, -3.5 + 7.525, -5) = (0.475, 4.025, -5)

(2 pts) Compute the world coordinate of the primary ray passing through the same pixel p at ray parameter $t = 10$. Assume that at $t = 1$ the ray will be on the image plane.

d = (s - e) = (2.525, 0.025, 10)
o + 10.d = (3, 4, 5) + (25, 0, 100) = (28, 4, 105)