LAST NAME: ______________________________

First name: ______________________________

McGill ID: ______________________________

Faculty of Science
COMP-557 - Fundamentals of Computer Graphics (Fall 2016)
Midterm Examination A

Thursday, 20 October, 2016, 8:35 am - 9:55 am, Trottier 0070 Examiner: Prof. Paul Kry

DO NOT TURN THIS PAGE UNTIL INSTRUCTED

Instructions:

- This is a closed book exam; notes, slides, textbooks, and other documentation are not allowed.
- Non-programmable calculators are allowed (and unnecessary).
- Computers, PDAs, cell phones, and other electronic devices are not allowed.
- Answer all questions on the examination paper; extra space is available on the last page.
- This exam has 9 pages including this cover page.
- Marks associated with each written answer is shown in the left margin.
- Multiple choice questions are worth 1 mark each
- Each unanswered multiple choice question is worth 0.2 marks.
- There is a total of 20 marks.
- Read questions carefully, and it is best to read all questions before starting to write answers.
- **Answers to multiple choice questions must be written on this page.**
- Keep your multiple choice answers hidden during the exam. When complete leave pages face down.

ENTER YOUR MULTIPLE CHOICE ANSWERS HERE:

1	2	3	4	5	6	7	8	9	10

MC	11	12	13	Total
/10	/3	/4	/3	/20

Pick the *best* answer for each of the following multiple choice questions.
Each correct answer is worth 1 mark.
Each unanswered question is worth 0.2 marks.
Answers *must* be entered in the boxes provided on the front page.

1. An implicit representation of a plane can be written as
   (a) $\left\{\mathbf{v} \in \mathbb{R}^3 \;\middle|\; \begin{pmatrix}\mathbf{v}^T & 1\end{pmatrix} \mathbf{Q} \begin{pmatrix}\mathbf{v} \\ 1\end{pmatrix} = 0\right\}$ for a given invertible symmetric matrix $\mathbf{Q} \in \mathbb{R}^{4\times4}$
   (b) $\{\mathbf{p} + s\mathbf{u} + t\mathbf{v} \mid s \in \mathbb{R}, t \in \mathbb{R}\}$ for a given $\mathbf{p}$, $\mathbf{u}$, and $\mathbf{v}$ in $\mathbb{R}^3$
   (c) $\{\mathbf{v} \in \mathbb{R}^3 \mid \mathbf{v} \cdot \mathbf{u} + k = 0\}$ for a given $\mathbf{u} \in \mathbb{R}^3$ and $k \in \mathbb{R}$
   (d) all of the above
   (e) none of the above

2. A rotation matrix
   (a) is always symmetric
   (b) has determinant equal to positive 1
   (c) has a unique equivalent unit quaternion rotation representation
   (d) all of the above
   (e) none of the above

3. The homogeneous representation of the point $\mathbf{p} = (x, y, z)^T$ is
   (a) is $(w, x, y, z)^T$ for $w \neq 0$
   (b) is $(x, y, z, w)^T$ for $w > 0$
   (c) is $(x, y, z, w)^T$ for $w \neq 0$
   (d) is $(wx, wy, wz, w)^T$ for $w \neq 0$
   (e) none of the above

4. How would you best scribe the transformation of the following matrix?
   $$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$
   (a) rotation
   (b) shear
   (c) translation
   (d) scale
   (e) none of the above

5. Assuming n and f are not equal and less than zero, the projection matrix
$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & n+f & -nf \\ 0 & 0 & 1 & 0 \end{pmatrix}$$
   (a) maps points behind the camera to points in front of the camera beyond the $z = n + f$ plane
   (b) preserves the z order of points between the near and far planes
   (c) is always invertible
   (d) all of the above
   (e) none of the above

6. In OpenGL, we can draw one camera's frustum from another camera's view by setting up the appropriate matrices for the projection and modelview matrix, and then using `glutWireCube` to draw an axis aligned cube centered at the origin and with side length 2. Let camera i have viewing transformation $\mathbf{V}_i$ and projection matrix $\mathbf{P}_i$. Using the technique described above, which of the following would be correct for using camera 2 to draw the frustum of camera 1?
   (a) `GL_PROJECTION_MATRIX` is $\mathbf{P}_2\mathbf{V}_2$ and `GL_MODELVIEW_MATRIX` is $\mathbf{V}_1^{-1}\mathbf{P}_1^{-1}$
   (b) `GL_PROJECTION_MATRIX` is $\mathbf{P}_2\mathbf{V}_2$ and `GL_MODELVIEW_MATRIX` is $\mathbf{P}_1\mathbf{V}_1$
   (c) `GL_PROJECTION_MATRIX` is $\mathbf{P}_2\mathbf{V}_2$ and `GL_MODELVIEW_MATRIX` is $\mathbf{V}_1\mathbf{P}_1^{-1}$
   (d) `GL_PROJECTION_MATRIX` is $\mathbf{P}_1\mathbf{V}_1\mathbf{V}_2^{-1}\mathbf{P}_2^{-1}$ and `GL_MODELVIEW_MATRIX` is the identity.
   (e) none of the above

7. Given two quaternions,
$$q_1 = a_0 + a_1 i + a_2 j + a_3 k$$
$$q_2 = b_0 + b_1 i + b_2 j + b_3 k,$$
   what is the coefficient of j term in the quaternion product $q_1 q_2$? Recall the multiplication rules:
$$i^2 = j^2 = k^2 = ijk = -1, \;\; ij = -ji = k, \;\; jk = -kj = i, \;\; ki = -ik = j.$$
   (a) The j term has coefficient $a_2b_0 + a_0b_2 - a_3b_1 + a_1b_3$
   (b) The j term has coefficient $a_1b_0 + a_0b_1 + a_2b_3 - a_3b_2$
   (c) The j term has coefficient $a_2b_0 + a_0b_2 + a_3b_1 - a_1b_3$
   (d) The j term has coefficient $a_1b_0 + a_0b_1 - a_2b_3 + a_3b_2$
   (e) none of the above

8. What is the field of view in the vertical direction `fovy`, for a 35 mm single lens reflex film camera with a 50 mm focal-distance lens? Recall that the film area exposed on the 35 mm film is 24 mm high and 36 mm wide. You can assume the camera, film, and world vertical direction are all the same.

   (a) `fovy` $= 2\tan^{-1}(50/12)$
   (b) `fovy` $= 2\sin^{-1}(12/50)$
   (c) `fovy` $= 2\cos^{-1}(24/25)$
   (d) `fovy` $= 2\tan^{-1}(24/50)$
   (e) none of the above

9. Suppose we compute the coefficients of a screen-space linear function for interpolating some quantity across a screen-space triangle $(x_0, y_0), (x_1, y_1), (x_2, y_2)$, and suppose we do this with the origin shifted to the point (x_0, y_0) to get

$$q(x, y) = c_x(x - x_0) + c_y(y - y_0) + q_0.$$

   If we have the value of quantity q at some point in the middle of the triangle, how will the quantity change if we step one screen-space pixel to the right?

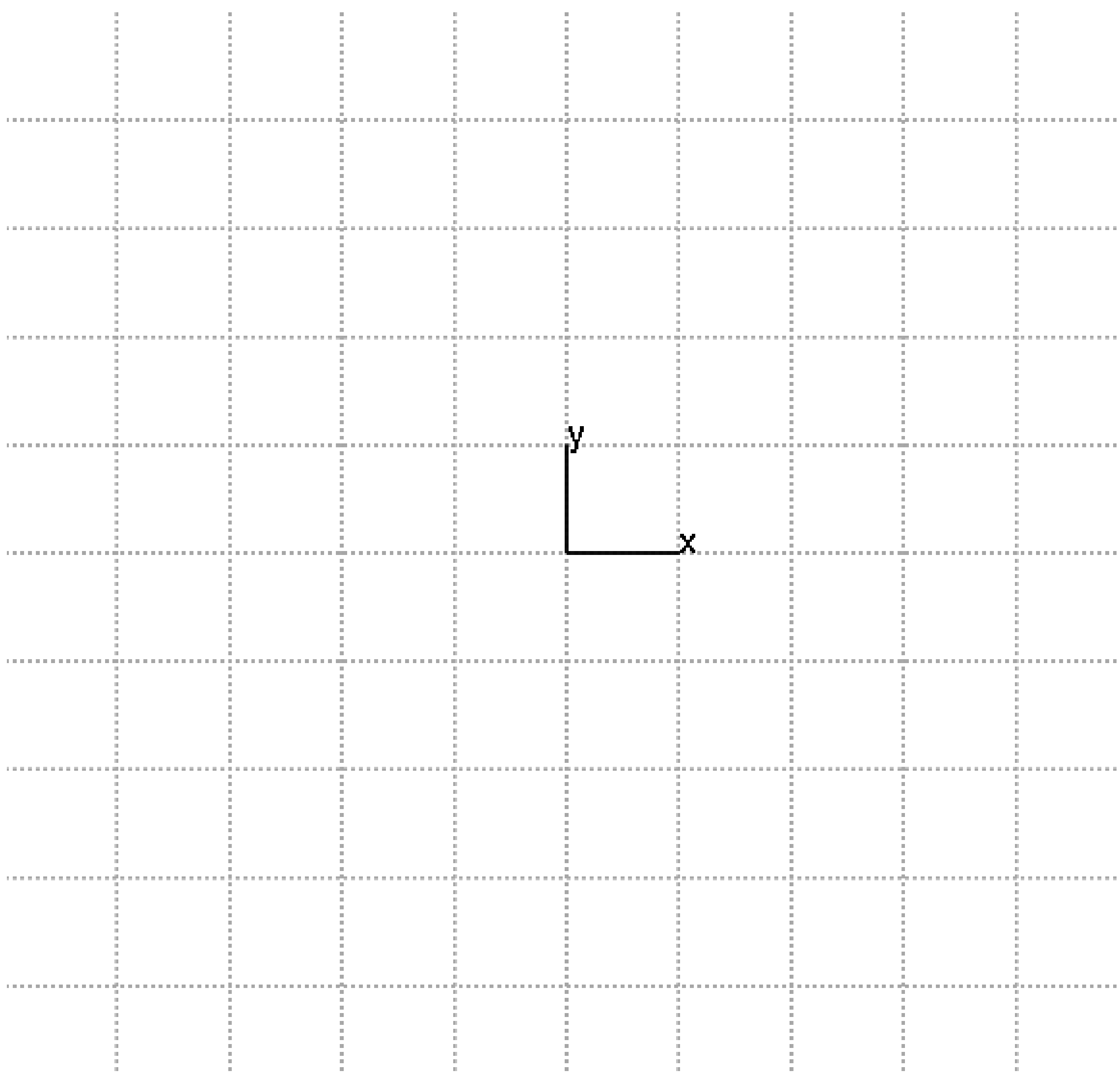
   (a) c_y
   (b) c_y/c_x
   (c) c_x
   (d) $-c_x x_0$
   (e) none of the above

10. Is the halfway vector for the Blinn-Phong local illumination model constant, that is, the same, for all fragments, and can thus be precomputed?

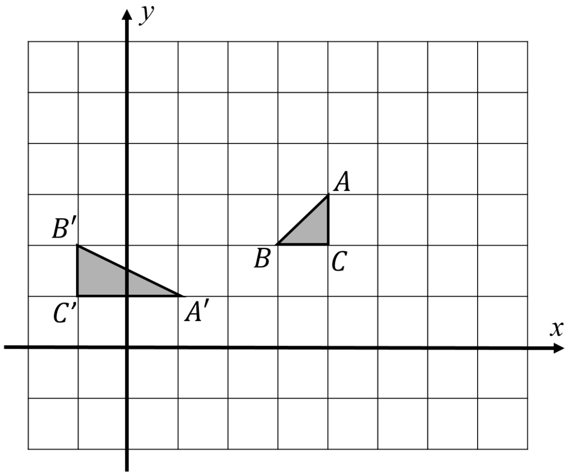
   (a) always
   (b) only for a directional light
   (c) only for an orthographic projection
   (d) only for an orthographic projection and a directional light
   (e) never

[3] 11. Consider the following code snippet, where `drawCircle` draws a circle of the specified *radius* in the xy plane, and `drawSquare` draws a square with the specified *side length* in the xy plane. Draw the output generated on the provided 10 by 10 grid.

```
drawCircle( gl, 1 );
gl.glRotated( -90, 0, 0, 1 );
gl.glPushMatrix();
    gl.glScaled( 2, 1, 1 );
    gl.glTranslated( 0, 3, 0 );
    drawSquare( gl, 2 );
gl.glPopMatrix();
gl.glPushMatrix();
    gl.glTranslated( 0, 3, 0 );
    gl.glRotated( 90, 0, 0, 1 );
    gl.glTranslated( 0, 1, 0 );
    drawSquare( gl, 2 );
gl.glPopMatrix();
```



[4] 12. Given the following figure, write down a product of 2D homogeneous transformation matrices (or matrix inverses) that will transform the points of triangle ABC to their corresponding points in triangle $A'B'C'$.



[3] 13. Write the formula for computing diffuse Lambertian illumination. Define all variables used in the equation.

EXTRA SPACE

EXTRA SPACE