UNIVERSITY OF OTAGO EXAMINATIONS 2012

COMPUTER SCIENCE

Paper COSC342

COMPUTER GRAPHICS

Semester 1

(TIME ALLOWED: THREE HOURS)

This examination consists of 4 pages including this cover page.

Candidates must answer **all** of the 15 questions within this examination.
Questions are worth various marks and are shown thus: (5)

The total number of marks for this exam is 60. You should keep your answers short. In general, if there are two points for an answer, you should have two things to say.

No supplementary material is provided for this examination.

Candidates **may not** bring calculators, reference books, notes, or other written material into this examination room.

At the end of the examination, hand in this exam paper attached to your answer book(s).

1. A point on an LCD display is lit. Describe how this works, including a diagram that illustrates the role of each of the main components. Explain what changes when this point is not lit. (6)

2. (a) Explain why a laser printer typically requires more energy than an inkjet printer to print its first page after it is turned on. (2)

   (b) To print on cloth rather than paper, indicate whether it is better to use a laser printer or an inkjet printer, and explain why. (2)

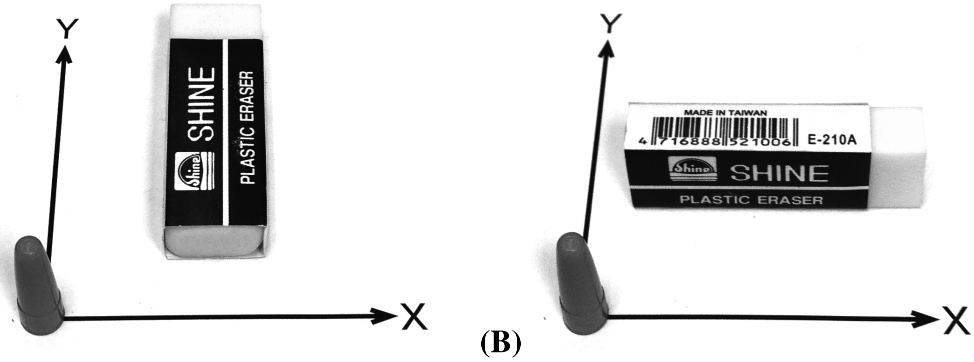
   (c) What extra components are needed in a laser printer that can do colour, not just black and white? (2)

3. A form of Bresenham's line drawing algorithm is reproduced below:

```
d = rx / 2;
incr = rx - ry;
for (i = 1; i <= rx; i++)
{   x = x + 1;
    if (d < ry)
    {   y = y + 1;
        d = d + incr;
    } else
        d = d - ry;
    pixel[x][y] = colour;
}
```

What is the role of `d`? What difference would initialising `d` to `0` instead of `rx / 2` make? Illustrate the part of the XY plane in which the above algorithm will operate correctly, when drawing lines outwards from the origin of that plane. (4)

4. A triangle mesh can be made to look smooth by interpolating colours across each triangle instead of shading them with a single colour. Describe a situation where the underlying, non-smooth geometry is still visible, despite the interpolated shading. What can be done to fix this problem? (2)



(A) **(B)**

5. The figure, above, shows a pencil eraser in two different axis-aligned orientations. Note that the text "Shine" is only printed on one face of the eraser. The X and Y axes are shown, and the pen lid sitting on the origin of the XY plane is pointing upwards in the direction of the positive Z-axis, giving a right handed coordinate system.

   (a) Describe the operations necessary to rotate the eraser from the position shown in **A** to the position shown in **B**. No shift is necessary. Just describe the rotations. (2)

   (b) Write down the matrices to represent these rotations. (2)

   (c) Multiply these matrices in the correct order to create the single matrix that performs this transformation. (2)

6. Assume that a complex scene has been displayed, using a Z-buffer for visible surface determination. Explain how an additional triangle is drawn into this scene, using the Z-buffer to maintain correct visible surface determination. (4)

7. Spatial subdivision techniques can help avoid unnecessary ray/object intersection tests. When might a non-uniform spatial subdivision be more effective than a uniform subdivision? What is a key disadvantage of non-uniform spatial subdivision algorithms compared to uniform spatial subdivision algorithms? (2)

8. (a) Show in homogeneous coordinate form, the 3D point p with $x = 1$, $y = 0$ and $z = 1$. (1)

   (b) Form a homogeneous transform matrix T_1 that translates points one unit in the negative x direction, and a matrix T_2 that translates points one unit in the negative z direction. (2)

   (c) Perform the necessary matrix multiplication using T_1 and T_2 to shift p to the origin, showing your working. Explain how you determine a 3D point from the vector produced by the previous matrix multiplication. (3)

9. Name two global illumination algorithms: one that computes energy transfer functions between geometric patches within a scene, and one that traces the path of light particles radiating from light sources. For each, give an example of a lighting effect that can be achieved. Describe a very basic approximation of global illumination that is often used in lighting calculations. (3)

10. Write down the specular lighting component used in Phong's lighting model, for a greyscale illumination equation, describing what each variable represents. (5)

11. Consider a flat, single-sided triangle in a 3D space with vertices (1,0,0), (0,1,0) and (0,0,1) that is facing away from the origin. Giving your answer as a vector, what is the direction of the normal to the surface of this triangle? If a point light source is at the origin, calculate $\hat{\boldsymbol{\ell}} \cdot \hat{\mathbf{n}}$ for the point on the triangle at (1,0,0), showing your working. (Remember that a 'hat' over a vector means that it is a unit vector.) What does it mean if $\hat{\boldsymbol{\ell}} \cdot \hat{\mathbf{n}}$ is negative? (4)

12. Why is Phong shading more computationally expensive than Gouraud shading? For a single shaded triangle occupying a large proportion of the viewplane, what type of local illumination can Phong shading render significantly more effectively than Gouraud shading, and why? (4)

13. When subdividing pixels using a regular pattern of supersampled rays, to antialias a scene containing textures that have a regular pattern, describe an undesirable effect that can appear in the rendered image. What can be done to avoid this problem? (3)

14. Explain why the use of bounding volumes can often significantly reduce the computational complexity of rendering a scene. Why is a sphere potentially a good bounding volume? Bounding volumes with more complex geometry can be used. What limits how much extra complexity will be useful? (3)

15. Consider a hypothetical output device that produces colour by mixing light from red, green and blue output components. Each component can add any possible non-negative amount of light energy into the output colour. Is this device able to display all of the colours that are visible to humans? Explain your answer with reference to the electromagnetic spectrum. (2)