

## 14

### Summary

A world in a nutshell

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[Lec11\\_Surfaces.pdf](#)[Edit](#)[Edit](#)

## 12. Tessellation Shader

[Lec12\\_Tessellation.pdf](#)[Edit](#)[QuadTessn.zip](#)[Edit](#)[TriTessn.zip](#)[Edit](#)[Edit](#)

## 13. Geometry Shader

[Edit](#)

This topic is not included in the exam.

[Lec13\\_GeometryShader.pdf](#)[Edit](#)[Edit](#)

## 14. Summary

[Summary.pdf](#)[Edit](#)[Exam Paper 2014](#)[Edit](#)[Exam Paper 2015](#)[Edit](#)[Exam Paper 2016](#)[Edit](#)[Exam Paper 2017](#)[Edit](#)

# Final Exam

- Duration: 3 Hours
- Closed book (No written or printed material allowed)
- **UC approved calculators allowed**
- Maximum marks: 100 (Contribution to final grade: 50%)
- Important formulae provided (see next slide)

# Equations that will be provided

- The following formulae will be provided if required for answering any of the questions:
  - Vector cross product
  - Projection of a vector
  - Rotation matrices
  - Shadow transformation matrix
  - Parametric equation of a ray
  - Equation for  $t$  at the point of intersection between
    - a ray and a plane
    - a ray and a sphere
  - Equation of the reflected ray
  - Bernstein polynomials for generating Bezier curves.

# Equations that will **NOT** be provided

- You will need to remember the equations for the following:
  - A vector from one point to another
  - Vector dot product, computation of angle
  - Magnitude of a vector, normalization of a vector.
  - Linear interpolation
  - Homogeneous to Cartesian coordinate conversion
  - Translation, Scale transformation matrices
  - Diffuse and specular reflections from a polygonal vertex
  - Half-way vector used in computing specular reflections

# 1 OpenGL Basics

You may be asked to write small OpenGL code segments (see exercise questions, past year exams) containing some basic functions. You must be able to use any of the following functions with relevant parameters in the code:

`glBegin()`, `glEnd()`

`glVertex3f()`, `glVertex4f()`

`glColor3f()`, `glColor4f()`

`glPushMatrix()`, `glPopMatrix()`

`glTranslatef()`, `glRotatef()`,  
`glScalef()`

`glTexCoord2f()`

`glutSolidCube()`

`glutSolidTeapot()`

`glutSolidSphere()`

# 1 OpenGL Basics

You must be familiar with the following OpenGL functions, and be able to explain their applications. The functions along with their parameters will be given.

`gluLookAt()`

`glutTimerFunc()`

`glMultMatrixf()`

`glFrustum()`

`glEnable(GL_COLOR_MATERIAL)`

`glColorMaterial()`

`glLightfv()`

`glMaterialfv()`

`glTexParameterf()`

# 1 OpenGL Basics

- Representation of R,G,B, C,M,Y,W,K colours using normalized floating point values.
- Right-handed reference frame for Cartesian coordinates.
- Event processing in OpenGL (general concepts only)
  - The glut timer call-back



## 2 Transformations

- Sequence of transformations
  - Order in which OpenGL transformation functions are called.
  - Order in which transformation matrices are multiplied.
- Rotations about pivot points
- OpenGL transformation stack
  - Specifying transformations inside nested `glPushMatrix()` – `glPopMatrix()` blocks.



## 3 Illumination Model

- OpenGL illumination model
  - Light-material interaction
  - Ambient, diffuse, specular reflections and their properties
- Spotlights
- Computation of the surface normal vector



## 4 Texture Mapping

- Assigning texture coordinates to vertices
- Texture wrap modes
- Minification and magnification filtering
- Mipmaps



## 5 Object Modelling

- Extruded surfaces
  - The process of constructing a surface from a base polygon
- Triangle strips and quad strips
- Surfaces of revolution
  - The process of constructing a surface from a base curve
- You will not be asked to write any OpenGL code for constructing sweep surfaces using rotational transforms.

## 6 Mathematical Aspects

- Homogeneous coordinates
- Vector operations
  - Dot products, Orthogonality of vectors, Angle between vectors
  - Cross products, Surface normal computation
  - Projection of a vector
- Matrices
  - Transformation matrices (Rotation matrices will be given)
- Linear interpolation
- You should be able to multiply a vector by a transformation matrix.

## 7 Mathematics of Lighting

- The lighting equation
  - Vectors used in the lighting equation
  - Ambient, diffuse and specular terms
- Computation of planar shadows (shadow transformation matrix will be given)

## 8 Viewing and Projection

- The eye coordinate frame.
- `gluLookAt()`
- The view transformation matrix and the projection matrices will not be required for answering any questions.
- View volumes
  - `glFrustum(L, R, B, T, N, F)`
  - `gluPerspective(aspect, fov, N, F)`
  - Conversions between parameters of the above two frustum definitions
- Clip coordinates

## 9 Ray Tracing

- Global illumination models
- Ray definition (parametric equation)
- Equations for computing reflected rays, ray-plane intersections and ray-sphere intersections will be given.
- Equations of planes and spheres will also be given.
- Anti-aliasing
- The following topics are **not** covered in the exam
  - Refractions
  - Equations of cones, cylinders etc.



## 10 OpenGL-4

- Vertex and Fragment shaders (General concepts, structure, applications)
- Vertex buffer objects (General concepts)
- You are not required to remember any OpenGL-4, GLM functions.
- Mechanisms for passing values between application and shaders, and between shaders.
- Typical outputs of a vector and a fragment shader



# 11 Bezier Surfaces

- Bernstein polynomials of degree 2 and 3 will be given.
- Quadratic and cubic Bezier curves
- General properties
- Bi-cubic Bezier surfaces

## 12 Tessellation Shader

- GL\_PATCHES (general properties)
- Tessellation Coordinates (Normalized coordinate domains)
- Barycentric coordinates
- Tessellation levels
- Tessellation control shader and evaluation shader
  - Usefulness and main applications
  - Built-in variable `gl_in`



# 13 Geometry Shader

Not included in the exam.



# Reminders/Announcements

- Quiz-10 closes on Friday, 1<sup>st</sup> June.
- Assignment-2 due on Thursday, 31 May.
- Extra lab session: Lab-4, 5pm-7pm, Wed, 30 May.
- Lab session on Friday, 1<sup>st</sup> June cancelled.

# Reminders/Announcements


- Calculator checks (Ref: Examinations webpage):

<http://www.canterbury.ac.nz/study/examinations/exam-instructions/>

## Calculator checks

Calculator checks will now take place from the Information Desk (Matariki, Level 1) on a drop-in basis between the hours of 8.30am and 4.30pm.

- **Approved exam calculators** for a UC sticker in 2018.

If your calculator was stickered before 2017, the sticker is still valid, even if your calculator model is not on the list. Alternatively, you may borrow an approved calculator from the **UCSA**  (a bond of \$27 is applicable).

A list of **Exams Requiring a Calculator Sticker (PDF 12KB)** for the 2018 Mid Year Examination Period.

Your Personal Timetable that is e-mailed to you will advise if you are required to have your calculator to be checked and stickered for a particular exam.

Students are responsible for ensuring that their calculators meet requirements. No spare calculators will be provided to the exam room.

No other supplementary material or equipment relating to the use or operation of the calculator, other than spare batteries is permitted.



Good Luck!