COMP330

Computer Graphics

S1 Day 2013

Computing

Contents

General Information

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Credit points
3

Prerequisites
39cp and (COMP225(P) or COMP229(P)) and (DMTH137(P) or MATH237(P) or DMTH237(P))

Corequisites

Co-badged status

Unit description
This unit is the study of pictures, images and animations generated by computers, as well as tools used to produce these pictures. This unit introduces the mathematical foundations of computer graphics, examines how to model three-dimensional objects, introduces techniques for creating animations, and explores how realistic scenes are rendered. Practical work involves using a graphics library, such as OpenGL, under Unix or Windows platforms.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

an understanding of the core foundations, principles and components of computer graphics

an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Assessment Tasks

Name	Weighting	Due
Assignment 1:	15%	Week 5
Assignment 2:	8%	Week 7
Assignment 3	20%	Week 12
Exercises	12%	Weekly
Final exam	45%	TBA

Assignment 1:

Due: **Week 5**
Weighting: **15%**

2D drawing program

Assignment 1 will require a significant amount of time and effort. In this Assignment you will develop a 2D program for interactive drawing on the screen using the OpenGL library.
You are encouraged to:

- set your personal deadline earlier than the actual one;

- keep backups of all your important files;
- make sure that no-one else picks up your printouts.

You should submit your work via iLearn. A submission will consist of a zipped archive file containing your Eclipse project folder. More detailed instructions concerning the contents of your Eclipse project folder will be provided together with the Assignment 1 description.

Late work will not be accepted. If you cannot submit on time because of illness or other circumstances, please contact the lecturer before the due date.

On successful completion you will be able to:

- an understanding of the core foundations, principles and components of computer graphics
- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Assignment 2:

Due: **Week 7**
Weighting: **8%**

Assignment 2: Transformations

For Assignment 2, you will practise using geometric transformations. This will be mainly a paper based Assignment.
You are encouraged to:

- set your personal deadline earlier than the actual one.

You should submit your work into the COMP330 assignment box located on level 1 of building E6A by the deadline.

Late work will not be accepted. If you cannot submit on time because of illness or other circumstances, please contact the lecturer before the due date.

On successful completion you will be able to:

- an understanding of the core foundations, principles and components of computer graphics

Assignment 3

Due: **Week 12**
Weighting: **20%**

Assignment 3: 3D graphics package

Assignment 3 will require a significant amount of time and effort. For this Assignment, you will create an interactive 3D graphics package.

You are encouraged to:

- set your personal deadline earlier than the actual one;
- keep backups of all your important files;
- make sure that no-one else picks up your printouts.

You should submit your work via iLearn. A submission consists of a zipped archive file containing your Eclipse project folder. Detailed instructions concerning the contents of your Eclipse project folder will be provided together with the Assignment 3 description.

Late work will not be accepted. If you cannot submit on time because of illness or other circumstances, please contact the lecturer before the due date.

On successful completion you will be able to:

- an understanding of the core foundations, principles and components of computer graphics
- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Exercises

Due: **Weekly**
Weighting: **12%**

Exercises for workshops.

Each week your answers to the requested homework exercises must be submitted via iLearn by the due date.

On successful completion you will be able to:

- an understanding of the core foundations, principles and components of computer graphics
- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Final exam

Due: **TBA**
Weighting: **45%**

Final exam

Your performance in the final exam constitutes 45% of your final mark. The exam will focus on material that was covered in the lectures, on-line lecture notes and mixed workshop classes. There could also be some exam questions designed to test how well you understood the assignments you did. The final exam will be a closed book three hour paper and will be held in

the examination period at the end of the semester.
The final examination will consist of four parts, which roughly correspond to the following four topic groupings:
* 2D and raster graphics
* transformations
* 3D graphics including modelling and viewing
* animation, rendering, virtual reality

Within each part there is a mixture of short answer questions and more complex questions. The more complex questions could require you to write a few paragraphs of prose, to develop some code, or to perform some mathematical computations.

Regarding the examination process, note that

- you must attend all required classes and submit all required assessment, otherwise the Executive Dean of the Faculty or delegated authority has the power to refuse permission to attend the final examination
- the University examination period for Mid-Year 2013 is from Monday 10 June to Friday 28 June 2013
- you are expected to present yourself for examination at the time and place designated in the University Examination Timetable
- the timetable will be available in draft form approximately eight weeks before the commencement of the examinations and in final form approximately four weeks before the commencement of examinations
- no early examinations for individuals or groups of students will be set. All students are expected to ensure that they are available until the end of the teaching semester, that is the final day of the official examination period
- The only exception to not sitting an examination at the designated time is because of documented illness or unavoidable disruption. In these circumstances you may wish to consider applying for Special Consideration.

On successful completion you will be able to:

- an understanding of the core foundations, principles and components of computer graphics
- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Delivery and Resources

Classes

Each week you should attend three hours of lectures. Each week you should also attend your

two hour mixed workshop class (a tutorial and a practical combined in a single session). Most weeks some assessable work will need to be submitted after your workshop (details are provided below under Assessment). For details of days, times and rooms for classes consult the timetables webpage. Note that mixed workshop classes commence in week 1. You should have selected a mixed workshop class during enrolment. You should attend the mixed workshop class which you are enrolled in. If you do not have a class, or if you wish to change one, you should see the enrolment operators in the E7B courtyard during the first two weeks of the semester. Thereafter you should go to the Student Centre. Please note that you are required to attend and submit work after your mixed workshop classes. Failure to do so may result in you failing the unit or being excluded from the exam (see the rules regarding the examination process which are detailed below).

Resources to assist your learning

Echo360 Lecture Recordings (previously known as iLecture) are available. For more information see Echo360 student guide.

The textbook for COMP330 used this semester is: Hill, F.S., Kelley, S.M., Computer Graphics Using Open GL (3rd Edition), Pearson Education, Sydney, 2007. A useful reference work is: Shreiner, Woo, Neider, Davis, OpenGL Programming Guide (4th Edition), Addison Wesley, Boston, 2004. The textbook (by Hill and Kelley) is available from the University Co-op Bookshop. You should purchase a copy of it, or the second edition of it (by Hill only). We will use the textbook as our primary source for the conceptual and theoretical issues in computer graphics. The OpenGL Programming Guide ("The Red Book") is available online and can be downloaded from the unit web page. This book provides a number of valuable examples in using OpenGL. You do not need to purchase the Red Book (RB), and you do not need to print RB (remember your print quotas). You should skim the readings for the week before the lecture (see Unit Schedule). The lectures will focus and expand on key areas.

There are a number of online resources about OpenGL. You can use http://www.opengl.org/, as your starting point or use Google to look for specific items.

Technology used and required

An Eclipse SDK (software development kit) package, with the C/C++ development toolkit (CDT), MinGW (gcc compiler and tools), and OpenGL/freeglut libraries, is being installed on the computers in the 300-level laboratory. (It is expected that the lab will be ready for the first workshop classes on Wednesday 27 Feb.) A Windows package containing these resources is available for you from the COMP330 unit pages (see Support Materials section) on iLearn, if you wish to install it on your home machine (if running Windows). Installation hints for both Windows and nonWindows machines are also available there.

Websites

We will be using the University's online learning system iLearn. Students should check COMP330 on iLearn regularly for updates.

Discussion Boards

We will use the forums hosted within iLearn. Feel free to post questions there. Important

announcements (such as tips and clarifications on assignments) will often be posted there.

Teaching and learning strategy

COMP330 is taught via lectures in a lecture room and mixed workshop classes in a laboratory. The work you do and the feedback that you receive play a crucial role in your learning. Lectures are used to introduce new material, give examples of the use of programming methods and techniques and put them in a wider context. Furthermore, to highlight the relationship between teaching, research and learning, an advanced topic will occasionally be introduced during the lectures. This additional material will not be examined as such but may prove useful to complete the assignments. You learn by processing concepts, not just by hearing them. Mixed workshop classes are small group classes in the laboratories which give you the opportunity to do exactly that by interacting with a tutor who has a sound knowledge of the subject and with your peers. This also gives you a chance to practice your programming skills. You have many opportunities to seek and to receive feedback. During lectures, you are encouraged to ask the lecturer questions to clarify anything you might not be sure of. Each week, you will be given problems to solve in the mixed workshop classes and you will have to submit your solutions to some of these problems via iLearn after your class. The comments and the solutions provided will help you to understand the material in the unit, to do the work for the assignments, and to prepare you for the final exam. It is important that you keep up with these problems every week. Each week you should:

- Attend lectures, take notes, ask questions
- Study the on-line lecture slides/notes and textbook as directed by the lecturer
- Attend your mixed workshop class and seek feedback from your tutor on your work
- Submit homework weekly and read any feedback provided
- Start working on any assignments as soon as they have been released.

Time management and programming

COMP330 is a three credit point unit. You are therefore expected to spend approximately nine hours per week on this unit. Since each week each student should attend three hours of lectures, and attend a two hour mixed workshop, the remaining four hours per week will be spent on assigned assessable work outside of class. A significant portion of the outside time will be spent on programming. Mastering some basic skills early in the semester can save you tenfold in time and energy. In particular, many students have difficulty managing large projects and have problems with some of the trickier aspects of C/C++. There are many C/C++ tutorials and online books available. Go through a couple of them - or simply look back over your notes, textbooks and programs from previous programming units - to refresh your memory (if you have studied C++ before). You cannot learn graphics programming - or any kind of programming for that matter - simply by reading a textbook. You could make a start by copying some of the programs from the unit website, then modifying and running the programs to gain an understanding of how they work. Make sure you try to understand each line of code. Programming is a science and an art; it is not magic. The assignments in this unit could take many hours to complete. Don't expect to complete any of the assignments over a single weekend. Start each assignment early, get some basic functionality going, and try to become

proficient in the parts of OpenGL that will be necessary for the assignment. It is often a good idea to write sample programs that let you test a single feature you are exploring before embedding it in the large project. Small tricks can save you hours. For example, instead of changing and recompiling your code every time, it may be possible to pass in some command line arguments to get the desired effect, or to read a specific file that sets the options for your program. Use global (or external) variables and symbolic constants wherever possible to facilitate adjustment. It might even be possible to convert some of your global variables to parameters that get passed around in order to provide more modularity. Your text editor and compiler are amongst the basic tools of your trade as a programmer. They should help you to avoid making mundane mistakes and should make it easier for you to debug your programs. Spend some time to learn about their functionality. Even if it takes you a couple of hours to learn a new tool, it can still save you time in the long run. For example, using Notepad and Textpad to write programs is like trying to run on a rocky surface without any shoes. You can do it, but it will be slow and painful. Most modern development environments provide you with editors that do syntax highlighting, parenthesis matching, line numbering and automatic indentation that keep you from making silly mistakes. Do yourself a favour, get comfortable with and learn the features of Eclipse. Lecture slides are made available each week but these notes are intended as an outline of the lecture only and are not a substitute for your own notes or reading additional material.

Standards

We will use standards based assessment to reflect the level of performance students achieve in this unit. Five standard levels for the assessment tasks during the semester (excluding the final exam) are: unsatisfactory, developing, functional, proficient and advanced. These standard levels summarize different levels of achievement in relation to learning outcomes and are defined below.

Standards

Learning Oucome #1	Unsatisfactory	Developing	Functional	Proficient	Advanced
gain understanding of the core foundations, principles and components of computer graphics	Unsatisfactory or poor understanding of computer graphics principles. Significantly more work is needed to achieve final grade of Pass.	Developing understanding of computer graphics principles. Improvement is needed to achieve final grade of Pass.	Satisfactory understanding of graphics principles.	Good to very good understanding of principles.	Superior understanding of principles.
Learning Oucome #2	**Unsatisfactory**	**Developing**	**Functional**	**Proficient**	**Advanced**

gain understanding of the concepts, tools and skills needed to successfully build graphics application programs	Unsatisfactory implementation of computer graphics applications. Unable to successfully implement at least one third of the compulsory features listed in the assignments. Significantly more work is needed to achieve final grade of Pass.	Developing ability to implement computer graphics applications. Successfully implement at least one third, but less than one half, of the compulsory features listed in the assignments. Improvement is needed to achieve final grade of Pass.	Satisfactory implementation of computer graphics applications. Successfully implement at least half of the compulsory features listed in the assignments.	Good to very good quality computer graphics applications. Successfully implement most or all compulsory features listed in the assignments, but not necessarily the bonus features.	Superior quality computer graphics applications with the addition of originality and/or creativity. Successfully implement all compulsory features and at least one or two bonus features listed in the assignments.

Each assignment and workshop homework submitted will be given a numerical mark, and an indication of the standard level reached (according to the above table).

Final Grades

At the end of the semester, you will receive a final grade that reflects your overall achievement in the unit including the final exam. The different possible final grades are defined in general terms below.

- **Fail (F)**: does not provide evidence of attainment of all learning outcomes. There is missing or partial or superficial or faulty understanding and application of the fundamental concepts in the field of study; and incomplete, confusing or lacking communication of ideas in ways that give little attention to the conventions of the discipline. That is, overall work is unsatisfactory or still developing according to the standards defined above.
- **Pass (P)**: provides sufficient evidence of the achievement of learning outcomes. There is demonstration of understanding and application of fundamental concepts of the field of study; and communication of information and ideas adequately in terms of the conventions of the discipline. The learning attainment is considered satisfactory or adequate or competent or capable or functional in relation to the specified outcomes.
- **Credit (Cr)**: provides evidence of learning that goes beyond replication of content knowledge or skills relevant to the learning outcomes. There is demonstration of substantial understanding of fundamental concepts in the field of study and the ability to apply these concepts in a variety of contexts; plus communication of ideas fluently and clearly in terms of the conventions of the discipline. The overall learning attainment is proficient.
- **Distinction (D)**: provides evidence of integration and evaluation of critical ideas, principles and theories, distinctive insight and ability in applying relevant skills and concepts in relation to learning outcomes. There is demonstration of frequent originality in defining and analysing issues or problems and providing solutions; and the use of means of communication appropriate to the discipline and the audience. The overall

learning attainment is advanced.

- **High Distinction (HD)**: provides consistent evidence of deep and critical understanding in relation to the learning outcomes. There is substantial originality and insight in identifying, generating and communicating competing arguments, perspectives or problem solving approaches; critical evaluation of problems, their solutions and their implications; creativity in application. The overall learning attainment is outstanding.

Your final grade depends on your performance in each part of the assessment. For each task, you receive a mark that reflects your standard of performance regarding each learning outcome assessed by this task. Then the different component marks are added up (with appropriate weightings applied) to determine your total mark out of 100. Your grade then depends on this total mark and your overall standards of performance. Concretely, **in order to pass the unit**, you must demonstrate satisfactory understanding and implementation of computer graphics applications, have a basic understanding of the lecture material and workshops, successfully implement at least half of the compulsory features listed in the assignments and demonstrate satisfactory level of achievement in the exam. In order to obtain a grade higher than a Pass, you have to fulfill additional conditions. See below the grade standards made specific for this unit:

High Distinction: Outstanding quality computer graphics applications with the addition of originality and/or creativity achieved by an outstanding understanding of concepts. Students are expected to go beyond the limits of lecture material and workshops. They are expected to successfully implement all compulsory features and at least one or two bonus features listed in the assignments, and demonstrate superior/outstanding level of achievement in the exam.

Distinction: Superior quality computer graphics applications achieved by superior understanding of concepts. Students are expected to master the lecture material and workshops. They are expected to successfully implement all compulsory features listed in the assignments, but not necessarily the bonus features and demonstrate high level of achievement in the exam.

Credit: Good understanding of concepts and good quality computer graphics applications. Students are expected to have good understanding of the lecture material and workshops. They are expected to successfully implement most of the compulsory features listed in the assignments, and demonstrate good level of achievement in the exam.

What has changed?

Dr Timothy Lambert, an experienced computer graphics lecturer formerly with UNSW, will join our teaching team this year as Lecturer and Tutor.

Unit Schedule

The following schedule is provisional. In the Reading column HK stands for the textbook by Hill and Kelley, and RB stands for the red book (OpenGL Programming Guide).

Week	Topic (with Subtopics)	Reading

1	Introduction (A/Prof Kavakli and Dr McCallum) 27-28 Feb 1: Introduction to computer graphics and its applications 2: Introduction to raster graphics and graphics pipeline 3: Introduction to C++ programming	HK: Ch1, 2.1, 2.2; RB: Ch1; opengl.org: Beginner FAQ
2	Drawing Figures (Dr McCallum) 6-7 Mar 1: Drawing in 2D with OpenGL, dot plots of functions 2: Line drawings, interaction with mouse and keyboard 3: Use of random numbers in drawing	HK: Ch 2.2, 2.3, 2.4; RB: Ch 2
3	Additional Drawing Tools (Dr McCallum) 13-14 Mar 1: More on interaction with mouse, bitwise logical operations 2: Menus, world windows and viewports, clipping 3: Circles and tilings	HK: Ch 2.5, 3
4	Geometric Transformations - 2D (Dr McCallum) 20-21 Mar 1: Vectors and matrices 2: 2D transformations 3: Composing 2D transformations	HK: Ch 4, 5.2
5	Geometric Transformations - 3D (Dr McCallum) 27-28 Mar 1: Rotations in 3D 2: Affine transformations in 3D 3: Composing 3D transformations 31 March (11 pm): Assign 1 due	HK: Ch 5.3; RB Ch 3
6	Object Hierarchy & Drawing 3D Scenes (Dr McCallum) 3-4 Apr 1: Matrix stacks and object hierarchy 2: Drawing 3D scenes with OpenGL 3: Simple 3D hierarchical structures	HK: Ch 5.5, 5.6; RB: Ch 3
7	3D Modelling (A/Prof Kavakli and Dr Lambert) 10-11 April 1: 3D modelling and data structures 2: Object representation techniques 3: 3D modelling in OpenGL in practice 14 April (11 pm): Assign 2 due	HK: Ch 6
Recess		

8	3D graphics programming (A/Prof Kavakli and Dr Lambert) 1-2 May 1: Designing a 3D application 2: 3D modelling using Blender 3: Putting it all together	
9	3D Viewing (Dr McCallum and Dr Lambert) 8-9 May 1: 3D perspective projections 2: 3D perspective viewing in OpenGL 3: 3D viewing in OpenGL in practice	HK: Ch 7; RB: Ch 3
10	Animation (A/Prof Kavakli and Dr Lambert) 15-16 May 1: Introduction to animation techniques 2: Use of Buffers 3: Demos of modelling and animation in OpenGL	HK: Ch 5.6, 6
11	Rendering (A/Prof Kavakli and Dr Lambert) 22-23 May 1: Introduction to rendering, lighting and shading 2: Hidden surface removal 3: Demos of lighting and shading	HK: Ch 8
12	Games and Virtual Reality (A/Prof Kavakli) 29-30 May 1: Introduction to computer games 2: Introduction to virtual reality 3: Visit to VR Lab 2 June 11 pm: Assign 3 due	
13	Revision -- Exam preparation (A/Prof Kavakli and Dr McCallum) 5-6 June	

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central. Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy http://www.mq.edu.au/policy/docs/academic_honesty/policy.html

Assessment Policy http://www.mq.edu.au/policy/docs/assessment/policy.html

Grading Policy http://www.mq.edu.au/policy/docs/grading/policy.html

Grade Appeal Policy http://www.mq.edu.au/policy/docs/gradeappeal/policy.html

Grievance Management Policy http://mq.edu.au/policy/docs/grievance_management/policy.html

Special Consideration Policy http://www.mq.edu.au/policy/docs/special_consideration/policy.html

In addition, a number of other policies can be found in the Learning and Teaching Category of

Policy Central.

Staff-Student Liaison Committee

The Department has established a Staff-Student Liaison Committee at each level (100, 200, 300) to provide all students studying a Computing unit the opportunity to discuss related issues or problems with both students and staff.

The committee meets three times during the semester. For each meeting, an agenda is issued and minutes are taken. These are posted on the web at http://www.comp.mq.edu.au/undergrad/info/liaison/

If you have exhausted all other avenues, then you should consult the Director of Teaching (Dr. Christophe Doche) or the Head of Department (Prof. Bernard Mans). You are entitled to have your concerns raised, discussed and resolved.

Student Support

Macquarie University provides a range of Academic Student Support Services. Details of these services can be accessed at: http://students.mq.edu.au/support/

UniWISE provides:

- Online learning resources and academic skills workshops http://www.students.mq.edu.au/support/learning_skills/
- Personal assistance with your learning & study related questions.
- The Learning Help Desk is located in the Library foyer (level 2).
- Online and on-campus orientation events run by Mentors@Macquarie.

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

Details of these services can be accessed at http://www.student.mq.edu.au/ses/.

IT Help

If you wish to receive IT help, we would be glad to assist you at http://informatics.mq.edu.au/help/.

When using the university's IT, you must adhere to the Acceptable Use Policy. The policy applies to all who connect to the MQ network including students and it outlines what can be done.

Graduate Capabilities

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to

demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcome

- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Assessment task

- Assignment 3

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- an understanding of the core foundations, principles and components of computer graphics
- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Assessment tasks

- Assignment 1:
- Assignment 2:
- Assignment 3
- Exercises
- Final exam

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to

have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- an understanding of the core foundations, principles and components of computer graphics
- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Assessment tasks

- Assignment 1:
- Assignment 3
- Exercises
- Final exam

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

- an understanding of the core foundations, principles and components of computer graphics
- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Assessment tasks

- Assignment 1:
- Assignment 2:
- Assignment 3
- Exercises
- Final exam

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We

want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcome

- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Assessment tasks

- Assignment 1:
- Assignment 3

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcome

- an understanding of the concepts, tools and skills needed to successfully build graphics application programs

Assessment tasks

- Assignment 3
- Final exam