



Lahore University of Management Sciences
CS 452– Computer Graphics
Fall 2023

COURSE DESCRIPTION

Computer Graphics is one of the most exciting ‘application’ fields of Computer Science. This course is intended to introduce the basics of Computer Graphics, laying the foundation for more advanced graduate classes or industry work. The basic graphics pipeline is covered in this course, along with an introduction to OpenGL. This course will be conducted with an application perspective. Therefore students will be expected to implement several techniques learnt in the lectures.

Course Distribution

Core	No
Elective	Yes
Open for Student Category	Graduate, Senior, Junior
Close for Student Category	Freshman

COURSE PREREQUISITE(S)

<ul style="list-style-type: none">••	CS 200 - Introduction to Programming Math 120/ Math 121 – Linear Algebra
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**COURSE OFFERING
DETAILS**

Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2 (MoWe)	Duration	75 min (8:00 – 9:15 pm)
Recitation/Lab (per week)	Nbr of Lec(s) Per Week	0	Duration	N/A
Tutorial (per week)	Nbr of Lec(s) Per Week	1 (Fri)	Duration	TBA
Instructor	Murtaza Taj			
Room No.	9-G11A			
Office Hours	TBA			
Email	murtaza.taj@lums.edu.pk			
Telephone	3301			
Secretary/TA				
TA Office Hours	TBA			
Course URL (if any)	LMS			

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)	
PEO-01	Demonstrate excellence in profession through in-depth knowledge and skills in the field of Computing.
PEO-02	Engage in continuous professional development and exhibit quest for learning.
PEO-03	Show professional integrity and commitment to societal responsibilities.

COURSE OBJECTIVES	
.	Motivate the class about Computer Graphics
.	Introduce the basic theory and applications of Computer Graphics
.	Provide a basic foundation for further work in this area

COURSE LEARNING OUTCOMES (CLOs)	
CLO1:	To familiarize students with the Computer Graphics pipeline and the processing going on within each block
CLO2:	Introduce various data structure and algorithms designed to increase the computational efficiency of graphics algorithms
CLO3:	Make students confident that they can solve Computer Graphics problems, through the use of several programming assignments and examples

Grading Breakup and Policy	
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Assessment	Weight (%)	Related CLOs
Assignments	35%	CLO1 – CLO3
Quizzes	5%	CLO1, CLO2
Project	20%	CLO1 – CLO3
Mid-term	20%	CLO1 – CLO3
Final	20%	CLO1 – CLO3

Examination Detail	
Midterm Exam	Yes/No: Yes Combine Separate: N/A Duration: N/A Preferred Date: N/A Exam Specifications: Writtens
Final Exam	Yes/No: Yes Combine Separate: Comprehensive Duration: 150 min Exam Specifications: Written

COURSE OVERVIEW

Module		Sessions	Topics Covered	Book Chapters	Related CLOs
1	Introduction	1	Graphics Pipeline Graphics Applications	Shirley Chapter 1	CLO1
2	Rasterization	1	<u>Display Technologies</u> CRT Displays, Raster Scan Displays <u>Drawing on Raster Displays</u> Line Drawing, Circle Drawing, Ellipse, Parabola	Shirley Chapter 3	CLO1, CLO2
		1	<u>Drawing and Filling Polygon</u> Boundary Fill, Flood Fill, Scanline Fill	Foley Section 3.3, 3.4 & 3.5	
3	Transformations	1	<u>Rigid & Non-rigid Transformations</u> Basic 2D/3D Transformations Properties of Rotation Rotation about parallel and arbitrary axis Transforming Normals	Shirley Chapter 5 & 6	CLO1, CLO2
		1	<u>Composing Transformations</u> Coordinate Transformation Matrix (CTM) Decomposing Transformations	Shirley Chapter 5 & 6	
4	OpenGL	1	<u>OpenGL</u> Rigid Transformations Coordinate Transformation Matrix Loading Models in a scene	OpenGL Programming Guide, The Red Book OpenGL SDK Documentation Handout (OpenGL)	
5	Lighting & Shading	1	<u>Lighting</u> Vectors & Barycentric Coordinates Natural Lighting Effect Camera Model	Shirley Chapter 2 & 9	CLO1, CLO2
		1	<u>Shading</u> Surface Reflection & Lighting Effecting Reflection Models The Blinn-Phong Model Type of Light Source Gouraud Shading Phong Shading	Shirley Chapter 5 & 9	

Module		Sessions	Topics Covered	Book Chapters	
6	Ray Casting & Tracing	1	<u>Ray Casting</u> Local vs. Global Illumination	Shirley Chapter 10	CLO1, CLO2
		2	<u>Ray Tracing</u> Forward & Backward Ray Tracing Recursive Ray Tracking Algorithm Ray Object Intersection (Sphere - Plane - Polygon - Triangle) Ibn Sahl Law & Refracted Rays , Shadows (Hard - Soft) Anti Aliasing, Limitations of Ray Tracing	Shirley Chapter 2& 10 Tutorial (SIGGRAPH)	
7	Viewing	1	<u>Projections</u> Orthographic Projection, Perspective Projection	Shirley Chapter 7	CLO1, CLO2
8	Clipping	1	<u>Line Clipping</u> Cohen-Sutherland Line Clipping Midpoint Subdivision Cyrus Beck Line Clipping	Hearn & Baker Chapter 6	CLO1, CLO2
		1	<u>Polygon Clipping</u> Sutherland-Hodgeman Polygon Clipping Weiler-Atherton Polygon Clipping	Hearn & Baker Chapter 6	
9	Spatial Data Structures	1	Bounding Volumes, Uniform Grids, Octrees, BSP Trees	Shirley Section 10.9 & Chapter 8	CLO1, CLO2
		1	Hidden Surface Removal	Shirley Section 10.9 & Chapter 8	
10	Texture Mapping	2	Texture Coordinates, Displacement Mapping Texture Mapping in OpenGL Bump Mapping O-mapping	Shirley Chapter 11 Shirley Chapter 11 Hearn & Baker Section 10.17 & 10.18 Watt Section 6.1	CLO1, CLO2
11	Particle Systems	2	<u>Particle Systems</u> Particle Dynamics, Differential Equation Solver, Cloth Simulation, Fluid Simulation		CLO1, CLO2
12	Photon Mapping (tentative)	1	<u>Photon Mapping</u> Photon Tracing, Radiosity, Caustics	Paper (Global Illumination using Photon Maps)	CLO1, CLO2
13	Curves and Surfaces	1	<u>Parametric Curves</u> Basis and Control Points Splines	Shirley Chapter 15	CLO1, CLO2

Module		Sessions	Topics Covered	Book Chapters	
		1	<u>Splines</u> Spline Interpolation, Bezier Curve, B-Spline, Spline Fitting, Parametric Surfaces. Bezier Patches, Surface Fitting	Shirley Chapter 15, Watt Sections 3.1, 3.2 3.3 & 3.7.1 Paper (Interactive 3D Face Models)	
		1	<u>Subdivision</u> Subdivision Schemes, Refinement Matrix Subdivision vs. Spline	Paper (Subdivision in Character Animation)	
14	Game Engine	2	Guest Lectures		CLO1, CLO2
15	Graphics Hardware	2	GLSL Shaders		CLO1, CLO2

Textbook(s)/Supplementary Readings

Required:

[Shirley] Fundamentals of Computer Graphics, Peter Shirley, A. K. Peters, 2nd Edition/3rd Edition

Reference:

[Baker] Donald Hearn, M Pauline Baker, Computer Graphics with OpenGL, Prentice Hall

[Foley] Computer Graphics: Principle and Practice, J. D. Foley, A. van Dam, S. K. Feiner and J. F. Hughes

[Watt] Advanced Animation and Rendering Techniques: Theory and Practice

[OpenGL] OpenGL Programming Guide, The Red book

[OpenGL Primer] Edward Angel, OpenGL: A Primer, Longman

Assignment Details:

Sr#	Assignment Title	Topics Covered	Description of skills, tools, platform, etc. (e.g., Programming in C/C++, MS Visual Studio, Windows/Linux)	Duration in Weeks
1	Lab/HW0:	Synthetic Lighting	C++, OpenGL, Ubuntu/Linux/MacOS	1
2	Lab/HW1:	Rasterization	C++, OpenGL, Ubuntu/Linux, MacOS	1
3	Lab/HW2:	Sampling		1
4	Lab/HW3:	Raytracing		1
5	Lab/HW4:	Bounding Volume Hierarchy		1
6	Lab/HW5:	Reflection and Refraction		1
7	Lab/HW6:	OpenGL		1
8	Lab/HW7:	Bezier Curves & Surfaces		1
9	Lab/HW8:	Average Normals for Half-Edge		1
10	Lab/HW9:	Character Animation		1
11	Lab/HW10:	Cloth Collisions		1
12	Project	Game/Animation	Game Engine	6