



## Lahore University of Management Sciences

### CS 452- Computer Graphics Fall 2018-19

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Course URL (if any)	LMS

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2 (TuTh)	Duration	75 min (9:30 – 10:45 am)
Recitation/Lab (per week)	Nbr of Lec(s) Per Week	0	Duration	N/A
Tutorial (per week)	Nbr of Lec(s) Per Week	0	Duration	N/A

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

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 PREREQUISITE(S)
<ul style="list-style-type: none"><li>• CS 200 - Introduction to Programming</li><li>• Math 220/ Math 221 – Linear Algebra</li></ul>

COURSE OBJECTIVES
<ul style="list-style-type: none"><li>• Motivate the class about Computer Graphics</li><li>• Introduce the basic theory and applications of Computer Graphics</li><li>• Provide a basic foundation for further work in this area</li></ul>

Learning Outcomes
<ul style="list-style-type: none"><li>• To familiarize students with the Computer Graphics pipeline and the processing going on within each block</li><li>• Introduce various data structure and algorithms designed to increase the computational efficiency of graphics algorithms</li><li>• Make students confident that they can solve Computer Graphics problems, through the use of several programming assignments and examples</li></ul>



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Grading Breakup and Policy	
Assignment(s):	45%
HomeWork:	10%
Quiz(s):	5%
Class Participation:	0%
Attendance:	0%
Midterm Examination:	20%
Final Examination:	20%

Examination Detail	
Midterm Exam	Yes/No: Yes Combine Separate: N/A Duration: 120 min Preferred Date: 7 <sup>th</sup> Week Exam Specifications: Written
Final Exam	Yes/No: Combine Separate: Comprehensive Duration: 150 min Exam Specifications: Written

	Module	Sessions	Topics Covered	Book Chapters
1	Introduction	1	Graphics Pipeline Graphics Applications	Shirley Chapter 1
2	Rasterization	1	<u><b>Display Technologies</b></u> CRT Displays Raster Scan Displays  <u><b>Drawing on Rater Displays</b></u> Line Drawing Circle Drawing Ellipse, Parabola	Shirley Chapter 3
		1	<u><b>Drawing and Filling Polygon</b></u> Boundary Fill Flood Fill Scanline Fill	Foley Section 3.3, 3.4 & 3.5
3	Transformations	1	<u><b>Rigid &amp; Non-rigid Transformations</b></u> Basic 2D/3D Transformations Properties of Rotation Rotation about parallel and arbitrary axis Transforming Normals	Shirley Chapter 5 & 6
		1	<u><b>Composing Transformations</b></u> Coordinate Transformation Matrix (CTM) Decomposing Transformations	Shirley Chapter 5 & 6
4	OpenGL	1	<u><b>OpenGL</b></u> Rigid Transformations Coordinate Transformation Matrix Loading Models in a scene	OpenGL Programming Guide, The Red Book OpenGL SDK Documentation Handout (OpenGL)



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Module		Sessions	Topics Covered	Book Chapters
5	Lighting & Shading	1	<b>Lighting</b> Vectors & Barycentric Coordinates Natural Lighting Effect Camera Model	Shirley Chapter 2 & 9
		1	<b>Shading</b> Surface Reflection & Lighting Effecting Reflection Models The Blinn-Phong Model Type of Light Source Gouraud Shading Phong Shading	Shirley Chapter 5 & 9
6	Ray Casting & Tracing	1	<b>Ray Casting</b> Local vs. Global Illumination	Shirley Chapter 10
		2	<b>Ray Tracing</b> 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	<b>Projections</b> Orthographic Projection Perspective Projection	Shirley Chapter 7
8	Clipping	1	<b>Line Clipping</b> Cohen-Sutherland Line Clipping Midpoint Subdivision Cyrus Beck Line Clipping	Hearn & Baker Chapter 6
		1	<b>Polygon Clipping</b> 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
		1	Hidden Surface Removal	Shirley Section 10.9 & Chapter 8
10	Texture Mapping	2	Texture Coordinates Displacement Mapping Texture Mapping in OpenGL	Shirley Chapter 11
			Bump Mapping O-mapping	Shirley Chapter 11 Hearn & Baker Section 10.17 & 10.18 Watt Section 6.1




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Module		Sessions	Topics Covered	Book Chapters
11	Particle Systems	2	<u><b>Particle Systems</b></u> Particle Dynamics Differential Equation Solver Cloth Simulation Fluid Simulation	
12	Photon Mapping (tentative)	1	<u><b>Photon Mapping</b></u> Photon Tracing Radiosity Caustics Photon Scattering: Russian Roulette	Paper (Global Illumination using Photon Maps)
13	Curves and Surfaces	1	<u><b>Parametric Curves</b></u> Basis and Control Points Splines	Shirley Chapter 15
		1	<u><b>Splines</b></u> Spline Interpolation Example 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><b>Subdivision</b></u> Subdivision conditions, Subdivision Schemes, Refinement Matrix Subdivision vs. Spline 4 Point Scheme, Chaikin's Algorithm, Catmull Clark Scheme, Doo-Sabin Scheme Subdivision of Gery's Hand	Paper (Subdivision in Character Animation)
14	Unity 3D	1	Guest Lecture	
15	Cocos-2Dx	1	Guest Lecture (tentative)	
16	Graphics Hardware	2	GLSL Shaders	



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Assignments			
Module		Duration (wks)	Topics Covered
1	Rasterization	2	<b>Drawing and Filling Polygons</b> Line drawing, circle drawing, flood fill, boundary fill, scanline algorithm
2	Ray Casting	2	<b>Photorealistic Rendering</b> Ray casting, ray-sphere intersection, ray-triangle intersection
3	Ray Tracing	2	<b>Photorealistic Rendering</b> Forward ray tracing, Phong illumination model, Acceleration data structures
4	Mesh Editing	2	<b>Curves &amp; Surfaces</b> Loop subdivision, GLSL Shader
5	Particle Systems	2	<b>Cloth Simulation</b> Mass-spring system
6	Blend Shapes (tentative)	2	<b>Mesh Animation</b> Character Animation
7	Unity	2	<b>Game Development</b> Hands-on sessions, Augmented Reality(Vuforia)
8	Written Assignment (Pre-mid)	1	Theory based questions to help prepare for exam
9	Written Assignment (Pre-Final)	1	Theory based questions to help prepare for exam

Textbook(s)/Supplementary Readings
<p><b>Required:</b></p>  <p>[Shirley] Fundamentals of Computer Graphics, Peter Shirley, A. K. Peters, 2<sup>nd</sup> Edition/3<sup>rd</sup> Edition</p> <p><b>Reference:</b></p> <p>[Baker] Donald Hearn, M Pauline Baker, Computer Graphics with OpenGL, Prentice Hall</p> <p>[Foley] Computer Graphics: Principle and Practice, J. D. Foley, A. van Dam, S. K. Feiner and J. F. Hughes</p> <p>[Watt] Advanced Animation and Rendering Techniques: Theory and Practice</p> <p>[OpenGL] OpenGL Programming Guide, The Red book</p> <p>[OpenGL Primer] Edward Angel, OpenGL: A Primer, Longman</p>