

# Computer Graphics Programming II



## The Art Institute of Portland<sup>SM</sup>

### Course Description

VGP352A

Winter 2013, 3 credits

Wednesday, 6:00PM - 9:45PM

Final exam: Wednesday, March 20<sup>th</sup>, 2013 at 5:30PM

Room #214

In this course students will be introduced to principles of 3D computer graphics using the OpenGL programming interface. Students will learn fundamental concepts of transformation, lighting, and texturing.

By the end of the course, students will be able to:

- Understand and implement advanced per-pixel lighting algorithms.
- Understand and implement render-to-texture type algorithms.
- Read, understand, and make use of information in academic papers.

The complete, up to date, course syllabus is also available on-line at the course website (<http://people.freedesktop.org/~idr/2013Q1-VGP352/>). The syllabus is available as both HTML and PDF ([http://people.freedesktop.org/~idr/2013Q1-VGP352/WI13\\_VGP352\\_A.pdf](http://people.freedesktop.org/~idr/2013Q1-VGP352/WI13_VGP352_A.pdf)).

### Prerequisite

Successful completion of VGP351 or consent of instructor is required.

This course is both programming and math intensive. A strong background in C or C++ programming is required. Familiarity with object oriented programming principles will be very helpful but is not strictly required. Previous knowledge of matrix math and trigonometry is required and will be extremely important. Particularly tenacious students may be able to learn the required math during the term, but it will be a lot of extra work.

### Texts

Required text:

Akenine-Moeller, Tomas and Haines, Eric and Hoffman, Mathaniel. *Real-Time Rendering (3rd Ed.)*, AK Peters, Ltd., 2008. ISBN 978-1-56881-424-7.

There will be weekly assigned readings from this book. Equivalent readings from the second edition will also be listed. This textbook will also be used in VGP352 and VGP353. However, there will be readings in those courses that were added in the third edition.

The book also has a website (<http://www.realtimerendering.com>) that includes numerous additional references and sample code.

The following OpenGL reference books may prove to be very useful.

Rost, Randi J.. *OpenGL Shading Language (2nd. Ed.)*, Addison-Wesley Professional, January 25, 2006. ISBN 0-32133-489-2.

Wright, Richard S.; Lipchak, Benjamin; and Haemel, Nicholas. *OpenGL SuperBible: Comprehensive Tutorial and Reference (4th Ed.)*, Addison-Wesley Professional, June 2007. ISBN 0-321498-828.

*OpenGL Superbible* has a website (<http://www.starstonesoftware.com/OpenGL/>), that includes source code and pre-built binaries. Earlier editions of this book are *not* suitable for this course because they do not cover the OpenGL shading language.

*OpenGL Shading Language* also has a website (<http://3dshaders.com/>), that includes example shaders and some references. Earlier editions of this book should also be sufficient for this course.

## Required Materials

In addition to paper and writing utensils, each student will need a removable storage device. The storage device will be used to both bring documents and sample code home from class and bring homework completed assignments to class. The storage requirements should be minimal, so a small USB flash-drive (256MB) should be sufficient.

## Grading

Each student's grade in this course will be primarily based on a total of four single-week programming assignments and two two-week programming assignments. The remainder of the student's grade will be based on bi-weekly quizzes and a final exam.

Programming assignments will be graded first and foremost on whether or not correct output is produced. The remaining points are based on the style of the program. This includes, but is not limited to, algorithm selection, code formatting, and naming conventions. A detailed rubric will be provided with each assignment.

### *Programming Assignments*

Programming assignment #1 and #2	15 pts. each
Programming assignment #3, #4, and #5	25 pts. each
Subtotal	105 pts. (54%)

### *Tests*

In-class quizzes	40 pts.
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Final Exam	50 pts.
Subtotal	90 pts. (46%)
Total	195 pts. (100%)

Some assignments *may* carry extra-credit opportunities, but they will be infrequent.

## Grading Scale

A	=	93% and above
A-	=	90%-92%
B+	=	87%-89%
B	=	83%-86%
B-	=	80%-82%
C+	=	77%-79%
C	=	73%-76%
C-	=	70%-72%
D+	=	67%-69%
D	=	60%-66%

## Late Work

I do not accept late work. If you miss a deadline, you will not earn the points for that activity. There are no make-up opportunities. If you are unable to attend class on the due date for a assignment, please submit it by e-mail *before* class.

## Attendance and Participation

If you are not in class for an in-class exercise, you cannot earn those points. If you miss an entire class, you are responsible for obtaining copies of handouts and other classroom materials from your classmates.

## AiPD Policies

### Lab Policies

Leave food and drink outside the class. Disciplinary action will be taken toward any student found using the equipment in an inappropriate manner, taking cell phone calls or surfing the web. Disruptive, disrespectful or rude behavior will not be tolerated.

## Plagiarism

Presenting the writings, images or paraphrased ideas of another as one's own, is strictly prohibited at the Art Institute of Portland. Properly documented excerpts from other's works, when they are limited to an appropriate amount of the total length of a student's paper, are permissible when used to support a researched argument.

## ADA Statement

It is AiPD policy not to discriminate against qualified students with a documented disability in its educational programs, activities or services. If you have a disability-related need for adjustments or other accommodations in this class, contact Student Support and Disabilities Coordinator, Daynia Flynn at ext. 4836 <djflynn@aii.edu>

## Attendance Policy for the Art Institute of Portland

Students who are absent from all scheduled classes over a 14-day period (2 weeks) are subject to automatic attendance suspension - from the Institute, not just from this course. This means the student is administratively withdrawn from all courses and cannot attend classes or continue in the current quarter unless he/she successfully appeals for reinstatement. Students who anticipate violating the attendance policy should contact their Academic Advisor or Academic Department Director immediately to discuss options such as withdrawing from the Institute or navigating the appeals process.

## Absences Policy

Regular attendance is required for successful completion of this course. A student who misses the equivalent of three (3) classes will not pass this class. Exceptions for extenuating circumstances will be considered at the discretion of the instructor.

## Adding, Dropping and Withdrawing From Courses

*Schedule Adjustment period:* The schedule adjustment period runs through the first week of the quarter (ending at 5 pm on Monday of Week 2). To add or drop a course, the student must complete a schedule adjustment form, available from the Registrar's Office. The signature of the student's academic advisor is required to make any changes to the student's schedule.

*Withdrawal (W/WF):* The student who withdraws from a course or from the program during the first nine weeks of the quarter will be assigned a "W" code for each course. The "W" code is not used in computation of the student's grade point average; however, "W" credits are counted toward total credits attempted. The student who withdraws from a course or from the program after the ninth week of the quarter will be assigned a "WF" code for each course. The "WF" code is the equivalent of a grade of "F" and is used in computing the student's grade point average. Students wishing to withdraw from The Art Institute of Portland must file an official status change form with the Registrar.

## Tutoring

One-on-one tutoring is available to you across all subjects through the Tutoring Center at no extra cost. The goal of tutoring is to help you learn and master skills so you can then confidently apply them on your own. Tutoring is helpful for students at all levels. Our tutors are faculty or, most often, fellow students who have excelled in the subject. You may find a tutor by visiting [aidepartments.com](http://aidepartments.com) or dropping by the Tutoring Center in Room 328 inside the Education Department. You may also contact Kathleen O'Brien <[kpobrien@aii.edu](mailto:kpobrien@aii.edu)>.

## Student Assistance Program

The college provides confidential short-term counseling, crisis intervention, and community referral services through the Wellness Corporation Student Assistance Program (SAP) (<https://artinstitutes.personaladvantage.com>) for a wide range of concerns, including relationship issues, family problems, loneliness, depression, and alcohol or drug abuse. Services are FREE and available 24 hours a day, 7 days a week, at 1.800.326.6142. If you have any further questions or are ever in need of immediate on-campus assistance, please stop by the Student Services Office on the 2nd Floor or email Daynia Flynn (Director) at <[djflynn@aii.edu](mailto:djflynn@aii.edu)>. Her phone number is 503 382 4836.

## Campus Email Policy

Email communication will be through eCompanion. Be sure to check your Profile in eCompanion to update your email address so that you will receive course communications in a timely manner.

## Evacuation Procedures

Please proceed to the nearest exit when the strobe lights flash and an audible alarm occurs. AiPD's evacuation location is around the corner on 10th between Everett and Davis; do not stand in front of the Armory or Deschutes Brewery - someone will come to tell you when it is safe to come back in the building. ALWAYS ASSUME ANY EVACUATION IS REAL!

## Quarter Credit Hour Definition

A quarter credit hour is an amount of work represented in intended learning outcomes and verified by evidence of student achievement that is an institutionally established equivalency that reasonably approximates not less than:

1. One hour of classroom or direct faculty instruction and a minimum of two hours of out-of-class student work each week for 10-12 weeks, or the equivalent amount of work over a different amount of time; or
2. At least an equivalent amount of work as required in paragraph (1) of this definition for other academic activities as established by the institution including laboratory work, internships, practica, studio work, and other academic work leading to the award of credit hours.

## Course Calendar

### Week 1 ( January 9<sup>th</sup>, 2013 )

Lecture topics:

- Course road-map
- A tour of the GPU pipeline
- Overview of OpenGL “objects”
  - The Gen / Bind pattern
  - Textures
  - Buffer objects
  - Vertex array objects
- Shaders and programs

Homework assignments:

- Programming assignment #1: (20130109\_Assignment.pdf) Instanced array optimizations. Due 1/23.
- Read to recap this week:

Real-Time Rendering, 3rd edition, chapter 2 and chapter 3. You may skim section 3.3 (The Evolution of Programmable Shading) and 3.5 (The Geometry Shader).

- Read to prepare for next week:

Real-Time Rendering, 3rd edition, chapter 5 up to section 5.6.

### Week 2 ( January 16<sup>th</sup>, 2013 )

Quiz #1. **DO NOT BE LATE TODAY!**

Lecture topics:

- The physics of light and energy transport
- Computer lighting models
  - Lambert
  - Phong
  - Blinn

- Shading
  - flat
  - Goraud
  - Phong
- Types of lights
  - infinite / directional
  - point
  - area

Homework assignments:

- Read to recap this week:
  - Real-Time Rendering, 3rd edition, section 7.4 (Light Source Types).
- Read to prepare for next week:
  - Real-Time Rendering, 3rd edition, section 6.7 (Bump Mapping) up to, but not including, section 6.7.3 (Parallax Mapping). We'll come back to parallax mapping, relief mapping, and other related techniques later in the term.

### **Week 3 ( January 23<sup>th</sup>, 2013 )**

Quiz #2. **DO NOT BE LATE TODAY!**

Lecture topics:

- Texture mapping in OpenGL

### **Week 4 ( January 30<sup>th</sup>, 2013 )**

Quiz #3. **DO NOT BE LATE TODAY!**

Lecture topics:

- Bump mapping / Normal mapping
  - Surface-space
  - Basic usage
  - Normal map storage
- Improving the reflection model
  - Fresnel reflection

Homework assignments:

- Read to prepare for next week:

Real-Time Rendering, 3rd edition, section 7.5 (BRDF Theory) up to, but not including, section 7.5.4 (Local Subsurface Scattering).

## Week 5 ( February 6<sup>th</sup>, 2013 )

Quiz #4. **DO NOT BE LATE TODAY!**

Lecture topics:

- Bi-directional reflection distribution function
- Common terminology and notation
- Cook-Torrance model
- Microfacet-based BRDFs
  - Normal distribution
  - Occlusion

Homework assignments:

- Programming assignment #2 (20130130\_Assignment.pdf): Blinn lighting in surface-space. Due 2/13.
- Read to recap this week:

Real-Time Rendering, 3rd edition, section 7.5.4 (Local Subsurface Scattering) up to, but not including, section 7.7 (BRDF Acquisition and Representation).

- Read to prepare for next week:

Ward, Gregory J., "Measuring and modeling anisotropic reflection." In *Proceedings of the 19th annual conference on Computer graphics and interactive techniques*, pages 265--272. ACM, 1992.  
<http://www.cs.virginia.edu/~gfx/courses/2006/DataDriven/bib/appearance/ward92.pdf>

## Week 6 ( February 13<sup>th</sup>, 2013 )

Quiz #5. **DO NOT BE LATE TODAY!**

Lecture topics:

- Anisotropic BRDFs
  - What does anisotropy mean in this context?
  - Ward BRDF
  - Ashikhmin BRDF



- Metals
  - How metals reflect light
  - Lafortune BRDF

Homework assignments:

- Read to recap this week:

Walter, Bruce, Notes on the Ward BRDF. Cornell Program of Computer Graphics. April 29, 2005.  
<http://www.graphics.cornell.edu/pubs/2005/Wal05.html>

- Read to prepare for next week:

Goldman,, Dan B., "Fake fur rendering." In *SIGGRAPH '97: Proceedings of the 24th Annual Conference on Computer Graphics and Interactive Techniques* , pages 127--134. ACM Press/Addison-Wesley Publishing Co., 1997. <http://www.danbgoldman.com/misc/fakefur/fakefur.pdf>

## Week 7 ( February 20<sup>th</sup>, 2013 )

Quiz #5. **DO NOT BE LATE TODAY!**

Lecture topics:

- Fur and hair
  - Goldman's "Fake Fur Rendering"
  - Shells and fins
  - Banks BRDF

Homework assignments:

- Programming assignment #3 (20130220\_Assignment.pdf): Improved lighting with BRDFs. Due 2/27.
- Read to prepare for next week:

Bruce Gooch and Peter-Pike J. Sloan and Amy Gooch and Peter S. Shirley and Rich Riesenfeld, "Interactive Technical Illustration." In *1999 ACM Symposium on Interactive 3D Graphics* , pages 31--38. 1999.  
<http://www.thegooch.org/Publications.php>

Lake, Adam and Marshall, Carl and Harris, Mark and Blackstein, Marc, "Stylized rendering techniques for scalable real-time 3D animation." In *NPAR '00: Proceedings of the 1st international symposium on Non-photorealistic animation and rendering* , pages 13--20. ACM, 2000.  
[http://www.markmark.net/npar/npar2000\\_lake\\_et\\_al.pdf](http://www.markmark.net/npar/npar2000_lake_et_al.pdf)

Card, Drew and Mitchel, Jason. "Non-Photorealistic Rendering with Pixel and Vertex Shaders" in Engel, Wolfgang F. (editor) *ShaderX*, Wordware Publishing, Inc., May 2002. <http://tog.acm.org/resources/shaderx/>

## Week 8 ( February 27<sup>th</sup>, 2013 )

Quiz #6. **DO NOT BE LATE TODAY!**

Lecture topics:

- Non-photorealistic rendering
  - Cel (toon) shading
  - Silhouette edge rendering
  - Technical illustration

Homework assignments:

- Read to prepare for next week:

Mark Colbert and Jaroslav Krivanek. "GPU-based Importance Sampling" in Hubert Nguyen (editor) *GPU Gems 3*, Addison Wesley, 2007. [http://http.developer.nvidia.com/GPUGems3/gpugems3\\_ch20.html](http://http.developer.nvidia.com/GPUGems3/gpugems3_ch20.html)

## Week 9 ( March 6<sup>th</sup>, 2013 )

Quiz #7. **DO NOT BE LATE TODAY!**

Lecture topics:

- Implementing BRDFs in real-time rendering engines

Homework assignments:

- Read to prepare for next week:

van Dongen, Joost, "Interior Mapping - A new technique for rendering realistic buildings." In *Computer Graphics International Conference (CGI)*. 2008.  
<http://student-kmt.hku.nl/~joost1/Oogst3D/index.php?file=CODING/InteriorMapping/InteriorMapping.txt>

Donnelly, Willaim. "Per-Pixel Displacement Mapping with Distance Functions" in Fernando, Randima (editor) *GPU Gems 2*, Addison Wesley, 2005.  
[http://download.nvidia.com/developer/GPU\\_Gems\\_2/GPU\\_Gems2\\_ch08.pdf](http://download.nvidia.com/developer/GPU_Gems_2/GPU_Gems2_ch08.pdf)

Policarpo, Fábio and Oliveira, Manuel M. and Comba, João L. D., "Real-time relief mapping on arbitrary polygonal surfaces." In *Proceedings of the 2005 symposium on Interactive 3D graphics and games*, pages 155--162. ACM, 2005. <http://www.inf.ufrgs.br/~oliveira/RTM.html>

## Week 10 ( March 13<sup>th</sup>, 2013 )

Quiz #8. **DO NOT BE LATE TODAY!**

Lecture topics:

- Interior mapping
- Parallax textures
- Displacement mapping

## **Week 11 ( March 20<sup>th</sup>, 2013 )**

**FINAL EXAM - 5:30PM - 7:30PM.DO NOT BE LATE TODAY!**