

CS559: Computer Graphics

Spring 2021

Lecture 1

Michael Gleicher

Department of Computer Sciences
University of Wisconsin - Madison



Welcome to CS559 Computer Graphics!

Before we start, please:

- 1. Turn off your video**
- 2. Mute your microphone**
- 3. Open the chat**

With all of us in 1 room, we
can't all speak



Lecture Capture Warning

I am trying to record these lectures

I will repeat questions so they are recorded (I'll try to remember)

We intend to provide the recordings.

Watching the video is not as good as attending.

CS559: Computer Graphics

Spring 2021

Lecture 1: Welcome

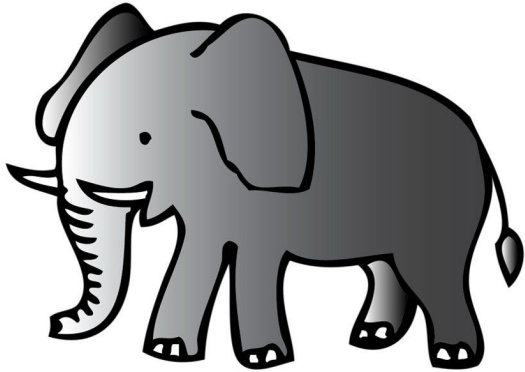
Michael Gleicher

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The Elephant in the Room



There is no room...

We'll talk about how the class
will adapt to the online setting

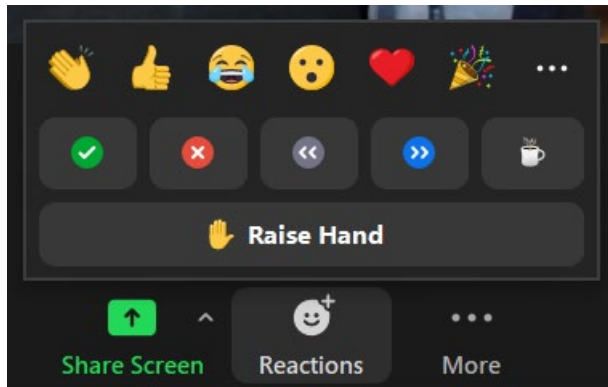
Lectures in Zoom

This is new for me!

Turn off your video/audio

Use chat

Use reactions



Let's try it...

Can you hear me [check or red x]?

Can you find the check mark?

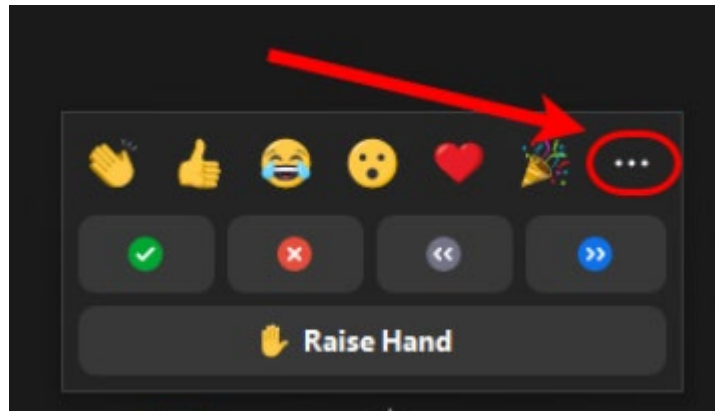
Can I find a way to reset it?

Emojis

They go away in 10 seconds
[maybe before I see them]

Let's try it...

Pick one to show how you're feeling
about class



Zoom Polls

Warning:

I have little experience with this

Let's try a poll...

Chat

It might scroll by fast...

There is a TA and a Peer Mentor helping me monitor it.

If something is really important, they will interrupt me

It might not be worse than the big lecture hall (where you can't hear)

The slides

They are a prop for the lecture

They are not meant to stand alone

Lots of space so I can draw
[not so much drawing today]

Usually, I'll be a postage stamp

Why online?

I decided to have this class online in September 2021

I thought the department should offer an online option

I did not expect virus variants

Why online?

I really believe:

Online is not worse than a big class

Online can be better for big classes



Agenda for today

What is this class?

How will this class work?

Getting yourself ready for class

Getting help if you need it

Some normalcy...

Every semester, I start with the same questions

This semester, we need different ways to talk about them

Topics to Start With

Why are you here? Why am I here?

What is Computer Graphics [the topic]?

What is Computer Graphics [the class]?

What will you learn?

How will you learn it?

Why are you here?

Why am I here?

You go first...

Let's try a poll...

Why are you here?

- CS540 (AI) is even harder to get into (maybe not this year)
- It's an upper level CS class available online
- To learn about **computer graphics**

Why are you here?

Games?

Movies? (animation, special effects)

Photography?

Virtual Reality?

Tools for Design?

User Interfaces?

**Applications
of
Computer
Graphics**

Just about anything we see...

Why are you here?

Write code that goes fast?

Make stuff that looks cool?

Think about geometry?

Apply math to something visible?

Great opportunities for creativity!

Why am I here?

I enjoy the topic

I enjoy teaching about the topic

I like seeing what students do when
given creative opportunities

Me and Computer Graphics...



Mike, summer 1989, driving back from summer internship

discovered **Computer Graphics** in **graduate school** [started 1988]

was a **Teaching Assistant** for **Graphics** in 1991 [never took class]

worked in **industry** for a while

Came to **Wisconsin** in 1998

Started teaching graphics in **1999**

OK, but...

What is Computer Graphics?

Computer graphics [the field] is the study of
How computers create things we see

Computer graphics [the class] is about
How to program computers to make pictures

How to program computers to make pictures

Not **what pictures to make**

that's art, design, visualization, ...

Not how to **use tools to make pictures**

this is how the tools work

Not about any **specific application**

focus on foundations

Artificial Boundaries

Neighboring Topics

HCI

Computational Geometry

Image Processing

Computer Vision

Art and Design

Perceptual Psychology

High-Performance Computing

Advanced Subfields

Rendering (high-quality)

Animation / Physics

VR / AR

Geometric Modeling

Fabrication

Computational Photography

Enough of what we're not going to do...

Course Goals

1. Teach you the key ideas of Computer Graphics
focus on the foundations
2. Give you experience doing graphics programming
it's not a spectator sport
3. Give you experience doing web programming
since it's a convenient way to do #2

CS 559 – Computer Graphics (Fall 2015)

Course Web for CS559 Fall 2015

The Key Ideas of Computer Graphics (559 Learning Goals)

by MIKE GLEICHER on [AUGUST 18, 2015](#) [EDIT]

A list of the key ideas of Computer Graphics that we want students to understand in CS559.

1. Work in convenient coordinate systems. Use transformations to get from where you want to be to where you need to be. Hierarchical modeling lets us build things out of pieces.
2. Use homogeneous coordinates and transformations to make common operations easy. Translation, projections, coordinate system shift all become simple matrix multiplies.
3. Create viewing transformations with projection. The geometry of imaging (pinhole camera model) leads to linear transformations in homogeneous coordinates.
4. Implement primitive-based rendering (interactive graphics) with a pipeline. The abstractions map nicely onto hardware, and let you do things like visibility computations easily. Be aware that there are other paradigms for drawing.
5. The abstractions of interactive rendering provide building blocks to do lots of things – beyond what they are obviously intended for. Many tricks involve putting these building blocks together in interesting ways to achieve interesting effects. The specific tricks change over time, but the paradigm of assembling the basic elements in interesting ways is fundamental.
6. Organize your computations for the hardware. Use programmable shading and block buffer transfers to make stuff go fast (if you're using an API that lets you talk to the hardware).
7. Determine apparent color of objects based on lighting models. Use simple, local lighting models for efficiency, and use other tricks for non-local effects.
8. Use texture to describe detail (such as color patterns) on objects. Set up texturing with texture coordinates and texture functions, and use proper sampling with image-based textures.
9. Describe shapes using appropriate methods. Often this is a collection of simple primitives, such as a triangle mesh. However, other representations (such as implicit forms) can be useful.
10. Represent smooth curves and surfaces using piecewise representations. Common forms of spline curves and surfaces often have polynomial forms and subdivision representations.
11. Consider the perceptual issues in how people will view the images we create. The psychology and physiology of perception can tell us a lot about how images will be perceived, which impacts how we should create them. In particular color and depth perception have important impact on graphics.
12. Be aware of (and attempt to mitigate) the effects of discrete representations. Sampling comes up everywhere in graphics: understanding aliasing as a fundamental issue and what we can and can't do about it is critical.
13. Use high-quality rendering techniques if you want to create more sophisticated visual appearances. Different drawing techniques have different pros and cons, and it is valuable to be able to choose amongst them.

RECENT POSTS

[Programming Assignment Group \(a.k.a. Project\) 1](#)

[Reading 3: Drawing in 3D](#)

[Reading and Homework Assignment 2: Transformations in 3D](#)

[Changes in CS559](#)

[Reading and Homework Assignment 1: Starting](#)

HANDY LINKS

[Course Canvas](#)

[Course Piazza](#)

[559 Tutorials](#)

[CS 638-JavaScript](#)

[CS 559 Fall 2014](#)

[Email Subscription](#)

IMPORTANT POSTS

ARCHIVES

[September 2015](#)

[August 2015](#)

CATEGORIES

[Assignments](#)

[Basic Info](#)

[News](#)

[Readings](#)

The Key Ideas of Computer Graphics (in a different order)

1. Work in convenient coordinate systems.
 - 1.b – use hierarchy and transformations
2. Represent transformations in homogeneous coordinates
3. Represent shapes as collections of simpler pieces
 - 3.b create smooth shapes with piecewise curves
4. Create views of 3D with projection
5. Use lighting and appearance models to determine colors
6. Use [image-based] texture to create complex appearance
7. Render using primitives, implement with a pipeline
8. Organize computations for the hardware

Course Outline

1. Pre-Graphics (web programming, interaction models)
2. Coordinate systems, transformations and drawing
3. Curves and shape representation
4. Drawing in 3D
5. Transformations in 3D
6. Shape in 3D
7. Appearance (lighting, texture)
8. Using Graphics Hardware
9. Advanced topics (shape, motion, high-quality rendering)

**What does this look like
(Demo time!)**

Graphics Programming

Class is about ideas, not about APIs* [Ideally]

The APIs will change. The ideas will not.

But you need to try things out!

you need to program

you need APIs [can't do everything yourself]

You need to learn how to use APIs [since you will need them]

get used to using lots of different kinds of APIs

Web-Browser Based Programming

The ideas of graphics are the same

Practical reasons for doing web browser stuff

Pedagogical reasons for doing web browser stuff

Learning about web programming is a goal of this class

Learning JavaScript

Yes we will help!

but really, it's mainly up to you

Don't: pretend it's some other language

Do:

You really need to practice

Use good tools

Embrace its great features

JavaScript is a part of the class content

JavaScript

Historically

A few flexible mechanisms

A few bad design decisions

A few missing features

Many ways to use flexible mechanisms to make up for problems

Now

Flexible mechanisms still there!

Ways to avoid bad parts

Feature complete (modules, exceptions, ...)

Just use the simple / modern / good parts of the language

Graphics Programming with APIs

application programming interfaces – basically libraries

Low-level APIs

Direct access to the hardware

You get to do everything

- total control

- must learn details

- can be really fast

You have to do everything

High-level APIs

Someone else took care of details

You have to trust what they did

- what abstractions?

- how does it work?

- is it efficient?

You can focus on making stuff

This class: try lots of APIs

Low Level APIs

WebGL (very little)

Immediate-
Mode

Retained-
Mode

High Level APIs

Canvas2D

SVG (not so much)

THREE.js

Idea of the class

Teach you what and why first

Then teach you what happens “under the hood”

Make stuff using high-level abstractions (in libraries)

Then see the math

Then worry about how the hardware works

This is not how the books go about it...

How will the class work?

This is the Course Web for **CS559 Computer Graphics** for Spring 2022.

You probably want to start with **Getting Started**.

I look forward to seeing everyone the first day of class, January 25th, 5:30pm, on Zoom. The link will be on the **Canvas Zoom List**.

GETTING STARTED

in Posts 🕒 January 12, 2022 (Last Modified: January 14, 2022) 📌 Getting Started, Start Here 📁 Basic Info

The course web has a lot to read. Here is a suggestion as to where to start (and a recommended order you could look at them).

[Read more...](#)

ENROLLMENT AND THE WAITING LIST

in Posts 🕒 November 26, 2021 (Last Modified: December 30, 2021) 📌 enrollment, waiting 📁 Getting Started

The class is full. There are many people on the waiting list. You might be wondering what is going on...

update 12/30/21: There are still 100 people on the waiting list. Many have really good reasons why they need the class. CS Enrollment services (**enrollment@cs.wisc.edu**) is prioritizing who gets into the class. Please contact them if you feel you should be prioritized.

[Read more...](#)

THIS WEEK

No class this week!
Get ready...

IMPORTANT PAGES/POSTS

- [Getting Started](#)
- [Getting Help](#)
- [Course Overview](#)
- [Policies](#)
- [Syllabus](#)
- [Calendar](#)
- [Course Staff](#)
- [Lecture Materials: Videos and Slides](#)
- [List of all pages](#)

USEFUL LINKS

- [Course Canvas](#)
- [Course Piazza](#)
- [Consulting Assistance Form](#)
- [Appointment Scheduling Form](#)
- [Very Late Workbook Form](#)
- [Spring 2021 Course Web](#)

RECENT POSTS

- [Getting Started](#)

The Course Web(s)

<https://pages.graphics.cs.wisc.edu/559-sp22/>

Problems: one way, students need to check, ...

Canvas

Problems: not good for discussion, hard to organize

Inflexible grading, doesn't handle big projects, ...

Piazza

Problem: not good for anything but discussion

Communication

Course web: long form information [announced on Canvas]

Canvas: announcements, grades, “quizzes”, slides, material

Piazza: communication, question and answer, ...

GitHub: for workbooks [get and turn in]

Please avoid email! [use Piazza to send messages to course staff]

Course Staff

Professor:

Michael Gleicher

Teaching Assistants (4):

Bo-Hsun Chen, Carter Sifferman, Hyojoon Park, Yiming Li

Peer Mentors (3):

Guoxuan Dong, Huan Xu, Ekaterina [Katia] Arshinova

Students (206)

As of 4pm today, at least 76 waiting



Getting Help

Ask!

Others have the same question!

Piazza

Consulting Hours

Individual Appointments

Avoid email (OK to respond)

GETTING HELP

In Pages January 12, 2022 (Last Modified: January 13, 2022) Getting Started, Start Here Basic Info

PAGE CONTENT

[Getting Help Online](#)

[Consulting Hours](#)

[Individual Appointments](#)

[Technology Help](#)

[Student Wellness Support](#)

The course staff is available to provide help!

GETTING HELP ONLINE

You can get help online using [Piazza](#). You can ask a question publicly - which is highly recommended as others with a similar question can benefit (see [Communications \(Using Piazza for Class\)](#)).

For most administrative questions, the answer is probably online. Notice that there is a search box on the top of the course web pages (look at the top right of this page).

CONSULTING HOURS

See [Consulting Hours](#)

INDIVIDUAL APPOINTMENTS

If you cannot come to consulting hours, you can schedule a meeting with course staff. Use the [Appointment Scheduling Form](#). You may request a specific member of the course staff, or anyone available.

Professor Gleicher holds office hours. See his home page ([Gleicher's Home Page](#) for the current schedule. From time to time, special hours for class will be announced (usually as a Canvas Annpincement).

Note: please try to use consulting hours. If you need one-on-one help, we can use a breakout room. The course staff has limited availability outside of consulting hours, and we may not be able to provide you with an immediate appointment. If you request an individual appointment, it might take some time for us to get back to you.

TECHNOLOGY HELP

Below are a variety of technology support resources available to you. (provided by L&S)

- **DoIT Help Desk:** The Help Desk provides free tech support and troubleshooting help with your computing needs by phone (608.264.4357), email (help@doit.wisc.edu), chat (<https://helpdesk.wisc.edu/chat>) or in-person at 1210 W. Dayton Street.

- **Download WiscVPN:** A VPN is a "virtual private network". WiscVPN allows you to access University resources without being on campus, and provides an extra layer of security. See [how to](#)

lunr search ...

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- [Getting Started](#)
- [Enrollment and the Waiting List](#)

CATEGORIES

- [Basic Info](#)
- [Getting Started](#)
- [Tutorials](#)

TAGS

- [ENROLLMENT](#)
- [EXAM](#)
- [GETTING STARTED](#)
- [GIT](#)

“Walk-in” Consulting Hours

Prof. Gleicher: to be determined

11am-noon Wednesday [this week, online, see Canvas]

“Consulting room” – on Zoom [see Canvas]

3-6pm Monday and in person

3-5pm Thursday

3-6pm Friday and in person

3-5pm Sunday

extra hours occasionally

Or... by appointment [use the form to request]

**Course Staff will be
“on duty”**

Questions

Re-grading: use regrade form

Grading, or individual issue: private message on Piazza

General question about class material: Piazza

Avoid posting code

[don't give away the answers]

Communication

Write to all of us using Piazza!

You will get a faster response

Do not send email to multiple course staff members!

Prefer Piazza to email (you will get a faster response)



How the class works...

Tuesday: lecture

Thursday: lecture

Friday: survey

Monday: workbook due

Weekly pattern...

2 Wednesday Exams

COURSE OVERVIEW

in Pages January 17, 2021 (Last Modified: January 14, 2022) Getting Started Basic Info

Here is a brief overview of what the class is and how it works. You may also want to see the [Getting Started](#) page.

WHAT THIS CLASS IS ABOUT

Computer Graphics is how we use computers to make pictures. This class is about how to program computers to draw. It is not about what pictures you should draw (that's art). The class is about how you program picture making, not how you use tools to make pictures. This class is how to write graphics programs not about how to use them.

You can see the [Learning Goals](#) page for a discussion of what we want you to learn in this class, and a summary of the key topics. You can also see what we're going to cover in class from the [Calendar](#).

To practice the graphics ideas, we will implement them with web programming. So, along the way, you will learn the basics of web programming and JavaScript (if you don't know it already). See the [Javascript in CS559](#) page which explains why we use JavaScript, as well as how to learn it.

HOW THE CLASS WILL WORK

Each week will follow the same pattern:

- On **Tuesday**: during the class period (5:30-6:45) we will have a **synchronous lecture** that introduces the week's topic. See [Policies \(lectures\)](#).
- On **Tuesday**: we will release the week's **workbook**. The workbook has readings and programming assignments. See [Workbooks](#).
- On two of the **Wednesdays** we will have exams. See [Exams \(policy\)](#).
- On **Thursday**: during the class period (5:30-6:45) we will have a **synchronous lecture**.
- On **Friday**: there will be a survey (quiz) that you can take any time during the day. See [Policies \(Surveys \(Quizzes\)\)](#).
- On Monday: the **workbook** is due. See [Workbooks](#).

This class will use a variety of different mechanism for communication. The are detailed on the [Communications](#) page. But briefly: The [Course Web](#) provides key information about the class. The course also uses [Canvas](#), [Piazza](#) and GitHub.

Announcements will be made on [Canvas](#) - you should configure Canvas to notify you about announcements. We also use Canvas for quizzes and surveys (a survey is a quiz that Canvas does not compute your grade) and for its caldenar.

If you have questions, you can post on [Piazza](#), come to [Consulting Hours](#) (online), or contact the [Course Staff](#). See [Getting Help](#). In general, we don't use email for class, except in emergencies.

BASIC INFO

lunr search ...

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TAGS



Lectures

Synchronous in Zoom

- live lectures feel different

- you can watch/review recordings

Some material in pre-recorded lectures

Slides are a prop for lecture... not a replacement

Exams

2 exams given on Wednesday evenings

Final exam in the University assigned exam period

Exams are 1 hours (3x20 min), you must complete in the period

Exams given using Canvas Quizzing

I do not intend to use online proctoring, but I reserve the right to introduce it if there is a problem.

Surveys

Weekly “quiz” to check on how things are going

We care that you complete the survey – we won't keep score
we may check your answers in boundary cases

We may make some surveys anonymous
we won't be able to connect answers to people
we do track who has completed the survey

Roles of the Surveys

1. Check knowledge of topic (exam practice)
2. Provide opportunities for reflection
3. Get feedback on how course is going
4. Get information to help adapt course

Workbooks

Mini websites with...

- things to read

- exercises to program [add to / edit our code]

- pointers to external things to read

Each week [pretty much]:

- Clone workbook [using GitHub classroom link]

- Edit workbook [do the assignments]

- Commit and push workbook [back to GitHub]

Grading

30% Exams, 60% Workbooks, 10% “final workbooks”
Other things to adjust boundaries

Workbooks

basic points: relatively straightforward to get to B/AB

advanced points: opportunities to excel (and get a better grade)

flexibility:

you need to be consistent in the core material

you can excel in the things you are interested in

The Readings...

Everything is either:

1. web based (in the workbook or linked)
2. available online from UW Library
3. things I can give you (from my friends, from UW library, ...)

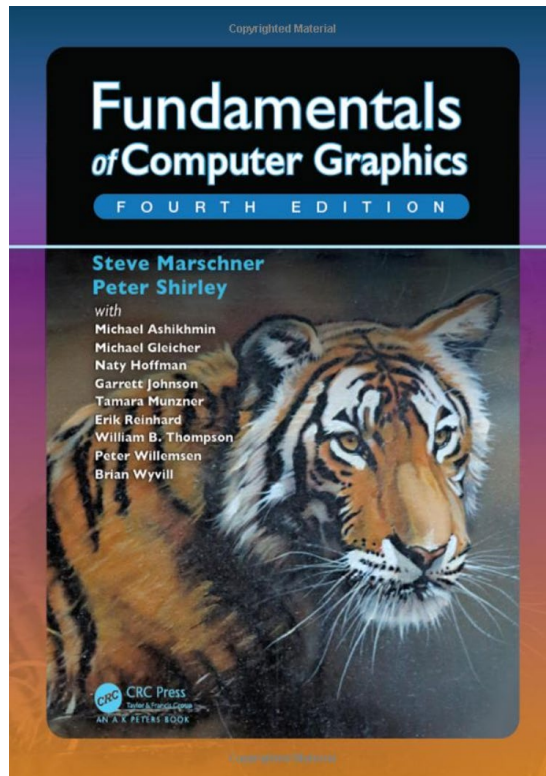
For things available from UW library:

1. you may want to buy a physical copy
2. we will give you the links

For resources provided on Canvas, do not share outside of class!

The main books

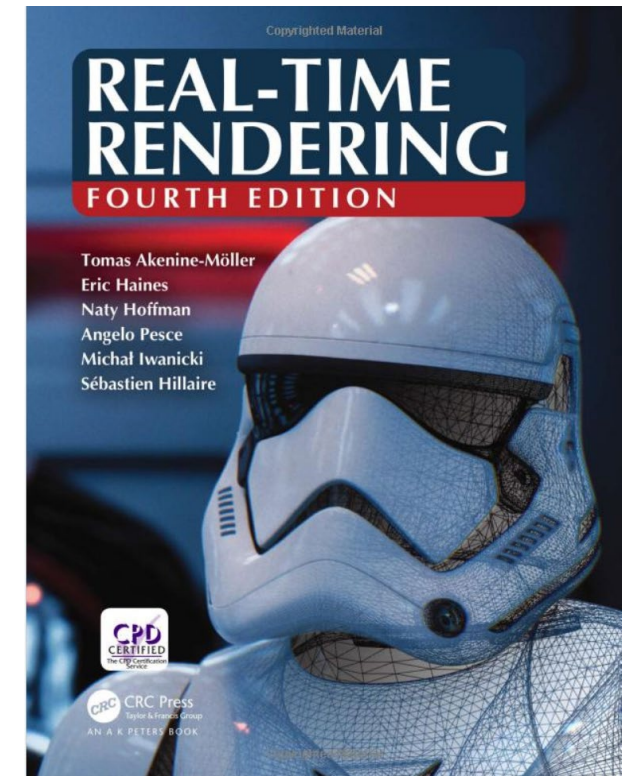
Foundations of Computer Graphics (FCG) – Shirley & Marschner & ...



**The Big Fun Graphics Book
John Hart**

The
BIG FUN
GRAPHICS
Book

Real-Time Rendering (RTR) – Moller, Haines, ...



Tools (for web programming)

Web browser (Chrome or Firefox)

GIT

Some JavaScript IDE

Some local web server

We recommend Visual Studio Code

See the course web

Workbooks via GitHub and GitHub Classroom

You must have a GitHub account

You must tell us [on Canvas] for the 1st assignment

For each workbook:

We give you a link to GitHub classroom

You go to this link

GitHub creates a copy of the workbook repository for you

You clone, do your work, commit and push it back, ...

We have a GIT tutorial
(video and instructions)

Summary...

Welcome to Computer Graphics!

We'll make lots of pictures this semester...

get ready

Look at the course web for information about how class works

I'll hang around to chat with people...