What is computer graphics about?
What is an image?
In 1801 Joseph Marie Jacquard invented a loom that could base its weave on a pattern that was automatically read from punched wooden cards held together by rope.
A programmable machine!

A program can be created on punched cards to direct the machine's actions and produce a particular pattern woven into a fabric.

Computer graphics?
The Analytical Engine
Charles Babbage, 1837, *designed* the first programmable mechanical computer.
The first "computer bug" – On September 9, 1947, Grace Hopper, working on the Harvard University Mark II discovered that the problem with a program was actually a moth trapped in a relay... the program was "debugged."
Vector Scopes and Display Lists

display list processor (DLP)
digital-to-analog converter (DAC)
network bus
controller
main memory
CPU

DLP: Display List Processor
DAC: Digital-to-Analog Converter

vector scope
Bitmapped Displays (frame buffer, CRT)

- CPU
- controller
- ALU
- system bus
- main memory
- ADC
- CLK
- Keyboard Interface
- CRT
- FB: Frame Buffer
- DAC: Digital-to-Analog Converter
Graphics Accelerators (early graphics cards)

RAS: accelerator hardware (usually a chip that performs rasterization of graphics primitives like polygons)
Graphics Accelerators (geometry + rasterization -> 3-D graphics)

GEO: accelerator hardware (usually a chip that performs transformations on vertices)
RAS: accelerator hardware (usually a chip that performs rasterization of graphics primitives like polygons)
Graphics Accelerators (geometry + rasterization $\rightarrow$ 3-D graphics)

GEO: accelerator hardware (usually a chip that performs transformations on vertices)
RAS: accelerator hardware (usually a chip that performs rasterization of graphics primitives like polygons)
Graphics Processing Units (geometry + rasterization –> 3-D graphics) (Nvidia, ATI,...)
iMac Intel 27" EMC 2639
Model A1419 / Late 2013 / 3.2 & 3.4 GHz Core i5
Kepler GPU Architecture
NVIDIA’s Kepler GPU architecture has been designed from the ground up for optimal performance per watt. The new SMS streaming multiprocessor is twice as efficient as the prior generation and the new geometry engine draws triangles twice as fast.

NVIDIA® GeForce™ Drivers

NVIDIA® PhysX® Technology
Full support for NVIDIA® PhysX® technology, enabling a totally new class of physical gaming interaction for a more dynamic and realistic experience with GeForce.

NVIDIA® CUDA™ Technology
NVIDIA CUDA technology unlocks the power of the GPU’s processor cores to accelerate the most demanding system tasks – such as photo editing – delivering incredible performance improvements over traditional CPUs.
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GPU Engine Specs:
- 1536CUDA Cores
- 823 + BoostClock Freq (MHz)

Memory Specs:
- 2500Memory Clock (MHz)
- 256 bitMemory Interface Width
- 160.0Memory Bandwidth (GB/sec)

Feature Support:
- 4.5OpenGL
- 1.1OpenCL
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<th>Model</th>
<th>GTX 780M</th>
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**GPU Engine Specs:**
- 1536 CUDA Cores
- 823 MHz + BoostClock Freq (MHz)

**Memory Specs:**
- 2500 Memory Clock (MHz)
- GDDR5 Standard Memory Configuration
- 256 bit Memory Interface Width
- 160.0 Memory Bandwidth (GB/sec)

**Feature Support:**
- 4.50 OpenGL
- 1.10 OpenCL
GPU Architecture - Kepler: CUDA Core

- Floating point & Integer unit
  - IEEE 754-2008 floating-point standard
  - Fused multiply-add (FMA) instruction for both single and double precision
- Logic unit
- Move, compare unit
- Branch unit