EE 7722
GPU Microarchitecture

```
        S2R R11, SR_TID.X;          }
        ISETP.GT.U32.AND P0, PT, R11, 0x3, PT;
  @!P0 SHL R10, R11.reuse, 0x4;
  @!P0 IADD R8.CC, R10, R2;
        MOV32I R3, 32@hi(d_app);
{  @!P0 SHR R0, R11, 0x1c;
        LDG.E R25, [R2];            }
{  @!P0 IADD.X R9, R0, R3  SLOT 0;
        S2R R0, SR_CTAID.X  SLOT 1;           }
  @!P0 LDG.E R4, [R8+0x4];
  @!P0 LDG.E R5, [R8+0x8];
  @!P0 LDG.E R6, [R8+0xc];
  @!P0 LDG.E R7, [R8+0x10];
        XMAD R9, R0.reuse, c[0x0] [0x8], R11;
        XMAD.MRG R11, R0.reuse, c[0x0] [0x8].H1, RZ;
{       XMAD.PSL.CBCC R24, R0.H1, R11.H1, R9  SLOT 0;
        LDG.E R0, [R2+0x44]  SLOT 1;          }
  @!P0 STS.128 [R10], R4;
        BAR.SYNC 0x0;
        ISETP.GE.AND P0, PT, R24, R0, PT;
   @P0 EXIT;
        LDS.U.128 R20, [RZ];
        LDS.U.128 R16, [0x10];
        LDS.U.128 R12, [0x20];
        LDS.U.128 R8, [0x30];
```

Where/When
109 Tureaud Hall MWF 11:30–12:20 **Spring 2021**
https://www.ece.lsu.edu/gp/

Who
David M. Koppelman, Room 3316r P.F. Taylor Hall
(225) 578-5482, koppel@ece.lsu.edu
Office Hours: Monday–Friday: 15:00–16:00.

☣ CoViD-19
Changes in the format of the course may be made during the semester to adapt to the CoViD-19 pandemic. Advance notice will be given. See the next page for additional information.

Prerequisites
By Topic: Computer architecture and digital logic.
Also, students must also have a familiarity machine language and C++ programming.

Topics
OVERVIEW—Accelerators (*e.g.*, NVIDIA GPU) and their role in typical systems. Characteristics of workloads. Survey of GPU APIs and systems, such as CUDA, OpenCL, OpenMP, OpenACC. A brief history.

PARALLELISM RELATED CONCEPTS—Threads, Speedup. Latency, Throughput. Performance Limiters.

CPU EXECUTION FEATURES—Dynamic scheduling, caches, branch prediction.

EXECUTION ARCHITECTURE—Thread organizations. Hardware organization, functional units, systolic arrays. Scheduling, instruction execution, latency hiding.

STORAGE HIERARCHY, SYNCHRONIZATION—Address spaces. Scratchpad stores and cache hierarchy. Basic data access strategies. Synchronization, atomic operations, message-driven execution. Basic reduction strategies.

INSTRUCTION SETS—Memory access, address spaces, locking, reduction. Predication, reconvergence.

BASIC ALGORITHMS AND TECHNIQUES—Matrix multiplication, tensor operations. Scientific, graphic, and machine-learning workloads. Reduction techniques. Stencil calculations. Sorting.

TENSOR PROCESSING—ML Dataflows. Specialized Instruction Sets. Large-Systolic-Array Accelerators (*e.g.*, Google TPU3). Wafer-Scale Message-Driven MAC Grid (*e.g.*, Cerebras CS-1). Exploiting weight regularity and sparsity.

RESEARCH DIRECTIONS—Workload studies. Warps v. vectors. Scratchpad v. cache. Many threads v. prefetch. Mixed CPU/GPU chips. Low-energy execution.

Text
Papers and other references.

Grading
35% Midterm Exam ● 35% Final Exam ● 30% Homework and Projects
Midterm exam grade may be replaced with final exam grade if it is higher.

Late assignment penalty: 10% per day late deducted. Missed-midterm-exam policy: at instructor's discretion either a makeup exam, use final exam grade for midterm grade (*i.e.*, 70% final exam weight), or use of zero for midterm grade. Daily attendance: optional, however students are responsible for all material, instructions, and notices presented in class.

A.D.A.

Louisiana State University is committed to providing reasonable accommodations for all persons with disabilities. This syllabus is available in alternate formats upon request. Any student with a documented disability needing academic adjustments is requested to speak with Disability Services and the instructor as early in the semester as possible. All discussions will remain confidential. Please contact Disability Services in 115 Johnston Hall, 225-578-5919 or at `http://www.lsu.edu/disability`.

☣ Computer Assignments

Some assignments for this course will have to be completed on computers in the ECE Workstation Lab, which are in room 2241 Patrick F. Taylor Hall. These machines can be used directly (within room 2241) or remotely, see the class procedures page for instructions. It is preferred that students use these computers directly since that facilitates inter-student discussion and provides the best experience when using graphical tools.

When in the ECE Workstation Lab students are expected to comply with LSU social distancing guidelines. Be sure to use hand sanitizer both before arriving at and after finishing with a workstation. Take care that a cry of computer-stoked frustration does not launch a virus-laden plume toward some other person. Remember that CoViD-19 has spread widely because many of the infectious are infectious without being aware of any symptoms at all.

☣ CoViD-19 Statement

We remain under pandemic conditions and expect to be in this state for the entire semester. In order to consistently provide the highest quality LSU education, all students should follow current LSU guidelines. These include the following:

1. If you have any signs of illness, do not come to class.
2. In order to protect all campus community members, the University requires everyone to wear face-masks/cloths on campus. Failure to do so is a violation of the code of student conduct.
3. Wash hands with soap and water or clean with sanitizer frequently, and refrain from touching your face.
4. If you have to cough or sneeze, please be mindful of others nearby and cough or sneeze into your elbow or shield yourself the best you can.
5. If you have been exposed to others who have tested positive for CoViD-19, self-quarantine consistent with current CDC guidelines.

☣ Daily Symptom Checker

You are required to respond to a daily symptom check request sent via email or text message each morning. Completing the symptom checker will take approximately one to two minutes. Once you have provided information about your symptoms, you will be given feedback on whether or not you are certified to return to campus and attend your classes. Additionally, if you test positive for CoViD-19, you are required to report it in your daily symptom checker application.

☣ Resources for Students

Your health and safety are LSU's top priority. If you are feeling ill or overwhelmed with anxiety, please contact the LSU Student Health Center for medical advice and mental health support. General health care and mental health support are available for all enrolled students through telehealth appointments.