



The University of Michigan
Department of EECS

EECS 573 – Microarchitecture
Prof. Todd Austin

Midterm Exam
November 29th, 2017
10:40pm-12:00pm
Open Book, Computer and Notes (no Internet or communication!)

Name: _____

Problem 1 – What this course is all about	_____ /18
Problem 2 – Reliable system design	_____ /10
Problem 3 – Secure and safe systems	_____ /10
Problem 4 – Application-specific processors	_____ /10
Problem 5 – Papers and presentations	_____ /12
TOTAL	_____ /60

Attempt to solve **all** the problems in this exam. Use your time wisely, and pay attention to the point distribution. Think before you plunge, if you are spending too much time on one part, move on to another one. All problems are divided in multiple parts; each part is independent from the others.

If you need more space to work out some the problems, use the backside of the exam sheets using a statement like “Go to back of page 6”. When in doubt, state any assumption you make. Show all your work, you will get partial credit for partial answers. Good luck!

HONOR PLEDGE:

“I have neither given not received aid on this exam, nor have I concealed any violations of the Honor Code.”

Signature:

1. What this course is all about – 18 points

[Hint: Don't write an essay. You should answer with just a few sentences per question.]

1A. (3 points) Please answer two questions on power-reliability trade-offs. a) Describe the three voltage margins used to ensure reliable circuit operation. b) How does Razor timing speculation affect these margins?

1B. (3 points) Process variation is a property of modern transistors where their dimensions and chemical makeup are statistical in nature. a) Why does high process variation lead to sub-optimal designs? b) Why is process variation on the rise? c) Who worries about process variation more, *and why*? i) The architect of a super-pipelined high-performance microprocessor with few levels of logic per stage, or ii) the architect of a low-power low-frequency embedded microcontroller with many levels of logic per stage?

1C. (3 points) Many are predicting (including Prof. Austin) that Moore's Law dimensional scaling will soon end -- please answer three questions about the end of Moore's Law. a) What two trends are leading to the end of Moore's Law? b) Why would we have to have to change the way we design systems if Moore's Law ended? c) What style of architectural design has the potential to overcome the end of Moore's Law and why is this so?

1D. (3 points) Please answer the following two questions about cryptography. a) How does cipher-block-chaining (CBC) change the operation of a cipher? b) Specifically, what additional protection does this mode of operation provide for encrypted memory?

1E. (3 points) Cold-boot attacks work to steal information from the DRAM of a secure system - please answer two questions about cold-boot attacks. a) What property of DRAM enables the cold-boot attack? b) What have CPU/memory vendors done to protect users from cold-boot attacks and has it worked?

1F. (3 points) Creating large-scale accelerator architectures is a game of tradeoffs. a) Briefly describe two reasons why Google chose ASICs for their TPU architecture instead of FPGAs. b) Name two physical constraints that prevented Microsoft from deploying GPUs in its datacenter servers. c) Why did Microsoft choose FPGAs instead of ASICs for their Catapult system?

2. Reliable System Design – 10 points

The following questions are related to reliable system design techniques from the papers we read this semester.

2A. (5 points) Hicks' CLANK paper examines how to build systems that run on intermittent energy supplies. a) What does it mean that code is idempotent and why is it useful in building machines that survive on intermittent power? b) How does CLANK utilize idempotency?

2B. (5 points) Zhang's MELLOW WRITES work to extend the lifetime of non-volatile memory. a) Why does non-volatile memory have a limited lifetime? b) What is a MELLOW WRITE and how does it reduce wear-out?

3. Secure and Safe Design – 10 points

The following questions are related to secure and safe design techniques from the papers we read this semester.

3A. (5 points) Nazari's EDDIE utilizes side-channels to detect security attacks. a) What is the side-channel that EDDIE uses and why does EDDIE monitor with side-channels? b) Briefly describe how EDDIE can "detect" anomalous program behavior. c) What would constitute a false positive in the context of EDDIE and does EDDIE suffer from them?

3B. (5 points) King's MALICIOUS HARDWARE attack wants to modify hardware to make secret backdoors. a) What is the trigger mechanism they use, and who can trigger it? b) What purpose does shadow mode serve, and how it is initialized? c) Describe a technique to detect if a machine has a non-trivially sized permanent shadow mode malicious code installed on it.

4. Application-Specific Processor Design - 10 points

The following questions are related to application-specific design techniques from the papers we read this semester.

4A. (5 points) Esmailzadeh *et al.*'s Truffle microarchitecture is designed to help integrate approximate computing into systems more effectively. a) What is 'disciplined' approximate programming, and why is it valuable? b) How, electrically, does approximation occur within Truffle, and how does this affect chip power consumption? c) Why does Truffle perform differently when applied to in-order vs. out-of-order processor microarchitectures?

4B. (5 points) Cherupalli *et al.*'s 'bespoke' processor is intended to align general-purpose processors more closely to the applications they run. a) Briefly, describe the approach the authors use to design bespoke processors. b) Name one advantage and one disadvantage of this approach compared to ASICs. c) Name one advantage and one disadvantage of this approach compared to FPGAs. d) How do the authors evaluate a single bespoke processor's support for multiple revisions of an application? Is their analysis realistic?

5. Papers and Presentations – 12 points

5A. (6 points) Possessing a well-developed skill for presentation will serve you in any walk of life. Please give three pitfalls to avoid when presenting technical research.

5B. (6 points) One of the goals of EECS 573 is to expose you to the research **process**. Please list three things you learned about conducting research? (Specifically, list here what you learned about *conducting* research, not presenting it or writing it up.)