Your name:

_____Patrick Woodrum_____

Final exam
CPSC+ECE 3220, Prof. Brygg Ullmer
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Please confirm you have 6 pages (14 multi-part questions, summing to 100 points). Some questions are complex and open-ended. Please insert your answers to this file, and upload to Canvas by 10:30am EST today. Please manage your time carefully. The exam will end at the time scheduled. Please particularly note italicized remarks. This is an open-book exam (e.g., you may access your textbook, notes, Wikipedia, and Internet searches); but you *may not consult in any fashion with other people (e.g., voice, chat, text, email, etc.).*

In Q1, you will be picking *three people* of interest, and *two contexts* of interest. In Q2-14, you will be explaining a *topic* relating to each of the chapters, readings, and guest lecture to one of these three people. You will also be *applying said topic to your context of interest*, as related to your chosen audience. You are *limited in how many questions* you may engage each audience and context. *You must use your own words, and write to your chosen audience (technical or general). Responses copied directly from the book or other sources will not receive full points. If you have questions, please ask your instructor via Zoom chat; and continue responding to other questions until he can respond.*

Q1: Getting started *(15 points)*

In the example exams, many questions were framed in terms of "to a technical audience" or "to a general audience." In this exam, we will be more specific. For exam questions 2-14, you will direct your response to one of three people; as well as in one of two contexts. Your choices in this question are completely up to you; but they will influence all of your subsequent answers. *Please read all of question 1 before beginning; part 1d is important.*

a) Your first choice of audience is either **Linus Torvalds** or Dr. Julia Lawall. For *1 point*, *please circle one of their names*. Torvalds is commonly identified as the creator of the Linux operating system. Dr. Lawall is a senior research scientist (a director of research) leading operating system-related research at a top French research institute (INRIA). Further details are unimportant here, beyond that both are experts on operating systems.

b) I invited you to consider any two living people you might have invited to hear your project 4 presentation. Here, please *name* and, in *one sentence*, describe one such person. Then, in *two sentences*, please describe your project 4, as addressed to that individual. *(E.g., in my case, I would begin "I pick Melinda Gates: a former Microsoft executive, co-director of the Gates Foundation, and author of the recent book "The Moment of Lift: How Empowering Women Changes the World.") (5 points).*

I choose Jaron Lanier, a former Atari employee who left to start VPL Research Inc., who is considered "the father of virtual reality." My Project 4 focuses on the potential impact that the new virtual reality technology could have alongside machine learning for new operating systems. It touches on the current uses of machine learning and virtual reality in the networking, automobile, and even medical fields including the ability to analyze an diagnose specific diseases utilizing operating systems that make the process faster and more efficient than human observation.

c) Please name your hometown (or one of them, if several alternatives could fit) and (if you know it; you may visit Wikipedia, etc.) its Mayor. In one sentence, summarize his/her primary background (or what you imagine it might be). Upon your graduation, imagine that s/he offers you $100k/year for 5 years, to focus on a topic of your choice. $50k/yr is for your starting salary; $50k/yr, for a co-founder or employee. Your job: to launch a computing-related company or non-profit, with the potential to contribute to the betterment of your hometown (creating local jobs, etc.). In two sentences, describe your hypothetical organization's general activities. (The specifics are not important, beyond that you will engage them in some of the remaining questions.) A name and two examples follow. "*One of my hometowns is Lexington, Kentucky. Mayor Linda Gorton spent most of her career as a nurse. My hypothetical non-profit would develop open-source designs making compelling applications of 3D printers and CNC routers with embedded computers and traditional crafts. Our designs would bring social media to the physical world.*" *Or as another example, same town and mayor: "My hometown, Lexington, is known for horse farms and horse racing; and my daughter likes a horse-related Netflix series. My company will use embedded computing technology to bring digital magic to little physical models of horses, somehow." Don't get stuck; any two-sentence computing-related example will earn full marks. If you feel stuck, you might try an Internet search like "recent computing startup companies," and select an idea you see described. (5 points)*

My birthplace and what I still consider my hometown is Florence, South Carolina. The mayor there is now the first woman and first African-American mayor of Florence named Teresa Myers Ervin who is focused on staying green and moving forward technologically. The organization I would launch and develop would be a large-scale software company that provides the API's and all-around software for Florence's companies, big and small. It would focus on modernizing the technology aspect of Florence's businesses, uniting them aesthetically and moving them forward as far as utilizing technological advances of the past decade that may not be present in a mid-scale southern town.

d) During the remainder of the exam, please fill out the following matrix. You may use person (a) (Torvalds or Lawall), person (b) (re PR4), and person (c) in up to four of the remaining exam questions. You may engage your PR4 in up to 7 of the remaining questions; and your hypothetical example of 1c in up to 7 of the remaining questions. This will become clear as you continue. As you complete the exam, please write the exam question numbers in the appropriate below box. If you did not complete PR4, please contact me via Zoom-chat immediately, and I will help you identify a topic. *(4pts)*

	Person 1a: *L. Torvalds*	Person 1b: *J. Lanier*	Person 1c: T. Myers Ervin
PR4 project theme	Q5, Q11, Q14	Q4, Q12	Q2, Q13
Q1c project theme	Q3, Q8, Q9	Q7, Q10	Q6

For example, one such matrix follows. I imagine answering Q2 in the context of my PR4 theme, with OS expert Dr. Lawall as the audience; Q3 in the context of my Q1c theme (horse tangibles) to Melinda Gates; etc. Note that you probably will not complete these table until you complete all 14 questions.
Example matrix:

	Person 1a: *J. Lawall*	Person 1b: *M. Gates*	Person 1c: *L. Gorton*
PR4 project theme	Q2, Q4	Q5, Q7, Q9	Q11, Q13
Q1c project theme	Q6, Q8	Q3	Q10, Q12, Q14

Q2: Chapter 4: Concurrency and Threads *(7 points)*
   a) Please pick a specific topic introduced in Chapter 4. Per question 1, please pick individual *A* (Torvalds or Lawall), *B*, or *C, circling your choice.* In two sentences, please explain the meaning and significance of your chosen topic to your chosen audience. (*3 points*.) *For example:* "*I would describe multithreading to Mayor Gorton. Threads are …. They are central to the future of computing-based systems, because…*"

I choose to describe multithreading to Mayor Myers Ervin. A thread in a computer is a single logical sequence containing a process for completing a task, imagine a single string on a guitar playing one note when plucked. Multithreading is the combined use of multiple threads, or "strings", that make use of multiple processes across different threads to perform one or more larger tasks, similar to multiple strings being strum on a guitar producing a chord such as "G" that makes a prettier and more effective sound.

   b) Per question 1d, please pick either PR4 or your hypothetical ~company of Q1c. In two sentences, please explain to the person you have identified in Q2a how the topic you have selected for Q2a holds relevance to PR4 or Q1C. *(4 points) For example: "I would explain to Melinda Gates the relevance of multithreading to my horse tangibles. I imagine my customers collecting a dozen or more horse tangibles, that glow at relevant moments (e.g., when the friends they represent become active on social media). Multithreading would be important to simplify the implementation and increase the performance."*

I would explain to Mayor Myers Ervin the relevance of multithreading to the machine learning portion of my project. For machines to learn quickly, they must operate in multiple places at one time, communicating with one another to both find data and eliminate it or pass it on as successful. Multithreading for a machine learning operating system would allow it to process exponentially more data and discover solutions in a fraction of the time, for example a machine hypothetically reading one book at a time before moving on to another book instead of utilizing a book club that reads 25 books at once and shares the group's knowledge.

Q3: Chapter 5: Synchronization (mutex locks, etc.) *(6 points)*
    a) Please pick a specific topic introduced in Chapter 5. Per question 1, please pick individual *A* (Torvalds or Lawall), *B*, or *C, circling your choice.* In two sentences, please explain the meaning and significance of your chosen topic to your chosen audience. (*3 points.*)

I would describe condition variables to Linus Torvalds. A condition variable is a simple way for a thread to wait on another thread to complete a task or to simply check if another thread has not done its job yet. Condition variables allow for smooth implementations of web servers or software that does not need to be updated constantly and can simply wait for a condition variable to trigger the update or event to happen, reducing constant CPU usage and avoiding error messages.

    b) Per question 1d, please pick either PR4 or your hypothetical ~company of Q1c. In two sentences, please explain to the person you have identified in Q3a how the topic you have selected for Q3a holds relevance to PR4 or Q1C.   (*3 points.*)

I choose to explain to Linus Torvalds the impact that condition variables will have on a software company's ability in Florence, SC. The purpose of my software company in Florence would be to provide software and/or web servers to businesses in the area which can easily utilize condition variables on their websites or inter-business software used for employee communication. The technology in businesses could use a re-haul of the software they use to operate their businesses and could effectively utilize a system, for example, in restaurants where a "processing orders" UI can be updated and completed as chefs and servers manage a customer's table.

Q4: Chapter 9: Caching *(6 points)*
    a) Please pick a specific topic introduced in Chapter 9. Per question 1d, please pick individual *A, B,* or *C, circling your choice.* In two sentences, please explain the meaning and significance of your chosen topic to your chosen audience. (*3 points.*)

I choose to describe memory caching to Jaron Lanier. A cache in computer memory is a storage device that accepts an address to a memory location and a value to help the processor locate that address. When utilizing a memory cache, accessing specific data stored inside the memory becomes quicker and more efficient, similar to a hash table allowing for quick access to specific locations holding data.

    b) Per question 1d, please pick either PR4 or your hypothetical ~company of Q1c. In two sentences, please explain to the person you have identified in Q4a how the topic you have selected for Q4a holds relevance to PR4 or Q1C.   (*3 points.*)

I would explain the effect of memory caching in machine learning and virtual reality operating systems to Jaron Lanier. For machine learning to most effectively "learn," it must have access to all its previous results so that it can compare different data and solutions. If a machine learning algorithm has access to memory and yet no way of accessing the data inside that memory quickly and efficiently, the machine learning algorithm has effectively been bottlenecked and all its progress slowed to a grinding halt. When algorithms can read data, search for similar data inside memory and immediately access it, it can compare and move on to other solutions exponentially faster than if it had to also search through all memory to find it.

Q5: Chapter 7: Scheduling *(7 points)*

    a) Per question 1d, please pick individual <u>*A*</u>, *B*, or *C, circling your choice.* Per question 1d, please pick either PR4 or your hypothetical ~company of Q1C. In two sentences, please explain to the person you have identified how scheduling holds relevance to your PR4 or Q1C. (*3 points.*)

I would explain scheduling to Linus Torvalds and its effect on a machine learning/virtual reality operating system. Scheduling is the process of determining which threads holding specific tasks should or could be run first to most effectively increase performance. Scheduling would allow for a machine learning algorithm's CPU to potentially knock out the most demanding threads first or decide a way for it to process the bulk of the information in the quickest way possible, thereby avoiding a slowdown in processing speed when the amount of tasks outweighs the number of threads to process those tasks and helping the algorithm come to a solution in the quickest time possible.

    b) Please pick *a specific scheduling algorithms named in Chapter 7,* writing its name here. Please identify how this algorithm might be applied to your Q5a choice, and a specific implication this choice might hold. (*4 points.*)

The specific scheduling algorithm I choose would be arguably one of the simplest yet most effective: First-In-First-Out scheduling. First-In-First-Out (FIFO) has the potential to be the fastest and most efficient scheduling process for completing the most tasks in the fastest time, which is the epitome of machine learning. The point of machine learning algorithms is to analyze large chunks of data for anomalies or exceptions, which when used on just a processor can utilize a FIFO scheduler to go through all the information extremely quickly and potentially, for specifics, recognize a cancer cell anomaly inside a bladder that doctors otherwise would have said was healthy and unaffected.

Q6: Chapter 11: File systems *(7 points)*

    a) Please pick a specific topic introduced in Chapter 11; an individual *A*, *B*, or <u>*C*</u>*;* and *your PR4 or Q1C.* In two sentences, please explain the meaning and significance of your chosen topic, for your chosen context, to your chosen audience. (*3 points.*)

I choose to explain API's to Mayor Myers Ervin and how to applies to my software company in Florence, SC. An API is essentially a skeleton for how a server, UI, or file system should run that makes development of that system much easier to program and design around. One of the tasks in my software company would be to provide Florence businesses with an API that can help them base their websites and company software on to make it efficient and easy to use, as well as decreasing the time spent teaching it to employees or trying to figure out menial processes.

b) Please pick a specific file system discussed in Chapter 11, writing its name here.   Please identify how this algorithm might be applied to your Q6a choice, and a specific implication this choice might hold. (4 *points.*)

I choose flash memory file system. Flash memory has the ability to be accessed and read faster than disk file systems and can be applied to an API for businesses that will speed everything up and make it faster to implement. An API for a business's software that utilizes flash memory will make the processes for that business's software faster than it previously was on disk storage file systems.

Q7: Cybersecurity + OS lecture *(4 points)*
Please pick a specific topic introduced in the TA's guest lecture; an individual *A*, *B*, or *C;* and *your PR4 or Q1C.* In two sentences, please explain the meaning and significance of your chosen topic, for your chosen context, to your chosen audience. (4 *points.*)

I choose to explain privacy and the importance of data privacy to Jaron Lanier. Privacy is essential to an operating system, as you don't want outside parties accessing your potentially sensitive information like employee records or bank information that is stored in your system. That stays the same for my hypothetical software company I am launching in Florence; we will be providing businesses with software or API's that require secure, private connections to ensure that these businesses are hacker-proof and do not lose sensitive information based on a flaw in our software design.

Q8: Chapter 12: Storage devices *(7 points)*
a) Please pick an individual *A*, *B*, or *C;* and *your PR4 or Q1C context. (1 pt)*
I choose Linus Torvalds.
Relative to computing, many application contexts involve some relatively mainstream aspects, and some unusual aspects. E.g., for both the postal service and police department, both mainstream office computers and specialized wearable computers would be of relevance. Similarly, for both agricultural and industrial applications, both desktop and drone computing deployments may often be important.

b) In two sentences, please describe a specialized computing context relative to your chosen PR4 or Q1C context.   (3 points)
Wireless communication and data transfer would be a specialized computing context relative to my Q1C scenario of implementing software for Florence businesses. If employees of a business can utilize a software that works over-the-air and updates in real time through wireless transmission, the need for sitting by computers waiting for information would be nullified and work could be taken outside the cubicle and into a work zone or group setting to further maximize efficiency in communication.

c) In two sentences, please describe your choice of storage device technology for this context, and briefly argue why. (3 points)
The specific file system I choose would be the Solid State Drive storage file system. The Solid State Drive (SSD) system provides larger sets of data with the ability to access the data extremely quickly using electrical circuits as opposed to moving physical parts. SSD's could be utilized effectively in businesses in Florence, SC that need faster file systems and the need for reading/writing large chunks of data in half the time, as well as processing different aspects of an API such as reading/writing new users to the system.

Q9: Chapter 13 meets PR1: Files and directories *(7 points)*
  a) Recall the specialized computing context you identified in Q8a and Q8b. Imagine you launch an ssh session to a compute processor in one of the most interesting, specialized domain-specific computing contexts. Imagine you wish to use the "ls" command to view the most illuminating, contentful directory. Please suggest a specific path for your envisioned system; and briefly describe the set of files you might see in response. (4 points)

The specific path I see when running "ls" on a wireless system would be /company/users which would hold the information for employees in the system, their schedules, and methods of contacting them. The specific directory would hold files including that employee's scheduler or a text file containing methods of contacting them.

  b) In this same ssh session, imagine you run the command "find / | wc -l" In two sentences, please describe a possible response you could imagine receiving; how this might compare with the results on your preferred laptop; and any differences might be contextually interpreted. (You may follow the links for "find" and "wc" if you wish.) Be specific. (3 points)

I would imagine that after running this command I would be met with a count of the number of files located outside the main directory, or behind the "/" main directory. The wireless system I set up for my company would hold potentially less information (for security reasons) than my laptop, so I would expect my preferred laptop to yield a much higher amount of results and file directories than the specialized computing context I identified previously.

Q10: Chapter 14: Reliable storage *(9 points)*
  a) Please pick an individual *A*, *B*, or *C;* and *your PR4 or Q1C context.* For your chosen context and audience, in two sentences, please identify the kind of data for which you envision reliable storage to be most critical. Be specific. *(3 points.)*

I choose to explain reliable storage to Jaron Lanier. The kind of data I envision as the most critical for reliable storage would be bank/profit/tax information held in a business. The last thing a business wants is to lose access to its bank records or tax information that contains all the numbers it needs to maintain a profit and stay legal, which is something that businesses in Florence, SC have had issues with in the past.

  b) Here, you will be comparing RAID5 and RAID10. In two sentences, for the audience identified in Q10a, please explain the difference between RAID5 and RAID10. *(3 points)*

RAID5 is also known as "rotating parity" which reduces overhead by storing chunks of data onto separate disks and then protecting all of the data using yet another separate disk that never changes. RAID10 is the combination of RAID 0 and RAID 1/5 in that it mirrors pairs of disks with data, treats them as one device, and then writes data across both, providing a backup with every write.

  c) For the context, audience, and data identified in Q10a, in 1-2 sentences, please chose between RAID5 and RAID10, and briefly support your choice. *(3pts)*

I would choose RAID10 simply because of the redundancy it creates and the amount of backup potential it provides. Disks lose storage or corrupt constantly, so having pairs of disks containing the same information can be extremely reliable.

Q11: OSes for low-end devices in the Internet of Things *(6 points)*

    a) Please pick a specific topic introduced in this reading. Per question 1d, please pick individual *A*, *B*, or *C, circling your choice.* In two sentences, please explain the meaning and significance of your chosen topic to your chosen audience. (*3 points.*)

I choose to explain the Internet of Things (IoT) to Linus Torvalds. The IoT is an interconnection of both high-end systems like Windows or Linux or consoles that connect with lower-end systems such as mobile device operating systems. The connection of these two ends is the definition of IoT, utilizing the transmission and workload across operating systems no matter the tier.

    b) Per question 1d, please pick either PR4 or your hypothetical ~company of Q1c. In two sentences, please explain to the person you have identified in Q11a how the topic you have selected for Q11a holds relevance to PR4 or Q1C. (*3 points.*)

My project 4 on machine learning and virtual reality operating systems applies to the IoT in more ways than one. Virtual reality on a mobile device could make doctors more mobile in the medical field if information they receive can be broadcast in a virtual environment away from the hospital itself. A doctor could become able to research a patient's issue or help diagnose it by transferring data from their high-end systems to the doctor's personal low-end mobile device for easy virtual viewing.

Q12: Cross-Platform Analysis of Potentially Harmful Libraries on Android and iOS *(6 points)*

    a) Please pick a specific topic introduced in this reading. Per question 1d, please pick individual *A, B*, or *C, circling your choice.* In two sentences, please explain the meaning and significance of your chosen topic to your chosen audience. (*3 points.*)

I choose to explain cluster packaging across Android and iOS to Jaron Lanier. Cluster packaging is a method of boxing together similar libraries from apps of the Android operating system, analyzing them, and using the analysis to effectively locate its counterpart in iOS systems which usually do not have crossing data. Cluster packaging helps determine how malicious software may be impacting iOS devices that cannot be scanned with antivirus software and confirmed that malicious viruses can be presented to these devices in such a way.

    b) Per question 1d, please pick either PR4 or your hypothetical ~company of Q1c. In two sentences, please explain to the person you have identified in Q12a how the topic you have selected for Q12a holds relevance to PR4 or Q1C. (*3 points.*)

As stated in my project 4 about machine learning, it can be effectively used to identify malicious fingerprints in devices it is connected to. Machine learning in operating systems can become an effective way, similar to cluster packaging methodology, of determining which libraries contain malicious information, viruses or fingerprints. Machine algorithms will be able to access all of the information extremely quickly and notify a user of a file or file system that is out of the ordinary and potentially harmful.

Q13: Tangible Bits *(7 points)*
   a) Please pick a specific topic introduced in this reading. Per question 1d, please pick individual *A, B,* or *C, circling your choice.* In two sentences, please explain the meaning and significance of your chosen topic to your chosen audience. (*3 points.*)

I choose to explain the meaning of Interactive Surfaces to Mayor Myers Ervin. Interactive Surfaces, as similarly described in Tangible Bits, is the transformation of a surface such as a wall into an interactive user interface. A user will be able to touch or access the interface with a device and transform that ordinary surface into a workstation or viewing station, thereby removing the need for specific monitors or displays.

   b) Per question 1d, please pick either PR4 or your hypothetical ~company of Q1c. In two sentences, please explain to the person you have identified in Q13a how the topic you have selected for Q13a holds relevance to PR4 or Q1C. (*3 points.*)

The idea of interactive surfaces can play a huge part in the virtual reality aspect of my PR4. As stated before, the medical field is a huge proponent of virtual reality, and alongside interactive surfaces could prove to be a new horizon for the ability to analyze different parts of a person's body or the structure of a harmful cell. Virtual reality and interactive surfaces could make it possible for doctors to access a virtual world on a wall or table that gives full 3 dimensional access and change the way we are able to view cells, organisms, or viruses inside the workplace.

Q14: PR3 *(6 points)*
Please pick an individual *A*, *B*, or *C;* and *your PR4 or Q1C context.* Imagine you were applying your parallelized PR3 in an "interesting context" of your PR4 or Q1C. In 2-3 sentencesyou're your chosen audience, please describe the "interesting context" you have in mind; and which physical locale the actual execution of your code would strategically be located.

I choose to explain the use of parallel virtual reality comparisons in the medical field to Linus Torvalds. Imagine a circumstance where a patient comes into a hospital and requires an analysis of their cells to scan for outside, harmful cancer cells. With the new virtual reality technology established in this futuristic hospital, the doctor can pull up a virtual image of the patient's cells but cannot quite determine if the cell looks abnormal or average. The doctor then utilizes a special function located inside the virtual reality software that begins a multithreaded operation of pulling up a parallel image of the patient's healthy cells in the exact same location side-by-side with the cell they are trying to determine is cancerous, thereby allowing the doctor to directly compare in virtual reality the two cells and determine whether the current analysis contains a harmful cancer cell.