Welcome to Math 330 Discrete Math – Winter 2023

Class Meetings WF 1-1:50 pm in SAMU 113
Webpages: (course) http://canvas.cwu.edu

Instructor: Dr. Jean Marie Linhart **Office:** SAMU 221B (SAMU 208A) **E-mail:** JeanMarie.Linhart@cwu.edu **Phone:** (509) 963-2123 (2109) **Student Drop-in Hours:** W 10-12, Thu 3-4, by appointment these are kept up to date on our Canvas page	**Tutor:** Andy Nguyen **Location:** SAMU 225 (usually) **E-mail:** Thuan.Nguyen@cwu.edu **Tutor Hours:** See our Canvas page

The best ways to contact me are email, Canvas message, and office hours. If there's something I need to remember for later PLEASE put it in an email! If I don't reply within 24 hours over a business day, please contact me again. I have had a few issues noticing I have Canvas messages last-term, but I am trying to proactively check for messages to deal with this. While I strive to be responsive and prompt, sometimes things get put off for later and unintentionally forgotten. **Please check your university email messages and Canvas messages daily.**

Please contact me ASAP if you are sick or if there's a reason why you need special consideration or an extension of due dates.

This syllabus is subject to modification. Students will be notified of changes in class and on Canvas.

Prerequisite: Math 260 with a grade of C or higher.

Technology & support: This is an hybrid course that will rely on the Canvas learning platform. Make an effort to become familiar with Canvas and seek support for technical issues. If you are having technical issues with Canvas, click the Help icon in Canvas to contact the 24/7 support hotline (877-399-8897). You will find additional Canvas support and technology requirements on the CWU online learning website (http://www.cwu.edu/online-learning). Additionally the CWU Service Desk can assist you with MyCWU network and login issues (servicedesk@cwu.edu): 509-963-2001

I highly recommend updating to the newest version of whatever browser you are using, as well as the most up-to-date Flash plug-in. If you have any issues with Canvas, a first thing to try is to switch browsers. I am using the Firefox browser on my laptop.

Canvas is not officially supported on mobile browsers, but it does offer an app for iOS and Android. However, because it is made to work on a desktop or laptop, the phone app is not the best interactive experience. Since Canvas uses small elements of Flash, not all Canvas features may be supported on mobile devices, especially on iOS.

Text: *Mathematics for Computer Science*, 2015 Edition, by Eric Lehman, F. Thomson Leighton, Albert R. Meyer, available freely for you on Canvas. You may notice that one of the authors of this book, F. Thomson Leighton, is CEO Akamai Technologies, and Eric Lehman is a software engineer at Google – they are doing their best to present ideas that will be of use to you later. I have enjoyed reading this book; it has a lot of subtle humor woven into the technical information. That said, you may need to use resources such as Khan Academy online in addition to the textbook to learn the material.

Course Goals: Math 330 is a course in the mathematics behind computer science concepts and applications. Mastery of college algebra is required for success in this course. This course is meant to familiarize you with mathematics foundational to computer science such as the logic rules you learned in Math 260, and math that is used to analyze algorithms, such as recurrence relations and counting arguments, and math in computer science applications, such as applications of graph theory. Understanding why things work, and being able to explain your logic is as or more important than getting the correct answer. Abstract thinking, logic and common sense are required for success.

A complete list of learning objectives for the course is provided at the end of this syllabus.

Grades/Exams/Homework

Grades: We will be using mastery testing this quarter in Discrete Math, which means that instead of doing a few big tests and a final exam, the course is broken down into smaller tests on areas of related

learning objectives that you can take more than once, but to pass you must earn an A or a B. The number and type of tests that you pass determine your final grade. One advantage to this is that you can choose your grade by putting more (or less) effort into the class – one bad day on a test will not hurt you. Another advantage is that there is not a cumulative final exam. Instead, the final exam period is an opportunity to pass more tests to raise your grade.

There are two take-home activities (Counting 4 and Recurrences 1) that may not be repeated.

At the end of the syllabus, you will find the learning objectives for the course separated into 18 areas (this is also on Canvas). All of these are assessed with a test that can be retaken, except for Counting 4 (C4) and Recurrences 1 (R1). These two areas are assessed by a take-home assignment that cannot be repeated. Eight of the 18 areas are required; to indicate this, they are marked with an R at the end of the name. Example: Counting 1R (C1R) is required, and Counting 3 (C3) is not. The grades assigned are A (40-49, excellent) or B (30-39, very good) or Not Yet (NY, 0-19) passed. On occasion a passing grade of C (20-29) may be assigned.

A table of the requirements for an A, B and C for the course is below. The student will earn the highest grade for which they have completed all of hte requirements in the row.

Course Grade	# of Passed Required	Must Pass	# Other Passed	# of As on Standards	Homework Percent	Other
C	ALL (8)	-	0	0	70+%	
$C+$	ALL (8)	-	1	0	75+%	
$B-$	ALL (8)	-	2	2	80+%	
B	ALL (8)	C3 or R1	2	4	80+%	
$B+$	ALL (8)	C3 or R1	3	6	85+%	
$A-$	ALL (8)	C3 or R1	4	7	90+%	At B or above
A	ALL (8)	C3 and R1	4	8	90+%	At B or above

That last column indicates students earning an $A-$ or an A must pass all of the standards required for that grade with a grade of B or above.

As a general rule, each missing requirement from a C grade will reduce the letter grade by $\frac{1}{3}$, i.e. a student with 8 passed required standards, and a homework percent below 70 will get a $C-$ in the course.

Testing and Retesting: Tests should be done using only your brain, a writing implement and paper, and a calculator, unless the directions say otherwise. On challenging material, students must retest. Retests must be completed within 2 weeks of when the original assessment was given in class.

If there's something going on so that this isn't a workable time-frame for you, please let me know what's going on so that we can figure out an alternative plan.

Some operating parameters

- Students can test on a required area up to 5 times.
- Students can earn an A on a required area on the first 4 attempts, thereafter the highest score earned will be a B.
- Students can test on an optional area up to 3 times, with the exception of Counting 3 (C3) and Recurrences 1 (R1) which may be taken up to 4 times. An A can be earned on any of these attempts, but not on an attempt purchased with a token unless a second token is used.
- C4, and R5 may not be retaken or handed in late; they are a one-shot deal.
- Students may be required to complete homework or a practice test with a minimum score in order to retest. Homework and practice tests are assigned to get you the practice you need to be successful on the tests.
- Students are given 5 tokens at the beginning of the term. A token can be exchanged to do one of the following:
  - An extra attempt at a test. You may use more than one token for more than one extra attempt at a test, for example you could use three tokens for three extra attempts on Counting 1R (C1R).
  - An opportunity to get an A on a test on an attempt where normally this is not possible. (I will not collect a token from you if you do not, in fact, earn the A on that attempt.)

  - Handing in C4, R5, or homework late when a student has not asked for an extension ahead of time. Late means up to 24 hours late, but longer extensions may be requested and must be agreed upon by the instructor. I also will consider extension requests without a token if they are made before the assignment is due.

- If you are ready for a test before it is ready, email me to let me know, and I will make an arrangement to get it to you within 2 business days.
- You may attempt to take a test on an area at most once a day. A token may not be used for an extra attempt on a day.
- You may request at most 2 tests outside of class per day, but you may request a third by using a token. If we are taking tests during class, you may take as many as you have time for.
- Tests are not returned to students, although I am always happy to go over these with you in office hours or make another arrangement to go over these with you.
- All tests and assignments for the term should be completed by the date listed in the Important Dates at the bottom of the syllabus before the Learning Objectives.

Roadmap for success: This is a hybrid course. The lecture material is provided online by video, and we will have twice-weekly in-person synchronous class meetings for students to work together on problem-solving (discussions) and homework, and for testing. You should have 1-1:50 pm on WF set aside in your schedule for this course. Usually the discussion for the week can instead be done in person with classmates during one of our weekly meetings.

Please log in to Canvas and watch the video lectures posted for you daily, and start assignments promptly – the expectation is that you should be spending about 15 hour per week on the course (1 hour class time, 2 hours homework per week day.) The due date for homework assignments should not also be the "do" date for the assignment! Spreading this work out so that you are working about 3 hours a day on 5 different days during the week will not only make it easier for you to learn the material, it will also greatly reduce your stress level.

The testing policy was created to make sure everyone can succeed. If you are not successful with a test the first time, do what you need to do to retest promptly.

Homework and Discussions: I assign homework (which includes a discussion post) to help you learn the material for the course and to hold you accountable for doing the things that will make you successful in the course. Generally the discussion post can be completed by coming to class in person and working with classmates during one of our weekly class meeting days. Due dates are to keep you on a schedule so that you will have time to successfully complete the course. If you are sick or have another special circunstance and need an extension, please ask. A minimum score of 50% will be assigned to homework and discussions in the case of missing or unsatisfactory work to deal with inequities with the 100-point scale.

Reading: Reading assignments are to familiarize you not only with material you will be tested on, but also to give you a broader perspective on the interplay between mathematics and computer science. Reading assignments consist of reading a section or several sections of material from the textbook.

Late Policy: Contact me ASAP if you are sick or if there's a reason why you need special consideration of an extension of due dates. I usually allow homework to be handed in 24 hours late without penalty, and a token can be used to get another 24 hours. In general, I will grant a 24 hour extension without the use of a token if it is requested before the due date, longer extension requests should be accompanied with an explanation of extenuating circumstances. Because of my time costs in dealing with late work, homework that comes in late may not get as many helpful comments or be graded as carefully as homework that comes in on time.

Office Hours and Getting Help: Our class time on Wednesdays and Fridays is generally available for you to get help, and Office Hours (also known as Student Drop-In Hours) are scheduled to make sure there is a time that you can talk to an instructor directly. In addition to office hours, you can also make an appointment if those times don't work for you. I regularly monitor the course discussions. Please post questions to these discussions because they can benefit everyone. If you need additional time to talk to an instructor, please email and ask for an appointment – we can meet in person or by Zoom. Please suggest at least 3 possible times that will work for you.

Academic Integrity: All tests are expected to be completed without any resources except those explicitly authorized by the instructor – generally the only resources you have are your brain and a calculator.

You are allowed to use the book and notes for C4, R5, and I2R, and you are allowed to discuss C4 with other human beings. Do not discuss tests with others who may not yet have taken the test yet, or within earshot of someone who may be taking it at a later time. Any work done at home may be discussed with others, unless the assignment instructions state otherwise.

Consult university policies (CWUP 5-90-040(22), CWUR 2-90-040(22), and WAC 106-125-020) for student conduct, cheating, plagiarism, and other academic expectations. CWU's policies and recommendations for academic misconduct will be followed, leading to disciplinary action up to and including failing the course.

Students with Disabilities: Central Washington University is committed to creating a learning environment that meets the needs of its diverse student body. Students with disabilities should contact Disability Services to discuss a range of options to removing barriers, including accommodations: Hogue Hall 126, (509) 963-2214, DS@cwu.edu

Diversity: As a member of a peer learning community, a high degree of professionalism is necessary. CWU expects every member of the university community to contribute to an inclusive and respectful classroom culture.

Mandatory Reporting: I am a mandatory reporter for sexual assault. If you disclose a sexual assault to me, I am required to report it to the University administration.

Religious observances: In compliance with RCW 28B.137.010, educational institutions must accommodate student absences to allow students to take holidays for reasons of faith or conscience or for organized activities conducted under the auspices of a religious denomination, church, or religious organization, so the students' grades are not adversely affected by the absences. Please let me know about these ahead of time.

Stress: Stress and other life circumstances that may be out of your control can make learning and focusing difficult. If you find stress or other mental health concerns make academics difficult, Central has resources to support you. I encourage you to reach out as soon as you notice you are struggling. Student Counseling Services – crisis appointments available – 509-963-1391 – http://www.cwu.edu/medical-counseling/counseling-clinic. Mental health crisis support outside of normal business hours – 1-800-273-8255; Text HOME to 741741; Call 9-1-1. Wellness Center – confidential sexual assault and other victum advocacy – 509-963-3213 – http://www.cwu.edu/wecare/. Disability Services – registration for disability accommodation – 509-963-2214 – https://www.cwu.edu/disability-services/. Case Management – connect students with resources and support those most at-risk – 509-963-1515 – https://www.cwu.edu/case-management/.

Important Dates

Students should have passed C1R, C2R, and R2R by the Uncontested Withdrawal Deadline to be considered passing the course at that time. Students who are not passing on the Uncontested Withdrawal Deadline will not be eligible for an incomplete grade.

January 10	Change of schedule period ends	Feb 17	Uncontested Withdrawal Deadline
January 16	MLK Day Holiday (no class)	February 20	President's Day (no class)
		March 15	All tests due by 5 pm

Learning Objectives

Required areas end in **R**, e.g. C1R is required, C3 is not required. Not all areas are the same length or difficulty. There is information up on Canvas to help you gauge the length and difficulty of each area. All areas are assessed by a test that may be retaken except C4 and R1, which are assessed by a take-home assignment and may not be handed in late unless a token is used for a (usually 24 hour) extension.

1. **(C1R) Counting 1R:** Book: 14-14.7.
   a. Students will use addition, multiplication, division, and combinations of these operations to solve counting problems.
   b. Students will know and be able to apply the definitions of a function, partial function, injective function, and bijective function in a counting context.
   c. Students will use addition, multiplication, division, and combinations of these operations to count functions, in particular they will be able to count functions, partial functions and injective functions with a given domain and co-domain, including functions with restrictions for certain inputs.
   d. Students will use permutations and combinations to solve counting problems.
   e. Students will use bijections to solve counting problems.

f. Students will determine which methods mentioned above are appropriate for solving a counting problem, apply these methods and solve.

2. **(C2R) Counting 2R:** Book: 14–14.7, 14.9 –14.9.4.

   a. All learning objectives from Counting 1 and
   b. Students will use the principles of inclusion-exclusion to solve counting problems.

3. **(C3) Counting 3:** Book: 14–14.7, 14.8–14.8.2, 14.9–14.9.4.

   a. All items from C1R and C2R and
   b. Students will use the Pigeonhole Principle to write a logically valid proof.

4. **(C4) Counting 4:** (Take-home activity) Book: 14–14.7, 14.9–14.9.4

   a. Students solve advanced counting problems using techniques from C1R and C2R that have not been explicitly explained in class.
   b. Students clearly explain the reasoning they use to come up with their solutions using complete sentences and correct mathematical notation.
   c. Students plan ahead to complete work neatly and on-time.

5. **(R1) Recurrences 1:** Some ideas on solving recurrences by finding patterns are taken from the book: 21–21.2.

   a. Students find patterns to solve first-order recurrences
   b. Students solve arithmetic and geometric first-order recurrences
   c. Students use the geometric sum formula to solve first-order recurrences
   d. Students apply the solution techniques above to solve application problems involving loans and investments.

6. **(R2R) Recurrences 2R:** Book: 21.3-21.3.2

   a. Students find a solution to a second order homogeneous linear recurrence with constant coefficients ($a_n = Aa_{n-1} + Ba_{n-2}$) using the characteristic equation.

7. **(R3R) Recurrences 3R:** Book: 21.3, A Short Guide to Solving Linear Recurrences

   a. Students find a solution to a second order non-homogeneous linear recurrence with constant coefficients ($a_n = Aa_{n-1} + Ba_{n-2} + Hp^n$) using a characteristic equation and guessing a particular solution.

8. **(R4) Recurrences 4:** Book: 21.3, A Short Guide to Solving Linear Recurrences

   a. Students find the characteristic equation of a higher-order linear recurrence with constant coefficients.
   b. Given a higher-order linear recurrence with constant coefficients, and either roots of the characteristic equation or a homogeneous solution to the recurrence, students will be able to find the form of the particular solution.

9. **(R5) Recurrences 5:** (Take-home activity) Book: 21.3, A Short Guide to Solving Linear Recurrences

   a. Given a solution to a homogeneous second order linear recurrence with constant coefficients, students explain how to generate the recurrence problem with that solution. E.g. Given $a_n = 3(2^n) + 5(3^n)$, students find a 2nd order linear recurrence with constant coefficients and initial conditions that has this as its solution.
   b. Given a solution to a non-homogeneous second order linear recurrence with constant coefficients, students explain how to generate the non-homogenous recurrence problem with that soltuion. E.g. Given $a_n = 3(2^n) + 5(3^n) + 2(-1)^n$ students find a non-homogenous 2nd order linear recurrence with constant coefficients and initial conditions that has this as its solution.
   c. Students explain ther logic and reasoning using complete sentences.
   d. Students plan ahead to complete work neatly and on-time.

10. **(I1) Induction 1:** Book: 5.1-5.3. Students will construct sound proofs using either ordinary or strong mathematical induction for problems involving a summation rule like $\forall n \in \mathbb{Z}^+, \sum_{k=0}^{n} k = \frac{n(n+1)}{2}$, a division rule like $\forall n \in \mathbb{N}, 3|(8^n - 5^n)$, or making postage or change like "every amount of postage greater than or equal to 8¢ can be made from a collection of 3¢ and 5¢ postage stamps".
11. **(I2R) Induction 2R:** (take-home test) Book: 5.1-5.3. Students will construct a sound proof using strong mathematical induction to show that a given expression is the solution to a second-order homogeneous linear recurrence with constant coefficients.
12. **(Num1R) Number Theory 1R:** The material on number bases is not in the book. The Greatest Common Divisor (GCD) and divisibility are covered in the beginning of chapter 9.
    a. Students will use the definition of a numerical base to convert between bases.
    b. Students will be able to reconstruct the definition of the greatest common divisor (GCD), and find the GCD of two or more numbers by prime factorization.
    c. Students will be able to reconstruct the definition of the Least Common Multiple (LCM) and find the LCM of two or more numbers by prime factorization
13. **(Num2R) Number Theory 2R :** Book: 8.2, we read 8.2–8.5
    a. Students use Euclid's Algorithm to finding the GCD of two positive integers, clearly documenting their work and identifying a well-defined stopping condition.
    b. Students use the extended Euclidean Algorithm to find the GCD of two positive integers and a linear combination of the two positive integers that gives the GCD.
14. **(Num3R) Number Theory 3R:** Book: 8.6–8.9.2, we read 8.11
    a. Students add, subtract and multiply numbers in $\mathbb{Z}_n$.
    b. Students use fast exponentiation to compute exponential powers in $\mathbb{Z}_n$.
    c. Students use Euclid's extended algorithm to compute multiplicative inverses in $\mathbb{Z}_n$.
    d. Students use multiplicative inverses to solve linear equations in $\mathbb{Z}_n$.
15. **(GTM) Graph Theory Matching Algorithm:** Book: 11.5
    a. Students use the bipartite matching algorithm known as the mating ritual and correctly document their work to find stable matchings benefitting a given group.
    b. Students use the bipartite matching algorithm to determine whether a stable matching is unique.
    c. Students identify a rogue couple in an unstable matching to demonstrate that it is unstable.
16. **(GTC) Graph Theory Coloring:** Book: 11.6
    a. Students take a problem involving conflicts between items and create a graph in which the items are the vertices and the edges are the conflicts.
    b. Students find a minimal coloring for a graph and solve the conflict problem using the coloring.
17. **(Net1) Networks 1 Butterfly Networks:** Book: 10–10.8, especially 10.8
    a. Students recursively construct a butterfly network of a given size.
    b. Students compute the diameter and congestion of a butterfly network of a given size.
    c. Students route information through a butterfly network given a routing problem.
    d. Students complete the definition a routing problem for a butterfly network so that it has minimal congestion.
18. **(Net2) Networks 2 Beneš Networks:** Book: 10–10.9, especially 10.9
    a. Students recursively construct a Beneš network of a given size.
    b. Students compute the diameter and congestion of a Beneš network of a given size.
    c. Students route information through a Beneš network using graph coloring; given a routing problem, students give all conflict graphs and colorings that determine their routing.