Request for Renewal of ICS 141 as an FS course

Kapiʻolani Community College, Spring 2012

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I. Course Description (from Course Outline)

COURSE INFORMATION: date of outline (2/3/2012)

ICS 141 Discrete Mathematics for Computer Science I (3) AA/FS
3 lecture hours per week
Prerequisite(s): qualification for MATH 135; or consent of instructor

ICS 141 includes logic, sets, functions, elementary number theory, matrices, algorithmic concepts, mathematical reasoning, recursion, counting techniques, and probability theory.

COURSE OBJECTIVES/COMPETENCIES:

Upon successful completion of ICS 141, the student should be able to:

• Solve problems in propositional logic, work with truth tables, and use Venn diagrams.
• Solve problems in elementary set theory.
• Prove theorems using mathematical induction.
• Use the formulas for permutations, combinations, and binomial coefficients.
• Perform general analysis of algorithms.
• Use recursive algorithms.
• Solve problems in elementary probability
• Solve elementary problems of relations
• Explain the concept of functions
• Solve basic matrix operations

II. Changes

The course title has been changes slightly to reflect the content covered; otherwise, there are no significant changes from the previous renewal of ICS 141. The hallmarks for FS are maintained in ICS 141.
III. Assessing of Course. Below and on the next five pages are examples of course materials that illustrate how the course meets the foundations hallmarks.

**Hallmark 1.** Exposed students to the beauty, power, clarity and precision or formal systems.

ICS 141 faculty cover topics such as but not limited to logic, sets, functions, matrices, mathematical reasoning, counting techniques, equivalence relations and partial ordering which involve formal systems in Mathematics and in Computer Sciences. Students reinforce their learning of these topics through the assigned homework and through in class discussion activities.

Example homework problems on sets and logic are given below.

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Let A, B, and C be sets. Show that

a) \((A \cup B) \subseteq (A \cup B \cup C)\)

b) \((A \cap B \cap C) \subseteq (A \cap B)\)

c) \((A - B) - C \subseteq A - C\)

(*Above example illustrates formal system of sets, including set notation and set operations*)

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Show that \(\neg(p \lor (\neg p \land q))\) and \(\neg p \land \neg q\) are logically equivalent using a proof by rules of inference and a proof by truth table.

(*Above example illustrates formal system of logic, including propositions, logical operators and rules of inference*)

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Let: \(P(x,y) = “x + 2y = xy”\), where x and y are integers. What are the truth values of:

a) \(P(1, -1)\)

b) \(P(0, 0)\)

c) \(\exists y \ P(3, y)\)

d) \(\forall x \exists y \ P(x, y)\)

e) \(\exists x \forall y \ P(x, y)\)

(*Above example illustrates formal system of functions, including propositions, predicates and quantifiers*)
Hallmark 2. Help students understand the concept of a proof as a chain of inferences.

ICS 141 is inherently a Mathematical and Computer Science course involving proofs. Initially, students are taught the basic concept of “what is a proof” and are taught a variety of methods to proof Mathematical and Computer Science lemmas, theorems, and corollaries. Mathematical proof methods such as but not limited to modus ponens, modus tollens, hypothetical syllogism, and include direct and indirect (contraposition) proofs and proofs by contradiction are taught. Homework sets involving proofs are assigned throughout the semester.

Example homework problems involving a direct proof and a proof as a chain of inferences are given below.

Give a direct proof of the following theorem: If x is an odd integer, then x + 2 is an odd integer. For two points extra credit, perform the indirect proof as well.

(Students are given building blocks of proof, for example, what does it mean for an integer to be odd \((n = 2k + 1)\), and even \((n = 2k)\). Proof involves chaining these inferences to reach a valid conclusion)

Prove that \(x\) is irrational and \(x \geq 0\), then \(\sqrt{x}\) is irrational.

(Again, students are given the building block of the proof, including the definition of a rational number \((n = p/q)\). Proof involves chaining this inference to reach a valid conclusion)
**Hallmark 3.** Teach students how to apply formal rules of algorithms.

ICS 141 covers algorithms which is an essential part of all programming courses in ICS. Students are taught how to apply the formal rules of an algorithm. They are assigned homework problems to analyze computer programming segments for appropriateness of an algorithm and also to compare, contrast, and apply algorithms.

The following are example homework set problems involving algorithms.

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Determine which characteristics of an algorithm the following procedures have and which they lack.

a) procedure double(n: positive integer)
   while n > 0
       n := 2n

b) procedure sum(n: positive integer)
   sum := 0
   while i < 10
       sum := sum + i

*(Before students can apply formal rules of algorithms, they must first understand the properties that constitute a valid algorithm, including input, output, definiteness, correctness, finiteness, effectiveness and generality. Once these concepts are understood, they can progress to the application of algorithms.)*

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Describe an algorithm that takes as input a list of n integers and produces as output the largest difference between consecutive integers in the list.

*(In the above example, students are required to synthesize their knowledge of what properties constitute an algorithm and derive an algorithm to solve a problem)*

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List all the steps used to search for 9 in the sequence 1, 3, 4, 5, 6, 8, 9, 11 using

a) linear search

b) binary search

*(In the above example, students must apply well known algorithms to solve searching problems common in the area of computer science)*
Hallmark 4. Require students to use appropriate symbolic techniques in the context of problem solving, and in the presentation and critical evaluation of evidence.

ICS 141 instructors cover symbolic techniques used in the context of problem solving and in the presentation and critical evaluation of evidence throughout the course. Students are assigned homework problems which they must use the appropriate symbolic techniques in solving problems and in the presentation and critical evaluation of evidence in topics such as but limited to logic, sets, relations, equivalences, and probability.

Example homework problems involving the use of appropriate symbolic techniques in the context of problem solving, and in the presentation and critical evaluation of evidence are given below.

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**Draw Venn Diagrams for the following sets:**

- a) $A \cap B \cap C$
- b) $\neg (A \cup B \cup C)$

*(The example above illustrates graph theory and graph oriented operations, in addition to sets and set operations.)*

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**Define propositions (or propositional functions) for the following premises and use rules of inference to come to at least one conclusion. Please number each statement and state the rule of inference used for each intermediate step. (Don’t forget quantifiers)*

Every student in ICS 141 lives in Hawaii.
Sam likes Spam, but does not live in Hawaii.

*(The example above illustrates logic and its associated lemmas, corollaries and theorems, as well as the application of rules of inference.)*
Hallmark 5. Not focus solely on computational skills.

In ICS 141, students learn proofing techniques as a reasoning skill.

The following is an assigned homework problem that involves logical arguments and rules of inferences.

Read the following excerpts of Lewis Carroll’s writing on symbolic logic. Describe in detail some of the models he used to represent logical arguments and the rules of inference he used in these arguments.

1. Colored flowers are always scented;
2. I dislike flowers that are not grown in the open air;
3. No flowers grown in the open air are colorless.

1. Showy talkers think too much of themselves;
2. No really well-informed people are bad company;
3. People who think too much of themselves are not good company.

1. Promise-breakers are untrustworthy;
2. Wine-drinkers are very communicative;
3. A man who keeps his promises is honest;
4. No teetotalers are pawnbrokers;
5. One can always trust a very communicative person.

(The above example illustrates the requirement that students synthesize their knowledge of logic to read formal writings of mathematicians and logicians to dissect and understand more complicated proofs than those presented in the textbook)
**Hallmark 6.** Build a bridge from theory to practice and show students how to traverse this bridge.

ICS 141 students learn about bridging theoretical knowledge into practical application throughout the course. ICS 141 instructors facilitate the bridging of this process of theory to practice by first distilling real world problems that are within the students’ zone of proximal development. The first iteration of simplified problems is the scaffolding for students to attempt the more challenging practical problems, which complete the bridge from theory to practice.

One example covered involves Prime number theory and modular arithmetic which have practical applications of data security through encryption and decryption of messages.

Example homework problems on encryption and description are given below.

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Encrypt the message “DO NOT PASS GO” by translating the letters into numbers, applying the encryption function given, and then translating the numbers back into letters.

a) \( f(p) = (p + 3) \mod 26 \)  
b) \( f(p) = (p + 13) \mod 26 \)  
c) \( f(p) = (3p + 7) \mod 26 \)

*(The above example illustrates the first iteration of practical problems, which will serve as the scaffolding for real world exercises.)*

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Decrypt these messages encrypted using the Caesar cipher.

a) EOXH MHDQV  
b) WHVW WRGDB  
c) HDW GLP VXP

*(The above example serves as a real world encryption exercise.)*