1. (2pt) **Name:** _____

INSTRUCTIONS: Carefully read each question, and write the answer in the space provided. If answers to free response questions are written obscurely, zero credit will be awarded. The correct answer to a free response question with a short answer (i.e., one word or phrase) will never contain any significant words used in the question itself (i.e., "crossword rules"). You are permitted to use any **hand-written** notes (including "hand-written" on e.g., a tablet, as long as you did the writing) from our last two classes; all other aids (other than your brain) are forbidden. Questions may be brought to the instructor.

For **TRUE** or **FALSE** and multiple choice questions, circle your answer.

On free response questions only, you will receive **20%** credit for any question which you leave blank (i.e., do not attempt to answer). Do not waste your time or mine by making up an answer if you do not know. (Note though that most questions offer partial credit, so if you know part of the answer, it is almost always better to write something rather than nothing.)

To get credit for this question, you must print your name (e.g., "Martin Kellogg") in the space provided on this page and rint your UCID (e.g., "mjk76") in the space at the top of **each** page of the exam.

Contents (blanks for graders only):

Writing your UCID on every page:	**2** / 2
I. Very Short Answer:	**4** / 4
II. Short Answer:	**6** / 6
III. Extra Credit:	**1** / 0
Total:	**13** / 12

I. Multiple Choice and Very Short Answer (4pts). In the following section, either circle your answer (possible answers appear in **bold**) or write a very short (one word or one phrase) answer in the space provided.

2. (1pt) The least upper bound function for an abstract interpration must be **monotonic**: that is, it must preserve the ordering relationship between abstract values.

3. (2pt) The lattice of an abstract domain must be both a *join semi-lattice* (meaning it has a **unique top** element) and a *meet semi-lattice* (meaning it has a **unique bottom** element).

4. (1pt) In Chapter 5 of *EaC* (today's reading), the discussion of compiler IRs is organized around a taxonomy with three axes. Which of these is *not* one of those three?

A level of abstraction

B naming conventions

C structure

D memory model

II. Short answer (6pts). Answer the questions in this section in at most two sentences.

5. (2pt) How do you convert a *may* analysis to a *must* analysis? (Hint: this was discussed in the reading, but not in class.) **Turn the lattice upside down. (See section 2.16 of Ernst.)**

6. Consider an abstract interpretation for proving that an integer is prime.

   (a) (1pt) Draw a reasonable lattice for such an abstract interpretation. Be sure to define the meaning of each element of the lattice. **A powerset lattice over the set {prime, composite} is fine, as is any other reasonable lattice.**

   (b) (1pt) Define a transfer function for multiplication over integers for the lattice you drew above. **Answers vary based on the drawn lattice. However, multiplying two integers should never result in a prime number unless one of them is one.**

   (c) (1pt) Argue for one strength of your design for this abstract interpretation. **Answers vary, but simplicity is one good thing to mention. We will evaluate the strength of the argument.**

   (d) (1pt) Point out one weakness of your design. (Hint: the easiest way to do this is to show an example of a program on which your design is imprecise.) **Answers vary, but I expect most students to write a short code snippet that their design can't prove.**

III. Extra Credit. Questions in this section do not count towards the denominator of the exam score.

7. (1pt) Who wrote the most important classic paper on abstract interpretation? **Cousot and Cousot, but full credit for just "Cousot".**