Exam Performance Feedback Form

COMP11120, Semester 1

2016/2017

First some general remarks. 227 students sat the exam. The median mark was 32 out of 60 (or 53.6%), and the average also 32 (53%). This was a better performance than last year, and we felt overall that students knew the material better but made a number of sometimes silly mistakes that prevented a higher set of marks. See below regarding the mistakes that were typically made.

Sixty-one students had a failing mark, that is, a mark of less than 24 out of 60, or a mark of less than 40%. Of these, twenty-nine students had a mark below 18 (which is below 30%), with a lowest mark of 9. At the top end, forty-four students achieved first class marks with a top mark of 57, which is 95%.

Statistical analysis of individual questions:

Question 1. The average for Question 1 was 47%. Eighty students had a failing and thirty-eight students a first class mark. Two students achieved full marks.

Question 2. This had an average mark of 56%, with sixty-nine students on a failing, and ninety-five student on a first class mark, of which thirteen had full marks.

Question 3. Overall average: 53.1%. Seven students got 18-20/20 (1 person got 20/20). Fifty students had a failing and fifty-five students a first class mark for this question.

Question 1. Overall the answers to this question were rather mixed.

a) This is quite a short proof, but not many students received all three marks. Some students were confused about the 'divides' relation and had it the wrong way round—these students could not do anything productive (and indeed the statement is false if one reads the relation in their way). Many students introduced variables without properly declaring them, losing a mark. (If is not okay to say that if i divides j then $j = ia$, $a \in \mathbb{Z}$—you need to state that there exists $a \in Z$ with that property.) Some students wrote fractions such as j/i, which are not defined in $\mathbb{Z}$, presumably they meant that if one performs this action in $\mathbb{Q}$ one gets an integer back, but they did not say so and could not use this properly. other students used the $\div$ operation in an incorrect way.

b) The given function is neither injective nor surjective. Quite a few students did not have any sensible arguments here. Those who did comply with the standard shape of such an argument and got the wrong answer at some point performed a division by 0. For example, if we know that $b = b'$ and $ab = a'b'$ then this does *not* imply $a = a'$ since the second equality is always valid when $b = b' - 0$. Similarly, when trying to find a complex number that is mapped to a given element of the source set, there was an explicit division that did not check what happens if the number one wants to divide by is 0.

c) Most students could answer part (i) correctly. The operation is commutative, and for three marks a proof had to be included (stating that union and intersection are commutative was fine since that is in the notes or exercises)¿ Part (ii) caused a few more problems. There is a unit, and it is the empty set (not the 'void set'). For full marks this had to e stated with a proof, and both equalities had to be shown or commutativity had to be invoked explicitly for all three marks. Curiously some students thought that commutativity amounts to

$$(S \cup T) \setminus (S \cap T) = (S \cap T) \setminus (S \cup T).$$

This does not hold, but then it has nothing to do with commutativity of the given operation.

d) One mark was available for stating that f eventually dominates g, which almost all students could work out. (No marks for stating that eventually one will dominate the other without saying which way round.) For giving any correct number from which onwards f dominates g another mark was awarded. The remaining two marks were for a proper proof that from the given number onwards, f really does dominate g, and very few students could do that.

e) I was looking for the statement that such a function has to be bijective (or injective and surjective). Either of the two got the two marks, and many students managed this. Students who only stated one of the two properties, or who also included an incorrect statement, received at most one of the two marks.

Question 2. Overall this was quite well answered. Clearly whether or not one could perform Bayesian updating made a huge difference to the final mark. Some students seemed to be completely unaware of the definition of an expected value of a random variable. Stating that a given outcome was the one that occurs with the highest probability of all the possible outcomes was not asked, and did not get any marks.

Where the answer is a number, some students had the correct fraction and then wrote that that is *equal* to some decimal number, where this was not the case (eg $10/3 = 3.3$). Students who did this had an incorrect final answer and lost a mark.

a) I asked specifically for a probability space, and many students only gave some of the required data, losing a mark.

b) Everybody answered this correctly.

c) Almost everybody got this right—the answer is $3/16$. Some students were confused about the proper probabilities to use here.

d) The simple way of answering this is to calculated the expected value of X, which is $7/2$, and to argue that we need twice that value since $E(X+Y) = EX + EY$ for random variables X and Y. It is also possible to construct a new random variable which consists of adding up the two numbers thrown and arrive at the correct answer.

e) Noting that throwing the two four-sided dice gives us two independent random variables makes it easy to argue that the required expected value is the square of $7/2$, but again it is possible to calculate this from scratch. Students who did not mention independence when applying the first method lost a mark.

f) This caused the most problems of the expected value parts. Outcomes are restricted to 0, 2 and 8 by the given condition. There are two ways of calculating the desired expected value, either via giving the new probability distribution, which means that every of the remaining outcomes occurs with probability $1/3$, or to use the formula from the notes. The answer is $10/3$.

g) Bayesian updating is explained in the notes. Some students had their own procedure which sort of worked for the first update, where the original distribution makes all outcomes equally likely, but not for subsequent updates. Clearly that did not get them a lot of marks since they did not perform the proper procedure. After the second update the outcomes 0 and 2 each have probability 1/6, and the other two 1/3.

Question 3. Overall the quality of the answers was better for the material that was already examined in the mid-term test; the marks for the natural deduction and first-order logic sections were generally lower. Attendance in the relevant examples classes was lower, which were in the same week as the mid-term test. In addition one can note that these were the last questions of the exam paper, so perhaps some students did not have enough time to give these questions proper attention.

a) Average mark: 88%. 173 students got full marks.

   This part posed no problems. Most got 2/2 and a few 1/2, nobody got less. Mistakes for which marks were lost were: not knowing the truth values for $\leftrightarrow$, and mistakes in computing truth columns of complex subformulas or the whole formula.

b) Average mark: 59%. 35 students got full marks.

   This was a bookwork question where two concepts needed to be explained. Quality to answers varied from perfect and very good to weak.

   Answers needed to be to the point. For example, for iii), not explaining what 'equivalent replacement' is but instead saying why it is useful did *not* get any marks.

   Common mistakes for which marks were lost:

   – Answers being too vague and informal, not using our terminology and notation from class and Renate's notes.
   – The question asked for an explanation, so just giving and example in the case of i) of a propositional formula, for example, is not enough and did not receive any marks.
   – In ii) several student confused the concept of a Boolean valuation with Boolean interpretation of a formula, or the process to compute the truth value for a formula; both are incorrect.
   – Question iv) required to explain what a ND proof is. This is *not* the process of finding one or the system of rules.

   Less common:

   – In iii) a small minority of students confused equivalent replacement with substitution for a variable.
   – Some students did not read the question properly and answered all four parts. I looked at all answers but that did not help in any of the cases, so answering all four subparts was not a good strategy, if this was done intentionally.

c) Average mark: 66%. 55 students got full marks.

   Overall this question was answered well. Common mistakes for which marks were lost:

   For i)

- Not knowing how to apply Step 4 correctly (generalised distributivity) or making mistakes in applying distributivity laws (because it leads to a long calculation).
- Mistakes in applying laws: e.g., when applying De Morgan laws forgetting that both operands need to be negated and the operator changes from disjunction to conjunction; not knowing how to eliminate $\rightarrow$.
- Not flattening; it's not essential but removes brackets and makes it easier to see what is going on and work out how to proceed next, and how to apply the Step 4 transformation.
- Less common: not knowing how to eliminate $\rightarrow$, not knowing the laws at all, computing a DNF.

For ii)

- Mistakes in the use of laws which should have been simple: $\top \vee R$ is *not* equivalent to R, $\neg Q \vee R \vee \neg Q$ is *not* equivalent to R.
- Not realising that the absorption laws are applicable for the simplification; a bit of rearranging in the formula was needed using commutativity and associativity laws to see this.

For iii)

Not saying why the formula is not a tautology; after all, the question already made it explicit that the formula is not a tautology. An explicit reason needed to be stated, e.g., an example of a Boolean valuation which makes the formula false, or a truth-table that shows this could have been given. Note that our CNF algorithm does *not* guarantee that $\top$ can be derived when the formula is a tautology. It is therefore not possible to conclude that the formula is not a tautology because $\top$ was not obtained.

Some used the truth table method to compute the CNF, which is fine; marks were deducted for mistakes.

A minority of students were sloppy with bracketing, which led to deduction of marks, and wrong turns in the calculations.

d) Average mark: 40%. 50 students got full marks.

This question was a variation of a question from the assessed exercises. It required a natural deduction proof to be given. *No* marks could be given for truth tables or steps using the fundamental equivalences.

The quality of the answers varied quite a bit. Most students who knew what judgement to prove in order to show a formula is a tautology, could also construct a natural proof. Many did not know what to prove and struggled constructing legal steps even though the rules where included at the end of the exam paper.

Common mistakes for which marks were lost:

- Not knowing how to use natural deduction to show a formula is a tautology.
- Not applying the rules properly despite the fact that they were provided. Some used their own rules (not good).
- Wrong use of the weakening rule; note the weakening rule requires a premise.
- For multiple premise rules such as negation elimination or implication elimination, not making sure that the sequence of assumptions on the LHSs of the premises agree.

- Not properly justifying every step in the proof. E.g., for multiple premise rules, all premises need to specified.
- In our ND system, it is *not* legal to use logical equivalences.

e) Average mark: 24%. 6 students got full marks

Parts i) and ii) were easiest and most should have been able to do these. However, a large number of answers weren't even well-formed formulas, which shows a confusion about the language of first-order logic, in particular, how symbols may be used to construct FOL formulas. Note that:

- Predicate symbols cannot appear in argument positions. Predicate symbols are used to encode properties and relations: being a sports car, one person knowing another. They are used to encode information which is either true or false.
- Constants cannot be quantified; they represent concrete objects or individuals in the domain of interpretation. Only variables, which represent unnamed objects/individuals, can be quantified.

Part iii) was hard and I didn't expect a lot of correct answers. Nevertheless there were a few correct answers, which was very pleasing to see!