- Assignments must be completed ***individually***, and you must submit a *single* solution in a PDF file named `a2.pdf`, submitted to MarkUs. Handwritten submissions are acceptable as long as they are written ***neatly*** and ***legibly*** (typed submissions are preferable but not required).
- Please refer to the course information sheet for the ***late submission policy***.
- For each question, please write up detailed answers carefully. Make sure that you use ***notation*** and ***terminology*** correctly, and that you explain and ***justify*** what you are doing. Marks will be deducted for incorrect or ambiguous use of notation and terminology, and for making incorrect, unjustified, ambiguous, or vague claims in your solutions.
- Please read and understand the policy on Academic Integrity given on the course information sheet. Then, to protect yourself, list on the front of your submission ***every*** source of information you used to complete this assignment (other than the lecture and tutorial material). For example, indicate clearly the ***name*** of every student with whom you had discussions, the ***title and sections*** of every textbook you consulted (including the course textbook), the ***source*** of every web document you used, etc.

1. (Chapter 11, Exercise 1 of the textbook) Consider the following assertions:

- *Canadians are typically not francophones.*
- *All Québecois are Canadians.*
- *Québecois are typically francophones.*
- *Robert is a Québecois.*

Here is a case where it seems plausible to conclude by default that Robert is a francophone.

(a) Represent these assertions in first-order logic using two abnormality predicates, one for Canadians and one for Québecois, and argue that, as it stands, minimizing abnormality would not be sufficient to conclude that Robert is a francophone.

(b) Show that minimizing abnormality will work if we add the assertion

All Québecois are abnormal Canadians,

but will not work if we only add

Québecois are typically abnormal Canadians.

(c) Repeat the exercise in default logic: Represent the assertions as two facts and two normal default rules, and argue that the result has two extensions. Eliminate the ambiguity using a non-normal default rule. You may use a variable-free version of the problem where the letters q, c, and f stand for the propositions that Robert is a Québecois, Canadian, and francophone, respectively, and where defaults are considered only with respect to Robert.

(d) Write a variable-free version of the four assertions in autoepistemic logic, and show that the procedure described in the lecture generates two stable expansions.

2. (Chapter 11, Exercise 4 of the textbook) This question concerns the interaction between defaults and knowledge that is disjunctive. Starting with autoepistemic logic, there are different ways one might represent a default like "Birds fly." The first way is what we might call a *strong default*:

$$\forall x(Bird(x) \wedge \neg\mathbf{B}\neg Flies(x) \supset Flies(x))$$

Another way is what we might call a *weak default*:

$$\forall x(\mathbf{B}Bird(x) \wedge \neg\mathbf{B}\neg Flies(x) \supset Flies(x))$$

In this question, we will work with the following KB:

$$Bird(a), Bird(b), (Bird(c) \vee Bird(d)), \neg Flies(b)$$

where we assume that a, b, c, d are constants denoting *distinct* individuals.

(a) Propositionalize and show that the strong and weak defaults lead to different conclusions about flying ability.

(b) Consider the following version of the default:

$$\forall x(\mathbf{B}Bird(x) \wedge \neg\mathbf{B}\neg Flies(x) \supset \mathbf{B}Flies(x)).$$

Show that this version does not lead to reasonable conclusions.

(c) Now consider using default logic and circumscription to represent the default. Show that one of them behaves more like the strong default, while the other is more like the weak one.

3. Recall that the GCWA presented in the lecture is an attempt to restrict CWA so as to preserve consistency in the presence of disjunctions.

Consider a slightly different version of GCWA, which we call *weak GCWA*, with the following definition:

$$\begin{aligned} WeakGCWA(\Phi) = \Phi \cup \{\neg\alpha \mid\ & \alpha \text{ is an atomic ground formula in the vocabulary of } \Phi \text{ s.t. } \Phi \not\models \alpha \\ & \text{and for all collections of } \textbf{literals } \beta_1, ..., \beta_n, \text{ if } \Phi \models (\alpha \vee \beta_1 \vee ... \vee \beta_n), \\ & \text{then } \Phi \models (\beta_1 \vee ... \vee \beta_n)\} \end{aligned}$$

Compare GCWA and weak GCWA by answering the following questions:

- Does weak GCWA preserve consistency? Explain why.
- Are there any subset relationships between GCWA and weak GCWA? That is, can we say that for any arbitrary set of sentences Φ, either of $WeakGCWA(\Phi) \subseteq GCWA(\Phi)$ or $GCWA(\Phi) \subseteq WeakGCWA(\Phi)$ holds? Explain why.