# CPSC 322 2018W2 Assignment 4

Make sure you follow all assignment instructions on the course website and in the assignment description on Canvas. Failure to do so may result in heavy penalties.

Make sure that in your answers you clearly indicate the exact section you are answering.

**Please start each question on a new page (eg. don't put your answer to Q3 on the same page as your answer to Q2).**

## Question 1 [20 points] Probabilities

| A | B | C | p |
|---|---|---|---|
| T | T | T | 0.1 |
| T | T | F | 0.1 |
| T | F | T | 0.4 |
| T | F | F | 0.3 |
| F | T | T | 0.1 |
| F | T | F | 0.2 |
| F | F | T | 0.1 |
| F | F | F | 0.1 |

Consider the above joint probability distribution over the three random variables A, B, C.

**(a) [5 points]** You are told that it contains **only one** incorrect value. What is that value? Do you have sufficient information to fix it? If that is the case, how would you fix it? If not, why not?

**(b) [8 points]** With the joint resulting from the previous question (after you fixed the error), compute the marginal probability distributions for P(A) and P(B). Are A and B independent? Also, what is the value of P(A=T | B=F)?

**(c) [7 points]** ***Without performing any calculations***, is it true that P(A) * P(B | A) * P(C | A, B) = P(C) * P(B | C) * P(A | B, C)? Why or why not?

## Question 2 [20 points] Bayes' rule

You've taken your prized sports car into a repair shop for a routine maintenance check. As part of a standard set of diagnostics, the car's onboard computer is checked for logged problems. The mechanic tells you that they have good and bad news. The bad news is that the car's computer has reported that it has detected a failure in the electrical system that will definitely cause an electrical fire in the near future (thus you may treat the failure and the resulting fire as the same "thing"). The probability of the computer reporting this warning given that there is actually a failure in the electrical system is 0.95, as is the probability that the computer will correctly not report anything if the failure isn't present. The good news is that this type of failure and the consequent electric fire will only occur in one out of every ten thousand cars of this model on the road.

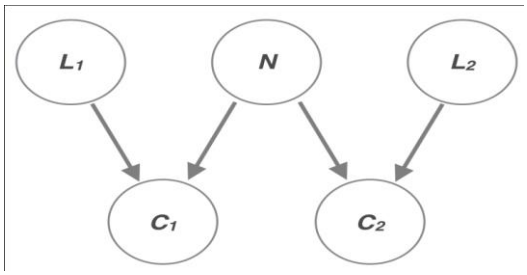
(a) **[12 points]** What are the chances that an electrical fire will occur in your car if don't opt to repair it? (Show your calculations as well as giving the final result.)

(b) **[4 points]** Repeat the calculation of part (a), but for the case where the failure occurs in one out of every hundred cars of this model.

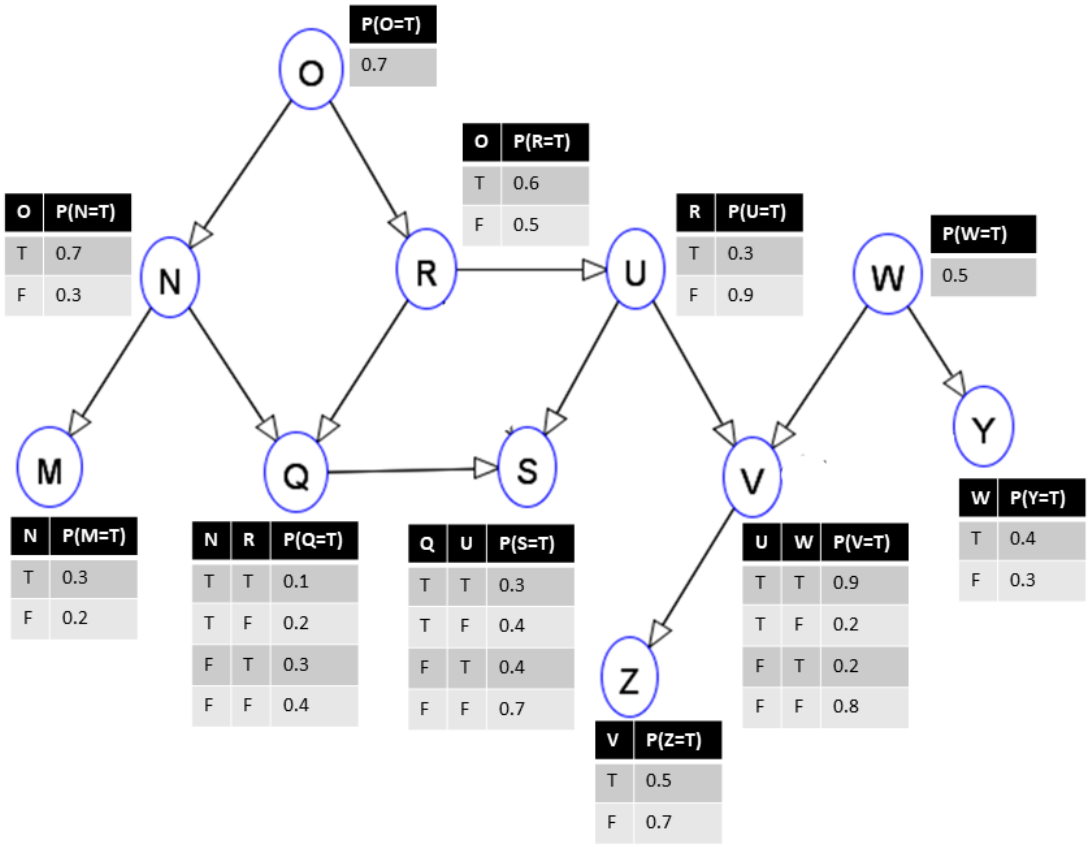
(c) **[4 points]** Given the logged report of a problem, why is it good news that the issue is so rare in part (a)?

## Question 3 [15 points] Bayesian/Belief networks

Consider a probabilistic problem that can be represented by the simple Bayesian Network given below. Let $L_1$ and $L_2$ be Boolean variables, and let $C_1$, $C_2$, and $N$ have 51 possible values each. Compute the **representational saving** (i.e. how many fewer values you need to store) between this belief network and the joint distribution for this problem. Show your work.



## Question 4 [40 points] Variable Elimination




Carry out variable elimination (VE) on this network to compute P(S|Q=F).

1. [10 marks] indicate which nodes can be pruned (justifying each pruning step), and list the factors (with their values) that VE needs to initially create.
2. [5 marks] Assuming that the elimination ordering is alphabetical, show how the factors and the summations should be ordered.
3. [15 marks] step through VE, showing what operations are performed, the resulting intermediate factors (with their values) and how P(S|Q=F) is finally computed (**hint:** see the example we traced in class and the factor operations we covered in the slides).