Assignment 1: Probability & structural causal models

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Instructions

All the problems in this assignment should be solved and handed in **individually**. You should be prepared to answer questions about your solutions yourself. The full set of solutions should be submitted as a single PDF document in Canvas. If you don't have Canvas access, submit your solution as a pdf in an email to the examiner. Feel free to use any software of your choosing for preparing illustrations and drawings.

Problem 1 [Probability]:

You are suspecting that the grades awarded to assignments in Calculus 101 depend on how long before the deadline they were handed in. To test this hypothesis, you collect m samples $(x_1, y_1), \ldots, (x_m, y_m)$of times X (in minutes before deadline) and grades Y (0-100). You fit a linear regression model of y onto x and find that the slope is 0.

Q 1: Can you conclude that X and Y are independent? Why/why not? What assumptions have you made? Are there additional assumptions that could change your conclusion? Which?

Problem 2 [Probabilistic graphical models]:

Q 2: Draw *the set of* DAGs with d-connections corresponding *exactly* to (only) the independencies:

a) $A \perp C \mid B$, for variables A, B, C

b) $A \perp C,\ A \perp D \mid B,\ C \perp D \mid B$, for variables A, B, C, D

c) $C \perp B,\ \ A \perp D,\ \ C \perp D \mid A$, for variables A, B, C, D

Problem 3 [Structural causal models]:

Q 3: Consider the following set of structural equations with noise variables $U_{(\cdot)}$, all distributed according to a standard Normal distribution $N(0, 1)$

$$A = 3U_A$$

$$B = 3C + U_B$$

$$C = U_C$$

$$D = 5B + A + U_D$$

a) Draw the corresponding DAG

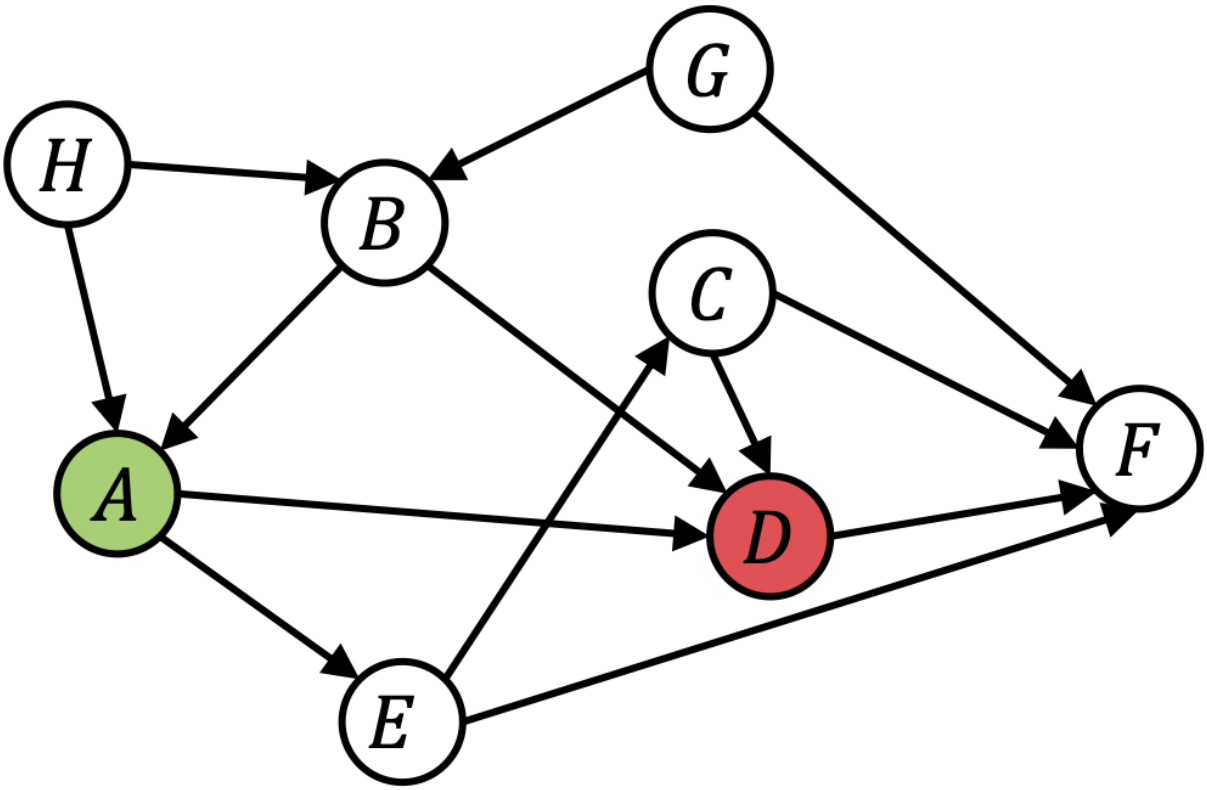
b) Draw the mutilated graphs following the interventions

- $do\,(B = b)$
- $do\left(B = C^2 + U_B\right)$

c) Compute $\mathbb{E}[D \mid do(C = 2)]$

Problem 4 [Backdoor criterion]:

Q 4: Consider the DAG below. Give *two* valid adjustment sets for identifying the effect of intervening on A on D, that is, $p(D|do(A = a))$. *Hint: Use the backdoor criterion.* Are there smaller adjustment sets?



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