1. The university is conducting an analysis of changes in its attractiveness to students over the years. They will be using the following variables. Each variable’s possible values are given in parentheses.

- **EB**: Federal and state education budget (low/high)
- **RF**: Research funding situation (good/bad)
- **AD**: Alumni donations (low/high)
- **RP**: Research performance (good/bad)
- **UB**: University budget (low/median/high)
- **SP**: Performance of basketball/football teams (poor/median/good)
- **TP**: Quality of teaching (low/median/high)
- **AT**: Attractiveness (low/high)

Education budget (EB), alumni donations (AD) and research funding (RF) are marginally independent. Research funding (RF) is exclusive for research topics (RP). The university budget (UB) depends heavily on the education budget (EB) and donations (AD), lack of sufficient grants or donations will lead to a deficit with high probability (UB = low). University budget is used to support research projects (RP), teaching (TP) and sports teams (SP). This means that a difficult fiscal situation is likely to jeopardize the university’s performance in all areas. Performance in these areas will eventually affect the university’s attractiveness to new students.

The distribution of a variable is fully decided given those factors specified above.

(a) Build a Bayesian network to represent the conditional probabilities.

(b) How many *parameters* are needed to represent the conditional probabilities in (a)?
2. Consider the following Bayesian network of Boolean variables and joint probabilities:

Compute the conditional probabilities (a)–(k). Show your work, round your answers to three digits after the decimal point if necessary.

To calculate the conditional probabilities, you first need to calculate some marginals from the joint probabilities, and then apply the equation:

\[
P(B|A) = \frac{P(A, B)}{P(A)} = \frac{P(A, B)}{P(A, B) + P(A, \neg B)}
\]
3. Consider the following Bayesian network of Boolean variables:

Use variable elimination to compute the following probabilities and show your work. Round your answers to three digits after the decimal point if necessary.

(a) $P(C, D)$ (elimination order: B, A, E)
(b) $P(\neg E, B)$ (elimination order: A, C, D)
(c) $P(E)$ (elimination order: B, A, C, D)
4. Given the Bayesian network in question 3, compute the most probable explanation (MPE) for variables in following situations: (4hr students)

(The problem of Most Probable Explanation is to find an assignment to all variables that has the maximum likelihood given some evidence, so it will be helpful to calculate their likelihoods first.)

(a) \( \neg B \) and \( E \) observed
(b) without any observation