# ASEN 5264 Decision Making under Uncertainty
# Homework 1: Probabilistic Models

January 13, 2026

A submission should consist of two or three files:

- A single PDF file containing answers to questions (typed, handwritten, or exported notebook).
- JSON file output from `DMUStudent.HW1.evaluate`.
- A code listing *if the code is not included in the PDF*.

## 1 Questions

**Question 1.** (15 pts) Consider the following joint distribution of three binary-valued random variables, $A$, $B$, and $C$:

| $A$ | $B$ | $C$ | $P(A, B, C)$ |
|---|---|---|---|
| 0 | 0 | 1 | 0.15 |
| 0 | 1 | 0 | 0.05 |
| 0 | 1 | 1 | 0.01 |
| 1 | 0 | 0 | 0.14 |
| 1 | 0 | 1 | 0.18 |
| 1 | 1 | 0 | 0.27 |
| 1 | 1 | 1 | 0.06 |

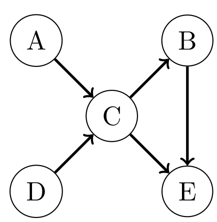
a) What is the probability of the outcome $A = 0$, $B = 0$, $C = 0$?

b) What is the marginal distribution of $A$?

c) What is the conditional distribution of $A$ given $B = 0$ and $C = 1$?

**Question 2.** (20 pts) 2% of women at age forty who participate in routine screening have breast cancer. 91% of those with breast cancer will get positive mammograms. 8% of those without breast cancer will also get positive mammograms. A woman in this age group had a positive mammogram in a routine screening. What is the probability that she actually has breast cancer?

**Question 3.** (40 pts) Consider the following Bayesian network structure where all variables are binary:




a) Is it possible to conclude from the structure that $A \perp E \mid C$? Justify your answer.
b) Is it possible to conclude from the structure that $A \perp D \mid C$? Justify your answer.
c) Suppose that $P(E = 0 \mid A = 0, C = 1, B = 1) = 0.3$. What is $P(E = 1 \mid A = 1, C = 1, B = 1)$? Justify your answer.
d) Assume that $P(B = 1 \mid C = 0) = 0.6$, $P(E = 0 \mid B = 1, C = 0) = 0.1)$ and $P(E = 0 \mid B = 0, C = 0) = 0.8$. If we observe that $C = 0$ and $E = 0$, what is the probability that $B = 1$? Justify your answer.

(assignment continues on next page)

## 2 Auto-graded Programming

**Question 4.** (20 pts autograder + 5 pts code) In this exercise, you will write and test a Julia function to ensure that you can get Julia and the course-specific code running and help you learn how to do a task that sometimes trips students up in homework 2. Your function should take two arguments:

- `a`: a matrix, and
- `bs`: a non-empty vector of vectors.

The function should multiply all of the vectors in `bs` by `a` and then return a vector where the $i$th element is the maximum of the $i$th elements of all of the resulting vectors, that is, the *elementwise* maximum of the resulting vectors.

Example: if

$$\texttt{a} = \begin{bmatrix} 2 & 0 \\ 0 & 1 \end{bmatrix} \text{ and } \texttt{bs} \text{ has the vectors } \begin{bmatrix} 1 \\ 2 \end{bmatrix} \text{ and } \begin{bmatrix} 2 \\ 1 \end{bmatrix}, \tag{1}$$

then, after multiplication, the resulting vectors are

$$\begin{bmatrix} 2 \\ 2 \end{bmatrix} \text{ and } \begin{bmatrix} 4 \\ 1 \end{bmatrix}, \text{ and the elementwise maximum that should be returned is } \begin{bmatrix} 4 \\ 2 \end{bmatrix}. \tag{2}$$

In order to get full-credit, the function must be completely "type-stable" (see the "Performance Tips" section of the Julia manual). Your function should always return a vector with the same element type as `a`. You can assume the vectors in `bs` will have the same element type as `a`, but you should be able to handle `a` with any numeric element type.

Evaluate this function with `DMUStudent.HW1.evaluate` and submit the resulting json file *along with a listing of the code*. A score of 1 will receive full credit.