

ASEN 5264 Decision Making under Uncertainty

Homework 1: Probabilistic Models

January 15, 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

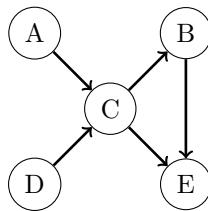
Question 1. (15 pts) Consider the following joint distribution of three binary-valued random variables, A , B , and C :

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

$$\mathbf{a} = \begin{bmatrix} 2 & 0 \\ 0 & 1 \end{bmatrix} \text{ and } \mathbf{bs} \text{ has the vectors } \begin{bmatrix} 1 \\ 2 \end{bmatrix} \text{ and } \begin{bmatrix} 2 \\ 1 \end{bmatrix}, \quad (1)$$

then, after multiplication, the resulting vectors are

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

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.