Status	Finished
Started	Tuesday, 20 January 2026, 9:22 AM
Completed	Tuesday, 20 January 2026, 10:44 AM
Duration	1 hour 22 mins
Marks	36.00/38.00
Grade	**9.47** out of 10.00 (**94.74**%)

Information

1. Distributions and BNs

Consider the following slightly extended model of the climate in Death Valley. Assume all variables are Boolean (two-valued):
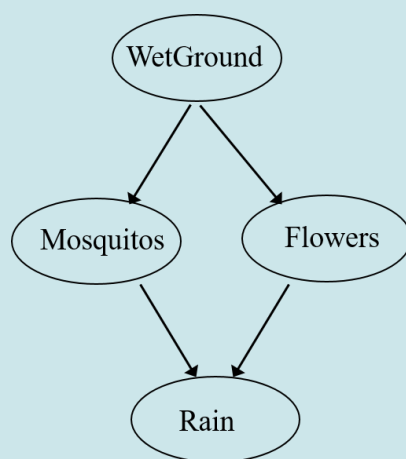
Information

a. Which of the following statements are true, which ones are false, given the structure of this model? (We abbreviate variable names by their initial letter)

Question 1

Correct

Mark 1.00 out of 1.00

M and F are independent.

○ True

◉ False ⊘

The correct answer is 'False'.

Question 2

Incorrect

Mark 0.00 out of 1.00

The full joint distribution contains only 9 non-redundant parameters.

○ True

● False ⊗

Question 3

Correct

Mark 1.00 out of 1.00

If both M and F are false, then W=true can change my degree of belief about R.

○ True

● False ⊘

Question 4

Correct

Mark 1.00 out of 1.00

If we reversed the direction of the arrow F⟶R, the number of parameters in the model remains the same.

● True ⊘

○ False

Question 5

Correct

Mark 1.00 out of 1.00

$$P(W, M, F, R) = P(W, M, F)P(R|M, F)$$

● True ⊘

○ False

Question 6

Correct

Mark 1.00 out of 1.00

It is possible to parametrise this model such that M and F are perfectly correlated (whenever M is true, F is true, and vice versa).

○ True ✓

○ False

The correct answer is 'True'.

Question 7

Correct

Mark 1.00 out of 1.00

Learning about the value of R cannot change my degree of belief regarding W.

○ True

● False ✓

The correct answer is 'False'.

Information

b. Now assume we remove all edges from this graph, leaving four unconnected variables.

Which of the following statements are true, which ones are false, given the structure of this model?

Question 8

Correct

Mark 1.00 out of 1.00

A model with this structure cannot encode a correlation between M and F (except if both of them are always true/false)

● True ✓

○ False

The correct answer is 'True'.

Question 9

Correct

Mark 1.00 out of 1.00

In this model, for any probabilistic query, $P(\mathbf{X} \mid \mathbf{e}) = P(\mathbf{X})$.

(Ignore pathological cases where $\mathbf{e} = \mathbf{x}$.)

○ True ⊘

○ False

The correct answer is 'True'.

Question 10

Correct

Mark 1.00 out of 1.00

In this model, it does not matter which parameters we choose for the probability tables, because the variables cannot influence each other.
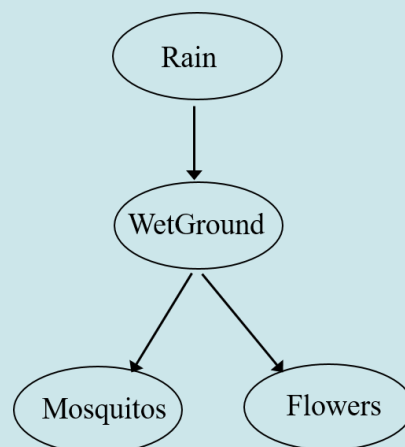
○ True

○ False ⊘

The correct answer is 'False'.

Information

2. Inference in BNs

Consider the following model of Death Valley (again, assume Boolean variables):

a. Exact Inference

Which of the following statements are true, which ones are false for a model with this structure?

Question 11

Correct

Mark 1.00 out of 1.00

In answering the query $P(W|F)$, we need to sum over R before we sum over M.

○ True

◉ False ✓

The correct answer is 'False'.

Question 12

Correct

Mark 1.00 out of 1.00

Any query that involves M and/or F as evidence requires evidential reasoning. (Ignore pathological cases like $P(M \mid M)$.)

◉ True ✓

○ False

The correct answer is 'True'.

Question 13

Incorrect

Mark 0.00 out of 1.00

To answer the query $P(F \mid \neg w)$, we need not consider R.

○ True

◉ False ✗

The correct answer is 'True'.

Question 14

Correct

Mark 1.00 out of 1.00

$P(f \mid w, r)$ can never be larger than $P(f \mid w)$.

- ◉ True ✓
- ○ False

The correct answer is 'True'.

Information

b. Approximate Inference

Consider the following probability tables for variables Rain and WetGround:

P(R)	t	f
	0	1

$P(W \mid R)$	t	f
t	1	0
f	.1	.9

Which of the following statements are true, which ones are false for this model?

Question 15

Correct

Mark 1.00 out of 1.00

The Forward Sampling algorithm cannot produce a single sample with Rain=true.

- ◉ True ✓
- ○ False

The correct answer is 'True'.

Question 16

Correct

Mark 1.00 out of 1.00

In Gibbs Sampling, resampling R can always be done independently of the values of M and F.

- ○ True ✓
- ○ False

The correct answer is 'True'.

Question 17

Correct

Mark 1.00 out of 1.00

Rejection Sampling for the query $P(R \mid m, f)$ cannot return a probability $P(R = true \mid m, f) > 0$.

- ○ True ✓
- ○ False

The correct answer is 'True'.

Information

3. Parameter Learning

Consider a thumbtack learning scenario similar to the one in the lecture slides: we are trying to estimate $\theta = P(heads)$ from a dataset $\mathcal{D}$ of N example tosses. Let us assume that exactly $k = N/2$ of these examples have resulted in heads, the other half are tails (which means that N is even).

Which of the following statements are true, which are false in this situation:

Question 18

Correct

Mark 1.00 out of 1.00

Bayesian estimation with a uniform (i.e., constant) prior will lead to a posterior distribution function that is identical to the likelihood function.

- ○ True
- ○ False ✓

The correct answer is 'False'.

Question 19

Correct

Mark 1.00 out of 1.00

$L(0.5 : \mathcal{D}) = 1$

○ True

◉ False ✓

The correct answer is 'False'.

Question 20

Correct

Mark 1.00 out of 1.00

Laplace smoothing will not change the maximum likelihood estimate $\hat{\theta}$, regardless of the constant α used.

◉ True ✓

○ False

The correct answer is 'True'.

Question 21

Correct

Mark 1.00 out of 1.00

The likelihood function $L(\theta : \mathcal{D})$ for this dataset is zero (0.0) at $\theta = 0$ and $\theta = 1$.

◉ True ✓

○ False

The correct answer is 'True'.

Question 22

Correct

Mark 1.00 out of 1.00

The likelihood function is exactly symmetric.

◉ True ✓

○ False

The correct answer is 'True'.

For this specific situation ($k = N/2$), the posterior $P(\theta \mid \mathcal{D})$ will have its maximum at 0.5, regardless of the prior.
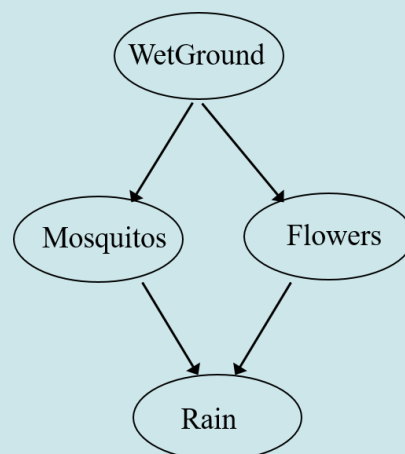
○ True

◉ False ⊘

The correct answer is 'False'.

Information

4. Structure Learning

Consider the task of learning a Death Valley climate model from a training set $\mathcal{D} = \{\mathbf{x}_1, \ldots, \mathbf{x}_N\}$ consisting of N atomic events, defined over four Boolean random variables Rain (R), WetGround (W), Mosquitos (M), Flowers (F).

Also assume that our learning algorithm is currently considering two competing model graph structures, which we will call G_1 (the top one) and G_2 (the bottom one), respectively:

G_1:

G_2:
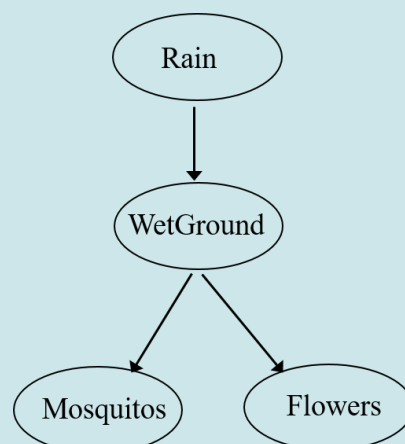
Which of the following statements are true, which are false in this situation:

Question 24

Correct

Mark 1.00 out of 1.00

If G_1 and G_2 have the same Maximum Likelihood score, the BIC score would favour model G_1.

○ True

◉ False ✓

The correct answer is 'False'.

Question 25

Correct

Mark 1.00 out of 1.00

If we doubled the training set $\mathcal{D}$ by duplicating all training examples, the Maximum Likelihood score for both models would increase

○ True

◉ False ✓

The correct answer is 'False'.

Question 26

Correct

Mark 1.00 out of 1.00

Any model structure G with five edges would have a higher $\mathrm{Dim}[G]$ in the BIC score than both G_1 and G_2.

◉ True ✓

○ False

The correct answer is 'True'.

Question 27

Correct

Mark 1.00 out of 1.00

G_1 cannot have a higher Maximum Likelihood score than G_2 because it is (partly) anti-causal.

○ True

◉ False ✓

The correct answer is 'False'.

5. Hidden Markov Models

Your neighbours in the little apartment above yours have a semi-smart probabilistic vacuum cleaner robot. Every now and then it turns itself on and runs for a (probabilistic) while. You cannot see the robot, but you infer its behaviour from various noises it makes (squeaking, rattling, none). During long hours of boredom while studying for exams, you have learned the robot's behaviour and have notated it for yourself as a HMM, as follows:

$$\mathcal{S} = \{on, \, off\} \quad \mathcal{O} = \{squeak, \, rattle, \, none\}$$

$$\mathbf{\Pi} = \begin{bmatrix} 0.5 \\ 0.5 \end{bmatrix} \quad \mathbf{A} = \begin{bmatrix} 0.8 & 0.2 \\ 0.5 & 0.5 \end{bmatrix} \quad \mathbf{B} = \begin{bmatrix} 0.5 & 0.0 \\ 0.4 & 0.0 \\ 0.1 & 1.0 \end{bmatrix}$$

Which of the following statements are true, which are false in this situation:

Question 28

Correct

Mark 1.00 out of 1.00

The probability that the robot is on for 1000 time steps is zero.

○ True

◉ False ⊘

The correct answer is 'False'.

Question 29

Correct

Mark 1.00 out of 1.00

If any entry in the $\mathbf{\Pi}$ vector is zero, then there is at least one state that is unreachable for the state transition Markov process.

○ True

◉ False ⊘

The correct answer is 'False'.

If any entry in the $\mathbf{A}$ matrix is zero, then there is at at least one state that is unreachable for the state transition Markov process.

○ True

◉ False ✓

The correct answer is 'False'.

If $o^{(1)} = none$, the robot cannot be on at $t = 1$.

○ True

◉ False ✓

The correct answer is 'False'.

When $o^{(t)}$ is *none*, $P(S^{(t)} \mid o^{(1:t)})$ is $[1, 0]$ regardless of what $o^{(1:t-1)}$ were.

○ True

◉ False ✓

The correct answer is 'False'.

If we added another state *charging*, the $\mathbf{B}$ matrix would become a 3×3 matrix.

◉ True ✓

○ False

The correct answer is 'True'.

6. Kalman Filters

Consider the simple "Consumer Confidence Index" model from the lecture slides, with (real-valued) random variables X (consumer confidence) and Z (survey outcome):
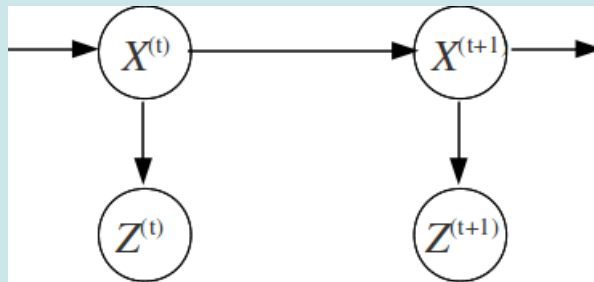
Which of the following statements are correct?

Question 34

Correct

Mark 1.00 out of 1.00

With this type of model, we cannot model a survey technique whose precision changes with the actual level of the consumer confidence

- ⦿ True ⊘
- ○ False

The correct answer is 'True'.

Question 35

Correct

Mark 1.00 out of 1.00

With this model, we cannot model the fact that consumer confidence tends to worsen more quickly than it improves

- ⦿ True ⊘
- ○ False

The correct answer is 'True'.

The coefficient matrix $\mathbf{A}$ can be used to encode certain assumptions about the expected precision of the survey

○ True

◉ False ✓

The correct answer is 'False'.

If the consumer confidence improves over a long time, the $\mathbf{A}$ matrix will change

○ True

◉ False ✓

The correct answer is 'False'.

To adapt this model to a population with a more volatile mood (stronger tendencies to change confidence, but still symmetric), the following parameter of the model has to be adapted:

Select one:

○ a. $\mathbf{A}$

○ b. $\mathbf{B}$

◉ c. $\mathbf{\Sigma}_x$ ✓

○ d. $\mathbf{\Sigma}_z$

The correct answer is: $\mathbf{\Sigma}_x$