

# CS-171, Intro to A.I. — Quiz #4 — Fall Quarter, 2017 — 20 minutes

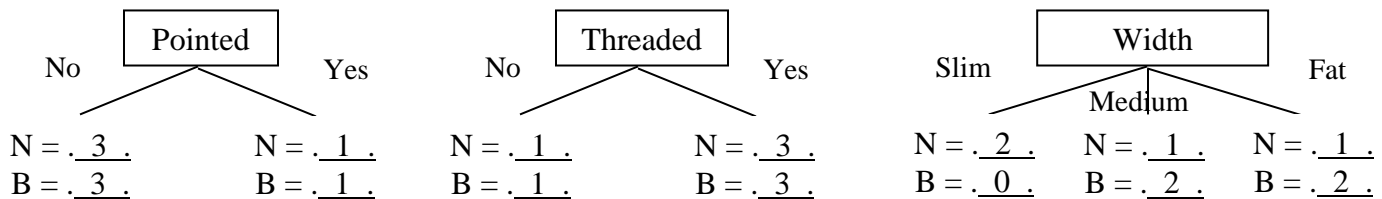
YOUR NAME AND EMAIL ADDRESS: \_\_\_\_\_

YOUR ID: \_\_\_\_\_ ID TO RIGHT: \_\_\_\_\_ ROW #: \_\_\_\_\_ SEAT #: \_\_\_\_\_

**1. (60 pts total) Learning Decision Trees.** You are a robot in the fasteners section of a hardware store and must learn to discriminate Nails from Bolts. You choose to learn a Decision Tree classifier from various nails and bolts that you have observed. Unfortunately, your sensors are noisy, and so your training data has a few errors. This table summarizes the noisy, error-prone data you have accumulated for training:

Example	Pointed	Threaded	Width	Class
Example #1	No	Yes	Slim	Nail
Example #2	No	Yes	Slim	Nail
Example #3	No	No	Medium	Nail
Example #4	Yes	Yes	Fat	Nail
Example #5	Yes	Yes	Medium	Bolt
Example #6	No	Yes	Fat	Bolt
Example #7	No	Yes	Medium	Bolt
Example #8	No	No	Fat	Bolt

**1.a. (10 pts total, 5 pts each) Root Variable Selection.** For each possible choice of the root variable, indicate how it would partition the examples. Write your answer as the number of Nails (N= \_\_\_\_ ) and Bolts (B= \_\_\_\_ ) in each partition. **The first one is done for you as an example.**

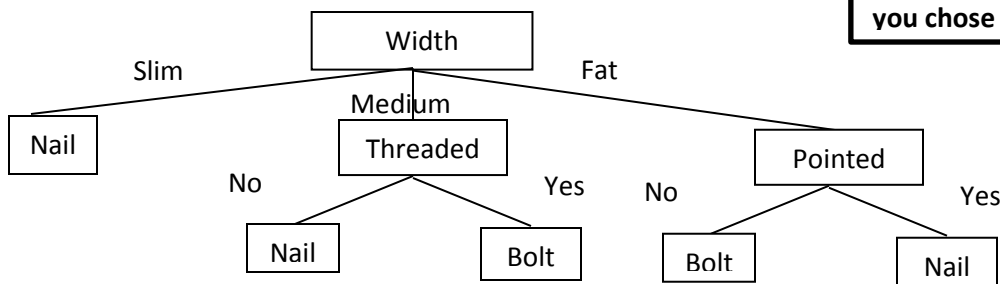


**1.b. (10 pts)** Which attribute would information gain choose as the root of the tree?

Width

**Full credit if your answer is right for the partitions you gave in 1.a, even if 1.a was wrong.**

**1.c. (20 pts)** Draw the decision tree that would be constructed by recursively applying information gain to select roots of sub-trees, as in the Decision-Tree-Learning algorithm.



**Full credit if your answer is right for the root you chose in 1.b, even if 1.b was wrong.**

**Classify these new examples as Nail or Bolt using your decision tree above.**

**1.d. (10 pts)** What class is [Pointed=No, Threaded=No, Width=Slim]? Nail

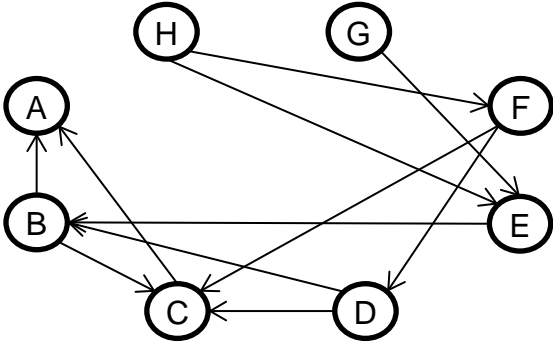
**1.e. (10 pts)** What class is [Pointed=No, Threaded=No, Width=Fat]? Bolt

\*\*\*\* TURN PAGE OVER AND CONTINUE ON THE OTHER SIDE \*

**Full credit if your answers are right for the tree you drew in 1.c, even if 1.c was wrong.**

**2. (40 points total, 10 pts each) Bayesian Networks.**

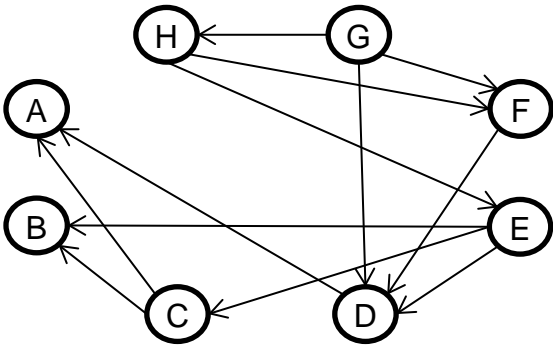
**2.a. (10 pts)** Write the factored conditional probability expression corresponding to this Bayesian Network:



$$P(A \mid B, C) P(B \mid D, E) P(C \mid B, D, F) P(D \mid F) P(E \mid G, H) P(F \mid H) P(G) P(H)$$

**2.b. (10 pts)** Draw the Bayesian Network corresponding to this factored conditional probability expression:

$$P(A \mid C, D) P(B \mid C, E) P(C \mid E) P(D \mid E, F, G) P(E \mid H) P(F \mid G, H) P(G) P(H \mid G)$$



**2.c. (20 pts total, 10 pts each)** Below is the Bayesian network for the WetGrass problem [Fig. 14.12(a), R&N].

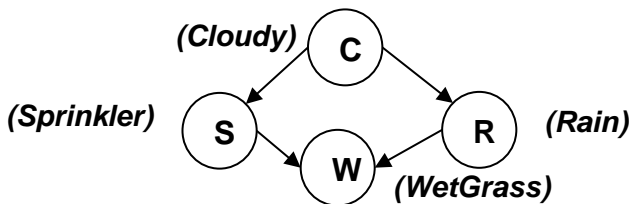
Write down a numerical expression that will evaluate to  $P(C=f \wedge R=f \wedge S=t \wedge W=t)$ .

**First line (1):** Convert the conjunction into a symbolic factored conditional probability formula according to the network.

**Second line (2):** Substitute numerical probabilities from the tables to yield numbers separated by multiplication symbols.

Remember that the tables show the probability that each variable is True, e.g.,  $P(C)$  means  $P(C=t)$ .

You do not need to do the multiplications to produce a number (the probability).



P(C)
.5

C	P(S)
t	.1
f	.5

C	P(R)
t	.8
f	.2

S	R	P(W)
t	t	.99
t	f	.90
f	t	.90
f	f	.00

$$P(C=f \wedge R=f \wedge S=t \wedge W=t)$$

(1)  $= P(W=t \mid R=f \wedge S=t) * P(R=f \mid C=f) * P(S=t \mid C=f) * P(C=f)$

(2)  $= .90 * .8 * .5 * .5$

Full credit for (2) if your answer is right for the formula you gave in (1), even if (1) was wrong. Trivial answers to (1) are excluded.