# Examination
# Artificial Intelligence
# Module Intelligent Interaction Design
# December 2014

## Introduction

This exam is closed book, you may only use a simple calculator (addition, substraction, multiplication and division).
This examination consists of 28 multiple-choice questions, for which you have 3 hours and 30 mins. At the end of the exam you must hand in this question paper and the answer form.
Each correctly answered multiple choice question counts for 4 points.
Tips:

- Read each question carefully keeping the possible answers covered.
- Try to answer the question yourself, before you look at the answers you are given to choose from. Make a note of your first thoughts and calculations on a scribbling-paper (kladpapier).
- Beware of double negations (negatives) as these can be confusing.
- If you have any time over at the end, check your answers.
- Fill in your answers on this question form first and transfer them to the answer form at the end.
- At the last page of this exam you can find a table with $-p \log_2(p)$ values.

Good luck!

# Multiple-choice questions

## Questions about search and problem solving

1. Underlying each search problem is a *search graph* in which the states are the vertices of the search graph and the edges (connections) are determined by the possible actions; there is an edge from $s$ to $s'$ with label $a$ in the search graph, if and only if there is an action $a$ which leads from state $s$ to state $s'$. These two conditions together completely define the *search graph*. A cycle in the search graph is a vertex (state) $s$ and a non-empty sequence of actions $as$ such that if we start in $s$ and execute the sequence of actions $as$ then we will end up in $s$ again. Consider the following statements about search problems and graphs:

   **(i)** If the Depth First Search Algorithm does terminate on a given search problem then the corresponding search graph is finite and contains no cycles.

   **(ii)** If the corresponding search graph is infinite or contains cycles then the Depth First Search Algorithm does not terminate on the corresponding search problem.

   Which of the following claims is true?

   (a) Both statements (i) and (ii) are false.

   (b) Only statement (i) is true

   (c) Both statements (i) and (ii) are true.

   (d) Only statement (ii) is true.

2. Which of the following search strategies belongs tot the class of uninformed search?

   (a) $A^*$ Search

   (b) Greedy Search

   (c) Breadth-First Search

   (d) None of the above

3. Consider the following Tower of Hanoi problem.

Left: Initial state Right: Goal state

The cost of moving the small disk is 1, moving the middle sized disk is 2, and moving the large disk is 3. Hence the average cost is 2. Define the heuristic function $h$ as follows: $2 \times$ *number of disks not on the rightmost peg.*
What is the $h$ value of the initial state?

(a) 3

(b) 4

(c) 5

(d) 6

4. Assume that we apply A$^*$ search to the above Tower of Hanoi problem. Which node will be the **second** one that will be expanded after the initial node (node corresponding to the start state) of the search tree?

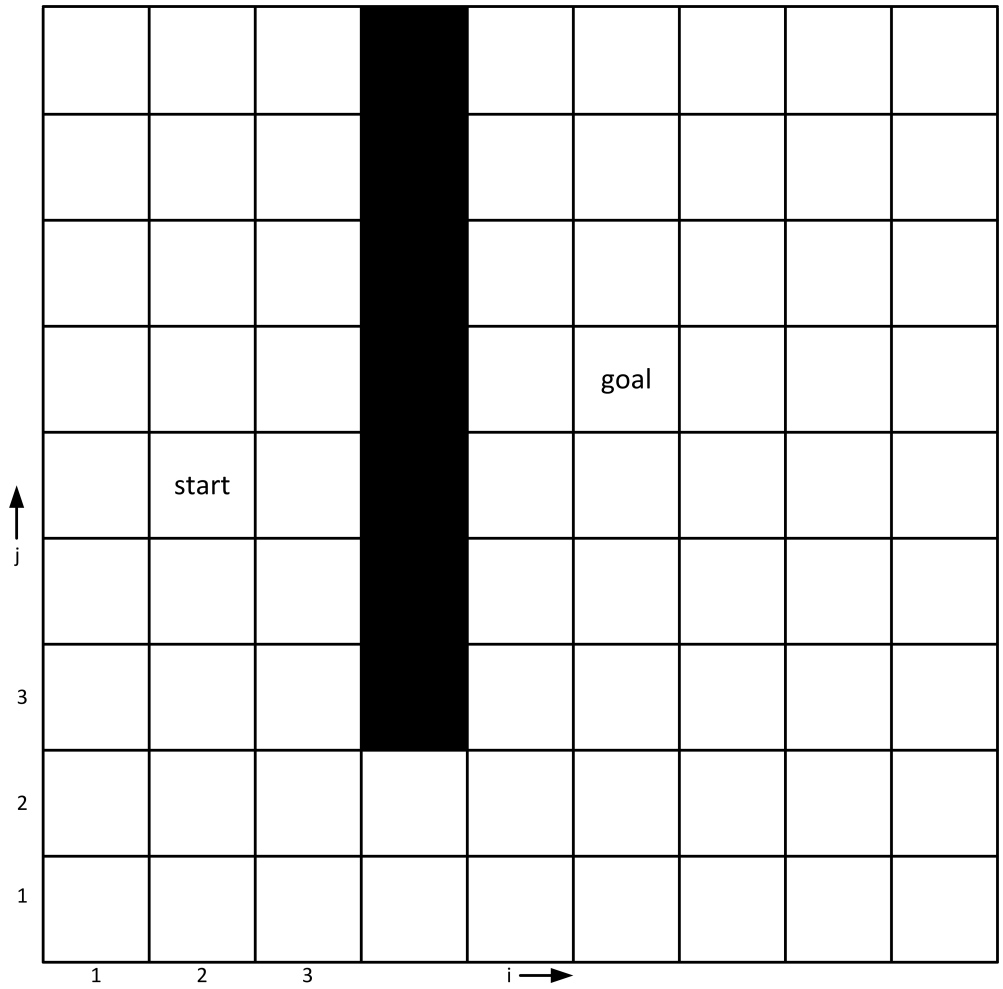
(a) The node corresponding to the state which arises from the initial state by moving the small disc to the rightmost peg and then afterwards moving the middle sized disc to the empty peg.

(b) The node corresponding to the state which arises from the initial state by moving the small disc to the middle peg and then afterwards moving the middle sized disc to the rightmost peg.

(c) The node corresponding to the initial state, i.e. moving the small disc to an empty peg and back.

(d) The node corresponding to the state which arises from the initial state by moving the small disc first to the rightmost peg and afterwards moving the small disc to the middle peg.

5. Consider the following path finding problem in which an agent wants to go from the start cell $(2, 5)$ to the goal cell $(6, 6)$. The agent can only make the following moves: *one cell up, down, left or right* and each move has a cost of 1. The black cells with coordinates $(4, 3)$, $(4, 4)$, $(4, 5)$, $(4, 6)$, $(4, 7)$, $(4, 8)$ and $(4, 9)$ form a barrier which the agent cannot pass. Assume the agents applies $A^*$**-search** with heuristic function $h$ the Manhattan distance. Which of the nodes will be in the list of open nodes, called `Frontier` in the video lectures, after **5 iterations** of the search algorithm?



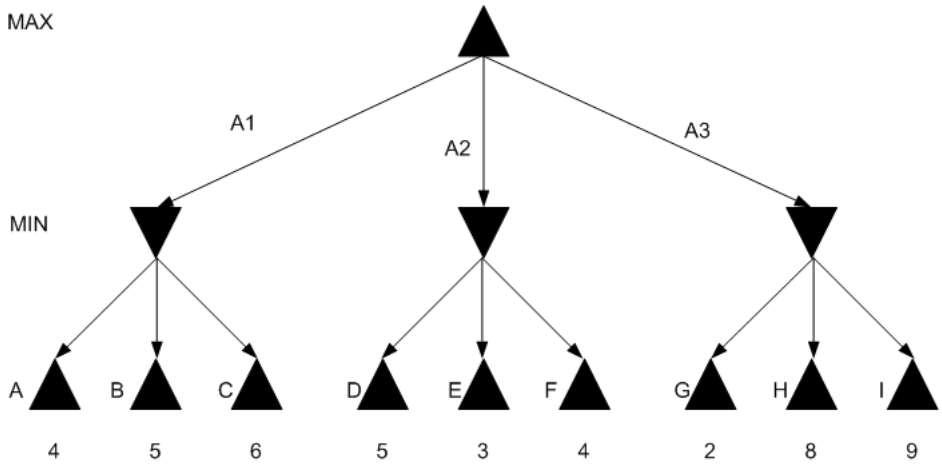

(a) node corresponding to cell (state) $(3, 3)$.

(b) node corresponding to cell (state) $(3, 6)$.

(c) node corresponding to cell (state) $(2, 4)$.

(d) None of the above.

6. Consider the following part of a two-player game tree.




What will be the value of the top MAX node

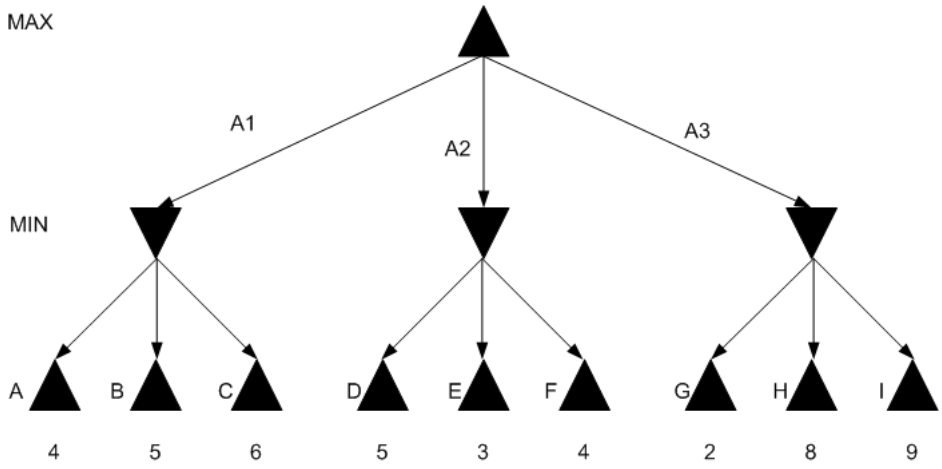
(a) 4

(b) 6

(c) 8

(d) 9

7. Consider the two-player game tree:




Assume one applies alpha-beta pruning. Which of the following collection of nodes will **all not** being explored?

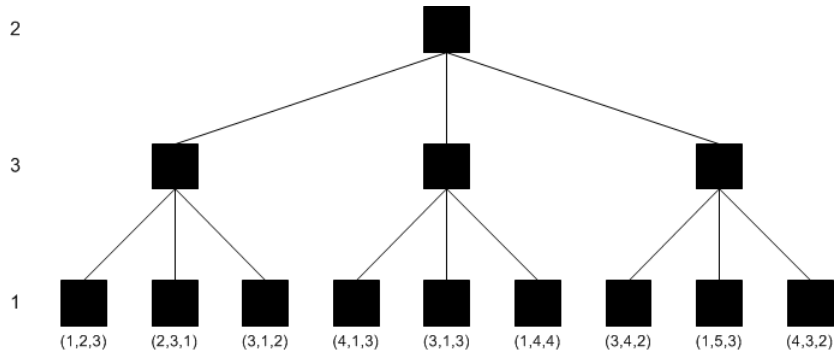
(a) $\{A, D, G\}$

(b) $\{G, H, I\}$

(c) $\{C, F, I\}$

(d) $\{F, H, I\}$

8. Consider the following game tree for three players, player 1, 2 and 3.




At the lowest nodes the evaluation value of the relevant node is given (the value of the evaluation function) for each of the players. In the i position the evaluation value of the node for player i is given, $i = 1, 2, 3$. What is the value or are the values of the nodes for player 2 in the above representation?

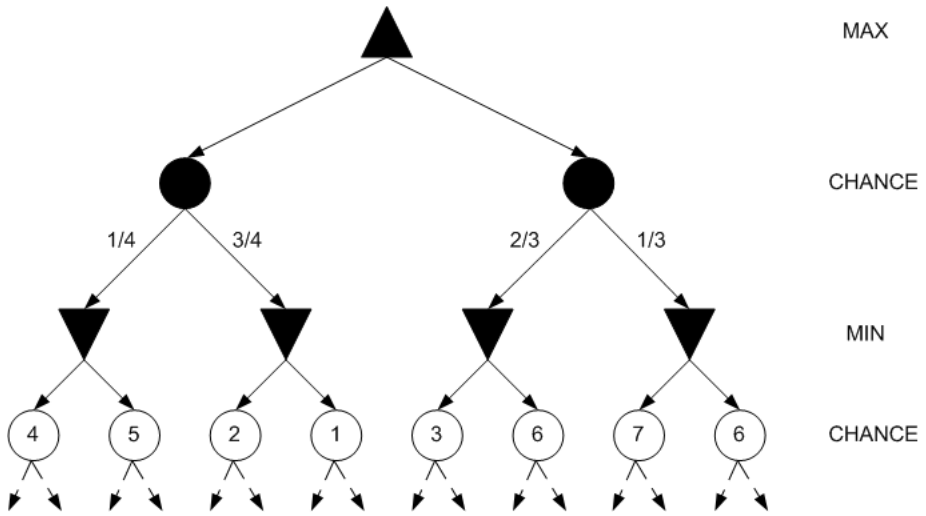
(a) (3,4,3)

(b) (1,5,3)

(c) 5

(d) (1,4,4)

9. Consider the following two-player game tree in which the game has an element of chance, which is shown by the so-called probability nodes in the game tree.




What is the correct value for the top MIN-node if one applies the expectiminimax algorithm?

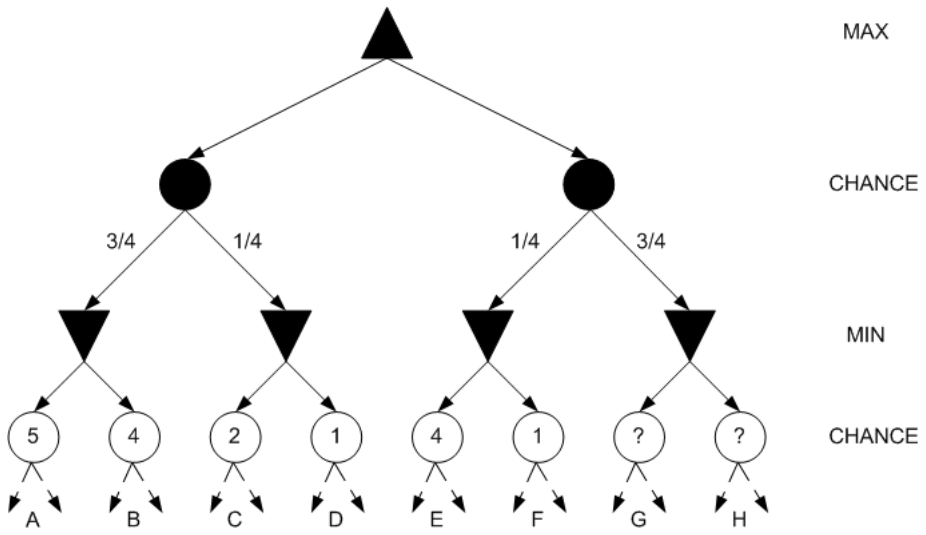
(a) 6

(b) 2

(c) 4

(d) 7

10. Consider the following game tree with an element of chance.




The letters under the bottom row of chance nodes are labels for the nodes just above the letter. One can also apply $\alpha - \beta$ pruning to this game tree. The numbers inside the chance nodes on the bottom row are the computed values of these chance nodes; ? indicates not computed yet. For which values of node G is it **not** necessary to expand node H (to compute the value of node H)?

(a) $\alpha - \beta$ pruning will **always** expand node H.

(b) If the value of node G is less or equal to 4 then $\alpha - \beta$ pruning will **not** expand node H.

(c) If the value of node G is greater than 4 then $\alpha - \beta$ pruning will **not** expand node H.

(d) $\alpha - \beta$ pruning will **never** expand node H.

## Questions about logic and reasoning under uncertainty

11. How many models does the propositional formula $A \Rightarrow (B \Rightarrow \neg C)$ have

    (a) 1
    (b) 7
    (c) 5
    (d) None of the above

12. Which of the two following statements is true?

    I $A \Rightarrow (B \Rightarrow C)$ is logically equivalent with $(A \Rightarrow B) \Rightarrow C$.
    II $P(A|B) = 1$ is logically equivalent with $B \Rightarrow A$.

    (a) Both are true
    (b) I is true, II is false
    (c) Both are false
    (d) I is false, II is true

13. When we transform the formula

$$(\neg P \vee Q) \wedge R \Rightarrow Q \wedge R$$

    into conjunctive normal form, we obtain the following formula:

    (a) $(R \vee \neg R \vee Q \vee R) \wedge (\neg Q \vee \neg R \vee Q \vee R)$
    (b) $(P \vee \neg Q) \wedge \neg R \wedge (Q \vee R)$
    (c) $P \vee Q$
    (d) None of the above

14. We are given the following premisses:

    - $(P \vee Q) \Rightarrow R$
    - $\neg(\neg P \vee \neg Z)$
    - $\neg(P \Rightarrow \neg R) \Rightarrow W$

    The question is whether we can prove $W$ from these premisses. Which of the following answers is correct?

    (a) Yes, the conclusion follows.

    (b) No, the conclusion does not follow, but if you add the premiss $P$ the conclusion can be derived.

    (c) No, the conclusion does not follow, but if you add the premiss $\neg Q$ the conclusion can be derived.

    (d) None of the above.

15. Which of the following statements is true?

    I Resolution is a *sound* proof method for propositional logic.

    II Using the resolution rule it can be proven that $A \wedge A \vee \neg A$ is a tautology

    (a) Both are true

    (b) I is true, II is false

    (c) Both are false

    (d) I is false, II is true

16. A man was murdered and Mrs.$S$ was arrested, suspected of committing the crime. Forensic investigation produced a dna match between $S$'s dna stored in the DNA dBase and material found on the body. Let $M$ denote the statement "A match was found with Mrs.S's dna". Let $G$ denote the statement Mrs. S is guilty of the murder. It is known that $P(M|\neg G)$ is 1 in 1.000.000. Furthermore it is assumed that $P(M|G) = 1$, the probability that a match is there if $S$ is guilty equals 1. The size of the "catchment area", i.e. the DNA dBase from which the dna was drawn when the match was produced, is 3.000.000, the number of potential murderers. Suppose there is no additional evidence in favor of the guilt of $S$ apart from the dna match and that there is a single murderer. The *posterior* (i.e. after the match was found) *odds on $S$ guilt* is

$$\frac{P(G|M)}{P(\neg G|M)}$$

and the *prior* (e.g. before the match is taken into account) *odds on Mrs.S's guilt* is

$$\frac{P(G)}{P(\neg G)} \approx 1/3.000.000$$

What is the numerical value of the posterior odds on Mrs.S guilt given the approximate value of the prior odds on her being guilty?

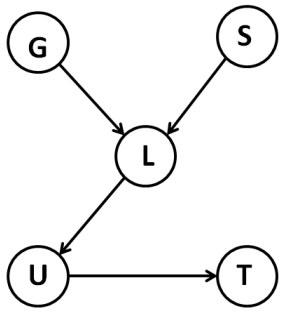
(a) 1.000.000

(b) 3.000.000

(c) 1/3

(d) 1/3.000.000.

17. A user interface designer developed a system with a special help feature as part of the interface. By means of a user test he collected data about (dis)liking of this feature and task completion for a certain task. Based on the data collected from this user test the designer modeled the relevant parameters and the dependencies with a Bayesian Network. The structure of this network is shown in the figure below. The variables/nodes are: $G$ - gender of user; $S$ - study course followed by user; $L$ - likes the GUI feature; $U$ - uses the GUI feature; $T$ - task completed.




The Bayesian Network used by the interface designer.

One of the following statements is true. Which one?

(a) $P(U|L) = P(U|L, G)$, i.e. if we know whether the user likes or dislikes the feature then the probability that he will use it does not change if we get information whether the user is a male or a female person.

(b) $P(U|L) < P(U|L, G)$

(c) $P(U|L) > P(U|L, G)$

(d) It depends on the probabilities. So we can not tell.

18. Again, consider the network of the figure above. Consider the two statements:

I If we have to compute $P(U|L)$ we can delete/ignore node T from the network (together with the incoming arc of $T$).

II If we have to compute $P(T|G)$ we can delete/ignore node $S$ from the network (together with the outgoing arc from $S$).

Which of the two statements is true?

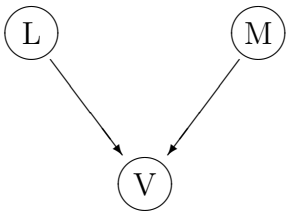
(a) Both are true

(b) I is true, II is false

(c) Both are false

(d) I is false, II is true

19. The Bayesian Network $LMV$ below has three nodes for boolean variables, $L$, $M$ and $V$. The probabilities for $L$ and $M$ are: $P(M = true) = 0,2$ and $P(L = true) = 0.7$. The conditional probabilities for variable $V$ are as shown in the table below.




| L | M | $P(V = true \mid L, M)$ |
|---|---|---|
| true | true | 0.9 |
| true | false | 0.5 |
| false | true | 0.3 |
| false | false | 0.05 |

Which value is closest to the value of $P(V = false \mid L = false)$ ?

(a) 0.3

(b) 0.7

(c) 0.9

(d) 0.1

## Questions about Machine Learning

20. Given the following text:

> *attention if you are in debt. if you are then we can help. qualifying is now at your fingertips and there are no long distance calls*

Assume that we use as vocabulary (or bag of words model) {attention, adult, debt, publications, qualifying, xxx, }. How would this piece of text be coded using a binary coding and this vocabulary?

(a) $< 1, 1, 0, 0, 0, 0 >$

(b) $< 1, 0, 0, 1, 0, 0 >$

(c) $< 1, 0, 1, 0, 1, 0 >$

(d) None of the above.

21. For convenience consider a smaller vocabulary {attention, adult, debt} and assume that we have a dataset consisting of 100 emails of which 30 are spam and with the following vocabulary frequency list:

| Word | Ham | Spam |
|---|---|---|
| attention | 30 | 10 |
| adult | 0 | 22 |
| debt | 4 | 20 |

This means for instance that the word "attention" occurs in 30 ham emails and in 10 spam emails. Given an new email with feature vector (binary coding, boolean model) $x =< x_1, x_2, x_3 >$. What is the value of $P(x_3 = 1 \mid ham)$? That is what is the probability that an *ham* email contains the third word of the vocabulary, in this case "debt". Assume that no smoothing is applied.

(a) 4/30

(b) 4/70

(c) 20/70

(d) 24/100

22. Next assume that a new email with coding $x =< 0, 1, 1 >$ arrives. What is the probability of $P(x \mid spam)$ if one applies Naive Bayes and no smoothing?

    (a) 0.3259

    (b) 0.1630

    (c) 0

    (d) 0.4889

23. Consider the same situation as in the above two question, but now assume that smoothing is applied with smoothing formula $N_{w,c} + k/(N_c + 2k)$, where $N_{w,c}$ is the number of emails in the class which contain word $w$ and $N_c$ is the total number of emails in the class. What will be the value for $P(x \mid spam)$ (same $x$ is in the above question) if one applies smoothing with $k = 2$ and apply Naive Bayes?

    (a) 0.3259

    (b) 0.1630

    (c) 0.2955

    (d) 0.1612

24. For marketing purposes a retailer wants to distinguish between costumers younger than 35 (class Y) and customers older than 35 (class O). The following table summarizes the data set in the data base of the retailer in an abstract form. The relevant attributes, determined by domain knowledge, are for convenience denoted by $A$ with values *a1*, *a2* and *a3*, $B$ with values *b1* and *b2*, $C$ with values *c1* and *c2* and $D$ with values *d1* and *d2*

| A | B | C | D | Number of Instances | |
|---|---|---|---|---|---|
| | | | | Y | O |
| a1 | b1 | c1 | d1 | 12 | 4 |
| a2 | b1 | c1 | d2 | 4 | 6 |
| a3 | b1 | c1 | d1 | 6 | 0 |
| a1 | b2 | c1 | d2 | 0 | 12 |
| a2 | b2 | c1 | d1 | 4 | 2 |
| a3 | b2 | c1 | d2 | 0 | 4 |
| a1 | b1 | c2 | d1 | 0 | 8 |
| a2 | b1 | c2 | d2 | 8 | 0 |
| a3 | b1 | c2 | d1 | 4 | 0 |
| a1 | b2 | c2 | d2 | 0 | 4 |
| a2 | b2 | c2 | d1 | 8 | 0 |
| a3 | b2 | c2 | d2 | 4 | 0 |

Given a new customer $x$, what is the information content in the answer to the question: "What is the class (Y or O) of $x$"? Or in other words what is entropy of the data set above with respect to the class labels Y and O. Choose the alternative which is closest to your answer.
You can find a table of $-p\log_2(p)$ values at the last page of this exam.

(a) 1.00

(b) 0.00

(c) 0.99

(d) 0.01

25. The analyst wants to learn the above classification problem using decision trees. If he uses "information gain" as selection criteria what will be the information gain of attribute $A$? Choose the alternative which is closest to your answer.
You can find a table of $-p\log_2(p)$ values at the last page of this exam.

(a) 0.83

(b) 0.16

(c) 0.82

(d) 0.17

26. Consider the following confusion matrix

| | | Predicted class | | |
|---|---|---|---|---|
| | | $C_1$ | $C_2$ | $C_3$ |
| Actual Class | $C_1$ | 120 | 15 | 20 |
| | $C_2$ | 16 | 150 | 10 |
| | $C_3$ | 22 | 3 | 130 |

What is the accuracy of this classifier?

(a) 150/486

(b) 120/158+150/168+130/160

(c) 120/135+150/176+130/155

(d) 400/486

27. Once again consider the confusion matrix of the previous question. What is the precision for class $C_2$?

(a) 150/486

(b) 150/168

(c) 150/176

(d) 150/400

28. Given a linear classification model determined by $(w_0, w_1, w_2) = (3, -2, 2)$ and the data point $x = (-1, -1)$. Assume that the data point $x$ is misclassified. What will be the new values for $(w_0, w_1, w_2)$ if one applies a learning rate $\alpha = 0.4$?

(a) (3.4,-2.4,2.4)

(b) (2.6,-1.6,1.6)

(c) (3.5,-2.5,2.5)

(d) (2.5,-1.5,1.5)

## Table for $-p\log(p)$

| $p$ | $-p\log_2(p)$ | $p$ | $-p\log_2(p)$ | $p$ | $-p\log_2(p)$ |
|---|---|---|---|---|---|
| 0 | 0 | 1/8 | 0.38 | 1/10 | 0.33 |
| 1 | 0 | 2/8 | 0.50 | 2/10 | 0.46 |
| 1/2 | 0.50 | 3/8 | 0.53 | 3/10 | 0.52 |
| 1/3 | 0.53 | 4/8 | 0.50 | 4/10 | 0.53 |
| 2/3 | 0.39 | 5/8 | 0.42 | 5/10 | 0.50 |
| 1/4 | 0.50 | 6/8 | 0.31 | 6/10 | 0.44 |
| 2/4 | 0.50 | 7/8 | 0.17 | 7/10 | 0.36 |
| 3/4 | 0.31 | 1/9 | 0.35 | 8/10 | 0.26 |
| 1/5 | 0.46 | 2/9 | 0.48 | 9/10 | 0.14 |
| 2/5 | 0.53 | 3/9 | 0.53 | 1/11 | 0.31 |
| 3/5 | 0.44 | 4/9 | 0.52 | 2/11 | 0.45 |
| 4/5 | 0.26 | 5/9 | 0.47 | 3/11 | 0.51 |
| 1/6 | 0.43 | 6/9 | 0.39 | 4/11 | 0.53 |
| 2/6 | 0.53 | 7/9 | 0.28 | 5/11 | 0.52 |
| 3/6 | 0.50 | 8/9 | 0.15 | 6/11 | 0.48 |
| 4/6 | 0.39 | | | 7/11 | 0.42 |
| 5/6 | 0.22 | | | 8/11 | 0.33 |
| 1/7 | 0.40 | | | 9/11 | 0.24 |
| 2/7 | 0.51 | | | 10/11 | 0.13 |
| 3/7 | 0.52 | | | | |
| 4/7 | 0.46 | | | | |
| 5/7 | 0.35 | | | | |
| 6/7 | 0.19 | | | | |