UNIVERSITY OF GHANA
COLLEGE OF BASIC AND APPLIED SCIENCES
SCHOOL OF ENGINEERING SCIENCES
FIRST SEMESTER EXAMINATIONS: 2014/2015
LEVEL 400: BACHELOR OF SCIENCE IN ENGINEERING

CPEN 405: ARTIFICIAL INTELLIGENCE [*3 Credits*]

TIME ALLOWED: 2 HRS 30 MINS

Instruction: Answer **ALL** questions in the answer booklet provided.

SECTION A [40 marks]

A1. Name and describe four (4) main features of Genetic Algorithms. **(2 marks)**

A2. Explain Turing definition of Artificial Intelligence (AI). **(2 marks)**

A3. Draw the McCulloch-Pitts neuron and explain its operation. **(4 marks)**

A4. A 4-input neuron has weights 1, 2, 3 and 4. The transfer function is linear with the constant of proportionality being equal to 2. The inputs are 4, 10, 5 and 20 respectively. What is the output? **(2 marks)**

A5. Is it true that "on average, neural networks have higher computational rates than conventional computers"? Explain. **(2 marks)**

A6. What is a zero-sum game? Give an example. **(2 marks)**

A7. Which type of search algorithms uses the problem-specific knowledge beyond the definition of the problem? Give an example. **(2 marks)**

A8. When do we say that a heuristic is admissible? Give an example of admissible heuristic (name it $h_1(n)$) and an example of non-admissible heuristic (name it $h_2(n)$). Discuss and compare the quality of algorithms using either $h_1(n)$ or $h_2(n)$. **(6 marks)**

A9. Describe two (2) parameters used to evaluate the quality of a search algorithm. **(2 marks)**

A10. Can A∗ search be used in robotics where percepts, states, and actions are continuous? Explain. **(3 marks)**

A11. Is there any causality relationship between a dominant strategy of a game player and her/his best outcome? Explain with an example. **(3 marks)**

A12. Consider a set of all integers $z \in Z$ such that $z^2 < 10$. Is this a finite set? If the condition is changed to $z^3 < 10$, is the set finite? Justify your answers. **(4 marks)**

A13. Consider the following graph:

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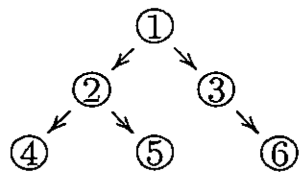
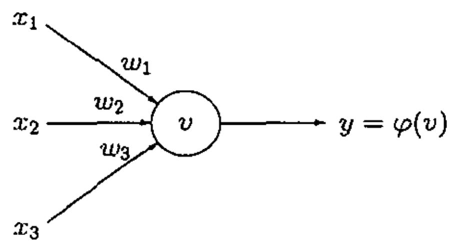


Starting at root node 1, give the order in which the nodes will be visited by the breadth-first and depth-first algorithms. **(2 marks)**

A14. The single artificial neuron below has three inputs $\mathbf{x} = (x_1, x_2, x_3)$ that receive only binary signals (either 0 or 1). How many different input patterns can this node receive? Give a formula that computes the number of binary input patterns for a given number of inputs?



(4 marks)

SECTION B [60 marks]

B1. Answer the following:

a. In the following pure strategies non-zero-sum game, find dominant strategies for each player (if they exist) and all Nash equilibra.

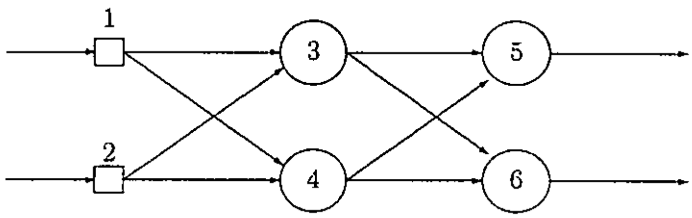
		Player 2		
		Left	**Middle**	**Right**
Player 1	**Up**	**0 , 1**	**9 , 0**	**2 , 3**
	Straight	**5 , 9**	**7 , 3**	**1 , 7**
	Down	**7 , 5**	**10 , 10**	**3, 5**

(8 marks)

b. Suppose that players A and B play the Rock-Paper-Scissors game (paper wins over rock, scissors win over paper, rock wins over scissors, and draw for any matching pair). Let S_A and S_B be the sets of strategies for both players in each game where $S_A = S_B = \{r, p, s\}$, and correspond to rock, paper and scissors respectively. Suppose that player A uses mixed strategy $P_A = \{0.1, 0.2, 0.7\}$, where each number is the probability of rock, paper or scissors respectively. Suggest a winning mixed strategy for player B. Use the expected payoff to prove that the strategy is winning. **(12 marks)**

B2.

a. The following diagram represents a feed-forward neural network with one hidden layer:



A weight on connection between nodes i and j is denoted by w_{ij}. The following table lists all the weights in the network:

$w_{13} = -2$	$w_{35} = 1$
$w_{23} = 3$	$w_{45} = -1$
$w_{14} = 4$	$w_{36} = -1$
$w_{24} = -1$	$w_{46} = 1$

Each of the nodes 3, 4, 5, and 6 uses the following activation function:

$$\phi(x) = \begin{cases} 1 & \text{if } x \geq 0 \\ 0 & \text{otherwise} \end{cases},$$

where x denotes the weighted sum of a node. Each input is binary. Calculate the output (y_5, y_6) for each of the following input patterns:

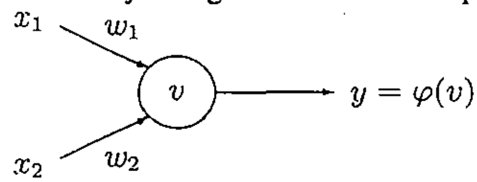
Pattern	*P1*	*P2*	*P3*	*P4*
*Node*1	0	1	0	1
*Node*2	0	0	1	1

(10 marks)

b. Logical operators (i.e. NOT, AND, OR, XOR, etc) are the building blocks of any computational device. Logical functions return only two possible values, true or false, based on the truth or false values of their arguments. For example, operator AND returns true only when all of its arguments are true, otherwise (if any of the arguments is false) it returns false. If we denote truth by 1 and false by 0, then logical function AND can be represented by the following table:

x_1 :	0	1	0	1
x_2 :	0	0	1	1
x_1 AND x_2 :	0	0	0	1

This function can be implemented by a single-unit with two inputs as shown below:



The weights are $w_1 = 1$ and $w_2 = 1$ and the activation function is:

$$\varphi(v) = \begin{cases} 1 & \text{if } v \geq 2 \\ 0 & \text{otherwise} \end{cases}$$

Note that the threshold level is 2.

i. Test how the neural AND function works.
ii. Suggest how to change either the weights or the threshold level of this single-unit in order to implement the logical OR function (true when at least one of the arguments is true)
iii. The XOR function (exclusive or) returns true only when one of the arguments is true and another is false. Otherwise, it returns always false. Do you think it is possible to implement this function (XOR) using a single unit? A network of several units? **(10 marks)**

B3.

a. Suppose A* search algorithm is used to solve a minimal cost path search problem (case 1). Suppose now (case 2) that we take an initial search problem and we add $(C > 0)$ to the actual costs on all edges.
   i. Under what condition will the algorithm in case 1 yield an optimal path?
   ii. What is the condition on the added cost C for the optimal algorithm in case 1 (with the same characteristics) to remain optimal for case 2 as well?

(8 marks)

b. Consider a state space where the start state is number 1 and each state k has three (3) successors, numbers 2k-1, 2k, and 2k + 1.
   i. Draw the portion of the state space for states 1 to 25.
   ii. Suppose the goal state is 18. List the order in which nodes will be visited for breadth first search, depth-limited search with limit 3, and iterative deepening search.
   iii. How well would bidirectional search work on this problem? What is the branching factor in each direction of the bidirectional search?
   iv. Call the action going from k to 2k-1 **Left**, the action going to 2k **Straight**, and the action going to 2k + 1 **Right**. Can you find an algorithm to output the solution to this problem without any search at all?

(12 marks)

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