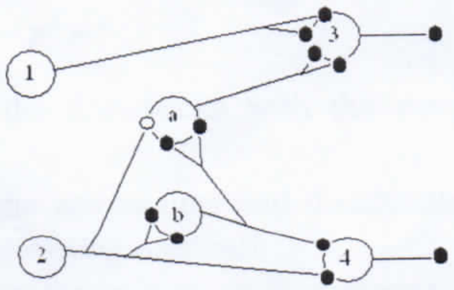
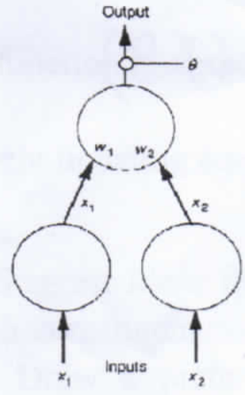
ANN Exam. (Time: 3 hrs.; Total: 155 pts)

1. (3 pts) (a) Give three example tasks that conventional computers outperform the human brain. (b) Give three example tasks that the human brain outperforms conventional computers.
2. (5 pts) Give at least (a) three characteristics of biological nervous systems, (b) three characteristics of artificial neural networks, and (c) three basic functions of artificial neural networks.
3. (3 pts) There are three major types of neurons. What are the types? Address their functions.
4. (4 pts) There are two major neural operations or phases. What are they? Address their objectives.
5. (4 pts) Draw a figure to illustrate the synaptic function between two neurons.
6. (3 pts) There are three basic neural circuits in the McCullock-Pitts Theory. What are the circuits? convergence divergence, feedback
7. (6 pts) Give the propositional expressions and draw the neural circuits of (a) disjunction and (b) conjoined negation.
8. (6 pts) Write propositional expressions for $N_3(t)$ and $N_4(t)$ in the following neural circuit.



evolve

9. (5 pts) Graphically illustrate the Hebb's learn theory.
10. (2 pts) What is a dynamic system?
11. (2 pts) What are the full names of adaline and madaline?
12. (6 pts) Describe the steps of the steepest descent learning method for determining the weight vector of an adaline using a set of training input and output pairs.
13. (6 pts) Figure (a) shows a perceptron and Figure (b) shows a truth table of the *XOR* problem. Illustrate graphically why the *XOR* problem cannot be solved by the perceptron.



(a)

x_1	x_2	Output
0	0	0
0	1	1
1	0	1
1	1	0

(b)

14. (10 pts) The objective of the least mean square learning rule has often been used to find a weight vector for an adaline using a set of training input and output pairs. Given training pairs: input vectors $\{\boldsymbol{x}_1, \boldsymbol{x}_2, \cdots, \boldsymbol{x}_L\}$ and output values $\{d_1, d_2, \cdots, d_L\}$, suppose that the actual output values are $\{y_1, y_2, \cdots, y_L\}$. Let $\xi = \langle \varepsilon_k^2 \rangle$, $\boldsymbol{p} = \langle d_k \boldsymbol{x}_k \rangle$, $R = \langle \boldsymbol{x}_k \boldsymbol{x}_k^T \rangle$. (1) Formulate the mean squared error $\xi(\boldsymbol{w})$. (2) Derive the optimal weight vector $\boldsymbol{w}^*$ that minimizes $\xi(\boldsymbol{w})$. (3) Show that the minimum value of $\xi(\boldsymbol{w})$ can be written as $\xi_{\min}(\boldsymbol{w}^*) = \langle d_k^2 \rangle - \boldsymbol{p}^T \boldsymbol{w}^*$.
15. (5 pts) Address the drawbacks with the steepest descent learning approach?
16. (5 pts) Address the advantages and disadvantages of the conjugate gradient descent learning method?
17. (4 pts) What does the minimum disturbance principle mean when training a madaline?
18. (3 pts) Address the characteristics of a back-propagation (BP) neural network.
19. (3 pts) What learning rule and objective function are employed when training a BP?
20. (15 pts) A network has quadratic output neurons. The net input to such a neuron is $net_k = \sum_j w_{kj}(i_j - v_{kj})^2$, where w_{kj} and v_{kj} are weights and are independent and i_j is the jth input value. The

output function is sigmoidal $f_k^o(net_{jk}^o) = (1 + e^{-\lambda net_{jk}})^{-1}$. Determine

the weight updating equations of Δw_{kj}^o and Δv_{kj}^o for output-layer

neurons.

21. (5 pts) Suggest ideas for determining the numbers of hidden layers and their constituent nodes.
22. (4 pts) Draw a picture to illustrate how a BP performs image compression.
23. (8 pts) (a) The mechanism of lateral interaction is typically governed by the Mexican-hat function. Draw its figure and illustrate the interactions between neurons based on this function. (b) The Mexican function can be realized using a DOG (Difference of Gaussians) or an LOG (Laplacian of Gaussian) function. Give the definitions of these two functions.
24. (9 pts) Discuss and give matrix memory representations for (i) local addressable memory (LAM), (ii) content addressable memory (CAM), and (iii) associative memory (AM).
25. (5 pts) Suppose we have a training set $\{(\boldsymbol{b}^{(m)}, \boldsymbol{a}^{(m)}), m = 1, 2, \ldots\ldots, M\}$, where $\boldsymbol{b}^{(m)}$ and $\boldsymbol{a}^{(m)}$ are input and output vectors, respectively. Construct the weight matrices of an interpolative AM with the training set if $\boldsymbol{b}^{(m)}$ and $\boldsymbol{a}^{(m)}$ are (a) continuous-valued and (b) binary-valued vectors.
26. (4 pts) Show that we encode an example $(\boldsymbol{x}, \boldsymbol{y})$, also encode its complement $(\boldsymbol{x}^c, \boldsymbol{y}^c)$.
27. (3 pts) Draw the architecture of a bidirectional association memory (BAM).
28. (2 pts) Illustrate the crosstalk phenomenon with a memory.
29. (5 pts) Discuss the properties of an energy function E of a neural system.
30. (10 pts) Let the energy function of a BAM be $E = -\boldsymbol{y}^T W \boldsymbol{x}$, where $\boldsymbol{x}$ and $\boldsymbol{y}$ are bipolar vectors and $W = [w_{ij}]$. Show $E_{\min} = -\sum_{i=1}^{m}\sum_{j=1}^{n} |w_{ij}|$.