Q1 Score: **8.0**

1. True/False Questions (10 points)

For each of the statements below, fill in the box 'T' if the statement is always and unconditionally true, or fill in the box 'F' if it is always false, sometimes false, or just does not make sense.

	T	F
1	T	■
2	■	F
3	■	F
4	T	■
5	T	■
6	T	■
7	■	F
8	T	■
9	■	F
10	T	■

1) The exact evaluation function values affect minimax decision even if the ordering of these values is maintained.

2) Soundness of an inference algorithm means that the algorithm doesn't reach bogus conclusions.

3) The number of hidden layers needed in a neural network cannot be calculated from the input provided.

4) Bayes' Theorem takes you from a prior belief to a posterior belief after you've collected some additional data

5) If all cars would be self-driving, the world's roads would be a deterministic environment.

6) The entropy of a binary random variable decreases as data become less ordered.

7) Even a good knowledge base will not be able to answer any question.

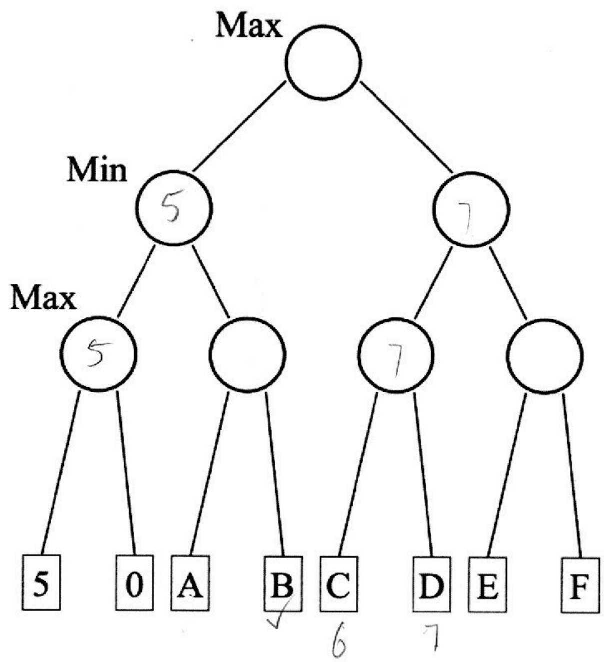
8) Perceptrons, arranged with no hidden layer, cannot express logical NOT.

9) SVM can classify data that is not linearly separable.

10) The back-propagation learning algorithm is based on the gradient descent method.

2. Game Trees (20 points)

Consider the game tree picture below where *A-F* represent some integer values.
Assume the nodes are explored from left to right and standard alpha beta pruning is used.



(a) [4 pts] Give a value of *A* such that *B* is pruned.

A = 6

(b) [4 pts] Give a value of *A* such that *B* is not pruned.

A = 4

Q3 Score: **12.0**

(c) [4 pts] **True of False:** There are SOME values of A and B such that the subtree containing C and D is pruned. Explain Why.

False.
This subtree has no pruning relations with A and B.
The subtree containing C and D will never be pruned.

(d) [4 pts] Assuming that $B = 5$ and $A = 5$, give a value of C and D such that the subtree containing E and F is pruned.

C=1 , D=2

(e) [4 pts] If you are allowed to assign A-F arbitrarily, what is the MAXIMUM number of leaves that can be pruned? Provide the name of the leaves as well.

3 B, E, F

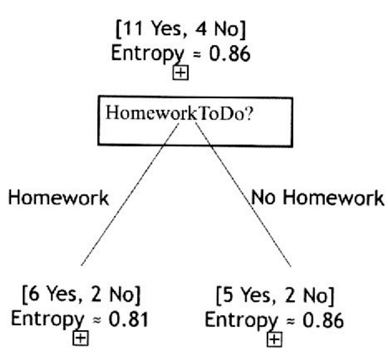
Q4 Score: **0.0**

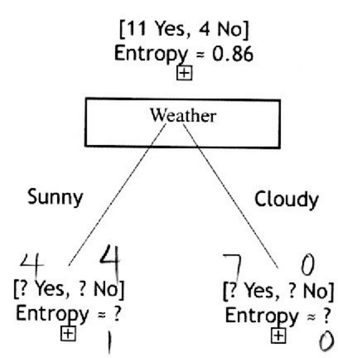
3. Decision Trees (20 points)

In trying to decide whether or not to go jogging, some of the factors I consider are the weather and whether or not I have homework to do. There are other factors as well of course. Some example decisions are summarized in the table below.

Weather	HomeworkToDo	Jogging
Sunny	No Homework	Yes
Sunny	Homework	No
Sunny	No Homework	Yes
Sunny	Homework	No
Sunny	Homework	Yes
Sunny	No Homework	No
Sunny	Homework	Yes
Sunny	No Homework	No
Cloudy	Homework	Yes
Cloudy	Homework	Yes
Cloudy	Homework	Yes
Cloudy	No Homework	Yes
Cloudy	Homework	Yes
Cloudy	No Homework	Yes
Cloudy	No Homework	Yes

With 11 positive examples of jogging and 4 negatives, the entropy or information of this decision in bits is 0.84. Consider the following decision trees, reflecting splitting on the attributes of **Weather** or **HomeworkToDo**.





Q5 Score: **15.0**

A. [8 pts] The HomeworkToDo tree has been filled out. Complete the values for the Weather tree, including entropy. (Show your work)

$P_1 = 4$

$n_1 = 4$

$P_1 + n_1 = 8$

$$I\left(\frac{P_1}{P_1+n_1}, \frac{n_1}{P_1+n_1}\right) = -\frac{4}{8}\log_2\frac{4}{8} - \frac{4}{8}\log_2\frac{4}{8}$$

$$= \frac{1}{2} + \frac{1}{2}$$

$$= 1$$

$P_2 = 7$, $n_2 = 0$, $P_2 + n_2 = 7$

$$I\left(\frac{P_2}{P_2+n_2}, \frac{n_2}{P_2+n_2}\right) = -\frac{7}{7}\log_2\frac{7}{7} - 0$$

$$= 0$$

8

B. [8 pts] Calculate the information gain IG from splitting on HomeworkToDo and Weather. Please show formulas used and steps clearly. You do not need to compute a final numerical result. Plug in values to the formulas so that the result could be calculated with a calculator.

IG(HomeworkToDo) = $I\left(\frac{P}{P+n}, \frac{n}{P+n}\right) - \sum_i \frac{P_i+n_i}{P+n} I\left(\frac{P_i}{P_i+n_i}, \frac{n_i}{P_i+n_i}\right)$

$$= I\left(\frac{11}{11+4}, \frac{4}{11+4}\right) - \left[\frac{6+2}{11+4} I\left(\frac{6}{6+2}, \frac{2}{6+2}\right) + \frac{5+2}{11+4} I\left(\frac{5}{5+2}, \frac{2}{5+2}\right)\right]$$

$$= -\frac{11}{15}\log_2\frac{11}{15} - \frac{4}{15}\log_2\frac{4}{15} - \left[\frac{8}{15}\cdot\left(-\frac{6}{8}\log_2\frac{6}{8} - \frac{2}{8}\log_2\frac{2}{8}\right) + \frac{7}{15}\cdot\left(-\frac{5}{7}\log_2\frac{5}{7} - \frac{2}{7}\log_2\frac{2}{7}\right)\right]$$

-1 I(jogging) is provided

IG(Weather) =

$$I\left(\frac{11}{15}, \frac{4}{15}\right) - \left[\frac{4+4}{11+4} I\left(\frac{4}{4+4}, \frac{4}{4+4}\right) + \frac{7+0}{11+4} I\left(\frac{7}{7+0}, \frac{0}{7+0}\right)\right]$$

$$= -\frac{11}{15}\log_2\frac{11}{15} - \frac{4}{15}\log_2\frac{4}{15} - \left[\frac{8}{15}\cdot\left(-\frac{4}{8}\log_2\frac{4}{8} - \frac{4}{8}\log_2\frac{4}{8}\right) + \frac{7}{15}\left(-\frac{7}{7}\log_2\frac{7}{7} - 0\right)\right]$$

Q6 Score: **4.0**

C. [4 pts] Which of the two attributes is a better choice in constructing a decision tree? Why?

$IG(\text{HomeworkToDo}) = I(\frac{11}{15}, \frac{4}{15}) - [\frac{8}{15} I(\frac{6}{8}, \frac{2}{8}) + \frac{7}{15} I(\frac{5}{7}, \frac{2}{7})]$

$= 0.86 - (\frac{8}{15} \times 0.81 + \frac{7}{15} \times 0.86)$

$IG(\text{Weather}) = I(\frac{11}{15}, \frac{4}{15}) - [\frac{8}{15} I(\frac{1}{2}, \frac{1}{2}) + \frac{7}{15} I(1, 0)]$

$= 0.86 - (\frac{8}{15} \times 1 + 0)$

4

$IG(\text{HomeworkTodo}) < IG(\text{Weather})$ So Weather is better.

$\frac{8}{15} \times 0.81 - \frac{8}{15} \times 1 + \frac{7}{15} \times 0.86$

$\frac{7}{15} \times 0.86 - \frac{8}{15} \times 0.19$

$7 \times 0.86 - 8 \times 0.19 > 0.$

$IG(1) < IG(2)$

$6.3^{6.02}$ 8 1.52

$0.86 - (\ ) - 0.86 + (\ )$

$\frac{8}{15} - \frac{8}{15} \times 0.81 - \frac{7}{15} \times 0.86$

$\frac{8}{15} \times (1 - 0.81) - \frac{7}{15} \times 0.86$

$\frac{8}{15} \times 0.19 - \frac{7}{15} \times 0.86$

$0.19 \times 8 = 1.52$ $\quad 0.86 \times 7 = 6.02$

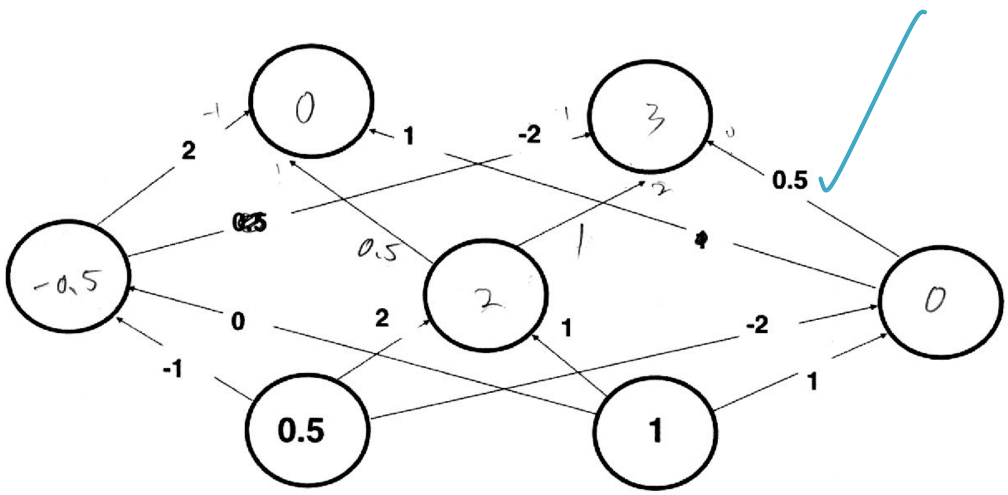
$\frac{8 \times 0.19 - 7 \times 0.86}{15}$

$1.52 - 6.02 < 0$

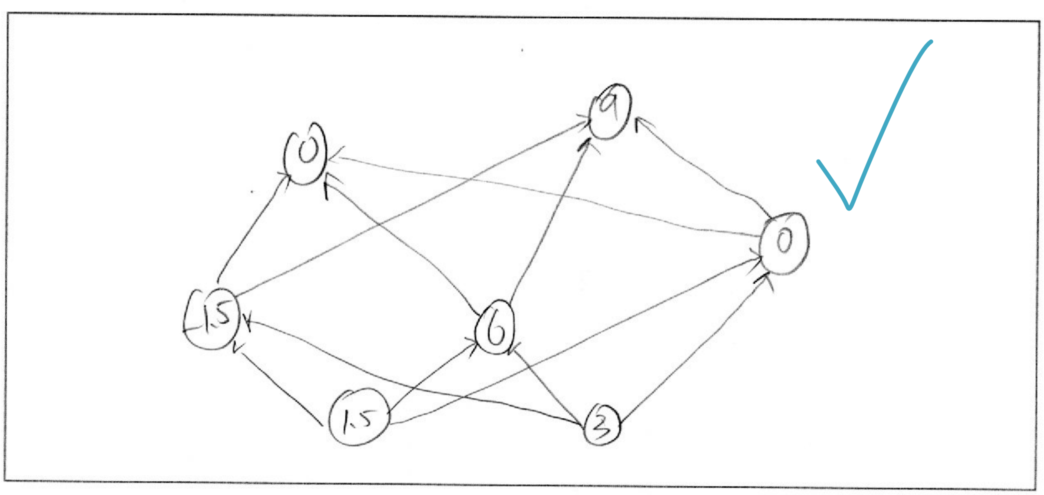
4. Neural Networks (25 points)

The following is a network of **linear** neurons, that is, neurons whose output is identical to their net input. The numbers in the circles indicate the output of a neuron, and the numbers at connections indicate the value of the corresponding weight. (Check the directions of the arrows on the connections while answering the questions).

a) [10 pts] Compute the output of the hidden-layer and output-layer neurons for the given input and enter those values into the corresponding circles.



b) [10 pts] What is the output of the network for the input (1.5,3) i.e. the left input neuron having the value 1.5 and the right one having the value 3? Fill in values for all the circles.



Q8 Score: **5.0**

c) [5 pts] To answer part (b), do you have to do all the network computations once again? Explain why you do or do not have to do this.

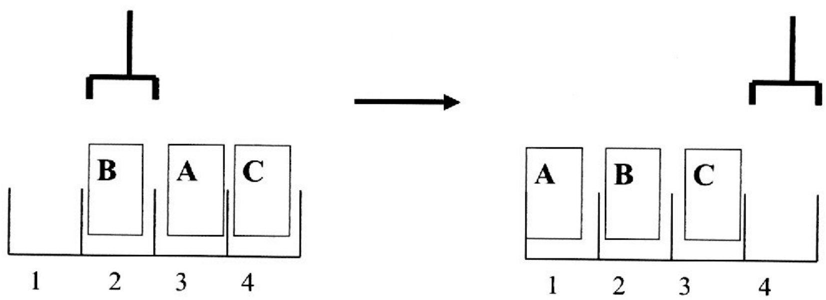
No,

Neurons are linear. And both of the inputs are multiplied by 3. It is like given $a+b=c$. Then $3a+3b=3(a+b)=3c$. So we can just get each value multiplied by 3.

Q9 Score: **3.0**

5. Planning (15 points)

Consider writing a planner that will solve the following block-moving problem:
6.1 [10pts] Consider the given domain, and formalize the following sentences:



There are three operators available:

- **pickup (obj1,pos1)**
  Pick up the object **obj1**, which is currently at position **pos1**. The gripper must also be at **pos1**.
- **putdown (obj2,pos2)**
  Put down the object **?obj2**, which is currently being held, at position **pos2**. Gripper must be at **pos2** as well.
- **move-gripper (pos1,pos2)**
  Move the gripper from position **pos1** to position **pos2**.

The gripper can only be holding one thing at a time, and there can be at most one block at a position at a time.

a) [5 pts] Write the operator definitions for **pickup**, **putdown**, and **move-gripper**.

① pickup(obj1, pos1)

-2, wrong expression ObjAt(obj1, pos1), GripperAt(pos1), Held(obj1, No)

Effect: Held(obj1, Yes)

③ move-gripper (pos1, pos2)

Precond: GripperAt(pos1)   Effect: GripperAt(pos2)

② putdown (obj2, pos2)

Precond:

ObjAt(obj2, pos2), GripperAt(pos2), Hold(obj2, Yes)

Effect: Held

Q10 Score: **8.0**

b) [5 pts] Demonstrate a regression search for a solution: show the goal and two regressions, one that fails, and one that succeeds.

+5

Goal: ObjAt(A, pos1), ObjAt(B, pos2), ObjAt(C, pos3)
GripperAt(pos4)

Fail: pickup(B, pos2) → move-gripper(pos2, pos1) →
putdown(B, pos1)

Succeed: move-gripper(pos2, pos3) → pickup(A, pos3) →
move-gripper(pos3, pos1) → putdown(A, pos1) →
move-gripper(pos1, pos4) → pickup(C, pos4) →
move-gripper(pos4, pos3) → put down(C, pos3) →
move-gripper(pos3, pos4)

c) [5 pts] Demonstrate a plan-space search for a solution: show the initial plan and three refinements: one that links to the initial state, one that involves adding an operator, and one that involves resolving a threat.

-2,wrong regression

Initial plan:

ObjAt(B, pos2) ObjAt(A, pos3) objAt(C, pos4)
GripperAt(pos2) Held(A, No) Held(B, No) Held(C, No)

Added operator:

pickupAndMove(obj1, pos1, pos2)
pick up the object obj1, which is currently at position pos1.
The gripper must also be at pos1. Then move the gripper from position pos1 to position pos2.

Q11 Score: **6.0**

6. Short Answers (10 points)

1. [2 pts] List 2 reasons why machine learning is needed?

① AI Application can be more intelligent and do more things

② With machine learning, human effort can be saved

1

2. [2 pts] What is Ockham's razor? How is it used in decision tree learning?

3. [6 pts] Choose 2 research topics from the poster sessions and describe each topic, including the limitations/pitfalls and future directions. Compare and contrast how uncertainty was handled.

① Robot controlled by human thoughts.

5

The signal transmission distance is limited. But may be the signal transmission can rely on the Internet, though there are still delay. The uncertainty is from useless human brain's signals. The researcher has developed an algorithm to automaticly discard non-help signals

② Cecus. The first solved AI playing poker

The only pitfall maybe the space it needs to operate. Because there are like 10^8 card cases. In future, after hardware develops, the space may be not a problem. The uncertainty is from what kind of rules of playing cards being used. This is handled by giving the robot direction directly.