625 Final Exam Type Practice (Spring 2023): **Lastname**: _____, **First name**: _____
If I cheat, I will accept an automatic 'F' in this course. **Signature:** _____ **Date:** _____

Problem 1(15 points)

Using Resolution, show the following. Predicates;P, Q, R; Variables: x, y, z, w; Constants: A, B, C; Funcitons: $f, g, ...$ (1) Turn the peoblem below to standard form (clauses). Don't forget to negate the conclusion. (2) Use resolution to derive False. Do not use any other inference rule. Use scratch paper to work out the solution, then write your answer here. Answer written on the scratch paper will NOT be graded.

Given

1. $\forall x(P(x) \rightarrow \exists y(Q(x,y) \wedge R(y)))$
2. $\exists y(P(y) \wedge S(y))$
3. $\forall z \forall w(Q(w,z) \rightarrow S(z))$

Show that $\exists x(R(x) \wedge S(x))$ is
a logical consequence.

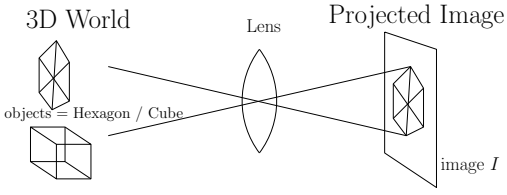
Problem 2(10 points)

In situation calculus, there are two types of basic axioms: (1) possibility axiom and (2) effect axiom. Consider the two axioms below. Mark which axiom type each axiom belongs to. You must mark both correct to get full credit (no partial credit). Note: $Poss(a, s)$ means it is possible to execute action a in situation s. Also, x, y are locations, s is a situation, etc. (Hint: think in terms of the preconditions for actions and the resulting effects.)

1. $At(Agent, x, s) \wedge Adjacent(x, y) \rightarrow Poss(Go(x, y, s))$. (Possiblility Axiom/ Effect Axiom)
2. $Poss(Grab(g), s) \rightarrow Holding(g, Result(Grab(g), s))$ (Possibility Axiom/ Effect Axiom)

Problem 3(10 points)

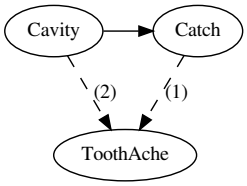
Consider the task below. Given a projected image I, you want to know what is the object in the environment that gave rise to the projected image: a hexagon or a cube (note: both objects can result in the projected image, depending on the viewing angle). Mark below: (1) Which is more difficult to compute: $P(Image|Object)$ or $P(Object|Image)$? (Hint: think in terms of cause and effect.) (2) Which one is greater, $P(Image = I|Object = Hexagon)$ or $P(Image = I|Object = Cube)$, given the projected image shown in the figure below? (Hint: consider for each object, the number of viewing angles that can give a projection similar to I.) (3) Given a projected image I, assuming $P(Object = Hexagon) = P(Object = Cube)$, which object is more likely to have caused the image I (consider $P(Object = Hexagon|Image = I)$ vs. $P(Object = Cube|Image = I)$)?



Mark one each:
(1) $P(Image|Object)$ or $P(Object|Image)$
(2) $P(Image = I|Object = Hexagon)$ or $P(Image = I|Object = Cube)$
(3) $Hexagon$ or $Cube$

Problem 4(5 points)

Consider the three nodes $Cavity, Catch, ToothAche$ that are being added to the belief network. Let's say $Cavity$ and $Catch$ are already added and connected as shown below (solid arrow). Once $ToothAche$ is added, which dashed arrow(s) need to be connected? (1 or 2 or both: mark below)? Explain why. (Hint: think in terms of cause and effect.)



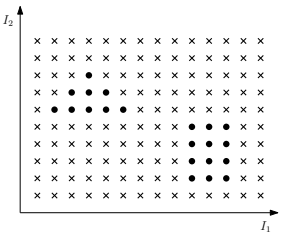
Problem 5(10 points)

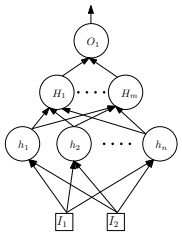
Consider the data set (E) below. (1) Show how the data set is split for the two attributes, (2) Indicate which one is greater $Gain(E, Attr1)$ or $Gain(E, Attr2)$? You don't need to calculate the information gain value – just provide an explanation.

Example	Attr1	Attr 2	Class
X1	a	y	+
X2	a	y	-
X3	b	n	+
X4	c	n	-
X5	b	n	+
X6	c	n	-

Problem 6(10 points)

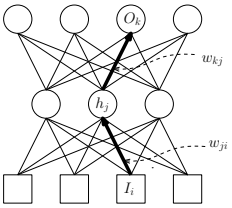
In the training set shown below, • represents class 1 and $\times$ represents class 2 (x and y axes are the inputs). (1) Can the neural network shown to the right possibly learn (using backprop) the data set perfectly without error? (Yes / No) (2) Explain how or why not: show the decision boundaries of each neurons $h_1, h_2, ...H_1, H_2, ..., O_1$ (show as many as needed).





Problem 7(10 points)

Unlike output units (O_k), hidden units (h_j) in a multilayer perceptron does not get direct target value (T_k), but using back-propagation, it can compute its error. This error is needed to update w_{ji} of the hidden unit h_j. Explain how this error is computed, in terms of $\Delta_k = Error_k \times g'(WeightedSum_k) = (T_k - O_k) \times g'(WeightedSum_k)$ and w_{kj} (k is the index for the output units, and $g()$ is the sigmoid activation function). Hint: write Δ_1, Δ_2, ... on the output units, and see how those could be used to compute Δ_j for hidden unit h_j.



Problem 8(10 points)

In deep learning, we discussed (1) Convolutional Neural Networks (CNN), (2) Deep Reinforcement Learning (RL), and (3) Recurrent Neural Networks (RNN) / Transformers. What are the main application areas for each of these three? Choose from (A) robotics/autonomous driving, (B) natural language processing, and (C) computer vision. Mark only one per each.

(1) CNN: A, B, or C (2) Deep RL: A, B, or C (3) RNN/Transformer: A, B, or C

Problem 9(10 points)

How does deep learning differ from classical machine leanring? Explain in terms of how the input features are extracted, prior to the final feature-to-output mapping stage.

Problem 10(10 points)

Deep Q Network (DQN) is a reinforcement learning algorithm that produces an output that helps choose an appropriate action a given an input state s. For example, in the Atari 2600 game, s is the video sequence and a is the joystick control (stick and button). What are the output values computed by DQN, given the input video sequence s?

Scratch paper

Last name:_____ First name:_____

* DO NOT write your solutions on the scratch paper. They will not be graded.
* Write your name on your cheat sheet.
* Submit: Your exam + Scratch paper + Cheat sheet (in that order).
* Degree candidates: Submit to a separate stack.