Machine Learning Final

This TWO-SIDED exam is open book. You may bring in your homework, class notes and text- books to help you. You will have 1 hour and 15 minutes. Write all answers in your blue book. Please make sure YOUR NAME is on each of your blue books. Square brackets [] denote the points for a question. ANSWER ALL FOUR QUESTIONS FOR FULL CREDIT

1. **Reinforcement Learning(RL)**
   Consider the modules approach to RL.
   (a) [5] *BRIEFLY* describe one advantage if the approach over conventional RL
   (b) [5] *BRIEFLY* describe one disadvantage if the approach over conventional RL
   (c) [5] Could there be a problem with too many modules? *BRIEFLY* discuss
   (d) [10] Describe one function that chooses a **policy** from a set of modules and defend your choice.

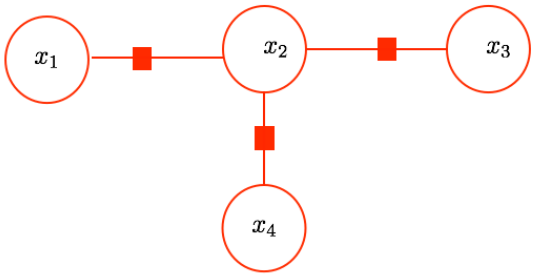
2. **Deep Learning**

   (a) [15] The early backpropagation networks used a sigmoid activation function $g(u)$ where
   $$g(u) = \frac{1}{1+e^{-u}}$$
   but this had the "vanishing gradient" problem: $g'(u) \to 0$ as $|u|$ becomes large. Show this problem by using the derivative explicitly.

   (b) [10] Using the $H = \frac{1}{2}||\mathbf{x}^K - \mathbf{d}||^2 + \sum_{k=0}^{k=K-1}(\lambda)^{k+1}(-\mathbf{x}^{k+1} + g(W^k\mathbf{x}^k))$, the sigmoid gradient is given by:
   $$\frac{\partial H}{\partial w_{ij}^k} = \lambda_i^{k+1} x_j^k g'(\mathbf{w}_i^k \mathbf{x}^k) \tag{1}$$
   Changing the activation to a 'semi-linear' function allowed very deep layers in networks to use backpropagation. Show how equation (1) is modified when using the new activation function.

3. **Graphical Models**

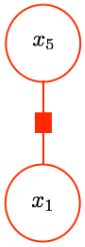
Consider the following 4-node graph:



where

$$p(x_2) = \sum_{x_1} \sum_{x_3} \sum_{x_4} f_a(x_1, x_2) f_b(x_2, x_3) f_c(x_2, x_4)$$

(a) [10] Show the **extra messages** necessary for $p(x_2)$ when the following subgraph is added to the original.



(b) [15] What is the formula for $p(x_2)$ when x_1 is **observed**?

4. **Markov Random Fields**

A **transparent** image is defined as $y(y_1, y_2)$ where y_1 and y_2 are $\in \{+1, -1\}$ How would you set up a Markov Random Field process using an image (x_1, x_2) to de-noise transparent images? Show all notation that you come up with.

[10] What would the energy functions look look like?

[15] What would the network look like?