# CSC412/2506 Final Exam Topics to Focus Study

version 1

The exam will cover lecture content from week 1 to week 12.
During the exam you are permitted a non-programmable calculator and one double-sided, handwritten $8.5'' \times 11''$ aid sheet.

To focus your study, consider in particular the following topics:

## Common Distributions

- Details for main distributions we considered in class (Bernoulli, Categorical, Univariate and Multivariate Gaussian).
- How to evaluate densities under these distributions.
- Computational complexity for evaluating their density.
- Number of parameters.
- Kinds of data they describe.
- Their conjugate priors.

## Probability Fundamentals

- Definitions of expectation and variance.
- Manipulate expectations as integrals.

## Exponential Family models

- Understand the different terms in the canonical representation.
- Be able to manipulate the canonical representation to identify parameters and sufficient statistics for examples of exponential family models.

## Basic Classifiers

- Probabilistic formulation of models (e.g. regression, clustering) from joint density.
- Understand fundamental operations.
- Maximum likelihood on basic models.
- Maximum Likelihood vs Maximum a Posteriori.

## Graphical Models

- Distinctions between directed and undirected graphical models.
- Evaluate conditional probability statements (e.g. Bayes' Ball).
- Semantics for conditional independence in graphs (e.g. Markov Blanket, Global Markov Property).
- Cliques, maximal cliques and their relationship with factors / potentials.

## Exact Inference

- Bayes' theorem.
- Variable elimination algorithm.
- Elimination ordering and its relationship to computational complexity.
- Sum Product belief propagation algorithm.
- Evaluate conditional likelihoods in graphical model conditioned on observations (e.g. with message passing)

## Variational Inference

- Forward vs Reverse KL-Divergence.
- Deriving the Evidence Lower Bound (ELBO).
- Relationship between ELBO and variational and model parameters.
- Relationship between ELBO and KL-Divergence between variational and model distributions.

## Sampling

- Simple Monte Carlo.
- Bias and variance of a Monte Carlo estimator.
- Algorithm, properties, and weaknesses of sampling methods from lecture (Rejection, Metropolis-Hastings, Importance)

## Sequential Models

- Understand parameterization of Hidden Markov Model (Initial Distribution, Transition, Emission).
- Dependences in $n$-th order Markov Models.

## Latent Variable Models

- Relationship between terms in ELBO and latent variables.
- Understand how ELBO is used to train latent variable models.
- Semi-supervised learning where latent variables are sometimes observed.

## Stochastic Variational Inference

- Simple Monte Carlo for unbiased gradient estimation (score function vs pathwise derivative estimators).
- Reparameterization Trick.
- SVI algorithm for learning latent variable models.
- Variational vs Monte Carlo methods.

## Generative Adversarial Networks

- Understand distinction between implicit and explicit density model.
- Understand components in GAN and their purpose.
- Understand the formulations of the adversarial objectives in GANs.
- Derivation of optimal properties for Discriminator and Generator.
- Understand "non-saturating" generator objective and purpose.