ESS 5203: Winter 2020 EXAM Notes:

As in past exams posted on the web site, the exam paper will have two parts:

- Section A These questions require reasonably **short (usually less than one page)** answers. Use equations as necessary but add words of explanation! Answer all of these 5 questions. (40% total)
- Section B Answer 3 out of these 5 questions only (20% per question)

The exam is to be completed individually. Specifically, you are not to discuss or share the questions or potential answers with anyone, including other students in this course. Students will abide by the Senate Policy on Academic Honesty (<u>https://secretariat-policies.info.yorku.ca/policies/academic-honesty-senate-policy-on/</u>).

Aids allowed; No limitations but your answers must be hand written and primarily in your own words. If you are quoting text, insert "quotation marks" and indicate the source. Some figures may be on the exam paper and you may be asked to make additions to them.

For Questions please phone PT: 647-966-9293 or MG: 647-453-0150.

ESS5203.03 - Turbulence and Diffusion in the Atmospheric Boundary Layer

Topics that were covered are listed below, though not necessarily in this order. **Bold topics** are things we covered in some detail. There will be exam questions on all sections.

1) General Introduction. Laminar and Turbulent flow, the atmospheric boundary-layer. **Diurnal cycle**, role of density stratification. Review of governing equations for incompressible flow, continuity, Navier Stokes, equation of state, thermodynamic equation.

2) Simplification of the basic equations, **Reynolds averaging**. Statistical description of turbulence, integral statistics (variances etc.), scales of turbulent flow, **the Turbulent Kinetic Energy (TKE) equation**. Boundary-layers over horizontally homogeneous terrain - **constant flux layers**, surface roughness - the Surface Boundary-Layer (SBL).

3) **Surface Energy Budget**. Dimensional Analysis and Similarity, Buckingham Pi theorem, **Monin-Obukhov similarity theory**. The diabatic surface boundary layer. Other stratified boundary layers (suspended material).

4) **The Planetary Boundary Layer (PBL)** or Atmospheric Boundary-Layer (ABL). Ekman spirals, PBL, Inertial oscillations and low level jets. RANS models.

5) Flow in and over canopies, turbulence and diffusion in canopies.

6) Measurements, Instruments and Experiments. Flux measurements.

7) Spectral Analysis. PDFs, Time and Space spectra, **Energy spectra**, Kolmogorov, **inertial and dissipation subranges**, **-5/3 law**.

8) Atmospheric Diffusion. Diffusion from point sources, Fickian diffusion, **Gaussian plume** models, G.I. Taylor's diffusion equation.

9) Flow in complex terrain, hills and roughness changes, marine boundary layers.
