The University of British Columbia
Christen / GEOB 300 / October 10, 2014

Midterm Examination

Name	Student #	
Signature	*for marking only* Score	Grade

Write answers directly into space provided. Additional pages are not allowed and will not be marked. There are 9 pages. Make sure you have all. Marks are indicated in square brackets. Total possible marks are 100 (Part A: 32, Part B: 28, Part C: 40). Time allowed - 50 min.

Part A: Multiple choice questions

Solve all multiple choice questions. Check only one box per question. If you check none or multiple boxes, your answer will be invalid and you receive zero points.

1. What is the correct formulation that defines Q^*? [4]

   ◯ $Q^* = K_\downarrow - K_\uparrow + L_\downarrow - L_\uparrow$ ◯ $Q^* = \varepsilon\sigma T^4$ ◯ $Q^* = \varepsilon \frac{K^*}{L^*}$ ◯ $Q^* = Q_H / Q_E$

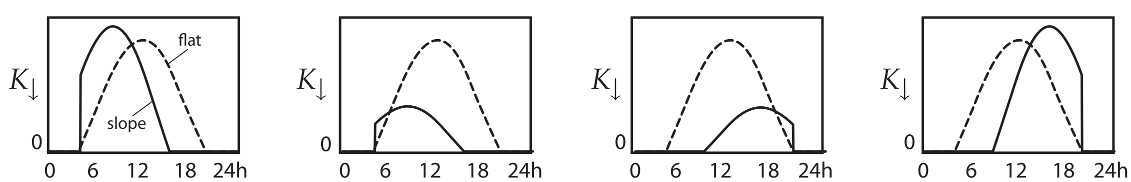
2. Which form of water has the lowest heat capacity C [4]

   ◯ Liquid water ◯ Ice ◯ Fresh snow ◯ Old snow

3. Beer's law describes the transmission of radiation through a homogeneous medium, such as snow or water: $I_z = I_0 e^{-k\,z}$. What is the name of k? [4]

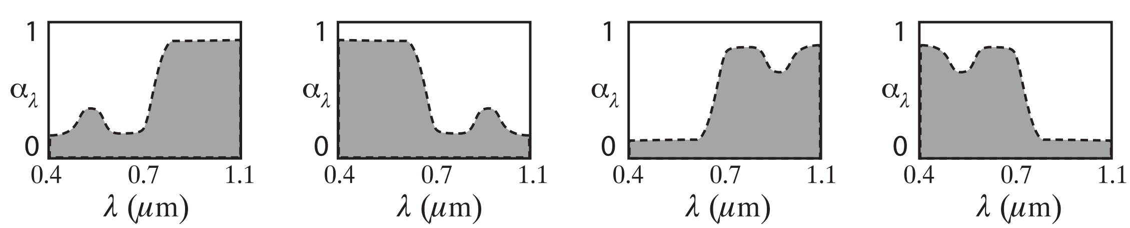
   ◯ Beer's constant ◯ Transmittance ◯ Absorption coefficient ◯ Extinction coefficient

4. How do you expect short-wave irradiance $K_\downarrow$ on a East-facing slope (45° slope angle) to change over the course of a day relative to $K_\downarrow$ on flat surface (dashed line) in Vancouver? [4]



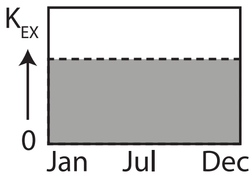
   ◯ ◯ ◯ ◯

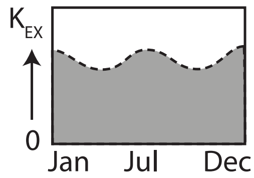
5. How does spectral reflectivity α_λ of a green leaf change with wavelength λ? [4]

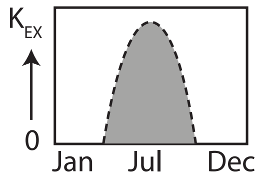


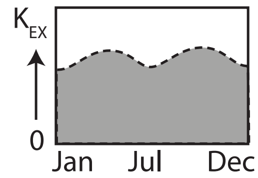
   ◯ ◯ ◯ ◯

6. At the North Pole, how does the daily total of extraterrestrial short-wave irradiance K_{EX} change with time of year? [4]



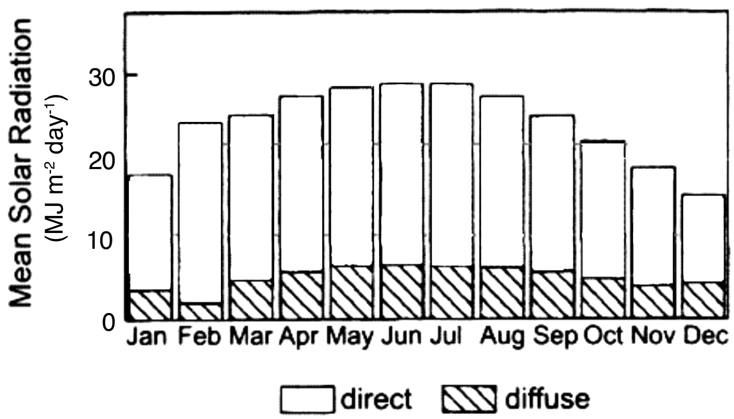






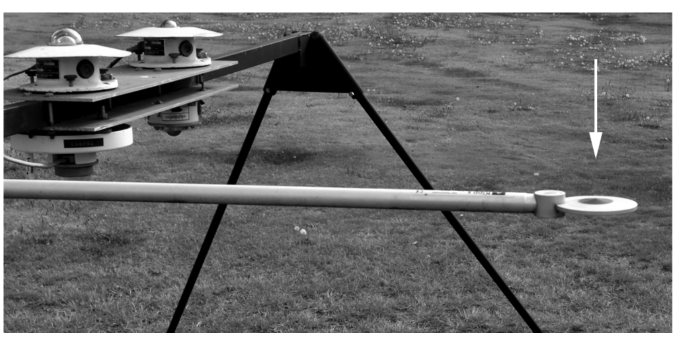
○ ○ ○ ○

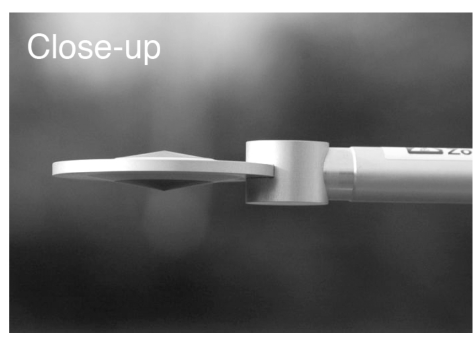
7. The following graph shows the distribution of direct beam and diffuse irradiance for a given station. Where is this station most likely located? [4]



○ Manaus, Brazil (3°S, Equatorial Rainforest)
○ Vancouver, Canada (49°N, Coastal BC)
○ Tamanrasset, Algeria (23N°N, Sahara Desert)
○ South Pole Station, Antartica (90S°N, Ice Shield).

8. You saw the following meteorological instrument on UBC Totem Field. What is this instrument measuring? [4]





○ Net all-wave radiation Q^*
○ Net short-wave radiation K^*
○ Albedo α
○ Diffuse solar irradiance D

Part B: Short answer questions.

Answer only four out of these five short answer questions. Note: the first four questions with any answer written into the space provided will be marked, hence solving more than four questions is not to your advantage.

1. Briefly explain the difference between a *pyranometer* and a *pyrgeometer*. [7]

2. Briefly explain the difference between *albedo* and *reflectance* of a surface. [7]

3. Briefly explain the difference between the *atmospheric boundary layer depth* and the *damping depth* in a soil. [7]

4. Briefly explain the difference between the *solar declination* and the *solar constant*. [7]

5. The heat capacity C of ice is roughly $2.0 \times 10^6\,\mathrm{J\,m^{-3}\,K^{-1}}$. Its thermal conductivity k is roughly $2.0\,\mathrm{W\,m^{-1}\,K^{-1}}$. Calculate the thermal admittance μ of ice. [7]

Part C: Problem questions

Answer only four out of the following six questions. Again: the first four questions with any answer written into the space provided will be marked, hence solving more than four questions is not to your advantage.

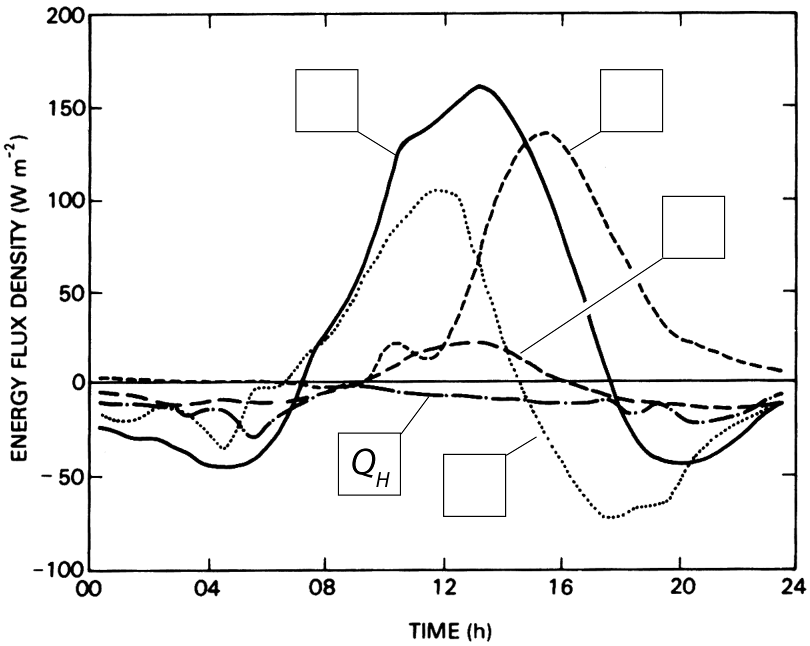
1. The following table shows simultaneous measurements of all components of the radiation balance from two stations in Metro Vancouver on July 15, 2014 at 12:00 PST. July 15, 2014 was a clear day without any clouds. One station listed is Totem Field at UBC (where you have been during the field visit - relatively dry and short lawn ≈5 cm tall), the other station is located in Burns Bog (Delta, very wet peat soil, unmanaged, ≈30 cm tall grasses). At both stations, all components or the radiation balance are measured at 2 m above ground.

Component	Station 1	Station 2
$K_\downarrow$	890 $\mathrm{W\,m^{-2}}$	885 $\mathrm{W\,m^{-2}}$
$K_\uparrow$	99 $\mathrm{W\,m^{-2}}$	173 $\mathrm{W\,m^{-2}}$
$L_\downarrow$	360 $\mathrm{W\,m^{-2}}$	373 $\mathrm{W\,m^{-2}}$
$L_\uparrow$	495 $\mathrm{W\,m^{-2}}$	550 $\mathrm{W\,m^{-2}}$

(a) Which station has the higher K^*, which one has the higher L^* at 12:00 [4]?
(b) Based on the measurements above, attribute the stations to 'Burns Bog' and 'UBC Totem Field'. Justify your choice using indicators from selected short-wave and long-wave components measured [6].

2. The graph below shows all terms of the energy balance of a melting snow pack at Bad Lake (Saskatchewan, 51°N) over the course of a day.

   (a) Q_H is labelled. Label the remaining curves with correct symbols [4]?
   (b) What are the major energetic contributors to snow melt at 15:00. Sort them by magnitude. [3]
   (c) What are the processes that cause the snow-pack to continue melting at 19:00? [3]



3. The following differential equation is valid for temperatures in a soil of homogenous structure.

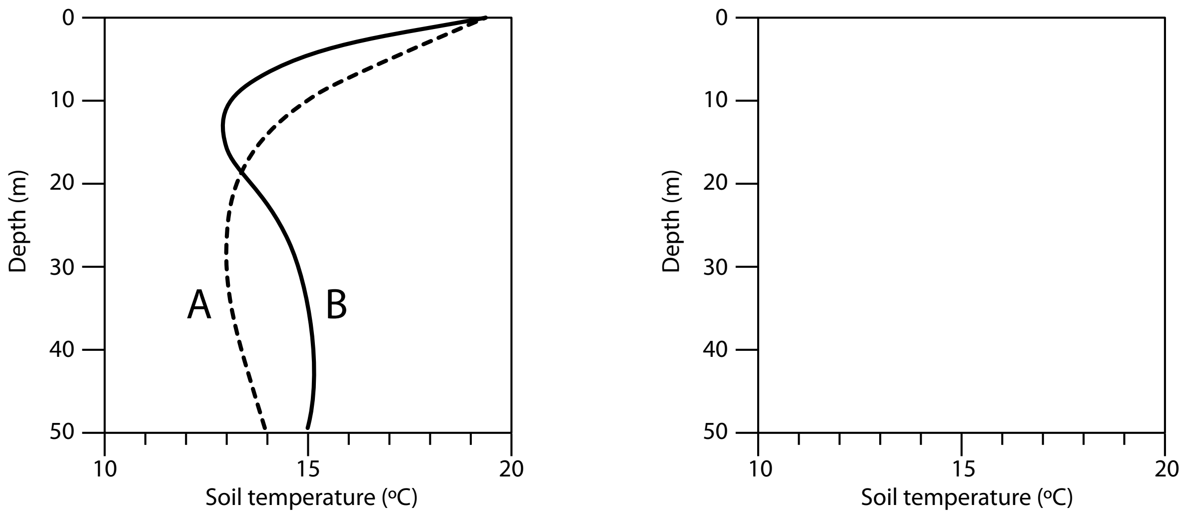
   (a) Generally, what does this equation describe [2]?
   (b) What are the two basic laws or considerations that lead to this formulation? [5]
   (c) Can we use this equation to forecast soil temperatures into the future? Justify, and list any limitations. [3]

$$\frac{\partial T}{\partial t} = -\frac{k}{C_s}\frac{\partial}{\partial z}\left(\frac{\partial T}{\partial z}\right) = -\kappa_s\frac{\partial^2 T}{\partial z^2}$$

4. The left graph shows how soil temperatures change with depth in two different soils at the same time of day with the same energy input / loss at the surface.

(a) Speculate, <u>when</u> during the day the profiles on the graph were measured. Justify your choice. [3]
(b) Which of the two soils, A or B, has the higher thermal diffusivity κ_s? Justify you choice. [3]
(c) In the empty panel on the right, sketch how the profiles for soils A and B would approximately look like 12 hours later. [4]

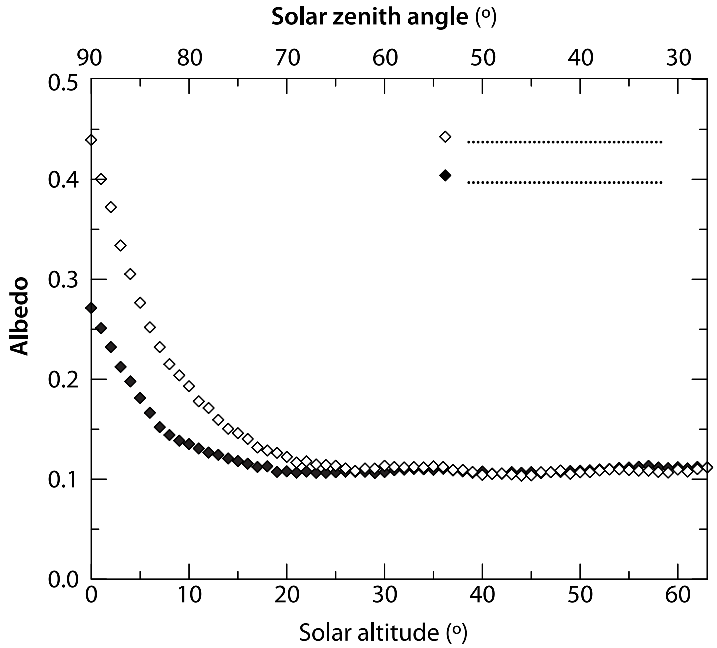
For all questions, assume homogeneous soil properties and a clear (cloudless) summer day in Vancouver.



5. In this field, young raspberry plants have been planted on small ridges (ridge and furrow geometry). In addition, the ridges are covered by an opaque black plastic sheet with holes for the plants.

(a) Discuss in detail how the ridge and furrow structure modifies the radiation balance to the benefit of plant growth. [6]
(b) Discuss how the dark plastic sheet enhances the beneficial effects. [4]

6. This graph shows albedo α as a function of solar altitude (or solar zenith angle) as measured over an urban surface in the City of Vancouver. The radiometers to measure albedo were mounted on a tall 30-m tower above the city's buildings and trees.



(a) What causes the curves to behave as observed? [4]

(b) Once curve has been measured during clear skies, the other curve summarizes data from overcast situations. Complete the legend by adding 'clear-sky' and 'overcast' (no justification needed). [2]

(c) Draw a third line directly into the graph that shows the expected relationship for a short grass surface (e.g. Totem Field) under clear sky conditions [4]

END OF EXAM