Study Guide For
Mass Balance, Glacial Hydrology, Glacial Flow

A. Mass balance

1. (3 pts) Glaciers and ice sheets exist due to a balance between mass accumulation and ablation. Identify the ways ice mass accumulates and ablates.

2. (3 pts) A glacier (or an ice sheet) can be divided into two parts, the accumulation zone and the ablation zone. Describe each and how they differ. What is the name of the dividing line between them.

3. (4 pts) For a glacier on Mount Hood graph the mass balance versus time for one year. Focus your attention on three points on the glacier, one in the accumulation zone, on in the ablation zone and one on the line in between. Draw a separate graph for each site, and use the seasons (F, W, S, S) for time on the abscissa. Label all parts of all graphs.

4. (4 pts) How would you remotely measure the mass balance of part of Antarctica that resides on bedrock? Use the continuity equation and describe how you would evaluate each term. Please discuss uncertainties.

5. (3 pts) What does AAR stand for? Please define it, and briefly explain its usefulness.

6. (3 pts) Describe the relation between the ELA and glacier mass balance. Drawing a graph of ELA on the y-axis and balance on the x-axis will help your explanation.

B. Glacier Hydrology

1. (4 pts) What are the effects of glacier melt on runoff in alpine watersheds compared to basins with no glaciers? Your answer must illustrate you knowledge of glacier effects as opposed to just snow effects.

2. (3 pts) What is the pattern of diurnal variations in runoff from a glacier and how does it change from early in the season (late May) to late in the season (late August).

3. (9 pts) A glacier cross-section can be divided into 3 main zones, supraglacial, englacial, and subglacial. Identify the hydraulic features (components) that govern water flow in each zone.

4. (5pts) For the subglacial system describe the hydraulic mechanics of the two main systems that route most of the water flow. That is, how can they stay open under hundred's of meters of ice? Clue: Till is not one of the systems.

5. (4pts) Describe several methods to investigate how water flows through a glacier.

6. (4 pts) What are the processes keeping a conduit open? That is, why doesn't the ice squeeze closed? What is the pressure difference between large diameter passages and small ones? Explain the process.

7. (4 pts) What are the processes keeping a cavity open? That is, why doesn't the ice squeeze closed?

8. (4 pts) A subglacial conduit and a link-cavity system operate very differently. Explain.

9. (3pts) What causes an outburst flood?

10. (5pts) Describe the relevance of subglacial hydrology to glacier motion including surging.

11. (3 pts) How do subglacial cavities affect glacier sliding? Explain the process.

12. (2pts) How does subglacial till affect glacier movement? Explain the process.

13. (8pts) (a) Draw a cross-section of a temperate glacier and identify the major hydrologic processes by which water gets from the surface to the bed. Be sure to include both the accumulation zone and the ablation zone. Identify features on your diagram. (b) Which, if any, of these processes occur on a polar glacier where summer temperatures barely reach 0°C and only for a few weeks.

14. (4pts) Two main subglacial hydraulic systems were discussed in class. These two systems convey the majority of the subglacial water. Identify each and explain how each works.

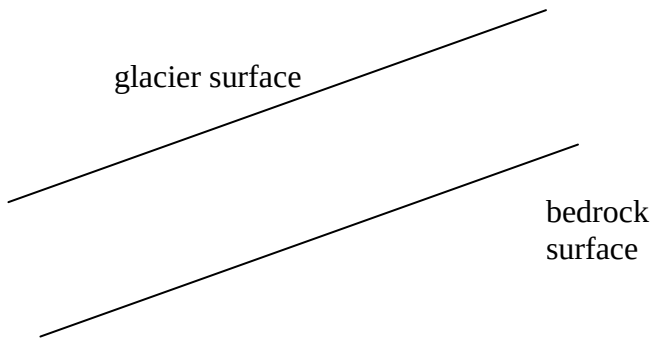
15. (2pts) What is a moulin?

C. Glacier Movement

1. (4pts) What is the equation relating the stress and strain-rate for ice? This is known as "Glen's flow law". Identify all terms and make sure the units for each are correct.

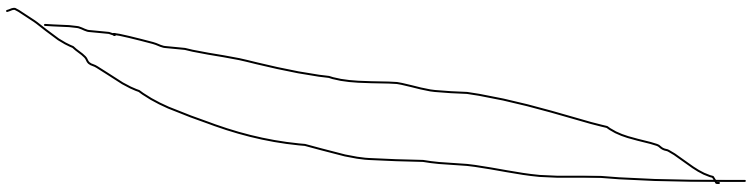
2. (2pts) Describe the effects of temperature and impurities on the viscosity of ice.

3. (5 pts) Draw the force diagram for a glacier with an inclined surface at a constant slope and constant thickness lying on a parallel bedrock surface. Label all vectors. Be careful with this drawing such that the geometry of the vectors makes sense.



4. (3 pts) What is the equation for the shear stress at the bottom of a glacier? Define each term and include units. Show that the units work out.

5. (3pts) On the longitudinal (down glacier) cross-section of a glacier show the flow lines in the ice and direction of movement. Include the position of the equilibrium line for reference.



6. (4 pts) How do glaciers flow down slope? That is, what two mechanisms exist? Do all glaciers flow this way? What is the relevance to landscape modification?

Flow processes: a._____; b. _____

7. (6pts) Do all glaciers utilize both flow mechanisms, why? What is the relevance to landscape modification by glaciers? Explain how landscape modification might differ.

8. (6pts) Describe in pictures and words the regelation process, which controls the movement at the base of the glacier. Include directions of ice flow, water flow, and heat flow. Also explain, in words, the order of the thermodynamic processes. That is, what happens first, then what happens second, and so on?

9. (4 pts) How does water pressure affect glacier movement? Please describe.

10. (5 pts) A glacier changes speed from winter to summer and from early part of the day to latter part of the day. Please describe this change in motion and explain why it happens.

11. (2 pts) The critical shear stress for ice is 1 bar (10^5 Pascals). What does this mean, that is, what is meant by the critical shear stress for ice?