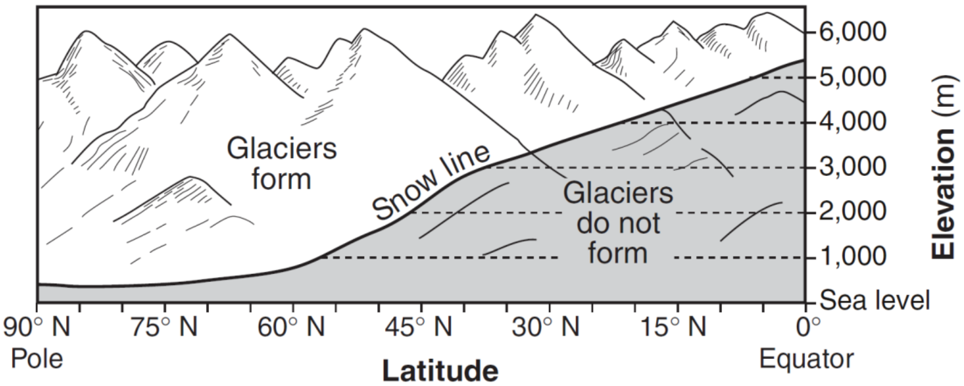
**GLACIER CHALLENGE #1: Where are glaciers and why are they there?**

*by Charles Burrows*

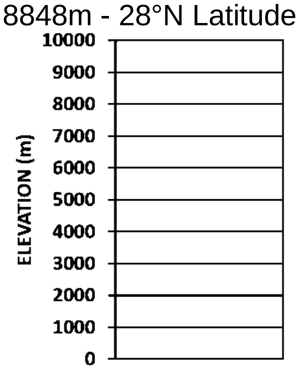
The graph below shows the snow line (the elevation above which glaciers form at different latitudes in the Northern Hemisphere).

**SNOW LINE GRAPH**

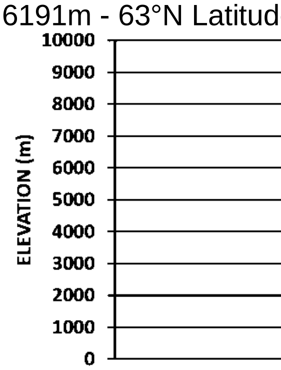



1. On the graphs below, **draw** each mountain in the shape of an upside-down "V" (like this: Λ ). The peaks should be at the given elevations. (Note: The bases of the mountains are not at sea level, but for this activity, we can ignore that, and draw the bases down to the bottoms of the graphs.)
2. Use the "Snow Line Graph" above to **draw** a horizontal line on each mountain showing where the snowline is. With a dark color, **shade** in the portion of the mountain below the snow line. The unshaded white portion of the mountain that is above the snow line is where permanent glaciers will stay on the mountain peaks.

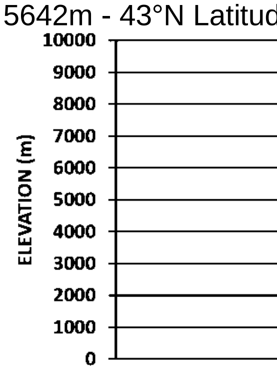
**Mt. Everest** (Nepal/China)
Tallest Mountain in Asia
8848m - 28°N Latitude



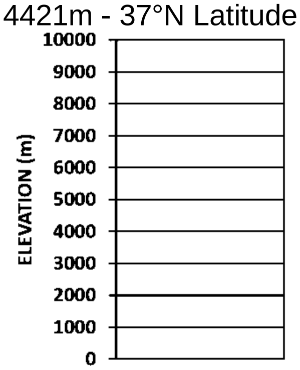

**Denali** (Alaska)
Tallest Mountain in North America
6191m - 63°N Latitude



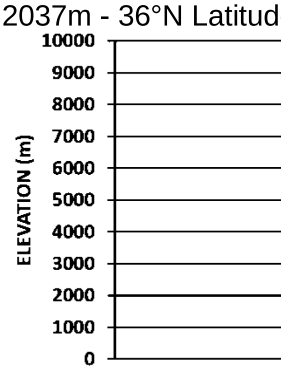

**Mt. Elbrus** (Russia)
Tallest Mountain in Europe
5642m - 43°N Latitude



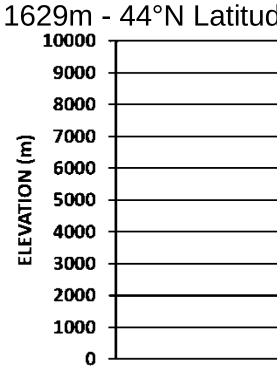

**Mt. Whitney** (California)
Tallest Mountain in Continental US
4421m - 37°N Latitude




**Mt. Mitchell** (North Carolina)
Tallest Mountain on U.S. E. Coast
2037m - 36°N Latitude




**Mt. Marcy** (NY)
Tallest Mountain in NY
1629m - 44°N Latitude




3. Do all of these mountains have permanent glaciers on their peaks? Explain.

4. What is the relationship between snow line elevation and latitude (distance from the equator)?

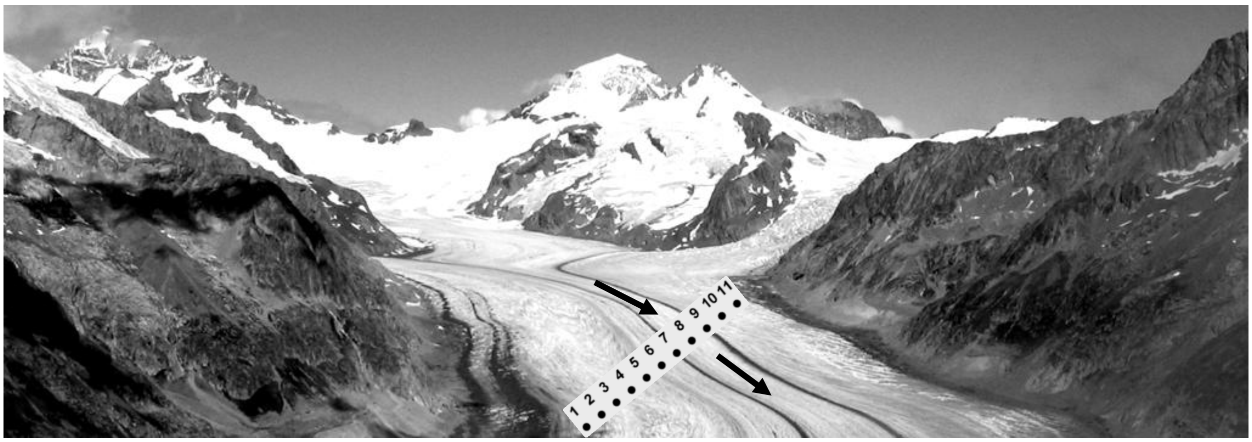
5. How would the "Snow Line Graph" have to change if global warming continues?

**<u>GLACIER CHALLENGE #2</u>: How does the surface of a glacier move?**
*by Charles Burrows*

Valley glaciers have been called "rivers of ice." The ice is moving downhill under the force of gravity. Though glacial ice is solid, these thick masses of compressed snow and ice behave like a very viscous fluid, moving slowly downhill.

If you were to watch a valley glacier for several hours, or if you just were to look at it every day for several weeks, it would be hard to tell that it was moving. However, flow rates for glaciers are very commonly measured and reported.

Survey flags (represented by black dots in the photograph below) are used to measure the flow rate of a glacier. The glacier is moving in the direction of the arrows in this photograph. Eleven survey flags were pounded into the surface of the glacier along a straight line perpendicular to the glacier's flow. Using the change in position of the flags over time, scientists can calculate the speed of the glacier.




1. Use the following data table to calculate how fast the survey flags moved **<u>in one day</u>**.

**EQUATION: Rate of Change = Change in Value ÷ Time**

**<u>SURVEY FLAG LOCATION DATA</u>***
*distances from initial position, in **centimeters**

| Flag # | 8/1/98 | 8/8/98 | Rate of Flag Motion **per Week** | Rate of Flag Motion **per Day** |
|---|---|---|---|---|
| 1 | 0 | 2.5 | | |
| 2 | 0 | 5.7 | | |
| 3 | 0 | 14.4 | | |
| 4 | 0 | 22.9 | | |
| 5 | 0 | 25.6 | | |
| 6 | 0 | 27.1 | | |
| 7 | 0 | 26.4 | | |
| 8 | 0 | 26.3 | | |
| 9 | 0 | 23.0 | | |
| 10 | 0 | 16.0 | | |
| 11 | 0 | 8.7 | | |

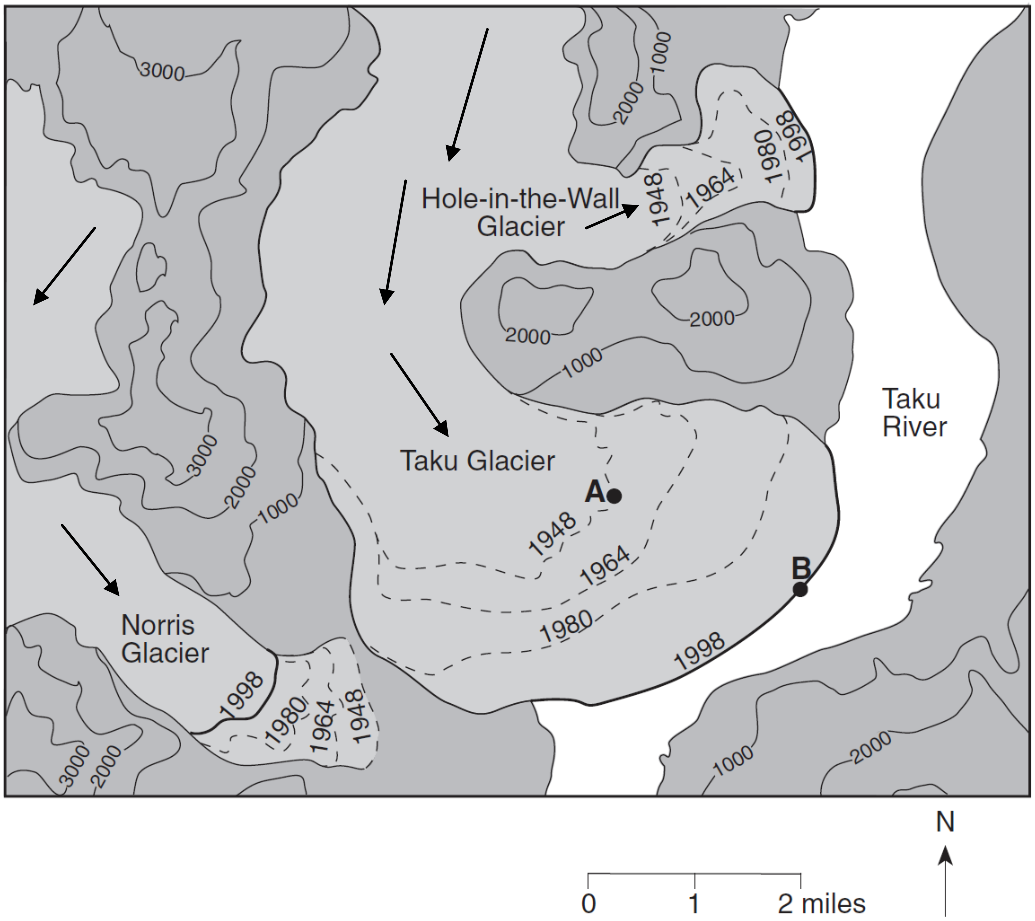
2. Which stakes moved the fastest? Why?

3. These data show how far the flags moved in one week. At this rate, calculate how far flag #6 would move in one year. SHOW YOUR WORK.

**<u>GLACIER CHALLENGE #3</u>: How quickly does a glacier advance or retreat?**

*by Charles Burrows*

Base your answers to questions 1 through 4 on the topographic map below, which shows three glaciers found in Alaska. Dashed lines show the inferred location of the front edge of each glacier in 1948, 1964, and 1980. Solid lines show the location of the front edge of each glacier in 1998. Points *A* and *B* show the location of the front edge of the Taku Glacier in 1948 and 1998. Arrows show the direction of downhill ice flow. Elevations are in feet.




**EQUATION: Rate of Change = Change in Value ÷ Time**

1. Determine the rate, in miles per year, that the front edge of the <u>Taku Glacier</u> moved between point *A* and point *B*. SHOW YOUR WORK.

2. Determine the rate, in miles per year, that the front edge of the <u>Hole-in-the-Wall Glacier</u> moved between 1948 and 1998. SHOW YOUR WORK.

3. Determine the rate, in miles per year, that the front edge of the <u>Norris Glacier</u> moved between 1948 and 1998. SHOW YOUR WORK.

4. Are the three glaciers advancing or retreating? How can you tell?

**<u>GLACIER CHALLENGE #4</u>: How does a glacial budget show us if a glacier is advancing or retreating?**

*by Charles Burrows*

**Accumulation**: New snow that falls on the glacier adds to the glacier's total mass and volume.

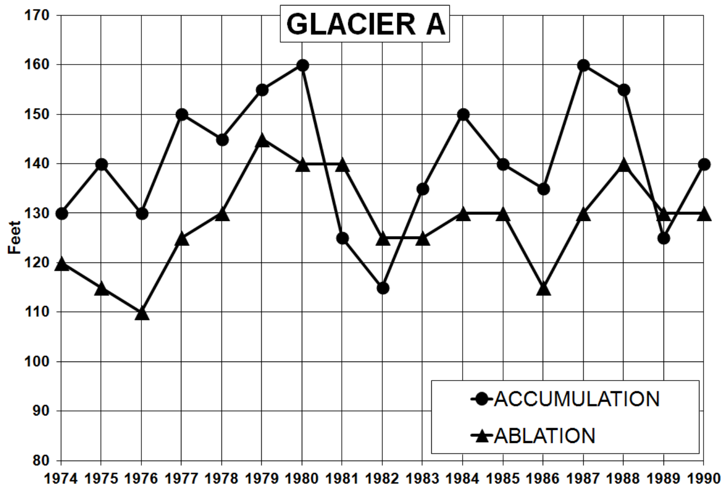
**Ablation**: The snow and ice that a glacier loses due to melting, sublimation, breaking off and floating away as icebergs, etc., causes a glacier to lose mass and volume.

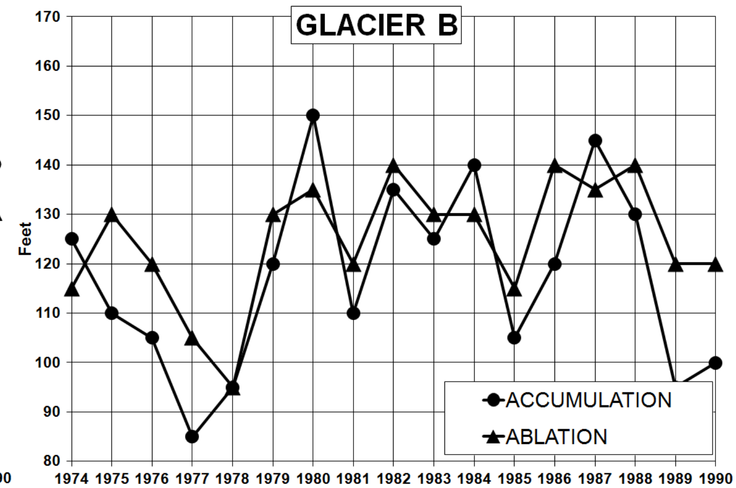
**Glacial budgets**: The balance between accumulation and ablation on a glacier in a specified amount of time. Glacial ice retreats or advances depending on the balance between accumulation and ablation.

**Zone of accumulation**: Region of a glacier where accumulation exceeds melting (surplus), usually at higher elevations near the beginning of the glacier.

**Zone of ablation**: Region of a glacier where ablation exceeds accumulation (deficit), usually at lower elevations near the end of the glacier.

1. On both graphs, lightly shade in the area <u>between the lines</u> where accumulation is greater than ablation. Fill in with diagonal lines the areas where ablation is greater than accumulation.




2. Fill in the last **<u>five</u>** empty cells in both data tables below:

| GLACIER A* | | | |
|---|---|---|---|
| Year | Accum. | Ablat. | Diff. |
| 1974 | 130 | 120 | 10 |
| 1975 | 140 | 115 | 25 |
| 1976 | 130 | 110 | 20 |
| 1977 | 150 | 125 | 25 |
| 1978 | 145 | 130 | 15 |
| 1979 | 155 | 145 | 10 |
| 1980 | 160 | 140 | 20 |
| 1981 | 125 | 140 | -15 |
| 1982 | 115 | 125 | -10 |
| 1983 | 135 | 125 | 10 |
| 1984 | 150 | 130 | 20 |
| 1985 | 140 | 130 | 10 |
| 1986 | 135 | 115 | 20 |
| 1987 | 160 | 130 | |
| 1988 | 155 | 140 | |
| 1989 | 125 | 130 | |
| 1990 | 140 | 130 | |
| CALCULATE TOTAL: | | | |

| GLACIER B* | | | |
|---|---|---|---|
| Year | Accum. | Ablat. | Diff. |
| 1974 | 125 | 115 | 10 |
| 1975 | 110 | 130 | -20 |
| 1976 | 105 | 120 | -15 |
| 1977 | 85 | 105 | -20 |
| 1978 | 95 | 95 | 0 |
| 1979 | 120 | 130 | -10 |
| 1980 | 150 | 135 | 15 |
| 1981 | 110 | 120 | -10 |
| 1982 | 135 | 140 | -5 |
| 1983 | 125 | 130 | -5 |
| 1984 | 140 | 130 | 10 |
| 1985 | 105 | 115 | -10 |
| 1986 | 120 | 140 | -20 |
| 1987 | 145 | 135 | |
| 1988 | 130 | 140 | |
| 1989 | 95 | 120 | |
| 1990 | 100 | 120 | |
| CALCULATE TOTAL: | | | |

*(*measurements are in feet of snow)*

3. What relationship between accumulation and ablation is necessary for the ice front of a glacier to advance?

4. If the ice front of a glacier remained stationary, what would be the relationship between accumulation and ablation?

5. Which glacier shows a surplus accumulation?

6. Which glacier is advancing and which is retreating?

How do you know?