Air Temperature With Flow Over a Mountain

WHAT YOU SHOULD LEARN IN THIS EXERCISE:
- **Identify how air temperature changes when wind flow encounters topography.**

BACKGROUND INFORMATION

Program
In the program for today, you will see a graphic representing two mountains. The first is 2000 m high (2 km) and the second is 3000 m high (3 km). The small circle windward of the mountains represents an air parcel.

Clicking the "Start" button will cause the air parcel to move toward the mountain, and to flow over it. There is a information about the air parcel temperature, dewpoint temperature, relative humidity and altitude to the right of the mountain diagram.

After you start the experiment and the parcel moves to the lee of both mountains, you can drag the air parcel with the mouse back over the mountains.

Necessary Knowledge
A lapse rate is a variable that describes how much temperature changes with altitude:

$$\text{Lapse Rate} = -\ \frac{\text{change in temperature}}{\text{change in altitude}}$$

The units of lapse rate are: $\dfrac{°C}{km}$

Example:

If your data shows: T = 10°C at 1 km
                        T = 5°C at 2 km

The lapse rate is:

$$LR = -\ \frac{(10°C - 5°C)}{1\ km - 2\ km} = \frac{-5°C}{-1\ km} = \frac{5°C}{1\ km}$$

WHAT YOU NEED TO DO IN THE COMPUTER LAB:

Part A: Getting Started

A1. Launch the application:
- → Go to the Hands-On Meteorology web page
- → Open the program "Mountains"

Part B: Investigating Air Temperature over a Mountain

B1. Click the Start button. [Run the program using the initial settings
(Temperature = 25°C; Dewpoint temperature = 17°C).]

B2. Move the air parcel circle back over the mountain to the locations listed in Table B,
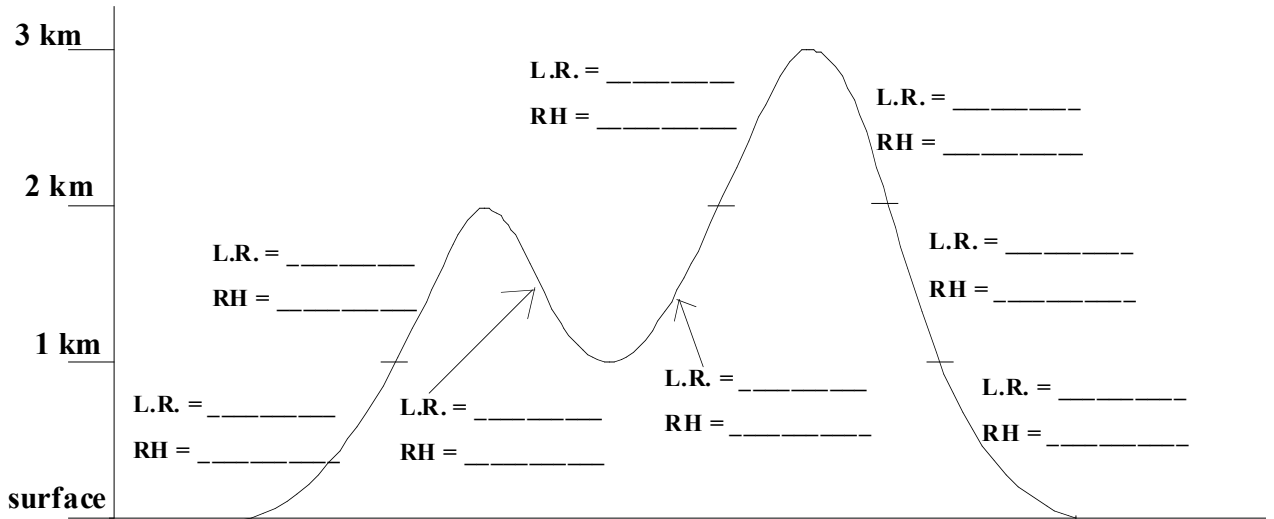and fill in the table.

Table for Part B

What were the temperature, dewpoint temperature, and relative humidity at each of
the following altitudes and locations?

Table B

	Temperature (°C)	Dewpoint Temperature (°C)	Relative Humidity (%)
surface *windward of 2 km* high mountain			
1 km altitude *windward of 2 km* high mountain			
top of 2 km mountain			
1 km *between mountains*			
2 km altitude *windward of 3 km* mountain			
top of 3 km mountain			
2 km altitude *lee of 3 km* mountain			
1 km altitude *lee 3 km* mountain			
surface *lee* of both mountains			

B3. Fill in the lapse rate (LR) and relative humidity (RH) found between altitude levels.
Use the data from Table B and by sliding the air parcel on the computer application.

Figure 1

3 km

L.R. = _____
RH = _____

L.R. = _____
RH = _____

2 km

L.R. = _____
RH = _____

L.R. = _____
RH = _____

1 km

L.R. = _____
RH = _____

L.R. = _____
RH = _____

L.R. = _____
RH = _____

L.R. = _____
RH = _____

L.R. = _____
RH = _____

L.R. = _____
RH = _____

surface

B4. Identify where clouds formed and dissipated during your simulation. What is the relationship between cloud formation and dissipation and the relative humidity of the air parcel?

Part C: Investigating air flow with different temperature & dewpoint temperatures.

C1. Hit the "Reset" button.

Run the program again, but this time try to get each of the following scenarios to occur by choosing your own starting temperature and dewpoint temperatures.

C2. A cloud forms below 1 km.   T = _____ T_d = _____

C3. A cloud forms windward of the
3 km mountain but not during
its ascent of the 2 km mountain.   T = _____ T_d = _____

C4. No cloud forms at all.   T = _____ T_d = _____

C5. A cloud forms while the parcel
is descending the lee side
of either mountain.   T = _____ T_d = _____
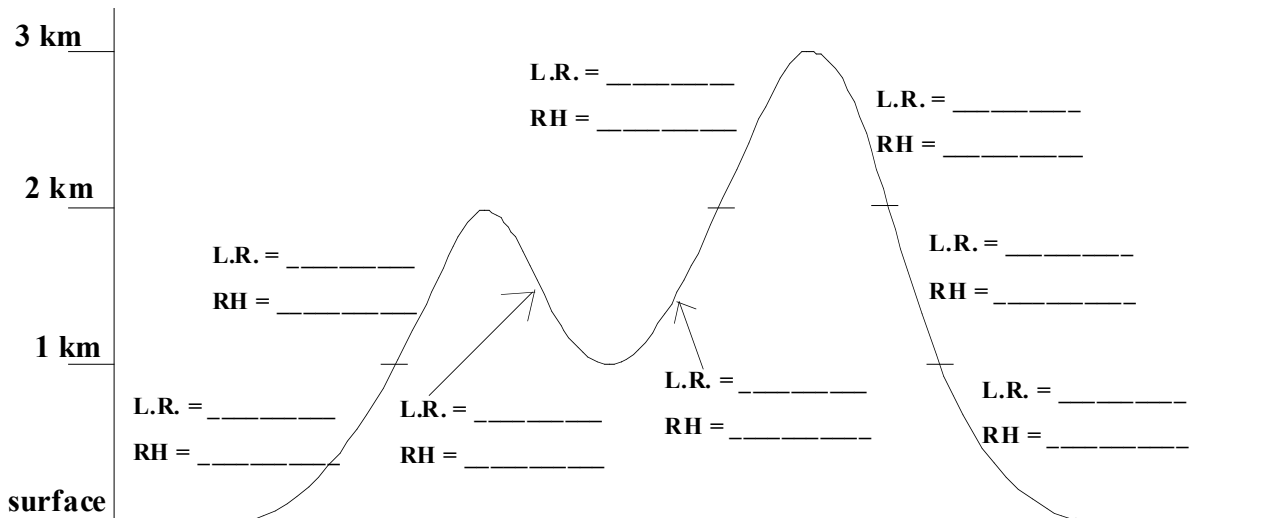(This one is tough! Think about it…)

Name: _____   *(Use this page to copy your work neatly to turn in)*

Table B

	Temperature (°C)	Dewpoint Temperature (°C)	Relative Humidity (%)
surface *windward of 2 km mountain*			
1 km *windward of 2 km mountain*			
top of 2 km mountain			
1 km *between mountains*			
2 km *windward of 3 km mountain*			
top of 3 km mountain			
2 km *lee 3 km mountain*			
1 km *lee 3 km mountain*			
surface *lee of mountains*			

B3. Fill in the diagram using the data from your table above and by sliding the air parcel on the computer application.

Figure 1

Extended Exercise #2:
Due at the beginning of Hands-On class October 3/4

WHAT YOU NEED TO TURN IN:
Please organize the following materials <u>in the order they are listed</u>, staple, and turn in.

- Cover page with your name, the date, title of exercise: "Air Temperature with Flow Over a Mountain," and your section number and instructor
- The neatly copied page of Table B and Figure 1
- The answers to questions 1 – 6 below (part D)

Note: Your answers should be typed. This will provide you with a backup copy of your assignment and prevent any misinterpretation by the TA grading the assignment.

PART D: QUESTIONS FOR THOUGHT

Complete the following:

1. List your temperature and dewpoint temperature values for parts C2, C3, C4, and C5. Briefly explain why a cloud would not form in C5. (Be sure to include units.)

2. Building on what you learned in this exercise:
    (a) What is a "rain shadow?"
    (b) Where are they found in relation to mountain ranges?
    (c) Explain why they are found in this location.

3. Denver, Colorado receives an average annual precipitation on the order of 15.4 inches. Seattle, Washington has mean annual precipitation on the order of 105 inches. Provide a reasonable explanation for this difference. Your answer should reflect what you have learned from this exercise and in class. (If you are unfamiliar with these cities geographically, look at a topographic map.)

4. (a) List the two ways that relative humidity can be changed.
    (b) You are talking to an old friend that you have not seen for several years. "Misty" tells you that she has a new roommate this year and that her roommate is complaining already that the apartment is too "dry" and she was spending all her extra money on moisturizing lotion. Provide Misty with one practical way to change the atmosphere in her apartment to solve the "dryness" problem.
    (c) After talking with Misty some more, you ask why she got a new roommate this year. She says, "My old roommate 'Rein' was always complaining that the apartment was too humid." Give Misty one easy solution that she could have used to solve the humidity problem and saved herself the trouble of getting a new roommate.

5. TA Eric and Prof. Di Girolamo take a well deserved break from ATMOS 100 and relax on the Quad with a fruity cup of mango juice. They have a cool new invention of a thermometer-swizzle stick in the juice. As the mango juice cup cools (because of

the ice), suddenly moisture starts condensing on the outside of the cup. The mango juice cup temperature is 10.0 °C when this happens. The air temperature is 20.0 °C.

    (a) Estimate the dew point temperature of the air outside the cup.
    (b) Estimate the vapor pressure of the atmosphere outside the cup.
    (c) Estimate the relative humidity (in percent) of the atmosphere outside the cup.
    (d) Where did the water that is on the outside of the cup come from?

6. By mid-afternoon on a warm summer day, cumulus clouds develop. You check the local weather report and find that the base of the cumulus clouds are at approximately 2,000 m. You assume that it is an average fair weather cumulus cloud with typical horizontal and vertical dimensions.

    (a) Briefly explain how the cloud most likely formed.
    (b) What is the altitude of the condensation level?
    (c) Estimate the lapse rate of the air parcel at 2200 m.
    (d) Estimate the lapse rate of the atmosphere at 2200 m.
    (e) Estimate the lapse rate of the air parcel at 200 m.
    (f) Estimate the lapse rate of the atmosphere at 200 m.
    (g) Sometimes cumulus clouds will grow into towering cumulonimbus clouds. Identify two conditions of the atmosphere that would prevent this from happening.