Student Name: **Grade: _____**

Physical Geology 101 Laboratory

. Structural Geology I – Classifying and Recognizing Folds and Faults

Introduction & Purpose: Structural geology is the study of how geologic rock units are initially arranged and later deformed. Changing spatial relations between geologic units and the stress and strain that occur during deformation events are key aspects in understanding geologic structures. The purpose of this lab is to both learn and apply the concepts of structural geology to reading and interpreting geologic structures, including tilted beds, folds, and faults. The terms and concepts of geologic structures, the application of structural geology to mountain building events, and the techniques used to interpret geologic structures will be presented and discussed. The three types of graphic representations of geologic structures: 1) geologic maps, 2) geologic cross sections, and 3) block diagrams will also be highlighted and discussed.

The purpose of this laboratory is to become successful at applying the principles of structural geology for both, interpreting surface and subsurface structural and geologic relations, stress and strain regimes, and solving structural problems, concerning geographic regions that expose a rock record of igneous, metamorphic, and sedimentary events, folding and faulting, and surface erosion.

Part I. PRELAB SECTION – To be completed before labs starts:

A. Measuring the Attitude of Rock Units: ***Attitude*** is the spatial orientation of planar rock structures. Two aspects of attitude are needed to constrain a rock unit or surface orientation in three-dimensional space: **1)** *Strike* and **2)** *Dip*. ***Strike*** is the compass bearing of a line formed by the intersection of a horizontal plane and the (inclined) plane of the layered rock feature. Strike can be expressed as either a quadrant, or an azimuth bearing. ***Dip*** is the angle between the horizontal plane and the planar rock unit or feature. Dip direction is always down the inclined plane and is perpendicular to the strike. Strike and dip are drawn on geologic maps as a "T-like" symbol – the long segment is the strike; the short segment the dip. A number nest to the short segment represents the dip angle. Geologists measure attitude with a compass (strike) and an inclinometer (dip).

B. Geologic Map Symbols: Geologic symbols are used on geology maps to indicate one or more characteristics of the rock formation at the point on the map that they (the symbols) are placed. Some commonly used map symbols are found in **lab manual** (you will refer to these symbols for interpreting and making geologic maps, cross sections, and block diagrams). Map symbols indicate **1**) *attitude* (e.g. strike and dip of either, bedding or foliation), **2**) *formation contacts*, **3**) *fault lines* (rock type, location, and planar orientation), **4**) *fold axes* (type, location, and their limb orientations), and **5**) rock formation information (type, name, and age). You will need to be able to recognize and interpret these symbols while working on geologic maps and diagrams.

C. Major Types of Geologic Structures

Mapable rock units are called **formations**. Locations where rock formations are exposed at the earth's surface are called **outcrops**. Undisturbed rock formations such as sedimentary beds and lava flows are typically horizontal and planar in spatial orientation. However, shifting tectonic plates produce a variety of stresses in the crust that will, over time, cause crustal deformation such as uplift, tilting, erosion, faulting, and folding of formations. **Faults** and **folds** exposed at the earth's surface in outcrops have unique structural characteristics that can be recorded, mapped, identified, categorized, and analyzed. Carefully study the major structural features listed and described in your lab manual. You will get to analyze these structures in Part II. Three-dimensional visualization of folds and faults are found on the web link at http://geology.asu.edu/~reynolds/blocks/menulist.htm. At this web site, you to be able to interactively manipulate the fold and fault blocks.

D. Structure Vocabulary - Define these basic terms used in structural geology below (from lab lecture and lab text):

1) Outcrop - ____

2) Formation - ____

3) Strike - ____

4) Dip -____

5) Contact - ____

6) Anticlines - ____

7) Synclines - ____

8) (Fold) Plunge - ____

9) Footwall - ____

10) Hanging wall - ____

11) Normal Fault - ____

12) Reverse Fault - ____

13) Thrust Fault - ____

14) Strike-Slip Fault - ____

15) Slickensides - ____

E. Rules for Interpreting Geologic Structures

There is a set of rules of structural geology used for interpreting geologic structures found in **Figure 10.11** in your lab manual. Carefully study and make use of these rules for completing Part II. The most important rules are listed below:

1) Strike of beds is always parallel to the direction of the contacts.

2) Rock layers dip towards the youngest exposed rock layers.

3) Oldest rocks exposed in the center of eroded anticlines and domes.

4) Youngest rocks exposed in the center of eroded synclines and basins.

5) Horizontal folds form parallel sets of belt-like outcrop patterns.

6) Plunging anticlines form “V” of "U" shaped, belt-like outcrop patterns.

- ✓ Anticline fold plunges toward *closed* end of “V” or “U” pattern.

7) Plunging synclines form ”V” of “U" shaped, belt-like outcrop patterns.

- ✓ Syncline fold plunges toward *open* end of “U” pattern.

8) Steeper the dip of the layer, the more narrow the width of its outcrop.

9) Hanging wall *moves up* relative to foot wall in reverse and thrust faults.

10) Hanging wall *moves down* relative to foot wall in normal faults.

11) Slickenside grooves that are oriented horizontal in fault scarp indicate strike-slip offset.

12) Slickenside grooves that are oriented vertical in fault scarp indicate dip-slip offset.

Part II. IN-LAB SECTION:

Introduction: Three-dimensional geologic block diagrams are scaled-down, abstract, simple representations, or models of Earth's crustal rock structures, which include 1) formations, 2) unconformities, 3) faults, 4) folds, and 5) topography. Block diagrams are a 3-dimensional composite of both, a geologic map (horizontal map-view) and geologic cross-sections (vertical side-views). The key to successfully completing the block diagrams lies in *visualizing* the 2-D representations as 3-D structure.

A. STRIKE AND DIP BED AND BLOCK EXERCISES

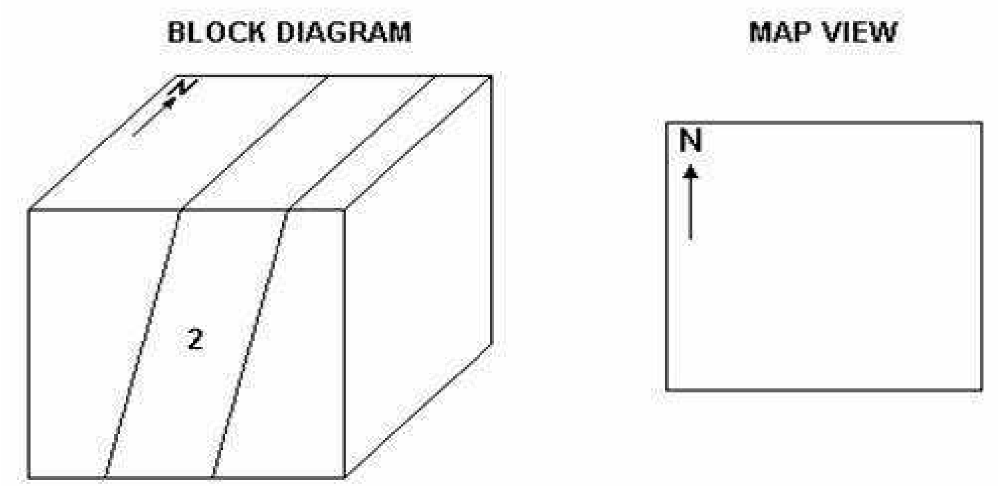
1. Measure the strike and dip of the two planar objects the instructor has set up in the class:

a) Planar Object "X" - Strike =________Dip = ______

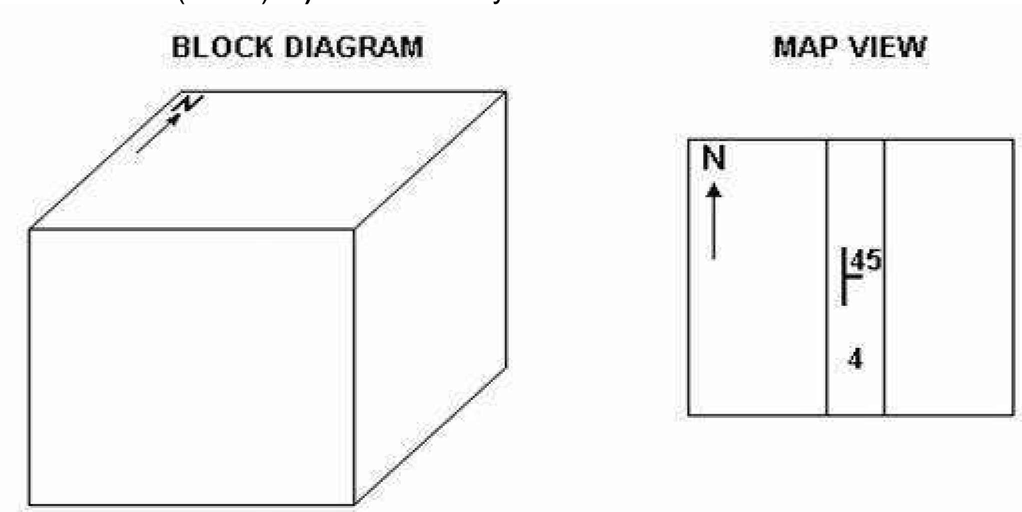
b) Planar Object "Z" - Strike =________Dip = ______

2. a) Number the layers on all sides of the block (below). b) Place a strike and dip symbol on top of layer 2. **c)** Complete the geological map showing the outcrop of layer 2 and its strike and dip symbol.

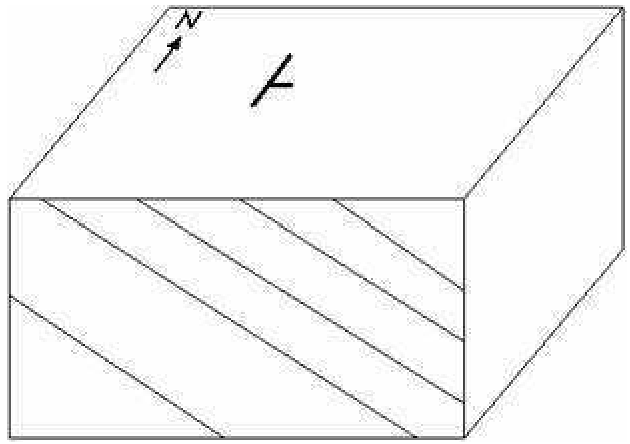
Estimate and record the strike and dip here: __________________



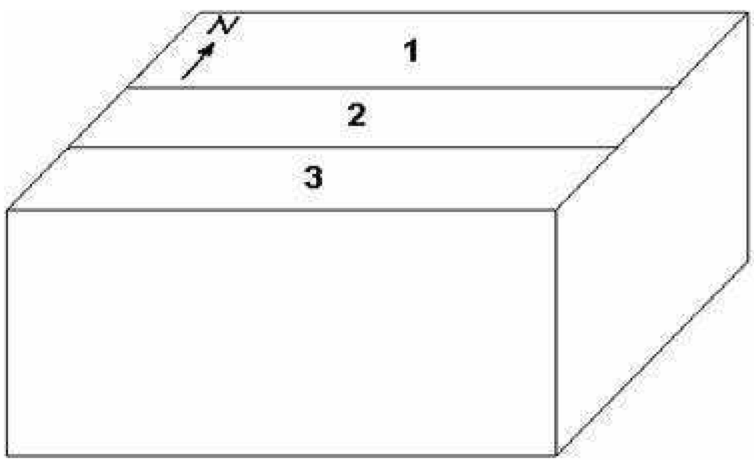
3. a) Complete the block (below). **b)** Number all layers on all surfaces.



4. **a)** Complete the block (below) using the strike and dip shown on block's top. **b)** Number all the beds. **c)** Estimate the dip amount and write it next to the strike and dip symbol. **d)** State the strike and dip in words here: ____________________



5. **a)** Complete the block below using a **60° dip amount**. Note that the dip (tilt) direction must be determined from the age of the layers. **b)** Place a strike and dip symbol on the top of the block.
Estimate the strike and dip of the beds. ____________________



Part III - Identifying, Describing, and Interpreting Geologic Structures in 3-D Block Diagrams

Introduction: Three-dimensional geologic block diagrams are scaled-down, abstract, simple representations, or models of Earth's crustal rock structures, which include 1) formations, 2) unconformities, 3) faults, 4) folds, and 5) topography. Block diagrams are a 3-dimensional composite of both, a geologic map (horizontal map-view) and geologic cross-sections (vertical side-views).

In this exercise, you will construct and analyze geologic block models using the six cardboard models provided in the very back of your lab manual. These models are pre-constructed and will be provided by your instructor.

A. Geologic Model #1 Activities

Directions: Complete the block diagram by doing the following:

1) Construct the vertical cross section on the north side of the block. Include 1) the formations, contacts, and formation attitudes. Note that the yellow sandstone unit dips 25 degrees to west and the gray shale unit is vertical.

2) Place attitude symbols on the map view (top) portion of the block diagram

3) Note that both, the yellow sandstone, and gray shale units have the same bed thickness. However, in map view (top of block), the yellow sandstone unit appears much wider.

Question: Why? ____

B. Geologic Model #2 Activities

Directions: Complete the block diagram by doing the following

1) Construct the north and east sides of the block. Notice that the rock units are folded.

Question: What type of fold do these rocks units exhibit? ____________________

Question: Is the fold plunging or non-plunging? ___________________________

Question: How can you tell? ____

2) On the geologic map (top portion) draw in the proper strike and dip symbols for formation **E** at the points **I, II, III**, and **IV.** Also draw in the proper fold symbol along the axis of the fold

Question: How do the strike and dip symbols at all locations compare with each other?

____

____

Question: How does the dip direction at points **I** and **II** compare with the dips direction of **III** and **IV?**

____

____-____________

3) On the geologic map (top portion) there is a distinctive pattern of the outcropping map units, both spatially, and temporally (age sequence of formation)

Question: Which unit is the oldest?__________Which is the youngest? __________

Question: What stratigraphic principle are you using to answer the above question?

____

Question: What is the age sequence of the units in map view as you go from the center of the fold (axis) outward (from C to G)?

____

C. Geologic Model #3 Activities

1) Complete the north, south, and east sides of the block. Notice that the rock units are folded.

Question: What type of fold do these rocks units exhibit? ________________________

Question: Is the fold plunging or non-plunging? ________________________________

Question: How can you tell? ____

2) On the geologic map (top portion) draw in the proper strike and dip symbols for formation **C** at the points **I, II, III**, and **IV.** Also draw in the proper fold symbol along the axis of the fold

Question: How does the dip direction at points **I** and **II** compare with the dips direction of **III** and **IV?**

____

____

3) On the geologic map (top portion) there is a distinctive pattern of the outcropping map units, both spatially, and temporally (age sequence of formation)

Question: Which unit is the oldest?__________Which is the youngest? __________

Question: What stratigraphic principle are you using to answer the above question?

____

Question: What is the age sequence of the units in map view as you go from the center of the fold (axis) outward (from A to E)? Oldest versus youngest?

Center = __________ Outer edge of fold = ____________

D. Geologic Model #4 Activities

1) Complete the north and east sides of the block. Notice that the rock units are folded.

Question: What type of fold do these rocks units exhibit? _________________________

Question: Is the fold plunging or non-plunging? __________________________________

Question: How can you tell? ____

Question: If it is plunging, then which direction? _______________________________

Question: How can you tell? (Which rule in figure 10.13 helps you to tell)?

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2) On the geologic map (top portion) draw in the proper strike and dip symbols for formation "**E**" at the points **I, II, III**, **IV and V.** Also draw in the proper fold symbol along the axis of the fold, including its direction of plunge.

Question: How do the strike and dip symbols at all five locations compare with each other?

____

Question: How do the strike and dip attitudes of this model compare with those of model #3**?**

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3) On the geologic map (top portion) draw in the proper strike and dip symbol for the orientation of formation **I** at the point **VI.**

Question: What type of unconformity is at the base of formation "**I**" ?

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4) On the geologic map (top portion) there is a distinctive pattern of the outcropping map units, both spatially, and temporally (age sequence of formation)

Question: Which unit is the oldest?__________Which is the youngest? __________

Question: What stratigraphic principle are you using to answer the above question?

____

Question: What is the age sequence of the units in map view as you go from the center (core) of the fold (axis) outward (from formation **B** to **H**)?

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E. Geologic Model #5 Activities

1) Complete the north and east sides of the block. Notice that the rock units are folded.

Question: What type of fold do these rocks units exhibit? ___________________________

Question: Is the fold plunging or non-plunging? ____________________________________

Question: How can you tell? ____

Question: If it is plunging, then which direction? __________________________________

Question: How can you tell? Which rule in figure 10.13 helps you to tell?

____

2) On the geologic map (top portion) draw in the proper strike and dip symbols for formation **G** at the points **I, II, III**, **IV and V.** Also draw in the proper fold symbol along the axis of the fold, including its direction of plunge.

Question: How do the strike and dip symbols at all five locations compare with each other?

____

Question: How do the strike and dip attitudes of this model compare with those of models #3 and #4**?**

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3) On the geologic map (top portion) there is a distinctive pattern of the outcropping map units, both spatially, and temporally (age sequence of formation)

Question: Which unit is the oldest?__________Which is the youngest? __________

Question: What stratigraphic principle are you using to answer the above question?

____

Question: What is the age sequence of the units in map view as you go from the center (core) of the fold (axis) outward (from formation **H** to **C)?**

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Question: Compare your answer above to the same question asked for **model #4**.

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F. Geologic Model #6 Activities

Note: Model **#6** includes a fault structure. The fault strikes due west and dips 45 degrees to north.

Directions: Complete the block diagram by doing the following:

1) a) At point "**I**", draw a strike and dip symbol showing the *orientation* of the fault.
b) On the west edge of the block, draw arrows parallel to the fault, indicating relative motion.
c) Label the hanging wall and footwall.

2) Complete the vertical cross section on the east side of the block. Draw arrows parallel to the fault, indicating relative motion.

3) Note points **II** and **III** on the top (map) view of the block. Write the letter "**U**" on the side of the fault that went up, and a letter "**D**" on the side that went down. Draw strike and dip symbols at points **IV** and **V** for formation **B**.

Question: Which type of fault is shown in model #6? ____________________________

Question: How can you tell? ____

Question: On the geologic map (top view), what happened to the contact between units **A** and **B** where it crosses the fault?

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Question: Could the same apparent offset motion along this fault have been produced by strike-slip motion? Explain why or why not.

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Part IV – Structural Geology I Laboratory Reflection

Directions: Write a 120 word minimum reflection of the lab activity, explaining its purpose, the methods used, the results obtained, and a brief personal reflection of what you enjoyed and learned about doing this lab (*3 points possible*). Answer the following 3-point question reflection set on a separate sheet of paper:

1) What was the purpose of this lab? What did you actually discover and learn during this lab?

2) What did you enjoy most about this lab? Also, what was challenging or thought-provoking?

3) What are your constructive comments about the design and execution of this lab? What's good? What's bad? Offer suggestions for making the lab better.

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