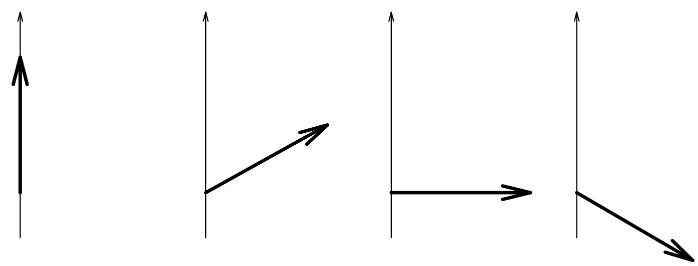
Tutorial 1: Projections

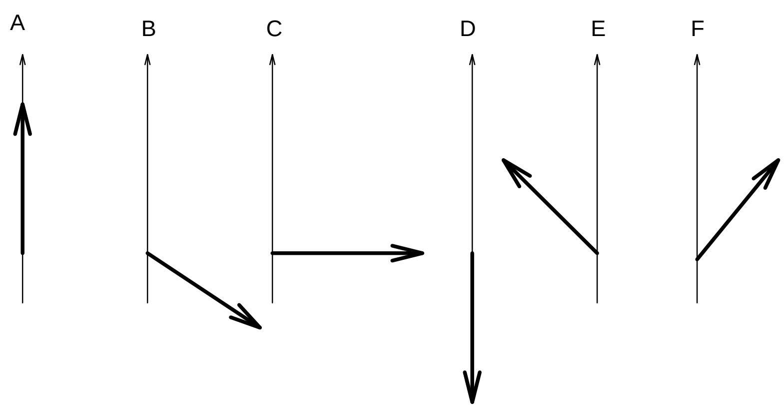
This tutorial worksheet is not to be handed in, it is yours to keep as a reference for helping with the homework and the exams.

1. Projections

(a) Using the rules listed on page 8 of *Strange World*, describe the projections of the short thick arrows on the axes indicated by the long arrows. Use words like small, large, positive, negative, zero etc. Discuss your descriptions with other members of your group.



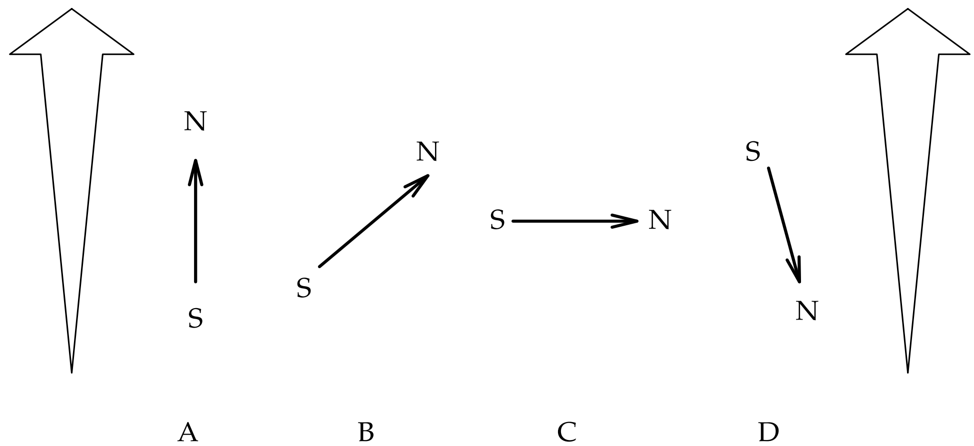
(b) Rank the following projections from largest to smallest. Do not ignore the sign. For example, a negative projection will rank **smaller than** a small positive projection. If two projections are equal, say so.



Make sure everyone in your group agrees on the rankings before proceeding to the next section.

2. Net force on a magnetic needle in a field

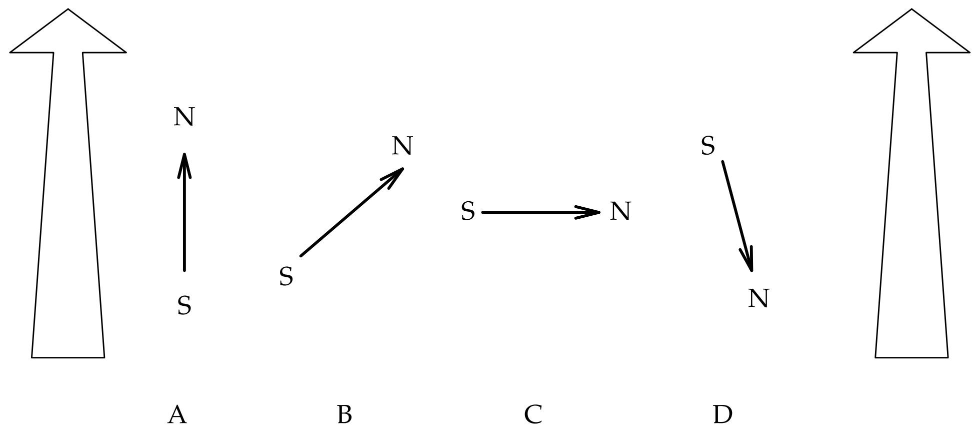
(a) Consider the four magnetic needles in the nonuniform magnetic field shown below. For each magnetic needle, draw little arrows to indicate the direction and size of the force experienced by the N and S poles. The length of each little arrow should depict the strength of the force on the N or S pole and each needle should have two little arrows drawn on it.



Using the little arrows drawn in the figure above, determine the size (*e.g.*, large, small) and the direction (*e.g.*, same as or opposite to the magnetic field) of the net force on each needle.

Now find the projection of each of the four needles *along the direction of increasing magnetic field* by using the rules for projections developed in class. Qualitatively describe these projections (*e.g.*, large and negative).

(b) Consider the same magnetic needles in the different field shown below. For each magnetic needle, draw little arrows to indicate the direction and size of the force experienced by the N and S poles (do not calculate the projections here).



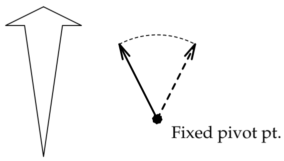
What is the size (*e.g.*, large, small) and direction (*e.g.*, same as or opposite to the magnetic field) of the net force on each needle?

Determine the projection of each of the needles along the *direction of increasing magnetic field.* Describe these projections.

(c) Based on your answers to parts 2(a) and 2(b) above, can you suggest a general rule for using projections to determine the net force on a magnetic needle in a nonuniform field?

Check with an instructor before proceeding.

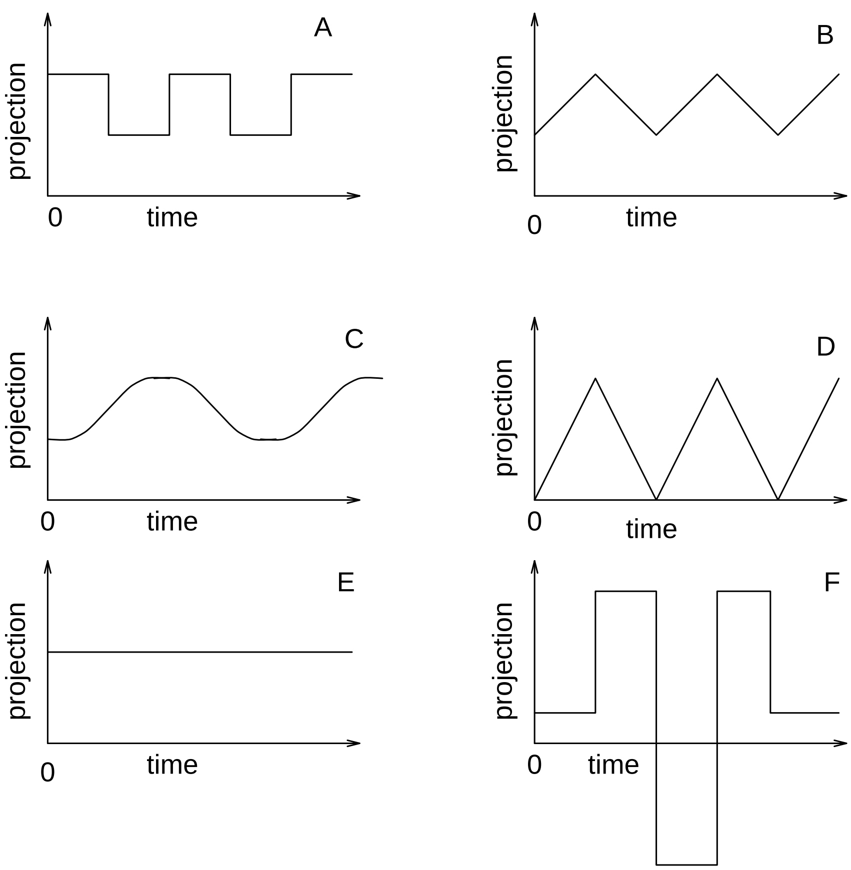
3. Projection of an oscillating magnetic needle



A magnetic needle has it's base fixed on a pivot, so it can only rotate about the pivot point. It is placed in a magnetic field that points up and increases in the vertical direction. Ignore any effects due to friction.

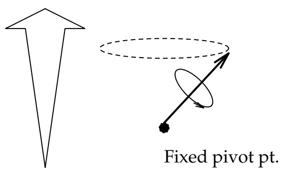
(a) Describe the motion of the needle.

(b) Which of these graphs could represent the projection of the needle on the direction of increasing magnetic field as a function of time? (Assume that at time=0, the orientation of the needle is given by the solid arrow shown above.) Describe what is wrong with the graphs you did not choose.



(c) When will the projection be the same as the initial (time=0) projection? Indicate these points on the graph(s) that you chose above. Draw pictures showing the orientation of the needle at each of the times you mark.

4. Current loop in a magnetic field



A current loop is now placed in the same magnetic field. Recall that the current loop is represented by an effective arrow, in the same way that a magnetic needle was represented by an arrow. Suppose the base of the effective arrow is fixed on a pivot.

(a) Describe the motion of the arrow representing the magnetic needle. (Hint: consider the dashed lines.)

(b) Which of the graphs on the previous page describe the projection of the arrow on the direction of increasing field as a function of time?

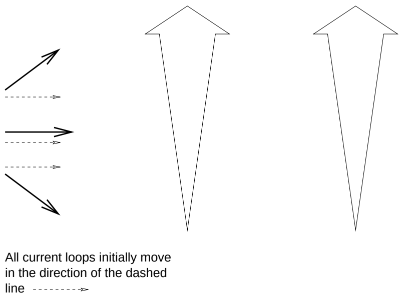
Two students, Beavis and Butthead, are having a discussion about the projection of the current loop (now that they no longer appear on MTV):

- *Beavis*: The arrow that represents the current loop moves when the loop is placed in a magnetic field. Therefore the projection must change as a function of time.
- *Butthead*: I disagree, buttmunch. The arrow moves, but it moves in such a fashion that the projection always remains the same. Iron Maiden rules!

With which student do you agree ? Explain your reasoning (drawing some diagrams might help).

Check with an instructor before proceeding to the next section.

4. The Classical Stern-Gerlach experiment



A collection of current loops move from left to right in a nonuniform magnetic field. Three representative loops are depicted by the three effective arrows shown above (in bold). Their velocity is shown with the dashed-line arrows, and is the same for all current loops in the beam. Describe what happens to each of the current loops as it passes from left to right through the nonuniform field. *Note there are many arrows on this page—the magnetic field direction, the axis of increasing magnetic field, the effective needle that represents the current loop, the velocity of the current loop as it passes through the magnetic field and so on. Be sure you keep these different "arrows" clear in answering this problem.*
It might be helpful to consider the following questions:

- Do the effective arrows that represent the current loops oscillate or precess in the magnetic field?

- How does the projection of each effective needle on the direction of increasing magnetic field change as a function of time?

- What is the net force (size and direction) on each of the three current loops shown in the figure above?

- Sketch the path each current loop takes as it moves from left to right through the nonuniform field (Is this path a straight line or a curve? Explain.).