

Deadline: 26 March

## Writing

- Select **one** of the following items and write a 500-600 word essay in response. Address the issues posed, but feel free to extend their scope.
- Using *concise and clear sentences*, incorporate symbols and illustrations into your text. Have an audience in mind. Focus on *developing* an explanation or argument. Using specific examples to illustrate a general idea or claim is often a helpful tactic. What are you trying to show and how are you're trying to show it?
- Writing well is difficult and can be painful. For writing assistance, consult the style and content guide at the class website. There's no required stylistic format; writing can range from technical to literary.
- Typed work is expected. Hand-drawn figures are acceptable.
- Submit to the appropriate Beachboard dropbox.
- You may work with a partner. Submit one paper for the group.

- 1) Pooh looked at his two paws. He knew that one of them was the right, and he knew that when you had decided which one of them was the right, then the other was the left, but he never could remember how to begin.

—*The House at Pooh Corner*

Is the conceptual distinction between up and down easier to acquire than that between left and right? What about front and back? Defend your answer.

- 2) In *Symmetry and conservation laws*, Wigner claims that the discovery of physical laws depends on their invariance under certain transformations—translation, rotation in space and translation in time. That is, if the laws didn't have these symmetries, we wouldn't have discovered them in the first place. Critically assess this claim—either defend it or argue against it. You might try using specific and concrete examples to develop your case.
- 3) Carefully explain how Madam Wu's Cobalt-60 experiment (showing that certain nuclear processes are not mirror-symmetric) allows a viewer to determine whether a motion picture of the experiment is running with left and right reversed—that is, with the film flipped over.
- 4) **Spinning cylinder and cone.** Sitting still, a cylinder and a cone are both achiral. What happens if you start them spinning about their axes of rotational symmetry? Are the *spinning objects* achiral? Recall Madam Wu's Cobalt-60 experiment that revealed a lack of reflective symmetry in nuclear decay. Does her experiment indicate that nuclear decay processes behave like a spinning cylinder or cone?
- 5) In spacetime we can treat time as a dimension in much the same way as the dimensions of space. Discuss the ways in which *time-reversal*—having things run backwards in time—is like a reflection in space. (Try using a graphical depiction of spacetime. Let one axis represent the time dimension and the other axis stand for the space dimensions.) Give an example of a path in spacetime (called a “worldline”) that looks the same if time is reversed at some moment.
- 6) **From micro-symmetry to macro-asymmetry.** At a microscopic level, material objects appear to consist of very large collections particles in motion. What kind of symmetry holds at the level of the particles when they are considered *individually*? Does a system like this—a bottle of gas, say—have time-reversal symmetry? Now, consider the particles *collectively*. Does the collection have time-reversal symmetry? Conduct an explicit thought experiment to investigate the issue.

7) Consider a ball on a curved track as shown in Figure 1. Starting at the bottom of the “well” suppose you give the ball exactly the amount speed so that it climbs the hill and stops when it reaches the top.

Explain 1) how this *seems* to be a violation of time-reversal symmetry and 2) that it isn't really.

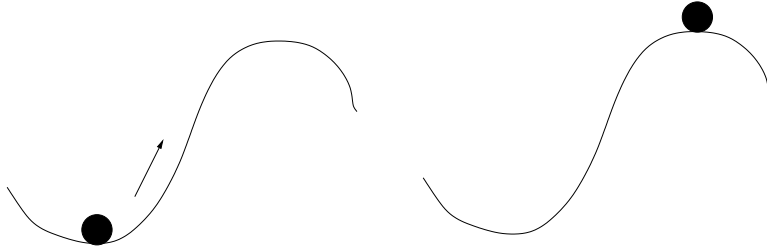


Figure 1: The ball rolls to the peak and then stops.