# Homework One

## Thermodynamics

## College of the Atlantic

**Due Friday, April 2, 2021**

There are two parts to this assignment.

**Part 1: Short Reflection**. There is prompt on google classroom that I'd like you to write a short response to.

**Part 2: Problems from the Textbook**. Here are some instructions for how to submit this part of the assignment.

- Do the problems by hand using pencil (or pen) and paper. There is no need to type up this assignment.
- Make a pdf scan of your work using genius scan or some similar scanning app. Please make the homework into a single pdf, not multiple pdfs.
- Submit the assignment on google classroom. Please don't email it to me.
- Do the last problem in the groups you were in on the first day of class. Hand in only one write-up for your group.
- If you want, you can do other problems in your group and hand in only one set of solutions for those problems, too.

1. 1.4
2. 1.9
3. 1.11
4. 1.14
5. This is a problem based on question 1.16 from the textbook. The goal is to use Newton's second law ($\vec{F}_{\text{net}} = m\vec{a}$) and the ideal gas law to derive the barometric equation. To do so, consider a slab of air with a thickness of $\Delta z$ at rest at a height $z$ above the surface of the earth. Denote by $M$ the mass of the air in the slab. Let $A$ be the horizontal area of the slab.

   (a) Use Newton's law to derive an expression for $\frac{dP}{dz}$, the rate at which pressure changes with altitude. *Hints:*

   - The derivative is defined as:

   $$\frac{dP}{dz} = \lim_{\Delta z \to 0} \frac{P(z + \Delta z) - P(z)}{\Delta z} \,. \tag{1}$$

   - There are three forces acting on the slab.

(b) Use your answer to the previous problem and the ideal gas law to show that:

$$\frac{dP}{dz} = -\frac{mg}{kT}P \,, \tag{2}$$

where $m$ is the average mass of the air molecules. This equation is known as the barometric equation.

(c) Show that, assuming that $T$ is constant, the solution to Eq. (2) is given by:

$$P(z) = P(0)e^{-mgz/kT} \,, \tag{3}$$

where $P(0)$ is the pressure at sea level.

(d) Use Eq. (3) to calculate the pressure, in atmospheres, at the following locations:

i. Cadillac Mountain
ii. Katahdin Mountain
iii. Cerro El Pital
iv. Гора Эльбрус

Assume that the pressure at sea level is 1 atm.