

1 Power from the Ocean

It has been proposed to use the thermal gradient of the ocean to drive a heat engine. Suppose that at a certain location the water temperature is 22°C at the ocean surface and 4°C at the ocean floor.

- (a) What is the maximum possible efficiency of an engine operating between these two temperatures?
- (b) If the engine is to produce 1 GW of electrical power, what minimum volume of water must be processed every second? Note that the specific heat capacity of water $c_p = 4.2 \text{ Jg}^{-1}\text{K}^{-1}$ and the density of water is 1 g cm^{-3} , and both are roughly constant over this temperature range.

2 Violating the Second Law

It is very common for people to come up with schemes and inventions that violate the Second Law of Thermodynamics. These schemes consistently fail to work, and it is valuable to learn to evaluate whether a scheme will indeed violate the Second Law. In this problem, I'm going to ask you to skim through one or more recent articles, and identify and explain *one* claim that violates the Second Law. Not every article below contains a violation of the Second Law, so you may need to read more than one article.

- “Physicists build circuit that generates clean, limitless power from graphene” (phys.org)
- “Fluctuation-induced current from freestanding graphene: towards nanoscale energy harvesting” (arxiv.org)
- “Fluctuation-induced current from freestanding graphene” (Physical Review E)

As an alternative to finding a violation in the Second Law in one of the above articles, you could find another publication violating the Second Law, and share that.

Once you have identified a violation of the Second Law, please write up a short paragraph explaining *why* it violates the Second Law of Thermodynamics, including a direct quote demonstrating the error. Sometimes it is helpful to construct a scenario in which the proposed invention or observation could be used to heat up a system that is warmer using thermal energy extracted from a system that is cooler.

Hint: papers that claim not to violate the Second Law frequently do.