Physics 524 Week 10 Homework Exercises

Due: Tuesday 11/5/2024 at noon

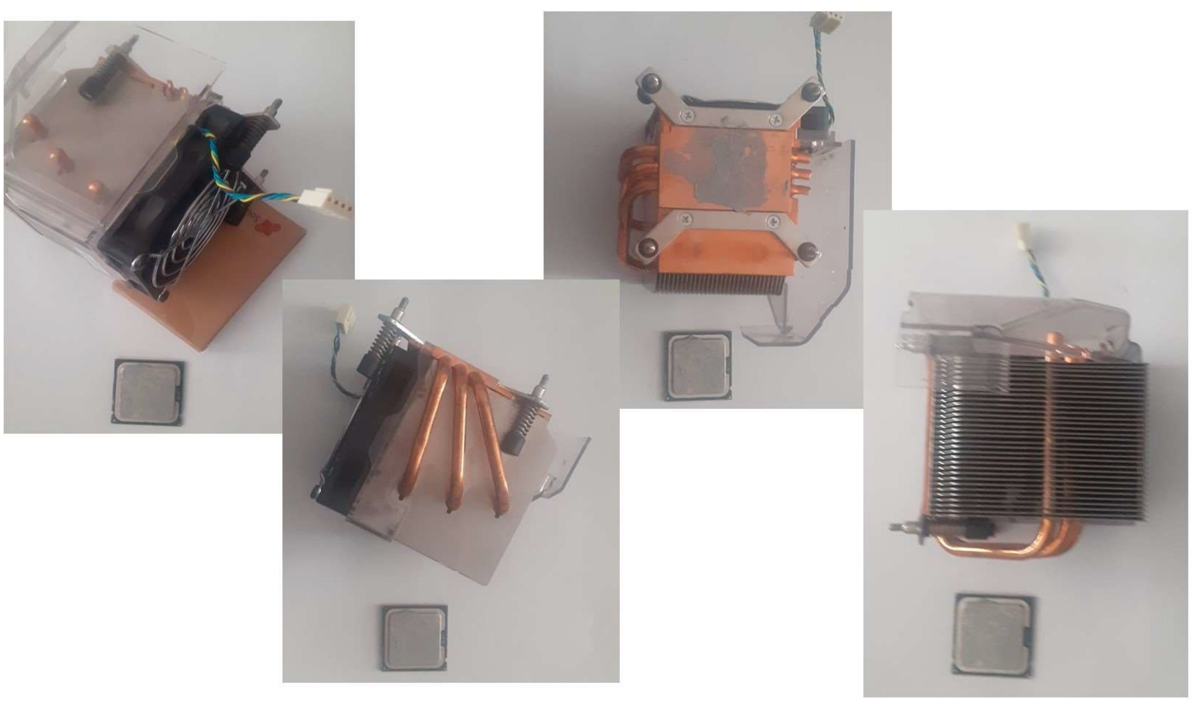
Due date reminder, etc.

Please email your completed assignment to the course TA by Tuesday next week before class.

Your homework submissions—code, cell phone photos, etc. must include enough identifying information for us to tell who you are!

Section 3: Problem (2)

A processor chip dissipating 75W needs to be cooled by conducting heat away to a finned heat exchanger (the heat sink). The cooling block in contact with the chip through a thin thermal grease joint has grooves for three 6 mm diameter heat conduits, as shown in the figure. The total cooling path from the center of the cooling block to the center of the finned radiator is 15 cm. The fan is powerful enough (and has enough range of driving voltage) to keep the heat sink at 40˚C under all circumstances. This temperature is maintained by feedback from a temperature sensor mounted near the fan itself (note the 4-wire connector in the photo montage).

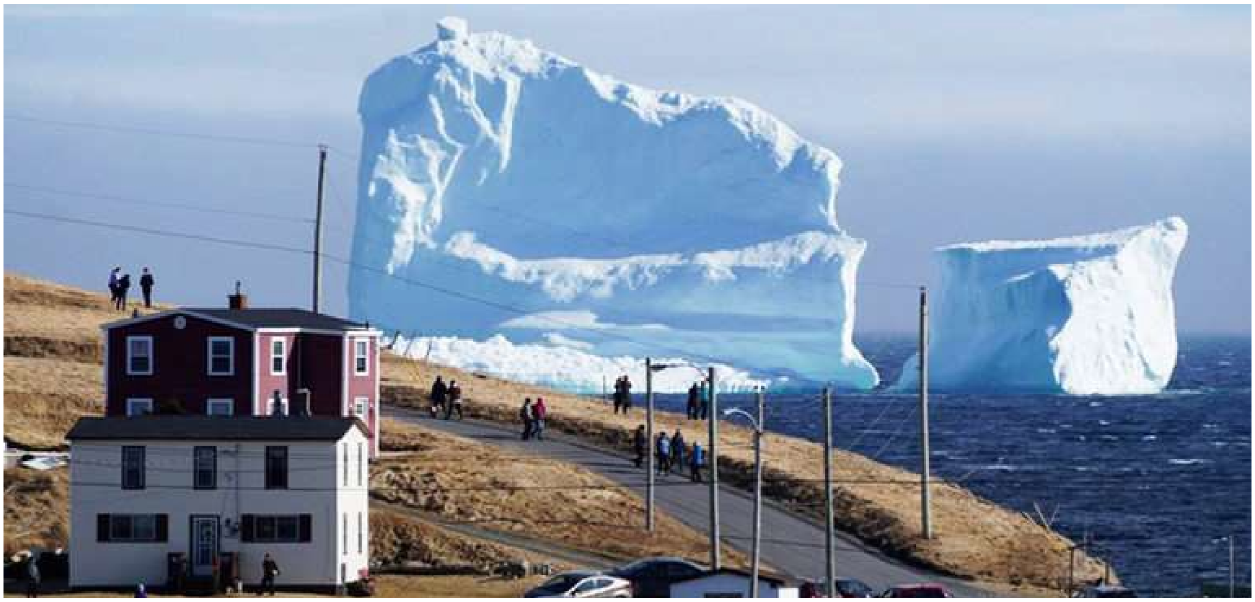


The computer user notices that, after turn-on the processor chip (monitored by its own internal temperature sensor) rapidly increases to over 12˚C higher than its normal operating temperature before the system annoyingly takes remedial action by decreasing the processor clock frequency etc. Doing some research the user finds that this cooling configuration uses three low-pressure water-filled copper heat pipes with 1mm wall thickness and a nominal thermal conductivity 20000 $W.m^{-1}.K^{-1}$ and surmises that one might have failed (leaked up to atmospheric pressure).

- Would the user be correct in this assumption?
- Why, or why not? Show your reasoning with a calculation.

Hint: a failed heat pipe would revert to the thermal conductivity of a copper tube of 6mm outer diameter and 1mm wall thickness.

Section 3: Problem (3)



Part of the Larsen-C ice shelf broke off from Antarctica in July 2017 and drifted North as iceberg A-68 before melting away. A-68 was 170 km long, 50 km wide with an average thickness of 200m.

(a) Using the Latent heat of fusion L of water (333 kJ/kg) estimate the combined energy absorbed from the sea and atmosphere to melt A-68. The density of ice is 917kg/m^3.

(b) Let's assume that the energy from (a) comes from global warming. It is estimated (with big uncertainties as inspections are less frequent than they used to be) that the World's stockpile of nuclear weapons is around 10 000 megatonnes of TNT equivalent. The explosion of 1 megatonne of TNT has an energy release of around 4.2×10^{15} Joules. What percentage of the World's 10000 Mt stockpile of nuclear weapons would need to be exploded to melt iceberg A-68? (Assume all the energy goes into melting ice). How many gigajoules is that?

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(c) Now let's pretend that A-68 never existed (i.e. that there is no ice to buffer atmospheric heating), and that the global warming energy calculated from (a) above went instead into heating the Earth's

atmosphere. Taking the Earth's radius as 6370 km and assuming the effective atmospheric depth to be 16 km (this height contains more than 90% of the atmospheric mass), how much would the atmospheric mass be raised in temperature?

(d) Should we be worried? Why, or why not?

Hints

(1) use "average values" of the C_p (1.0036 kJ.kg^{-1}.K^{-1}) and density of air (0.45 kg.m^{-3}) at the temperature of – 43˚C and pressure (0.3 barabs), corresponding to an altitude of 8 km: half the 90% mass height of 16km;

(2) The average sea depth is 3688 metres and sea covers 71% of the Earth's surface. Oceans hold 96.5% of the Earth's water. According to the U.S. Geological Survey, there are over 1,386,000,000 cubic kilometers of water on the planet. Of this vast volume NOAA's National Geophysical Data Center estimates that 1,335,000,000 cubic kilometers is in the oceans. Ocean water mass = 1.335x10^{18} tonnes.