PH315 Physics of Contemporary Challenges Winter 2018

Practice Midterm Exam

Time: 12.00 – 12.50pm

This practice midterm has more questions than the actual midterm.

Show your working unless the problem states otherwise.

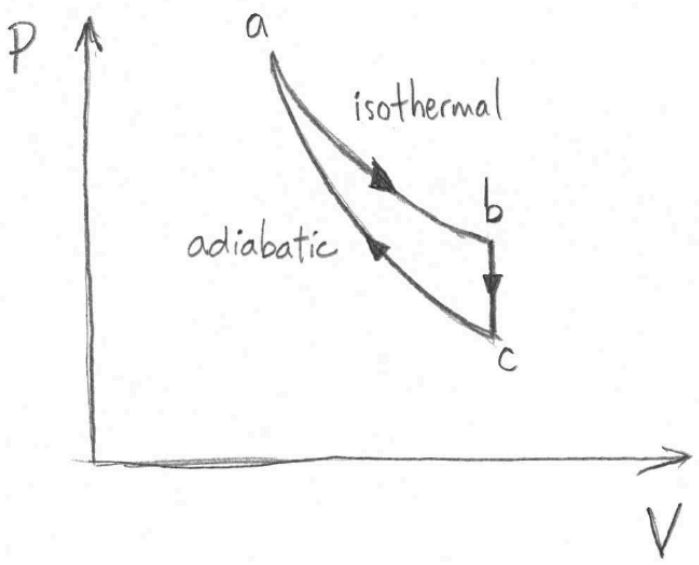
You may use any information on your note card (single-sided 8.5 x 11" page). You may also use a calculator. Otherwise, the exam is closed book.

You may ask me any questions you wish. I may or may not answer.

Q1 (10pts)	Q2 (10pts)	Q3 (10pts)	Q4 (10pts)	Q5 (10pts)	Total (50pts)

1. Thermal insulation
The thermal conductivity of glass is 1 W/(m·°K). Consider a window that is made out of a single sheet of glass. The glass is 4 mm thick and the surface area is 3 m^2. Calculate the rate that heat is transmitted through the glass when the inside surface is 20°C and the outside surface is 0°C. Give your answer in units of kWh/day.

2. Gas cycle
Consider an ideal gas that undergoes the following cycle:



a) Determine the sign of ΔU, Q and W for each step of the process. Fill in the chart below with +, - or 0. Use the standard sign conventional for work

$$W = -\int_i^f P dV$$

	ΔU	Q	W
a -> b			
b -> c			
c -> d			

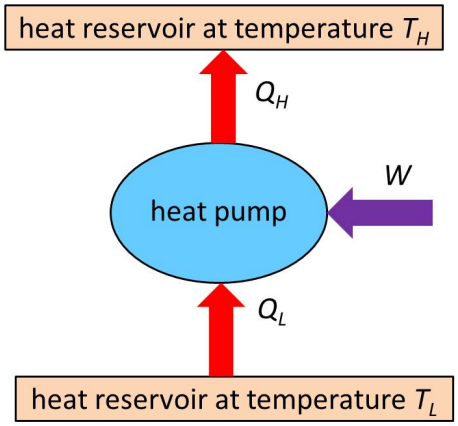
b) At what point in the cycle is the temperature of the gas lowest?

c) Is the gas working as a heat engine or a heat pump?

3. Heat Pump

When a small amount of heat, Q, is added to a large mass of material, the temperature of the material, T, stays practically constant. In a case like this, the change in the entropy of the large material is Q/T.

a) Using the definition of entropy for a large material, and the second law of thermodynamics, find the maximum performance of a heat pump (see diagram below). Express your answer as the ratio Q_H/W.



b) A company claims they can pump 4 kWh of heat into your home using just 1 kWh of electrical energy. They claim their machine works even when it is snowing outside and comfortably warm inside. Is this plausible, or ridiculous?

4. Sustainable energy

Estimate how much energy is required to heat the water each time someone has a bath. Give your answer in units of kWh.

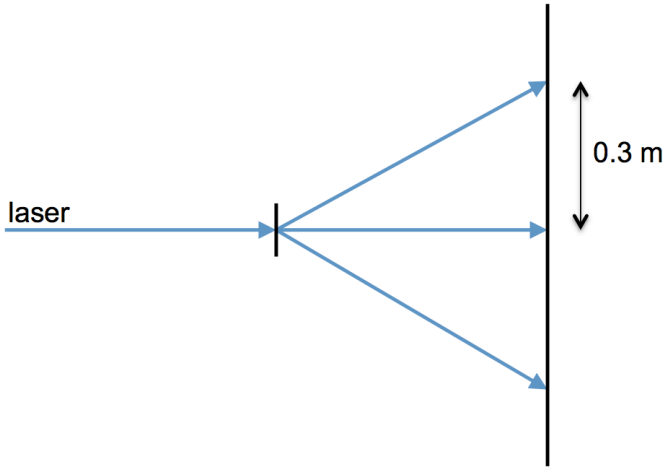
Hint: You can estimate the volume of water by comparing to the mass of an adult person (the mass of water will be at least twice the mass of a person). You can estimate the water temperature with a couple reference points: Human body temperature is 37 C (this is too cold for a good bath). Boiling water is 100 C (this is too hot for a bath).

5. Internal energy
At room temperature, the oxygen atoms in an O_2 molecule don't vibrate relative to each other, a phenomena that is explained by quantum mechanics. However, if temperature is increased sufficiently, the two oxygen atoms do start to vibrate relative to each other.

At these high temperatures, what is the internal energy per O_2 molecule? Express your answer in terms of *T* and fundamental constants.

7. Carnot efficiency
Use the equation for Carnot efficiency to determine the maximum electrical energy you could get from burning 1000 kg of coal. Assume T_C = 300 K and T_H = 800 K. Make an appropriate approximation for the energy density of coal. Express your final answer in kWh.

6. Interference effects
Consider an interference pattern that is created by shining a laser on a grating that has 500 lines/mm. The grating is 0.4 m away from a screen. There is a bright spot at the center of the screen, and bright spots on either side of the screen as shown in the figure below.



What is the wavelength of the laser?

8. Musical instrument
Find the lowest frequency that can be played by a flute that is 2 feet long.