# Classical Thermodynamics Problem sheet 1

1. Consider a wire under tension.
   1. What are the relevant variables needed to describe the system?
   2. What are the constraints on these?
   3. How many degrees of freedom does such a system have?
2. If show that
3. Briefly comment on the following from a thermodynamic point of view:
   1. A length of steel spring that has been wound into a tight coil is dissolved in hydrochloric acid. What happens to the mechanical energy spent winding the coil?
   2. Energy is liberated when hydrogen and oxygen explode. Is this an exception to the First Law?
4. A spring obeys Hooke’s Law, , where is the tensional force, is the length and is the unstretched length. Show that the work done in stretching it from length to is given by[[1]](#footnote-1):
5. The equation of state of an idealised elastic substance (e.g. rubber) is, in one dimension,

where , and are as above, is a constant and is the temperature; is a function of temperature only. Calculate the work required to compress this material reversibly and isothermally from to .



1. (see picture above) A system is taken from state *a* to state *b* along path *acb* during which 800 J of heat flows into the system and the system does 300 J of work.
   1. How much heat flows into the system along path *adb* if the work done by the system is then 100 J?
   2. When the system returns from *b* to *a* along the curved path, the work done on the system is 200 J. Does the system absorb or liberate heat, and how much?
2. A heat engine can be made out of rubber bands. (See e.g. <http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1537&context=iracc>) For such a rubber-band system, if ideal, we can write  
   where is force, is extension, and is temperature, is internal energy, and and are constants. Show that, along an adiabatic path,
3. Write down a suitable definition for a linear coefficient of thermal expansion of an object. If is independent of temperature and pressure, then show that the length of the object is given by
4. Is it possible for for a material to be zero? Is it possible for to be negative?
5. A body of heat capacity and temperature is placed in thermal contact with a second body with parameters . They are otherwise isolated. Show that the final equilibrium temperature T is:
6. An inventor claims to have developed an engine which takes in 100,000 Btu from its fuel supply, rejects 25,000 Btu in the exhaust, and delivers 25 kW h of mechanical work. Do you advise investing money to put this engine on the market? (the use of non-SI units to obscure things makes you suspicious, but you easily establish that 1 J = 95 × 10-5 Btu).
7. A heat engine operates between heat baths at constant temperatures 500 K and 350 K. If the hotter bath supplies 2 kJ of energy to the engine, how much work is done and how much energy is transferred to the colder bath? What is the efficiency of the heat engine?

1. From C. J. Adkins, *Equilibrium Thermodynamics* 1975(McGraw-Hill) 2nd ed., p258 [↑](#footnote-ref-1)