Professor Jon Goff
Department of Physics
Royal Holloway
University of London

Classical & Statistical Thermodynamics
PH2610
Problem Sheet 1

Hand in solutions to questions on this Problem Sheet to the Submission Box by the deadline stated on Moodle.

Heat engines & the second law

1. A scientist applies to a research council for a grant to develop a high-performance engine. She claims that it will extract 5 kJ of heat per cycle from a reservoir at $T = 400$ K, reject 3.5 kJ of heat per cycle to a reservoir at $T = 300$ K, and do 1.5 kJ of work per cycle on the surroundings. Would you recommend funding?

2. A refrigerator is to freeze 150 g of water at 0 ℃ in one minute, the ambient temperature being 20 ℃. Calculate in Watts the minimum motor power required. [The specific latent heat of fusion of water is 333 kJ kg^{-1}.]

3. A building is to be maintained at some internal temperature T_1 by a heat pump operating between this temperature and the lower ambient temperature T_2. The rate of heat loss from the building is proportional to the temperature difference $T_1 - T_2$ and is given by

$$\frac{dQ}{dt} = c(T_1 - T_2)$$

where the constant $c = 0.8$ kW K^{-1}. Given that the heat pump is driven by a 2 kW motor, calculate the lowest external temperature at which the interior can be maintained at 20 ℃.