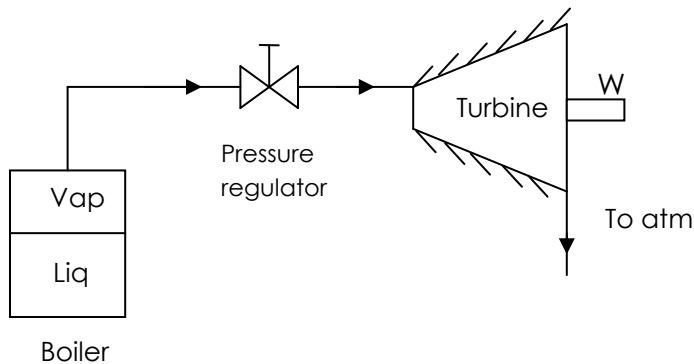
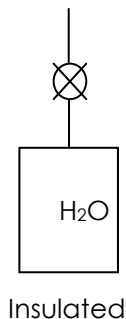


Assignment 5

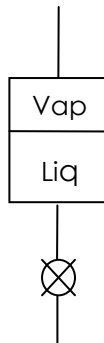
1. A Steam engine based on turbine is shown in the figure. The boiler tank has volume of 100litres and initially contains saturated liquid with a very small amount of vapor at 100kPa. Heat is now added by the burner and the pressure regulator does not open before the boiler pressure reaches 700kPa, which is kept constant. The saturated vapor enters the turbine at 700kPa and is discharged to the atmosphere as saturated vapor at 100kPa. The burner is turned off when no more liquid is present in the boiler. Find the total turbine work and the total heat transfer to the boiler for this process. (Ans: $Q = 224.7 \text{ MJ}$, $W = 8.398 \text{ MJ}$)



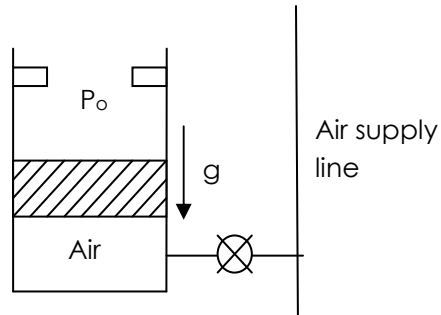
2. A 2 m^3 insulated vessel shown in figure contains saturated vapor- steam at 4MPa. A valve on the top of the tank is opened and steam is allowed to escape. During the process any liquid formed collects at the bottom of the vessel so that only saturated vapor exits. Calculate the total mass that has escaped when the pressure inside reaches 1MPa. (Ans: 27.3 kg)
3. A 750L rigid tank shown in figure initially contains water at 250°C . 50% liquid and 50% vapor by volume. A valve at the bottom of the tank is opened and liquid is slowly withdrawn. Heat transfer takes place such that the temperature remains constant. Find the amount of heat transfer required to reach the state where half the initial mass is withdrawn.(Ans: 167 MJ)



Prob 2

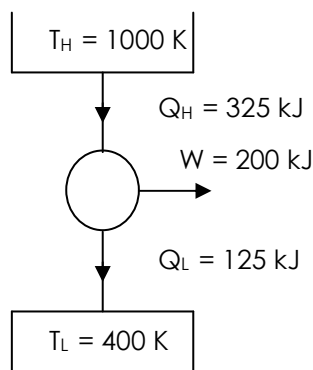


Prob 3

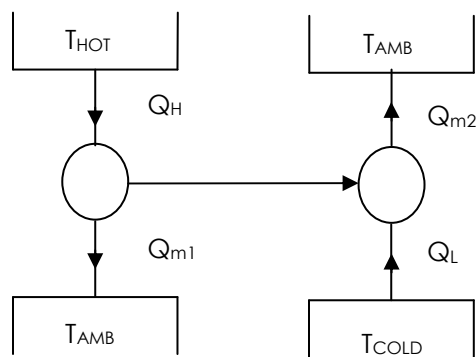


Prob 4

4. A mass loaded piston shown in figure containing air at 300kPa, 17°C with a volume of 0.25m³, while at the stops V=1m³. An airline, 500kPa, 600K, is connected by a valve that is then opened until the final inside pressure of 400kPa is reached, at which point T=350K. Find the air mass that enters, the work, and heat transfer. (Ans: 3.081 kg, 225 kJ, -819.1 kJ)
5. In a steam power plant 1MW is added at 700°C in the boiler, 0.58MW is taken out at 40°C in the condenser, and the pump work is 0.02MW. Find the plant thermal efficiency. Assuming the same pump work and heat transfer to the boiler is given, how much turbine power could be produced if the plant were running in a Carnot cycle? (Ans: 0.698 MW)
6. A car engine operates with a thermal efficiency of 35%. Assuming the air conditioner has COP that is 1/3rd of the theoretical maximum and it is mechanically pulled by the engine, how much fuel energy should you spend extra to remove 1kJ at 15°C when the ambient is at 35°C? (595.2 J)
7. A cyclic machine shown in figure receives 325kJ from a 1000K energy reservoir. It rejects 125kJ to a 400K energy reservoir and the cycle produces 200kJ of work as output. Is this cycle reversible, irreversible or impossible? (Ans: Impossible)



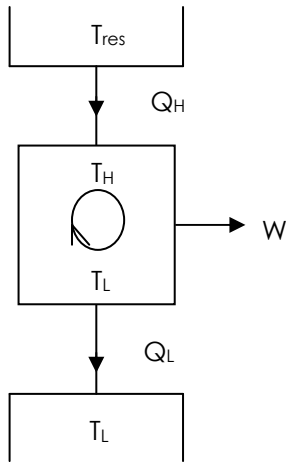
Prob 7



Prob 9

8. A 4L jug of milk at 25°C is placed in a refrigerator where it is cooled down to 5°C. The high temperature in the Carnot refrigeration cycle is 45°C and the properties of milk are the same as for liquid water. Find the amount of energy that must be removed from the milk and the additional work needed to drive the refrigerator. (Ans: 334.6 kJ, 48.1 kJ (If the refrigerator is assumed to be a large surface at 5 °C and heat rejection happens at this temperature) or 34.7 kJ (if the heat rejection is assumed to be at a variable temperature from 25 °C to 5 °C as discussed in class))
9. We wish to produce refrigeration at -30°C. A reservoir shown in figure is available at 200°C and the ambient temperature is 30°C. Thus work can be done by a cyclic heat engine operating between 200°C reservoir and the ambient. This work is used to drive the refrigerator. Determine the ratio of the heat transferred from the 200°C reservoir to the heat transferred from the -30°C reservoir, assuming all the processes are reversible. (0.686)

10. A Carnot heat engine shown in figure receives energy from a reservoir at T_{res} through a heat exchanger where the heat transfer is proportional to the temperature difference as $\dot{Q}_H = K(T_{\text{res}} - T_H)$. It rejects heat at a given low temperature T_L . To design the heat engine for maximum work output, show that the T_H in the cycle should be selected as $T_H = \sqrt{T_L * T_{\text{res}}}$.



Prob 10