Mansoura University		Mechanical Power Department Total Marks 100	Faculty of Engineering
Course Title: Thermodynamics I Date: Jan 2019 (Final) نهاية العام		Allowed Time 3 hour	Course Code: MPE4114 No of Pages: 1
يجب توضيح وحدات جميع الكميات التي يتم حسابها لكي تعتبر الإجابة كاملة. مصرح باستخدام جداول الديناميكا الحرارية			

1. Air is adiabatically compressed in a compressor. It enters at 1 bar and ambient temperature 27°C, and leaves at 17.65 bar. Compressor isentropic efficiency is 74.6%. Assuming air is a semi-ideal gas, calculate exit conditions (temperature, enthalpy and entropy). Deduce availability gained and availability paid and hence the second law efficiency.
2. In order to produce a cooling effect, one of the methods is to compress a gas and then let it cool to ambient temperature. Afterwards, when this gas expands in a turbine, it may exit from it at a very low temperature. Ammonia (NH_3), treated as a real gas using thermodynamic tables, enters a turbine at 5 bar and 30°C, to leave at 1 bar. If turbine isentropic efficiency is 80%, calculate outlet conditions (temperature, enthalpy and entropy).
3. Steam is compressed in a piston and cylinder arrangement starting from 3 bar, 200°C and 2 liters, to 10 bar. Compression is reversible and isothermal. Find steam entropy change during this process and hence deduce heat rejected by steam. Use result to calculate work exchanged. During compression, in order to keep the temperature constant, heat is extracted to ambient air, which is at 27°C. Finally deduce entropy change of ambient air and that of universe.
4. In a mixer enters two streams: CO_2 at a rate of 2kg/s and 35°C as well as N_2 at a rate of 3 kg/s and 50°C. During mixing, 100kW of heat is added while all inlet and outlet streams are at 4 bar. Obtain outlet mixture temperature, partial pressures of each gas and hence deduce entropy change in the mixer.
5. It is required to provide 35kW of power over 10 years (24 hours per day, 365.25 days per year). Compare between the costs of the following 2 solutions. Either use a diesel engine having an efficiency which is 50% that of a Carnot engine working between 1200°C and 50°C. Or use solar photovoltaic cells having an efficiency of 10% in transforming solar radiation into electricity in a place where the average solar radiation over the whole year (including day and night as well as summer and winter) is 300 W/m^2. Main cost component for the diesel engine solution is that of fuel which costs 5 EGP per liter for a fuel that delivers 8.33 kWh of heat when burned. Main cost component of the solar energy solution, including concentrators and all electric components and accessories, is 1,000 EGP per m^2 of area.

G O O D L U C K

Prof. Mohamed-Nabil Sabry

Mansoura University		Mechanical Power Department Total Marks 100	Faculty of Engineering
Course Title: Thermodynamics I Date: Jan 2018 (First Term) **نهاية الفصل**		Allowed Time 3 hours	Course Code: MPE4114 No of Pages: 1
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1. In a refrigerator, refrigerant R134a enters a throttle as saturated liquid at 36°C. At throttle exit temperature is -20°C. Refrigerant then enters a heat exchanger (the freezer compartment) where it evaporates at constant pressure and exits as saturated vapor. Heat is supplied by freezer contents surrounding the heat exchanger, which are kept at -18°C. Find work and heat exchanged per kilogram in the throttle and in the heat exchanger. Find availability loss in the throttle and in the freezer, express each as a ratio of the heat exchanged in the freezer (25 points)

2. In a piston and cylinder arrangement, 1 liter of steam expands from 10 bar and 300°C according to a polytropic process with index 1.26 until it reaches 4 bar. Ambient temperature is 300°C. Find work and heat exchanged by steam as well as entropy change of steam and universe. (20 points)

3. In a power station, combustion flue gases are flowing out of the station at a rate of 1 kg/s, a temperature of 1,000K and a pressure of 1 bar. Mass ratio of each component is N_2: 77%, CO_2: 17% H_2O: 6%. Find mol ratios. They are used in a heat exchanger to produce heat to another process, from which they exit at 350K. Find partial pressure of H_2O: will it be at vapor or liquid phase at exit? Find heat exchanged and entropy change assuming each component acts as a semi-ideal gas. (20 points)

4. An air conditioner is used to keep a room at 20°C for an outside temperature of 40°C. Heat taken by the conditioner from the room is 4kW. If its coefficient of performance was 30% that of a reversible refrigerator, find electric power consumption. In order to reduce it, new regulation stipulates that room temperature should be 25°C minimum. Heat power required to be evacuated from the room would be less since it is proportional to temperature difference between outside (40) and inside air (20 or 25). Also, coefficient of performance is improved due to higher room temperature. Find the new electric power consumption due to both effects. (15 points)

5. A 100-liter rigid tank containing Butane (C_4H_{10}) initially at 1 bar and 30°C, is connected to a line carrying Butane flowing at 5 bar and 40°C, until pressure in the tank is equal to that of the line. During the process, tank is cooled by extracting 42kJ of heat. Considering specific heat ratio of Butane is 1.33, find temperature and mass of Butane in the tank at end of filling. (20 points)

GOOD LUCK

Prof. Mohamed-Nabil Sabry

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1. Steam enters a steam turbine at 60 bar 440°C and a rate of 36 tons/hour and leaves it as saturated steam at 20kPa.
   a. Find the change of enthalpy and entropy within the turbine
   b. Knowing that the turbine is NOT thermally insulated and that it produces 4 MW, find the rate of heat loss to ambient air
   c. Find entropy change of the universe as well as availability loss, knowing that ambient temperature was 27°C
2. Air is compressed adiabatically in an insulated compressor from 1 bar and 300K to 15.77 bar. Compressor has an isentropic efficiency of 72%
   a. Assuming air is an ideal gas, find final temperature and work per kg of air
   b. Repeat above calculations assuming air was a semi-ideal gas.
3. The freezer compartment of a refrigerator is a heat exchanger, in which a fluid (R22) enters through tubes to evaporate at constant pressure and hence cools the surroundings. R22 enters the tube at 2bar and a dryness fraction of 0.2 at a rate of 2.5 g/s and leaves at the same pressure and a temperature of – 20°C. Surroundings are maintained at a constant temperature of – 18°C. Find inlet temperature of R22, heat gained by R22 per second, as well as its entropy change. Find entropy change of surroundings and hence of universe.
4. A refrigerator freezer compartment is maintained at –18°C. Refrigerator consumes 0.25 kW of electric power when ambient temperature is at 37°C. Its coefficient of performance (COP) is 40% that of Carnot working between the same temperatures.
   a. Find the amount of heat power extracted from the freezer.
   b. Find the time needed to cool and freeze 10 kg of meat starting from ambient temperature until its temperature reaches –18°C, knowing that:
      - Heat capacity of meat BEFORE freezing is: 3.24 kJ/kg K
      - Meat solidifies at –2°C with a latent heat of 190 kJ/kg
      - Heat capacity of meat AFTER freezing is: 2.31 kJ/kg K
5. In a frictionless piston and cylinder arrangement, Nitrogen is initially at a pressure of P_1=1 bar and a specific volume of v_1=0.9 m^3/kg. It undergoes a cycle composed of the following three processes:
      - Process 1 – 2: Isentropic compression from state 1 to P_2= 7 bar
      - Process 2 – 3: Constant pressure heating from state 2 to $v_3 = v_1$
      - Process 3 – 1: Constant volume cooling from state 3 to state 1

   Assuming N_2 behaves as an ideal gas, find:
   a. Temperatures of all states, T_1, T_2 and T_3
   b. Heat exchanged per kg in each process, indicating if it is added or rejected
   c. Total cycle work per kg and efficiency

GOOD LUCK