Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-2 Date: 14th January 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 17th-01-22*
- *This will give you **1 point** towards your total evaluation,*
- *Late submission lead to deduction of **half point.***

1. The molar specific volume of a system V is defined as the ratio of the volume of the system to the number of moles of substance contained in the system. Is this an extensive or intensive property? (**0.2 P**)

2. Define the isothermal, isobaric, and isochoric processes. (**0.2 P**)

3. What is steady flow process? (**0.2 P**)

4. When a hydrocarbon fuel is burned, almost all of the carbon in the fuel burns completely to form CO_2 (carbon dioxide), which is the principal gas causing the greenhouse effect and thus global climate change. On average, 0.59 kg of CO_2 is produced for each kWh of electricity generated from a power plant that burns natural gas. A typical new household refrigerator uses about 700 kWh of electricity per year. Determine the amount of CO_2 production that is due to the refrigerators in a city with 300,000 households. (**0.2 P**)

5. If you would like do a metabolism (energy) analysis of a person. How would you define the system for this purpose? (**0.2 P**)

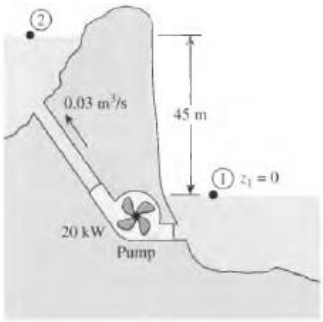
Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-3 Date: 21st January 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 23rd-01-22*
- *This will give you **1 point** towards your total evaluation,*
- ***Late submission lead to deduction of half mark. (Very Important)***

1. Water is pumped from a lower reservoir to a higher reservoir by a pump that provides 20 kW of shaft power. The free surface of the upper reservoir is 45 m higher than that of the lower reservoir. If the flow rate of water is measured to be 0.03 m^3/s, determine mechanical power that is converted to thermal energy during this process due to frictional effects.



2. A well-insulated electric oven is being heated through its heating element. If the entire oven, including the heating element, is taken to be the system determine whether this is heat or work interaction? Describe it.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-5 Date: 3rd February 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 06-02-22*
- *This will give you **1 point** towards your total evaluation,*
- ***Late submission lead to deduction of half mark. (This is Very Important)***

1. One kilogram of water fills a 150-L rigid container at an initial pressure of 2 MPa. The container is then cooled to 40°C. Determine the initial temperature and the final pressure of the water. **(0.2 P)**

2. Determine the specific volume, internal energy, and enthalpy of compressed liquid water at 80°C and 20 MPa using the saturated liquid approximation. Compare these values to the ones obtained from the compressed liquid tables. **(0.2 P)**

3. A rigid tank contains water vapor at 250°C and an unknown pressure. When the tank is cooled to 124°C, the vapor starts condensing. Estimate the initial pressure in the tank. **(0.2 P)**

4. A piston-cylinder device initially contains 1.4-kg saturated liquid water at 200°C. Now heat is transferred to the water until the volume quadruples and the cylinder contains saturated vapor only. Determine ***(a)*** the volume of the tank, (*b*) the final temperature and pressure, and *(c)* the internal energy change of the water. **(0.2 P)**

5. Ethylene is heated at constant pressure from 5MPa and 20°C to 200°C. Using the compressibility chart, determine the change in the ethylene's specific volume as a result of this heating. **(0.2 P)**

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-6 Date: 17th February 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 20-02-22*
- *This will give you **1 point** towards your total evaluation,*
- ***Late submission lead to deduction of half mark. (This is Very Important)***

1. A frictionless piston-cylinder device initially contains 50 L of saturated liquid refrigerant-134a. The piston is free to move, and its mass is such that it maintains a pressure of 500 kPa on the refrigerant. The refrigerant is now heated until its temperature rises to 70°C. Calculate the work done during this process. **(0.2 P)**

2. A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas-tight, frictionless piston-cylinder device. The air is now compressed to a final pressure of 600 kPa. During the process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process. **(0.2 P)**

3. A fixed mass of saturated water vapor at 300 kPa is isothermally cooled until it is a saturated liquid. Calculate the amount of heat rejected during this process, in kJ/kg. **(0.2 P)**

4. Air is contained in a cylinder device fitted with a piston-cylinder. The piston initially rests on a set of stops, and a pressure of 300 kPa is required to move the piston. Initially, the air is at 100 kPa and 27°C and occupies a volume of 0.4 m3. Determine the amount of heat transferred to the air, in kJ, while increasing the temperature to 1200 K. Assume air has constant specific heats evaluated at 300 K. **(0.4 P)**

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-7 Date: 24th February 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 27-02-22*
- *This will give you **1 point** towards your total evaluation,*
- ***Late submission lead to deduction of half mark. (This is Very Important)***

1. Air is contained in a piston-cylinder device at 600 kPa and 927°C, and occupies a volume of 0.8 m^3. The air undergoes and isothermal (constant temperature) process until the pressure in reduced to 300 kPa. The piston is now fixed in place and not allowed to move while a heat transfer process takes place until the air reaches 27°C. (a) Sketch the system showing the energies crossing the boundary and the ***P-V*** diagram for the combined processes. ***(b)*** For the combined processes determine the net amount of heat transfer, in kJ, and its direction. Assume air has constant specific heats evaluated at 300 K.

2. Steam enters a nozzle at 400°C and 800 kPa with a velocity of 10 m/s, and leaves at 300°C and 200 kPa while losing heat at a rate of 25 kW. For an inlet area of 800 cm^2, determine the velocity and the volume flow rate of the steam at the nozzle.

3. Argon gas enters an adiabatic turbine steadily at 1600 kPa and 450°C with a velocity of 55 m/s and leaves at 150 kPa with a velocity of 150 m/s. The inlet area of the turbine is 60 cm^2. If the power output of the turbine is 190 kW, determine the exit temperature of the argon.

4. An adiabatic gas turbine expands air at 1300 kPa and 500°C to 100 kPa and 127°C. Air enters the turbine through a 0.2-m^2 opening with an average velocity of 40 m/s, and exhausts through a 1-m^2 opening. Determine ***(a)*** the mass flow rate of air through the turbine and (***b***) the power produced by the turbine.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-8 Date: 06th March 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 06-03-22*
- *This will give you **1 point** towards your total evaluation,*
- ***Late submission lead to deduction of half mark.***

A tank (1 L) initially contains 0.4 kg of saturated mixture of R-134a at 26 ^{o}c. A valve is opened and R-134a vapor only is allowed to escape slowly such that temperature remains constant and the final mass of R-134a is 0.1 Kg. The heat transfer necessary with the surroundings to maintain the temperature and pressure of the R-134a constant is to be determined.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-9 Date: 24th March 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 27-03-22*
- *This will give you **1 point** towards your total evaluation,*
- ***Late submission lead to deduction of half mark.***

1. An automobile engine consumes fuel at a rate of 22 L/h and delivers 55 kW of power to the wheels. If the fuel has a heating value of 44,000 kJ/kg and a density of 0.8 g/cm^3, determine the efficiency of this engine.

2. A heat pump is used to maintain a house at a constant temperature of 23 °C. The house is losing heat to the outside air through the walls and the windows at a rate of 60,000 kJ/h while the energy generated within the house from people, lights, and appliances amounts to 4000 kJ/h. For a COP of 2.5, determine the required power input to the heat pump.

3. A heat pump operates on a Carnot heat pump cycle with a COP of 8.7. It keeps a space at 26 °C by consuming 4.25 kW of power. Determine the temperature of the reservoir from which the heat is absorbed and the heating load provided by the heat pump.

4. The food compartment of a refrigerator, is maintained at 4°C by removing heat from it at a rate of 360 kJ/min. If the required power input to the refrigerator is 2 kW, then determine the coefficient of performance (COP) of the refrigerator and also determine the rate of heat rejection (Q_H) to the room that houses the refrigerator.

5. An air-conditioner with a power input of 1.2 kW is working as a refrigerator (COP = 3) or as a heat pump (COP = 4). It maintains an office at 20 °C year round which exchanges 0.5 kW per degree temperature difference with the atmosphere. Find the maximum and minimum outside temperature for which this unit is sufficient.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-10 Date: 31st March 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 03-04-22*
- *This will give you **1 point** towards your total evaluation,*
- ***Late submission lead to Zero Marks.***

1. A completely reversible heat pump produces heat at a rate of 300 kW to warm a house maintained at 24 °C. The exterior air, which is at 7 °C, serves as the source. Calculate the rate of entropy change (kW/K) of the two reservoirs.

2. Two Carnot heat engines are operating in series such that the heat sink of the first engine serves as the heat source of the second one. If the source temperature of the first engine is 1300 K and the sink temperature of the second engine is 300 K and the thermal efficiencies of both engines are the same, the temperature of the intermediate reservoir is:

3. Derive the expression for entropy, temperature using Boltzmann's statistics

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-11 Date: 7th April 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 10-04-22*
- *This will give you **1 point** towards your total evaluation,*
- ***Late submission lead to Zero Marks.***

1. An insulated rigid tank is divided into two equal parts by a partition. Initially, one part contains 5 kmol of an ideal gas at 250 kPa and 40 °C, and the other side is evacuated. The partition is now removed, and the gas fills the entire tank. Determine the total entropy change during this process.

2. A constant-volume tank contains 5 kg of air at 100 kPa and 327 °C. The air is cooled to the surroundings temperature of 27 °C. Assume constant specific heats at 300 K. (*a*) Determine the entropy change of the air in the tank during the process, in kJ/K, *(b)* determine the net entropy change of the universe due to this process, in kJ/K, and (c) sketch the processes for the air in the tank and the surroundings on a single *T-s* diagram. Be sure to label the initial and final states for both processes.

3. The theoretical minimum work required to separate one mole of liquid mixture at 1 atm containing 50 mole % each of n-heptane and n-octane into pure compounds each at 1 atm.

4. Consider the entropy of mixing of more than two components. Let the total number of sites be N, the number of A atoms be NA and the number of B atoms be NB. And NC is the number of empty sites, i.e. NC = N − NA – NB. Obtain the the expression for the number of arrangements of A and B atoms on a lattice where some of the lattice sites can be left empty. Also, Assume the empty sites are occupied by atoms of type C and give an expression for the entropy of mixing (ΔS) in terms of the mole fractions x_A, x_B and x_C. Use the sterling approximation

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Assignment-12 Date: 13th April 2022

Maximum points: 1 **Instructions:**

- *Answer all the questions*
- *Please write your solutions/explanations on a paper with your handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 15-04-22*
- *This will give you **1 point** towards your total evaluation,*
- ***Late submission lead to Zero Marks.***

1. Consider a thermal energy reservoir at 1500 K that can supply heat at a rate of 150,000 kJ/h. Determine the exergy of this supplied energy, assuming an environmental temperature of 25°C.

2. A piston-cylinder device initially contains 2 L of air at100 kPa and 25°C. Air is now compressed to a final state of 600 kPa and 150°C. The useful work input is 1.2 kJ. Assuming the surroundings are at 100 kPa and 25°C, determine *(a)* the exergy of the air at the initial and the final states, (*b*) the minimum work that must be supplied to accomplish this compression process, and (c) the second-law efficiency of this process

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-1 Date: 12th January 2022

Instructions:

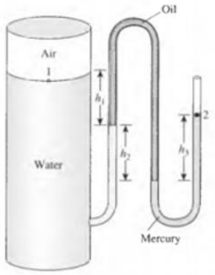
- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *Late submission lead to deduction of **half mark.***

1. Is the weight of a system an extensive or intensive property?

2. For a system to be in thermodynamic equilibrium, do the temperature and the pressure have to be the same everywhere?

3. What is a quasi-equilibrium process? What is its importance in engineering?

4. The water in a tank is pressurized by air, and the pressure is measured by a multi-fluid manometer as shown in figure given. Determine the gage pressure of air in the tank if h_1= 0.2 m, h_2 = 0.3 m, and h_3 = 0.46 m. Take the densities of water, oil, and mercury to be 1000 kg/m^3, 850 kg/m^3, and 13,600 kg/m^3, respectively.



5. Consider an alcohol and a mercury thermometer that read exactly 0°C at the ice point and 100°C at the steam point. The distance between the two points is divided into 100 equal parts in both thermometers. Do you think these thermometers will give exactly the same reading at a temperature of, say, 60°C? Explain.

6. A classroom that normally contains 40 people is to be air-conditioned with window air-conditioning units of 5-kW cooling capacity. A person at rest may be assumed to dissipate heat at a rate of about 360 kJ/h. There are 10 light bulbs in the room, each with a rating of 100 W. The rate of heat transfer to the classroom through the walls and the windows is estimated to be 15,000 kJ/h. If the room air is to be maintained at a constant temperature of 21°C, determine the number of window air-conditioning units required.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-2 Date: 19th January 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages and upload in google classroom before **6 AM (20th January 2022)***
- *This will give you **1 point** towards your total evaluation*
- *Late submission lead to deduction of **half mark.***

1. For a cycle, is the network necessarily zero? For what kind of systems will this be the case?

2. Consider a river flowing toward a lake at an average velocity of 3 m/s at a rate of 500 m^3/s at a location 90 m above the lake surface. Determine the total mechanical energy of the river water per unit mass and the power generation potential of the entire river at that location.

3. A fan is to accelerate quiescent air to a velocity of 8 m/s at a rate of 9 m^3/s. Determine the minimum power that must be supplied to the fan. Take the density of air to be 1.18 kg/m^3.

4. Balloons are often filled with helium gas because it weighs only about one-seventh of what air weighs under identical conditions. The buoyancy force, which can be expressed as $F_b = \rho_{air}\, g\, V_{balloon}$, will push the balloon upward. If the balloon has a diameter of 12 m and carries two people, 85 kg each, determine the acceleration of the balloon when it is first released. Assume the density of air is ρ_{air} = 1.16 kg/m^3, and neglect the weight of the ropes and the cage.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-3 Date: 02nd February 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *Late submission lead to deduction of **half mark.***

1. Using the steam tables, complete this table for H_2O:

T, °C	P, Kpa	V, m^3/kg	Phase description
50		7.72	
	400		Saturated vapor
250	500		
120	5000		

2. Water initially at 300 kPa and 250°C is contained in a piston-cylinder device fitted with stops. The water is allowed to cool at constant pressure until it exists as a saturated vapor and the piston rests on the stops. Then the water continues to cool until the pressure is 100 kPa. On the T-v diagrams sketch, with respect to the saturation lines, the process curves passing through both the initial, intermediate, and final states of the water. Label the T, P and v values for end states on the process curves. Find the overall change in internal energy between the initial and final states per unit mass of water.

3. A piston-cylinder device contains 0.8 kg of steam at 300°C and 1 MPa. Steam is cooled at constant pressure until one-half of the mass condenses.
   A. Show the process on a T-v diagram.
   B. Find the final temperature.
   C. Determine the volume change.

4. A 0.3 m^3 rigid vessel initially contains saturated liquid-vapor mixture of water at 150°C. The water is now heated until it reaches the critical state. Determine the mass of the liquid water and the volume occupied by the liquid at the initial state.

5. A 4-L rigid tank contains 2 kg of saturated liquid-vapor mixture of water at 50°C. The water is now slowly heated until it exists in a single phase. At the final state, will the water be in the liquid phase or the vapor phase? What would your answer be if the volume of the tank were 400 L instead of 4 L?

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-4 Date: 09th February 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *Late submission lead to deduction of **half mark.***

1. A rigid tank whose volume is unknown is divided into two parts by a partition. One side of the tank contains an ideal gas at 927°C. The other side is evacuated and has a volume twice the size of the part containing the gas. The partition is now removed and the gas expands to fill the entire tank. Heat is now applied to the gas until the pressure equals the initial pressure. Determine the final temperature of the gas.

2. Determine the specific volume of superheated water vapor at 15 MPa and 350°C, using **(a)** the ideal-gas equation, **(b)** the generalized compressibility chart, and **(c)** the steam tables. Also determine the error involved in the first two cases.

3. Determine the specific volume of refrigerant-134a vapor at 0.9 MPa and 70°C based on ***(a)*** the ideal-gas equation, (***b***) the generalized compressibility chart, and (***c***) data from tables. Also, determine the error involved in the first two cases.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-5 Date: 16th February 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *Late submission lead to deduction of **half mark.***

1. A piston-cylinder device initially contains 0.07 m^3 of nitrogen gas at 130 kPa and 120°C. The nitrogen is now expanded polytropically to a state of 100 kPa and 100°C. Determine the boundary work done during this process.

2. Carbon dioxide contained in a piston-cylinder device is compressed from 0.3 to 0.1 m3. During the process, the pressure and volume are related by $P = aV^{-2}$, where a = 8 kPa-m6. Calculate the work done on the carbon dioxide during this process.

3. A piston-cylinder device contains 0.15 kg of air initially at 2 MPa and 350°C. The air is first expanded isothermally to 500 kPa, then compressed polytropically with a polytropic exponent of 1.2 to the initial pressure, and finally compressed at the constant pressure to the initial state. Determine the boundary work for each process and the net work of the cycle.

4. 1.5-kg water that is initially at 1 MPa and 30 percent quality occupies a spring-loaded piston-cylinder device. This device is now cooled until the water is a saturated liquid at 100°C. Calculate the total work produced during this process, in kJ.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-6 Date: 23rd February 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *Late submission lead to deduction of **half mark.***

1. Steam flows steadily through an adiabatic turbine. The inlet conditions of the steam are 6 MPa, 400°C, and 80 m/s, and the exit conditions are 40 kPa, 92 percent quality, and 50 m/s. The mass flow rate of the steam is 20 kg/s. Determine (a) the change in kinetic energy, (b) the power output, and (c) the turbine inlet area.

2. A well-insulated rigid tank contains 2 kg of a saturated liquid-vapor mixture of water at 150 kPa. Initially, three-quarters of the mass is in the liquid phase. An electric resistor placed in the tank is connected to a 110-V source, and a current of 8 A flows through the resistor when the switch is turned on. Determine how long it will take to vaporize all the liquid in the tank. Also, show the process on a T-v diagram with respect to saturation lines.

3. Air at 80 kPa and 127°C enters an adiabatic diffuser steadily at a rate of 6000 kg/h and leaves at 100 kPa. The velocity of the air stream is decreased from 230 to 30 m/s as it passes through the diffuser. Find ***(a)*** the exit temperature of the air and (***b***) the exit area of the diffuser.

4. Helium is to be compressed from 120 kPa and 310 K to 700 kPa and 430 K. A heat loss of 20 kJ/kg occurs during the compression process. Neglecting kinetic energy changes, determine the power input required or a mass flow rate of 90 kg/min.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-7 Date: 2nd March 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *Late submission lead to deduction of **half mark.***

1. Saturated liquid-vapor mixture of water, called wet steam, in a steam line at 2000 kPa is throttled to 100 kPa and 120°C. What is the quality in the steam line?

2. An insulated cylinder equipped with an external spring initially contains air at 150 kPa pressure, 22 ºC temperature and volume of 0.11 m^3. The tank is connected to a supply line, and air is allowed to enter the cylinder until its volume doubles. At this condition pressure is 0.7 MPa and temperature is 22ºC. The mass of the air that entered and the final temperature in the cylinder are to be determined

3. An evacuated bottle is surrounded by atmospheric air. A valve is opened, and air is allowed to fill the bottle. The amount of heat transfer through the wall of the bottle when thermal and mechanical equilibrium is established is to be determined.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-8 Date: 23rd March 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *Late submission lead to deduction of **half mark.***

1. A refrigerator operating on the reversed Carnot cycle has a measured work input of 200 kW and heat rejection of 2000 kW to a heat reservoir at 27 °C. Determine the cooling load supplied to the refrigerator, in kW, and the temperature of the heat source, in °C.

2. A household refrigerator that has a power input of 450 W and a COP of 2.5 is to cool five large watermelons, 10 kg each, to 8 °C. If the watermelons are initially at 20 °C, determine how long it will take for the refrigerator to cool them. The watermelons can be treated as water whose specific heat is 4.2 kJ/kg °C. Is your answer realistic or optimistic? Explain.

3. A coal-burning steam power plant produces a net power of 300 MW with an overall thermal efficiency of 32 percent. The actual gravimetric air-fuel ratio in the furnace is calculated to be 12 kg air/kg fuel. The heating value of the coal is 28,000 kJ/kg. Determine ***(a)*** the amount of coal consumed during a 24-hour period and (***b***) the rate of air flowing through the furnace.

4. Refrigerant-134a enters the evaporator coils placed at he back of the freezer section of a household refrigerator at100 kPa with a quality of 20 percent and leaves at 100 kPa and - 26 °C. If the compressor consumes 600 W of power and the COP the refrigerator is 1.2, determine (a) the mass flow rate of the refrigerant and (b) the rate of heat rejected to the kitchen air.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-9 Date: 30th March 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *No late submission please! (zero marks for late submission)*

1. A completely reversible heat pump produces heat at a rate of 300 kW to warm a house maintained at 24 °C. The exterior air, which is at 7 °C, serves as the source. Calculate the rate of entropy change of the two reservoirs and determine if this heat pump satisfies the second law according to the increase of entropy principle.
2. Steam is expanded in an isentropic turbine with a single inlet and outlet. At the inlet, the steam is at 2 MPa and 360°C. The steam pressure at the outlet is 100 kPa. Calculate the work produced by this turbine, in kJ/kg.
3. Refrigerant-134a enters the coils of the evaporator of a refrigeration system as a saturated liquid-vapor mixture at a pressure of 160 kPa. The refrigerant absorbs 180 kJ of heat from the cooled space, which is maintained at -5°C, and leaves as saturated vapor at the same pressure. Determine *(a)* the entropy change of the refrigerant, (*b)* the entropy change of the cooled space, and (c) the total entropy change for this process.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-10 Date: 6th April 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *No late submission please! (zero marks for late submission)*

1. A 25-kg iron block initially at 350 °C is quenched in an insulated tank that contains 100 kg of water at 18 °C. Assuming the water that vaporizes during the process condenses back in the tank, determine the total entropy change during this process.

2. A 50-kg iron block and a 20-kg copper block, both initially at 80 °C, are dropped into a large lake at 15 °C. Thermal equilibrium is established after a while as a result of heat transfer between the blocks and the lake water. Determine the total entropy change for this process.

3. Liquid water enters an adiabatic piping system at 15°C at a rate of 8 kg/s. If the water temperature rises by 0.2°C during flow due to friction, the rate of entropy generation in the pipe is

4. Determine the change in entropy when 2 kg of a gas at 277 K is heated at constant volume to a temperature of 368 K. Take the specific heat at constant volume = 1.42 kJ/kg K.

5. What is the change in entropy when 0.7 m^3 of CO_2 and 0.3 m^3 of N_2, each at 1 bar and 25 ˚C blends to form a gas mixture at the same conditions? Assume ideal gases.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Tutorial-11 Date: 13th April 2022

Instructions:

- *Answer all the questions*
- *Please write your solutions/explanations on an A4 size paper with your own handwriting*
- *Scan all pages as a single pdf file and upload in google classroom before 8 PM same day*
- *This will give you **1 point** towards your total evaluation*
- *No late submission please! (zero marks for late submission)*

1. A Refrigerant-134a enters a steady-flow adiabatic compressor as a saturated vapor at 320 kPa and is compressed to 1200 kPa. The minimum power supplied to the compressor is found to be 100 kW.
   (a) Sketch the T-s diagram with respect to the saturation lines for this process.
   (b) Determine the volume flow rate of the refrigerant-134a at the compressor inlet, in m^3/s.

2. A heat engine that receives heat from a furnace at 1200 °C and rejects waste heat to a river at 20 °C has a thermal efficiency of 40 percent. Determine the second-law efficiency of this power plant

3. A house that is losing heat at a rate of 50,000 kJ/h when the outside temperature drops to 4°C is to be heated by electric resistance heaters. If the house is to be maintained at 25°C at all times, determine the reversible work input for this process and the irreversibility.

4. Refrigerant-134a enters an adiabatic compressor at -26 °C as a saturated vapor at a rate of 0.45 m 3/min and leaves at 800 kPa and 50°C. Determine *(a)* the power input to the compressor, (*b*) the isentropic efficiency of the compressor, and (c) the rate of exergy destruction and the second-law efficiency of the compressor. Take T_0 = 27°C.

(P)Quiz 7

Please submit the quiz before 4:50 PM. Select the correct answers from the given options only.As this quiz involves the numerical problems.I would like to see your rough work on any form of the paper. You have to submit your rough work by either scanning or taking a photograph. No marks will be provided if you failed to submit your rough work.

* Required

A steel ball weighing 30 kg at 427 oC is dropped in 150 kg of oil at 27 oC. The specific heat of steel 0.46 kJ/kg K and specific heat of oil 2.5 kJ/kg K. Estimate the entropy change of total system * 1 point

- 81.3 kJ/K
- 6.28 kJ/K
- 32.2 kJ/K
- 2.3 kJ/K
- 16.22 kJ/K
- 17.34 kJ/K
- 1.11 kJ/K
- -11.05 kJ/K

A heat engine receives heat from a source at 1500 K at a rate of 600 kJ/s and rejects the waste heat to a sink at 300 K. If the power output of the engine is 400 kW, the second law efficiency (i.e. ratio of theoretical to reversible engine) of this heat engine is * 1 point

- 15 %
- -12 %
- 17 %
- 22 %
- 42 %
- 16 %
- 67 %
- -22 %
- 53 %
- 83 %

Consider a Carnot cycle executed in a closed system with 0.6 kg of air. The temperature limits of the cycle are 300 and 1100 K, and the minimum and maximum pressures that occur during the cycle are 20 and 3000 kPa. Assuming constant specific heats, determine the network output per cycle. The properties of air at room temperature are C_p =1.005 kJ/kg.K, C_v= 0.718 kJ/kg.K, R= 0.287 kJ/kg.K * 1 point

- 0 kJ
- 22.1 kJ
- -6.2 kJ
- 63.8 kJ
- 11.3 kJ
- 31.2 kJ
- 122.2 kJ

An insulated rigid tank contains 0.9 kg of air at 150 kPa and 20°C. A paddle wheel inside the tank is now rotated by an external power source until the temperature in the tank rises to 55°C. If the surrounding air is at T0 = 20°C, determine the exergy destroyed (Xdest) * 1 point

- 23.3 kJ
- 22.6 kJ
- 21.4 kJ
- 1.2 kJ
- 12.6 kJ
- 18.6 kJ
- 1.2 KJ

A heat engine operates at 75% of the maximum possible efficiency. The ratio of the heat source temperature (in K) to the heat sink (in K) is 5/3. The fraction of the heat supplied that is converted to work is * 1 point

- 0.4
- 0.2
- 0.8
- 0.6
- 0.1
- 0.7
- 0.9
- 0.3

A 50-kg iron block at 80°C is dropped into an insulated tank that contains 0.5 m3 of liquid water at 25°C. Determine the temperature (°C) when thermal equilibrium is reached. The specific heat of iron and water are 0.45 and 4.18 kJ/(kg.oC) respectively. * 1 point

- 9.9
- 25.6
- 52.5
- 80.0
- 10.3
- 25.0
- 16.6
- 21.1

What is the change in entropy when 0.7 m3 of CO2 and 0.3 m3 of N2, each at 1 bar and 25 ˚C blends to form a gas mixture at the same conditions? Assume ideal gases * 1 point

- 111 J/K
- 123 J/K
- 100 J/K
- 204 J/K
- 772 J/K
- 0 J/K
- 323 J/K
- 120 J/K

Steam is condensed at a constant temperature of 30°C as it flows through the condenser of a power plant by rejecting heat at a rate of 55 MW. The rate of entropy change of steam as it flows through the condenser is: * 1 point

- -0.56 MW/K
- -1.83 MW/K
- -13 MW/K
- -2.6 MW/K
- 15.3 MW/K
- 16 MW/K
- -0.18 MW/K
- -1 MW/K
- 0 MW/K

Submit Clear form

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Quiz-4 Date: 16th February 2022

Maximum points: 2 **Instructions:**

- *Each question carries* **1 point**
- *No late Submission are allowed (leads to zero marks)*
- *Please write your answers in A4 type sheet and upload within 15 mins* ***(5 to 5:15 PM)***

1. 10 moles of ideal gas with $\gamma = 1.4$ is compressed reversibly and adiabatically from 100 kPa and 27 ^{o}C to 1 MPa. Then determine following:
(a) Final temperature of the gas (in K)?**(0.4 P)**
(b) Work done on the gas (in kJ) ? **(0. 4 P)**
(c) Change in internal energy (in kJ)? **(0.2 P)**

Please state the formulations/ equations clearly.

2. An Ideal gas is heated at constant volume until its temperature is doubled and then cooled at constant pressure to original temperature. Finally the gas is allowed to expand isothermally to the initial state.
(a) Draw p-v diagram with specifying various processes **(0.2 P)**
(b) Calculate the individual work done on each processes **(0.6 P)**
(c) Derive a relation to estimate network done **(0.2 P)**

Please state the formulations/ equations clearly.

Thermodynamics (MEL2020)
Indian Institute of Technology Jodhpur

Quiz-5B Date: 9th March 2022

Maximum points: 7 **Instructions:** **Time: 5:10 to 5:35**

- Each question carries **1 point**, there are 7 questions
- Please write your final short answers in A4 type sheet and upload within 25 mins
- No extra time is given for Scanning and uploading.
- **-1 negative marking for each minute of late submission**
- No Step wise marks are provided here (Each question caries 1 point)

Part 2: Write only final values or expressions or draw in A4 sheet.

1. Draw the correct T-ν diagram if steam at $\nu_1 = 0.00001$ m^3/kg is heated to $\nu_2 = 8$ m^3/kg while maintaining P = 10 kPa. The dots are states 1 and 2 with 1 being on the left. **(1P)**

TABLE A–5

Saturated water—Pressure table

		Specific volume, m³/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg·K		
Press., P kPa	Sat. temp., T_{sat} °C	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
1.0	6.97	0.001000	129.19	29.302	2355.2	2384.5	29.303	2484.4	2513.7	0.1059	8.8690	8.9749
1.5	13.02	0.001001	87.964	54.686	2338.1	2392.8	54.688	2470.1	2524.7	0.1956	8.6314	8.8270
2.0	17.50	0.001001	66.990	73.431	2325.5	2398.9	73.433	2459.5	2532.9	0.2606	8.4621	8.7227
2.5	21.08	0.001002	54.242	88.422	2315.4	2403.8	88.424	2451.0	2539.4	0.3118	8.3302	8.6421
3.0	24.08	0.001003	45.654	100.98	2306.9	2407.9	100.98	2443.9	2544.8	0.3543	8.2222	8.5765
4.0	28.96	0.001004	34.791	121.39	2293.1	2414.5	121.39	2432.3	2553.7	0.4224	8.0510	8.4734
5.0	32.87	0.001005	28.185	137.75	2282.1	2419.8	137.75	2423.0	2560.7	0.4762	7.9176	8.3938
7.5	40.29	0.001008	19.233	168.74	2261.1	2429.8	168.75	2405.3	2574.0	0.5763	7.6738	8.2501
10	45.81	0.001010	14.670	191.79	2245.4	2437.2	191.81	2392.1	2583.9	0.6492	7.4996	8.1488
15	53.97	0.001014	10.020	225.93	2222.1	2448.0	225.94	2372.3	2598.3	0.7549	7.2522	8.0071

2. Air enters an adiabatic compressor at 300 K. Find the exit temperature for a compression ratio of 3, assuming air to be an ideal gas (γ =7/5) and the process to be reversible **(1 P)**

3. A rigid tank contains 4 kg of an ideal gas at 5 atm and 80°C. Now a valve is opened, and half of mass of the gas is allowed to escape. If the final pressure in the tank is 2.2 atm, the final temperature (°C) in the tank is **(1 P)**

4. Carbon dioxide contained in a piston-cylinder device is compressed from 0.3 to 0.1 m3. During the process, the pressure and volume are related by $P = aV^{-2}$, where a = 8 kPa-m^6. Calculate the work done on the carbon dioxide during this process. **(1 P)**

5. Steam enters a diffuser steadily at 0.5 MPa, 300°C, and 122 m/s at a rate of 4 kg/s. The inlet area of the diffuser is (1 point)

	P = 0.50 MPa (151.83°C)				P = 0.60 MPa (158.83°C)				P = 0.80 MPa (170.41°C)			
Sat.	0.37483	2560.7	2748.1	6.8207	0.31560	2566.8	2756.2	6.7593	0.24035	2576.0	2768.3	6.6616
200	0.42503	2643.3	2855.8	7.0610	0.35212	2639.4	2850.6	6.9683	0.26088	2631.1	2839.8	6.8177
250	0.47443	2723.8	2961.0	7.2725	0.39390	2721.2	2957.6	7.1833	0.29321	2715.9	2950.4	7.0402
300	0.52261	2803.3	3064.6	7.4614	0.43442	2801.4	3062.0	7.3740	0.32416	2797.5	3056.9	7.2345
350	0.57015	2883.0	3168.1	7.6346	0.47428	2881.6	3166.1	7.5481	0.35442	2878.6	3162.2	7.4107

6. Steam at 1000 bar and 300 K undergoes Joule-Thomson expansion to 1 atm. What would be the temperature of steam after expansion? Assume steam to be an ideal gas. **(1 P)**

7. An ordinary egg with a mass of 0.1 kg and a specific heat of 3.32 kJ/kg.°C is dropped into boiling water at 95°C. If the initial temperature of the egg is 5°C, the maximum amount of heat transfer to the egg is **(1 P)**