KATHMANDU UNIVERSITY
End Semester Examination
February, 2025

Marks Scored:

Level : B.E.
Year : II

Course : MEEG 207
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date : 20 FEB 2025

Assume suitable data, if missing. The use of steam Tables is allowed.

SECTION "A"

[20 Q. × 1 = 20 marks]

Choose and encircle the most appropriate option from each set of choices

1. The volume of a cube of side 1 cm is equal to
   a. 1L b. 0.1L c. 0.01L d. 0.001L

2. A spring has a natural length of 10 cm and a spring constant of 150 N/m. What is the magnitude of the force required to stretch this spring to a length of 11 cm?
   a. 16.5 b. 15 c. 15.75 d. 1.5

3. Which of the following statements is/are true about a pure substance?
   I. A pure substance has to be a single chemical element or a compound.
   II. A pure substance need not have to be a single chemical element or a compound.
   III. Even though air is a mixture of several gases, it can be approximated to be a pure substance provided it is homogeneous.
   IV. A mixture of oil and water is not a pure substance, since oil is not soluble in water.
   a. I and II only b. II and III only c.II, III, and IV only d. IV only

4. Which of the following pairs of thermodynamic properties can uniquely fix the state of substance like water irrespective of its thermodynamic state?
   I. Temperature and specific volume
   II. Pressure and specific volume
   III. Temperature and pressure
   IV. None of the above
   a. I and II only b. I only c. I, II and III only d. II and III only

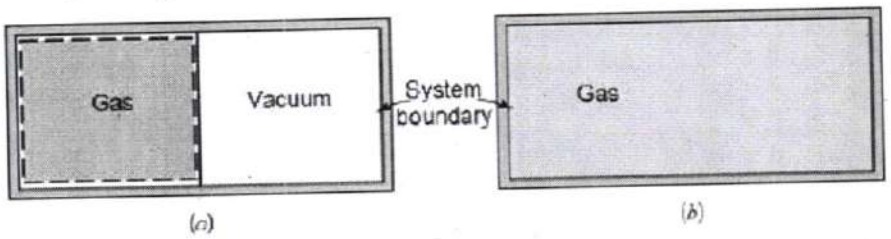
5. Determine the phase of water for the state (120 ^{0}C, 0.5 m^3/kg).
   a. Saturated liquid-vapor mixture b. Subcooled liquid
   c. Superheated vapor d. Critical point

6. Saturated water vapor at 200 kPa is in a constant-pressure piston/cylinder assembly. At this state the piston is 0.1 m from the cylinder bottom. How much is the distance covered if the temperature is changed to 2000C?
   a. 0.0144 m b. 0.0820 m c. 0.6955 m d. 0.1220 m

7. A sealed rigid tank contains 1 kg of water (liquid+vapor) at 50 ^{0}C with a volume of 0.002 m^3. The tank is now slowly heated. What happens to the liquid level inside the tank?
   a. The liquid level will not change during the process.
   b. The liquid level will eventually drop to the bottom of the tank
   c. The liquid level will eventually rise to the top of the tank
   d. None of the above.

20 FEB 2025

8. The figure below shows a gas seperated from the vacuum by a membrane. The membrane ruptures and the gas fills the entire volume. Considering gas as the system, which among the following statements regarding the work done by the gas during this process is/are true. Neglect any work associated with the rupturing of the membrane.



I. The system undergoes a change in volume and hence work is done during this process of filling the vacuum.

II. The work done during the process can be calculated from the expression of $\int_1^2 Pdv$

III. The work done during the process cannot be calculated from the expression of $\int_1^2 Pdv$

IV. No work is done during this process of filling the vacuum.

a. III and IV only b. I and II only c. III only d. None of the above

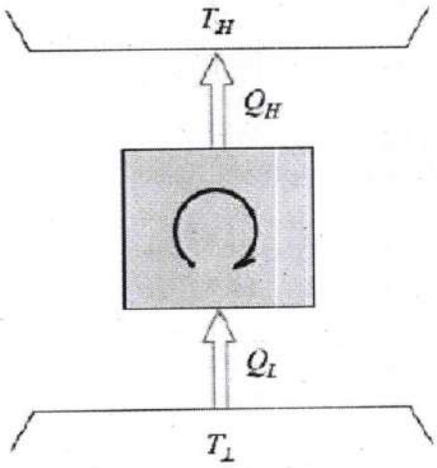
9. Heat engines and heat pumps (refrigerators) are energy conversion devices altering amount of energy transfer between heat Q, and work, W. Which conversion direction ($Q \rightarrow W$) or ($W \rightarrow Q$) is limited (100% conversion not possible) and which is unlimited (100% conversion possible) according to second law ?

a. The conversion dirction $Q \rightarrow W$ is limited but $W \rightarrow Q$ is unlimited
b. The conversion direction $W \rightarrow Q$ is limited but $Q \rightarrow W$ is unlimited.
c. Both conversion directions $Q \rightarrow W$ and $W \rightarrow Q$ are limited.
d. Both conversion directions $Q \rightarrow W$ and $W \rightarrow Q$ are unlimited.

10. A constant pressure piston cylinder assembly contains 0.8 kg water as saturated vapor at 400 kPa. It is now cooled so that the water occupied half ot the original volume. Find the heat transferred to the water in this process.

a. -855.5 kJ b. -1069.4 kJ c. -781.5 kJ d. -74 kJ

11. Consider a refrigerator that operates in a cycle, receives a given amount of heat Q_L from low temperature thermal reservoir and transfer the same amount of heat Q_H (= Q_L) high temperature thermal reservoir as shown in the figure below. Which of the following statements about this refrigerator is **TRUE**?



a) It violates both the first and second law of thermodynamics.
b) It violates the first law but obeys the second law of thermodynamics
c) It obeys the first law but violates the second law of thermodynamics
d) It obeys both the first law and second law of thermodynamics.

12. Choose the correct definition of a reversible process.
a. A reversible process for a system is defined as a process that, once having taken place can be reversed and in doing so leaves no change in the system but may change in surroundings.
b. A reversible process for a system is defined as a process that , once having taken place can be reversed and in doing so may change the system but leaves no change in the surrounding.
c. A reversible process for a system is defined as a process that, once having taken place can be reversed and in doing so may change either the system or its surroundings.
d. A reversible process for a system is defined as a process that, once having taken place can be reversed and in doing so leaves no change in either the system or its surroundings.

13. Consider the following process.
I. A cold cannned drink is left in a warmer room where its temperature rises as a result of heat transfer
II. By means of a refrigerator, heat is transferred from a low temperature reservoir (refrigerated space) to a high temperature reservoir (the kitchen air).

Choose that statements that is/are true about these processes.
A. Process I obeys the second law of thermodynamics but process II is a violation of the second law.
B. Both the processes I and II violate the second law of thermodynamics.
C. Both the processes I and II obey the second law of thermodynamics.
D. Process I is a reversible process.
E. Process I is an irreversible process.

a. A only b. C and E only c. B and D only d. E only

14. Air enters a diesel engine with a density of 1.0 kg/m^3. The compression ratio is 21. At steady state, the air intake is 30×10^{-3} kg/s and the net work output is 15 kW. The mean effective pressure (in kPa) is

a. 525 kPa b. 500 kPa c. 450 kPa d. 600 kPa

15. Which one of the following is NOT a necessary assumption for the air standard otto cycle?

a. All processes are both internally as well as externally reversible.
b. Intake and exhaust processes are constant volume heat addition process.
c. The combustion process is constant volume heat addition process.
d. The working fluid is an ideal gas with constant specific heats.

16. Consider two systems, A and B with the source and sink temperatures defined as follows. Both the systems exchange heat with source and sink.

System A	System B
Source Temperature: 500 K	Source Temperature: 600 K
Sink temperature : 400 K	Sink Temperature: 550 K

Which system do you think is more reversible?

a. System A
b. System B
c. Both are equally reversible
d. The given data is insufficient to comment

17. A heat reservoir at 900 K is brought into contact with the ambient at 300 K for a short time. During this period 9000 kJ of heat is lost by the heat reservoir. The total loss in the availability due to this process is

a. 18000 kJ b. 9000 kJ c. 6000 kJ d. It cannot be answered.

18. Constant pressure line in the superheated region of the Mollier diagram will have

a. A positive slope b. A negative slope
c. Zero slope d. Both positive and negative slope

19. A house is maintained at 21 ^{0}C in winter by electric resistance heaters. If the outdoor temperature is 9 ^{0}C, the second-law efficiency of the resistance heaters is_____.

20. A vertical cylinder with a freely floating piston contains 0.1 kg air at 1.2 bar and a small electrical resistor. The resistor is wired to an external 12 volt battery. When a current of 1.5 amps is passed through the resistor for 90 secs, the piston sweeps a volume of 0.01 m^3. Assume piston and cylinder are insulated and air behaves as an ideal gas with c_v= 700 J/kg K. Find the rise in temperature of air. _____.

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F. M. : 55

The use of steam Tables is allowed.

SECTION "B"

Attempt ALL questions. Assume suitable data, if missing.

1.

a. A mercury (Hg) manometer is used to measure the pressure in a vessel as shown in Figure 1. The mercury has a density of 13,590 kg/m^3, and the height difference between the two columns is measured to be 24 cm. Determine the pressure inside the vessel. Define gauge and absolute pressure with respect to absolute vacuum. [3+2]

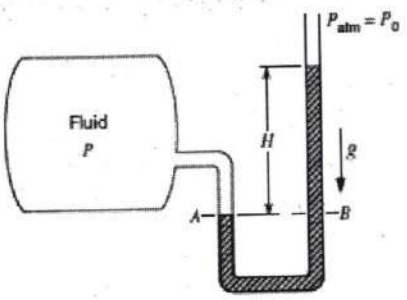

Figure 1

b. Write a state postulate and differentiate between open and closed systems. [1+1+1]

2.

a. Write the concept of internal energy from the view of the First law of thermodynamics. [1]

b. Water is heated from 100 kPa, 20°C to 1000 kPa, 200°C. In one case, pressure is raised at $T = C$; then T is raised at $P = C$. In a second case, the opposite order is used. Does that make a difference for ${}_1Q_2$ and ${}_1W_2$? Justify your answer. [2]

3. An ideal Otto cycle has a compression ratio of 8. At the beginning of the compression process, air is at 100 kPa and 17 ^{0}C, and 800 kJ/kg of heat is transferred to air during the constant-volume heat-addition process. Accounting for the variation of specific heats of air with temperature, determine (*a*) the maximum temperature and pressure that occur during the cycle, (*b*) the net work output, (*c*) the thermal efficiency, and (*d*) the mean effective pressure for the cycle. (*e*) Also, determine the power output from the cycle, in kW, for an engine speed of 4000 rpm (rev/min). Assume that this cycle is operated on an engine that has four cylinders with a total displacement volume of 1.6 L. [7]

P.T.O.

4.

a. Water at 400 kPa with a quality of 25% has its pressure raised 50 kPa in a constant-volume process. What is the new quality and temperature? [2]

b. A piston/cylinder arrangement, shown in Fig. 2, contains air at 250 kPa and 300 ^{0}C. The 50-kg piston has a diameter of 0.1 m and initially pushes against the stops. The atmosphere is at 100 kPa and 20^{0}C. The cylinder now cools as heat is transferred to the ambient surroundings. [6]

   i. At what temperature does the piston begin to move down?
   ii. How far has the piston dropped when the temperature reaches ambient?
   iii. Show the process in a P–v and a T–v diagram.

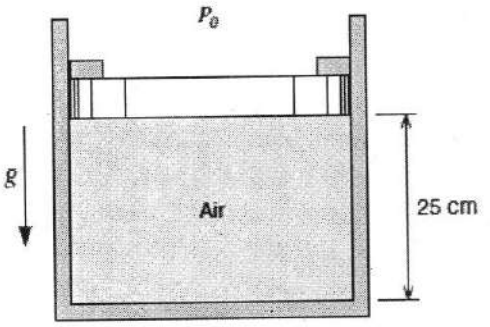

Figure 2

5.

a. A cyclic machine, shown in Fig. 5., receives 325 kJ from a 1000K energy reservoir. It rejects 125 kJ to a 400 K energy reservoir, and the cycle produces 200 kJ of work as output. Is this cycle reversible, irreversible, or impossible? [2]

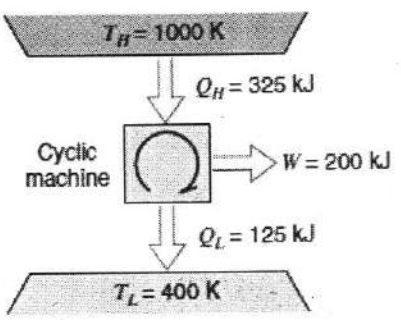

Figure 3

b. A heat pump is used to heat a house during the winter. The house is to be maintained at 20 ^{0}C at all times. When the ambient temperature outside drops to −10 ^{0}C, the rate at which heat is lost from the house is estimated to be 25 kW. What is the minimum electrical power required to drive the heat pump? [5]

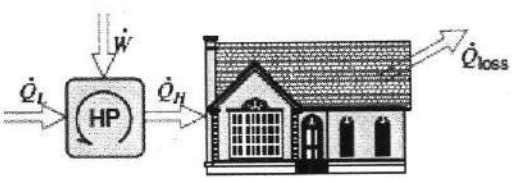

Figure 4

20 FEB 2025

6.

a. A rigid tank *A* of volume 0.6 m^3 contains 3 kg of water at 120^{0}C, and rigid tank *B* has a volume of 0.4 m^3 with water at 600 kPa, 200^{0}C. The tanks are connected to a piston/cylinder initially empty with closed valves as shown in Fig. 3. The pressure in the cylinder should be 800 kPa to float the piston. Now the valves are slowly opened and heat is transferred so that the water reaches a uniform state at 250^{0}C with the valves open. Find the final volume and pressure, and the work and heat transfer in the process. [6]

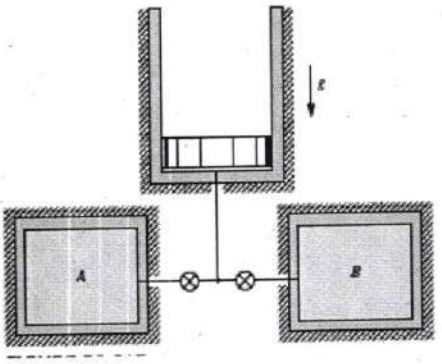

Figure 5

b. Two steady flows of air enter a control volume, as shown in Fig. 4. One is a 0.025 kg/s flow at 350 kPa, 150^{0}C, state 1, and the other enters at 450 kPa, 15 ^{0}C, state 2. A single flow exits at 100 kPa,−40^{0}C, state 3. The control volume ejects 1 kW heat to the surroundings and produces 4 kW of power output. Neglect kinetic energies and determine the mass flow rate at state 2. [5]

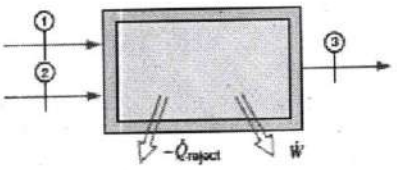

Figure 6

7. Steam enters an adiabatic turbine steadily at 3 MPa and 400 ^{0}C and leaves at 50 kPa and 100 ^{0}C. If the power output of the turbine is 2 MW, determine (*a*) the isentropic efficiency of the turbine and (*b*) the mass flow rate of the steam flowing through the turbine. [6]

8. How can you improve the efficiency of the rankine cycle. Describe with appropriate diagram. State carnot Principle. [3+2]