Roll No.												

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 1

Semester: 3
Course Code: MEC 201
Course Name: BASIC THERMODYNAMICS
Program & Sem: B.Tech, 3

Date: 27/09/2019
Time: 2.30PM to 3.30 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) ***Student should bring their own belongings like Pen, Pencil, Calculators, etc. Exchange of any material will be treated as malpractice***
(ii) ***No Student will be allowed to go from the examination hall before the end of examination.***
(iii) ***Use of Un-programmable calculators is permitted.***
(iv) ***Use of Steam Tables is permitted.***

Part A

Answer any THREE the Questions. Each question carries 4 marks. (3Qx4M=12)

Q.NO. 1 Describe in brief (in few sentences) a) State of a system, b) Isothermal Process c) Thermal Equilibrium d) Intensive property [4] (C.O.NO 1) [Knowledge]

Q.NO. 2 What is pressure? What is the value of pressure exerted by atmosphere at sea level? Give the equation to determine pressure using a barometer. [4] (C.O.NO 1) [Knowledge]

Q.NO. 3 Describe in few sentences with T-V or P-V diagram: a) Saturated Liquid, b) Saturated Vapor, c) Saturation Temperature. [4] (C.O.NO 1) [Knowledge]

Q.NO. 4 What is a pure substance? Differentiate between Sensible Heat & Latent Heat. [4] (C.O.NO 1) [Knowledge]

Q. NO. 5 What is critical point? Give a neat sketch of Pressure-Temperature curve for water highlighting all the relevant points and regions. [4]
(C.O.NO 1) [Knowledge]

Part B

Answer ALL the Questions. Each question carries 2 marks. **(4Qx2M=8M)**

Q.NO. 6 A bullet is fired vertically up into the air from earth and the distance travelled is calculated. When the same shot is fired from the surface of moon it is observed that the bullet travels longer distance. Why? [2] (C.O.No: 2) [Comprehension]

Q.NO. 7 At high altitudes a car engine generates less power. Why? [2]

(C.O.No: 2) [Comprehension]

Q.NO. 8 Is the use of pressure cooker beneficial in cooking food? How? [2]

(C.O.No: 2) [Comprehension]

Q.NO. 9 Which law of thermodynamics: (C.O.No: 2) [Comprehension]

a) Discusses the conservation of energy?,
b) Discusses the direction of heat transfer? [2]

Part C

Answer ALL the Questions.

Q.NO. 10 Determine the missing properties and the phase descriptions in the following table for water: [16 M] (C.O.NO 2) [Application]

	T (°C) Temperature	P (kPa) Pressure	U (kJ/kg) Internal energy	X Dryness Fraction	Phase description
A		200		0.8	
B	125		1600		
C		1000	3000		
D	85	500			

Q.NO. 11 A cooking pan whose inner diameter is 20 cm is filled with water and covered with a 4-kg lid. If the local atmospheric pressure is 101 kPa, determine the temperature at which the water starts boiling when it is heated. (C.O.NO 2) [Application]

SCHOOL OF ENGINEERING

Semester: 3

Course Code: MEC 201

Course Name: BASIC THERMODYNAMICS

Date: 27/09/2019

Time: 2.30PM to 3.30 PM

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO .	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]		Total Marks
			K			C			A		
1	1	1		K	4						4
2	1	1		K	4						4
3	1	1		K	4						4
4	1	1		K	4						4
5	2	2		K	4						4
6	1	1					C	2			2
7	1	1					C	2			2
8	1	1					C	2			2
9	1	1		K	2						2
10	2	2							A	16	16
11	2	2							A	4	4
	Total Marks										48

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I here certify that All the questions are set as per the above lines Dr Sudheer

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

SOLUTION

Semester: 3

Course Code: MEC 201

Course Name: BASIC THERMODYNAMICS

Date:

Time:

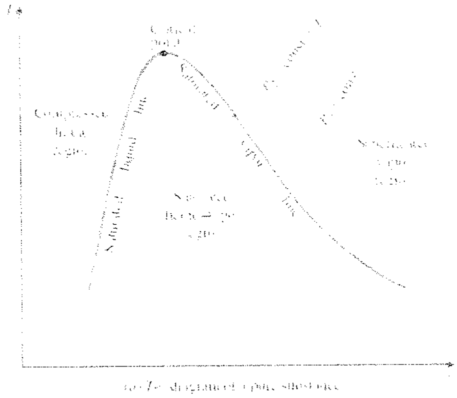
Max Marks: 40

Weightage: 20%

Part A

(Q x M = Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	State : The condition of system described by properties like Temperature, Pressure etc is called state of a system	1	
	Isothermal process is a process in which the temperature of the system stays constant.	1	
	Thermal equilibrium is a state at which the system is in same temperature as the surrounding.	1	
	Intensive properties are those properties which are independent of the size of the mass considered.	1	
	....		
2.	Pressure is force per unit area.	1	
	101.325 kPa	1	
	ρ gh, where ρ is density of fluid, g is acceleralation due to gravity and h is the height of fluid column.	2	
	....		
3	Saturated Liquid: Liquid that is at saturation temperature and would vaporize on heat addition, At a given pressure.	1	
	Saturated Vapor: Vapour at saturation temperature which would condense on heat removal, At a given pressure.	1.5	
	Saturation temperature : The temperature at which phase change can occur on addition or withdrawal of heat at constant pressure.	1.5	
	....		
	A substance that has a fixed chemical composition throughout is called a pure substance.	1	

4.	**Sensible heat : Heat transferred that leads to a change in temperature is called sensible heat.** **Latent Heat : Heat transferred which leads to a change in phase.**	1.5 1.5	
5.	**Critical point: The point at which the saturated liquid and saturated vapor states are identical** 	1 3	

Part B (Q x M = Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6.	At moon the gravity force is less, g value is around 1.3 m/s2. So the bullet covers longer distance.	2	
7.	Air density is less at higher altitudes. So oxygen necessary for combustion of fuel is not available in sufficient.	2	
8.	Inside cooker, the pressure is higher than the atmospheric pressure value. So the boiling happens at higher temperatures to 100C. As more steam is generated, the pressure increase and so does the saturation temperature. So, the food particles are maintained at a much higher temperature in the pressure cooker. This is beneficial as cooking happens quickly.	2	
9.	a) First Law b) Second Law	1 1	

Part C (Q x M = Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
10.	(see below)		

10.

	T (°C) Temperature	P (kPa) Pressure	U (kJ/kg) Internal energy	X Dryness Fraction	Phase description
A	120.21	200	504 + 0.8(2024.6)	0.8	Wet steam
B	125	198.67	1600	0.54	Wet steam
C	426.3	1000	3000	1	Super steam
D	85	500	362	0	Compressed water

A:
From Steam Table , For Pressure 200kPa, Tsat = 120.21C
Internal Energy, U = Uf + xUfg = 504 + 0.8 (2024.6) =Wet Steam.

4

B:
For T of 125C, From steam table, Psat = 198.67 kPa.
U = Uf + x Ufg, U= 1600kJ/kg, Uf and Ufg from steam table — 4
x = 0.54

C:
For pressure of 1000kPa, from steam table T sat = 179.88C
Ug = 2582 kJ.
With this it is understood that, The steam is in superheated state. — 4
The excess energy, 418kJ is accounted for the superheat. The superheat temperature can be located from Table 6 in the steam tables.
The change in temperature is located using lever rule between 450C and 350C.
T = 426.3C

D:
Tsat from steam table is 151.3C
The current temperature being 85C. So the state is compressed liquid. — 4
U = Uf – C Δ T = 362 kJ

Uf = from steam table
C = 4.19 kJ/kg/K
Δ T = 151.3-85 C

....

11.	Pressure inside cooker = 101 kPa + pressure due to weight of lid Pressure due to weight of lid = $4*9.81/ \pi d^2$ Use the interpolation techniqueto locate saturation temperature. From steam tables, Temperature of boiling is 100.2 C.	1 1 1 1	

Roll No.													

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20
Course Code: MEC 201
Course Name: BASIC THERMODYNAMICS
Program & Sem: B.Tech & III

Date: 16.11.2019
Time: 2.30 PM to 3.30 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) Use of Un-programmable calculators is permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries four marks. (4Qx4M=16M)

1. Describe Carnot cycle and carnot principles with suitable figures.
(C.O.NO 4) [Knowledge]
2. Differentiate between reversible and irreversible processes with a suitable example.
(C.O.NO 4) [Knowledge]
3. (a) What is a control volume?
(b) What is a steady flow process?
(c) Give the energy balance equation for a steady flow process.
(C.O.NO.3) [Knowledge]
4. What is moving boundary work? Prove that $P_1V_1\ln\frac{V_2}{V_1}$ is the boundary work in an isothermal process.(where P is pressure and V is Volume).

(C.O.NO.3) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries two marks. (2Qx2M=4M)

5. A refrigerator is designed to maintain a chamber at 10°C when the outside air temperature is 40°C. Identify the thermal source and sink for the refrigerator.

(C.O.NO.3) [Comprehension]

6. What is the work done by a compressed gas when it expand into a vaccum chamber? Explain in brief. (C.O.NO.3) [Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. **(3Q=20M)**

7. The power output of an adiabatic steam turbine is 10MW. The inlet and outlet conditions are as follows.

	Inlet	Outlet
Enthalpy of steam in kJ/kg	3300	2400
Velocity of steam in m/s	60	200
Elevation from ground in m	12	8

(a) Determine the work done per unit mass of the steam flowing through the turbine,
(b) Calculate the mass flow rate of the steam. [8M] (C.O.NO.3) [Application]

8. A person wanted to maintain a room temperature of 25°C in his house during the winter when the outside air temperature went down to -15°C. For this condition he observed that heat loss from the house occurred at a rate of 37.5kW. He installed a Heat Pump for this purpose which consumed 6.25kW of electrical energy. Was his decision right? Justify.
Predict the highest room temperature in this case which can be achieved using the purchased heat pump. [8M] (C.O.NO.4) [Application]

9. Heat is transferred to a heat engine from a furnace at a rate of 100 MW. If the rate of waste heat rejection to a nearby river is 60 MW, determine the net power output and the thermal efficiency for this heat engine. [4M] (C.O.NO.4) [Application]

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

Semester: 3
Course Code: MEC 201
Course Name: BASIC THERMODYNAMICS

Date: 16/10/2019
Time: 2.30PM to 3.30 PM
Max Marks: 40
Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	4	4		K	4							4
2	3	3		K	4							4
3	3	3		K	4							4
4	4	4		K	4							4
5	3	3					C	2				2
6	3	3					C	2				2
7	3	3								A		8
8	4	4								A		8
9	4	4								A		4
10												
11												
	Total Marks											40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

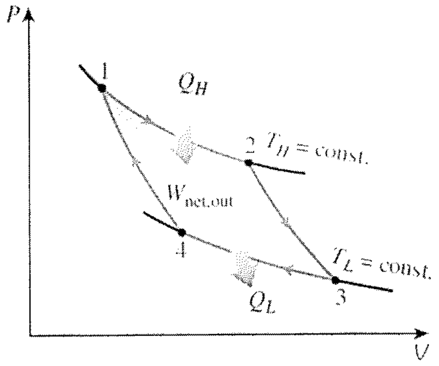
SCHOOL OF ENGINEERING

SOLUTION

Semester: 3
Course Code: MEC 201
Course Name: BASIC THERMODYNAMICS

Date: 16/10/2019
Time: 2.30 to 3.30 PM
Max Marks: 40
Weightage: 20%

Part A (4Q x 4M = 16Marks)

<table>
<tr><th>Q No</th><th>Solution</th><th>Scheme of Marking</th><th>Max. Time required for each Question</th></tr>
<tr><td>1</td><td>


Carnot cycle comprises of 4 processes

- Reversible Isothermal Expansion (process 1-2, *TH*=constant)
- Reversible Adiabatic Expansion (process 2-3, temperature drops from *TH*to *TL*)
- Reversible Isothermal Compression (process 3-4, *TL*=constant)
- Reversible Adiabatic Compression (process 4-1, temperature rises from *TL*to *TH*)

Carnot Principle
The efficiency of an irreversible heat engine is always less than the efficiency of a reversible one operating between the same two reservoirs.
The efficiencies of all reversible heat engines operating between the same two reservoirs are the same.

The Carnot heat engine cycle is a totally reversible cycle. Therefore, all the processes that comprise it can be reversed , in which case it becomes the Carnot refrigeration cycle.
</td><td>1

1

2</td><td>6</td></tr>
<tr><td>2.</td><td>A reversible process is defined as a process that can be reversed without leaving any trace on the surroundings. That is, both the system and the surroundings are returned to their initial states at the end of the reverse process. This is possible only if the net heat and</td><td>1</td><td>6</td></tr>
</table>

	net work exchange between the system and the surroundings is zero for the combined (original and reverse) process. Processes that are not reversible are called **irreversible processes.** Reversible processes actually do not occur in nature. They are merely *idealizations* of actual processes. Reversible processes can be approximated by actual devices, but they can never be achieved. That is, all the processes occurring in nature are irreversible. : Some examples of nearly reversible processes are: (i) Frictionless relative motion. (ii) Expansion and compression of spring. (iii) Frictionless adiabatic expansion or compression of fluid. (iv) Polytropic expansion or compression of fluid. (v) Isothermal expansion or compression. (vi) Electrolysis. Relative motion with friction (ii) Combustion (iii) Diffusion (iv) Free expansion (v) Throttling (vi) Electricity flow through a resistance (vii) Heat transfer (viii) Plastic deformation.	1 2	
3.	**Control volume** is a **volume** in space of special interest for particular analysis. A **steady flow process** is a **process** in which matter and energy **flow** in and out of an open system at **steady** rates. Moreover , an open system undergoing a **steady flow process** does not experience any change in the mass and energy of the system. Steady Flow Energy Equation (SFEE) is given as : $\dot{Q} - \dot{W} = \underbrace{\sum_{out} \dot{m}\left(h + \frac{V^2}{2} + gz\right)}_{\text{for each exit}} - \underbrace{\sum_{in} \dot{m}\left(h + \frac{V^2}{2} + gz\right)}_{\text{for each inlet}}$ Where m˙=m˙=mass rate flow in kg/s, h=specific enthalpy in J/kg, V is velocity in m/s, Z is elevation from datum, Q is rate of heat transfer in J/s and W is rate of work transfer in J/s.	1 1 1 1	6
4.	**Boundary work** occurs because the mass of the substance contained within the system **boundary** causes a force, the pressure times the surface area, to act on the **boundary** surface and make it **move**. *Analysis* For an ideal gas at constant temperature T_0, $PV = mRT_0 = C \quad \text{or} \quad P = \frac{C}{V}$ where C is a constant. Substituting this into Eq. 4–2, we have $W_b = \int_1^2 P\,dV = \int_1^2 \frac{C}{V}dV = C\int_1^2 \frac{dV}{V} = C \ln\frac{V_2}{V_1} = P_1V_1 \ln\frac{V_2}{V_1}$	1 3	6

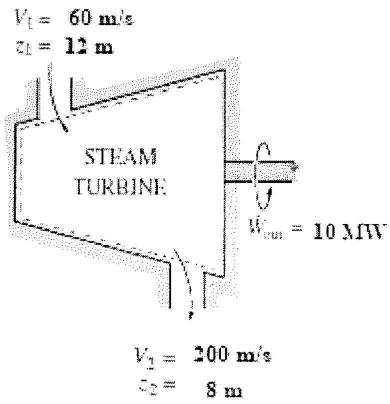
Part B

(2Q x 2M = 4 Marks)

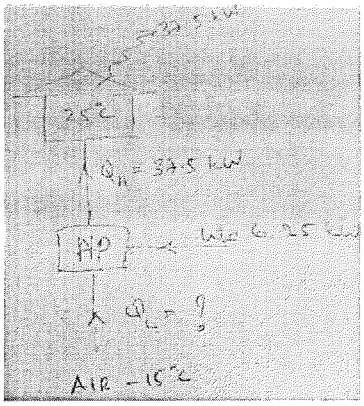
Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	Thermal source : Chamber maintained at 10C Thermal Sink : Outside air at 40C	1 1	2
6	Boundary work done by the expanding air is ZERO. As the air expanded freely into the vacuum chamber, no force or pressure was exerted on the system (air) boundary.	1 1	2

Part C

(3Q x M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7	 $\dot{Q} - \dot{W} = \underbrace{\sum_{out} \dot{m}\left(h + \frac{V^2}{2} + gz\right)}_{\text{for each exit}} - \underbrace{\sum_{in} \dot{m}\left(h + \frac{V^2}{2} + gz\right)}_{\text{for each inlet}}$ Q = 0, as it is an adiabatic steam turbine. h, V, z values given in the question. w = 700 +18.2 +0.0392 kJ/kg = 718.2392 kJ/kg mass flow rate = W/w = 10000/718.2392 = 13.92kg/s	Figure and given data = 2 1 Calculation = 3 2	12
8.	For this The purchased heat should be compared with the carnot heat pump that operates between the same temperature limits. COP of the carnot heat pump = $\frac{T_H}{T_H - T_L}$ = 7.5 COP of the purchased Heat Pump = $\frac{Q_H}{W}$ = 37.5/6.25 = 6	1 1 1	12

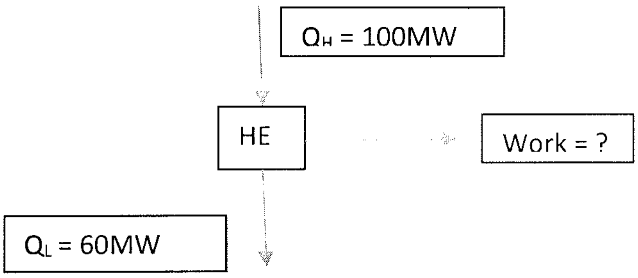
<table>
<tr>
<td>11.</td>
<td>
Carnot COP > COP heat pump. So the purchase was right. The desired temperature can be achieved.



To predict the highest temperature, the purchased heat pump with COP 0f 6 is considered as a carnot heat pump of COP= 6.

COP = $6 = \frac{T_H}{T_H - T_L}$ T_L = 15C.

We get T_H = 309 K = 36C.



Work Done = $Q_H - Q_L$ = 100 – 60 = 40MW
Thermal efficiency = Work/ Q_H = 40%
</td>
<td>
1

Figure and given data = 2

2

1

1
2
</td>
<td>8</td>
</tr>
</table>

Roll No												

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20
Course Code: MEC 201
Course Name: BASIC THERMODYNAMICS
Program & Sem: B.Tech (MEC) & III

Date: 23 December 2019
Time: 1:00 PM to 4:00 PM
Max Marks: 80
Weightage: 40%

Instructions:
(i) Read the all questions carefully and answer accordingly.
(ii) Steam table and non-programmable calculator is permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 4 marks. (5Qx4M=20M)

1. Define the COP of refrigerator with neat figure. (C.O.No.4) [Knowledge]
2. Write down expressions of first law of thermodynamics for a cycle and a process. (C.O.No.3) [Knowledge]
3. Explain available energy and unavailable energy with the help of diagram (C.O.No.5) [Knowledge]
4. What are intensive and extensive properties? Write definition with examples. (C.O.No.1) [Knowledge]
5. What is the difference between critical point and triple point? Write pressure and temperature critical point values for water. (C.O.No.2) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries 5 marks. (4Qx5M=20M)

6. An ideal gas at a given state expands to a fixed final volume first at constant pressure and then at constant temperature. For which case is the work done greater? Explain. (C.O.No.3) [Comprehension]
7. Consider two actual power plants operating with solar energy. Energy is supplied to one plant from a solar pond at 80 °C and to the other from concentrating collectors that raise the water temperature to 600°C. Which of these power plants will have a higher efficiency? Explain. (C.O.No.4) [Comprehension]

8. Is the exergy of a system different in different environments? Explain.

(C.O.No.5) [Comprehension]

9. Why do frozen water pipe tend to burst? Suggest methods to reduce it.

(C.O.No.2) [Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each Question carries 10 marks. **(4Qx10M=40M)**

10. A blower handles 1 kg/s of air at 20°C and consumes a power of 15 kW. The inlet and outlet velocities of air are 100 m/s and 150 m/s respectively. Find the exit air temperature, assuming adiabatic conditions. Take c_p of air is 1.005 kJ/kg-K. (C.O.No.3) [Application]

11. Heat is transferred to a heat engine from a furnace at a rate of 130 MW. If the rate of waste heat rejection to a nearby river is 50 MW, determine the net power output and the thermal efficiency for this heat engine. (C.O.No.4) [Application]

12. Show that there is a decrease in available energy when heat is transferred through a finite temperature difference. (C.O.No.5) [Application]

13. A heat engine receives reversibly 420 kJ/cycle of heat from a source at 327°C, and rejects heat reversibly to a sink at 27°C. There are no other heat transfers. For each of the three hypothetical amounts of heat rejected, in (a), (b), and (c) below, compute the cyclic integral of dQ /T. from these results show which case is irreversible, which reversible, and which impossible:

    a. 210 kJ/cycle rejected
    b. 105 kJ/cycle rejected
    c. 315 kJ/cycle rejected

(C.O.No.4) [Application]

SCHOOL OF XXXXXX

GAIN MORE KNOWLEDGE REACH GREATER HEIGHTS

END TERM FINAL EXAMINATION

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	A	
1	CO 04	Module 4 2^{nd} law of thermodynamics	4			4
2	CO 03	Module 3 First law applied to control mass and control volume system	4			4
3	CO 05	Module 5 Exergy Analysis	4			4
4	CO 01	Module 1 Introduction	4			4
5	CO 02	Module 2 Properties of Pure substance	4			4
6	CO 03	Module 3		5		5

		First law applied to control mass and control volume system				
7	CO 04	Module 4 2^{nd} law of thermodynamics		5		5
8	CO 05	Module 5 Exergy Analysis		5		5
9	CO 02	Module 2 Properties of Pure substance		5		5
10	CO 03	Module 3 First law applied to control mass and control volume system			10	10
11	CO 04	Module 4 2^{nd} law of thermodynamics			10	10
12	CO 05	Module 5 Exergy Analysis			10	10
13	CO 04	Module 4 2^{nd} law of thermodynamics			10	10

	Total Marks		20	20	40	80

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I hereby certify that all the questions are set as per the above guidelines.

Faculty Signature:

Reviewer Commend:

Format of Answer Scheme

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

SCHOOL OF ENGINEERING

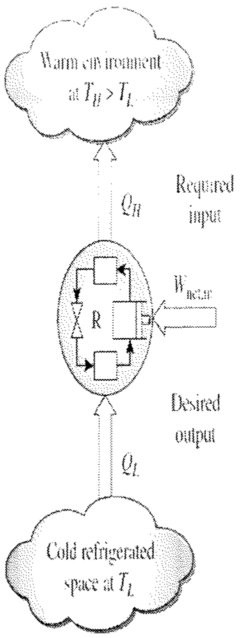
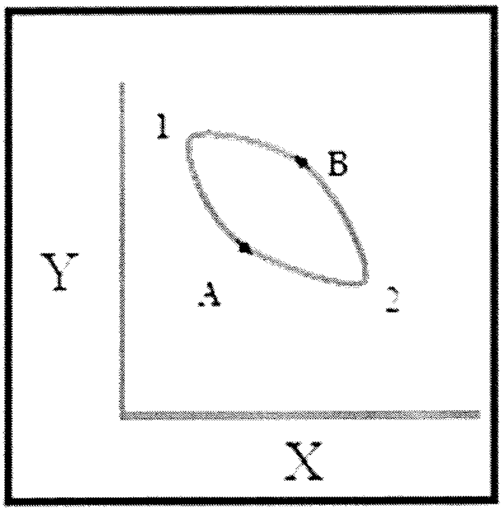
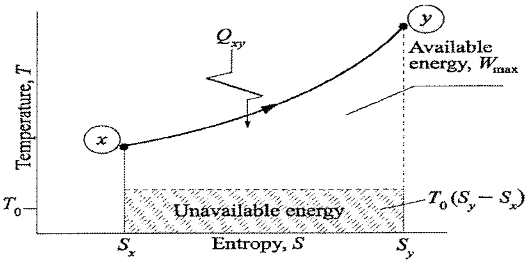
SOLUTION

Semester: Odd Sem. 2019-20
Course Code: MEC 201
Course Name: Basic Thermodynamics
Program & Sem: B.Tech (Mech) & Third

Date: 23.12.2019
Time: 3 HRS
Max Marks: 80
Weightage: 40%

Part A (5Q x 4M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question

1	 $COP_R = \frac{\text{Desired output}}{\text{Required input}} = \frac{Q_L}{W_{net,in}}$ $W_{net,in} = Q_H - Q_L$ (kJ) $COP_R = \frac{Q_L}{Q_H - Q_L} = \frac{1}{Q_H/Q_L - 1}$	2 2	10
2	When a closed system executes a complete cycle the sum of heat interactions is equal to the sum of work interactions • ΣQ=Σ W the FIRST LAW for a process as **δQ-δW=dE**  	2 2	10
3	• The maximum work output obtainable from a certain heat input in a cyclic heat engine is called available energy (A.E.).  	2	10

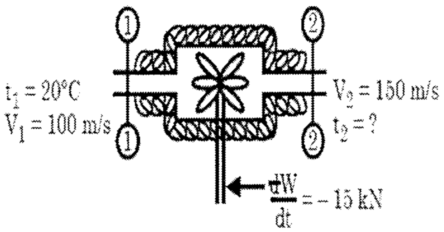
	• The minimum energy that has to be rejected to the sink (surrounding) is called Unavailable Energy.	**2**	
4	Extensive property: whose value depends on the size or extent of the system (upper case letters as the symbols). eg: Volume, Mass (V,M). If mass is increased, the value of extensive property also increases. Intensive property: whose value is independent of the size or extent of the system. eg: pressure, temperature (p, T).	**2** **2**	**10**
5	A **critical point** (or **critical** state) is the end **point** of a phase equilibrium . **Triple point** of a substance is the temperature and pressure at which the three phases (gas, liquid, and solid) of that substance coexist in thermodynamic equilibrium . Tc= 647 K and Pc= 22.064 MPa	**3** **1**	**10**

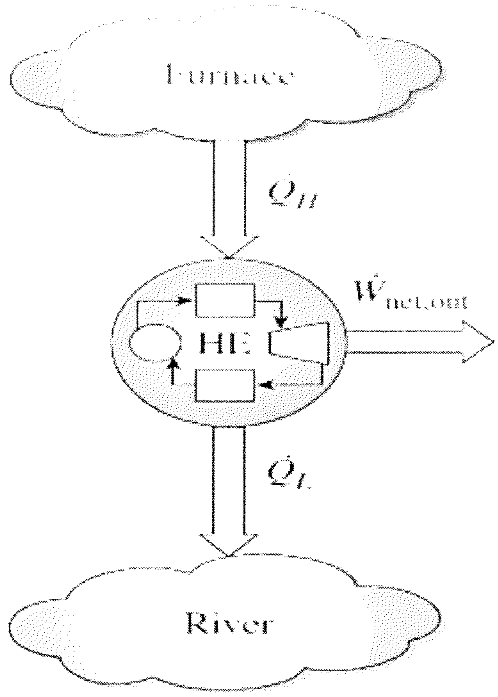
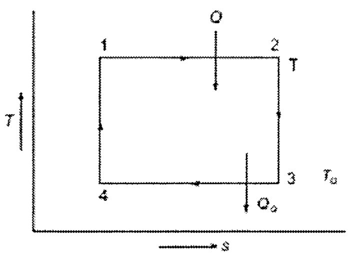
Part B (4Q x 5M = 20 Marks)

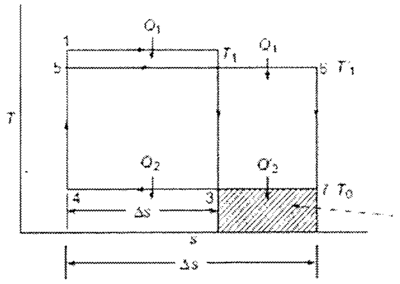
Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	It will be more for isobaric process because area is under p-v diagram for isobaric process is higher as compare to isothermal process.	5	12
7	If we assume that the sink temperature is same in both cases than the efficiency of concentrating collectors will be high as we know that the its $\eta_{th} = 1 - \frac{T_L}{T_H}$	5	12
8	Yes, Exergy has been viewed thus far as the maximum theoretical work obtainable from an overall system of system plus environment as the system passes from a given state to the dead state.	5	12
9	Perhaps surprisingly, freezing pipes don't burst because of ice expanding in place. Instead, it has to do with pressure inside the pipes. When water freezes, its molecules crystalize into an open hexagonal form, which takes up more space than when the molecules are in their liquid form — that is, the water molecules expand as they freeze. As the ice expands, it pushes water toward the closed faucet. This causes an immense amount of water pressure to build between the ice blockage and the faucet — eventually, the pipe ruptures under the pressure, usually at a spot where there's little or no ice. The pipe areas upstream of the ice clog aren't typically in danger of bursting because the pressure isn't great enough. In this case, the water isn't blocked, and can	5	12

	always retreat back to its source. Pipes that are the most at risk of bursting are those located outside of building insulation, or those in unheated interior areas, including basements, attics and crawl spaces. Heating or insulating these vulnerable pipes with fiberglass or foam sleeves can help prevent them from bursting. Additionally, keeping the facet open and letting the water run — even at just a trickle — will help prevent the water pressure from building to dangerous levels.		

Part C (4Q x 10M = 40Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
10	Solution:  From S.F.E.E. $w_1\left(h_1 + \frac{V_1^2}{2000} + \frac{gZ_1}{1000}\right) + \frac{dQ}{dt} = w_2\left(h_2 + \frac{V_2^2}{2000} + \frac{gZ_2}{1000}\right) + \frac{dW}{dt}$ Here $w_1 = w_2 = 1$ kg/s ; $Z_1 = Z_2$; $\frac{dQ}{dt} = 0$. $\therefore \quad h_1 + \frac{100^2}{2000} + 0 = h_2 + \frac{150^2}{2000} - 15$ $\therefore \quad h_2 - h_1 = \left(15 + \frac{100^2}{2000} - \frac{150^2}{2000}\right)$ or $\quad C_p(t_2 - t_1) = 8.75$ or $\quad t_2 = 20 + \frac{8.75}{1.005} = 28.7°C$	4 4 2	20

11	 Q_H = 130 MW, Q_L = 50 MW Work output = Q_H - Q_L = 130- 50 = 80 MW $\eta = Q_H - Q_L$ / Q_H = 80 /130 = 0.615 OR 61.5 %	3 2 2 3	15
12	Whenever heat is transferred through a finite temperature difference, there is a de crease in exergy output. Let us consider a reversible heat engine operating between T_1 and T_o (Fig. 8.3). Then $Q_1 = T_1 \Delta s$, $Q_2 = T_o \Delta s$, and $W = AE = X = (T_1 - T_o) \Delta s$  	2 2	25



2

Fig. 8.4 Decrease in exergy due to heat transfer through a finite temperature difference

Let us now consider that heat Q_1 is transferred through a finite temperature difference from the reservoir or source at T_1 to the engine absorbing heat at lower than T_1 (Fig. 8.4). The exergy of Q_1 received by the engine at T'_1 can be found by allowing the engine to operate reversibly in a cycle between, T_1 and T_0, receiving Q_1 and rejecting Q_2.

2

Now, $Q_1 = T_1\Delta s = T_1'\Delta s'$. Since $T_1 > T_1'$, $\Delta s' > \Delta s$

$Q_2 = T_0\Delta s$ and $Q_2' = T_0\Delta s'$

$\therefore$ $Q_2' > Q_2$

$W' = Q_1 - Q_2' = T_1'\Delta s' - T_0\Delta s' = (T_1' - T_0)\Delta s'$

and $W = (T_1 - T_0)\Delta s$

$\therefore$ $W' < W$

Exergy lost due to irreversible heat transfer through a finite temperature difference between the source and the working fluid during the heat addition process is given by

$$W - W' = Q_2' - Q_2 = T_0(\Delta s' - \Delta s) \qquad (8.1)$$

Exergy destroyed in the process is thus the product of the lowest feasible temperature, i. e., the dead state, and the additional entropy change in the system while receiving heat irreversibly, compared to the case of reversible heat transfer from the same source.

The greater is the temperature difference (T_1 - T'_1), the greater is the heat rejection Q'_2 and greater will be the exergy lost, or the unavailable part of the energy supplied Q_1. Exergy is said to be destroyed each time it flows through a finite temperature difference.

2

1 3	Solution: (a) $\oint \frac{dQ}{T} = \frac{+420}{(327+273)} - \frac{210}{(27+273)} = 0$ $\therefore$ Cycle is Reversible. Possible (b) $\oint \frac{dQ}{T} = +\frac{420}{600} - \frac{105}{300} = 0.35$ $\therefore$ Cycle is Impossible (c) $\oint \frac{dQ}{T} = +\frac{420}{600} - \frac{315}{300} = -0.35$ $\therefore$ Cycle is irreversible but possible.	4 3 3	20