

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Name: \_\_\_\_\_

Self Assessment - Preparatory

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching					
		SD				SA	SD				SA	
1.	I have read the chapter before coming to the discussion session today.	1	2	3	4	5		1	2	3	4	5
2.	I realize that I can write all the expressions for the first law in units of kilojoule, kilowatts or kilojoule per kilogram. Hence the energy balance can be expressed as $\frac{\text{Energy gain}}{\text{by a system}} - \frac{\text{Energy lost}}{\text{by a system}} = \frac{\text{Total energy change}}{\text{within the system}}$ . Or mathematically, $E_{in} - E_{out} = DE_{sys}$ in kJ, or $\dot{E}_{in} - \dot{E}_{out} = D\dot{E}_{sys}$ , in kW, or $e_{in} - e_{out} = De_{sys}$ in kJ/kg. Alternatively, it can written as $(Q_{in} - Q_{out}) + (W_{in} - W_{out}) + (E_{mass,in} - E_{mass,out}) = DU + DKE + DPE$ in kJ or $\left( \dot{Q}_{in} - \dot{Q}_{out} \right) + \left( \dot{W}_{in} - \dot{W}_{out} \right) + \left( \dot{E}_{mass,in} - \dot{E}_{mass,out} \right) = D\dot{U} + D\dot{K}E + D\dot{P}E$ in kW or $(q_{in} - q_{out}) + (w_{in} - w_{out}) + (J_{mass,in} - J_{mass,out}) = Du + Dke + Dpe$ .	1	2	3	4	5		1	2	3	4	5
3.	Hence, for a <u>stationary closed system</u> , the first law of thermodynamics energy balance can be written in any of the following ways: $(Q_{in} - Q_{out}) + (W_{in} - W_{out}) = DU$ or $\left( \dot{Q}_{in} - \dot{Q}_{out} \right) + \left( \dot{W}_{in} - \dot{W}_{out} \right) = D\dot{U}$ or $(q_{in} - q_{out}) + (w_{in} - w_{out}) = Du$ .	1	2	3	4	5		1	2	3	4	5
4.	I know that for a stationary-closed system undergoing a cyclic (starts and end at the same state) process, the total energy for the final and initial states are the same, hence $DE_{sys} = DU = 0$ . Due to this, the energy balance can be written as $(Q_{in} - Q_{out}) + (W_{in} - W_{out}) = 0$ . This means that $Q_{in} - Q_{out} = W_{out} - W_{in}$ . The physical interpretation of this is very significant since many engineering devices operate in a cycle. This expression clearly indicates that if the left side of the expression is positive then the right side must also be positive and vice-versa. In other words, for a system such as water in a turbine <i>to produce work and hence electricity</i> , a <u>net amount of heat must be transferred to the system</u> ( $Q_{in} \gg Q_{out}$ ). On the other hand, <i>in order to have a net amount of heat transferred out of a system</i> such as an air conditioner, a <u>net amount of work must be done on the system</u> ( $W_{in} \gg W_{out}$ ).	1	2	3	4	5		1	2	3	4	5
5.	I realize that processes in thermodynamics are mostly processes that operate for long periods of time. Hence we need to consider properties that are steady over that long period during which devices operate. So, we will always consider <u>steady-state flow</u> , where properties remain constant over a long period of time. The most important consequence for the situation is <u>no change in properties within the system's boundary</u> . Hence, the total energy, the	1	2	3	4	5		1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching				
		SD				SA	SD				SA
	mass and total volume MUST remain constant throughout the process. Then, $m_{in} = m_{out}$ , since $Dm_{sys} = 0$ (kg) OR $\dot{m}_{in} = \dot{m}_{out}$ (kg/s) and $D\dot{E}_{sys} = 0$ , (kW). The mass flow rate can be written in terms of the mass velocity, the perpendicular surface area and the specific volume of the mass. An expression for this is $\left(\frac{\bar{v}A}{u}\right)_{in} = \left(\frac{\bar{v}A}{u}\right)_{out}$ , (kg/s)										
6.	I can now write the energy balance for steady flow CV as $\dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} + \sum(\dot{m}q)_{in} - \sum(\dot{m}q)_{out} = 0$ , (kW). Rearranging the expression, I can write the energy balance for steady flow CV as $\dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} = \sum(\dot{m}q)_{out} - \sum(\dot{m}q)_{in}$ , (kW) or in units of kJ/kg, it is $q_{in} - q_{out} + w_{in} - w_{out} = \sum(q)_{out} - \sum(q)_{in}$ . Note that the right side of this expression represents the energy of the moving mass. If the mass is not flowing, then the right side is zero and the expression is similar to the stationary closed system discussed before. The summation in the expression is needed to safeguard you against making assumptions that each inlet or outlet carries the same energy. Each inlet has a unique energy that must be distinguished from other inlets or outlets. If there are <u>2 inlets and one outlet</u> and if state 1, state 2 and state 3 are used to label the inlets and outlet respectively, then the energy balance is $\dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} = \dot{m}_3 q_3 - \dot{m}_1 q_1 - \dot{m}_2 q_2$ and the mass balance is $\dot{m}_1 + \dot{m}_2 = \dot{m}_3$	1	2	3	4	5	1	2	3	4	5
7.	For a <u>single stream (one inlet and one outlet only) steady flow</u> CV, the mass balance is $\dot{m}_1 = \dot{m}_2$ and the energy balance is $\dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} = (\dot{m}q)_2 - (\dot{m}q)_1 = \dot{m}(q_2 - q_1)$ . In terms of the mass flow total energy, it is $\dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} = \dot{m}(q_2 - q_1) = \dot{m}(h_2 - h_1 + ke_2 - ke_1 + pe_2 - pe_1) = \dot{m}(Dh + Dke + Dpe)$ or in units of kJ/kg, it is $q_{in} - q_{out} + w_{in} - w_{out} = q_{out} - q_{in} = Dh + Dke + Dpe$ where $q = \frac{\dot{Q}}{\dot{m}}$ , & $w = \frac{\dot{W}}{\dot{m}}$ . Note that the kinetic and potential energy changes are $Dke = \frac{\bar{v}_2^2 - \bar{v}_1^2}{2000}$ , (kJ/kg) and $Dpe = \frac{gy}{1000}$ , (kJ/kg), respectively where y is the vertical distance.	1	2	3	4	5	1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching					
		SD				SA	SD				SA	
8.	I am aware that processes always occur in its natural direction and not the reverse. A cup of hot coffee naturally will cool to room temperature when placed on a table. An object at a certain height will naturally fall down to the ground when it is released. An object moving at a certain speed will naturally slow down as time goes by due to frictional forces acting on it. In all the examples above, processes will occur in its natural direction as dictated by nature. In addition, each example mentioned above obeys the energy conservation. When the hot coffee cools down to room temperature, its thermal energy is lost to the room ( $0 - q_{out} + 0 = \mathbf{Du}_{coffee}$ ). The amount of energy lost for each unit mass is the amount gain by the room ( $q_{in} - 0 + 0 = \mathbf{Du}_{room}$ ). For the case of the falling object, the potential energy lost is transformed ( $0 - 0 + 0 = 0 + \mathbf{Dke} + \mathbf{Dpe}$ ) into kinetic energy and when the object eventually hits the ground, all of the kinetic energy will be converted into thermal energy and sound. The total energy before the fall and after the fall remains the same. <u>Hence, all processes that occur in real life must follow its natural direction and must satisfy the energy conservation.</u>	1	2	3	4	5		1	2	3	4	5
9.	I am confident that I can write the energy balance for a steam power plant. Since this is a <u>stationary closed system operating in a cycle</u> , the <u>energy change of the system is zero</u> . Hence the right side of the energy balance is zero. Then the energy balance is $q_{in} - q_{out} + \mathbf{w}_{in} - \mathbf{w}_{out} = 0$ . It can be rearranged to be $q_{in} - q_{out} = \mathbf{w}_{out} - \mathbf{w}_{in}$ or simply written as $q_{net,in} = \mathbf{w}_{net,out}$ or $q = \mathbf{w}$ . I am very comfortable to write this energy balance in units of both kilojoule and kilowatt: $Q_{net,in} = W_{net,out}$ or $Q = W$ in kJ and $\dot{Q}_{net,in} = \dot{W}_{net,out}$ or $\dot{Q} = \dot{W}$ in kW. Then the thermal efficiency is $Efficiency = \frac{Desired\ Output}{Re\ quired\ Input}$ or written as $\mathbf{h}_{th} = \frac{\mathbf{w}_{out} - \mathbf{w}_{in}}{q_{in}} = \frac{q_{in} - q_{out}}{q_{in}} = \frac{q_{in}}{q_{in}} - \frac{q_{out}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}}$ . Of course I can write, the expressions in different ways: $\mathbf{h}_{th} = 1 - \frac{Q_{out}}{Q_{in}}$ and $\mathbf{h}_{th} = 1 - \frac{\dot{Q}_{out}}{\dot{Q}_{in}}$ . I must remember that I use the subscript <u>in</u> to denote into the system and subscript <u>out</u> to denote out of the system. In addition, since thermal efficiency is a number that is less than 1, it is usually expressed in percentage form.	1	2	3	4	5		1	2	3	4	5
10.	I can write the energy balance for a refrigerator as $q_{in} - q_{out} + \mathbf{w}_{in} - \mathbf{w}_{out} = 0$ or $q_{out} - q_{in} = \mathbf{w}_{in} - \mathbf{w}_{out}$ . Then the performance of the refrigerator or coefficient of performance can be obtained by recognizing that the desired output is to cool a space by removing heat $q_{in} = q_L$ from the space intended to be cooled (subscript <u>L</u> is used to denote from a <u>cold reservoir</u> and subscript <u>H</u> is used to denote from a <u>hot reservoir</u> ). The required input is the external work done, $\mathbf{w}_{in} = q_{out} - q_{in} = q_H - q_L$ . Hence the coefficient of performance is		2	3	4	5		1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching					
		SD				SA	SD				SA	
$COP_R = \frac{q_{in}}{w_{in}} = \frac{q_{in}}{q_{out} - q_{in}} = \frac{I}{\frac{q_{out} - q_{in}}{q_{in}}} = \frac{I}{\frac{q_{out} - q_{in}}{q_{in}}} = \frac{I}{\frac{q_{out} - q_{in}}{q_{in}}} = \frac{I}{\frac{q_{out} - q_{in}}{q_{in}}}$ $COP_R = \frac{I}{\frac{Q_H}{Q_L} - 1} \text{ or } COP_R = \frac{I}{\frac{\dot{Q}_H}{\dot{Q}_L} - 1}$ <p>The expression can also be written as                  Since the amount of heat rejected to the hot surrounding is bigger than the heat removed from the cold surrounding, <math>q_{out} = q_H = w_{in} + q_L</math>, than the COP can have numbers larger than unity. The COP can be as high as 40 and hence it is not written in percentage form.</p>												
11.	<p>I know that a <u>heat pump</u> is like a refrigerator but its purpose is to <u>maintain a heated space at a high T</u>. In order to serve its purpose, thermal energy (heat) has to be supplied to the warm space. Hence the <u>desired output</u> is <math>q_{out} = q_H</math> while the required input remains the same since the device still require the use of a compressor. Hence the coefficient of performance is <math>COP_{HP} = \frac{q_{out}}{w_{in}} = \frac{q_{out}}{q_{out} - q_{in}} = \frac{I}{\frac{q_{out} - q_{in}}{q_{out}}} = \frac{I}{\frac{q_{out} - q_{in}}{q_{out}}} = \frac{I}{\frac{q_{out} - q_{in}}{q_{out}}}</math>. The expression can also be written as <math>COP_{HP} = \frac{I}{1 - \frac{Q_L}{Q_H}}</math> or <math>COP_{HP} = \frac{I}{1 - \frac{\dot{Q}_L}{\dot{Q}_H}}</math>. Again the COP is bigger than 1, hence it is not written in percentage form. Note that an air-conditioner when reversed will operate as a heat pump. Reversing the air-conditioner automatically reverses the space. Hence the thermal energy from the surrounding is removed and rejected into the room maintained at a high temperature.</p>	1	2	3	4	5		1	2	3	4	5
12.	<p>I realize that reversible means that a process when done along the same path forward and backward will not leave any traces on both the system and the surrounding. In other words the systems' properties must be returned to its original state after the forward and reversed process. Bringing the system back to its original state after the reversed process is called the internally reversible process. In addition, the surrounding's original state must also be returned upon completion of the reversed cycle. If heat was drawn from the surrounding during the forward process, then the surrounding must receive the same amount of heat during the reversed process. If work was done <b>BY</b> the surrounding during the forward process then the same amount of work must be done <b>ON</b> the surrounding during the</p>	1	2	3	4	5		1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching					
		SD				SA	SD				SA	
	<p>reversed process. Returning the surrounding to its original state means that the process is externally reversible. Total reversibility or simply referred to as <u>reversible process</u> means that the process must be <u>internally and externally reversible</u>. Whenever heat is drawn during the forward process and work is returned to the surrounding during the reversed process, then the process is rendered <u>irreversible</u>. Processes in real life are ALL IRREVERSIBLE. Reversible processes are ideal processes, dream processes, a model, which we set in order to have a maximum target whenever we deal with real engineering devices. So, don't get carried away. We only need the model so that we can make comparisons as to how efficient our machines are with respect to our dream machines. In addition, it is much easier to perform numerical calculations with ideal devices; hence it is possible to set the maximum achievable efficiency for our real everyday machine.</p>											
13.	<p>I know that irreversibilities are caused by three major factors:</p> <p>(i) <u>Frictional forces</u> that exist between two moving surfaces. The energy dissipated due to friction is usually lost in the form of heat. Hence the surrounding usually end up having more internal energy at the end of the reversed cycle, <math>DU_{surr} \neq 0</math>, due to receiving more heat than was drawn during the forward process.</p> <p>(ii) <u>Non-quasi equilibrium expansion and compression</u> (at every state during the expansion or compression, the path followed does not contain equilibrium states). This usually happens because processes are done too fast resulting in the system not having sufficient time to achieve equilibrium. As a result the surrounding cannot return to its original state after the reversed cycle (the amount of heat drawn is not equal to the amount of heat received, <math>(Q_{out} - Q_{in})_{surr} \neq 0</math>, and work done by the surrounding is not equal to the amount of work done on the surrounding, <math>(W_{in} - W_{out})_{surr} \neq 0</math>).</p> <p>(iii) <u>Non-isothermal heat transfer (heat transfer through a finite temperature difference)</u>. Ideally, when heat is drawn or returned to the surrounding, it must be done very slowly in order for the system and surrounding to be in thermal equilibrium (isothermal) during the process of heat transfer. Unfortunately, this is not possible because it may take a very long time (could be years) to complete a cycle. Real expansion and compression happens very fast, hence the process is non-isothermal. Furthermore, recall that heat transfer at the system's boundary can only happen if there is a temperature difference between the system and the surrounding. Hence, an isothermal heat transfer is only a dream process.</p>	1	2	3	4	5		1	2	3	4	5
14.	<p>I realize that the most efficient engine, which has the highest engine's efficiency, is an engine that employs reversible cycles. It means that every process in the cycle for a power plant must be reversible. This cycle is called the Carnot cycle and the efficiency is called the Carnot efficiency, <math>\eta = \eta_{rev}</math>. Recalling that in power plant, the purpose is to produce work by absorbing heat from a high temperature reservoir (source).</p> <p>(i) The first process in the cycle is a <u>reversible isothermal expansion</u>. Heat is transferred to the system causing the system to expand and hence do work on the surrounding. Then employing the first law for this process, I can write, <math>Q_{in} - 0 + 0 - W_{out} = 0</math>.</p>	1	2	3	4	5		1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching					
		SD				SA	SD				SA	
(ii)	The second process in the cycle is the <u>reversible adiabatic expansion</u> . Since the system is perfectly insulated, and there is no heat transfer through the system's boundaries, the expansion process is a spontaneous expansion. The internal energy of the system is used for the expansion resulting in the drop of the internal energy at the end of the expansion as indicated by the drop in temperature and the pressure of the system. The energy balance can be written as $0 - 0 + 0 - W_{out} = U_2 - U_1 < 0$ .											
(iii)	The third process is to reject the excess heat into a low-temperature surrounding (sink). Again, this is an isothermal (hence reversible) process or isothermal compression. The energy balance is $0 - Q_{out} + W_{in} - 0 = 0$ . Clearly, all the work done on the system is rejected isothermally to the low-temperature sink.											
(iv)	The last process in the Carnot cycle is the <u>reversible adiabatic compression</u> . Further compression of the system while the system is insulated from the surrounding is done to return the system to its original state. The energy balance is $0 - 0 + W_{in} - 0 = U_2 - U_1 > 0$ . Since there is no way for heat to be rejected, then all the work done on the system will be stored as internal energy of the system. This is shown by the increase in the system's internal energy as physically indicated by the increase in the system's temperature and pressure.											
15.	I am able to sketch a P-v diagram for the Carnot cycle and label the energy exchanges. In addition, I can also write the <u>energy balance for the cycle</u> by treating the cycle as a stationary closed-system undergoing a cycle. The energy balance is $Q_{in} - Q_{out} + W_{in} - W_{out} = 0$ . The energy balance can be simplified as $W_{out} - W_{in} = Q_{in} - Q_{out}$ or in unit mass form, $w_{out} - w_{in} = q_{in} - q_{out}$ or in rate form, $\dot{W}_{net,out} = \dot{W}_{out} - \dot{W}_{in} = \dot{Q}_{in} - \dot{Q}_{out}$ . I also realize that the area underneath the P-v diagram represents the specific work done by the power plant. In addition, I know that by <u>reversing the direction of the cycle on the P-v diagram</u> , I am representing the <u>operation of a refrigerator or a heat pump</u> . <u>Then the area under the diagram represents the electrical work done required by the device</u> to remove heat from the refrigerator or to supply heat to the space maintained at a high temperature. The area is $W_{in} - W_{out} = Q_{out} - Q_{in}$ or in unit mass form, $w_{in} - w_{out} = q_{out} - q_{in}$ or in rate form, $\dot{W}_{net,in} = \dot{W}_{in} - \dot{W}_{out} = \dot{Q}_{out} - \dot{Q}_{in}$ .	1	2	3	4	5		1	2	3	4	5
16.	I realize that I can determine the maximum efficiency of a real engine by determining the efficiency of the Carnot engine since this engine employs reversible processes in its cycle. In order to do that I must first be able to state the <u>Carnot's Principle</u> . The principle states that for heat engines operating between the <i>same hot and cold reservoirs</i> , the efficiencies of the engines are equal for all reversible engines, $\eta_{rev1} = \eta_{rev2} = \eta_{rev3}$ but irreversible engines have smaller efficiencies than the reversible engines, $\eta_{irrev} < \eta_{rev}$ regardless of the working fluid used in the engines. The	1	2	3	4	5		1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching					
		SD				SA	SD				SA	
implication of this principle is that all real devices will always have efficiencies smaller than the Carnot (reversible) engines. Another more important implication of the Carnot Principle is the definition of absolute temperature that is measured in Kelvin. Of significance is the fact that the ratio of heat exchanges can be replaced by the ratios of absolute temperatures for Carnot engines and can be written as, $\left(\frac{Q_L}{Q_H}\right)_{rev} = \frac{T_L(K)}{T_H(K)}$ , or in the unit-mass basis, it is, $\left(\frac{q_L}{q_H}\right)_{rev} = \frac{T_L(K)}{T_H(K)}$ , and in the rate-form it is, $\left(\frac{\dot{Q}_L}{\dot{Q}_H}\right)_{rev} = \frac{T_L(K)}{T_H(K)}$ .												
17.	I realize that the <u>purpose of a steam power plant is to produce work from the heat absorbed</u> and I am confident that the efficiencies for Carnot (reversible) steam power plants can be written as, $h_{rev} = \left(\frac{w_{net,out}}{q_{in}}\right)_{rev} = 1 - \left(\frac{q_L}{q_H}\right)_{rev} = 1 - \frac{T_L(K)}{T_H(K)}$ . Hence for Carnot engines, I can just determine the efficiencies if I know the reservoirs' absolute temperatures, $T_L$ and $T_H$ .	1	2	3	4	5		1	2	3	4	5
18.	I realize that the <u>purpose of a refrigerator is to cool a space or maintain a space a low temperature by removing heat from the space</u> . Then I can confidently write the efficiencies for a Carnot (reversible) refrigerator as $COP_{R,rev} = \left(\frac{q_{in}}{w_{in}}\right)_{rev} = \left(\frac{q_{in}}{q_{out} - q_{in}}\right)_{rev} = \frac{1}{\left(\frac{q_H}{q_L}\right)_{rev} - 1} = \frac{1}{\frac{T_H(K)}{T_L(K)} - 1}$ . I also realize that the area under a P-v diagram represents the specific work done on the system.	1	2	3	4	5		1	2	3	4	5
19.	I realize that the <u>purpose of a heat pump is to maintain a space at a high temperature by supplying heat to the space</u> . Then I can confidently write the efficiencies for a Carnot (reversible) heat pump as $COP_{HP,rev} = \left(\frac{q_{out}}{w_{in}}\right)_{rev} = \left(\frac{q_{out}}{q_{out} - q_{in}}\right)_{rev} = \frac{1}{1 - \left(\frac{q_L}{q_H}\right)_{rev}} = \frac{1}{1 - \frac{T_L(K)}{T_H(K)}}$ .	1	2	3	4	5		1	2	3	4	5
20.	I know a thermodynamic processes that obey the 2 <sup>nd</sup> law must satisfy the <u>Carnot Principle</u> which states that, <b>reversible engines which receive and reject heat to a common hot and cold reservoir will have the same</b>	1	2	3	4	5		1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

	Please use the following codes and please mark your selection. 1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree					Before peer teaching					After peer teaching				
	SD				SA	SD				SA	SD				SA
	<p><b>performances, <math>h_{rev1} = h_{rev2} = h_{rev3}</math> or <math>COP_{R,rev1} = COP_{R,rev2} = COP_{R,rev3}</math>, while an irreversible engine will always have a smaller performance than the reversible engines, <math>h_{irrev} &lt; h_{rev}</math> or <math>COP_{R,irrev} &lt; COP_{R,rev}</math>. The reversible engines deal with equality while the irreversible engines deal with inequality since the performance is always less than the performance of a reversible engine. Processes, which do not satisfy the Carnot Principle, do not obey the second law and hence violate the law of nature. These processes cannot occur in the real world.</b></p>														
21.	<p>In addition to the Carnot Principle, the process must also satisfy the <u>Clausius Inequality which states that the sum of the ratio of heat exchange with respect to the reservoir's absolute temperature in a cyclic process must be zero for all reversible processes or less than zero for real (irreversible processes).</u> Mathematically, the Clausius Inequality can be represented as <math>\oint \frac{dQ}{T} = 0</math> in units of <math>\frac{kJ}{K}</math> for reversible processes and <math>\oint \frac{dQ}{T} &lt; 0</math> in units of <math>\frac{kJ}{K}</math> for irreversible processes. Combining both the expressions above, the Clausius Inequality is written as <math>\oint \frac{dQ}{T} \leq 0</math>.</p>														
22.	<p>The expressions can be understood by considering a steam power plant that receives heat <math>Q_{in}</math> or <math>Q_H</math> from a source at a temperature <math>T_H</math> and reject the excess heat <math>Q_{out}</math> or <math>Q_L</math> to a sink. Since this is a cyclic process, then according to Clausius Inequality, the sum <math>\frac{Q_H}{T_H} - \frac{Q_L}{T_L} \leq 0</math>. <b>If the processes in the cycle are reversible processes</b> such as a Carnot steam power plant, then the inequality is written as <math>\frac{Q_H}{T_H} - \frac{Q_L}{T_L} = 0</math> This can be proven to be true since for reversible processes, the <u>ratio of Q can be replaced by the ratio of T.</u> If the expression above is multiplied by <math>\frac{T_H}{Q_H}</math>, the expression becomes <math>\left( \frac{Q_H}{T_H} \frac{T_H}{Q_H} - \frac{T_H}{Q_H} \frac{Q_L}{T_L} \right)_{rev} = 1 - \frac{T_H}{T_L} \left( \frac{Q_L}{Q_H} \right)_{rev} = 1 - \frac{T_H}{T_L} \frac{T_L}{T_H} = 0</math>. <b>If the processes in the cycle are irreversible processes</b> such as real processes, then the Clausius inequality is just <math>\frac{Q_H}{T_H} - \frac{Q_L}{T_L} &lt; 0</math>.</p>														
23.	<p>All processes must satisfy both the Carnot Principle and the Clausius Inequality in order to obey the second law of thermodynamics. The inequality can be understood in a more general situation although chances are that the following situation does not represent a real physical one. For a cyclic device that receives heat from sources at temperatures</p>														



**Self- Assessment Before and After Facilitating Session.**

**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching					
		SD				SA	SD				SA	
	<p><math>T_1, T_2,</math> and <math>T_3,</math> while rejecting heat to sinks at temperatures <math>T_4</math> and <math>T_5,</math> then the Clausius Inequality is <math>\oint \frac{dQ}{T} = \frac{Q_1}{T_1} + \frac{Q_2}{T_2} + \frac{Q_3}{T_3} - \frac{Q_4}{T_4} - \frac{Q_5}{T_5} \leq 0.</math> For real (irreversible) processes, the sum will be negative (<math>&lt; 0</math>).</p>											
24.	<p>I realize that I can <u>define entropy</u> as <math>dS = \left( \frac{dQ}{T} \right)_{int, rev}</math>. Entropy is also a system's property since the change in entropy is zero, <math>\mathbf{DS} = \oint dS = \left( \int_1^2 dS \right)_{int, rev} + \left( \int_2^1 dS \right)_{int, rev} = S_2 - S_1 + S_1 - S_2 = 0</math> <b>when the system goes through a cyclic process</b> just like any other property. Recall that in a cyclic process, the system's state (properties such as volume or internal energy) must be returned to its original state. Since entropy, <math>S,</math> is a property, then it must have a value at any state and entropy is defined to be zero at absolute zero temperature that is at <math>0K.</math> I also realize that entropy is a property that measures disorder or randomness of molecule and hence, is a method to quantify <u>irreversibilities</u> in engineering devices. I am also aware that entropy, like any property can be written in many forms; the total entropy, <math>S</math> in <math>\frac{kJ}{K},</math> the unit-mass entropy or specific entropy, <math>s</math> in <math>\frac{kJ}{kg \circ K},</math> and the rate-form entropy, <math>\dot{S}</math> in <math>\frac{kW}{K}.</math></p>	1	2	3	4	5		1	2	3	4	5
25.	<p>I am aware that the <u>entropy change</u> for a system <u>during a process</u> is <math>\mathbf{DS}_{sys} = s_2 - s_1 = \left( \int_1^2 \frac{dq}{T} \right)_{int, rev},</math> Since entropy is a property and the entropy change does not depend on the path that I choose to go from the initial to the final state, I need to find a path which is internally reversible to determine the entropy change. This is true for <u>ALL</u> processes regardless of whether it is a REAL (irreversible) process or a DREAM (reversible) process.</p>	1	2	3	4	5		1	2	3	4	5
26.	<p>I know for an isothermal (reversible) process at temp. <math>T_0,</math> <math>\mathbf{DS}_{sys} = \left( \int_1^2 \frac{dq}{T} \right)_{rev} = \frac{1}{T_0} \int_1^2 dQ = \frac{q}{T_0},</math> [kJ/K].</p>	1	2	3	4	5		1	2	3	4	5
27.	<p>I am aware that for any cyclic process I can choose the path for the reverse process to be internally reversible and hence I can write Clausius Inequality as <math>\oint \frac{dq}{T} = \int_1^2 \frac{dq}{T} + \left( \int_2^1 \frac{dq}{T} \right)_{int, rev} \leq 0,</math> Then the entropy change in this cyclic process</p>	1	2	3	4	5		1	2	3	4	5

	Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>					Before peer teaching					After peer teaching				
	SD				SA	SD				SA	SD				SA
<p>is <math>\int_1^2 \frac{dq}{T} + \left( \int_2^1 \frac{dq}{T} \right)_{int, rev} \leq 0</math>. Recognizing that the second term in the expression is the definition of entropy change from state 2 to state 1, I can then write the expression as <math>\int_1^2 \frac{dq}{T} + s_1 - s_2 \leq 0</math>. Rearranging the expression, I will obtain,</p> <p><math>s_2 - s_1 \geq \int_1^2 \frac{dq}{T}</math> or can be written as <math>Ds_{sys} = s_2 - s_1 \geq \int_1^2 \frac{dq}{T}</math>. This expression is a very powerful representation of the Clausius Inequality since the physical meaning of this expression is that the <u>entropy change in any process</u> must either be <math>\int_1^2 \frac{dq}{T}</math> <u>or greater than</u> <math>\int_1^2 \frac{dq}{T}</math>. For <u>reversible processes</u>, the <u>entropy change</u> is <math>Ds_{sys} = s_2 - s_1 = \int_1^2 \frac{dq}{T}</math> and for <u>irreversible (real) processes the entropy change</u> is <math>Ds_{sys} = s_2 - s_1 &gt; \int_1^2 \frac{dq}{T}</math>. I realize that the term, <math>\int_1^2 \frac{dq}{T}</math>, is the <u>entropy transfer that is associated with heat transfer, <math>s_{heat}</math></u>. Hence, for <u>adiabatic (no heat transfer) processes</u>, this term is zero.</p> <p><math>s_{heat} = \int_1^2 \frac{dq}{T} = 0</math>. For the case where a process is <b>both reversible and adiabatic, the entropy change is zero. This process is called isentropic where the initial and final entropies are the same (<math>s_2 = s_1</math>)</b>. For an <u>irreversible and adiabatic process, the entropy change is greater than zero</u>. In order to make the word "greater than zero" more quantifiable, we assign the expression <math>s_{gen}</math>, to mean <u>entropy generated</u>, to represent the word "more than zero". I also realize that <b>entropy generation is due to irreversibilities such as friction, non-quasi equilibrium expansion and compression and also non-isothermal heat transfer (heat transfer at a finite temperature difference)</b>.</p>															
<p>28. I realize that I can now rewrite the entropy change in any process which was in an inequality form,</p> <p><math>Ds_{sys} = s_2 - s_1 \geq \int_1^2 \frac{dq}{T}</math> into an equality form <math>Ds_{sys} = s_2 - s_1 = \int_1^2 \frac{dq}{T} + s_{gen} = s_{heat} + s_{gen}</math> For a <u>reversible process</u>,</p> <p><math>Ds_{sys} = \int_1^2 \frac{dq}{T} + 0 = s_{heat} + 0</math>, &amp; for an <u>isentropic (reversible and adiabatic) process</u>, <math>Ds_{sys} = s_2 - s_1 = 0 + 0</math>. Hence</p>	1	2	3	4	5						1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching				
		SD				SA	SD				SA
	$s_2 = s_1$ . For an <u>irreversible process</u> , $Ds_{sys} = \int_1^2 \frac{dq}{T} + s_{gen} = s_{heat} + s_{gen}$ . Note that these expressions can be written in the form of total entropy, S, and total heat transfer, Q.										
29.	I realize that for an <u>irreversible adiabatic process</u> , $Ds_{sys} = s_{gen}$ . In other words, <b>the entropy change is always positive (greater than zero), <math>Ds_{sys} &gt; 0</math></b> . I am aware that for an <u>isolated system</u> (such as the universe), a system that does not allow heat transfer, mass transfer and work done through its boundary, the system can contain many subsystems and surrounding that I am studying. If I only consider one subsystem and its surrounding within the isolated system, than I can write the <u>entropy change for the isolated system</u> to be $Ds_{isolated, sys} = Ds_{sys} + Ds_{surr} = s_{gen}$ . Since <u>entropy is always generated in an irreversible process due to irreversibilities</u> , <u>the entropy change of the isolated system will always be positive</u> . Hence, $Ds_{isolated, sys} = Ds_{sys} + Ds_{surr} \geq 0$ . The only way the entropy change is zero is when the processes inside the isolated system are reversible (dream) processes.	1	2	3	4	5	1	2	3	4	5
30.	I can state the <b>Increase of Entropy Principle</b> which is the entropy in an isolated system will always increase and I can write the expression for the Increase of Entropy Principle that is in unit-mass form as $Ds_{total} = s_{gen} = Ds_{sys} + Ds_{surr} \geq 0$ or $Ds_{total} = s_{gen} = Ds_{sys} + Ds_{surr} \geq 0$ . <b>The values for <math>Ds_{sys}</math> or <math>Ds_{surr}</math> can be positive or negative but the sum of both of them have to be positive.</b>	1	2	3	4	5	1	2	3	4	5
31.	I realize that when dealing with pure substances, I can determine the initial and final entropies for that system by reading them from the property table and then determine the entropy change for that system, $Ds_{sys} = s_2 - s_1$ , or $Ds_{sys} = m(s_2 - s_1)$ . On the other hand, the entropy change of the surrounding can be determined by finding out the amount of heat transfer into the system (out of the surrounding) or out of the system (into the surrounding) through the use of the first law of thermodynamics (energy balance) and divide it by the surrounding's temperature, $Ds_{surr} = \frac{q_{surr}}{T_{surr}}$ or $Ds_{surr} = \frac{Q_{surr}}{T_{surr}}$ . As an example, when heat is transferred out of a piston-cylinder device during a cooling process, the amount of heat lost by the system is received by the surrounding. Hence, $Ds_{surr} = \frac{q_{surr}}{T_{surr}} = \frac{(q_{in} - q_{out})_{surr}}{T_{surr}} = \frac{(q_{out} - q_{in})_{sys}}{T_{surr}} = \frac{(u_2 - u_1 + w_{out} - w_{in})_{sys}}{T_{surr}}$ . <b>Since heat is transferred out of the</b>	1	2	3	4	5	1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**  
**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

	Please use the following codes and please mark your selection. 1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree					Before peer teaching					After peer teaching				
	SD				SA	SD				SA	SD				SA
	<p><b>system and into the surrounding, then the entropy change of the surrounding must increase while the entropy change of the system must decrease.</b> Then the <u>total entropy change in the process must obey the Increase of Entropy Principle</u>, <math>Ds_{total} = s_2 - s_1 + \frac{(q_{in})_{surr}}{T_{surr}}</math> and the <u>value must be positive</u>. I also realize that <b>temperatures must be the absolute temperatures in Kelvin</b>.</p>														
32.	<p>I am able to draw a T – s diagram for an isothermal (constant temperature) and an isentropic (constant entropy that is a reversible and adiabatic) process. I also know that the area under a T-s diagram represent the specific heat transfer during a process. In fact, I can show that this is true by writing the definition for entropy, <math>ds = \frac{dq}{T}</math>. Hence, the infinitesimal heat transfer is <math>dq = Tds</math>. Then the heat transfer for the process is <math>q = \int_1^2 dq = \int_1^2 Tds</math>. The infinitesimal area under a T – s diagram is the product of the height and the width of the figure in question, <math>dA = Tds</math>. The total area is obtained by summing up all this infinitesimal area, <math>A = \int_1^2 dA = \int_1^2 Tds</math> which is the amount of specific heat transfer for that process. For an <u>isothermal process at a constant temperature <math>T_0</math></u>, the area and hence the specific heat transfer, is <math>A = \int_1^2 dA = \int_1^2 Tds = T_0 \int_1^2 ds = T_0(s_2 - s_1) = q</math>.</p>														
33.	<p>I know that entropy is not a conserved quantity. Hence when dealing with open systems, I can write the entropy balance as <i>Entropy entering – Entropy leaving + Entropy generated = Entropy change in system</i> or in mathematical form, <math>S_{in} - S_{out} + S_{gen} = DS_{sys}</math>. Using the unit-mass form the expression is <math>s_{in} - s_{out} + s_{gen} = Ds_{sys}</math> and in rate-form it is <math>\dot{S}_{in} - \dot{S}_{out} + \dot{S}_{gen} = D\dot{S}_{sys}</math>. Note that the difference between this and the energy balance is the fact that there is a term associated with the entropy generation due to irreversibilities. I realize that in the case of a reversible process, the entropy generation term is zero. The terms <math>s_{in}</math> and <math>s_{out}</math> are for the <u>entropy transfer due to heat, <math>(s_{in} - s_{out})_{heat}</math> and mass transfer, <math>(s_{in} - s_{out})_{mass}</math></u>.</p>														
34.	<p>I am aware that in the case of a closed system, the entropy associated with mass transfer, <math>(s_{in} - s_{out})_{mass}</math>, is zero and</p>														

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>		Before peer teaching					After peer teaching				
		SD				SA	SD				SA
	<p>the entropy balance is <math>(s_{in} - s_{out})_{heat} + s_{gen} = Ds_{sys} = s_2 - s_1</math>. Recall that <math>(s_{in} - s_{out})_{heat} = \int_1^2 \frac{dq}{T} = \frac{(q_{in} - q_{out})_{sys}}{T}</math>. Hence</p> <p>the entropy generated is <math>s_{gen} = s_2 - s_1 + (s_{out} - s_{in})_{heat} = s_2 - s_1 + \frac{(q_{out} - q_{in})_{sys}}{T}</math>. For adiabatic processes in a closed system, the generated entropy is <math>s_{gen} = s_2 - s_1 + 0</math> since there is no heat transfer through the system's boundaries.</p>										
35.	<p>For an <u>isolated</u> system, <math>S_{in} = S_{out} = 0</math>, hence <math>S_{gen} = DS_{sys} + DS_{surr} = m(s_2 - s_1) + \left(\frac{Q}{T}\right)_{surr}</math>, <math>\Delta S_{surr} = 0</math> if adiabatic. kJ/K.</p> <p>Note again that <math>Q_{in, sys} = -Q_{out, surr}</math>.</p>	1	2	3	4	5	1	2	3	4	5
36.	<p>For CV open system, the entropy balance is: <math>\sum \left(\frac{\dot{Q}}{T}\right)_{in} - \sum \left(\frac{\dot{Q}}{T}\right)_{out} + \sum (\dot{m} s)_{in} - \sum (\dot{m} s)_{out} + \dot{S}_{gen} = D\dot{S}_{sys}</math></p>	1	2	3	4	5	1	2	3	4	5
37.	<p>For a <u>steady-flow</u>, the entropy balance is: <math>\dot{S}_{gen} = \sum (\dot{m} s)_{out} - \sum (\dot{m} s)_{in} + \left( \sum \left(\frac{\dot{Q}}{T}\right)_{out} - \sum \left(\frac{\dot{Q}}{T}\right)_{in} \right)_{sys}</math>. since <math>D\dot{S}_{sys} = 0</math>. For a mixing chamber with 2 inlets, state 1 and 2, and a single exit, state 3, the entropy balance is</p> <p><math>\dot{S}_{gen} = \dot{m}_3 s_3 - \dot{m}_1 s_1 - \dot{m}_2 s_2 + \left( \left(\frac{\dot{Q}}{T}\right)_{out} - \left(\frac{\dot{Q}}{T}\right)_{in} \right)_{sys}</math>, where the rate of heat transfer is determined by the control volume</p> <p>energy balance, <math>\dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} = \dot{m}_3 J_3 - \dot{m}_1 J_1 - \dot{m}_2 J_2</math> and the mass balance is <math>\dot{m}_3 = \dot{m}_1 + \dot{m}_2</math>.</p>	1	2	3	4	5	1	2	3	4	5
38.	<p>For a <u>steady-flow single-stream</u> CV, where state 2 is the exit and state 1 is the inlet,</p> <p><math>\dot{S}_{gen} = \left(\frac{\dot{Q}}{T}\right)_{out} - \left(\frac{\dot{Q}}{T}\right)_{in} + (\dot{m} s)_{out} - (\dot{m} s)_{in} = \left(\frac{\dot{Q}}{T}\right)_{out} - \left(\frac{\dot{Q}}{T}\right)_{in} + \dot{m}(s_2 - s_1)</math> since <math>\dot{m}_{in} = \dot{m}_{out}</math>. Hence for a heat</p>	1	2	3	4	5	1	2	3	4	5

**Self- Assessment Before and After Facilitating Session.**

**Topic: Entropy: Chapter 6**

Facilitators's Name: \_\_\_\_\_

Your Name: \_\_\_\_\_

Please use the following codes and please mark your selection. <b>1=- Strongly Disagree: 2=Disagree 3 = Unsure/Undecided 4=Agree 5 = Strongly Agree</b>	Before peer teaching					After peer teaching				
	SD				SA	SD				SA
<p>exchanger, the entropy balance is <math>\dot{S}_{gen} = \left(\frac{\dot{Q}}{T}\right)_{out} - \left(\frac{\dot{Q}}{T}\right)_{in} + \dot{m}(s_2 - s_1)</math>, the energy balance is</p> <p><math>\dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} = \dot{m}(J_2 - J_1)</math> and the mass balance is <math>\dot{m}_2 = \dot{m}_1</math>. In the case where the system is chosen without including heat transfer across its boundary, the heat transfer terms in the above expressions is set to be zero. The expressions above are valid for ALL single-stream steady-flow engineering devices including a nozzle/diffuser or a turbine/compressor.</p>										