Roll No: --------------------------

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2018

Program: M Tech ES		**Semester –**	**II**
Subject (Course): Thermal Utilities I		**Max. Marks**	**: 100**
Course Code: EPEC7012		**Duration**	**: 3 Hrs**
No. of page/s: 2			

<table>
<tr><td colspan="4">SECTION A</td></tr>
<tr><td>S. No.</td><td></td><td>Marks</td><td>CO</td></tr>
<tr><td>Q 1</td><td>Is there a physical application for the Carnot cycle? Can we design a Carnot engine for a propulsion device?</td><td>4</td><td>CO4</td></tr>
<tr><td>Q 2</td><td>When is enthalpy the same in initial and final states? Give examples.</td><td>4</td><td>CO5</td></tr>
<tr><td>Q 3</td><td>Would it be practical to run a Brayton cycle in reverse and use it as refrigerator?</td><td>4</td><td>CO4</td></tr>
<tr><td>Q 4</td><td>How does one interpret T-s diagrams?</td><td>4</td><td>CO1</td></tr>
<tr><td>Q 5</td><td>Enumerate four energy efficiency opportunities for Boiler Operations.</td><td>4</td><td>CO1</td></tr>
<tr><td colspan="4">SECTION B</td></tr>
<tr><td>Q 6</td><td>Compare and contrast the advantages and disadvantages of calculating Boiler efficiency by Direct Method and Indirect Method.

Further reflect on the significance of Boiler Efficiency Calculation.</td><td>8</td><td>CO1</td></tr>
<tr><td>Q 7</td><td>An induced draft system consists of the steam generator, air heater, electrostatic precipitator, wet scrubber, chimney, and the interconnecting ductwork. Flue gas from the steam generator leaves the common air heater outlet plenum and flows to two parallel electrostatic precipitators and four parallel wet scrubber modules.
<table>
<tr><th>Component</th><th>Flue gas flow rate, 1,000 lb/h</th><th>Total pressure loss, in. wg</th></tr>
<tr><td>Steam generator</td><td>5,000</td><td>8</td></tr>
<tr><td>Air heater</td><td>5,000</td><td>6</td></tr>
<tr><td>Precipitator, each</td><td>2,500</td><td>2</td></tr>
<tr><td>Wet scrubber, per module</td><td>1,750</td><td>5</td></tr>
<tr><td>Chimney</td><td>5,000</td><td>2</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Total 23</td></tr>
</table>
</td><td>8</td><td>CO4</td></tr>
</table>

	How does this total system resistance change if one precipitator and one scrubber module are removed from service and the total system flow at 5,000,000 lb/h is held constant?		
Q 8	A boiler is provided with a chimney of 26m height. The boiler house temperature is 30°C and temperature of flue gases leaving chimney is 300°C. If air supplied to the boiler is 20kg/kg of fuel. Estimate: **(i) Draught in mm of water,** **(ii) Velocity of gases passing through chimney with 50% loss of draught in Chimney.**	**8**	**CO1**
Q 9	Elaborate on the five different losses encountered in Furnace operations. Concept diagram can be used to explain the same.	**8**	**CO2**
Q 10	Explain any five factors that affect Economic Thickness of Insulation. What are the various selection criteria for refractory materials? Explain the significance of Pyrometric Cone Equivalent Test for refractory materials.	**8**	**CO3**
SECTION-C			
Q 11	A practical OTTO cycle engine has an efficiency of 20%, while a practical methanol fuel cell may have an efficiency of 60% (this is the efficiency of the practical cell compared with that of the ideal cell). If methanol fueled IC car has highway performance of 10 km per liter, what is the performance of the fuel cell car assuming that all the other characteristics of the cars are identical? Assume unit yield from methanol is 21.2 MJ of energy/ kg of fuel consumed. For the solution from above, assume that if you drive 2000 km per month and a gallon of methanol costs $2.40, how much do you save in fuel per year when you use the fuel cell version compared with the IC version? (Given: 1 Gallon = 3.78 Liters) Can you think of other savings besides that in the fuel?	**20**	**CO5**
Q 12	A duct system with multiple elbows, dampers, sudden enlargements, and contractions has been tested to have a system resistance of 2 in. of water gauge (in. wg) when the flow through the system is 50,000 actual cubic feet per minute (acfm) and the gas density is 0.075 lb/ft^3. How does this system resistance change as the flow rate changes from 50,000 to 75,000 acfm with gas densities of 0.075 and 0.06 lb/ft^3? Explain Frictional losses and dynamic losses for a gas forced through a duct system and in that context explain Air horse Power (AHP) and Break Horse Power (BHP).	**20**	**CO4**

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Name of the College (Please tick, symbol is given)	:	**SOE**	✓	**SOB**		**SOL**	

Program	:	**M Tech Energy Systems**
Semester	:	**II**
Name of the Subject (Course)	:	**Thermal Utilities I**
Course Code	:	**EPEC7012**
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Note: NOT APPLICABLE

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Time of Examination	:	
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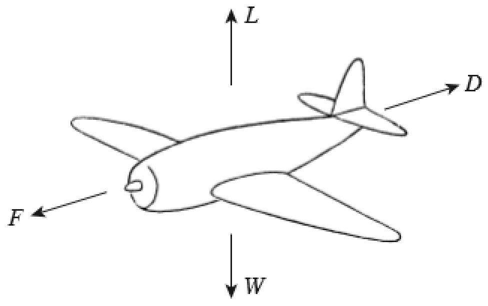
No. of page/s: 3	

	SECTION A		
S. No.		**Marks**	**CO**
Q 1	In the filling of a tank, why (physically) is the final temperature in the tank higher than the initial temperature?	**5**	**CO5**
Q 2	How do we know which cycles to use as models for real processes?	**5**	**CO4**
Q 3	Is heat transfer across a finite temperature difference only irreversible if no device is present between the two to harvest the potential difference?	**5**	**CO2**
Q 4	Do we ever see an absolute variable for entropy? So far, we have worked with deltas only.	**5**	**CO5**
	SECTION B		
Q 5	A domestic fuel cell system in a rural area is to be fed by butane. This gas is to be steam reformed and the resulting carbon monoxide is to be shifted to hydrogen. Assuming no losses, how many kg of hydrogen can be extracted from each kg of butane? Also calculate percentage yield for hydrogen.	**8**	**CO5**
Q 6	Perform a feasibility analysis between an oil fired boiler and a coal fired boiler having steam production capacity of **10 TPH**. Heat content of steam at boiler outlet is 660 kCal/kg, with inlet enthalpy at 60 kCal/kg. Consider an annual operation of 24 hours 300 days a year. Given oil fired boiler efficiency is 82%, and for the coal fired boiler 72%. The cost of oil and coal are US $300/ton and US $45/ton respectively. Additionally, the GCV of oil is 10, 000 kCal/kg and that of coal is 4200 kCal/kg. With the help of given data compute, the following: **a. Annual consumption of oil in Tons per Year.** **b. Annual consumption of coal in Tons per year.** **c. Annual fuel cost saving in US $.**	**8**	**CO1**

Q 7	Draught produced by chimney is 2 cm of water column. Temperature of flue gas is 300°C and ambient temperature is 33°C. The flue gas formed per kg of fuel burnt is 24 kg. Neglect the losses and take the diameter of chimney as 1.75 m. Calculate: a. Height of Chimney in meters. b. Mass of flue gas flowing through the chimney in kg/min. Density of flue gases is given by: $\rho_g = \left\{\frac{m_a+1}{m_a}\right\} \frac{353}{T_g}$	**8**	**CO4**
Q 8	Enumerate five advantages of using a **Feed water Heater** in the context of Steam based Thermal Power Plants. Elaborate on the role of **Superheater** and **Reheater** in the context of Boiler operation. You may use a concept diagram to explain the same.	**8**	**CO1**
Q 9	What are the various objectives of Furnace Design? With the help of a neat diagram show any three Furnaces classified based on the type of heat source and type of heat sink. Comment on Combustion chemistry inside a furnace and the effect of partial oxidation of Carbon on furnace efficiency.	**8**	**CO2**
	SECTION-C		
Q 10	Consider an aircraft in level flight, with weight W. The rate of change of the gross weight of the vehicle is equal to the fuel weight flow:  For the given figure evaluate the following: a. The Propulsion Energy Conversion Chain. b. Operation of the gas turbine engine with block diagram. c. Operation of Gas Turbines as applied to Thermal Power Generation Utilities.	**20**	**CO4**

<table>
<tr>
<td>Q 11</td>
<td>
Convert model fan (b) performance to that of a full-size fan (a) with different speed and operating temperature as indicated below. Assume that the inlet pressure and gas molecular weight are the same for the model and full size fan.
<table>
<tr><th>Parameter</th><th>Model Fan (b)</th><th>Full size Fan (a)</th></tr>
<tr><td>Diameter, inches</td><td>20</td><td>80</td></tr>
<tr><td>RPM</td><td>1200</td><td>900</td></tr>
<tr><td>Temperature</td><td>60°F (520°R)</td><td>320°F (780°R)</td></tr>
</table>
The model fan performance data is given as:
<table>
<tr><th>Flow (acfm)</th><th>ΔP, in w.g.</th><th>bhp</th></tr>
<tr><td>3000</td><td>9</td><td>7</td></tr>
<tr><td>6000</td><td>10</td><td>16</td></tr>
<tr><td>12000</td><td>8.6</td><td>25</td></tr>
<tr><td>18000</td><td>5.2</td><td>28</td></tr>
<tr><td>24000</td><td>3.1</td><td>30</td></tr>
</table>
</td>
<td>20</td>
<td>CO4</td>
</tr>
</table>