Model Question Paper-2 for 21-Scheme (CBCS Scheme)

USN | | | | | | | | | | |

Third Semester B.E. Degree Examination

THERMODYNAMICS

TIME: 03 Hours **Max. Marks: 100**

Note: 01. Answer any **FIVE** full questions, choosing at least **ONE** question from each **MODULE**.
02. Thermodynamics Data Hand Book/Steam Table are permitted
03. Missing data may be assumed suitably by giving proper reason.

		Module – 1	**Marks**
Q.1	**(a)**	State Zeroth law of Thermodynamics and explain how it helps in the measurement of temperature.	05
	(b)	Derive an expression for displacement work for an isothermal process.	05
	(c)	The resistance of the windings in a certain motor is found to be 80 ohms at room temperature of 25^0C. When operating at full load under steady-state conditions the motor is switched off and the resistance of the windings immediately measured again. It is found to be 93 ohms. The windings are made of copper whose resistance at t^0C is given by $R_t = R_0$ [1+ 0.00393 t] where R_0 is the resistance at 0^0C. Find the temperature attained by the coil during the full load	10
		OR	
Q.2	**(a)**	Prove that the internal energy is a property of the system.	05
	(b)	A spherical balloon has a diameter of 0.3 m and contains air at a pressure of 150 kPa. The diameter of the balloon increases to 0.4 m due to the heating and during this process the pressure is proportional to the diameter. Calculate the work done by the air during this process. Also find the index 'n' for the process.	07
	(c)	Air flows through an air compressor at the rate of 20 kg/min. The inlet conditions are 6 m/s, 1 bar, 0.6 m^3/kg. The exit conditions are 8 m/s, 7 bars and 0.16 m^3/kg. The internal energy of air at exit is 160 kJ/kg greater than that of inlet air. Heat absorbed by the cooling water in compressor jacket is 6800 kJ/min. Find the power input to the compressor and ratio of inlet and outlet pipe diameters.	08
		Module – 2	
Q.3	**(a)**	State the Kelvin-Planck and Clausius statements of second law of thermodynamics.	04
	(b)	A reversible heat engine operates between two reservoirs maintained at 500 K and 290 K. If the work output of the engine is 2000 N-m, evaluate the heat received and rejected by the engine. If the above engine is operated as a refrigerator operating between the same two reservoirs, find the power input required for extracting heat from the reservoir at 290 K at the rate of 2400 kJ/hr.	08
	(c)	A 5 kg copper block at a temperature of 20^0C is dropped into an insulated tank containing 100 kg oil at a temperature of 30^0C. Find the increase in entropy of the universe due to this process when copper block and the oil reach thermal equilibrium. Assume that the specific heats of copper and oil are, respectively, 0.4 kJ/kg-K and 2.1 kJ/kg-K.	08
		OR	
Q.4	**(a)**	Show that Entropy is a property of a system.	06
	(b)	Explain Available and Unavailable energies. When does the system becomes dead.	06
	(c)	One kg of air is compressed polytropically from 1 bar pressure and temperature of 300K to a pressure of 6.8 bar and temperature of 370K. Determine the irreversibility if the sink temperature is 293K. Assume R = 0.287 kJ/kg K, Cp = 1.004 kJ/kg K and Cv = 0.716 kJ/kg K.	08

Module – 3			
Q.5	(a)	Explain Reduced properties and Compressibility chart.	06
	(b)	A container of 3 m^3 capacity contains 10 kg of CO_2 at 27°C. Estimate the pressure exerted by CO_2 by using: (i) Perfect gas equation (ii) Van der Waals' equation	08
	(c)	Explain Maxwell's relations and Clausius-Clapeyron equation	06
OR			
Q.6	(a)	With neat sketch, explain the Orsat's apparatus using for exhaust gas analysis.	08
	(b)	The following is the ultimate analysis of a sample of petrol by weight: Carbon = 85 percent; Hydrogen = 15 per cent. Calculate the ratio of air to petrol consumption by weight if the volumetric analysis of the dry exhaust gas is : CO_2 = 11.5 %; CO = 1.2 %; O_2 = 0.9 %; N_2 = 86 %. Also find percentage excess air.	12
Module – 4			
Q.7	(a)	Define: i) Dryness fraction, ii) Triple point, iii) Critical Point, iv) Sensible heat.	04
	(b)	Sketch and Explain P-T diagram as applied to Steam generation.	06
	(c)	Steam at 1 MPa and 250^{0}C enters a nozzle with a velocity of 60 m/s and leaves the nozzle at 10 kPa. Assuming the flow process to be isentropic and the mass flow rate to be 1 kg/s, determine: (i) the exit velocity and (ii) the exit diameter.	10
OR			
Q.8	(a)	With a neat schematic diagram and T-S diagrams, derive an expression for the thermal efficiency in a reheat vapour power cycle.	10
	(b)	A small steam turbine is designed to operate with steam at a pressure of 15 bar. The turbine is to be employed in a simple Rankine cycle which rejects heat at the condenser temperature of 29^{0}C. To what temperature must the high-pressure steam be heated to ensure that the moisture content does not exceed 5% in the turbine. Determine the Rankine cycle efficiency at these conditions assuming isentropic expansion in the turbine	10
Module – 5			
Q.9	(a)	Derive an expression for air standard efficiency of an engine working on dual cycle by showing the cycle on P-V and T-S diagram.	10
	(b)	An engine working on constant volume cycle has a suction pressure of 1 bar and a pressure of 13.5 bar at the end of compression. For air take γ =1.4, find: (i) compression ratio (ii) the percentage of clearance (iii) thermal efficiency (iv) temperature at the end of compression if initial temperature is 27^{0}C and (v) mean effective pressure if the pressure at the end of combustion is 23 bar.	10
OR			
Q.10	(a)	Explain with schematic diagram and T-S diagram Brayton cycle with i) Regenerator and ii) Intercooler. Write an equation for thermal efficiency	10
	(b)	Air enters the compressor of an open cycle gas turbine at a pressure of 1 bar and temperature of 20^{0}C. The pressure of air after compression is 4 bar. The isentropic efficiency of compressor and turbine are 80% and 85% respectively. The air fuel ratio is 90:1. If air flow rate is 3 kg/s, γ =1.4 and C_p= 1.0 kJ/kg-K and calorific value of fuel is 41800 kJ/kg, find the power developed and thermal efficiency of the cycle.	10

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		Module – 1	**Marks**
Q.1	**(a)**	State Zeroth law of Thermodynamics and explain how it is the base for Temperature measurement.	05
	(b)	Define work from the thermodynamic point of view and List the similarities between Heat and Work.	07
	(c)	The temperature 't' on a certain Celsius thermometric scale is given by means of a property through a relation $t = a\ln(P) + b$, where a and b are constants and P is the property of the fluid. If, at the ice point and steam point the values of P are found to be 4 and 20 respectively, what will be the temperature reading corresponding to a reading of P =16.	08
		OR	
Q.2	**(a)**	Derive an expression for displacement work for an adiabatic process	08
	(b)	State and explain first law of thermodynamics for a cyclic and non-cyclic process.	04
	(c)	The power capacity of the system is 3000 kW. For the following data, determine the fluid flow rate. Inlet velocity=300 m/s, Inlet pressure=$6\times10^5 N/m^2$, Inlet internal energy =2000kJ/kg, Initial Volume = 0.4 m^3/kg. Outlet velocity=120m/s, Outlet pressure = 1.5×10^5 N/m^2, Outlet internal energy = 1500kJ/kg, Final volume=1.2m^3/kg. Fluid enters and leaves the system at the same level.	08
		Module – 2	
Q.3	**(a)**	What are the limitations of First law of thermodynamics.	04
	(b)	State and explain Kelvin-Planck and Clausius statements of second law of thermodynamics.	08
	(c)	Using usual notations State and prove Clausius inequality.	08
		OR	
Q.4	**(a)**	Show that Entropy is a property of a system.	06
	(b)	Explain Available and Unavailable energies. When does the system becomes dead.	06
	(c)	A mass of 5 kg air in a rigid vessel at 2 bar, 27°C is heated to 327°C by bringing it in communication with a reservoir at 727°C. Calculate the maximum useful work and the irreversibility.	08
		Module – 3	
Q.5	**(a)**	Explain Reduced properties and Compressibility chart.	06
	(b)	Calculate the reduced pressure and reduced temperature of a gas which is at a pressure of 7 MPa and temperature of 150°C. Also calculate the specific volume of the gas if Z = 0.54. Compare this with the specific volume given by the ideal gas equation. Use the values; Critical pressure = 4.26MPa, Critical Temperature = 370°C and R = 0.189 kJ/kg-K.	08
	(c)	Explain Maxwell's relations and Clausius-Clapeyron equation	06
		OR	

Q.6	**(a)**	Define the following terms with respect to combustion process: i) Enthalpy of formation ii) Enthalpy of combustion iii) Combustion efficiency iv) Adiabatic flame temperature v) Stoichiometric air.	10
	(b)	The products of combustion of an unknown hydrocarbon C_xH_y have the following composition as measured by an Orsat apparatus. CO_2 =8%, CO=0.9%, O_2=8.8%, N_2= 82.3%. Determine: i) The composition of the fuel ii) The air-fuel ratio iii) The percentage of excess air used.	10
		Module – 4	
Q.7	**(a)**	Define the Terms; i) Dryness fraction, ii) Saturation temperature, iii) Dry saturated vapor, iv) latent heat of vaporization, v) sensible heat.	10
	(b)	Sketch and Explain P-T diagram as applied to Steam generation.	04
	(c)	Determine the amount of heat which should be supplied to 2 kg of water at 25° C to convert it into steam at 5 bar and 0.9 dry.	06
		OR	
Q.8	**(a)**	With a neat schematic diagram and T-S diagrams, explain the working of regenerative vapour cycle with open feed water heater. Derive the thermal efficiency expression for the same.	10
	(b)	In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. Mass flow rate of steam to be 9.5 kg/sec. Calculate the following: (a) The power for the Pump (b) The dryness fraction at the end of expansion (c) Turbine power (d) Rankine cycle efficiency (e) Condenser heat flow.	10
		Module – 5	
Q.9	**(a)**	Derive an expression for air standard efficiency for diesel cycle with P-V and T-S diagram.	10
	(b)	The minimum pressure and temperature in an Otto cycle are 100 kPa and 27°C. The amount of heat added to the air per cycle is 1500 kJ/kg. Determine a) The pressure and temperature at all points of the air standard Otto cycle. b) The specific work and thermal efficiency of the cycle for a compression ratio of 8:1.	10
		OR	
Q.10	**(a)**	With a neat sketch, explain the working of Ramjet	10
	(b)	Explain with schematic diagram and T-S diagram Brayton cycle with i) Regenerator and ii) Intercooler and write equation for thermal efficiency	10