ME43

MODEL QUESTION PAPER

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

Fourth Semester B.E. Degree Examination, February/March 2004

Mechanical Engineering

Applied Thermodynamics

Time: 3 hrs.] [Max.Marks : 100

Note: *1. Answer any FIVE full Questions.*
2. Use of steam table, charts, psychrometric tables charts is permitted.

1. (a) Briefly describe the following in light of "Availability" concept.
   i) Available and unavailable energy
   ii) Irreversibility **(5 Marks)**

   (b) Show that the available energy decreases with heat transfer over finite temperature range. **(5 Marks)**

   (b) Hot flue gas in furnace supplies its heat to water and gets cooled from 1000^0C to 500^0C. Water boils at 180^0C in the pressurised condition, which has a latent heat of 2018 kJ/kg. Determine per kg of water
   i) total entropy increase of the universe,
   ii) the increase in unavailable energy referred to a surrounding temperature of 25^0C **(10 Marks)**

2. (a) Define the following and explain the concept briefly
   i) Enthalpy of formation ii) Combustion Efficiency **(5 Marks)**

   (b) Explain the technique of analysis of exhaust gas by using Orsat apparatus with suitable diagram. **(5 Marks)**

   (c) In an engine test, the dry volumetric analysis of the products was $CO_2 = 0.0527$, $O_2 = 0.1338$ and $N_2 = 0.8135$. Assuming that the fuel is a pure hydrocarbon and that it is completely burnt, estimate the ratio of carbon to hydrogen in the fuel by mass and the air fuel ratio by mass. **(10 Marks)**

3. (a) State the assumptions made in the derivations of air standard cycles. **(2 Marks)**

   (b) Derive an expression for the air standard efficiency of Diesel cycle in terms of compression ratio and cut-off ratio. **(8 Marks)**

   (c) The compressor and turbine units of a simple gas turbine each have an inentropic efficiency of 85%. The inlet air temperature is 15^0C and the maximum temperature of the gas 800^0C, while the pressure range is from 1 bar to 4 bar.

   Taking $C_p = 1.051$ and $C_v = 0.749kJ/kg$, determine
   i) the overall efficiency of the cycle,
   ii) the net output of air and
   iii) the work ratio of plant. **(10 Marks)**

Contd.... 2

4. (a) Describe why carnot vapour cycle is impractical. **(2 Marks)**

   (b) Explain the working of regenerative Rankine cycle with the help of schematic and TS diagrams. **(8 Marks)**

   (c) A steam engine uses steam at 10 bar and 0.9 dry and exhausts at 1.1 bar. Determine
   i) Rankine cycle efficiency
   ii) The percentage increase in efficiency if the steam has a temperature of 200^0C before entering the cylinder. **(10 Marks)**

5. (a) Explain how the efficiency of compression can be increased with the help of multistaging in reciprocating compressor. **(2 Marks)**

   (b) Show that the condition for maximum efficiency in multistaging is given by

   $$\frac{P_2}{P_1} = \frac{P_3}{P_2} = \frac{P_4}{P_3} = \ldots = \text{constant}$$ **(8 Marks)**

   (c) Air at 1 bar and 27^0C is compressed to 7 bar by a single stage reciprocating compressor according to the law $PV^{1.3} = C$. The free air delivered was $1m^3/min$. Speed of compressor 300 rpm. Stroke to bore ratio 1.5:1. Mechanical efficiency 85% and motor transmission efficiency 90%. Determine,
   i) Indicated power and isothermal efficiency,
   ii) Cylinder dimensions and power of the motor required to drive the compressor. **(10 Marks)**

6. (a) Define the following
   i) Unit of refrigeration
   ii) Coefficient of performance **(2 Marks)**

   (b) List desirable characteristics of a good refrigerator. **(8 Marks)**

   (c) An ammonia vapour compression refrigeration plant operates between evaporator pressure 1.907 and condensor pressure 15.57 bar. The vapour has a dryness fraction of 0.8642 at entry to the compressor. Determine copand refrigeration effect produced for a work input of 1KW. **(10 Marks)**

7. (a) Differentiate between the following:
   i) Dry bulb and wet bulb temperature
   ii) Specific and relative humidity **(5 Marks)**

   (b) Draw a typical psychrometric chart and show the important features. **(5 Marks)**

   (c) Atmospheric air at 43^0C and 40% relative humidity is to be conditioned to a temperature of 25^0C and 50% relative humidity. The method employed is to lower the temperature to dew point of conditioned air and then to raise it to the required temperature. The volume of conditioned air is $25m^3/min$. Find
   (a) the dew point
   (b) Mass of water drained out and
   (c) the amount of heat required to raise the temperature from the dew point to that of conditioned air. **(10 Marks)**

Contd.... 3

8. (a) Explain "Willan's line" method of determining friction power in a C.I engine. **(5 Marks)**

(b) Explain how the indicated power of a multicylinder engine can be measured using morse test. **(5 Marks)**

(c) From the data given below draw an energy balance for a two stroke diesel engine, run for 20 minutes at full load.

rpm	=350,
mcp	= 3bar,
Net brake load	= 640N,
cooling water	= 160kg,
fuel	= 1.5kg,
water temperature rise	25^0C
Air used per kg of fuel	= 30kg,
Room temperature	= 30^0C,
exhaust temperature	= 300^0C
cylinder bore	= 200mm,
stroke	= 280mm,
brake dia	=1m,
Cv of fuel	= 44,000kJ,
Steam formed per kg of fuel in the exhaust	= 1.35kg,
Sp. heat of steam	= 2.09 KJ/kg-K
Sp. heat of dry exhaust gas	= 1.005KJ/kg-K

(10 Marks)

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MODEL QUESTION PAPER

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

Fourth Semester B.E. Degree Examination, February/March 2004

(ME/MA/IM/IP/AU)

Applied Thermodynamics

Time: 3 hrs.] [Max.Marks : 100

Note: *1. Answer any FIVE full questions only.*
2. Use of only steam tables is permitted. No data books to be supplied.
3. Wherever required, assume for air, $C_p = 1.005 kJ/kgK$, and $C_p/C_v = 1.4$

1. (a) Define and briefly explain the following for a system undergoing a non-cyclic process; i) actual work, ii) maximum work, iii) maximum useful work and iv) irreversibility. **(3×4 Marks)**

(b) Air enters an adiabatic rotary compressor steadily at 1.4 bar, 37^0C, $70 m/s$ and leaves it at 3.5 bar, 147^0C, $110 m/s$. The surroundings are at 1 bar and 27^0C. Calculate per kg air i) the actual work, ii) the minimum work and iii) the irreversibility of the process. **(8 Marks)**

2. (a) In the context of combustion of fuels, define the following :
i) Stoichiometric air, ii) Actual air and iii) Excess air. **(3 Marks)**

(b) What is enthalpy of formation? Explain how the standard heat of reaction of CH_4 can be evaluated using the data on enthalpy of formation. **(7 Marks)**

(c) Methane gas (CH_4) is burnt with excess air. The Orsat analysis of the combustion products is as given below : 10% CO_2, 2.37% O_2, 0.53 % CO and 87.1% N_2. Calculate i) Air - Fuel ratio, ii) Theoretical air, and iii) Excess air. **(10 Marks)**

3. (a) With the help of a T - s diagram show that for a given minimum temperature (T_1) and a maximum temperature (T_3) in the cycle, $T_2 = T_4 = (T_3T_1)^{0.5}$ for maximum work output in an ideal gas turbine cycle (Brayton Cycle), where T_2 = temperature of air at the exit of compressor and T_4 = temperature of air at the exit of turbine. **(10 Marks)**

(b) The compression ratio of an air standard dual cycle is 8. Air is at $100 kPa$, $300 K$ at the beginning of the compression process. The temperature of air at the end of constant pressure heat addition process is 1300 K. The net heat transfer to the cycle is 480 kJ/kg. Determine the following : i) Heat transferred at constant volume per kg air and ii) the cycle efficiency. **(10 Marks)**

4. (a) Explain why a Carnot Cycle is not used as a reference cycle for vapour power cycles ? **(5 Marks)**

(b) Distinguish between open and closed feed water heaters used in steam power plants working on a Regenerative Rankine cycle. **(5 Marks)**

(c) In a steam power plant operating on Rankine Cycle, steam enters the turbine at 8 bar, 300^0C. The condenser pressure is 0.1 bar. Adiabatic efficiency of the turbine is 0.9. Calculate the thermal efficiency and the quality of steam at the exit of turbine. Neglect pump work. **(10 Marks)**

Contd.... 2

5. (a) Define volumetric efficiency of a reciprocating compressor. Derive the relation among the volumetric efficiency, clearance and the pressure ratio. Explain the effect of clearance and pressure ratio on volumetric efficiency. **(2+5+3 Marks)**

(b) A single stage reciprocating air compressor has a cylinder of 15cm bore and 15 cm stroke. The clearance is 5%. Air is sucked into the compressor at 1 bar, 27^0C. The discharge pressure is 5 bar. The polytropic exponent of compression and expansion is 1.3. i) Sketch the ideal indicator diagram and find the air handling capacity of the compressor in m^3/min (measured at suction conditions) given that the speed of the compressor is 720 rev/min. ii) Find also the ideal volumetric efficiency and iii) Compressor power in kW. **(5+2+3 Marks)**

6. (a) It is given that the refrigerating capacity of a vapour compression refrigeration system, operating with R - 12 as the refrigerant, is $300 kJ/min$. The refrigerant enters the compressor as saturated vapour at $140 kPa$ and is compressed to $800 kPa$. The enthalpy of vapour after compression is $215 kJ/kg$. Show the cycle on T - s and p - h diagrams with respect to saturation lines and determine i) the quality of refrigerant after throttling, ii) COP and the power input to the compressor. Use the following properties suitably. **(10 Marks)**

Extract of Saturated R - 12 Properties

P (kPa)	t (^0C)	h_f (kJ/kg)	h_g (kJ/kg)	S_f (kJ/kgK)	S_g (kJ/kgK)
140	-21.91	16.09	177.87	0.0663	0.7102
800	32.74	67.3	200.63	0.2487	0.6845

(b) With the aid of a neat diagram explain the operation of a Vapour Absorption Refrigeration System. **(10 Marks)**

7. (a) Explain clearly how the indicated power of a multi-cylinder internal combustion engine can be measured through Morse Test. **(8 Marks)**

(b) The following observations are recorded in a test of one hour duration on a single cylinder four stroke spark ignition engine : Bore = 220mm, stroke = 300 mm, fuel used = 4 kg, calorific value of the fuel = 42000 kJ/kg, shaft speed = 300 rev / min, mean effective pressure = 5 bar, load on the brake drum = 60 kg, spring balance reading = 30 N, diameter of the brake drum = 1.4m, quantity of the cooling water = 500 kg, temperature rise of cooling water = 20 deg., A/F ratio = 16, exhaust gas temperature = 410^0C, ambient temperature = 30^0C and the specific heat at constant pressure of exhaust gases = $1.1 kJ/kgK$. Calculate the following :
i) IP, ii) BP, iii) Brake thermal efficiency and iv) Brake specific fuel consumption. Draw a heat balance sheet in kJ / min and find the unaccounted losses due to radiation etc. **(12 Marks)**

8. Write short notes on any FOUR of the following :
i) Adiabatic saturation of atmospheric air
ii) Relation between relative humidity and absolute humidity
iii) Psychrometric chart
iv) Air standard cycles
v) Desirable properties of refrigerants. **(5×4=20 Marks)**

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NEW SCHEME

USN

Fourth Semester B.E. Degree Examination, July/August 2004

(ME/MA/IM/IP/AU)

Applied Thermodynamics

Time: 3 hrs.] [Max.Marks : 100

Note: ***1. Answer any FIVE full questions.***
2. Use of only steam tables is permitted.
3. Wherever required, assume for air, $C_p = 1.005kJ/kgK$, and $C_p/C_v = 1.4$
4. Any missing data may be suitably assumed.

1. (a) Define and briefly explain the following :
   i) Dead state of a system
   ii) Availability of a system
   iii) Availability of a steadily flowing stream and
   iv) Irreversibility and entropy generation (3 x 4=12 Marks)

   (b) 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. The surroundings are at 1 bar, 27°C. Calculate the maximum useful work and the irreversibility. (8 Marks)

2. (a) Find the stoichiometric air for the combustion of gaseous propane (C_3H_8) on mass basis and molar basis. (4 Marks)

   (b) 4.4 kg propane gas is burnt completely with 3.0 kmols of air. Find the excess air and the molar analysis of the dry combustion products. (7 Marks)

   (c) Define and explain the following briefly :
   i) Enthalpy of reaction,
   ii) Heat of formation and
   iii) Higher calorific value (9 Marks)

3. (a) With the help of superimposed p-V and T - s diagrams compare the efficiencies of air standard Otto and Diesel cycles for same state of air before compression and same maximum pressure and temperature in both the cycles. (8 Marks)

   (b) In a reheat gas turbine cycle, comprising one compressor and two turbines, air is compressed from 1 bar, 27°C to 6 bar. The highest temperature in the cycle is 900°C. The expansion in the first stage turbine is such that the work from it just equals the work required by the compressor. Air is reheated between the two stages of expansion to 850°C Assume that the isentropic efficiencies of the compressor, the first stage and the second stage turbines are 85% each and that the working substance is air and calculate the cycle efficiency. (12 Marks)

4. (a) Steam enters the turbine of a steam power plant, operating on Rankine cycle, at 10 bar, 300°C. The condenser pressure is 0.1 bar. Steam leaving the turbine is 90% dry. Calculate the adiabatic efficiency of the turbine and also the cycle efficiency neglecting pump work. (10 Marks)

   (b) Sketch the flow diagram and a corresponding T - s diagram for a steam power plant working on regenerative cycle with one open feed water heater. Describe its operation briefly. Write the energy balance for the feed water heater. (10 Marks)

Contd.... 2

a) Explain with the help of T-S diagrams the effects of varying boiler pressure and condenser pressure on the performance of a simple Rankine cycle. (8 Marks)

b) In an ideal reheat regenerative cycle, the high pressure turbine receives steam at 20 bar, 300°C. After expansion to 7 bar, the steam is reheated to 300°C and expands in an intermediate pressure turbine to 1 bar. A fraction of steam is now extracted for feed water heading in an open type feed water heater. The remaining steam expands in a low pressure turbine to a final pressure of 0.05 bar. Determine
   i) Cycle thermal efficiency
) Specific steam consumption in kg/kWh
   iii) Quality of steam entering the condenser. (12 Marks)

a) What are the disadvantages of a single-stage air compressor? Explain how these advantages are overcome in a multi-stage compressor. (6 Marks)

b) The following data refer to a single stage air compressor. Atmospheric conditions = 1.00 bar and 25°C ; Receiver pressure is 10 bar, Cylinder diameter = 12cm ; stroke to bore ratio is unity. Clearance volume is $\frac{1}{25}$th of stroke volume. Index for both compression and expansion = 1.25 ; Mechanical efficiency = 80%.

If the receiver capacity is 600 litres and it takes 8 minutes to fill the receiver till its pressure is 10 bar starting from 1 bar, determine :
   i) Actual volumetric efficiency
   ii) Mass of air compressed per second
   iii) Speed of the compressor
   iv) Power input.

Assume that the receiver temperature to remain at 25°C throughout the filling process. (14 Marks)

(a) An air refrigeration system is to be designed according to the following specifications:

Pressure of air at compressor inlet = 101 kPa
Pressure of air at compressor exit = 404 kPa
Temperature of air at compressor inlet = −6 °C
Temperature of air at turbine inlet = 27°C
Isentropic efficiency of compressor = 85%
Isentropic efficiency of turbine = 85%
Determine .
   i) COP of the cycle
   ii) Power required to produce 1 ton of refrigeration
   iii) Man flow rate of air required for 1 ton of refrigeration. (12 Marks)

(b) Explain the working of ammonia vapour absorption refrigeration system. (8 Marks)

(a) Define the following terms as applied to an air-water vapour mixture.
   i) Relative humidity
   ii) Dew point temperature
   iii) Wet bulb temperature
   iv) Adiabatic saturation temperature (8 Marks)

Contd.... 3

(b) Saturated air at 2^0C is required to be supplied to a room where the temperature must be held at 20^0C with a relative humidity of 50%. The air is heated and then water at 10^0C is sprayed in to give the required humidity. Determine the temperature to which the air must be heated and the mass of spray water required per m^3 of air at room conditions. Assume that the total pressure is 1.013 bar. **(12 Marks)**

8. (a) **The following observations were made during a trial of a single cylinder four stroke cycle gas engine having cylinder diameter of 18 cm and stroke of 24 cm.**

Duration of Trial	= 30 min
Total number of revolution	= 9000
Total number of explosion	= 4450
Indicated mean effective pressure	= 5 bar
Net load on the brake wheel	= 390 N
Effective diameter of the brake wheel	= 1m
Calorific value of gaseous fuel at NTP	= 19 MJ/m^3 .
Total fuel used at NTP	= 2.4 m^3
Total air used	= 36 m^3
Pressure of air	= 720 mm of mercury
Density of air at NTP	= 1.29 kg/m^3
Temperature of air	= 17^0C
Temperature of exhaust gas	= 350^0C
Specific heat of exhaust gas	= 1.0 kJ/kg-K
Room temperature	= 17^0C
Cooling water circulated	= 80 kg
Rise in temperature of cooling water	= 30^0C

Draw up a heat balance sheet and estimate the mechanical and indicated thermal efficiencies of the engine. Take R=287 kJ/kg-K. **(14 Marks)**

(b) Explain how Norse test will help in finding the indicated power of a multicylinder engine. **(6 Marks)**

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NEW SCHEME

USN

Fourth Semester B.E. Degree Examination, January/February 2005

Mechanical Engineering

Applied Thermodynamics

Time: 3 hrs.] [Max.Marks : 100

Note: *1. Answer any FIVE full questions.*
2. Use of thermodynamics Data hand book/charts/tables is permitted.
3. Any missing data may be suitably assumed

1. (a) Explain the following :

i) Availability, ii) Available energy, iii) Second law efficiency and iv) lost work. (8 Marks)

(b) Air expands through a turbine from 500KPa, 520^0C to 100 KPa, 300^0C. During expansion 10kJ/kg of heat is left to the surroundings which is at 98 KPa, 20^0C. Neglecting changes in Kinetic and potential energies, determine per unit mass of air i) decrease in availability ii) maximum work and iii) the inversibility. For air take $c_p = 1.005kJ/kg-K$ and assume that air behaves as a perfect gas. (12 Marks)

2. (a) Explain the following terms with reference to a combustion process

i) Stoichiometric air ii) Enthalpy of formation
iii) Adiabatic flame temperature iv) Combustion efficiency

(12 Marks)

(b) A hydrocarbon fuel, $C_{12}\ H_{26}$ is burnt with 50% excess air. Determine the volumetric (Molal) analysis of the products of combustion and also the dew point temperature of the products, if the pressure is 101 KPa. (8 Marks)

3. (a) From the PV diagram of an engine working on the Otto cycle, it is found that the pressure in the cylinder after $\frac{1}{8}^{th}$ of the compression stroke is executed is 1.4 bar. After $\frac{5}{8}^{th}$ of the compression stroke, the pressure is 3.5bar. Compute the compression ratio and the air-standard efficiency. Also if the maximum cycle temperature is limited to 1000^C, find the net work output. (8 Marks)

(b) In a simple gas turbine unit, the isotropic discharge temperature of air flowing out of the compressor is 195^0C, while the actual discharge temperature is 240^0C. Air conditions at the compression inlet are 1 bar and 17^0C. If the air fuel ratio is 75 and net power output from the unit is 650 kW compute i) isotropic efficiencies of the compressor and the turbine and ii) overall cycle efficiency. Calorific value of the fuel used is 46110 kJ/kg and the unit consumes 312 kg/hr of fuel. Assume for gases $C_p = 1.09kJ/kg-K$ and $\gamma = 1.32$ and for

Contd.... 2

air $C_p = 1.005kJ/kg-K$ and $\gamma = 1.4$. (12 Marks)

4. (a) Show that for a simple Rankine cycle the thermal efficiency of the cycle is given by

$$\eta = 1 - \left(\frac{T_2}{T_m}\right)$$

where T_m = Thermodynamic mean temperature at which heat is supplied to the working fluid and

T_2 = Temperature at which heat is rejected by the working fluid in the condenser. Assume that steam centers the turbine in dry saturated state. (6 Marks)

(b) Steam at 30 bar and 350^0C is supplied to a steam turbine in a practical regenerative cycle and the steam is bled at 4 bar. The bled steam comes out as dry saturated steam and heats the feed water in an open type feed water heater to its saturated liquid state. The rest of the steam in the turbine expands to a condenser pressure of 0.1bar. Assuming the turbine efficiency to be same before and after bleeding determine

i) the turbine efficiency ii) steam quality at inlet to the condenser

iii) mass flow rate of bled steam per unit mass flow rate at turbine inlet and

iv) the cycle efficiency (14 Marks)

5. (a) Obtain an expression for the volumetric efficiency of a single stage air compressor in terms of the pressure ratio, the clearance ratio and the index of expansion and explain the effect of clearance on the volumetric efficiency. (6 Marks)

(b) A single acting air compressor has a cylinder bore of 15cm and a Piston stroke of 25cm. The crank speed is 600 RPM. Air taken firm atmosphere (1 bar and 27^0C) is delivered at 11 bar. Assuming that both the compression and expansion processes are according to the law $PV^{1.25}$ = constant and the clearance is 5%, determine i) power required to drive the compressor assuming the mechanical efficiency to be 80%, ii) the time required to deliver $1m^3$ of air as measured at the compressor outlet conditions and iii) volumetric efficiency. (14 Marks)

6. (a) What are the desirable properties of refrigerants to be used in a vapour compression refrigeration cycle? (8 Marks)

(b) An air refrigeration plant is to be designed according to the following specifications

Pressure of air at compressor inlet = 101 KPa
Pressure of air at compressor exit = 404 KPa
Pressure loss in the intercooler = 12 KPa
Pressure Loss in the cold chamber = 3KPa
Temperature of air at compressor inlet = 6^0C
Temperature of air at turbine inlet = 27^0C
Insentropic efficiency of compressor = 85%
Insentropic efficiency of turbine = 85%

Determine i) COP of the cycle ii) Power required to produce 1 ton of refrigeration and iii) air circulation rate per ton of refrigeration. (12 Marks)

Contd.... 3

7. (a) Explain the following terms used in air conditioning

i) Absolute humidity (specific humidity) and relative humidity

ii) Saturated air and unsaturated air

(8 Marks)

(b) Air is to be conditioned from 40^0C (dry bulb temperature) and 50% relative humidity to a final temperature of 20^0C (dry bulb) and 40% relative humidity by a dehumidification process followed by a reheat process. Assuming that the entire process is at constant pressure of 101.325 KPa, determine i) the amount of water to be removed from air ii) the temperature of air leaving the dehumidifier iii) refrigeration in tons for an air flow rate of $0.47m^3/s$ and iv) heating required in kW.

(12 Marks)

(a) What are the different methods of measuring the 'Friction Power' of an IC engine?

(4 Marks)

(b) Explain 'Willan's Line' method of determining the friction power of an IC engine.

(6 Marks)

(c) (a) During the trial of a single-cylinder, four stroke oil engine, the following results were obtained

Cylinder diameter	=	20cm
Stroke	=	40cm
IMEP	=	6 bar
Torque	=	407 N-m
Speed	=	250 rpm
Oil consumption	=	4Kg/h
Calorific value of oil	=	43000 kJ/kg
Cooling water flow rate	=	4.5 kg/min
Air-fuel ratio	=	30:1
Rise in cooling water temperature	=	45^0C
Temperature of exhaust gases	=	420^0C
Room temperature	=	20^0C
Mean specific heat of exhaust gases	=	1.0 kJ/kg -K
Specific heat of water	=	4.18 kJ/kg-K

Draw up a heat balance sheet for the test in kW and in percent. (10 Marks)

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NEW SCHEME

USN

Fourth Semester B.E. Degree Examination, July/August 2005

Common to AU/IM/IP/MA/ME

Applied Thermodynamics

Time: 3 hrs.] [Max.Marks : 100

Note: *1. Answer any FIVE full questions.*
2. Use of thermodynamics Data hand book permitted.

1. (a) What is meant by second law efficiency and explain its significance. **(6 Marks)**

(b) Differentiate between available energy and availability of a system. **(6 Marks)**

(c) Hot gas enters the heat recovery steam generator of a cogeneration unit at 500^0C and 101.325 kPa and leaves at 150^0C. Water enters steadily at 100^0C and 2.0 MPa and leaves as dry saturated steam at 2MPa. The hot gas may be assumed as a perfect gas with $C_p = 1.05\ kJ/kg-k$. For a flow rate of hot gas of 25000 kg/h determine the irreversivility for the process in kJ/h. Neglect the pressure drops, the changes in kinetic and potential energies of the two streams and also the heat loss to the surroundings. **(8 Marks)**

2. (a) Explain the following with reference to a combustion process:

i) Percent excess air

ii) Enthalpy of formation

iii) Adiabatic flame temperature

iv) Enthalpy of combustion. **(8 Marks)**

(b) The products of combustion of an unknown hydrocarbon C_xH_y have the following composition as measured by an orsat apparatus

$CO_2 = 8.0\%$; $CO = 0.9\%$, $O_2 = 8.8\%$; $N_2 = 82.3\%$

Determine :

i) The composition of the fuel

ii) The air fuel ratio

iii) The percent excess air used. **(12 Marks)**

3. (a) An air standard diesel cycle has a compression ratio of 16. The temperature before compression is 27^0C and the temperature after expansion is 627^0C. Determine :

i) The net work output per unit mass of air

ii) Thermal efficiency

iii) Specific air consumption in kg/kWh. **(8 Marks)**

(b) In an open cycle gas turbine plant air enters the compressor at 1 bar and 27^0C. The pressure after compression is 4 bar. The isentropic efficiencies of the turbine and the compressor are 85% and 80% respectively. Air fuel ratio is 80:1. Calorific value of the fuel used is 42000 kJ/kg. Mass flow rate of air is 2.5 kg/s. Determine the power output from the plant and the cycle efficiency. Assume that C_p and r to be same for both air and products of combustion. **(12 Marks)**

Contd.... 2

4. (a) Describe why carnot vapour cycle is impractical. **(2 Marks)**

(b) Explain the working of regenerative Rankine cycle with the help of schematic and TS diagrams. **(8 Marks)**

(c) A steam engine uses steam at 10 bar and 0.9 dry and exhausts at 1.1 bar. Determine

i) Rankine cycle efficiency

ii) The percentage increase in efficiency if the steam has a temperature of 200^0C before entering the cylinder. **(10 Marks)**

5. (a) Explain how the efficiency of compression can be increased with the help of multistaging in reciprocating compressor. **(2 Marks)**

(b) Show that the condition for maximum efficiency in multistaging is given by

$$\frac{P_2}{P_1} = \frac{P_3}{P_2} = \frac{P_4}{P_3} = ... = \text{constant}$$ **(8 Marks)**

(c) Air at 1 bar and 27^0C is compressed to 7 bar by a single stage reciprocating compressor according to the law $PV^{1.3} = C$. The free air delivered was $1m^3/min$. Speed of compressor 300 rpm. Stroke to bore ratio 1.5:1. Mechanical efficiency 85% and motor transmission efficiency 90%. Determine,

i) Indicated power and isothermal efficiency,

ii) Cylinder dimensions and power of the motor required to drive the compressor. **(10 Marks)**

6. (a) Define the following

i) Unit of refrigeration

ii) Coefficient of performance **(2 Marks)**

(b) List desirable characteristics of a good refrigerator. **(8 Marks)**

(c) An ammonia vapour compression refrigeration plant operates between evaporator pressure 1.907 and condensor pressure 15.57 bar. The vapour has a dryness fraction of 0.8642 at entry to the compressor. Determine copand refrigeration effect produced for a work input of 1KW. **(10 Marks)**

7. (a) Differentiate between the following:

i) Dry bulb and wet bulb temperature

ii) Specific and relative humidity **(5 Marks)**

(b) Draw a typical psychrometric chart and show the important features. **(5 Marks)**

(c) Atmospheric air at 43^0C and 40% relative humidity is to be conditioned to a temperature of 25^0C and 50% relative humidity. The method employed is to lower the temperature to dew point of conditioned air and then to raise it to the required temperature. The volume of conditioned air is $25m^3/min$. Find

(a) the dew point

(b) Mass of water drained out and

(c) the amount of heat required to raise the temperature from the dew point to that of conditioned air **(10 Marks)**

Contd.... 3

8. (a) Explain "Willan's line" method of determining friction power in a C.I engine. **(5 Marks)**

(b) Explain how the indicated power of a multicylinder engine can be measured using morse test. **(5 Marks)**

(c) From the data given below draw an energy balance for a two stroke diesel engine, run for 20 minutes at full load.

rpm	=350,
mcp	= 3bar,
Net brake load	= 640N,
cooling water	= 160kg,
fuel	= 1.5kg,
water temperature rise	25^0C
Air used per kg of fuel	= 30kg,
Room temperature	= 30^0C,
exhaust temperature	= 300^0C
cylinder bore	= 200mm,
stroke	= 280mm,
brake dia	=1m,
Cv of fuel	= 44,000kJ,
Steam formed per kg of fuel in the exhaust	= 1.35kg,
Sp. heat of steam	= 2.09 KJ/kg-K
Sp. heat of dry exhaust gas	= 1.005KJ/kg-K

(10 Marks)

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ME43

USN

NEW SCHEME

Fourth Semester B.E. Degree Examination, July 2006
ME / IP / AU / IM / MA
Applied Thermodynamics

Time: 3 hrs.] [Max. Marks:100

Note: *1. Answer any FIVE questions.*
2. Use of thermodynamics data handbook/steam tables/ Mollier chart/Psychrometric chart is permitted.
3. Wherever required Cp=1.005 kJ/kg^{0}C and $\frac{Cp}{Cv} = 1.4$ for air may be assumed.
4. Any additional data, if required may be assumed but they should be clearly stated.

1 a. Explain the term "availability" and show that the availability (ϕ) of a closed system in a given state 1 is given by $\phi_1 = (U_1 - U_0) - T_0(S_1 - S_0) + P_0(V_1 - V_0)$. Where suffix '0' refers to the dead state. (08 Marks)

b. Steam enters a turbine steadily at 3 MPa and 450^{0}C at a rate of 8 kg/s and exits at 0.2 MPa and 150^{0}C. The steam is losing heat to the surrounding air at 100 KPa and 25^{0}C at a rate of 300 KW and the kinetic and potential energy changes are negligible. Determine :
i) The actual power output. ii) The maximum possible power output.
iii) The second law efficiency and iv) The irreversibility.
The values of the properties of steam at turbine inlet and exit states and the dead state given in the accompanying table may be used. (12 Marks)

State	P T	Enthalpy (h) kJ/kg	Entropy (S) kJ/kgK
Inlet state	P_1 = 3MPa T_1 = 450^{0}C	h_1 = 3344.0	S_1 = 7.0834
Exit state	P_2 = 0.2MPa T_2 = 150^{0}C	h2 = 2768.8	S_2 = 7.2795
Dead state	P_0 = 100KPa T_0 = 25^{0}C	h_0 = 104.89	S_0 = 0.3674

2 a. Show that the theoretical minimum quantity of air required for the complete combustion of a sample of coal is given by 4.35(2.667C+8H+S-O) kg per kg of coal where C, H, S and O are the mass fractions of carbon, Hydrogen, sulphur and oxygen in the sample of coal. (06 Marks)

b. Define the terms :
i) Stoichiometric air. ii) Percent excess air. iii) Enthalpy of combustion.
iv) Enthalpy of formation and v) Adiabatic flame temperature. (06 Marks)

c. Propane (C_3H_8) is burnt in atmospheric air and the mass analysis of the dry products of combustion is as follows :
CO_2 – 12.19 %, CO – 1.23 %, O_2=7.57 % and the balance N_2.
Determine :
i) The volumetric analysis of the dry products.
ii) Percent theoretical air. (08 Marks)

Contd.... 2

3 a. Sketch neatly the P-V and T-S diagrams of the air standard dual combustion cycle and derive the expression for the ideal efficiency of the cycle in terms of the compression ratio, the explosion ratio, the cut off ratio and the ratio of specific heats, stating clearly the assumptions made. **(10 Marks)**

b. A simple gas turbine plant operating on the Brayton cycle has air entering the compressor at 100 KPa and 27^0C. The pressure ratio = 9.0 and maximum cycle temperature = 727^0C. What will be the percentage change in cycle efficiency and net work output if the expansion in the turbine is divided into two stages each of pressure ratio 3, with intermediate reheating to 727^0C? Assume compression and expansion are ideal isentropic. **(10 Marks)**

4 a. Sketch the P-V and T-S diagrams of Carnot cycle with steam as the working substance. What are the drawbacks of Carnot cycle? Why Rankine cycle is preferred as the ideal cycle for comparing the performance of a steam power plant? **(08 Marks)**

b. The net power output of a regenerative-reheat cycle power plant is 80 MW. Steam enters the high pressure turbine at 80 bar 500^0C and expands to pressure P_2 and emerges as dry vapour. Some of the steam goes to an open feed water heater and the balance is reheated at 400^0C at constant pressure P_2 and then expanded in the low pressure turbine to 0.05 bars.
Determine :
i) The reheat pressure P_2. ii) The mass of bled steam per kg of boiler steam.
iii) The steam flow rate in the HP turbine. iv) Cycle efficiency
Neglect pumps work. Sketch the relevant lines on the enthalpy-entropy diagram. Assume expansion in the turbines is ideal isentropic. **(12 Marks)**

5 a. Derive the condition for minimum work input to a two stage reciprocating air compressor with perfect intercooling. State clearly the assumptions made. **(08 Marks)**

b. A multistage air compressor compresses air from 1 bar to 40 bars. The maximum temperature of air is not to exceed 400 K in any stage. If the law of compression is $PV^{1.3}$ = a constant, find the number of stages for minimum power input. Also find the actual interchange pressures and temperatures. What will be the minimum power input in KW required to compress and deliver 10 kg/min of air and the rate of heat rejection in each intercooler? Assume ambient temperature = 27^0C and perfect intercooling in between stages. **(12 Marks)**

6 a. Draw a neat diagram of the vapour-absorption system of refrigeration including all the auxiliaries to improve its performance. Briefly explain its principle of working. **(08 Marks)**

b. List any two important thermodynamic properties, a good refrigerant should possess. Explain why R-134a is considered to be an environment-friendly refrigerant. **(04 Marks)**

c. A 10 tonne ammonia ice plant operates between an evaporator temperature of 15^0C and a condenser temperature of 35^0C. The ammonia enters the compressor as dry saturated liquid. Assuming isentropic compression, determine :
i) Mass flow rate of NH_3. ii) C.O.P of the plant. iii) Power input in KW and iv) Tons of ice at 10^0C produced from water at 25^0C in a day.
[Enthalpy of fusion of ice = 334 kJ/kg, Cp for water = 4.187 kJ kg^{0}C and Cp for ice = 2.1 kJ/kg^{0}C] **(08 Marks)**

Contd... 3

7 a. Define relative humidity and degree of saturation and show that the relative humidity, ϕ and degree of saturation, μ are related by $\mu = \phi \times \frac{\left(1-\frac{P_S}{P_T}\right)}{\left(1-\frac{P_V}{P_T}\right)}$ where P_V = Actual partial pressure of water vapour in air, P_S = Partial pressure of water vapour in saturated air and P_T = Total pressure of atmospheric air. **(05 Marks)**

b. A room measures $5m \times 5m \times 3m$. It contains atmospheric air at 100KPa, DBT=30^{0}C and relative humidity = 30%. Find the mass of dry air and the mass of associated water vapour in the room. Solve the problem without the use of psychrometric chart and using the properties of water vapour from the steam tables. **(05 Marks)**

c. A summer air conditioning system for hot and humid weather (DBT=32^{0}C and RH=70%) consists in passing the atmospheric air over a cooling coil where the air is cooled and dehumidified. The air leaving the cooling soil is saturated at the coil temperature. It is then sensibly heated to the required comfort condition of 24^{0}C and 50% RH by passing it over an electric heater and then delivered to the room.

Sketch the flow diagram of the arrangement and represent the processes undergone by the air on a skeleton psychrometric chart and determine :

i) The temperature of the cooling coil.
ii) The amount of moisture removed per kg of dry air in the cooling coil.
iii) The heat removed per kg of dry air in the cooling coil and
iv) The heat added per kg of dry air in the heating coil. **(10 Marks)**

8 a. In a test of 4-cylinder, 4-stroke petrol engine of 75mm bore and 100mm stroke, the following results were obtained at full throttle at a constant speed and with a fixed setting of the fuel supply at 0.082 kg/min. BP with all the 4 cylinders working =15.24 KW, BP with cylinder No.1 cutoff = 10.45 KW, BP with cylinder No.2 cutoff = 10.38 KW, BP with cylinder No.3 cutoff = 10.23 KW, BP with cylinder No.4 cutoff = 10.45 KW. Determine :

i) The indicated power.
ii) The indicated thermal efficiency, if the calorific value of the fuel = 44 MJ/kg.
iii) Relative efficiency based on IP if clearance volume in each cylinder = 115 c.c. **(08 Marks)**

b. A test on a 2-srtoke oil engine gave the following results at full load :
Speed = 350 rpm, Net brake load = 650 N, i.m.e.p = 3 bar,
Fuel consumption = 4 kg/h, Jacket cooling water flow rate = 500 kg/h,
Jacket water temperature at inlet = 20^{0}C,
Jacket water temperature at outlet = 40^{0}C, Room temperature = 20^{0}C,
Exhaust gas temperature = 400^{0}C, Air used per kg of fuel = 32 kg,
Cylinder diameter=22cm, Stroke=28cm, Brake drum circumference=314 cm,
Calorific value of fuel = 43 MJ/kg,
Mean specific heat of exhaust gases = 1 kJ/kg^{0}C.
Determine : i) Mechanical efficiency ii) B.M.E.P
Draw energy balance sheet in KW and in percentage. **(12 Marks)**

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ME43

USN

NEW SCHEME

Fourth Semester B.E. Degree Examination, Dec.06 / Jan.07
ME/IP/AU/IM/MA

Applied Thermodynamics

Time: 3 hrs.] [Max. Marks:100

Note: ***1. Answer any FIVE full questions.***
2. Use of Steam table, refrigeration table/charts is permitted.

1 a. Explain "Thermodynamic dead state". (02 Marks)
b. Show that second law efficiency is equal to the ratio of first law efficiency to the Carnot efficiency. (05 Marks)
c. An insulated tank contains 0.6 kg of air initially at 200 kPa, 20°C. An impeller inside the tank is turned by an external motor until the pressure is 230 kpa. Ambient conditions are 95 kPa, 20°C. Determine the irreversibility of the process. (13 Marks)

2 a. Are complete combustion and theoretical combustion identical? If not, how do they differ? (02 Marks)
b. Explain,
i) Enthalpy of formation,
ii) Combustion efficiency,
iii) Adiabatic flame temperature. (09 Marks)
c. A sample of fuel has the following percentage composition : carbon = 86%, Hydrogen = 8%, Sulphur = 3%, Oxygen = 2%, Ash = 1%.
For an air fuel ratio of 12 : 1 calculate,
i) Mixture strength as a percentage of rich or weak.
ii) Volumetric analysis of the dry product of combustion. (09 Marks)

3 a. Prove that for the same compression ratio and heat input, Otto cycle efficiency is more than Diesel cycle. (06 Marks)
b. Show that the efficiency of air standard Brayton cycle is a function of isentropic pressure ratio. (06 Marks)
c. Obtain an expression for the air standard efficiency of Diesel cycle. (08 Marks)

4 a. Why is the Carnot cycle not a realistic model for steam power plant? Explain briefly. (06 Marks)
b. Explain any two methods of increasing efficiency of Rankine cycle. (06 Marks)
c. A steam power station uses the following cycle: Steam at boiler outlet – 150 bar, 550°C; reheat at 40 bar, 550°C; condenser at 0.1 bar. Using Mollier chart and assuming that all processes are ideal, find i) Quality at turbine exhaust ii) Cycle efficiency iii) Steam rate. (08 Marks)

5 a. Explain the effect of clearance volume on work of compression. (06 Marks)

Contd... 2

5 b. **What do you understand by multistage air compressor? Mention the advantages of multistage air compressor.** **(06 Marks)**

c. **A two stage air compressor with perfect intercooling takes in air at 1 bar and 27°C. The law of compression in both the stages is $pv^{1.3}$ = constant. The compressed air is delivered at 9 bar. Calculate for unit mass flow rate of air the minimum work done and the heat rejected to inter-cooler. Compare the values if compression is carried out in single stage compressor with after-cooler.** **(08 Marks)**

6 a. Explain with the aid of T-S diagram and P-H diagram, the effect of superheat and subcooling on the vapour compression refrigeration cycle. **(06 Marks)**

b. How are refrigerants numbered? Explain briefly. **(04 Marks)**

c. A cold storage is to be maintained at -5°C (268 K) while the surroundings are at 35°C. The heat leakage from the surroundings in to the cold storage is estimated to be 29 kW. The actual COP of the refrigeration plant is one third that of an ideal plant working between the same temperatures. Find the power required to drive the plant. **(10 Marks)**

7 a. Define the following terms,

i) Wet bulb temperature (WBT)
ii) Specific humidity (SH)
iii) Relative humidity (RH)
iv) Degree of saturation (DS) **(08 Marks)**

b. An air conditioning system is designed under the following conditions :
Outdoor conditions : 30°C DBT, 75% RH.
Required indoor conditions : 22°C DBT, 70% RH.
Amount of free air circulated 3.33 m^3/s,
Coil dew point temperature (DPT) = 14°C.
The required condition is achieved first by cooling and dehumidification and then by heating. Estimate

i) The capacity of the cooling coil in Tonnes of refrigeration.
ii) The capacity of the heating coil in kW.
iii) The amount of water vapour removed in kg/hr. **(12 Marks)**

8 a. Describe Morse test. What are the assumption, made in this test? **(08 Marks)**

b. A gas engine working on constant volume cycle gave the following results during a one hour test run. Cylinder diameter 24 cm ; stroke 48 cm. Effective diameter of brake wheel 1.25 m. Net load on brake 1236 N. Average speed 226.7 revolution per minute. Average explosions per minute 77. MEP 7.5 bar, gas used 13 m^3 at 15°C and 771 mm of mercury pressure. Lower calorific value of gas 22,000 kJ/m^3 at NTP. Cooling water used 625 kg. Inlet temperature of water 25°C. Outlet temperature of water 60°C. Determine

i) Mechanical efficiency
ii) The specific fuel consumption in m^3 IP.hour
iii) The indicated and brake thermal efficiencies.

Draw up a heat balance for the engine on minute basis. N.T.P conditions are 760 mm of Hg and 0°C. **(12 Marks)**

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06ME43

Fourth Semester B.E. Degree Examination, June / July 08

Applied Thermodynamics

Time: 3 hrs.

Max. Marks:100

Note : *1. Answer any FIVE full questions choosing at least TWO questions from each part.*
2. Use of Thermodynamic data hand book permitted.

PART - A

1 a. Explain the following : i) Stoichiometric air ii) Enthalpy of formation iii) Adiabatic flame temperature iv) Enthalpy of combustion v) Heat of reaction. (10 Marks)

b. Methane (CH_4) is burned with atmospheric air. The analysis of the products of combustion on a dry basis is as follows : CO_2 – 10.00% , O_2 – 2.37% , CO – 0.53% and N_2 – 87.10%. Calculate the air fuel ratio and the percent theoretical air and determine the combustion equation. (10 Marks)

2 a. For the same compression ratio and heat rejection, which cycle is more efficient, Otto, Diesel or Dual? Explain with P – V and T – S diagrams. (08 Marks)

b. Two engines are to operate on Otto and Diesel cycles with the following data. Maximum temperature : 1400K , Exhaust temperature : 700K. State of air at the beginning of compression 0.1MPa, 300K. Estimate the compression ratio, the maximum pressures, efficiencies and rate of work output (for 1kg/sec of air) of the respective cycles. (12 Marks)

3 a. Derive the expression of optimum pressure ratio for maximum net work output in an ideal Brayton cycle. What is the corresponding cycle efficiency? (06 Marks)

b. List the methods of improving the efficiency of Brayton cycle. (02 Marks)

c. A gas turbine power plant operates on the simple Brayton cycle with air as the working fluid and delivers 32MW of power. The minimum and maximum temperatures in the cycle are 310 and 900K, and the pressure of air at the compressor exit is 8 times the value at the compressor inlet. Assuming an isentropic efficiency of 80% for the compressor and 86% for the turbine, determine the mass flow rate of air through the cycle. (12 Marks)

4 a. Why is Carnot cycle not practicable for a steam power plant? Briefly explain. (02 Marks)

b. Discuss the effect of i) Boiler pressure ii) Condenser pressure iii) Superheat on the performance of a Rankine cycle. (06 Marks)

c. In a reheat cycle, steam at 500^{0}C expands in a H.P. turbine till it is saturated vapor. It is then reheated at constant pressure to 400^{0}C and then expanded in a L.P. turbine to 40^{0}C. If the maximum moisture content at the turbine exhaust is limited to 15%. Find i) the reheat pressure ii) the pressure of steam at the inlet to the H.P turbine iii) the net specific work output iv) the cycle efficiency and v) the steam rate. Assume all ideal processes. (12 Marks)

PART - B

5 a. What are the draw backs of single stage compressor for producing high pressure and how these are overcome by multi – stage compression? (04 Marks)

b. Derive an expression for the condition for minimum work input required for two stage compressor with perfect inter cooling. (06 Marks)

c. A reciprocating air compressor has 5 percent clearance with a bore of 25cm and length of stroke 30cm. The compressor operates at 500rpm. The air enters the cylinder at 27^0C and 95 kPa and discharges at 2000 kPa. If n = 1.3 for compression and expansion processes, determine i) the volumetric efficiency. ii) the volume of air handled at inlet conditions in m^3/sec iii) the power required iv) the mass of air discharged in kg/sec. (10 Marks)

6 a. Explain the effect of superheat and subcooling on the vapour compression cycle with the help of T – s and P – h diagrams. (06 Marks)

b. Why is the COP of a gas cycle refrigeration system low and why is it preferred in aircrafts? (02 Marks)

c. A Refrigerant – 12 vapour compression cycle has a refrigeration load of 3 tonnes. The evaporator and condenser temperatures are -20^0C and 40^0C respectively. If there is 5^0C of superheating of vapour before it enters the compressor and 5^0C sub cooling of liquid before it flows through the expansion valve, determine

i) The refrigerant flow rate in kg/s. ii) The volume flow rate handled by the compressor in m^3/s ; iii) The work input to the compressor in kW ; iv) The heat rejected in the condenser in kW ; v) The isentropic discharge temperature. (12 Marks)

7 a. Define i) Dry bulb temperature ii) Wet bulb temperature iii) Dew point temperature iv) Relative humidity. (04 Marks)

b. Show the following processes on psychrometric chart. i) Sensible heating and cooling ii) Cooling and dehumidification iii) Heating and humidification iv) Adiabatic mixing of two streams. (06 Marks)

c. For a hall to be air – conditioned, the following conditions are given

Outdoor conditions 40^0C DBT, 20^0C WBT ; Required comfort conditions 20^0C DBT, 60% RH ; Seating capacity of Hall – 1500 ; Amount of outdoor air supplied 0.3m^3/min per person.

If the required condition is achieved first by adiabatic humidification and then by cooling, estimate i) The capacity of the cooling coil in tonnes and ii) The capacity of the humidifier in kg/hr. (10 Marks)

8 a. Explain the method of findings friction power using i) Morse test ii) Motoring test of an engine. (08 Marks)

b. During a test on a single – cylinder, four stroke oil engine, the following results were obtained.

Cylinder diameter = 20cm ; Stroke = 40cm ; Mean effective pressure = 6 bar ; Torque = 407 Nm ; Speed = 250 rpm ; Oil consumption = 4 kg/h ; Calorific value of fuel = 43 MJ/kg ; Cooling water flow rate = 4.5 kg/min ; Air used per kg of fuel = 30 kg ; Rise in cooling water temperature = 45^0C ; Temperature of exhaust gases = 420^0C ; Room temperature = 20^0C ; Mean specific heat of exhaust gas = 1kJ/kg K ; Specific heat of water = 4.18 kJ/kg K. Find IP, BP and draw up a heat balance sheet for the test in kJ/h. (12 Marks)

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06ME43

Fourth Semester B.E. Degree Examination, Dec 08 / Jan 09

Applied Thermodynamics

Time: 3 hrs. Max. Marks:100

Note : *1. Answer FIVE full questions, selecting atleast TWO questions from each part.*
2. Use of Thermodynamics Data handbook, Steam tables, Mollier chart, Psychrometric chart is permitted.

Part A

1 a. With a neat sketch, explain the analysis of exhaust gases by orsat apparatus. **(08 Marks)**

b. The volumetric composition of the dry products of combustion of an unknown hydro carbon fuel C_xH_y, gives CO_2 12.1%, O_2 3.8%, CO 0.90% and N_2 83.2%. Determine i) Chemical formula of the fuel ii) Air Fuel ratio iii) % of excess air. **(12 Marks)**

2 a. Compare Otto, Diesel and Dual cycles on the basis of same compression ratio and same maximum pressure. **(10 Marks)**

b. In an air standard diesel cycle, the compression ratio is 16. At the beginning of Isentropic compression, the temperature is 15^{0}C and pressure is 0.1 MPa. Heat is added until the temperature at the end of the constant pressure process is 1480°C. Calculate i) cut – off ratio ii) heat supplied per kg of air iii) cycle efficiency and iv) mean effective pressure. **(10 Marks)**

3 a. With neat sketches, explain Turbo Jet and Ram Jet propulsions. **(08 Marks)**

b. A gas turbine plant draws in air at 1.013 bar 10^{0}C and has a pressure ratio of 5.5. The maximum temperature in the cycle is limited to 750^{0}C. Compression is conducted in an uncooled rotory compressor having an isentropic efficiency of 82% and expansion takes place in a Turbine with an isentropic efficiency of 85%. A heat exchanger with an efficiency of 70% is fitted between the compressor outlet and combustion chamber. For an air flow of 40 kg/sec, find i) Overall efficiency of cycle ii) Turbine output iii) Air – fuel ratio if the calorific value of fuel used is 45.22 MJ/kg. **(12 Marks)**

4 a. Explain with T-S diagrams, limitations of Carnot cycle and how we can overcome the same in Rankine cycle. **(08 Marks)**

b. The net power out put of an Ideal Regenerative – Reheat steam cycle is 80 MW. Steam enters the HP turbine at 80 bar, 500^{0}C and expands till it becomes saturated vapour. Some of the steam then goes to an open feed water heater and the balance is reheated to 400^{0}C, after which it expands in the LP turbine to 0.07 bar. Compute i) The reheat pressure ii) Steam flow rate to HP turbine iii) Cycle efficiency. **(12 Marks)**

Part B

5 a. Show that the optimum intermediate pressure of a two stage reciprocating air compressor for minimum work is the Geometric mean of the suction and discharge pressures. **(10 Marks)**

b. A single acting Air compressor has a bore and stroke of 12cms and 15cms. The speed is 1200 rpm. It compresses CO_2 gas from a pressure of 120 KPa, 20^{0}C to a temperature of 215^{0}C. Assume polytropic compression with n = 1.3, no clearance and volumetric efficiency of 100% . Calculate i) pressure ratio ii) indicate power iii) Shaft power if the mechanical efficiency is 80% iv) mass flow rate. If a second stage of equal pressure ratio were added, calculate the overall pressure ratio and bore of second stage if the same stroke was maintained. **(10 Marks)**

6 a. Derive an expression for COP of an Air Refrigeration system. (08 Marks)
b. A refrigerating unit takes air from a cold chamber at 5^0C and compresses it from 1 bar to 6.5 bar. The index of compression is 1.25. The compressed air is cooled to a temperature, which is 10^0C above the ambient temperature of 30^0C before being expanded isentropically in an expander. Neglecting the clearance volume of the compressor and expander find the COP and the amount of air circulated in m^3/minute, if 2000 kg of ice is to be formed per day at 0^0C from water at 25^0C. What is the tonnage of the unit? (12 Marks)

7 a. Define the following : i) DBT ii) Dew point temperature iii) Specific humidity iv) Relative humidity. (08 Marks)
b. It is required to design an A/C for the following condition :
Outdoor condition : 32^0C DBT and 65% RH ; Indoor conditions : 25^0C DBT and 60% RH
Amount of air circulated : 250m^3/min ; Coil dew temperature : 13^0C.
If the required condition is achieved first by cooling and dehumidifying and then by heating, calculate i) Cooling coil capacity and its by pass factor ii) Heating coil capacity and its surface temperature if its by pass factor is 0.3 iii) Mass of water vapour removed per hour. (12 Marks)

8 a. Explain any three methods to measure indicate power of an IC engine in laboratory. (06 Marks)
b. The following observations were recorded in a test of 1 hour duration on a single cylinder 4-stroke oil engine.
Bore = 220 mm, Stroke = 300mm, Fuel used = 4 kgs, Calorific value of fuel used = 42000 kJ/kg, Shaft speed = 300 rpm, Number of explosions per minute = 148, M.E.P = 5 bar, Load on brake drum = 60 kg's , Spring balance reading = 30N, Diameter of Brake drum = 1.4m , Quantity of cooling water Circulated = 500 kgs, Increase in Temperature of cooling water = 20^0C, Air Fuel ratio = 16 , Exhaust gas temperature = 410^0C , Specific heat of exhaust gases = 1.1 kJ/kg K , Ambient air temperature = 30^0C.
Determine IP, BP, Mechanical efficiency, Brake thermal efficiency, Specific fuel consumption. Draw the heat balance sheet in kJ/min. (14 Marks)

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06ME43

Fourth Semester B.E. Degree Examination, June-July 2009
Applied Thermodynamics

Time: 3 hrs.

Max. Marks:100

Note : *1. Answer any FIVE full questions, choosing at least TWO questions form each part.*
2. Thermodynamics data book allowed.

PART – A

1 a. Define i) Enthalpy of formation ii) Enthalpy of combustion iii) Stochiometric air iv) Excess air and v) Adiabatic flame temperature. **(10 Marks)**

b. Coal with following mass analysis is burnt with 100% excess air. C = 74%, H_2 = 4.3%, S = 2.7%, N_2 = 1.5%, H_2O = 5.5%, O_2 = 5%, Ash = 7%. Find moles of gaseous products if 100kg of fuel are burnt. **(10 Marks)**

2 a. Compare Otto and Diesel cycles, with the help of PV and T-S diagrams, based on the following conditions. i) When maximum cycle pressure and temperature are same. ii) When compression ratio and heat addition are same. **(08 Marks)**

b. The following data refers to an ideal sterling cycle with ideal regenerator. Pressure, temperature and volume of the working medium at the beginning of the isothermal compression are 100kPa, 30^0C and 0.05m^3 respectively. The clearance volume of the cycle is 1/10 of the initial volume. The maximum temperature attained in the cycle is 700^0C. Draw PV and T-S diagrams. Calculate i) The net work ii) Thermal efficiency with 100% regenerator efficiency iii) Thermal efficiency without the regenerator. **(12 Marks)**

3 a. Draw neat line diagram and T-S diagram for the following G.T. cycle.
i) Regeneration ii) Intercooling iii) Reheating. **(12 Marks)**

b. Air enters the compressor of an ideal air standard Brayton cycle at 100kPa, 300K with a volumetric flow rate of 6m^3/S. The compressor pressure ratio is 10. The turbine inlet temperature is 1500K. Determine i) The thermal efficiency ii) work ratio iii) The power developed. **(08 Marks)**

4 a. Draw neat line diagram and T-S diagram for the following vapour power cycle.
i) Practical regenerative Rankine cycle with closed feed water heaters.
ii) Practical regenerative Rankine cycle with open feed water heaters. **(08 Marks)**

b. Steam from a boiler enters a turbine at 25bar and expands to condenser pressure of 0.2 bar. Determine the Rankine cycle efficiency neglecting pump work ;
i) When steam is 80% dry at turbine inlet.
ii) When steam is saturated at turbine inlet.
iii) When steam is superheated at turbine inlet by 76.1^0C.
iv) Represent above 3 processes on same T-S diagram.

Pressure bar	h_f kJ/kg	h_g kJ/kg	s_f kJ/kg.K	s_g kJ/kg.K
25	962.0	2800.9	2.5543	6.2536
0.2	251.5	2609.9	0.8321	7.9094

Ts at 25 bar = 223.9^0C ; h_{sup} at 25 bar, 300^0C = 3008.8kJ/kg ;
S_{sup} at 25 bar, 300^0C = 6.644 kJ/kg K. **(12 Marks)**

PART – B

5 a. Derive an expression for work done in a reciprocating air compressor,
i) without clearance ii) with clearance. (06 Marks)

b. What is the purpose of multistaging in reciprocating compressor? How does it affect
i) Mechanical efficiency ii) Volumetric efficiency? (06 Marks)

c. A single cylinder, double acting air compressor is required to deliver 100 m^3/min of air at a mean piston speed of 500m/min measured at 1 bar and 15^0C. The air is delivered at 7 bar. Assume a clearance volume of 1/15th of swept volume per stroke. Find volumetric efficiency, speed, bore, stroke for the following two cases.
i) if ambient and suction conditions are same.
ii) if ambient and suction conditions are different.
Ambient pr. = 1.0 bar, Ambient temp. = 15^0C , Suction pr. = 0.98 bar,
Suction temp = 30^0C. Assume L/D = 1.25. (08 Marks)

6 a. Draw neat PV and TS diagram for reversed Brayton cycle. (02 Marks)

b. Show that COP reversed Brayton cycle = $\dfrac{1}{\left[R_P^{\frac{\gamma-1}{\gamma}}-1\right]}$

R_P = Pressure ratio ; $\gamma = C_p / C_v$ = remains same during expansion and compression process. (04 Marks)

c. A simple NH_3 vapour compression system has a condenser temperature of 30^0C and evaporator temperature of -15^0C. The liquid is subcooled by 10^0C. Calculate
i) Refrigerating effect ii) Mass flow rate per ton of refrigeration iii) COP
iv) Power per TR v) Represent on pH and TS diagram.
$Cp_{(vap)}$ = 2.805 kJ/kg K , $Cp_{(liq)}$ = 4.606 kJ/kg K. (14 Marks)

Properties of NH_3.

Temp	Enthalpy kJ/kg		Entropy kJ/kg K		SP. Vol. m^3/kg
	h_f	h_g	s_f	s_g	v_g
- 15	112.3	1426.0	0.457	5.549	0.509
+ 30	323.1	1469.0	1.204	4.984	

7 a. Define i) Specific humidity ii) degree of saturation iii) relative humidity. (06 Marks)

b. Moist air at 35^0C has a dew point of 15^0C. Calculate its relative humidity, specific humidity and enthalpy. Take Cp_v = 1.88 kJ/kg K. (06 Marks)

c. 30m^3/min of air at 15^0C DBT and 13^0C WBT is mixed with 12m^3/min of air at 25^0C DBT and 18^0C WBT. Calculate DBT, specific humidity of the mixture. Take atm. pressure as 760 mm of Hg. Calculate by calculation method only. (08 Marks)

8 a. Explain briefly the Morse test. (06 Marks)

b. A 4 cylinder engine has the following data :
Bore = 15cm, stroke = 15cm, Piston speed = 510m/min, BP = 60 kW, Mech. Efficiency 80%, Mep = 5bar, CV = 40000 kJ/kg. Calculate i) whether this is a two stroke OR 4 stroke cycle engine. (04 Marks)

c. Following data are available for SI engine, single cylinder stroke = 4, A:F = 16:1, CV = 45000 kJ/kg, mech, η = 80% , Air std, η = 50%, relative η = 70%, stroke to bore = 1.5, suction condition = 1 bar, 30^0C, speed = 2500 rpm, BP = 75 kW. Calculate
i) compression ratio, ii) indicated thermal η , iii) BSFC , iv) Brake thermal η ,
v) Bore and stroke : Assume volume η = 80%. (10 Marks)

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06ME43

Fourth Semester B.E. Degree Examination, Dec.09-Jan.10

Applied Thermodynamics

Time: 3 hrs. Max. Marks:100

Note:1. ***Answer any FIVE full questions, selecting at least TWO questions from each part.***
2. Use of thermodynamic data handbook permitted.

PART – A

1 a. Define the following :
i) Stoichimetric air ii) Enthalpy of combustion iii) Calorific value
iv) Adiabatic flame temperature v) Percentage excess air. **(10 Marks)**

b. The products of combustion of hydrocarbon fuel of unknown composition have the following composition as measured on dry basis : Co_2 = 80%, CO = 0.9%, O_2 = 8.8%, N_2 = 82.3%. Calculate :
i) Air fuel ratio
ii) Composition of fuel on mass basis
iii) The percentage of theoretical air on mass basis. **(10 Marks)**

2 a. Derive the expression for the air standard efficiency of a Diesel cycle with usual notations. State the assumptions made and represent the process on P-V and T-S diagrams. **(10 Marks)**

b. A petrol engine works on Otto cycle under ideal conditions. The initial pressure before the beginning of compression is 101Kpa at 340K. The pressure at the end of heat addition process is 2.5mpa. As per the details furnished by the manufacturer engine has stroke length twice the bore. Engine bore is 300mm and clearance volume is $4 \times 10^{-3} m^3$. Determine :
i) Compression ratio
ii) The air standard efficiency
iii) The mean effective pressure. **(10 Marks)**

3 a. Derive an expression for the work output of a gas turbine in terms of pressure ratio and maximum and minimum temperatures T_3 and T_1. Hence show that the pressure ratio for maximum specific work output is given by $R_p = \left[\frac{T_3}{T_1}\right]^{\frac{\gamma}{2(\gamma-1)}}$. **(10 Marks)**

b. In an open cycle gas turbine plant air enters the compressor at 1 bar and 27°C.The pressure after compression is 4 bar. The isentropic efficiencies of the turbine and the compressor are 85% and 80% respectively. Air fuel ratio is 80:1. Calorific value of the fuel used is 42000 KJ/kg. Mass flow rate of air is 2.5 kg/S. Determine the power output from the plant and the cycle efficiency. Assume that 'Cp' and 'γ' to be same for both air and products of combustion. **(10 Marks)**

4 a. Sketch the flow diagram and the corresponding temperature-entropy diagram of a reheat vapour cycle and derive an expression for the reheat cycle efficiency. What are the advantages gained by reheating the steam between stages? **(10 Marks)**

b. A steam power plant incorporates an ideal reheat cycle to improve the existing efficiency. Steam at 30 bar and 250°C is supplied at high pressure turbine inlet and expands till it is dry saturated at 3 bar. Now the steam is taken to a reheater and its temperature is again increased to 250°C by constant pressure reheating process. The reheated steam expands in the low pressure turbine to a condenser pressure of 0.04 bar. Determine the cycle efficiency. **(10 Marks)**

PART – B

5 a. Derive the expression for the work done for a single stage, single acting reciprocating compressor with clearance volume. (06 Marks)

b. Discuss applications of compressed air, and derive an expression for the volumetric efficiency of reciprocating air compressor. (06 Marks)

c. A two stage reciprocating compressor works between pressure limits of 1 bar and 8 bar and draws in air at 15°C at the rate of 467 lit/min. The compression in both the stages is isentropic and intercooling is perfect. Estimate the minimum power supplied. (08 Marks)

6 a. Write a brief note on properties of refrigerants. (04 Marks)

b. With a neat sketch, describe clearly the working of a Bell-Coleman cycle. (06 Marks)

c. A vapour compression refrigerator of 10 tonnes capacity using Freon-12 as the refrigerant has an evaporator temperature of – 10°C and a condenser temperature of 30°C. Assuming simple saturation cycle, determine :

i) Mass flow rate of refrigerant in kg/min
ii) Power input
iii) COP

Take $C_{pv} = 0.72 KJ/kgk$. (10 Marks)

7 a. Define the following clearly :
i) Dry bulb temperature ii) Wet bulb temperature iii) Specific humiity (06 Marks)

b. With a neat sketch, briefly describe a summer air-conditioning system. (06 Marks)

c. Atmospheric air at 101.325Kpa has 30°C DBT and 15°C DPT. Without using the psychrometric chart, using the property values from the tables, calculate :
i) Partial pressures of air and water vapour ii) Specific humidity
iii) Ralative humidity iv) Vapour density v) Enthalpy of moist air (08 Marks)

8 a. What do you understand by heat balance sheet? Enumerate the importance of the same. (06 Marks)

b. Describe the principle of conducting Morse test on IC engines. (04 Marks)

c. A 4-cylinder, 4 stroke SI engine 90mm bore and 90mm stroke was tested at constant speed. The fuel supply was fixed at 0.0008kg/sec and plug of 4 cylinders were successively short circuited without change of speed. The power measurement was as follows :
With all cylinders working 16.25 KW ; with number of 1 cylinder cut off 11.55 KW ; with number of 2 cylinder cut off 11.65 KW ; with number of 3 cylinder cut off 11.70 KW ; with number of 4 cylinder cut off 11.50 KW.
Find :
i) The indicated power
ii) Indicated and brake thermal efficiency, if the C.V. of fuel is 42500 KJ/kg.
iii) Relative thermal efficiency if the clearance volume is $65 cm^3$. (10 Marks)

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06ME43

Fourth Semester B.E. Degree Examination, May/June 2010
Applied Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting at least TWO questions from each part.***
2. Use of standard thermodynamic data book, psychrometric chart, steam tables, Mollier chart etc. permitted.

PART – A

1 a. Explain : i) enthalpy of formation ; ii) Enthalpy of combustion ; iii) Stoichiometric air, iv) Combustion efficiency. **(10 Marks)**

b. Methane (CH_4) is burned with atmospheric air. The analysis of the products on a dry basis is as follows : CO_2 = 10% , O_2 = 2.37% , CO = 0.53% and N_2 = 87.10%. Determine the combustion equation and calculate : i) Air fuel ratio on mole and mass basis ; ii) The percent theoretical air. **(10 Marks)**

2 a. Describe diesel cycle with P – V and T – S diagrams and derive an expression for efficiency in terms of compression ratio, cut off ratio and ratio of specific heats. **(10 Marks)**

b. The minimum pressure and temperature of the air standard Carnot cycle are 1 bar and 15°C respectively. The pressure after isothermal compression is 3.5 bar and the pressure after isentropic compression is 10.5 bar. Determine : i) Efficiency ; ii) Mean effective pressure and iii) Power developed if the Carnot engine makes 2 cycles/s. Take for air R = 0.287 kJ/kg K and γ = 1.4. **(10 Marks)**

3 a. Derive an expression for work ratio in terms of minimum and maximum cycle temperature, ratio of specific heats and pressure ratio for a simple gas turbine cycle. **(05 Marks)**

b. Write short notes on rocket propulsion. **(05 Marks)**

c. In a gas turbine plant the intake temperature and pressure are 18°C and 1 bar respectively. Air is compressed to a pressure of 4.2 bar by a compressor. The isentropic efficiency of compressor is 84%. Gas is heated to 650°C in the combustion chamber, where there is a pressure drop of 0.086 bar. The expansion of gas then occurs to atmospheric pressure in the turbine. The thermal efficiency of plant is 18%. Draw the T-S diagram and find the isentropic efficiency of the turbine. Neglect mass of fuel and take properties of gas as that of air. Take γ = 1.4 for air. **(10 Marks)**

4 a. With h – s diagram, explain the effects of the following on Rankine cycle performance :
i) Increasing the pressure of steam ; ii) Super heating of steam. **(06 Marks)**

b. Explain with T – S diagram the ideal regenerative Rankine cycle. **(05 Marks)**

c. Steam at 20 bar, 360°C is expanded in a steam turbine to a pressure of 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. Assuming the turbine and feed pump efficiencies as 60% and 90% respectively, determine per kg of steam, the net work, the heat transferred to the working fluid and the Rankine efficiency of the cycle. **(09 Marks)**

PART – B

5 a. Define the following with respect to a reciprocating air compressor :
i) Isothermal efficiency ; ii) Isentropic efficiency and iii) Mechanical efficiency. **(06 Marks)**

b. Derive an expression for volumetric efficiency of compressor in terms of clearance ratio, pressure ratio and index of compression. **(05 Marks)**

c. In a two stage reciprocating air compressor, 1.5 kg/min of air is compressed from 1 bar to 25 bar and the index of compression is 1.2. If the work of compression is minimum and the air is cooled in the intercooler so that its temperature is brought back to initial temperature of 15°C, determine : i) Heat rejected during compression ; ii) Heat rejected in the intercooler and iii) The power required to drive the compressor. Take for air C_P = 1 kJ/kg K and C_v = 0.714 kJ/kg K. **(09 Marks)**

6 a. Derive an expression for the maximum C.O.P of a vapour absorption refrigeration system in terms of generator, condenser and evaporator temperatures. **(05 Marks)**

b. With a neat diagram, explain steam jet refrigeration. **(05 Marks)**

c. A food storage locker requires a refrigeration system of 2520 kJ/min capacity at an evaporator temperature of - 8°C and a condenser temperature of 30°C. The refrigerant R – 12, is sub coded by 5°C before entering the expansion valve and the vapour is superheated to 6°C before leaving the evaporator. The compression of refrigerant is by reversible adiabatic process. A two cylinder, vertical single acting compressor with stroke equal to 1.5 times the bore is used and it runs at 900 RPM. Determine : i) Mass of refrigerant to be circulated ; ii) Theoretical power required ; iii) COP ; iv) Heat removed through condenser and v) Theoretical bore and stroke of compressor. Take the liquid refrigerant specific heat as 1.235 kJ/kg K and vapour refrigerant specific heat as 0.733 kJ/kg K. The properties of refrigerant, R – 12 are as given below :

Saturation temperature °C	Specific volume m^3/kg, v_g	Enthalpy, kJ/kg		Entropy, kJ/kg K	
		Liquid	Vapour	Liquid	Vapour
- 8	0.07313	411.30	569.81	4.1598	4.7577
30	0.02433	447.88	586.52	4.2870	4.7443

(10 Marks)

7 a. Define and then obtain an expression for the following in terms of partial pressures of water vapour and air.

i) Specific humidity ; ii) Degree of saturation. **(06 Marks)**

b. Draw the figure of a psychrometric chart showing the following processes starting from a common point '0'.

i) Sensible heating ; ii) Heating and humidifying process and iii) Cooling and humidifying process. **(06 Marks)**

c. Saturated air leaving the cooling section of an air conditioned system at 14°C DBT at a rate of 50 m^3/min is mixed adiabatically with the outside air at 32°C DBT and 60% RH at a rate of 20 m^3/min. Assuming that mixing process occurs at a pressure of 1 bar, determine the specific humidity, the RH, the DBT and the volume flow rate of mixture. **(08 Marks)**

8 a. Describe the following as applied to I.C. engines :

i) Morse test and ii) Energy balance. **(08 Marks)**

b. The following data refer to the test conducted on two stroke diesel engine, run for 20 minutes at full load. Mean effective pressure = 3 bar, speed = 350 RPM, net brake load = 650 N, fuel consumption = 1.52 kg, cooling water = 160 kg, water inlet temperature = 30°C and water outlet temperature = 52°C, air fuel ratio = 32, room temperature = 25°C, exhaust gas temperature = 300°C, cylinder bore = 200 mm, stroke = 280 mm, brake drum diameter = 100 cm, calorific valve fuel = 44000 kJ/kg, steam formed per kg of fuel in the exhaust = 1.35 kg, specific heat of steam in exhaust = 2.09 kJ/kg K, specific heat of dry exhaust gas = 1 kJ/kg K, the pressure of exhaust = 1 bar. Determine : i) Indicated power ; ii) Brake power ; iii) Mechanical efficiency and also write the energy balance on minute basis and percentage. **(12 Marks)**

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