BITS PILANI, DUBAI CAMPUS
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI, UAE
SECOND SEMESTER 2010-2011
COMPREHENSIVE EXAMINATION (Closed book)

Year : ***11***	*Date* : ***07.6.2011***	
Course No. : ***ME C211***	*Course Title* : ***Applied Thermodynamics***	
Duration : ***3 hours.***	*Max. Marks:* ***80***	*Weightage* : ***40%***

Note: (i) Answer all Question in a sequence (ii) Assume suitable value if required and clearly state them (iii) Thermodynamics tables will be provided (iv) Answer Every Question on a fresh page
*(v)**Answer in the BLUE COLOUR answer book only***

Q.1. In a constant volume 'Otto cycle', the pressure at the end of compression is **15** times that at the start, the temperature of air at the beginning of compression is 38°C and maximum temperature attained in the cycle is **1950°C**. Determine:

(i) Compression ratio (ii) Thermal efficiency of the cycle.
(iii) Work done Take **γ** for air = **1.4** and C_V **=0.717 kJ/kg-k**

[8 Marks]

Q.2 A **six** cylinder, **4**-stroke SI engine having a piston displacement of **700 cm^3** per cylinder, brake power developed **78 kW** at **3200 r.p.m** and consumed **27 kg** of petrol per hour. Air standard efficiency = **52 %**. Stroke / bore ratio=**1.25.** The calorific value of petrol is 44 MJ/kg. Take γ for air = 1.4. Estimate:

(i) Compression ratio
(ii) The volumetric efficiency of the engine if the air-fuel ratio is **12** and intake air is at **0.9 bar**, **32°C.**
(iii) The brake thermal efficiency
(iv) The brake torque
(v) Bore and stroke **[9 Marks]**

Q.3. The following data refer to a simple steam power plant:

S.No	Location	Pressure	Quality /temp	Velocity
1.	Inlet to turbine	6 MPa **(60 bar)**	**380°C**	-
2.	Exit from turbine inlet to condenser	10 kPa **(0.1bar)**	**0.9**	**200 m/s**
3.	Exit from condenser and inlet to pump	9 kPa **(0.09bar)**	Sat. Liquid	-
4.	Exit from pump and inlet to boiler	7 MPa **(70 bar)**	-	
5.	Exit from boiler	6.5 MPa **(65bar)**	**400°C**	-

Assume: Rate of steam flow=**10000 kg/h**, Specific heat of water is **4.18** kJ/kg-K

Calculate:

(i) Power output of the turbine

(ii) Heat transfer per hour in the boiler and condenser separately.

(iii) Mass of cooling water circulated per hour in the condenser. Choose the inlet temperature of cooling water **20°C** and **30°C** at exit from the condenser.

(iv) Diameter of the pipe connecting turbine with condenser. **[9 Marks]**

Q.4. A double-acting steam engine has a cylinder 200 mm bore by **300 mm** stroke and cut-off occurs at **0.4 stroke**. The admission and exhaust pressure is **7** and **0.38 bar**. If the diagram factor is **0.80**, calculate the indicated power of the engine at **200 r.p.m.**, neglecting the effect of clearance and assuming hyperbolic expansion.

If, however, clearance volume is **10%** of the swept volume, calculate the mean effective pressure, the cut-off remaining at the same point of stroke as before.

[9 Marks]

Q.5. A prime mover uses **15000 kg** of steam per hour and develops **2450 kW**. The steam is supplied at **30 bar** and **350°C**. The exhaust steam from the prime mover is condensed in the condenser at the pressure of **0.038 bar**. The condensate

temperature from the condenser is **31°C** and the rise of temperature of circulating water is from **8°C** to **18°C**. Specific heat of water is **4.18** kJ/kg-K `

Determine:

(i) The quality of steam entering the condenser,

(ii) The quantity of circulating water and the ratio of cooling.

[9 Marks]

Q.6. A F_{-12} vapour compression refrigeration system has a condensing temperature of **50°C** and evaporating temperature of **0°C**. The refrigeration capacity is **7 tons**. The liquid leaving the condenser is saturated liquid and compression is isentropic. Determine

i. The refrigeration flow rate

ii. The power required to run the compressor

iii. The heat rejected in the plant

iv. COP of the system.

v. Carnot COP

vi. Relative COP

The properties of F_{-12} as listed in the table

Temp (°C)	Pressure (bar)	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kg-K)	S_g (kJ/kg-K)
50	12.199	84.868	206.298	0.3034	0.6792
0	3.086	36.022	187.397	0.1418	0.6960

Take Enthalpy at the end of isentropic compression = **210 kJ/kg**. Assume 1 ton of TR = **3.5kW**. **[9 Marks]**

Q.7. From a given sample of atmospheric pressure of air at **30 ^{0}C** and **55 %** RH, **0.004 kg** of moisture per kg of atmospheric air is removed. After removing moisture the temperature reduced to **20 ^{0}C** and. Determine the following: (a) Relative humidity (b) Dew point temperature. **[9 Marks]**

Q.8. A gas turbine unit receives air at **1** bar and **300 K** and compresses it adiabatically to **6.2 bar**. The compressor efficiency is **88%**. The fuel has a heating value of **44186 kJ/kg** and the fuel-air ratio is **0.017 kJ /kg of air**. The turbine efficiency is **90%.** Calculate the work of turbine and compressor per kg of air compressed and thermal efficiency. Take: **γ** for products of combustion = **1.333**, **γ** for air = **1.4**, Specific heat of air $\mathbf{C_p}$ **= 1.005 kJ/kg k**, Specific heat for products of combustion $\mathbf{C_{pg}}$ **= 1.147 kJ/kg k.** **[9 Marks]**

Q.9. Following data relate to a performance test of a single-acting reciprocating compressor, having bore diameter **14 cm** and stroke **10 cm**.

Suction pressure	= 1 bar
Suction temperature	= 20°C
Discharge pressure	= 6 bar
Discharge temperature	= 180°C
Speed of compressor	= 1200 r.p.m.
Brake power	= 6.25 kW
Mass of air delivered	= 1,7 kg / min

Calculate the following

(i) The actual volumetric efficiency

(ii) The indicated power

(iii) The isothermal efficiency

(iv) The mechanical efficiency

(v) The overall isothermal efficiency.

Take **R** for air = **0.287 kJ/kgk** and Polytropic Index **'n'** = **1.32** **[9 Marks]**

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BITS, Pilani –Dubai

Dubai International Academic City, Dubai, U.A.E

II Year II Semester 2010-2011 [Mechanical]

Test No.2 (Open Book)

Course No. ME C 211 **Course Title:** Applied Thermodynamics **Weightage:** 20%

Date: 01-05-2011 **Max.Marks:** 20 **Duration:** 50 min.

Notes:

- *Answer all the questions*
- *Draw neat sketches wherever necessary*
- *Make suitable assumptions if required and clearly state them*

Q.1. A steam turbine develops **3000 kW** when the steam is supplied at **10** bar and **250 ^{0}C.** It then enters a condenser maintained at **0.13 bar**, where it is condensed to saturated liquid water. Choose the inlet temperature of cooling water **20 ^{0}C and 30 ^{0}C** at exit from the condenser. Neglect pump work. Determine:

[a] The dryness at the end of expansion [b] Specific steam consumption of the plant [c] The Rankine efficiency of the plant [d] Quantity of cooling water circulated through the condenser per hour. Take Specific heat of water **4.2 kJ /kg-K.** [6 M]

Q.2. The following readings were taken during the test at full load on a single-cylinder; double-acting condensing type throttle governed steam engine:

- Diameter of the cylinder :400 mm
- Stroke of the engine :600mm
- Cut-off :50 % of stroke
- Pressure of steam supplied :11 bar
- Back pressure :0.8 bar
- Speed of the engine :150 rpm
- Diagram factor :0.82
- Mechanical efficiency of full load :65.8%

(i) Find the indicated power and Brake power at full load.

(ii) If the load on the brake power is reduced to 50 % of the full load, find the Indicated power and admission of steam pressure into the cylinder. Assume the mechanical efficiency at reduced load is 46 %. [7 M]

Q.3. An ammonia ice plant operates between condenser temperature of **35 ^{0}C** and an evaporator temperature of - **15 ^{0}C.** It produces **5 tons** of ice per day from at **-5 ^{0}C**. The NH_3 enters the compressor as superheated vapour and leaves the condenser as saturated liquid. Assuming isentropic compression,

Determine: (i) The capacity of the refrigerating plant (ii) Mass flow of the refrigerant (iii) Discharge temperature of $NH_3$from the compressor (iv) Power of the compressor motor if the isentropic efficiency of the compressor is **85 %** and mechanical efficiency of the compressor is **90 %** (v) Relative efficiency.

Take: latent heat of ice = **335 kJ /kg**.

Specific heat of ice = **1.94 kJ /kg-k**

1TR is equivalent to **210 kJ / min** (or) **3.5 kW**

Use the following properties of **NH_3**.

Temperature ^{0}C	**Enthalpy (KJ / kg)**		**Entropy (KJ / kg-K)**		**Specific Heat (KJ / kg-K)**	
	h_f	**h_g**	**s_f**	**s_g**	**Liquid, C_{pf}**	**Vapour, C_{pg}**
- 15	112.3	1426	0.457	5.549	-	-
35	347.5	1471	1.282	4.930	4.6	2.8

[7 M]

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Dubai International Academic City, Dubai, U.A.E

II Year II Semester 2010-2011 [Mechanical]

Test No.1 (Closed Book)

Course No. ME C 211 **Course Title:** Applied Thermodynamics **Weightage:** 25%

Date: 10-03-2011 **Max.Marks:** 25 **Duration:** 50 min.

Notes:

- *Answer all the questions*
- *Draw neat sketches wherever necessary*
- *Make suitable assumptions if required and clearly state them*

Q.1. Briefly explain with neat sketch about crankcase scavenged two stroke engine? [5 M]

Q.2. In an air standard Diesel cycle, compression begins at **1 bar** and **300 ^{0}K**. The compression ratio is 16. Heat added per kg of air of **1000 kJ /kg**. Determine:

(i) Fuel cut off ratio (ii) Pressure and Temperature at the end of expansion

(iii) Thermal efficiency (iv) Mean effective pressure

Take **R = 0.286 kJ /kg-K** and C_P = **1.0 kJ /kg-K** [10 M]

Q.3. A test on single cylinder, 4-stroke oil engine, having bore **180 mm** and stroke **360 mm** gave the following results: Speed **290 rpm**, Brake torque **392 N-m**, Indicated mean effective pressure **7.2 bar**, oil consumption **3.5 kg / hour**, Cooling water flow **270 kg / hour** Cooling water temperature rise **36 ^{0}C**, air fuel ratio by weight **25**, exhaust gas temperature **415 ^{0}C**, Specific heat of exhaust gases **1.005 kJ /kg-K** Atmospheric pressure **1.013 bar**, Room temperature **21 ^{0}C**. Specific heat of water **4.2 kJ /kg-K,** The fuel has calorific value of **45,200 kJ /kg**.

Calculate: (a) The indicated thermal efficiency (b) The volumetric efficiency based on atmospheric condition (c) Brake power (d) Heat carried away by the cooling water (e) Heat carried away by the exhaust gas [10 M]

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BITS, Pilani –Dubai

PART-A

Dubai International Academic City, Dubai, U.A.E

II Year II Semester 2010-2011 [Mechanical]

Quiz.2 (Closed Book)

Course No. ME C 211 **Course Title:** Applied Thermodynamics **Weightage:** 7 %

Date: 17-05-2011 **Max.Marks:** 14 **Duration:** 20 min.

STUDENT NAME:----------I.D No:----------

Q.No	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Answer														

14 X 0.5 = 14 Marks

1. Function of D-slide valve in a steam engine is

   a) to guide motion of the piston rod and prevent it from bending
   b) to transfer motion from to piston to the crosshead
   c) to convert heat energy of the steam into mechanical work
   d) to exhaust steam from the cylinder at proper moment

2. Ratio of clearance volume to the swept volume is called

   a) cut-off ratio b) expansion ratio c) clearance ratio d) none of the above

3. Diagram factor is the ratio of

   a) area of the actual indictor diagram to the area of theoretical indicator diagram
   b) actual work done per stroke to the theoretical work done per stroke
   c) actual mean effective pressure to the theoretical mean effective pressure
   d) all of the above

4. By compounding the expansion of steam in two or more cylinders, the ratio of expansion
   a) decreases b) increases c) does not change d) none of the above

5. Throttle governing of steam engines is a method of controlling the engine output by varying
   a) volume of intake steam b) pressure of intake steam
   c) temperature of intake steam d) all of the above

6. Steam pressure in the engine cylinder as compared its atmospheric pressure is kept
   a) same b) below c) above d) none of the above

7. The steam is admitted on one side of the piston and one working stroke is produced during it revolution of the crank shaft, in

a) single acting steam engine b) double acting steam engine
c) reciprocating steam engine d) none of the above

8. In single acting steam engine, the number of working stokes per revolutions are

a) three b) two c) one d) four

9. The steam acts on one side of the piston in

a) single acting steam engine b) double acting steam engine

c) triple acting steam engine d) none of the above

10. The steam acts in both sides of the piston in

a) single acting steam engine b) double acting steam engine

c) triple acting steam engine d) none of the above

11. Ratio of the swept volume to the volume at cut-off, is known as

a) compression ratio b) clearance ratio

c) cut-off ratio d) expansion ratio

12. The actual power supplied by the engine crank shaft, is known as

a) Indicated horse power b) brake horse power

c) fractional horse power d)one boiler horse power

13. Willian's law states that, the rate of steam consumption of a steam engine provided with throttled governor is proportional to the

a) indicated horse power

b) square of indicated horse power

c)reciprocal of indicated horse power

d) reciprocal of square of indicated horse power

14. Willian's line for the steam engine is a straight line relationship between the steam consumption per hour and

a) steam pressure b)brake horse power

c) fractional horse power d) indicated horse power

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PART-B

BITS, Pilani –Dubai

Dubai International Academic City, Dubai, U.A.E

II Year II Semester 2010-2011 [Mechanical]

Quiz.1 (Closed Book)

Course No. ME C 211 **Course Title:** Applied Thermodynamics **Weightage:** 8 %

Date: 05-04-2011 **Max.Marks:** 8 **Duration:** 20 min.

STUDENT NAME:----------I.D No:----------

Q.No	1	2	3	4	5	6	7	8
Answer								

8 X 1 = 8 Marks

Q.1. Rankine cycle comprises of _____

(a) Two isentropic processes and two constant volume processes

(b) Two isentropic processes and two constant pressure processes

(c) Two isothermal processes and two constant pressure processes

(d) None of the above

Q.2 In Rankine cycle the work output from the turbine is given by

(a) Change of Internal energy between inlet and outlet

(b) Change of enthalpy between inlet and outlet

(c) Change of entropy between inlet and outlet

(d) Change of temperature between inlet and outlet

Q.3 In Rankine cycle efficiency of a good steam power plant may be in the range of

(a) 15 to 20 % (b) 35 to 45 % (c) 70 to 80 % (d) 90 to 95 %

Q.4. The adiabatic enthalpy drop across the primemover of the Rankine cycle is 840 kJ/kg. The enthalpy of steam supplied is 2940 kJ/kg. If the enthalpy of exhaust steam is 191.8 kJ/kg find the thermal efficiency. [Note: No Multiple Choice and solve the problem]

Q.5. In a steam engine D-slide valve controls the flow of steam into and out of the steam engine cylinder

a) Through one admission port and two exhaust ports

(b) Through one admission port and one exhaust port

(c) Through one exhaust port and two admission ports

(d) Through two exhaust ports and two admission ports

Q.6. For a steam engine the 'diagram factor' is defind

a) area of hypothetical indicator diagram X area of actual indicator diagram

(b) area of actual indicator diagram / area of hypothetical indicator diagram

(c) area of hypothetical indicator diagram / area of actual indicator diagram

(d) None of the above

Q.7 In a double-acting steam engine, stroke and cut-off occurs at 0.4 stroke. The admission and exhaust pressure are 7 bar and 0.38 bar. If the diagram factor is 0.8, calculate the actual mean effective pressure. [Note: No Multiple Choice and solve the problem]