BITS, PILANI – DUBAI
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
II Year II Semester : 2008 - 2009
Course: ME C 211 Applied Thermodynamics
Comprehensive Examination [Closed Book]

Max.Marks: 80 | **Section VI - Mechanical** | **Date: 20-05-2009**
Weightage: 40 % | **Time: 3 hours**

*Note: (i) Answer all Question in a sequence (ii) Assume suitable value if required and clearly state them (iii) Thermodynamics tables are permitted (iv) Answer in the **BLUE COLOUR** main answer book only*

Q.1. For an engine working on the ideal Dual cycle, the compression ratio is **10** and the maximum pressure is limited to **70 bar**. If the heat supplied is **1680 kJ /kg**, find the pressures and temperatures at the various salient points of the cycle and the cycle efficiency. The pressure and temperature of air at the commencement of compression are **1** bar and **100 ^{0}C** respectively. Assume C_p = **1.004 kJ /kg-K** and C_v = **0.717 kJ /kg-K** for air. **[10 Marks]**

Q.2. A **one-litre** cubic capacity, four-cylinder, four-stroke SI engine has a compression ratio of **8** and bore of **100 mm**, with stroke equal to the bore. The volumetric efficiency of each cylinder is equal to **75 %**. The engine operates at a speed of **4800 rpm** with an air-fuel ratio **15**. Given that the calorific value of fuel = **42 MJ / kg**, atmospheric density = **1.12 kg / m^3**, mean effective pressure in the cylinder = **10 bar** and mechanical efficiency = **80 %**, determine the clearance volume of the engine, indicated thermal efficiency and brake power. **[10 Marks]**

Q.3. In a steam power cycle, the steam supply is at **15 bar** and dry and saturated **(X = 100%)** is expanded to **0.4 bar**. Assume ideal processes, Calculate the Rankine efficiency of the cycle. Neglect pump work. **[7 Marks]**

Q.4. A single-cylinder double-acting steam engine runs at **250 rpm** and indicated power is **30 kW** with cut-off at **40 %** of stroke. The pressure limits of operation are **10** bar and **1** bar. The **L / D** ratio is **1.25** and the diagram factor is **0.75**. Assume dry saturated steam at inlet hyperbolic expansion and negligible effect of piston rod. Find (i) mean effective pressure(ii)cylinder dimensions and (iii)indicated thermal efficiency. **[10 Marks]**

Q.5. The LDO oil is to be cooled by water in a surface condenser. The oil flows steadily through a bundle of metal tubes submerged **90 ^{0}C** and leaves at **30 ^{0}C**. The cooling water enters at **25 ^{0}C** and leave at **70 ^{0}C**. The enthalpy of oil at **t ^{0}C** is given by **$h = 1.68\ t + 10.5 \times 10^{-4}\ t^2$ kJ / kg.** What is the cooling water flow required for cooling **2.78 kg/s** of oil? Neglect the sp.heat for oil. Take sp heat of H_2O= **4.187 kJ / kg-K**

[8 Marks]

Q.6. The sling psychrometer in a laboratory test recorded the following readings; Dry bulb temperature = **35 ^{0}C,** wet bulb temperature = **25 ^{0}C,**Take atmospheric pressure = **1.0132 bar**. Calculate (i) specific humidity (ii) relative humidity (iii) vapour density in air (iv) dew point temperature (v) enthalpy of mixture per kg of dry air. **[6 Marks]**

Q.7. In an air-standard regenerative gas turbine cycle the pressure ratio is 5. Air enters the compressor at **1** bar, **300K** and leaves at **490K**. The maximum temperature in the cycle is **1000K**. Calculate the cycle efficiency, given that the efficiency of the regenerator and the adiabatic efficiency of the turbine are each **80 %**. Assume for air, the ratio of specific heats is **1.4**. Also show the cycle in T-S diagram. **[10 Marks]**

Q.8. **F-12** vapour compression refrigeration cycle operating between an evaporator temperature of **-10^{0}C** and a condenser temperature of **40^{0}C.** The compressor employed is of **20 cm** diameter and **15 cm** stroke, twin cylinder, single acting compressor having a volumetric efficiency of **85 %** and runs at **500 RPM**. Take enthalpy at the end of compression is **220 kJ / kg,** the ambient temperature is **37 ^{0}C,** specific volume of the refrigerant at the compressor inlet **0.08 m^3 / kg.** Calculate: (a) the amount of refrigerant circulated per minute (b) cooling capacity in **TR** (c) compressor power (d) COP of the system (e) carnot COP and (f) relative COP. Assume **1 TR = 14000 kJ / hr.** Use the properties of **F-12** as listed below: **[10 Marks]**

T (^{0}C)	P(Mpa)	h_f (kJ/kg)	h_g (kJ/kg)
- 10	0.2191	26.85	183.1
40	0.9607	74.53	203.1

Q.9. **[a]** Explain the effect of area change in subsonic and supersonic flows with sketch**[5M]**

Q.10. **[b]** Draw the single stage reciprocating compressor on p-V diagram and indicate various salient points of the cycle. **[4 Marks]**

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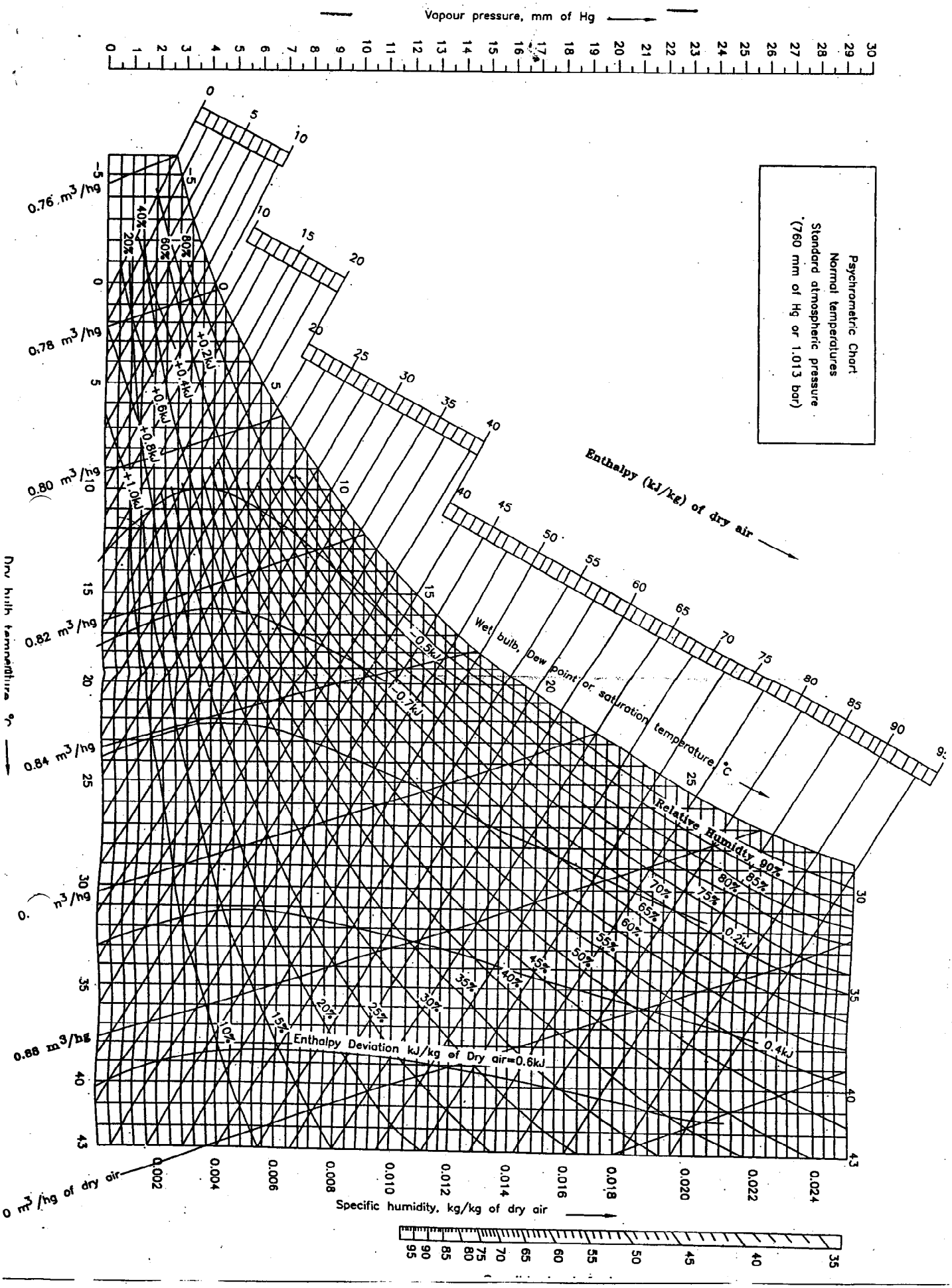
Psychrometric Chart
Normal temperatures
Standard atmospheric pressure
(760 mm of Hg or 1.013 bar)
Vapour pressure, mm of Hg
Enthalpy (kJ/kg) of dry air
Wet bulb, Dew point or saturation temperature °C
Relative Humidity 90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
Enthalpy Deviation kJ/kg of Dry air=0.6kJ
0.2kJ
0.4kJ
-0.5kJ
-0.7kJ
+0.2kJ
+0.4kJ
+0.6kJ
+0.8kJ
+1.0kJ
0.76 m³/kg
0.78 m³/kg
0.80 m³/kg
0.82 m³/kg
0.84 m³/kg
0.88 m³/kg
0 m³/kg of dry air
Dry bulb temperature °C
Specific humidity, kg/kg of dry air

BITS, Pilani –Dubai

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

II Year II Semester 2008-2009 [Mechanical]

Test No.2 (Open Book)

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

Date: 30 -04-2009 **Max.Marks:** 20 **Duration:** 50 min.

Notes:

- Answer all the questions
- Draw neat sketches wherever necessary
- Thermodynamics Tables are permitted.
- Make suitable assumptions if required and clearly state them

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Q.1. An ammonia refrigerator produces **20** tons of ice per day from and at 0^0C. The condensation and evaporation takes at **20^0C** and - **20^0C** respectively. The temperature of vapour at the end of isentropic compression is **50 ^{0}C** and there is no under cooling of liquid. The actual **COP** is **70 %** of the theoretical COP. Use the properties of NH_3 as listed below:

Temperature ^{0}C	**Enthalpy (KJ / kg)**		**Entropy (KJ / kg-K)**	
	h_f	h_g	s_f	s_g
20	274.98	1461.58	1.04341	5.0919
-20	89.72	1419.05	0.3682	5.6204

Take: (i) The relation of enthalpy for super heated vapour is $\mathbf{h = h_g + c_p (T_2 - T_1)}$ (ii) Specific heat for superheated vapour = **2.8 kJ/ Kg-k,** (iii) specific volume of the dry vapour of the refrigerant at the compressor inlet **(v) = 0.624 m^3 / kg**, (vi) The fusion of ice = **335 kJ / Kg.**

Determine: [a] The refrigerating capacity of the plant [b] Power required to drive the compressor [c] The mass flow rate of NH_3circulation [d] The cylinder dimensions of the single-acting compressor if the speed is **240 RPM**, assuming L = D and volumetric efficiency is **80 %.** **[7 Marks]**

Q.2. A single-cylinder double-acting steam engine with **15 cm** bore and **20 cm** stroke is developed **20 kW** at **300 rpm** with cut-off occurring at **20 %** of stroke. Back pressure is of the steam is **0.28** bar. Determine admission of the steam if diagram factor is **0.72**. Also calculate mass flow rate of steam and indicated thermal efficiency. Assume dry saturated steam at inlet hyperbolic expansion and negligible of area of the piston rod. **[7 Marks]**

Q.3. Refrigerant-134 a is to be cooled by water in a surface condenser. The refrigerant enters the condenser with mass flow rate of **6 kg / min** at **1 MPa** and **70 ^{0}C** and leaves at **35 ^{0}C**. The cooling water enters at **15 ^{0}C** and leave at **25 ^{0}C**. Neglect the specific heat of both fluid.

Calculate:

(i) Mass flow rate of cooling water required

(ii) Heat transfer rate from the refrigerant to water. **[6 Marks]**

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BITS, Pilani –Dubai

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

II Year II Semester 2008-2009 [Mechanical]

Test No.1 (Closed Book)

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

Date: 22-03-2009 **Max.Marks:** 25 **Duration:** 50 min.

Notes:

- Answer all the questions
- Draw neat sketches wherever necessary
- Thermodynamics Tables are permitted.
- Make suitable assumptions if required and clearly state them

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Q.1. What is meant by crankcase scavenged two stroke engine? **[3M]**

Q.2. A single- cylinder, four-stroke hydrogen fuelled spark-ignition engine delivers a brake power of 20 kW at 6000 rpm. The air-gas ratio is 8:1 and the calorific value of fuel is 11000 kJ /m^3. If volumetric efficiency is 70 %, Indicated efficiency is 33 %, and the mechanical efficiency is 90 %, calculate the cubic capacity of the engine. **[7M]**

Q.3. Draw the p-V diagram of a Dual cycle and mark the various processes. Why this cycle is also called limited pressure or mixed cycle? **[4M]**

Q.4. Determine the ideal efficiency of the diesel engine having a cylinder with bore 250 mm, stroke 375 mm and clearance volume of 1500 cc, with fuel cut-off occurring at 5 % of the stroke. Assume $\gamma = 1.4$ for air. **[6M]**

Q.5. A Steam turbine receives steam at a pressure of 1 MPa and temperature of 300 ^{0}C. The saturated steam leaves the turbine at a pressure of 15 kPa. The actual work output of the turbine is measured and is found to be 600 KJ / kg of steam flowing through the turbine. Determine the isentropic efficiency of the turbine. **[5M]**

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BITS, PILANI-DUBAI
Dubai International Academic City, Dubai
IInd Sem 2008-09

Subject: Applied Thermodynamics **Course No: ME C 211**

DATE: 4 / 0 5 / 09...

Duration: 15 Min **Max. Marks: 5**

Name of the student: ---------- **I.D.: ----------**

QUIZ III- QUESTION

aQ	1	2	3	4	5	6	7	8	9	10
Ans										

1. A single cylinder, double acting steam engine is required boiler inlet pressure is 1.25 MN/m^2, compression ratio is 3.33 and back pressure is 0.13 MN / m^2. Find the mean effective pressure.

[A] 700 kN / m^2 [B] 695 kN / m^2 [C] 699 kN / m^2 [D] 697 kN / m^2

2. 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 ports [C] Through one exhaust port and two admission ports

[D] Through two exhaust port and two admission ports

3. A single-cylinder double-acting steam engine with **15 cm** bore, **20 cm** stroke, at **300 rpm** with cut-off ratio 5. Calculate mass flow rate of steam. Assume specific volume of the dry saturated steam at inlet is 0.194 m^3 /kg.

[A] 0.16 3 kg/s [B] 0.12 3 kg/s [C] 0.14 3 kg/s [D] 0.15 3 kg/s

4. The COP for a carnot refrigerator is _____ than that of carnot heat pump.

[A] Less [B] More [C] One-third less [D] One-third more

5. A carnot refrigerator requires 1.3 kW per tonne of refrigeration to maintain a region at low temperature of – 38 °C. Calculate the maximum temperature of the cycle. Assume on tonne of refrigeration is 14000kJ/h

[A] 43 °C [B] 44 °C [C] 42 °C [D] 40 °C

6. Refrigerating system operates on the reversed carnot cycle. The higher temperature of the refrigerant in the system is 35 °C and the lower temperature is - 15 °C, the capacity is to be 12 tonnes. Assume on tonne of refrigeration is 14000 kJ/h. Find work input.

[A] 33558 kJ/h [B] 34558 kJ/h [C] 32558 kJ/h [D] 31558 kJ/h

7. In steam power plant, the function of a condensor is _____

[A] To maintain pressure below atmospheric to increase work output from the prime mover [B] To receive large volume of steam exhausted from steam prime mover

[C] To condense large volume of steam to water which may be used again in boiler

[D] All of the above

8. In Jet type condensers

[A] Cooling water passes through tubes and steam surrounds them

[B] Steam passes through tubes and cooling water surrounds them [C] Cooling water and steam mix [D] cooling water and steam do not mix

9. The outlet and inlet temperatures of cooling water to a condenser are 37.5 °C and 30 °C respectively. The saturation steam temperature is 40 °C. Find out the condenser efficiency.

[A] 75.3 % [B] 75.1 % [C] 75.2 % [D] 75 %

10. In a surface condenser if air is removed, there is

[A] fall in absolute pressure maintained in condenser [B] Rise in absolute pressure maintained in condenser [C] No change in absolute pressure maintained in condenser

[D] Rise in temperature of condensed steam

**********a

BITS, PILANI-DUBAI
Dubai International Academic City, Dubai
IInd Sem 2008-09

Subject: Applied Thermodynamics **Course No: ME C 211**

DATE: 4 / 05 / 09...

Duration: 15 Min QUESTION **Max. Marks: 5**

Name of the student: ---------- **I.D.: ----------**

QUIZ II

bQ	1	2	3	4	5	6	7	8	9	10
Ans										

1. 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 ports [C] Through one exhaust port and two admission ports

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2. The COP for a carnot refrigerator is _____than that of carnot heat pump.

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[A] 700 kN / m^2 [B] 695 kN / m^2 [C] 699 kN / m^2 [D] 697 kN / m^2

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8. A carnot refrigerator requires 1.3 kW per tonne of refrigeration to maintain a region at low temperature of – 38 °C. Calculate the maximum temperature of the cycle. Assume on tonne of refrigeration is 14000kJ/h

[A] 43 °C [B] 44 °C [C] 42 °C [D] 40 °C

9. In steam power plant, the function of a condensor is _____

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[C] To condense large volume of steam to water which may be used again in boiler
[D] All of the above

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[A] 75.3 % [B] 75.1 % [C] 75.2 % [D] 75 %

**********b

BITS, PILANI-DUBAI
Dubai International Academic City, Dubai
IInd Sem 2008-09

Subject: Applied Thermodynamics **Course No: ME C 211**

DATE: 25/ 03 / 09...

Duration: 15 Min **Max. Marks: 5**

Name of the student: ---------- Question ---------- **I.D.:** ----------

QUIZ II

cQ	1	2	3	4	5	6	7	8	9	10
Ans										

1. In Rankine cycle the work output from the turbine is given by_____

[A] Change in internal energy between inlet and outlet

[B] Change of entropy between inlet and outlet

[C] Change of temperature between inlet and outlet

[D] Change in enthalpy between inlet and outlet

2. In an otto cycle, Pressure at the beginning of compression is 1 bar at the end of compression is 11 bar. Calculate the air-standard efficiency of the engine. Assume $\gamma = 1.4$

[A] 50.6 % [B] 49.6 % [C] 48.6 % [D] 47.6 %

3. For an engine working on the ideal dual cycle, the compression ratio is 10 and clearance volume 0.2 cc. Find the Swept Volume.

[A] 1.9 cc [B] 1.8 cc [C] 1.7 cc [D] 1.6 cc

4. A four cylinder, four stroke SI engine has compression ratio is 10. Efficiency and power of the engine is 60.2 % and 40 kW respectively. Find out the heat supplied to the engine. Assume $\gamma = 1.4$.

[A] 65.5 kJ/s [B] 66.5 kJ/s [C] 67.5 kJ/s [D] 68.5 kJ/s

5. In steam power plant power output from the turbine is 1665 kW and pump work is 15 kW. Heat input to the plant is 3000 kW. Find the efficiency of the power plant.

[A] 55 % [B] 56 % [C] 54 % [D] 53 %

6. The air standard Otto cycle consists of_____

[A] Two constant volume and two isentropic processes

[B] Two constant pressure and two isentropic processes

[C] Two constant pressure and two constant volume processes

[D] Two isothermal and two adiabatic process_____

7. For given compression ratio the work output of Otto cycle is

[A] Increase with increase 'r' [B] Decrease with increase 'r' [C] is not affected

[D] None of the above

8. For the same compression ratio and heat addition _____

[A] $\eta_{Otto} > \eta_{Diesel} > \eta_{Dual}$ [B] $\eta_{Diesel} > \eta_{Otto} > \eta_{Dual}$ [C] $\eta_{Otto} > \eta_{Dual} > \eta_{Diesel}$

[D] $\eta_{Dual} > \eta_{Diesel} > \eta_{Otto}$ I.

9. The air standard Diesel cycle consists of_____

[A] Two constant volume and two isentropic processes

[B] Two constant pressure and one isentropic processes and one constant volume

[C] Two isentropic processes one constant volume and one constant pressure.

[D] Two isothermal and two adiabatic process_____

10. Rankine cycle efficiency of a good steam power plant may be in the range of

[A] 15 to 20 % [B] 70 – 80 % [C] 90 – 95 %

[D] 35 – 45 %

**********C

BITS, PILANI-DUBAI
Dubai International Academic City, Dubai
IInd Sem 2008-09

Subject: Applied Thermodynamics Question 4. **Course No: ME C 211**

Duration: 15 Min **DATE: 25/ 02 / 09...**

Max. Marks: 5

Name of the student: ---------- **I.D.: ----------**

QUIZ I

Q	1	2	3	4	5	6	7	8	9	10

1. Gudgeon pin forms the link between

   [A] Piston and big end of connecting rod **[B]** Piston and small end of connecting rod **[C]** Connecting rod and crank **[D]** Big end and small end

2. The range of volumetric efficiency of diesel engine is _____

   [A] 65 – 75 % **[B]** 75 – 85 % **[C]** 85 – 90 % **[D]** 90 – 95 %

3. Relative efficiency is the ratio of
   a) $\frac{\text{Actual thermal efficiency}}{\text{Mechanical efficiency}}$
   b) $\frac{\text{Actual thermal efficiency}}{\text{Air-Standard efficiency}}$
   c) $\frac{\text{Air-standard efficiency}}{\text{Actual thermal efficiency}}$
   d) $\frac{\text{Indicated thermal efficiency}}{\text{Actual thermal efficiency}}$

4. Equivalence ratio is

   [A] Actual fuel-air ratio / Stoichiometric fuel-air ratio

   [B] Stoichiometric fuel-air ratio / Actual fuel-air ratio

   [C] Theoretical fuel-air ratio / Stoichiometric fuel-air ratio

   [D] Stoichiometric fuel-air ratio / Theoretical fuel-air ratio

5. The stroke to bore ratio, where d > L is_____

[A] Square engine **[B]** Medium Square engine **[C]** Under square- engine **[D]** Over Square- engine

6. The mechanical efficiency of a single cylinder 4 stroke engine is 80 %. The frictional power is estimated to be 25 kW. Calculate the indicated power.

[A] 120 kW **[B]** 130 kW **[C]** 121 kW **[D]** 125 kW

7. A four stroke engine brake thermal efficiency is 24.96 % with running at a fixed speed. The fuel consumption rate is 20 kg / h. Find out the brake power. Assume CV = 42000 kJ / kg.

[A] 58 kW **[B]** 60 kW **[C]** 56 kW **[D]** 57 Kw

8. In a 4 cylinder, 4 stroke hydrogen fuelled SI engine, the actual volume of air inducted in to cylinder is 1105.44 cc with volumetric efficiency of 70 %. Calculate the cubic capacity of the engine.

[A] 6314.8 cc **[B]** 6318.8 cc **[C]** 6320 .8 cc **[D]** 6316.8 cc

9. A 4 stroke SI engine at full load delivers 50 kW with brake thermal efficiency of 25 %. Find out volume flow rate of fuel. Assume CV of fuel 42000 kJ / kg, and specifi gravity of petrol is 0.75.

[A] 5.34×10^{-6} m^3/s **[B]** 7.34×10^{-6} m^3/s **[C]** 6.34×10^{-6} m^3/s **[D]** 8.34×10^{-6} m^3/s

10. A 4 stroke four cylinder diesel engine running at 2000 rpm. The piston stroke length is 100 mm. Find the piston speed.

[A] 5.67 m/s **[B]** 6.00 m/s **[C]** 6.67 m/s **[D]** 5.99 m/s

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