BITS, PILANI – DUBAI
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
II Year II Semester : 2009 - 2010
Course: ME C 211 Applied Thermodynamics
Comprehensive Examination [Closed Book]

Max.Marks: 40 | **Date: 25-05-2010**
Weightage: 40 % | **Sec: VII and VIII - Mechanical** | **Time: 3 hours**

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 main answer book only

Q.1. The volume ratios of compression and expansion for a diesel engine as measured from an indicator diagram are **15.3** and **7.5** respectively. The pressure and temperature at beginning of the compression are **1 bar** and **27 ^{0}C.** The volume at the end of the compression is **1 m^3**.

Assuming an ideal engine, determine the mean effective pressure, the ratio of maximum pressure to mean effective pressure and cycle efficiency.

Also find the fuel consumption per kWh if the indicated thermal efficiency is **0.5** of ideal efficiency, mechanical efficiency is **0.8** and the calorific value of oil **42000 kJ / kg**.

Take for air: **c_p = 1.005 kJ / kg-K; c_v = 0.718 kJ / kg-K; γ = 1.4** **[5 Marks]**

Q.2. Following data relate to **4**-cylinder, **4**-stroke petrol engine. Air-fuel ratio by weight = **16:1,** calorific value of the fuel = **45200 kJ / kg,** mechanical efficiency= **82%**, air-standard efficiency= **52%**, relative efficiency = **70 %**, volumetric efficiency = 78 %, stroke / bore ratio = 1.25, suction condition = **1 bar** & **25 ^{0}C,** RPM = **2400** and brake power = **72 kW.** Assume for air **R = 287** J /kg-K. Calculate: (i) Compression ratio (ii) Indicated thermal efficiency (iii) Brake specific fuel consumption (iv) Bore and stroke **[5 Marks]**

Q.3. The enthalpy of steam supplied to a turbine of a power plant is **3200 kJ / kg** and enthalpy of steam leaving the turbine is **2500 kJ / kg**. If the temperature of saturated condensate is **50^{0}C,** find (i) Rankine efficiency and (ii) specific steam consumption

(b) If the highest temperature of steam supplied in the above power plant is **400 ^{0}C**, what would be the maximum possible efficiency of the plant?

(c) If the mass flow rate of steam supplied in the above power plant is **1 kg / sec,** find (i) Power developed by the turbine (ii) heat transfer in the condenser (iii) work required for the feed pump if the boiler pressure is **10 bar** (iv) Heat supplied in the boiler **[5 Marks]**

Q.4. The following data refer to a single cylinder double-acting condensing type steam engine. Diameter of the cylinder = **0.24 m**, speed of engine = **200 RPM**, admission steam pressure = **10 bar**, back pressure = **0.35 bar**, quality of steam supplied = **0.94** dry, cut off = **40 %** of the stroke, steam consumption = **750 kg/hr**, mechanical efficiency = **80 %**, and diagram factor **0.9**, find (i) Indicated power and brake thermal efficiency. Assume that the mean effective pressure for cover and crank end are same and neglect the area of piston rod. **[5 Marks]**

Q.5. In a surface condensating plant following data were obtained:
Temperature of exhaust steam entering the condenser=**42.32^{0}C**, temperature of condensate leaving the condenser=**35^{0}C**, Inlet temperature of cooling water=**16.5^{0}C**, Outlet temperature of cooling water=**30^{0}C**, Quantity of water / hour=**46250kg**, Quantity of condensate/ hour=**1190kg**, Take specific heat for water = **4.187 kJ/ Kg-k,** calculate the dryness fraction of steam entering the condenser. **[3 Marks]**

Q.6. An ammonia refrigerator produces **20** tons of ice per day from and at 0^{0}C. The condensation and evaporation takes at **20^{0}C** and **- 20^{0}C** 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. (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.**

Use the properties of NH_3 as listed below: Take:

Temperature ^0C	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

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 %**. **[5 Marks]**

Q.7. From a given sample of atmospheric air at **35 ^{0}C** and **60 %** RH, **7.8 gram** of moisture per kg removed. After removing moisture the temperature reduced to **22 ^{0}C** and. Determine the following: (a) Relative humidity (b) Dew point temperature. **[3 Marks]**

Q.8. A gas turbine unit has a pressure ratio of **6:1** and maximum cycle temperature of **610 ^{0}C.** The isentropic efficiencies of the compressor and turbine are **0.80** and **0.82** respectively. Calculate the power output in kilowatts of an electric generator geared to the turbine when the air enters the compressor at **15 ^{0}C** at the rate of **16 kg / sec.** Take for air: **c_p = 1.005 kJ / kg-K; c_v = 1.11 kJ / kg-K; γ = 1.33** **[5 Marks]**

Q.9. Actual volume of air taken in at **0.98** bar and **27 ^{0}C** by a single stage, single acting reciprocating air compressor is **8.5 m^3 / min.** The delivery conditions are **6.5 bar**. The clearances volume is 5 % of stroke volume, compression and expansion follows **$pv^{1.3}$=C**. If the speed is **300rpm**, **L/D** ratio is **1.1**. Find the cylinder dimensions by finding the volumetric efficiency required to run the compressor. Also find indicated power. **[4 Marks]**

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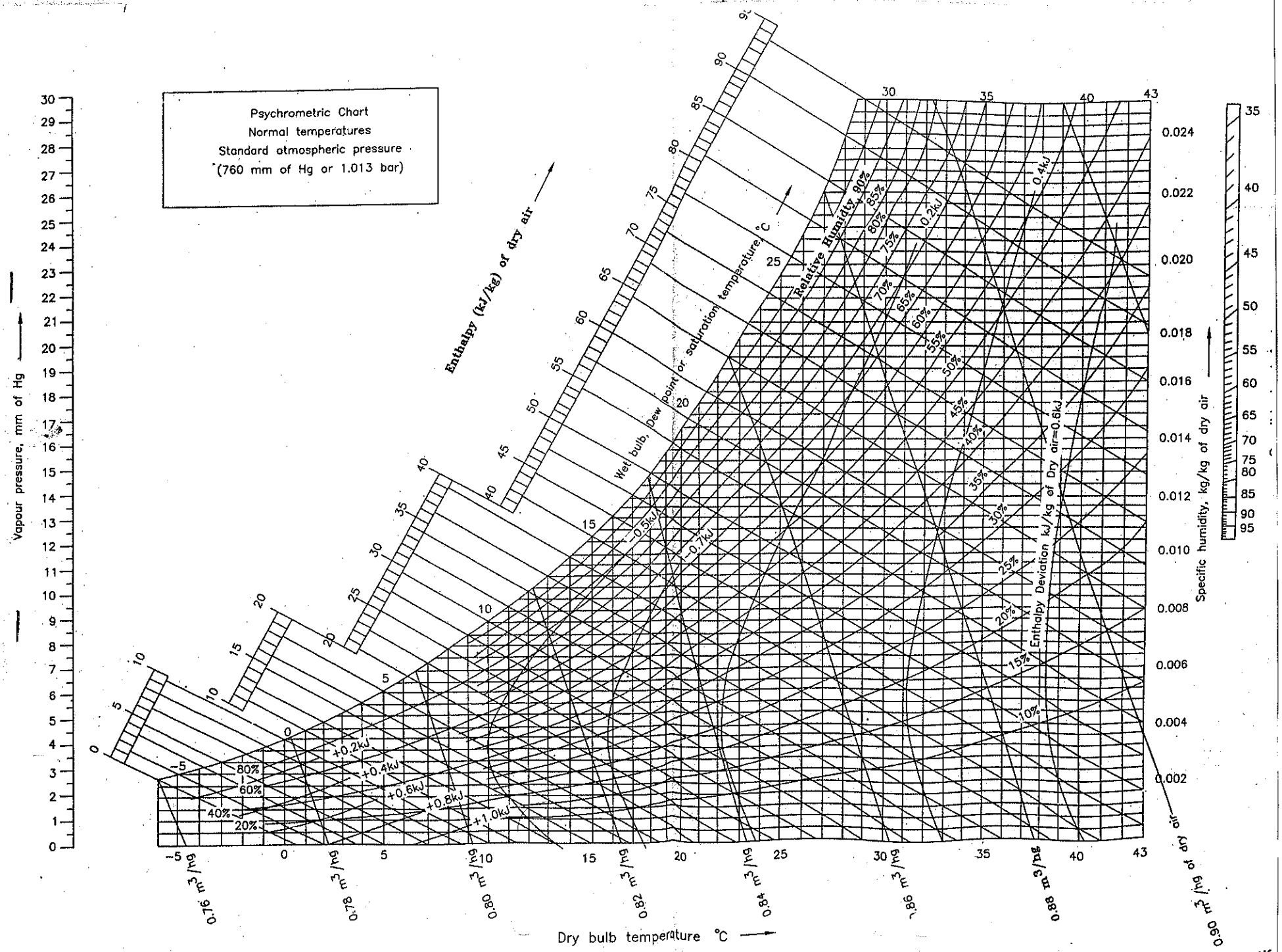
Psychrometric Chart
Normal temperatures
Standard atmospheric pressure
(760 mm of Hg or 1.013 bar)
Vapour pressure, mm of Hg
Enthalpy (kJ/kg) of dry air
Wet bulb, dew point or saturation temperature, °C
Relative Humidity
Enthalpy Deviation kJ/kg of Dry air
Specific humidity, kg/kg of dry air
Dry bulb temperature °C
0.76 m³/kg
0.78 m³/kg
0.80 m³/kg
0.82 m³/kg
0.84 m³/kg
0.86 m³/kg
0.88 m³/kg
0.90 m³/kg of dry air

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II Year II Semester 2009-2010 [Mechanical]

Test No.2 (Open Book)

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

Date: 02-05-2010 **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 double acting steam engine is supplied with dry and saturated steam at **16 bar**. The back pressure is **0.40 bar**. The cut-off occurs at **45** percent of the stroke. Now if the cut-off is adjusted to occurs at **30** percent of the stroke, but the power output of the engine remains unchanged,

Determine:(a) Percentage change in speed (b) Percentage saving in steam consumption. **Assume** that the diagram factor in both the cases remains unchanged.

[7M]

Q.2. An ammonia ice plant operates between condenser temperature of **35 ^{0}C** and an evaporator temperature of **- 15 ^{0}C** and there is no under-cooling of refrigerant liquid. It produces **5 tons** of ice per day and at **0 ^{0}C**. The **NH_3** enters the compressor as dry saturated 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 %** (v) Relative efficiency of the refrigerating plant.

Take: a) Latent heat of ice = **335kJ / kg** b) 1TR is equivalent to **210 kJ / min** (or) **3.5 kW** c) Specific heat for superheated vapour = **2.8 kJ/ Kg-k.** Use the following properties of **NH_3**. [8M]

Temperature ^0C	Enthalpy (KJ / kg)		Entropy (KJ / kg-K)	
	h_f	h_g	s_f	s_g
- 15	112.3	1426	0.457	5.549
35	347.5	1471	1.282	4.930

Q.3. A room **7 m X 4 m X 4m** is occupied by an air-water vapour mixture at **38 ^{0}C**. The atmospheric pressure is **1 bar** and the relative humidity is **70 %**. Determine the humidity ratio, dew point temperature, mass of dry air and mass of water vapour. If the mixture of air-water vapour is further cooled at constant pressure until the temperature is **10 ^{0}C**. Find the amount of water vapour condensed. [5M]

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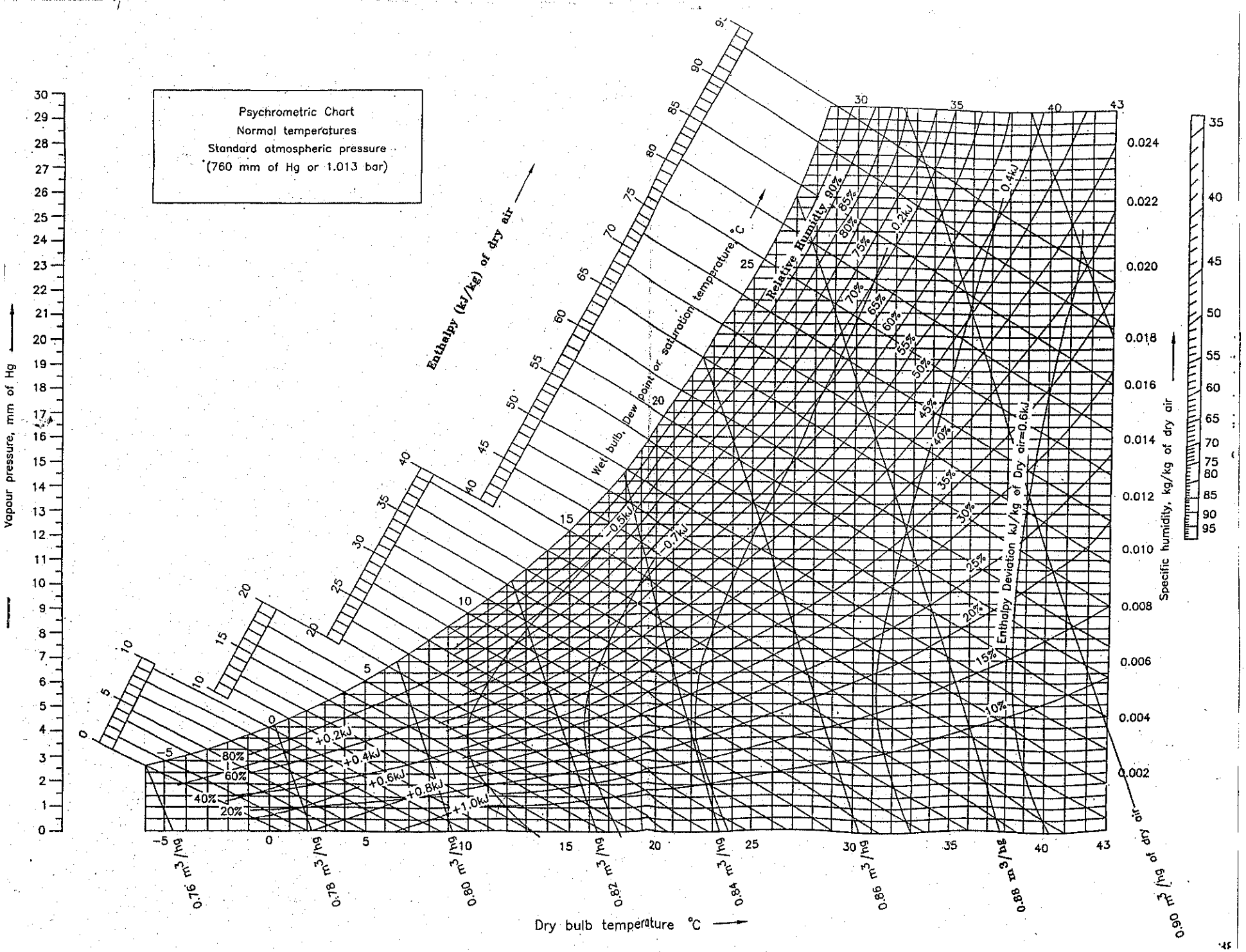
Psychrometric Chart
Normal temperatures
Standard atmospheric pressure
(760 mm of Hg or 1.013 bar)
Vapour pressure, mm of Hg
Enthalpy (kJ/kg) of dry air
Wet bulb, dew point or saturation temperature °C
Relative Humidity
Enthalpy Deviation kJ/kg of Dry air=0.6kJ
Specific humidity, kg/kg of dry air
Dry bulb temperature °C
0.76 m³/kg
0.78 m³/kg
0.80 m³/kg
0.82 m³/kg
0.84 m³/kg
0.86 m³/kg
0.88 m³/kg
0.90 m³/kg of dry air

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II Year II Semester 2009-2010 [Mechanical]

Test No.1 (Closed Book)

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

Date: 21-03-2010 **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. In I.C engine operating on the dual cycle the temperature of the working fluid (air) at the beginning of compression is **27^{0}C**. The ratio of the maximum and minimum pressure of the cycle is **70** and compression ratio is **15**. Assume the amounts of heat added at constant volume and at constant pressure are equal. Compute efficiency of the cycle. Assume γ = **1.4** for air [9M]

Q.2. A **4-** cylinder, **2**-stroke cycle petrol engine delivers a brake power of **30 kW** at **2500 rpm.** The mean effective pressure on each piston is **8 bar**, mechanical efficiency is **80%**, and fuel consumption is **8.0 kg** of petrol per hour. Assume for air **R = 0.287** kJ /kg-K. Calculate;

a) The diameter and stroke of each cylinder if stroke to bore ratio is **1.5**

b) The volumetric efficiency of the engine if the air fuel ratio is **12**, swept volume per hour of the engine is **120 m^3**, and intake air is at **0.9 bar, 32 ^{0}C**. [8M]

Q.3. In a Rankine cycle, the steam at inlet to turbine is saturated steam (x = 1) at pressure of **35 bar** and the exhaust pressure is **0.2 bar**. The mass flow rate of steam is **9.5 kg/s**. Determine: a) The pump work b) The turbine work c) The Rankine efficiency d) Heat losses in the condenser. Relevant steam table extract is given below. [8M]

p(bar)	t (^{0}C)	Sp.Volume(m^3/kg)		Sp.enthalpy (kJ/kg)			Sp.entropy(kJ/kgK)		
		v_f	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
0.20	60.09	0.001017	7.6498	251.5	2358.4	2609.9	0.8321	7.0773	7.909
35	242.5	0.001235	0.0570	1049.7	1752.3	2802.0	2.725	3.398	6.123

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IInd Sem 2009-10

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

DATE: 13/ 04 / 10

Duration: 20 Min **Max. Marks: 7**

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

QUIZ 2

1. A single-cylinder double acting steam engine with 15 cm bore and 20 cm stroke is to develop 20 kW at 300 r.p.m with cut off occurring at 20 % of stroke. Back pressure is 0.28 bar. Determine admission pressure of steam if diagram factor is 0.72. Also calculate indicated thermal efficiency if engine receives 222 kg of dry steam per hour. [Assume admission pressure of steam quality x = 1] Neglect area of piston rod. Relevant steam table extract is given below. [7M]

p(bar)	t (^{0}C)	Sp.Volume(m^3/kg)		Sp.enthalpy (kJ/kg)			Sp.entropy(kJ/kgK)		
		v_f	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
0.28	67.55	0.001021	5.5778	282.7	2340.0	2622.7	0.925	6.868	7.793
15.6	200	0.001156	0.12756	851.6	1939.2	2793.4	2.329	4.100	6.429

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IInd Sem 2009-10

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

DATE: 02/ 03 / 10

Duration: 15 Min **Max. Marks: 8**

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

QUIZ I

1. Calculate Bore and stroke of a 4-stroke petrol engine for the following data:

- Compression ratio :6
- Brake Power : 73.5kW
- Speed :400 rpm
- Brake mean effective pressure :8.5 bar
- Mechanical efficiency :80 %
- Brake specific fuel consumption :0.346kg/kWh
- Calorific value of fuel :44100 kJ/kg

Also calculate Indicated and Brake thermal efficiencies, Indicated air standard efficiency and relative efficiency based on BP and IP. [Assume bore = Stroke].

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