BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2011-2012

COMPREHENSIVE EXAMINATION

Year : II-MECHANICAL	Section: 3 and 5	Date : 12.6.2012
Course No. : ME C211	Course Title : APPLIED THERMODYNAMICS	
Duration : 3 hours.	Marks: 80	Weightage : 40%

Notes:: (i) *Answer all the questions* (ii) *Draw neat sketches wherever necessary*

(iii) *Make suitable assumptions if required and clearly state them (iv)Steam table will be provided*

Q.1. An engine working on Otto cycle has a volume of **0.45 m^3**, pressure **1 bar** and temperature **30°C** at the beginning of compression stroke and maximum cycle temperature is **899 ^{0}C**. At the end of compression stroke, the pressure is **11 bar**. **210 kJ** of heat is added at constant volume. Determine: (i) Pressures, temperatures and volumes at salient points in the cycle (ii) Percentage clearance (iii) Efficiency (iv) Net work per cycle. (v) Mean effective pressure. Take γ for air = **1.4** Take **R** for air = **0.287 kJ/kgk** **[11 M]**

Q.2 A six cylinder four stroke cycle petrol engine is to be designed to develop **300 kW** of brake power at **2500 rpm**. The bore stroke ratio is to be **1: 1.25** and the compression ratio of the engine is to be **6.5 : 1.** Assuming a mechanical efficiency of **83 %,** relative efficiency is **55 %,** calorific value of the petrol is **44770 kJ/ Kg** and indicated mean effective pressure of **9.5 bar**. Take γ for air = **1.4** determine (a) Indicated power (b) required bore and stroke (c) Air standard efficiency (d) Indicated thermal efficiency (e) consumption of petrol in kg/hr.

[11 M]

Q.3. In a thermal power plant operating on an ideal Rankine cycle produced at **5 MPa (50 bar)** and **500^{0}C** is fed to turbine where it expands to the condenser pressure of **10 kPa (0.1 bar).** The final condition of steam at the exit of condenser is saturated liquid. If the net power output of the plant is to be **20 MW**, determine: (a) pump work (b) heat added in the boiler per kg of water (c) turbine work per kg of water (d) rankine efficiency (e) specific steam consumption (f) mass flow rate of steam in kg/s (g) mass flow rate of cooling water in the condenser if the cooling water enters the condenser at **25^{0}C** and **35^{0}C** **[11 M]**

Q.4. Dry saturated steam at **900 kN /m^2** is supplied to a single cylinder double acting engine developing **22.5 kW** running at **240 rpm**. The exhaust pressure is **140 kN** /m^2. Cut off takes place at **0.4** of stroke. Assume a diagram factor of **0.8** and stroke to bore ratio of **1.25,** and hyperbolic expansion, determine (a) theoretical mean effective pressure (b) bore and stroke of engine cylinder (c) steam consumption per hour (d) specific volume of saturated steam. **[11M]**

Q.5 A food storage locker requires a refrigeration capacity of **50 kW**. It works between a condenser temperature of **35°C** and an evaporator temperature of **– 10°C**. The refrigerant is ammonia. It is sub-cooled by **5°C** before entering the expansion valve. The dry saturated vapour leaving the evaporator and enters into compressor. The compressor compress the refrigerant in to super heated state. Assume a single cylinder, single-acting compressor operating at **1000 r.p.m.** with stroke equal to **1.2 times** the bore. The properties of ammonia as listed in the table

Saturation temperature, °C	*Pressure bar*	*Enthalpy, kJ/kg*		*Entropy, kJ/kg K*		*Specific volume, m^3/kg*		*Specific heat kJ/kg K*	
		Liquid	*Vapour*	*Liquid*	*Vapour*	*Liquid*	*Vapour*	*Liquid*	*Vapour*
– 10	*2.9157*	*154.056*	*1450.22*	*0.82965*	*5.7550*	—	*0.417477*	—	*2.492*
35	*13.522*	*366.072*	*1488.57*	*1.56605*	*5.2086*	*1.7023*	*0.095629*	*4.556*	*2.903*

Determine: (a) Mass of refrigerant kg/s (b) power required for compressor (c) cylinder bore and length in meter. **[12 M]**

Q.6 A gas turbine unit receives air at **1 bar** and **300 K** and compresses it adiabatically to **6.2 bar**. The isentropic efficiency of compressor is **88%**. The fuel has a heating valve of **44186 kJ/kg** and the fuel-air ratio is **0.017 kJ/kg** of air. The isentropic efficiency of turbine is **90%.** Calculate the work of turbine and compressor per kg of air compressed and thermal efficiency of the plant. Specific heat of air C_p **=1.005 kJ/kg k**. Specific heat for products of combustion gas C_{pg} **= 1.147 kJ/kg k** and **γ = 1.333** **[12 M]**

Q.7. Following data relate to a performance test of a single-acting single stage reciprocating compressor:

Speed =**200rpm**, Volume of intake air = **6m^3/min**

Clearance volume = **6 %** of stroke volume, Suction pressure = **1bar (100kPa),** Temperature of air at inlet = **288 K**, Discharge pressure = **7 bar (700kPa).** Calculate the following:

(a) Temperature of air at delivery

(b) Volumetric efficiency with clearance volume

(c) Volume of air delivery at the outlet stroke

(d) Compressor Indicated power (or) workdone in kW, neglecting clearance

(e) Isothermal efficiency of the compressor.

Take: Polytropic Index **'n'** = **1.25** **[12 M]**

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS
II Year II Semester 2011-2012

Test No.2 (Open Book)

Course No. ME C211 **Course Title:** APPLIED THERMODYNAMICS **Weightage:** 20%

Date: 13-05-2012 **Max.Marks:** 40 **Duration:** 50 min.

Notes: (i) *Answer all the questions* (ii) *Draw neat sketches wherever necessary*
(iii) *Make suitable assumptions if required and clearly state them*
(iv) Thermodynamics tables will be provided

Q.1. One tone of refrigerator on vapour compression cycle works within the temperature limits of **268 K** and **313 K**. Refrigerator leaves the compressor dry and saturated. Assuming isentropic compression. Calculate the COP and Power required to run the refrigerator.

(i) If the Refrigerant is sub-cooled by 20^{0}C calculate the COP and Power required to run the refrigerator. Compare both results of the COP as well as power and give your justification.

(ii) At the rate of AED 3 per unit of electricity, find the running cost of system for 10 hrs.

Take: Specific heat of refrigerant = 1.03 kJ/kg-K **[15M]**

Use the following properties of refrigerant

Temperature ^{0}K	Enthalpy (KJ / kg)			Entropy (KJ / kg-K)		
	h_f	h_g	h_{fg}	s_f	s_g	s_{fg}
268	31.5	-	154	0.125	-	0.574
313	74.59	203.2	-	-5	0.6825	-

Q.2. Steam at **10 bar** and **200°C** is expanded in a double acting reciprocating steam engine and back pressure is **0.5 bar**. The cut-off occurs at **1/4th** of the stroke volume. The admission and back pressure are **1.5 bar and 0.5 bar** respectively. The twin cylinders of this engine have dimensions of **10 cm x 10** cm. The engine runs at **300 R.P.M**. Neglect clearance and assume hyperbolic expansion.

Calculate (i) Theoretical mean effective pressure (ii) Indicated Power (iii) Mass of steam consumption (iv) Indicated thermal efficiency **[15 M]**

Q.3. The Sling – psychrometer reads **40°C DBT and 28 °C WBT**. Calculate the following:

a) specific humidity

b) Relative humidity

c) vapour density in air

d) Dew – point temperature

e) Enthalpy of the mixture per kg of dry air.

Assume atmospheric pressure to be 1.03 bar and partial pressure of vapour (p_v) is **0.03038 bar** **[10 M]**

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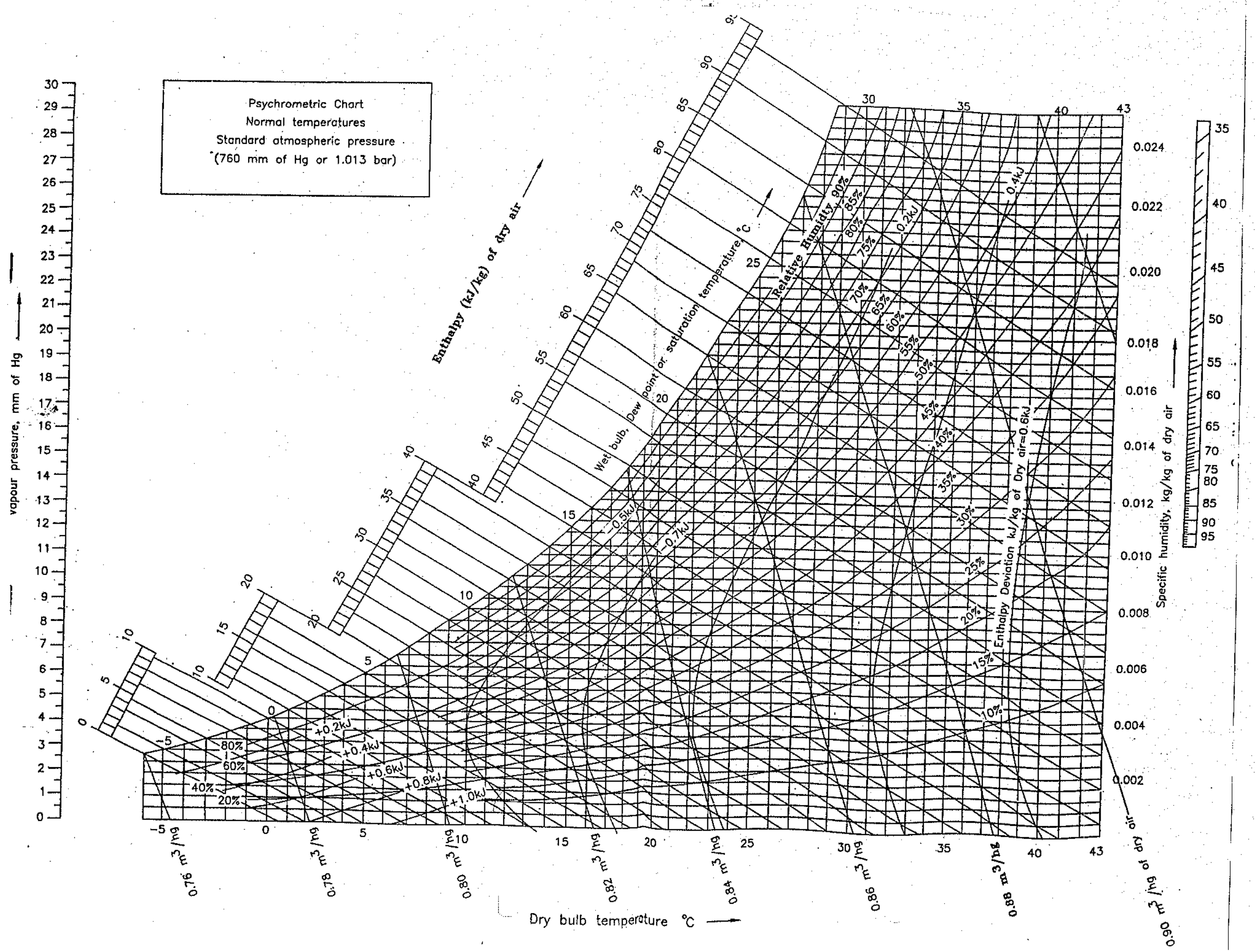

Psychrometric Chart
Normal temperatures
Standard atmospheric pressure
(760 mm of Hg or 1.013 bar)
vapour pressure, mm of Hg
Enthalpy (kJ/kg) of dry air
Wet bulb, Dew point or saturation temperature, °C
Relative Humidity 90%
Enthalpy Deviation kJ/kg of Dry air=0.6kJ
Specific humidity, kg/kg of dry air
Dry bulb temperature °C
0.76 m3/hg
0.78 m3/hg
0.80 m3/hg
0.82 m3/hg
0.84 m3/hg
0.86 m3/hg
0.88 m3/hg
0.90 m3/hg of dry air

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS
II Year II Semester 2011-2012

Test No.1 (Closed Book)

Course No. ME C211 **Course Title:** APPLIED THERMODYNAMICS **Weightage:** 25%

Date: 22-03-2012 **Max.Marks:** 25 **Duration:** 50 min.

***Notes*::** (i) *Answer all the questions* (ii) *Draw neat sketches wherever necessary*
(iii) *Make suitable assumptions if required and clearly state them*
(iv) Thermodynamics tables will be provided

Q.1. Obtain the cylinder dimensions of a twin cylinder, two-stroke IC Engines from the following data:

(i) Engine speed **: 4000 rpm** (ii)Volumetric efficiency **: 77 %**
(iii) Mechanical efficiency **: 75 %** (iv) Piston speed **:** 600 m /min
(v) Indicated mean pressure (IMEP) : **5 bar** (vi) Fuel consumption : **10 Lit /hr**
(vii) Sp. gravity of fuel : **0.73** (viii) Theoretical air to fuel ratio : **18:1**

Assume '$\mathbf{R'_{air}}$' : **0.287 kJ/kg-K,** Temp : **288 ^{0}K**, Atm.pressure : **1bar**

Find (a) Stroke length (b) Actual volume of air drawn into the cylinder per cycle (c) Cylinder bore diameter (d) Indicated power (e) Brake power [9 M]

Q.2 In an air standard diesel cycle, compression begins at **1.03** bar and **300^{0}K**. After compression, the heat addition is of **545 kJ/kg** of air and the peak pressure reached in the cycle is **47 bar**. Take for air: **c_p = 1.004 kJ / kg-K; c_v = 0.718 kJ / kg-K; γ = 1.4** Calculate: (a)compression ratio (b) Fuel cut of ratio (c) Maximum temperature in the cycle (d) Air standard efficiency [9 M]

Q.3 In a Rankine cycle, the steam at inlet to turbine is dry saturated steam at pressure of **30 bar** and exhaust pressure is **0.25 bar**. Determine: (i) The pump work (ii) Turbine power output (iii) Rankine cycle efficiency (iv) The condenser heat flow and (v) The dryness at the end of expansion (v) Carnot cycle efficiency. Assume mass flow rate of steam is **10 kg/s.** [7 M]

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Version 'A'

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

Course No: ME C211 **Subject: Applied Thermodynamics**

DATE: 23.04.12 **Duration: 20 Min**

Max. Marks: 14 **QUIZ -2** **Weightage : 7 %**

Qns	1	2	3	4	5	6	7	8	9	10	11
Ans											

1. In a single acting steam engine (1 M)

[A] the steam is admitted on one side of the piston and one working stroke is produced during each revolution of the crank shaft.

[B] the steam is admitted in turn, on both side of the piston and one working stroke is produced during each revolution of the crank shaft.

[C] the steam is admitted on one side of the piston and two working strokes are produced during each revolution of the crank shaft.

[D] the steam is admitted in turn, on both sides of the piston and two working strokes are produced during each revolution of the crank shaft.

2. A single acting steam engine produces ____________ power than that of double acting steam engine (1 M)

[A] equal **[B]** half **[C]** double **[D]** four times

3. The function of a piston rod is (1 M)

[A] to guide motion of the piston rod and to prevent it from bending
[B] to transfer motion from the piston to the cross head
[C] to convert heat energy of the steam into mechanical work
[D] to exhaust steam from the cylinder at proper moment

4. The theoretical indicator diagram of a simple steam engine is based upon the assumption that (1 M)

[A] there is no pressure drop due to condensation

[B] steam is admitted at boiler pressure and exhausted at condenser pressure

[C] the expansion (or compression) of the steam is hyperbolic

[D] all of the above

5. Expansion ratio is the ratio of (1 M)

[A] swept volume to the volume at cut off

[B] clearance volume to the volume at cut off

[C] volume at cut off to the swept volume

[D] swept volume to the clearance volume

6. The clearance in the engine cylinder (1 M)

[A] increases the mean effective pressure

[B] increases the workdone

[C] decreases the efficiency of the engine

[D] all of these

7. Which of the following is correct? (1 M)

[A] $p_a = p_m/K$ **[B]** $p_a = p_m \times K$ **[C]** $p_a = K/p_m$ **[D]** $p_a = p_m + K$

Where, p_a = Actual mean effective pressure

p_m = Theoretical mean effective pressure, and

K = Diagram factor

8. The actual power generated in the engine cylinder is called (1 M)

[A] indicated power **[B]** brake power

[C] frictional power **[D]** none of these

9. Besides mean effective pressure, the data required to determine the indicated power of an engine incude (1 M)

[A] piston diameter, length of stroke and calorific value of the fuel

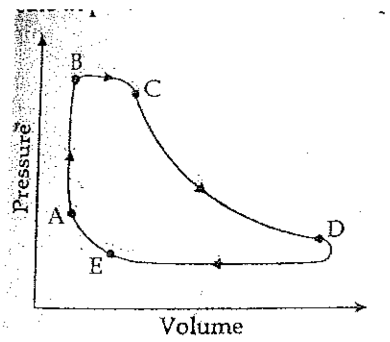
[B] piston diameter, specific fuel consumption and calorific value of the fuel

[C] piston diameter, length of stroke and speed of rotation

[D] specific fuel consumption, speed of rotation and torque

10. Fig shows the actual indicator diagram of a steam engine. The admission of steam from the steam chest to the cylinder occurs at position ______ of the piston. (1 M)

[A] E **[B]** A **[C]** B **[D]** C



11. The average value of diagram factor lies between (1 M)

[A] 0.4 – 0.5 **[B]** 0.5 – 0.6 **[C]** 0.6 – 0.75 **[D]** 0.75 – 0.85

12. A single-cylinder double acting steam engine with 15 cm bore and 20 cm stroke is to develop 20 kW at 300rpm. Determine theoretical mean effective pressure if diagram factor is 0.72. (1.5 M)

13. A single-cylinder double acting steam engine is required to develop 75 kW of brake power. The cut of occurs at 0.375 of stroke and diagram factor is 0.75. Calculate theoretical indicated power if the mechanical efficiency is 80 %. (1.5 M)

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

Course No: ME C211 **Subject: Applied Thermodynamics**

DATE: 05.03.12 **Duration: 20 Min**

Max. Marks: 16 **QUIZ -1** **Weightage : 8 %**

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

Q	1	2	3	4	5
Ans					

1. Gudgeon pin forms the link between (1 M)

   [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 _____________ (1 M)

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

3. The stroke to bore ratio, where d > L is____________ (1 M)

   [A] Square engine **[B]** Medium Square engine

   [C] Under square- engine **[D]** Over Square- engine

4. In a four - stroke cycle petrol engine, during suction stroke (1 M)

   [A] only air is sucked in **[B]** only petrol is sucked in

   [C] mixture of petrol and air is sucked in **[D]** none of the above

5 Equivalence ratio is (1 M)

[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

6. Write the ratio of Relative efficiency (1 M)

7. 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. (2 M)

8. 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. (2 M)

9. 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. (2 M)

10. 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. (2 M)

11. A 4 stroke four cylinder diesel engine running at 2000 rpm. The piston stroke length is 100 mm. Find the piston speed. (2 M)

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