BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

II SEMESTER 2011-2012

COMPREHENSIVE EXAMINATION (Closed book)

Year : III-MECHANICAL	Date : 12.6.2012	
Course No. : ME C314	Course Title : POWER PLANT ENGINEERING	
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. The input-output curve of a **50MW** power station is given by:

$$I = 4 \times 10^6 (8 + 8L + 0.4L^2) \text{ kJ / hour}$$

Where **I** is the input in kJ / hour and **L** is load in **MW**

(i) Determine the heat input per day to the power station if it works for 20 hours at full load and remaining period at no load.

(ii) Also find the saving per kWh of energy produced if the plant works at full load for all 24 hours generating the same amount of energy. **[10 M]**

Q.2 A steam turbine using regenerative feed heating cycle generates 27000 kW through a directly coupled electric generator as shown in Fig.1. Steam at 60 bar and 450°C is supplied to the turbine. The condenser pressure is 0.07 bar.. The steam is bled from the steam turbine at 3 bar. The heating of the feed water is done in direct contact heater. Assuming the isentropic efficiency of turbine of each portion of expansion at 87%, find a) the steam bled per kg of steam b) the steam generated per hour, c) heat supplied to the boiler d) net energy available from the turbine e) overall efficiency of the plant.

Assuming that 10% of the generator output is used to run the pump also the alternator efficiency is 95% and mechanical efficiency from turbine to generator is 98%. Neglect the pump work in calculating the input to the boiler. **[12 M]**

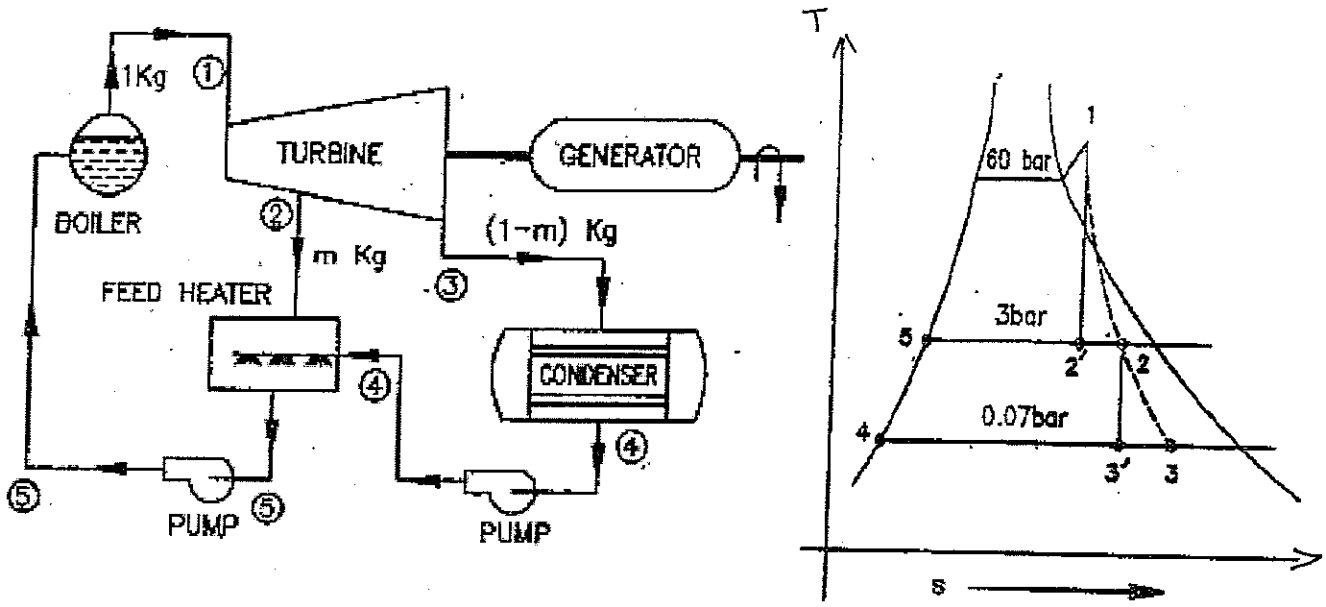

Fig.1

Q.3. A sample of fuel has the following percentage composition. C = 86 %, H_2 = 8 %, O_2 = 2 %, S = 3 % and the remainder is ash = 1%. For air-fuel ratio of 12:1,

Calculate: (i) Mixture strength as a percentage rich or high

(ii) Volumetric analysis of the dry products of combustion. **[11 M]**

Q.4. The following data relate to a boiler test: Coal used per hour, 6750 kg having a moisture content of 2% and gross calorific value (dry) of 35490 kJ/kg.

The ultimate mass analysis of dry coal being C = 84%, O_2 = 4%, and ash = 8%.

The dry flue analysis was, by volume, CO_2 = 9.5%, O_2 = 10.48%, and N_2 = 80.02%.

Temperature of flue gas 305°C, room temperature 32°C, mean specific heat of dry flue gas 1.0 and of steam in flue gas 2.0; mass of steam generated 60500 kg per hour, dry saturated at 16.5 bar from feed water at 47°C.

Draw up a heat balance sheet per kg of dry coal, above room temperature, given that air contains 23.1 percent by mass of O_2. **[12 M]**

Q.5 A Kaplan turbine develops 22000kW at an average head of 35 meters as shown in Fig.2. Assuming a speed of 2, flow ratio of 0.6, diameter of the boss equal to 0.35 times the diameter of the runner and an overall efficiency of 88%, calculate the diameter, speed and specific speed of the turbine. **[11 M]**

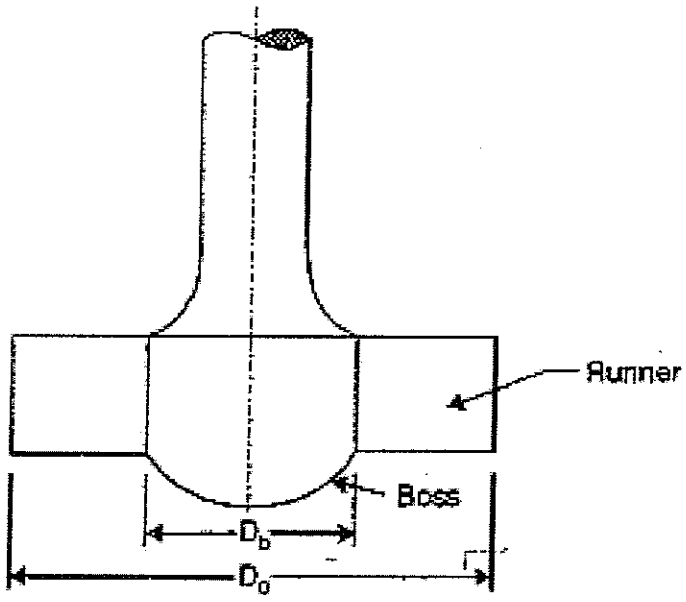

Fig.2. Kaplan turbine runner

Q.6. During the trial of a single cylinder oil engine, the following observations were recorded:

Engine data:	
Bore	300 mm
Stroke	400 mm
Speed	200 rev/min
Cycle four stroke	
Experimental observations:	
Duration of trial	60 min
Fuel consumption	7.050 kg
Calorific value of the fuel	44000 kJ/kg

Mean effective pressure	5.713 bar
Net load on brakes	1324.35 N
Brake drum diameter	1600 mm
Total mass of jacket cooling water	495 kg
Temperature rise of jacket cooling water	38°C
Temperature of exhaust gas	300°C
Air consumption	311 kg
Assumption:	
Specific heat of exhaust gases	1.004 kJ/kg K
Specific heat of water	4.186 kJ/kg K
Room temperature	20°C

Determine

(a) Power available at brakes (b) Indicated power developed (c) Mechanical efficiency (d) Thermal efficiency

Draw up a heat balance sheet of the trial on one hour basis. **[12 M]**

7. The air enters the compressor of an open cycle constant pressure gas turbine at a pressure of 1 bar and temperature of 20°C. The pressure of the air after compression is 4 bar. The isentropic efficiencies of compressor and turbine are 80% and 85% respectively. The air – fuel ratio used is 90: 1. If flow rate of air is 3.0 kg / s, find: a) power developed by turbine (b) power developed by compressor c) Thermal efficiency of the cycle. Assume C_p = 1.0 kJ/kg K and γ = 1.4 of air and gases. Calorific value of fuel = 41800 kJ / kg. **[12 M]**

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

III Year II Semester 2011-2012 [Mechanical]

Test No.2 (Open Book)

Course No. ME C 314 **Course Title:** POWER PLANT ENGINEERING **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*

Q.1. The fuel analysis has the percentage analysis by mass as follows.

C = 81%, H_2 = 5%, O_2 = 5%, Moisture = 2 % and Ash = 7 %.

Calculate theoretical minimum air required for complete combustion of 1 kg of the fuel. Also calculate the volumetric analysis of dry flue gases, if actual air supplied is 16 kg per kg of fuel. Assume that 80% of carbon is burnt to CO_2 and remaining to CO. Hydrogen from the fuel burns completely. **[17 M]**

Q.2. The data recorded during the trial of a processing plant steam boiler are given below:

Steam pressure	: 11 bar
Dryness fraction of steam	: 0.95
Steam produced	: 4500 kg/hour
Feed water temperature	: 70°C
Coal fired	: 400 kg/hour
Higher calorific value of coal	: 38000 kJ/kg
Moisture in fuel	: 5% by mass
Temperature of flue gases discharged	: 280°C
Room temperature	: 20°C

Analysis of dry coal by mass:

Carbon	: 88%
Hydrogen	: 3%
Ash	: 5%
Other volatile material	: 4%

Analysis of flue gas by volume:

Carbondioxide	: 11%
Carbonmonoxide	: 1.1%
Oxygen	: 7%
Nitrogen	: 81%
Take specific heat of dry flue gases	1.1 kJ/kg K
Specific heat of superheated steam	2.1 kJ/kg K

The moisture is carried away in the form of super heated steam at 0.1 bar and temperature is 280 ^{0}C. Saturation temperature of steam at 0.1 bar being 45.8^{0}C.

Draw up the heat balance sheet. **[17 M]**

Q.3 Give justifications on how the following functions are interrelated to each other in fluidized bed combustion. **[6 M]**

- Free board
- Transport disengaging height ((TDH)
- Elutriation

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BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

III Year II Semester 2011-2012 [Mechanical]

Test No.1 (Closed Book)

Course No. ME C 314 **Course Title:** POWER PLANT ENGINEERING **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*

Q.1. The yearly duration curve of a certain plant can be considered as a straight line from **300 MW to 80 MW** as shown in Fig.1. Power is supplied with one generating unit of **200 MW** capacity and two units of **100 MW** capacity each. Determine: (i) Installed capacity (ii) Load factor (iii) Plant factor (iv) Maximum demand (v) Utilization factor [9 M]

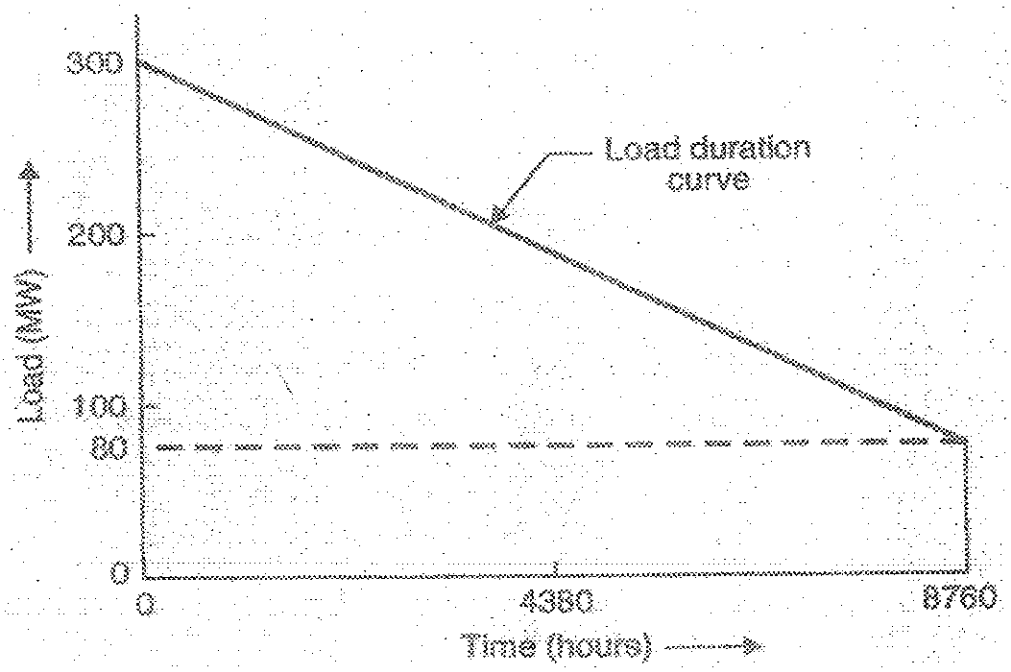

Fig.1

Q.2 In a single heater regenerative cycle the steam enters the turbine at **30 bar, 400^{0}C** and exhaust pressure is **0.10 bar** as shown in Figure.2. The superheated steam bled from the turbine at **172 ^{0}C** and **5 bar** and mixed with direct contact type feed water heater. Neglect the pump work. Find

(i) Mass flow rate of steam extracted from the Turbine (ii) Power output of the Turbine (iii) Rankine cycle efficiency with regeneration and without regeneration. (iv) Increase in cycle efficiency due to regeneration. [10 M]

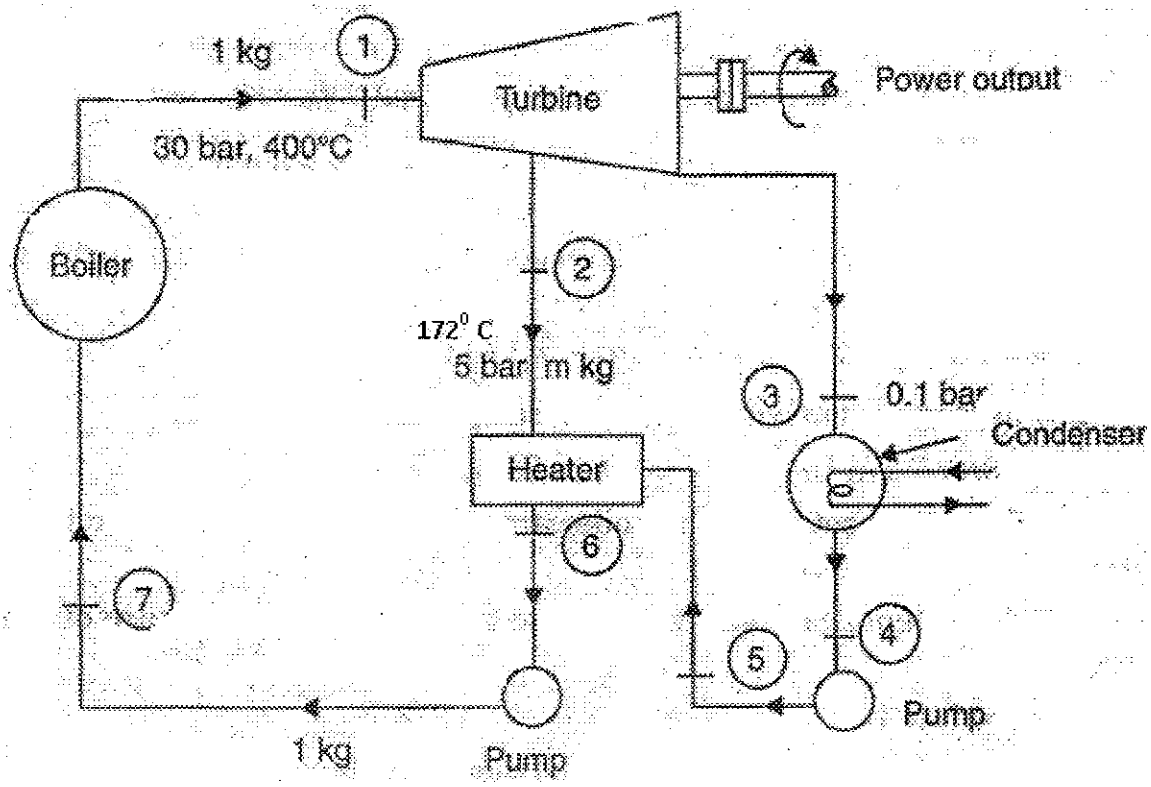

Fig.2

Q.3 What is IGCC? Explain its operation with neat sketch. [6 M]

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Version 'A'

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

Course No: ME C314 **Subject: Power plant Engineering**

Max. Marks: 21 **QUIZ -2** **Weightage : 7 %**

DATE: 21.4.12

Qns	1	2	3	4	5	6	7	8	9	10	11	12
Ans												

Qns	13	14	15	16	17	18	19
Ans							

1. Which of the following has the highest calorific value? (1 M)

   [A] Peat **[B]** Lignite **[C]** Bituminous coal **[D]** Anthracite coal

2. The fuel mostly used in cement industry and in metallurgical processes is (1 M)

   [A] wood charcoal **[B]** Bituminous coal **[C]** pulverized coal **[D]** coke

3. When coal is first dried and then crushed to a fine powder by pulverizing machine, the resulting fuel is called (1 M)

   [A] wood charcoal **[B]** Bituminous coal **[C]** briquetted coal **[D]** none of these

4. When the finely ground coal is moulded under pressure with or without a binding material, the resulting fuel is called briquetted coal (1 M)

   [A] yes **[B]** No

5. The ultimate analysis of coal consists of the determination of the percentage of (1 M)

   [A] carbon **[B]** hydrogen and nitrogen **[C]** sulphur and ash
   [D] all of these

6. The amount of heat obtained by the complete combustion of 1 kg of fuel when the products of its combustion are cooled down to the temperature of supplied air is called _____ calorific value of fuel. (1 M)

[A] higher **[B]** lower

7. Which of the following has the minimum atomic mass? (1 M)

[A] oxygen **[B]** sulphur **[C]** nitrogen **[D]** carbon

8. One mole of oxygen is _____ times heavier than the hydrogen atom (1 M)

[A] 12 **[B]** 14 **[C]** 16 **[D]** 32

9. One kg of carbon requires 4/3 kg of oxygen and produces _____ kg of carbon monoxide (1 M)

[A] 8/3 **[B]** 11/3 **[C]** 17/3 **[D]** 7/3

10. One kg of carbon monoxide requires 4/7 kg of oxygen and produces (1 M)

[A] 11/3 kg of carbon dioxide gas **[B]** 7/3 kg of carbon monoxide gas
[C] 11/7 kg of carbon dioxide gas **[D]** 8/3 kg of carbon monoxide gas

11. One kg of sulphur requires 1 kg of oxygen for complete combustion and produces 2 kg of sulphur dioxide (1 M)

[A] true **[B]** false

12. One kg of carbon monoxide requires_____ kg of oxygen to produce 11/7 kg carbon dioxide gas (1 M)

[A] 4/7 **[B]** 7/4 **[C]** 11/4 **[D]** 9/7

13. One kg of ethylene (C_2H_4) requires 2 kg of oxygen and produces 22/7 kg of carbondioxide and _____ kg of water and steam (1 M)

[A] 9/7 **[B]** 11/7 **[C]** 7/4 **[D]** 11/4

14. The mass of flue gas per kg of fuel is the ratio of the (1 M)

[A] mass of oxygen in 1 kg of flue gas to mass of oxygen in 1 kg of fuel
[B] mass of oxygen in 1 kg of fuel to mass of oxygen in 1 kg of flue gas
[C] mass of carbon in 1 kg of flue gas to mass of carbon in 1 kg of fuel
[D] mass of carbon in 1 kg of fuel to mass of carbon in 1 kg of flue gas

15. The mass of carbon per kg of flue gas is given by (1 M)

[A] $\frac{11}{3}CO_2 + \frac{3}{7}CO$ **[B]** $\frac{3}{7}CO_2 + \frac{11}{3}CO$ **[C]** $\frac{7}{3}CO_2 + \frac{3}{11}CO$
[D] $\frac{3}{11}CO_2 + \frac{7}{3}CO$

16. The mass of excess air supplied is equal to (1 M)

[A] $\frac{23}{100} \times mass\ of\ excess\ carbon$ **[B]** $\frac{23}{100} \times mass\ of\ excess\ oxygen$
[C] $\frac{100}{23} \times mass\ of\ excess\ carbon$ **[D]** $\frac{100}{23} \times mass\ of\ excess\ oxygen$

17. To ensure complete and rapid combustion of a fuel, some quantity of air, in excess of the theoretical or minimum air is supplied (1 M)

[A] yes **[B]** No

18. Bomb calorimeter is used to determine (1 M)

[A] calorific value of solid or liquid fuels
[B] calorific values of gaseous fuels
[C] ash content of solid fuels
[D] incombustible matter in solid fuel

19. Which of the following constituents of a fuel does not contribute to its calorific value on combustion? (1 M)

[A] carbon **[B]** hydrogen **[C]** sulphur **[D]** nitrogen

20. Match the correct answer from Group B for the average calorific value of the fuels given in Group A (2 M)

Group A	Group B	Answer
a) Wood	A) 33,500 kJ/kg	
b) Peat	B) 19,700 kJ/kg	
c) Lignite coal	C) 25,000 kJ/kg	
d) Bituminous coal	D) 23,000 kJ/kg	

Version 'A'

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, DUBAI CAMPUS

Course No: ME C314 **Subject: Power plant Engineering**

DATE: 06.03.12 **Duration: 20 Min**

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

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

Q	1	2	3	4	5	6	7
Ans							

1. Economics of power plant is greatly influenced by (1 M)

[A] Depreciation cost **[B]** power factor **[C]** Unit cost **[D]** Demand Factor

2. Load factor of a power plant station is defined as (1 M)

[A] Maximum demand / average load **[B]** average load **X** Maximum demand **[C]** average load / Maximum demand **[D]** None of the above

3. Load factor of a power station is generally (1 M)

[A] equal to unity **[B]** less than unity

[C] more than unity **[D]** none of the above

4. Demand factor is defined as (1 M)

[A] average load / maximum demand **[B]** maximum demand / connected load **[C]** connected load / maximum demand **[D]** connected load **X** maximum demand

5 High load factor indicates that (1 M)

[A] Cost of generation per unit power is increased

[B] total plant capacity is utilized for most of the time

[C] total plant capacity is not properly utilized for most of the time

6. A load curve indicates (1 M)

[A] average power used during the period

[B]average kWh energy consumption during the period

[C] Average connected load during the period **[D]** none of the above

7. Diversity factor is defined as (1 M)

[A] Sum of individual consumer groups / actual peak load of the system

[B] actual peak load of the system / Sum of individual consumer groups

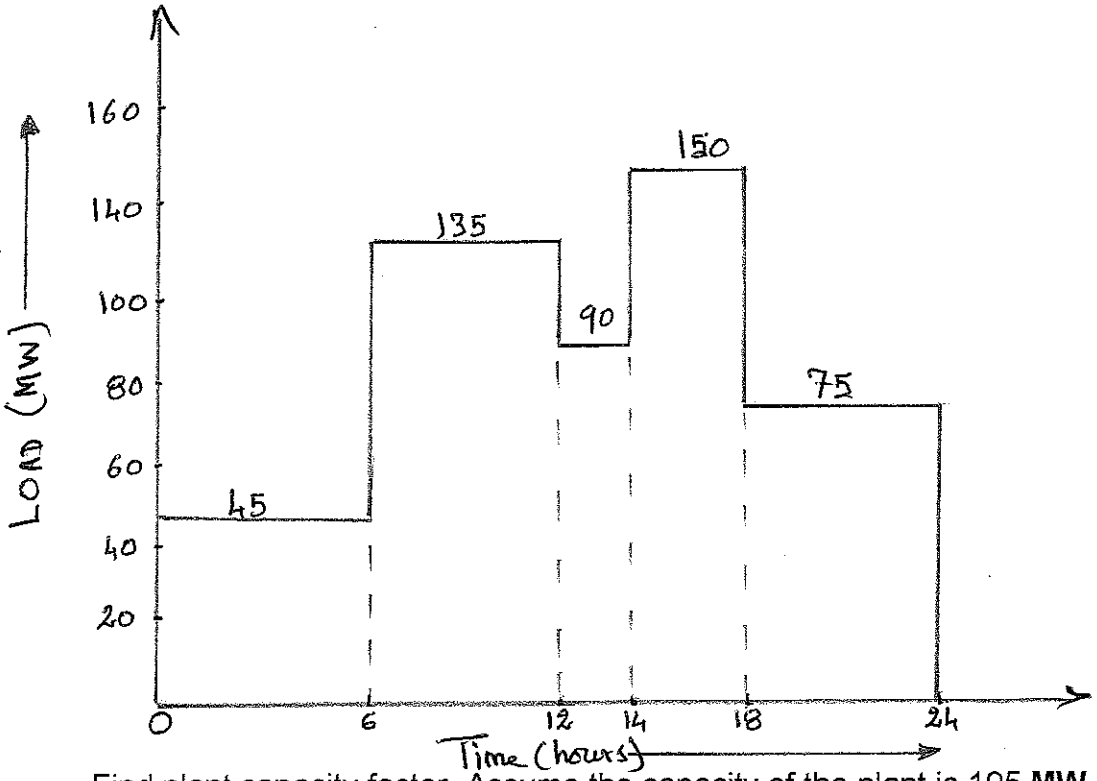
[C] actual load factor / capacity factor **[D]** capacity factor / actual load factor

8. The maximum demand of a power plant station is 96000 kW and daily load curve is described as follows:

Time (hrs)	**0 - 6**	**6 - 8**	**8 - 12**	**12 - 14**	**14 - 18**	**18 - 22**	**22 - 24**
Load (MW)	**48**	**60**	**72**	**60**	**84**	**96**	**48**

Determine the load factor of power station (3 M)

9. A power station has to supply load as displayed below:



Find plant capacity factor. Assume the capacity of the plant is 195 **MW.** (4 M)

10. A **60 MW** power station has an annual peak load of **50MW**. The power station supplies loads having maximum demands of **20 MW, 17 MW, 10 MW**, and **9 MW**. Find the diversity factor. (2 M)
