Time: 3 Hours **Marks: 80**

NOTE:

- Q1 is compulsory.
- Attempt any three from remaining five questions
- Assume suitable data wherever required

Q1 Answer any four from following: **20** Marks

1. Explain capillarity and surface tension. Derive the equation for the height to which the liquid rises in the tube
2. Define Mach number. Classify the types of fluid flow based on Mach number. Give examples for each type
3. A pipe has a diameter of 0.2 m and carries water at a flow rate of 0.4 m^3/sec. Calculate the Reynolds number for flow in the pipe if the kinematic viscosity of water is 1×10^{-6} m^2/sec. Is the flow laminar or turbulent?
4. State Bernoulli's theorem for steady, incompressible flow and derive its equation from first principles. List the assumptions involved.
5. A wooden block floats in water with 60% of its volume submerged. Calculate the specific gravity of the wood. If the volume of the block is 0.25 m^3, find the buoyant force acting on it.

Q2 **20** Marks

1. Two large horizontal plane surfaces are 25 mm apart. This gap is filled with a viscous fluid. Find the force required to drag a thin plate of area 0.75 m^2 between the two surfaces at a speed of 0.50 m/s:
   (a) If the plate is equidistant from the two surfaces.
   (b) If the plate is 10 mm from one of the surfaces.
   Given: Dynamic viscosity of the fluid = 1.2 Pa·s

2. A vertical rectangular plate of height 8 m and width 4 m is submerged in a fluid with specific gravity 0.95. The top edge of the plate is at a depth of 3 m below the free surface of the fluid. The plate is inclined at an angle of 15° with the vertical. Calculate the total pressure force acting on the plate. Also determine the location of the center of pressure.

Q3 **20** Marks

1. Sketch and explain the working principles of Venturimeter and Rotameter. Discuss their applications, advantages, and limitations.

2. Water flows through a pipe, and an Orifice meter is installed to measure the flow rate. The diameter of the pipe is 0.4 m, and the diameter of the orifice is 0.12 m. The differential pressure across the orifice is measured as 6000 Pa. The discharge coefficient of the orifice is 0.62. Calculate the flow rate of water through the pipe.

Q4 **20** Marks

1. (a) Define the terms streamline, streak line, and path line. Explain the differences between them with the help of appropriate diagrams.
   (b) Explain the concepts of equipotential lines and flow nets. Provide examples of practical applications where flow nets are used.

2. The stream function ψ for a two-dimensional flow is given by the equation:
   $\psi = 3x^2 - 2y^2$ where x and y are the Cartesian coordinates.
   (a) Determine the velocity components u and v in the x and y directions.
   (b) If the point (x, y) = (4,2) is within the flow field, calculate the velocity at this point.

Q5 **20** Marks

1. A tank with a rectangular base has dimensions 10 m x 4 m. An orifice of diameter 1 m is provided at the bottom of the tank. If the water level drops from a height of 6 m to 3 m, calculate the time required to empty the tank.
   Assume discharge coefficient, $C_d = 0.6$

2. How does the metacentric height influence the stability of floating and submerged bodies? Compare the stability of a floating body with a high and low metacentric height.

Q6. **20** Marks

1) An aeroplane is flying at an altitude of 5000 m, where the atmospheric pressure is 50 kPa and the temperature is 270 K. The velocity of the aeroplane relative to the air is 900 km/hr. Determine the stagnation pressure and stagnation temperature at the point where the airflow is brought to rest. Assume the specific gas constant for air is 287 J/ kg° K and k =1.4

2) Describe the different types of mouthpieces. Explain the working principle of a convergent-divergent mouthpiece and its applications.

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Time: (03 Hours) **Marks: 80**

Instructions:

1. Question No. 1 is **Compulsory.**
2. Answer **any three** questions from the **remaining.**
3. Each **full question** carries **20 marks.**
4. **Assume** suitable data, if needed and **state** it clearly.

Q. 1) Answer any **four** sub-questions.

a) Draw SFD & BMD for a simply-supported beam shown in fig. 1 **(05 M)**

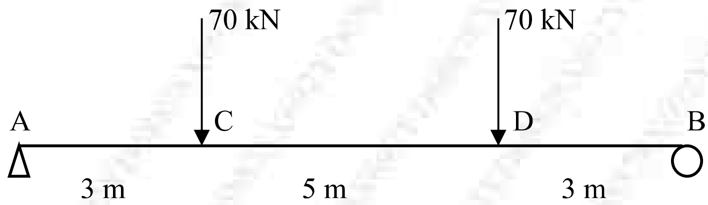

Fig. 1

b) Explain virtual work principle & Castigliano's theorems. **(05 M)**
c) State the assumptions of pure bending theory. **(05 M)**
d) Define core of a section. Locate core of a hollow rectangular section with external dimensions (400 mm width x 700 mm depth) & internal dimensions (370 mm width x 670 mm depth). **(05 M)**
e) Draw stress-strain curve for a mild steel bar under tension. Explain important points. **(05 M)**
f) State the assumptions of pure torsion theory. **(05 M)**

Q. 2) a) The C/S of a T-beam is shown in fig. 2. The permissible bending stress is 195 MPa. If the section is simply supported over a span of 4.4 m, what UDL can it carry safely? **(10 M)**

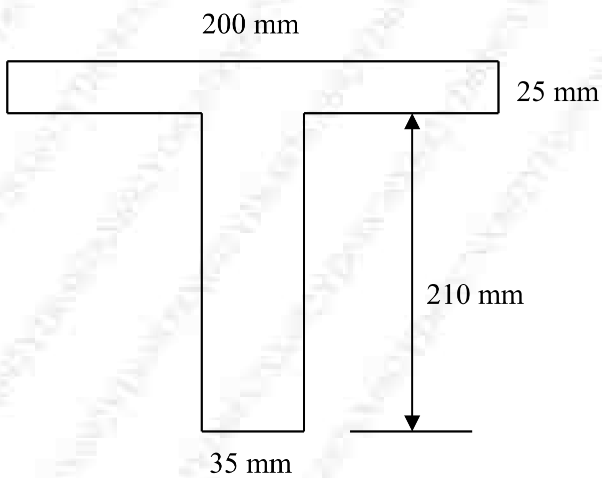

Fig. 2

b) A cylindrical shell of internal diameter 2 m and 3.8 m length is subjected to an internal fluid pressure of 4 MPa. If the permissible circumferential stress is 140 MPa, find out the shell thickness. Also determine longitudinal stress, maximum shear stress, changes in length, diameter and volume of the shell. Assume $E = 2.1 \times 10^5$ MPa & Poisson's ratio = 0.23. **(10 M)**

Q. 3) a) Draw AFD, SFD & BMD for the frame shown in fig. 3. **(10 M)**

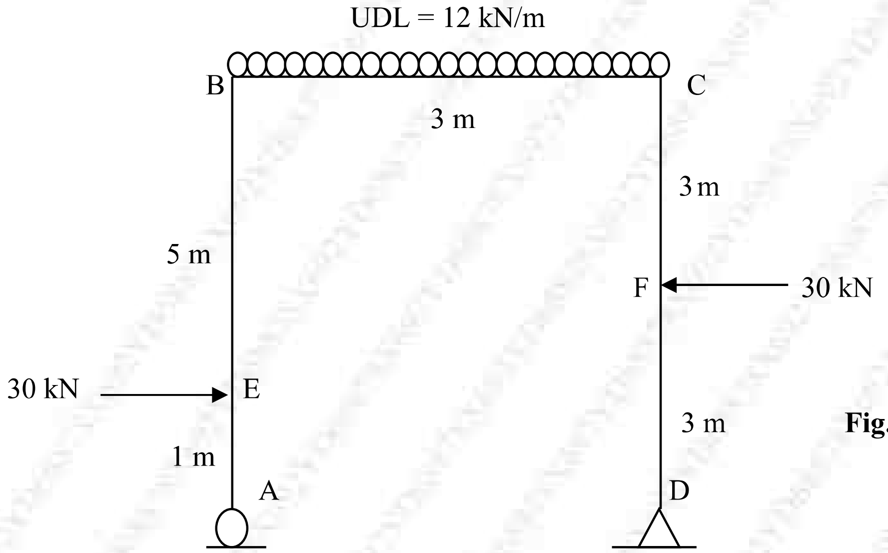

Fig. 3

b) An I-beam section has top flange of (200 mm x 35 mm), web of (25 mm x 130 mm) & bottom flange of (150 mm x 20 mm). It is subjected to a shear force of 170 kN. Draw shear stress distribution diagram across the C/S. **(10 M)**

Q. 4) a) A steel bar shown in fig. 4 has a diameter of 60 mm. Determine change in the length of bar. Young's modulus is 2.1 x 10^5 MPa. **(05 M)**

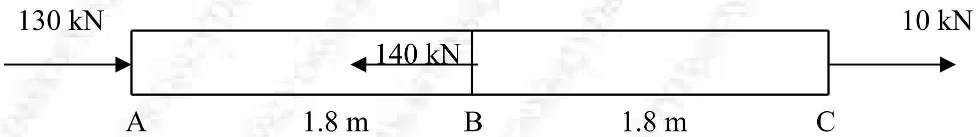

Fig. 4

b) A vertical steel bar 45 mm in diameter & 2.3 m long has a collar at the lower end. Determine the maximum weight that can be dropped through a height of 140 mm over the collar, if maximum allowable tensile stress in steel bar is 155 MPa. Take E = 200 GPa. **(05 M)**

c) A hollow circular shaft has an external diameter of 180 mm. Its internal diameter is 0.7 times the external diameter. Determine the power that can be transmitted if permissible shear stress is 150 MPa & maximum angle of twist is 2.5 degrees for 3.8 m length. Shaft sped is 175 RPM. Maximum torque exceeds average torque by 16%. Take modulus of rigidity as 80 GPa. **(10 M)**

Q. 5) a) For an overhanging beam shown in fig. 5, determine slope at D & deflection at A. Use Macaulay's double integration method. **(10 M)**

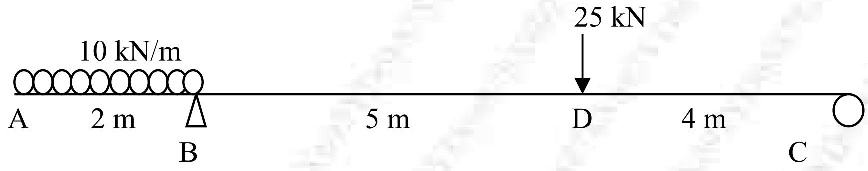

Fig. 5

b) The principal stresses at a point across two perpendicular planes are 165 MPa horizontal (Compressive) & 100 MPa vertical (Tensile). Calculate normal stress, tangential stress & resultant stress & its obliquity on a plane at 30 degrees with the major principal plane. **(10 M)**

Q. 6) a) A short hollow column has 280 mm external diameter & 210 mm internal diameter. When it is subjected to a load, stresses are 155 MPa (Compressive) at one end to zero at the other end. Determine the load value & distance of its line of action from the column axis. **(10 M)**

b) A hollow steel column of 5 m height has an outer diameter of 180 mm & thickness of 25 mm. It is pinned at both the ends. Determine Rankine's crippling load. Compare it with the Euler's crippling load. Take $E = 2.1 \times 10^5$ MPa, crushing stress = 330 MPa & Rankine's constant = (1/7350). **(10 M)**

(3 Hours)

Note: 1) Question No.**1** is **compulsory.** **Total Marks: 80**

2) Attempt **any THREE** from the remaining.

3) Figures to the right indicate full marks**.**

Q.1 A) Find the values of constants a,b,c and d if f(z) = $(x^2 + 2axy + by^2) + i(cx^2 + 2dxy + y^2)$ is analytic **5**

B) Find the Eigen Value of $A^3 - 3A^2$ **5**

Where A = $\begin{bmatrix} 4 & 6 & 6 \\ 1 & 3 & 2 \\ -1 & -4 & -3 \end{bmatrix}$

C) Find the Laplace Transform of t sin at **5**

D) Find the Fourier series expansion for f(x) = x defined in (-1,1) **5**

Q.2 A) If L[f(t)] = $\frac{s}{s^2+s+4}$ find L[$e^{-3t}f(2t)$] **6**

B) Find the Fourier series expansion for f(x) = x defined in $(-\pi, \pi)$ with period 2π **6**

C) Find the analytic function f(z) with the real part u = $x^3 - 3xy^2 + 3x^2 - 3y^2 + 1$ **8**

Q.3 A) Show that the function u = $x^3 - 3xy^2$ is harmonic function. Hence find the corresponding analytic function and harmonic conjugate. **6**

B) A string is stretched and fastened to two points distance L apart motion is started by displacing the string in the form u =$\alpha\sin(\frac{\pi x}{L})$ from which it is released at time t = 0. Show that the displacement of a point at a distance X from one end at time t is given by u(x,t) = $\alpha \sin\left(\frac{\pi x}{L}\right)\cos(\frac{\pi ct}{L})$ **6**

C) Obtain the Fourier series expansion of f(x) = $|x|$ where $-\pi \le x \le \pi$ **8**

Q.4 A) Find Laplace transform of $e^{-4t}\int_0^t u\sin 3u\, du$ **6**

B) Find Inverse Laplace transform of $\frac{2s+3}{s^2+2s+2}$ **6**

C) Verify Cayley – Hamilton theorem for the matrix A and hence find A^{-1} & A^4 **8**

where A = $\begin{bmatrix} 2 & 1 & 1 \\ 0 & 1 & 0 \\ 1 & 1 & 2 \end{bmatrix}$

Q.5 A) Solve by Crank-Nicholson simplified formula $\frac{\partial^2 u}{\partial x^2} - 16\frac{\partial u}{\partial t} = 0$,0$\le x \le 1$ subject to the condition u(0,t) = 0,u(1,t) = 100t , u(x,0) = 0, h = $\frac{1}{4}$ for one –time step. **6**

B) Find the inverse Laplace transform of log $\left(\frac{s+a}{s+b}\right)$ **6**

C) Show that the matrix A = $\begin{bmatrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 7 \end{bmatrix}$ is diagonalizable. Find transforming matrix and diagonal Matrix. **8**

Q.6 A) Evaluate $\int_0^\infty e^{-3t}\, t\sin t\, dt$ using Laplace transform. **6**

B) Find the solution $u_t = u_{xx}$ subject to u(0,t) = 0,u (5,t) = 0,u (x,0) = $x^2\,(25 - x^2)$ using Schmidt method taking h = 1 up to 3 seconds. **6**

C) Find the inverse Laplace transform of $\frac{s}{(s^2+1)^2}$ using convolution theorem. **8**

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Time: 3 Hour **Max. Marks: 80**

N. B.
1) Question No.1 is compulsory.
2) Attempt any three questions from the remaining five questions.
3) All questions carry equal marks.

Q1. Write notes on any FOUR [20]
- (a) Hume-Rothary conditions
- (b) Cooling curve of pure iron
- (c) Normalizing
- (d) Critical Resolved Shear Stress (C.R.S.S.)
- (e) Nano composites

Q2. (a) What is plastic deformation? Explain slip mechanism with a neat sketch. [10]
(b) Define fatigue failure. Discuss fatigue testing. Explain interpretation of S-N curve for ferrous and non –ferrous metals. [10]

Q3. (a) Classify various types of crystal defects? Discuss any one defect in details. [10]
(b) Draw the iron -iron carbide equilibrium diagram and write the important transformation seen in the diagram. [10]

Q4. (a) What is flame hardening process? Discuss advantages, disadvantages and applications of it. [8]
(b) Discuss the properties of polymer materials. [4]
(c) Derive an expression for Griffith's theory of brittle materials failure. [8]

Q5. (a) Draw and explain pack carburizing process. Discuss its applications. [8]
(b) Explain the processing of ceramics materials through injection moulding operation. [7]
(c) Define Shape Memory Alloys (SPA). Discuss their properties and applications. [5]

Q6. (a) Draw and explain Isomorphous and Eutectoid phase diagram. [6]
(b) Discuss working principle of ultrasonic testing machine with neat sketch. [8]
(c) Define nanotechnology? Discuss its applications in various fields. [6]

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Time: 3 hours | Max. Marks: 80

Note-
1. Question one is compulsory.
2. Solve any three out of remaining five.

Q.1		**Write Short notes with sketch wherever applicable. (Solve any Four)**	20
	a	Pattern Allowances	
	b	Friction welding	
	c	Rolling defects	
	d	Gear shaping	
	e	Industrial revolutions	
Q.2	a	Explain the desirables properties of molding sands, also explain different types molding sands used in the foundry	10
	b	Classify welding and compare soldering and brazing	10
Q.3	a	Describe different types of dies with neat sketches	10
	b	Write short not on column and knee type milling machine	10
Q.4	a	What are various methods of taper turning on lathe machine, explain any one type in detail with neat sketch	10
	b	Explain stepwise procedure of powder metallurgy.	10
Q.5	a	Describe the investment casting process with neat sketches.	10
	b	Write short note on thermit welding with their advantages, disadvantages applications.	10
Q.6	a	Compare the following 1. Shaper and planer 2. Hot chamber and cold chamber die casting	10
	b	List various nontraditional machining methods and explain electro-chemical machining in detail	10

3 Hours **Total Marks: 80**

- *Question-1 is compulsory.*
- *Answer any three from remaining five questions.*
- *Assume any suitable data, wherever required, but justify the same. Assumptions made should be clearly stated.*
- *Illustrate the answers with sketches, wherever required.*

I *Answer any four of the following:*

a. A brass bar with a cross section area of 1000 mm^2 (area of entire bar) is subjected to axial force as shown in Fig. 1. Determine total elongation of the bar. Take E =1.05×10^5 N/mm^2. **(05)**

Fig.1

b. A rectangular beam of 200 mm wide and 250 mm deep, is subjected to maximum shear of 50 kN. Determine 1) Average shear stress 2) Maximum shear stress. **(05)**

c. Determine the maximum power transmitted by a shaft of 60 mm diameter rotating at 300 rpm, given that maximum permissible shear stress is 80 N/mm^2. **(05)**

d. What are the assumption made in theory of bending. **(05)**

e. Differentiate between column and struts. State different end conditions for columns with equation **(05)**

f. Differentiate between thick cylinder and thin cylinder. Define hoop stress and Longitudinal Stress. **(05)**

II a) T-shaped cross section of a beam is subjected to a vertical shear force of 30 kN as shown in Fig. 2. Determine the shear stress at the neutral axis and at the junction of web and flange. Draw shear distribution for figure no.2. Assume the moment of Inertia about horizontal neutral axis is 29.56 × 10^6 mm^4 **(10)**

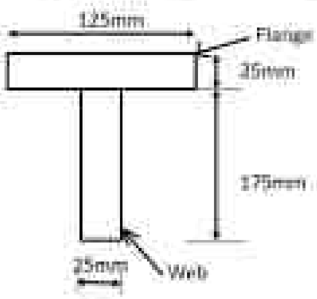

Fig. 2

II b) A 10 m long overhanging beam is loaded as shown in Fig. 3. Determine the shear force and bending moment with SFD and BMD diagram at various salient point. **(10)**

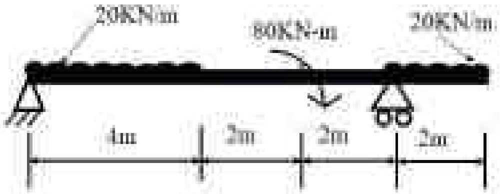

Fig.3

III a) A column of timber, with a section of 10 cm x 15 cm and length of 5 m has both ends fixed. If theYoung's modulus for timber = 17.5 kN/mm^2. Determine, i) Crippling load ii) Safe load for column if factor of safety is 3. **(10)**

III b) A simply supported beam of span 10 m, carries loads as shown in Fig. 4, with a hinge support at A and roller support at B. Determine the slope at the ends and deflection at point D, consider EI is constant. **(10)**

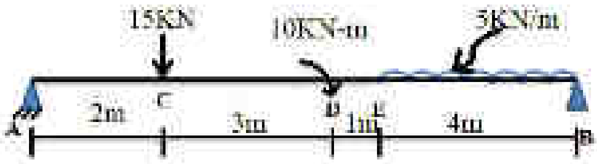

Fig. 4

IV a) At a certain point in a strained material, the stresses on the two planes at right angles to each other are 40 N/mm^2 and 20 N/mm^2 respectively (both tensile). They are accompanied by the shear stress of magnitude 20 N/mm^2. Determine the principal stresses and location of principal planes using Mohr circle and analytical method. **(10)**

IV b) A water main of 90 cm diameter contains water at a pressure head of 110 m. If the weight density of water is 9810 mm^3, determine the thickness of the metal required for the water main. Given the permissible stress as 22 N/mm^2. **(10)**

V a) A steel tube of 30 mm external diameter and 25 mm internal diameter encloses a gun metal rod of 20 mm diameter to which it is rigidly joined at each end. The temperature of the whole assembly is 140°C and the nuts on the rod are then screwed lightly on the ends of the tube. Calculate the intensity of stress in the rod when the common temperature has fallen to 30°C. The value of E for steel and gun metal is 2.1 x 10^5 N/mm^2 and 1 x 10^5 N/mm^2. The linear co-efficient of expansion for steel and gun metal is 12 x 10^{-6} per °C and 20 x 10^{-6} per °C. **(10)**

V b) A cast iron bracket, subjected to bending, has a cross-section of an 'I' shape with unequal flanges. If the compressive stress in top flange is not to exceed 17.5 N/mm^2, determine bending moment the section can withstand. Take dimensions of I section as: Top flange: 250 mm × 50 mm, web: 50 mm × 250 mm and bottom flange: 150 mm × 50 mm. **(10)**

VI a) A hollow circular shaft has inside diameter 60% as that of outside diameter. The solid shaft is replaced by a hollow shaft with same power and at the same speed. Determine percentage saving in material, if the same material to be used. **(10)**

VI b) Determine the instantaneous stress produced in a bar with a cross-sectional area of 10 cm^2 and a length of 4 m by the sudden application of the tensile load of unknown magnitude. Extension of the bar due to suddenly applied load is 1.35 mm. Also determine the magnitude of suddenly applied load. Take E= 2 x 10^5 N/mm^2. **(10)**

Duration: 3hrs **Marks:80**

N.B: (1) Question No 1 is Compulsory.
(2) Attempt any three questions out of the remaining five.
(3) All questions carry equal marks.
(4) Assume suitable data, if required and state it clearly.
(5) Use Steam Table.

1 Attempt any Five [20]

a) Define a thermodynamic system. Distinguish between open and closed systems with examples.

b) Define Thermal Reservoir. Difference between Heat Engine, Heat pump, Refrigerator Drive the COP of heat pump is greater than one

c) Define Joule Thomson coefficient and state its significance

d) Prove that Entropy is property of the system

e) Define a) Mach number b) Stagnation temperature c) Stagnation Pressure d) Sonic flow.

f) A gas undergoes a reversible non-flow process according to the relation p = (-3v +15) where V is the volume in $m^3$and p is the pressure in bar. Determine work done when the volume changes from 3 to 6 m^3.

2 a) Write two major statements of second law of thermodynamics and explain how the concept of thermal efficiency and coefficient of performance are generated by this law. [08]

b) 2 kg of an ideal gas occupies a volume of $0.3m^3$ at 10 bar pressure and 500K temperature when this gas expands polytropically $PV^{1.2}$ =C the internal energy decreases by 300KJ. and $\gamma = 1.4$ Determine a) Specific gas constant b) Final temperature, pressure and volume c) Heat and work interaction across the system boundary. [12]

3 a) What do you mean by availability? A system at 450 K receives 225 kJ/s of heat energy from a source at 1500K, and the temperature of both the system and source remain constant during the heat transfer process. Determine net change in entropy, available energy of heat sources and system, and decrease in available energy Take atmospheric temperature equal to 300 K. [10]

b) Explain various components of a simple steam power plant with sketch. [06]

c) Define and explain the terms Available energy, Un-available energy, irreversibility and Dead state. [04]

4 a) Sketch and explain the Rankine cycle on p-v and T-s plots. [08]

b) Define a) wet steam b) Superheated steam c) Dryness fraction d) Saturation temperature. Steam initially at 0.95 dry and 12 bar expands isentropic ally in a non-flow process in a final dryness fraction of 0.8. What is the final pressure of steam and enthalpy change during the process? [12]

5 a) In a thermal power plant operating on an ideal Rankine cycle, superheated steam produced at 5MPa and 500°C is fed to a turbine where it expands to the condenser pressure of 10kPa. If the net power output of the plant is to be 20MW, evaluate: [12]

i) Heat added in the boiler in kJ/k ii) The thermal efficiency.

iii) The mass flow rate of steam in kg/sec

b) What is cut off ratio? What are assumptions of air standard cycle? [08]

For same compression ratio and heat supplied, compare Otto and Diesel cycle with the help of P-V and T-S Diagram.

6 a) An oil engine takes in air at 1.01 bar. 20°C and the maximum cycle pressure is 69 bar. The compression ratio is 18. Calculate the air standard thermal efficiency based on the dual combustion cycle. Assume that the heat added at constant volume is equal to the heat added at constant pressure. [12]

b) Explain the effect of variation in back pressure on C-D nozzle performance [08]

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