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Bharatiya Vidya Bhavan's

Sardar Patel College of Engineering

(A Government Aided Autonomous Institute)
Munshi Nagar, Andheri (West), Mumbai – 400058.

RE-Examination, June 2016

M.Tech. (Thermal), Sem-I **M.Tech. in Mechanical Engineering**

TRANSPORT PHENOMENA

Max. Marks: 100 **Duration: 4 Hours**

Master file.

Instructions:

- Answer any **FIVE** from seven questions.
- Answers to all sub questions should be grouped together
- Make suitable assumption if needed with proper reasoning
- Figures on right in square bracket shows maximum marks for a particular sub-question.

1. A. Write boundary layer equation under the assumption proposed by Prandtl. What is Von Karmon's Momentum Integral equation? Derive a mathematical expression for it. **[10]**

B. Assuming second degree velocity distribution in the boundary layer, determine using the integral momentum equation, the thickness of boundary layer, friction coefficient, displacement and momentum thicknesses. **[10]**

2. A. What is meant by exergy? Derive the expression for exergy loss in a process executed by: **[10]**
(a) closed system,
(b) open system.

B. Differentiate between developed and developing region for laminar and turbulent flow, **[10]**

For a given flow field $\vec{V} = \left(y^2 + 2xz\right)\vec{i} + \left(-2yz + x^2yz\right)\vec{j} + \left(\frac{1}{2}x^2z^2 + x^3y^4\right)\vec{k}$ explain

(i) Is this flow possible?
(ii) Is this flow steady or unsteady?
(iii)Is it a possible incompressible flow?
(iv) Find an expression for shear stress τ_{xy} and τ_{yz}.

3. A Assume a steady incompressible laminar parallel flow between two parallel plates separated by a small gap 'b' and moving in opposite direction with equal velocity. Develop a governing equation for the problem using 2D-Navier Stokes equation and derive an expression for velocity profile Estimate following quantities: Maximum and average velocity, (ii) Volume flow rate, and (iii) Pressure drop **[10[**

B. Liquid water at 200 kPa and 20°C is heated in a chamber by mixing it with superheated steam at 200 kPa and 150°C. Liquid water enters the mixing chamber at a rate of 2.5 kg/s, and the chamber is estimated to lose heat to the surrounding air at 25°C at a rate of 1200 kJ/min. If the mixture leaves the mixing chamber at 200 kPa and 60°C, determine (*a*) the **[10[**

mass flow rate of the superheated steam and (b) the rate of entropy generation during this mixing process.

assuming minimum mesh size=12 cells and considering stability restriction imposed by explicit scheme, show time evolution of temperature for minimum 5 time steps in tabular form.

(Take thermal diffusivity α for the material as 10^{-5} m^2/s).

[20]

4. Answer any **four (04)** of the following with sufficient illustration:
   (i) What is the need of thermodynamic laws for the analysis of thermal a system?
   (ii) What do you understand by boundary condition? Write about common thermal and flow boundary conditions.
   (iii) Discuss characteristic features of a turbulent flow.
   (iv) Define boundary layer. Explain the concept of displacement and momentum thickness.
   (v) What is flow separation? Why does it occur?

5. A. What is heat transfer coefficient? List down the important parameters influencing it. [10]
Show the variation of h in laminar, transition and turbulent regions and explain the reasons for such variation.

B. Write the differential form of common conservation law applied to a thermal system [10]
and explain the meaning of each terms involved there.
A liquid flows down an inclined plane surface in a steady, fully developed laminar film of thickness h. Simplify the continuity and Navier Stokes equations to model this flow field. Clearly state all the assumption made reasons.

6. A. Define and Explain the physical meaning of following non-dimensional numbers: [10]
   a. Reynolds number,
   b. Nusselt number,
   c. Prandtl number and
   d. Grashof number

B. A pressure vessel has a volume of $2.83m^3$. It contains air at 7 MPa and 65°C. A valve is [10]
now opened and highly pressurized air at a rate of 0.455 kg/s and at temperature 144.4°C enters the vessel. Determine the gas pressure and temperature in the vessel after 1 minute of charging.

7. A. What is transient heat conduction? Explain it with suitable examples. Listing all [10]
assumption made in lumped parameter model analysis develop a governing equation and get a general solution. State the condition of its validity.

B. Write differential form of energy equation and explain the different terms involved [10]
Simplify the equation for the following cases:
   a. Two dimension transient heat conduction
   b. One dimension transient heat conduction with heat generation.

The temperature distribution across a copper plate 0.65 m thick heated from one side is given by $T = 70 - 80x + 24x^2$ where T is in K and x is in meters. Calculate the heat flux at x = 0, x = 0.25 m and x = 0.65 m. Thermal conductivity of the material is 386 W/mK.

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Sardar Patel College of Engineering
Department of Mechanical Engineering

MTech Thermal Sem I Reexamination June 2016

Subject: Energy Resources Conversion and Management

Use of Steam Tables and Mollier Diagram is permitted

Answer any 5 questions

Master file.

Q1

(a) Bhutan is a carbon positive country- Explain this statement (5)

(b) The world total coal reserves are estimated to be approximately 10^{12} tons. The current annual consumption rate is $6.62*10^9$ tons and the consumption of coal increases by 0.85% per year. Estimate the lifetime of this resource (5)

(c) What is cogeneration? What are its advantages? (5)

(d) Explain what is the HDI (Human Development Index)? (5)

Q2

(a) What are the main drawbacks of Indian coal? (5)

(b) With schematic and cycle diagram, explain Ultra Supercritical Generation Technology. (5)

(c) Derive an expression for the efficiency(η) of a Steam and Gas Combined Cycle plant, in terms of η_s the steam cycle efficiency and η_g the gas cycle efficiency (5)

(d) With a neat sketch, explain the principle of working of a Fluidized Bed Boiler. What are its advantages? (5)

Q3

(a) Steam enters a turbine at the rate of 6kg/s at a condition of 4MPa and 450°C and exits at 0.3 MPa and 150°C. The steam loses heat to the surrounding air at 100kPa and 25°C at the rate of 300W. Find the actual power output, maximum possible power output, second law efficiency, exergy destroyed and exergy of steam at inlet (8)

(b) A steam power plant uses a Rankine cycle with reheat. Steam enters the high pressure turbine at 10MPa and 500°C and leaves at 5MPa. Steam is then reheated at constant pressure to 500°C before it expands to 20kPa in the low pressure turbine. Determine the exergy destruction in each of the processes of the cycle and find second law efficiency of the cycle. Neglect pump work. Assume source temperature of 1800K and sink temperature of 300K. Isentropic efficiency of both HP and LP turbines are 80%. (Use Mollier chart to solve this problem) (12)

Q4

(a) Find the length and size of the shadow cast by a wind mill of 15m height. Assume that the windmill can be approximated to a cylinder of 3m diameter. Date: 23rd December, Time: 11hrs LAT. Location 19° N latitude

For a horizontal Surface, angle of incidence $\theta = \theta_z$ is given by,

$\cos\theta = \sin\delta \sin\varphi + \cos\delta \cos\varphi \cos\omega$.....where all notations are standard

Solar azimuth angle is given by

$\cos\gamma_s = (\cos\theta_z \sin\varphi - \sin\delta)/(\sin\theta_z \cos\varphi)$ (10)

(b) A remote village in India has a requirement of 50kW of power for lighting purposes from 6pm to 10pm everyday. Suggest a solution as to how this can be met using different renewable sources of energy (10)

Q5

(a) Explain the terms- Fissile and Fertile material. Give examples of each (5)

(b) The half life of ^{231}Pa is 3.25×10^4 years. How much of an initial 10.40 microgram sample remains after 3.25×10^5 years? (5)

(c) Discuss the variation of neutron cross section with neutron energy and use it to explain the function of the moderator in a nuclear reactor. (5)

(d) With a neat sketch explain the working of the BWR type of Nuclear reactor. How does it differ from the CANDU reactor (5)

Q6

(a) A wind tower measures the velocity of wind at a height 9.1 m to be 12 m/s. Calculate the power density of the wind at this height. A large wind turbine with 48 m diameter is placed at this location. The hub of the turbine is 50 m from the ground. Determine the power density of the wind at the hub. Also determine the maximum power that can be delivered by this turbine at this wind velocity. The wind velocity changes in proportion to the square of the height from the ground (10)

(b) An Anderson OTEC power plant generates 150 MW net power. It uses ammonia as its working fluid. Generation takes place at 21°C and condensation at 10°C. The turbine efficiency is 80% and turbine generator efficiency is 88%. The temperature rise of the seawater in the evaporator and in the condenser is 4°C. Find Mass flow rate of ammonia, Warm and cold sea water flow rates and plant thermal efficiency. Assume that condition of the ammonia vapor entering the turbine is dry saturated. (10)

Ammonia properties

Sat. temperature °C	Sat. pressure (Bar)	hf (kJ/kg)	hg(kJ/kg)	sf(kJ/kg.K)	sg(kJ/kg.K)
10	6.151	227.7	1454.2	0.8814	5.2141
21	8.85	270.8	1463.2	1.06	5.0843

Q7

Answer **any 4** of the following

(a) Write a note on Sankay and Grassmann diagram

(b) India's Nuclear energy program

(c) 2 time zones in India can reduce energy demand- True or false, explain

(d) Coal Gasification

(e) Use of PCM for energy storage in solar applications

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SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)

End Exam **May 2016**

Total Marks :100 Duration : 4 Hours

CLASS/SEM :ME Mechanical SEM-II SUBJECT :Design of Power Transmission System

- Attempt any five question out of seven questions
- Answers to all sub questions should be grouped together
- Figures to the right indicate full marks
- Use of Design Data Book is permitted
- Assume suitable data if necessary.

Master file.

Sr No.		Marks	CO	Module
1A	A countershaft receives 26.25 KW from a motor through a coupling and transmit it via two belt drives to two machine tools each consuming 11.25kw. The configuration is as follows. The motor is coupled at right side. The distance between the bearings is 1.5m. Both pulleys are 0.5 m apart. Pulley 1 is 0.4 m from left end bearing. Pulley 2 is 0.6m away from right end bearing. The diameters of the pulley are 0.25 and 0.6m and their corresponding weights are 400 N and 750 N. Shaft speed is 30rad /s. • Compute Total belt pull for Pulley 1 And Pulley 2 • Compute Bearing reaction in Horizontal Plane • Draw the BMD in Horizontal plane • Find bearing reaction in vertical plane • Draw the bearing reaction in Vertical Plane • Find the resultant bending moment for pulley section 1, 2 • Find the twisting moment • Show twisting moment • Find equivalent twisting moment at section 1 [of pulley 1] • Find equivalent twisting moment at section 2 [of pulley 2] • Find the shaft diameter.	[10]	CO3	M-3
1B	A journal bearing is proposed for a centrifugal pump. The diameter of the journal is 0.15m and the load on it is 40kN and the speed is 900 rev/min. Design the bearing. • Compute length of bearing • Compute bearing pressure • Calculate the bearing modulus • Comment on hydrodynamic conditions of bearing operation • Compute coefficient of friction • Compute heat generated • Compute heat dissipated • Compare and comment on heat dissipation and heat generation	[10]	CO3	M3

2A	A hydraulically operated clutch is to be designed for an automatically operated lathe. Determine the number of plates and the operating force required for a clutch which is to transmit the torsional moment of 35 Nm under normal operating conditions. The clutch is to be designed to slip under 300 percent of rated torsional moment to protect gears and other parts of the drive The limits for diameters for friction-surface are 100 mm and 62.5 mm	**[10]**	**CO3**	**M3**
2B	A speed reducer unit is to be designed for a special machine tool for an input of 0.75 kW with a transmission ratio of 27. The speed of the hardened steel worm is 1750 rev/min. The worm wheel is to be made of the phosphor bronze. The tooth form is to be 20° involute.	**[10]**	**CO1**	**M4**
3A	A rope drum of an elevator having 650 mm diameter is fitted with a brake drum of 1 m diameter. The brake drum is provided with four CI brake shoes each subtending an angle of 45^{0}. The mass of the elevator is 2000 kg and moves with a speed of 2.5m/s. The brake has capacity to stop the elevator in 2.75 m. Assume Coefficient of Friction between drum and shoes 0.2 Find width of shoe if allowable pressure on shoe is limited to $0.3N/mm^2$. Find also heat generated in stopping the elevator.	**[10]**	**CO3**	**M4**
3B	Prepare a comparative statement for different methods of flow control in hydraulic circuit.	**[10]**	**CO1**	**M2**
4A	Explain briefly the main parameters affecting the selection of a hydraulic pump.	**[10]**	**CO1**	**M2, M6**
4B	Explain the uses of Accumulator in a power transmission system with neat sketches.	**[10]**	**CO1**	**M2**
5A	Prepare a Comparative statement of different types of prime movers, characteristics, limitations, application and selection.	**[10]**	**CO1**	**M1**
5B	A Compressor is to run at 250 rpm and requires 90 KW. The drive is provided by the V-belts from an electric motor running at 750 rpm. The diameter of pulley on the compressor shaft is restricted to 1m. Whereas the centre distance between the pulleys is limited to 1.75m. The belt speed should not exceed 1600 m/min. Determine the number of V-belts required to transmit the power if each belt has a cross sectional area of $375mm^2$, Density $1000Kg/m^3$ and allowable tensile Stress of 2,5MPa.. The groove angle of pulley is 35°.The coefficient of friction between belt and pulley is 0.25. Also compute length of belt. Assume suitable data if required. Comment on Slip, Wear characteristics, Creep, Noise, Initial Cost, Maintenance cost.	**[10]**	**CO3, CO2**	**M2, M6**
6A	A rope drive transmits 250 kW at 300 rpm has pulley diameter 1.2m. Angle of lap 180^{0}. And groove angle 45^{0}. The ropes to be used are 50 mm in diameter. The mass of the rope is 1.3kg/m length. Each rope has maximum pull of 2200 N. the coefficient of friction between the rope and pulley is 0.3. Determine no. of ropes required. If the overhang of the pulley is 0.5 m suggest suitable size for the pulley shaft if it is made of steel with a shear stress of 40 MPa. Comment on Efficiency, slip, shaft layout, initial costs, operation cost, wear, Noise, Life.	**[10]**	**CO2, CO3**	**M2, M6**

6B	Design a chain drive to actuate a compressor from 15 kW electric motor running at 1000 rpm, the compressor speed being 350 rpm. The minimum centre distance is 500 mm. The compressor oprates 16 hours per day. The chain tension may be adjusted by shifting the motor on slides. Comment on Wear, Fatigue, Impact Characteristics, Efficiency, slip, shaft layout, initial costs, operation cost, wear, Noise, Life.	**[10]**	**CO2, CO3**	**M2, M6**
7A	A pair of cast iron bevel gears connect two shafts at right angle. The pitch diameter of the pinion and gear are 80 mm and 100 mm respectively. The tooth profile of the gears are of 14.5 ° composite form. The allowable static stress for both the gears is 55 MPa. If the pinion transmit the 2.75 kW at 1100 rpm find the module and number of teeth on each gear from the standpoint of strength and check the design from the stand point of wear. Take surface endurance limit as 630MPa and Modulus of elasticity for CI as 84 kN/mm^2	**[10]**	**CO2, CO3**	**M2, M6**
7B	Design a suitable compact system to conduct performance test of Pelton Wheel in a laboratory. The system will include all required elements like Pelton wheel, Centrifugal pump, Suction valve, suction pipe, Delivery valve, delivery pipe, Tank for flow measurement, etc. Justify the selection of each component. Assume suitable data. Comment on motor selection. Pump selection. Comment on Life, Noise, Vibration.	**[10]**	**CO1, CO3**	**M5, M7**

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BHARATIYA VIDYA BHAVAN'S

SARDAR PATEL COLLEGE OF ENGINEERING

Munshi Nagar, Andheri (West),Mumbai 400 058

(A Government Aided Autonomous Institute)

Re- Examination, June 2016

M.Tech. (Thermal), SEM-II — **COMPUTATIONAL FLUID DYNAMICS**

Duration: **4 Hour** Max Marks: **100**

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Instructions:

- Answer any **FIVE** (05) questions.
- Figure to the right of questions indicate full marks.
- Make suitable assumption if required.
- Answers to all sub-questions should be grouped together.

1. Assume volumetric heat generation $q = 500\ kW/m^3$ in a steady state heat conduction through a plane wall. Both face A and B of wall are maintained at constant temperatures, i.e., $T_A = T_B = 100°C$ **20**
   Data: Wall thickness L = 2cm,
   Constant thermal conductivity $k = 5\ W/m^2.K$,
   (a) Discretize the computational domain in 5 equal parts and and develop discretized equation.
   (b) Find nodal temperature by a direct method and compare it with a converged iterative solution.

2. a) Explain Crank-Nicolson differencing scheme to solve problems governed by parabolic equations. **10**
   b) Classify PDE's of flow problems and characterize them. **5**
   c) What is difference between modeling and simulation? **5**

3. a) Explain turbulence phenomena and its characteristic features? **10**
   b) What do you understand by turbulence model? Discuss the effect of turbulence on flow and heat transfer. **10**

4. a) Explain following discretization scheme with detail and proper illustration. **10**
      (i) Finite Difference Method
      (ii) Finite Volume Mehod
   b) Solve the following system of equations using Gauss-Seidel method **10**

$$5x_1 + 2x_2 + x_3 = 12$$
$$x_1 + 4x_2 + 2x_3 = 15$$
$$x_1 + 2x_2 + 5x_3 = 20$$

   Compare the result with Jacobi iterative method with 4 iterative solution.

5. a) What is up-winding? How does it differ from central difference scheme? Explain both clearly. **5**
   b) Discuss convergence and stability issues associated with one dimensional uncoupled transient convection-diffusion heat transfer under central difference interpolation of convective terms. **15**

6. a) Discuss the complexities associated with numerical modeling of flow problems. **5**

   b) Drive pressure correction equation for 2d-incompressible flow problem. **15**

7. a) What is the need of boundary condition to solve a flow problem? List down different thermal and flow boundary conditions used in CFD. Explain them by giving suitable example. **10**

   b) A long square cross section steel ingot of size 40cm at red hot temperature of 500°C is suddenly brought into blowing air 20°C with heat transfer coefficient 80 W/m^2K. To study the temporal evolution of temperature by neglecting any radiation if present, **10**

   (i) show the computational domain with proper reasoning.

   (ii) write the governing equation with initial and boundary condition.

   (iii) write numerical model to calculate domain temperature using ADI scheme.

   (iv) assuming minimum mesh size=12 cells and considering stability restriction imposed by explicit scheme, show time evolution of temperature for minimum 5 time steps in tabular form.

   (Take thermal diffusivity α for the material as 10^{-5} m^2/s).

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9/5/2016

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Sardar Patel College of Engineering

(A Government Aided Autonomous Institute)

Munshi Nagar, Andheri (West), Mumbai – 400058.

End Semester Exam

May 2016

Max. Marks: **100** Duration: **4 hrs**

Class: **M. Tech. (Thermal Engg)** Semester: **II** Program: **Mech Engg**

Name of the Course: **Design of Heat Exchanger** Course Code: **MTTH 201**

Master file.

Instructions:

- Use of HMT Data Book and HEAT EXCHANGER DESIGN DATA BOOK are allowed.
- **Question No. 1 is compulsory.**
- Attempt **any Four questions** out of remaining six questions.
- Answers to all sub questions should be grouped together.
- All questions carry equal marks.
- Make suitable assumptions with proper explanations.

Q. No.		Marks	CO No.	M No
Q. 1	**Answer the following questions (any five)**	**20**	1 - 3	1-6
a)	What are the advantages and the limitations of Gasketed plate heat exchangers?			
b)	What is Bell Delaware method of shell and tube heat exchangers?			
c)	State and explain problems that occur due to maldistribution? What are the causes of maldistribution?			
d)	State the shell and tube heat exchanger characteristics, typical areas of application, advantages, limitations and current status.			
e)	Explain the effects of fouling on heat transfer, pressure drop of heat exchanger.			
f)	Explain gas-to-gas heat exchangers and its applications.			
Q. 2	Distilled water with a flow rate of 50 kg/s enters a baffled shell and tube heat exchanger at 32°C and leaves at 22°C. Heat will be transferred to 150 kg/s of raw water coming from a supply at 20°C. Design a **heat exchanger** for this purpose. **A single shell and single tube pass is preferable.** The tube diameter is ¾ inch (19 mm OD with 16 mm ID) and tubes are laid out on a 1 inch square pitch. Use the baffle spacing of 0.5 m. A maximum length of the heat exchanger of 8 m is required because of space limitations. The tube material is 0.5Cr-alloy (K = 42.3W/m.K). Assume a total fouling resistance of 1.76×10^{-4} m^2.K/W. Note that surface over design should not exceed 30%. The maximum flow velocity through the tube is also suggested to be 2 m/s to prevent erosion. Perform thermal analysis of the heat exchanger by Kern Method. Take properties of shell side fluid and tubes side fluid at T_b from property table. Use correlation for shell side heat transfer coefficient as:	**20**	3	2 & 4

$Nu = \frac{h_o D_h}{k} = 0.36 (Re)^{0.55} (Pr)^{0.33}$

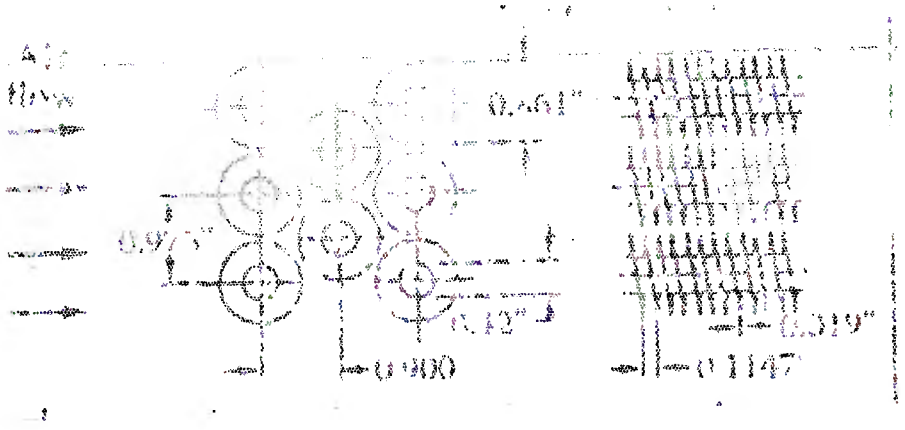
Use correlation for tube side heat transf. coefficient as

$$Nu = \frac{\frac{f}{2}(Re-2000)Pr}{1.07+12.7\sqrt{\frac{f}{2}}\left(Pr^{\frac{2}{3}}-1\right)} \quad \text{and} \quad f = [1.53\ln(Re) - 3.28]^{-2}$$

Use correlation for pressure drop on the shell side and tube side respectively:

$$(\Delta P)_S = \frac{f G_s^2 (N_b+1) D_s}{2\rho D_e \phi_s} \quad \text{and} \quad (\Delta P)_T = \left[4 f \left(\frac{L_t}{d_i}\right) + 4 N_p\right] \left[\frac{\rho v_m^2}{2}\right]$$

Q. 3 A)	Air enters the core of a finned-tube heat exchanger as shown in figure at 1 atm and 25°C. Surface (A = 8.7 ... tube OD = 1.07 cm, fin pitch = 3.13/cm, fin thickness = 0.04 cm, fin area / total area = ... tube passage hydraulic diameter = D_h = 0.443 ... free-flow area / frontal area = 0.494, heat transfer area / total volume = 445 m^2/m^3	10	2	3



The air flows at a rate of 1500 kg/h perpendicular to the tubes and exits with a mean temperature of 120°C. The core is 0.5 m long with a 0.25 m^2 frontal area. Calculate the total pressure drop between the air inlet and outlet and the average heat transfer coefficient on the air side.

Take air densities at the inlet (25°C) and outlet temperature (120°C) from properties table.

Also find properties of air at bulk mean temperature from property table.

Take f = 0.057 and colburn modulus = 0.0167 from TEMA at that Reynolds number.

Take air densities at the inlet and the outlet are: ρ_i = 1.177 kg/m^3 and ρ_o = 0.954 kg/m^3,

Take properties at mean temperature as C_p = 1.007 KJ/kgK, μ = 1.038 kg/m·s

Pr = 0.719, μ = 22.04 x 10^{-6} kg/m·s

B)	What do you mean by Enhancement Ratio in compact heat exchanger? What are the objectives of design of compact heat exchanger?	10	2	3

Q. 4	Gasketed-plate heat exchanger will be used for heating city water (R_{fc} = 0.00006 m^2.k/W) using the wastewater (R_{fh} = 0.00006 m2.k/W) available at 90°C. The vertical distance between the ports (L_v) of the plate is 1.60 m and the width of the plate (L_w) is 0.50 m with a gap between the plates (b) of 6 mm. The enlargement factor (ϕ) is given by the manufacturer as 1.17 and the chevron angle (β) is 50°. The plates are made of titanium (k = 20 W/m.k) with a thickness (t) of 0.6 mm. The port diameter (D_p) is 150 mm. The cold water enters the plate heat exchanger at 15°C and leaves at 45°C at a rate 6 kg/s and it will be heated by the hot water available at 90°C, flowing at a rate of 12 kg/s. Considering single pass arrangements for both streams. Consider total number of plates (Nt) = 100, Total effective area = 100 m^2. Use correlation as: $Nu = (hD_h/k) = 0.3\ (Re)^{0.663}\ (Pr)^{0.333}\ (\mu_b/\mu_w)^{0.17}$ Take friction coefficient for hot and cold fluids as $f = (1.441)/(Re)^{0.206}$ The maximum permissible pressure drop is 50 psi. Collect the properties of both water from property table. List the result in Table and compare the results. Calculate the pressure drop for both streams.	**20**	3	6
Q. 5 A)	Explain the design consideration to decrease the effects of fouling of heat exchanger. State the different types of fouling. Explain the importance of fouling factor in design of heat exchanger.	**10**	2 & 3	3
B)	What are the different classifications of heat exchangers? Explain each type in brief. Draw the temperature profile diagram of following heat exchanger: i) Condenser ii) Evaporator iii) Counter flow arrangement iv) Parallel flow arrangement	**10**	2 & 3	1 – 2
Q. 6	The objective of design of a **finned double-pipe heat exchanger** is to design an oil cooler with sea water. Engine oil at a rate of 3 kg/s will be cooled from 65°C to 50°C by sea water at 20°C. The sea water outlet temperature is 30°C, and it flows through the inner tube. The following design data are selected: Length of hairpin = 4.5 m, Annulus nominal diameter = 2 inch, Nominal diameter of the inner tube = ¾ inch, Fin height = 12.7 mm, Fin thickness = 0.9 mm, Number of fins per tube = 30, Material throughout = carbon steel (K = 60W/m. K), Number of tubes inside the annulus = 1. Select the nominal diameter of the inner tube ¾ inch schedule 40 (OD = 26.67 mm and ID = 20.93 mm), The properties of fluids are:	**20**	3	2 & 4

	Annulus fluid (Oil)	Tube-side fluid (Sea Water)
Density, kg/m^3	885.27	1013.4
Specific heat, J/kg.K	1902	4004
Viscosity, kg/m.s	0.075	9.64×10^{-4}
Thermal conductivity, w/m.k	0.1442	0.639
Prandtl number, Pr	1050	6.29

	Use correlation for inner tube $f = [1.58 \ln (Re) - 3.28]^{-2}$ $$Nu_b = \frac{\left(\frac{f}{2}\right) Re . Pr}{1.07 + 12.7 \ (Pr^{0667} - 1)\sqrt{\frac{f}{2}}}$$ Use correlation for Annulus tube: $Nu_b = 1.86 [Re \ Pr \frac{D_h}{L}]^{0.33} (\frac{\mu_b}{\mu_w})^{0.14}$ For $[Re \ Pr \ (D_h/L)]^{0.33} \times (\mu_b/\mu_w)^{0.14} \geq 2$ Assume fouling resistance for engine oil = 1.76 X 10^{-4} m^2.K/W and for sea water = 0.088 X 10^{-3} m^2.K/W and **Calculate**: 1) Surface area of heat exchanger, 2) Number of hairpins, 3) Pressure drops and pumping power for both streams.			
Q. 7	A) Define Condenser. Explain the different classifications of condensers. Explain the overall design considerations of condensers. B) Explain the effects of pressure drops, LMTD, Fouling factors and overall heat transfer coefficient on design of heat exchanger.	**10** **10**	2 2	7 1 & 2

BHARATIYA VIDYA BHAVAN'S

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(A Government Aided Autonomous Institute)

Munshi Nagar, Andheri (West), Mumbai – 400058.

End Semester Examination

May 2016

Maximum Marks: 100 **Q. P. Code:** **Duration: 4 Hrs**

Class: **F.Y. M. Tech. (Mechanical) Thermal Engineering** Semester: **II**

Program: **M. Tech. (Mechanical) Thermal Engineering**

Name of the Course: **Experimental Analysis and Instrumentation**

Course Code: **MTTH202**

Instructions:

1. **Attempt any five questions.**
2. **Draw neat diagrams wherever necessary.**
3. **Assume suitable data if necessary.**

Master file.

Q. No.		Max. Marks	CO No.	Module No
1 (a)	Explain generalized measurement system with neat schematic diagram. Further map the different constituents of generalized measurement system with the physical elements of rotameter.	10	1	1
(b)	In vertical pipe carrying water, pressure gauges are inserted at points A and B where the pipe diameters are 0.15m and 0.075m respectively. The point B is 2.5m below A and when the flow rate down the pipe is 0.02 cumecs, the pressure at B is 14715 N/m^2 greater than that at A. Assuming the losses in the pipe between A and B can be expressed as $kv^2/(2g)$ where v is the velocity at A, find the value of *k*. If the gauges at A and B are replaced by tubes filled with water and connected to a U-tube containing mercury of relative density 13.6, give a sketch showing how the levels in the two limbs of the U-tube differ and calculate the value of this difference in metres.	10	2	4
2 (a)	A single strain gauge having resistance of 130 Ω is mounted on a steel cantilever beam at a distance 0.12 m from the free end. The beam dimensions are 25 cm (length) x 2.0 cm (width) x 0.3 cm (depth). An unknown force F applied at the free end produces a deflection of 11.8 mm of the free end. If the change in gauge resistance is found to be 0.145 Ω, calculate the gauge factor. Deflection of the free end $\delta = FL^3/3EI$. Take Young's modulus for steel as 200×10^9 N/m^2 Also derive the equation of the limiting error in determination of the unknown force F.	10	1	6

(b)	Only draw neat self explanatory sketches of (i) Film coefficient transducer (ii) Radial heat conduction apparatus (iii) Saybolt viscometer (iv) Thermal conductivity comparator	**10**	**2**	**5, 6**
3 (a)	Following table list the measuring instruments (left hand side column of the table) for measuring mechanical properties (right hand side column of the table) of the system. Students shall match the measuring instrument with the corresponding mechanical property. **Measuring Instruments** / **Properties** Guarded Hot plate Apparatus / Thermal Conductivity Pirani gauge / Pressure Hot wire anemometer / Displacement Optical Encoder / Flow rate Further student shall explain only the working principle of the measurement instrument listed on left hand side column of the table with neat sketch.	**04** **12**	**2**	**3, 4, 5**
(b)	The speed of a shaft rotating at 2880 rpm is measured using stroboscope. The stroboscope dial is slowly turned from setting of 4320 rpm to 1400 rpm corresponding to flashing rates of 96 to 24 per second. Indicate the speed setting which give single, double steady images.	**04**	**2**	**3**
4 (a)	With neat sketch explain the working and features of thermocouple, thermistor and resistance thermometer. Further draw the rough nature of resistance against temperature characteristics of these devices.	**08**	**2**	**4**
(b)	With neat sketch explain working principle of potentiometer. Further, derive the equation describing characteristics e_0/e_i, against x_i/x_t (e_0, e_i being output and input voltages respectively; and x_t=total length of translation pot and x_i=displacement of wiper from its zero position). Draw characteristics under ideal case and also considering potentiometer resistance Rp and load resistance Rm of external output measuring device being implemented in parallel arrangement in the unit. Draw rough nature of the characteristics.	**12**	**1, 2**	**3**
5	With neat sketches explain (i) Laser Doppler anemometer (ii) Capillary tube viscometer (iii) Sling psychrometer (iv) Ionization gauge	**20**	**2**	**4, 6**
6 (a)	With illustrative example explain digital to analog converters and its significance.	**8**	**3**	**7**
(b)	In a rotating cylinder viscometer, the radii of the cylinders are 32 mm and 30 mm and the outer cylinder is rotated steadily at 200 rpm. For a certain liquid filled in the annular space to a depth of 80 mm, the torque produced on the inner cylinder is 1.2×10^{-4} Nm (considering viscous friction at the bottom plane also). Bottom plane of the inner cylinder is separated with plane of outer cylinder by distance1mm and filled with same liquid. Calculate the viscosity of the liquid.	**12**	**2**	**6**
7 (a)	With neat sketches explain operational amplifier and its various modes	**10**	**3**	**7**
(b)	Figure 1 shows the unit step response of a second order system. Determine the following from the plot: (i) Damping ratio (ii) Natural Frequency (iii) Transfer function	**10**	**1**	**2**

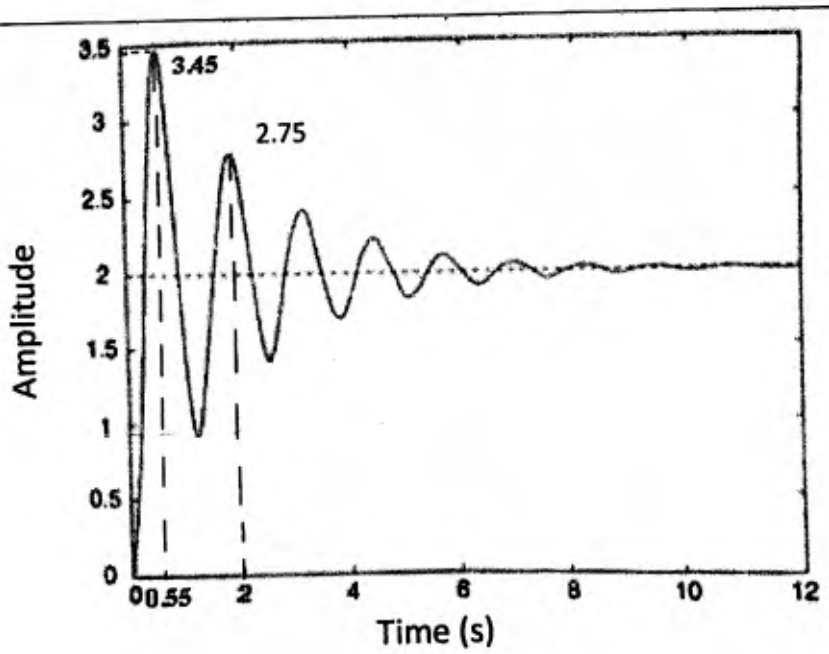

Figure 1

4th Sem
13/5/16

Bharatiya Vidya Bhavan's

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Munshi Nagar, Andheri (West), Mumbai – 400058.

End Semester Examination, May 2016

Master file.

M.Tech. (Thermal), Sem-II **M.Tech. in Mechanical Engineering**

COMPUTATIONAL FLUID MECHANICS

Max. Marks: 100 **Duration: 4 Hours**

Instructions:

- Answer any **FIVE** from seven questions.
- Answers to all sub questions should be grouped together
- Make suitable assumption if needed with proper reasoning
- Figures on right in square bracket shows maximum marks for a particular sub-question.
- Figure on the extreme right shows **course outcome number** and **module number** respectively as per the syllabus of the course.

1. Consider steady state heat conduction with heat generation. Both face A and B are maintained at constant temperatures. Data: Wall thickness L = 2cm, Constant thermal conductivity k = 5 $W/m^2.K$, $T_A = T_B = 100°C$, Volumetric heat generation q = 500 kW/m^3. **[20]** 1,6 &3

(a) Write the governing equation in both differential and integral form and mathematically represent appropriate boundary condition.

(b) Discretize the computational domain in 5 equal parts and write finite volume based nodal equation.

(c) Find nodal temperature by a direct method and compare it with a converged iterative solution.

2. A. List the different methods for discretization of governing equations. Explain any two of them in detail with proper illustration. **[10]** 2,4

B. Solve the following system of equations **[10]** 2,2

$$5x_1 + 2x_2 + x_3 = 12$$
$$x_1 + 4x_2 + 2x_3 = 15$$
$$x_1 + 2x_2 + 5x_3 = 20$$

using Gauss-Seidel method and compare the result with Jordon iterative method with 4 iterative solution and comment on the nature of solution.

3. A. Explain the relevance and significance of upwinding? How does it differ from central difference scheme? Explain both clearly. **[10]** 3,6

B. A long square cross section steel ingot of size 40cm at red hot temperature of 500°C is suddenly brought into blowing air 20°C with heat transfer coefficient 80 W/m^2K. To study the temporal evolution of temperature by neglecting any radiation if present, **[10]** 2,5

(i) show the computational domain with proper reasoning.

(ii) write the governing equation with initial and boundary condition.

(iii) write numerical model to calculate domain temperature using ADI scheme.
(iv) assuming minimum mesh size=12 cells and considering stability restriction imposed by explicit scheme, show time evolution of temperature for minimum 5 time steps in tabular form.
(Take thermal diffusivity α for the material as 10^{-5} m^2/s).

4. A. Explain turbulence phenomena and its characteristic features? **[10]** 3,7
B. What is the need of turbulence models? Classify them and list important features of at least two models. **[05]**
C. What is the effect of turbulence on heat transfer? Explain **[05]**

5. A. Explain Crank-Nicolson differencing to solve problems governed by parabolic equations. **[10]** 1,4
B. An insulated copper rod of length 1 m has initial temperature profile in degree Celsius is given by, $T(x, 0) = 5x^2+4x+20$. **[10]**
At $t = 0$. one end of the rod is brought in contact with 100°C and other end to 0°C. Use finite volume method for discretization and calculate the temperature across the rod after 4 time step where each time step may be assumed to be of 0.01s or any suitable time step to ensure the stability of solution.

6. A. Discuss the complexities associated with numerical modeling of flow problems. **[10]** 2,4
B. 'For incompressible flow problem, the continuity equation is a pressure equation.' Prove this statement in context to SIMPLE algorithm. [10]

7. A. Consider steady state heat diffusion in two dimension, **[10]** 1,5

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}=0$$

The boundary condition is given by:
$T(x,y)\ at\ x=0\ is\ 40°C,\quad and\quad T(x,y)\ at\ x=2m\ is\ 60°C$
$T(x,y)\ at\ y=0\ is\ 40°C,\quad and\quad T(x,y)\ at\ y=2m\ is\ 200°C$
Obtain the temperature profile T(x,y), considering 5 node in each direction and solving by line by line method for one vertical sweep.
B. Discuss convergence and stability issues associated with one dimensional uncoupled transient convection-diffusion heat transfer under central difference interpolation of convective terms. **[10]** 1,3

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End Semester Examination, May 2016

M.Tech. (Thermal), Sem-II **M.Tech. in Mechanical Engineering**

AIR CONDITIONING SYSTEM DESIGN

Max. Marks: 100 **Duration: 4 Hours**

Instructions: Master file.

- Answer any FIVE from seven questions.
- Answers to all sub questions should be grouped together
- Make suitable assumption if needed with proper reasoning
- Figures on the right shows maximum marks for a particular sub-question.
- Use of Psychrometric Chart, Copy of Carrier Handbook and Air conditioning charts and Tables is permitted

1. (a) Differentiate between Infiltration air and Ventilation Air. How do the two affect the Cooling Load estimation? **5**

(b) Effective Sensible Heat (ESH) is computed as Room Sensible Heat (RSH) plus Bypass Factor multiplied by Outside Air Sensible Heat (OASH). **5**

ESH=RSH+ BPF*OASH

Explain the logic behind this formula.

(c) The following data is available to design an air-conditioning system : **10**

(i) Indoor design condition	25°C DBT, 50% RH,
(ii) Outdoor design condition	35°C DBT, 28°C WBT,
(iii) Heat gain through walls	5.6 kW
(iv) Heat gain through roof	27.6 kW
(v) Heat gain through glass	3.2 kW
(vi) No. of people	60
(vii) Ventilation rate	0.5 cmm/person
(viii) Infiltration	5 cmm
(ix) Sensible heat gain from occupants	70 W per person
(x) Latent heat gain from occupants	90 W per person
(xi) Number of lights (60 W each)	10
(xii) By-Pass Factor (BF)	0.15

Assume duct heat gain of 5%, fan motor heat of 2.5%. A safety factor of 5% may be assumed for both sensible and latent heat.

Determine: (i) RSHF
(ii) Dehumidified air quantity
(iii) Ratio of OA to RA
(iv) Coil Apparatus dew point
(v) Tonnage of refrigeration.

2. (a) How do Variable Air Volume (VAV) systems reduce energy use? Compare it with Constant Air Volume (CAV) systems **10**

(b) Use a neat sketch and Name the essential components of a Cooling Tower 5

(c) Write a note on fans used in air conditioning practice 5

3. The following data was collected with respect to an OFFICE space to be conditioned. It is located on the TOP floor of a building. The floor below is non-a/c space 20

Floor area	112 m^2
Height	3.0 m
South wall area	24 m^2
North wall area (partition with non-a/c space)	24 m^2
East wall area	42 m^2
West wall area	42 m^2
Roof (un-shaded)	112 m^2
East sunglass (With Venetian blinds)	1.8 m^2
South sunglass	2.5 m^2
West sunglass (With Venetian blinds)	1.8 m^2
Number of occupants	40
Lights	5 W/ m^2
Equipment	3 kW

Choose suitable Indoor and Outdoor Conditions and Bypass factor.
Find total space heat, Coil ADP, dehumidified air quantity and refrigeration capacity.
Location is at Mumbai at approximately 20°N latitude
(Conversion factors:1 grain/lb = 0.143 gm/kg, 1 Btu/h = 0.2931 W)
Clearly Indicate assumptions used and explain each factor used from tables. Final answer should be in tabular form as in standard Heat load estimation chart.

4. (a) With a neat sketch explain a chilled water air conditioning system for a multi-storeyed building. Trace the following circuits: 8

(i) Refrigerant circuit (ii) Chilled water circuit (iii) Air circuit (iv) Cooling water circuit

(b) What are the main sources of Indoor Air pollutants? What are the methods for used for maintaining good Indoor Air Quality? 6

(c) Explain the working of an Energy Recovery wheel 6

5. (a) What do ASHRAE Standard 55 and ASHRAE Standard 62.1 specify? (in short) 6

(b) What are Anechoic rooms and Reverberant rooms? 4

(c) A room has a ceiling area of 20m^2 with acoustic material that has an absorption coefficient of 0.56, the walls have a total area of 100 m^2 with an absorption coefficient of 0.15 and the floor has a carpet with absorption coefficient 0.7. A sound source located in the centre of the room emits a sound power level (PWL) of 80dB. What is the Sound Pressure Level (SPL) at a location 3m from source? Use chart given on the last page of paper. 10

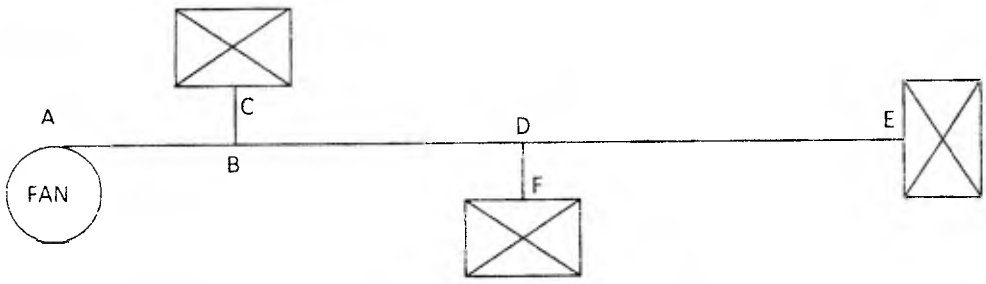
[Room Constant (R) is given by S α_{bar}/ (1- α_{bar})]

6. (a) An air distribution system for a commercial establishment is shown below. The velocity in the main duct should not be exceed 400 m/ min. Obtain, using equal pressure drop ($\Delta p/\Delta L$) method, the duct dimensions, total pressure drop and power for the blower if the efficiency is 0.7. (Take the depth of the duct as 2000mm throughout.) 10

AB = 40m, BC = 20 m, BD = 50 m, DF = 30 m, DE = 60m
Volume flow at C = 400 cmm, at F = 500 cmm, at E 100 cmm
The equivalent diameter is calculated using following equation, where 'a' and 'b' are the sides of the rectangle

$$Deq = \frac{[1.3\,(ab)^{0.625}]}{[(a+b)^{0.25}]}$$

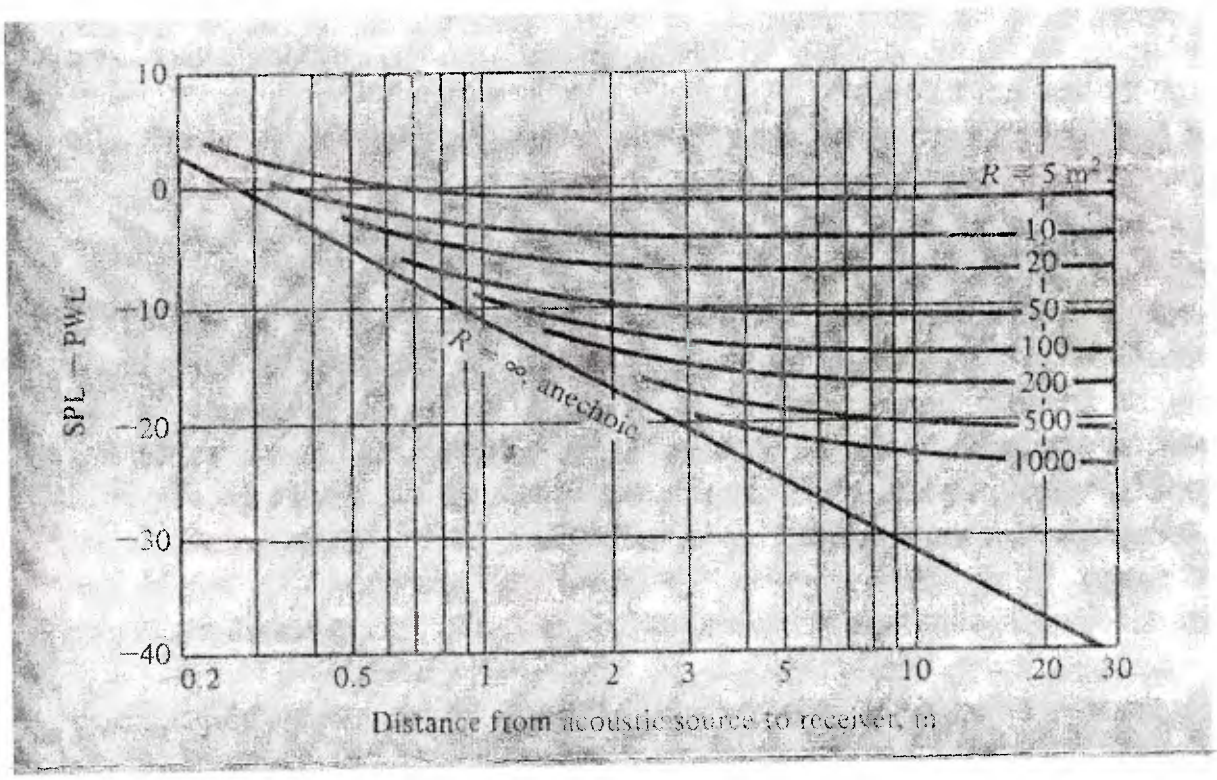
(b) Size the ducts BD and DE using static regain method (use regain efficiency as 70%). Comment on the differences between the two methods. 10



7. (a) Explain the following terms related to room air distribution, **8**
(i) Blow (ii) Drop (iii) Spread (iv) Entrainment Ratio

(b) The table shown below has the DBT and Air velocity measurements made at 9 points in the occupied zone of an air conditioned room. Calculate the Effective Draft Temperature given by EDT= (DBT- 24.4) - 0.1276(V- 0.15) and Air Distribution Performance Index (N_o/N) and comment on the design of the air distribution system. (Note: For comfort EDT has to lie between -1.7°C and + 1.1°C) **12**

	A	B	C
1	21.1°C, 0.3m/s	21.7°C, 0.25m/s	22.5°C, 0.2m/s
2	24.7°C, 0.08m/s	24.1°C, 0.1m/s	23.5°C, 0.21m/s
3	23.7°C, 0.11m/s	22.8°C, 0.19m/s	22.2°C, 0.24m/s



Q. 5(C)

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End Semester Exam
May 2016

Max. Marks: **100**
Class: **M.Tech.** Semester: **II**
Name of the Course: **Piping Engineering**

Duration: **4 Hours**
Program: **M.Tech. in Thermal Engineering**
Course Code: **MTTH213**

Instructions:

- Question no. **1** is **compulsory**. Attempt any **four** out of remaining six questions.
- Answers to all sub questions should be grouped together.
- Refer Annexure 1 for additional design data. Assume suitable data if necessary.

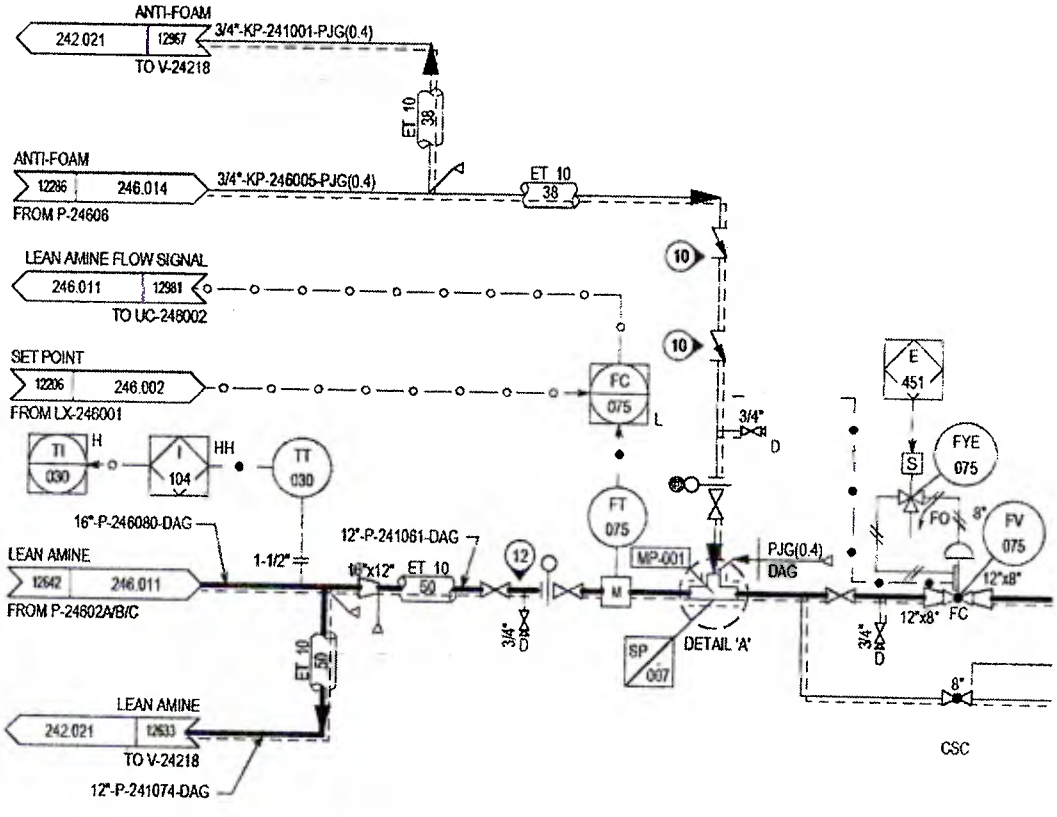
			Max. marks	CO No.	Module No.
Q1	a)	Is the role of piping engineer interdisciplinary? Justify your answer with appropriate examples.	**(4)**	*1*	*1*
	b)	You shall be visiting a prospective piping system supplier to inspect their fabrication facility. Compose a checklist covering all important equipment/facilities which you expect to inspect. Explain significance of each item from checklist.	**(4)**	*1*	*2*
	c)	What is difference between code, standard and specification employed in piping engineering? Give example of each and briefly explain its contents.	**(4)**	*1*	*3*
	d)	A 550 NB pipe has internal design pressure of 1.5 MPa and design temperature of 528°C. The pipe material is seamless carbon steel pipe with allowable stress of 21 MPa. Corrosion allowance is 1.0 mm. Factor W = 1.0 for T< 510°C and W = 0.5 for T>815°C. Calculate required schedule of the pipe.	**(4)**	*2*	*4*
	e)	List various types of supports employed in piping engineering with neat sketches. Explain the guidelines used to decide location of supports in a piping system.	**(4)**	*2,3*	*6*
Q2	a)	Which Indian statutory bodies/acts may be involved in design and manufacturing of piping systems? Briefly explain requirements mandated by each of the body/act.	**(5)**	*1*	*3*
	b)	A 600 NB sch 140 seamless pipe is intersected perpendicularly by 500 NB sch 140 pipe. Design pressure is 1.8 MPa, design temperature is 550 deg. C and corrosion allowance is 1 mm. Material is carbon steel with allowable stress of 15 MPa. Calculate size of reinforcing pad, if required.	**(10)**	*2*	*4*
	c)	Describe contents of a typical valve data sheet. Mention significance of each item of valve data sheet. Which specification covers guidelines for preparation of valve data sheet?	**(5)**	*1,2*	*5*

Q3 a) Write a short note describing different materials and their selection for process piping systems. **(5)** *1* *2*

b) Describe various types of steam traps employed in piping systems with neat sketches. Compare their relative merits. **(10)** *2,3*

c) You have been assigned a task to select a software to handle piping flexibility calculations. Make a detailed list of all features which you expect to be available for improving productivity of piping engineer. **(5)** *2*

Q4 a) Following figure shows part of P&ID for a process plant. Sketch the diagram and describe function/type of instrument/valve, nature of connection lines, interpretation of pipeline tag and other relevant information. **(7)** *1* *1*



b) Briefly explain procedure used for dynamic analysis of piping systems. **(3)** *2,3* *6*

c) Define following terms: (i) Stress Intensification Factor, (ii) Flexibility factor. **(2)** *2* *6*

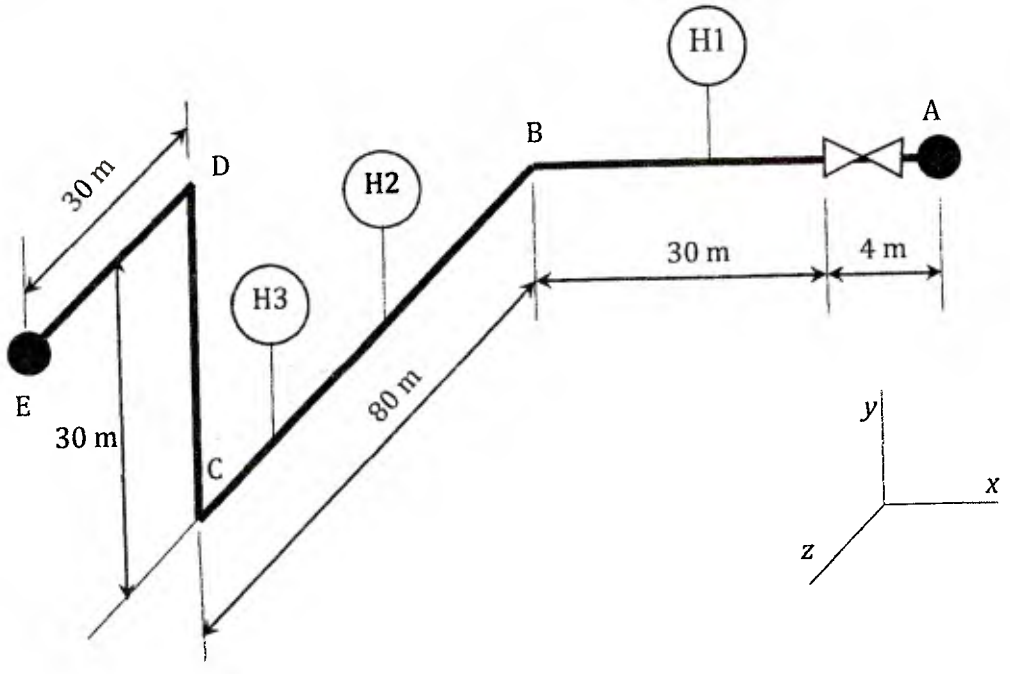
d) Explain with a sketch of typical P&ID, the standard piping arrangement around a centrifugal compressor. **(8)** *1* *7*

Q5 a) Find minimum required thickness of 500 NB mitre bend with θ = 15 deg. and mean radius as 4D. Internal pressure is 1.5 MPa, design temperature is 550 deg. C and corrosion allowance is 1.5 mm. Allowable stress is 14 MPa. Pipe material is carbon steel. **(6)** *2* *4*

b) Figure shows pipeline ABCDE connecting two process equipment. Design data is as follows. **(8)** *2* *6*

- Pipe size: 600 NB sch STD; Pipe material: SA106 Gr B; Elbows: LR type
- Allowable stress (cold/hot) = 140/130 MPa; Modulus of elasticity = 200,000 MPa, Corrosion allowance = nil
- Thermal expansion at operating temperature = 2.875 mm/m

- Suggested maximum span between supports = 60 m
- Displacement at point A in x,y,z directions = +8, -5, +5 mm
- Displacement at point E in x,y,z directions = 0, 0, 0 mm



(i) Select suitable locations for supports H1, H2 and H3.
(ii) If the reaction and corrected y-displacement at support H2 are 35,000 N and -40 mm (i.e., downwards) respectively, select variable spring hanger from spring catalogue (refer Annexure 1).

c) Explain with a sketch of typical P&ID, the standard piping arrangement around (i) control valve and (ii) storage tank. **(6)** *1* *7*

Q6 a) Describe the guidelines followed to develop equipment layout for a process plant. How this document is related to plot plan and piping isometric? **(5)** *1* *1*

b) A 200 NB sch XS pipeline (219.1 mm OD, 12.7 mm wall thickness) has equivalent length of 600 m for the purpose of pressure drop calculations. The pipe inside surface has surface roughness of 0.08 mm. The fluid flowing through pipeline has density of 925 kg/m^3, viscosity of 1.6 cP and mass flow rate of 110,000 kg/hr. Calculate the pressure drop inside the pipeline. **(8)** *3* *4*

c) What is a constant spring hanger? Describe with a neat sketch, its construction and working. Explain the procedure followed to select a constant spring hanger from the manufacturer's catalogue. **(7)** *2* *6*

Q7 a) For piping system described in question 5(b), check the need for performing flexibility analysis. Consider cyclic loading factor f = 0.9, factor $K_1 = 208300S_A/E_a$. **(7)** *2* *6*

b) A straight pipeline is laid on the bottom of a water reservoir of depth 50 meters. How will you calculate required thickness of the pipeline? Explain the procedure with necessary equations. Neglect effect of water currents. **(5)** *2* *4*

c) Classify different types of valves by their function. Describe construction and major components of *any two* of the following valves with sketch: Gate valve, Ball valve, Check valve. **(8)** *1,2* *5*

Annexure 1
Pipe Schedule

NPS inches	N.D.	O.D. mm	10	20	30	STD	40	60	XS	80	100	120	140	160
20	500	508	6.35	9.53	12.70	9.52	15.08	20.62	12.7	26.19	32.54	38.1	44.45	50.01
22	550	558.8	6.35	9.53	12.70	9.52	15.87	22.22	12.7	28.57	34.92	41.27	47.62	53.97
24	600	609.6	6.35	9.53	12.70	9.52	17.47	24.61	12.7	30.96	38.89	46.02	52.37	59.54

Factor Y

Materials	Temperature, °C (°F) ≤ 482 (900 & Lower)	510 (950)	538 (1000)	566 (1050)	593 (1100)	≥ 621 (1150 & Up)
Ferritic steels	0.4	0.5	0.7	0.7	0.7	0.7
Austenitic steels	0.4	0.4	0.4	0.4	0.5	0.7

Variable Spring Hanger Catalogue

Series VS3	VS2	VS1	Hanger size 11	12	13	14	15	16	17
Travel in mm			Load Capacity in Kgs						
4	2	1	546	672	890	1297	1565	1728	2466
0	0	0	558	688	913	1331	1610	1796	2553
8	4	2	580	720	958	1398	1700	1932	2726
16	8	4	603	752	1003	1466	1790	2068	2899
24	12	6	625	783	1048	1534	1880	2204	3073
32	16	8	648	815	1093	1602	1970	2340	3246
40	20	10	671	847	1138	1670	2060	2476	3419
48	24	12	693	878	1183	1737	2150	2612	3592
56	28	14	716	910	1228	1805	2240	2748	3765
64	32	16	738	942	1273	1873	2330	2884	3939
72	36	18	761	974	1318	1941	2420	3020	4112
80	40	20	784	1005	1363	2009	2510	3156	4285
88	44	22	806	1037	1408	2076	2600	3292	4458
96	48	24	829	1069	1453	2144	2690	3428	4631
104	52	26	851	1100	1498	2212	2780	3564	4805
112	56	28	874	1132	1543	2280	2870	3700	4978
120	60	30	897	1164	1588	2348	2960	3836	5151
128	64	32	919	1195	1633	2415	3050	3972	5324
136	68	34	942	1227	1678	2483	3140	4108	5497
140	70	35	953	1243	1700	2517	3185	4176	5584
4	2	1	964	1259	1723	2551	3230	4244	5671
12	6	3	987	1291	1768	2619	3320	4380	5844
20	10	5	1010	1322	1813	2687	3410	4516	6017

Pressure Drop Calculations

$f_D = 0.3164 {R_e}^{-0.25}$

Colebrook White equation: $\frac{1}{\sqrt{f_D}} = -2\log_{10}\left(\frac{e}{3.7D} + \frac{2.51}{R_e\sqrt{f_D}}\right)$

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Munshi Nagar, Andheri (West), Mumbai – 400058.

Re-Examination

June 2016

Max. Marks: **100** Duration: **4 hrs**

Class: **M. Tech. (Thermal Engg)** Semester: **II** Program: **Mech Engg**

Name of the Course: **Design of Heat Exchanger** Course Code: **MTTH 201**

Master file.

Instructions:

- Use of HMT Data Book and HEAT EXCHANGER DESIGN DATA BOOK are allowed.
- **Question No. 1 is compulsory.**
- Attempt **any Four questions** out of remaining six questions.
- Answers to all sub questions should be grouped together.
- All questions carry equal marks.
- Make suitable assumptions with proper explanations.

Q. No.		Marks	CO No.	M No
Q. 1	**Answer the following questions (any five)**	**20**	1 - 3	1-6
a)	State and explain different types of flow arrangements of Gasketed plate heat exchangers?			
b)	What are the basic requirements heat exchangers?			
c)	What are the different factors to be considered for surface selection of compact heat exchanger and shell and tube heat exchanger?			
d)	What are the different inputs to be considered for sizing and rating of shell and tube heat exchanger?			
e)	State and explain the applications of Disk and Doughnut baffles with neat sketches.			
f)	Explain the thermo-hydraulic and mechanical design aspects of heat exchangers.			
Q. 2 (A)	The steam condenser of a thermal power plant operates at a pressure of 7 kPa. Cooling water is circulated with a mass flow rate of 500 kg/s through 1000 tubes of 25 mm ID and 29 mm OD made of brass (K = 110 W/m.K). The steam side heat transfer coefficient is 11500 W/m^{2}K. Assuming average properties of water: K = 0.6 W/m.K, μ = 9 6 x 10^{-4} kg/ms, Pr = 6.6 Calculate the overall heat transfer coefficient based on the outer diameter of the tubes. If the inside surfaces of the tubes are fouled due to scale formation over a period of time, and the heat transfer coefficient is estimated to be 1968 W/m^{2}K, determine the corresponding fouling factor. Compute the exit temperature of water if the steam flow rate is 13 kg/s and the cooling water inlet temperature is 20°C.	**15**	3	2 & 3

	State assumptions considered if any. Take h_{fg} at 7 kPa = 2409.1 kJ/kg Use Dittus-Bilter co-relations $Nu = \frac{h_i d_i}{K} = 0.023\ (Re)^{0.8}\ (Pr)^{0.4}$			
(B)	Explain the following types of heat exchangers as per TEMA standards: AES, BGU, CKT, AFM, NEN	**05**	1	4
Q. 3 A)	Explain the optimization methods of determination of optimum baffle spacing in design process.	**05**	2	2
B)	Prove that heat transfer coefficient is a function of Reynolds number, Prandtl number, tube diameter and mass velocity.	**05**	2	2
C)	Explain the different types of plate heat exchanger. State the different geometrical properties and operating conditions which are required for design of plate heat exchanger	**10**	2	6
Q. 4 (A)	State and explain four main types of heat exchanger failures in detail.	**10**	3	1-7
(B)	What is cooling towers? Explain different types of cooling towers. State the factors which are responsible for performance of cooling towers.	**10**	2	7
Q.5 A)	A counter flow double-pipe heat exchanger is used to cool the engine oil for a large engine. The oil at a floe rate of 1.8 kg/s is required to be cooled from 95°C to 90°C using water at a flow rate of 1.2 kg/s and 25°C. Seven meter long carbon-steel hairpin is to be used. The inner and outer pipes are 1¼ and 2 nominal schedule 40, respectively (Use ID = 35 mm and OD = 42 mm). The engine oil flows through the inner tube. How many hairpins will be required? When the heat exchanger is initially in service (no fouling) with the hairpins, determine the outlet temperatures, the heat transfer rate, and the pressure drops for heat exchanger. Assume water outlet temperature as 30°C. Use ε -NTU method. Use thermal conductivity of material = 56.7 W/mK. Use properties of oil at Tb: ρ = 848 kg/m^3, Cp = 2161 J/kgK, K = 0.137 W/mK, μ = 2.52 x 10^{-2} Ns/m^2, Pr = 395 Find properties of water at Tb from property table. Use friction factor f (for turbulent flow): $f = [1.58 \ln (Re) - 3.28]^{-2}$ and for laminar flow: $f = \frac{16}{Re}$ for laminar flow: $Nu = 1.86 \left(\frac{D_h\ Re\ Pr}{L}\right)^{0.33}$ for turbulent flow: $$Nu_b = \frac{\left(\frac{f}{2}\right)(Re - 1000)Pr}{1 + 12.7\left(\frac{f}{2}\right)^{\frac{1}{2}}\left(Pr^{\frac{2}{3}} - 1\right)}$$	**20**	2 & 3	5
Q. 6 A)	Radiator is used to cool the engine at 50 km/h on a 7% grade road. Design engineer is to make sure that the coolant (50% water and 50% glycol) at the radiator inlet (top tank) does not exceed 120°C temperature at 100 kPa gauge radiator cap pressure. Determine the radiator top tank temperature for the following conditions: Engine heat rejection rate = 35 kW, Air flow rate = 0.75 kg/s, Air inlet temperature = 53°C, water glycol flow rate = 1.4 kg/s	**15**	2 & 3	5

	Take: UA = 1180 W/k, Cp for air 1009 J/kgK, Cp for coolant = 3664 J/kgK What will be the outlet temperature of coolant? Consider the radiator with both fluids unmixed.			
B)	Determine the type of heat exchanger to use for each of the following applications: 1) Heating oil with steam, 2) Cooling I C engines liquid coolant, 3) evaporating a hot liquid	**5**	1	1-6
Q. 7	~~**Answer the following questions. (any Four)**~~	**20**	1-6	
A)	Explain the effects of fouling on heat transfer, pressure drop of heat exchanger.			3
B)	What are the different surface cleaning techniques used to control fouling?			3
C)	Explain heat exchanger design methodology with flow diagram.			2
D)	Explain the variable overall heat transfer coefficient. How it is different from constant overall heat transfer coefficient?			2
E)	Explain the methods of design of plate-fin and tube-fin compact heat exchanger.			5
F)	Write short notes on Heat transfer in helical coils and spiral heat exchanger.			5 & 6