Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute)

Munshi Nagar, Andheri (W) Mumbai – 400058

END SEMESTER EXAMINATION DECEMBER 2022

Program: **T.Y .Mechanical Engineering** Sem V

Course Code: **MC- BT003**

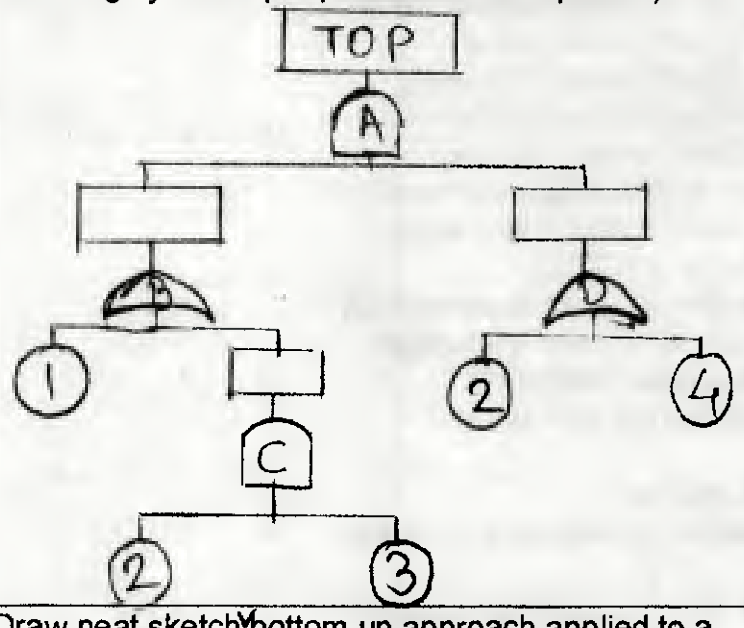
Course Name: **Health Safety and Environment**

Duration: 3 Hour

Maximum Points: 100

Semester: ~~II~~ V

Notes: 1. Questions number 01 is compulsory.
2. Solve any four main questions out of remaining six main questions.
3. Draw neat schematic diagrams wherever is necessary, highlight important points.
4. Assume suitable data if necessary and mention it.

Q.No.	Questions	Point	CO	BL	Module
Q1 A	Write a short note on cut set method? Using MOCUS algorithm find minimal cut-set for the following system? (Stepwise answer expected) 	10	2	L1	4
B	Draw neat sketch of bottom up approach applied to a system using failure mode and effect analysis (FMEA) technique? Draw sketch of methodology and documentation table of FMEA?	10	1	L1	3
Q2 A	Write a short note OHSAS 18001 and its PDCA tool? With the help of sketch justify using 2-3 points, how entropy risk model helpful for OHS management?	10	1	L3	1

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B	A technician working at a height, and fitting a heavy hazardous chemical tank at that location, draw safety domain ontology for this case? Enlist hazardous elements, initiating mechanism and threat elements as in general case?	10	2	L3	2
Q3 A	Write all steps involved while applying PHL methodology to a system? Explain each step in brief?	10	1	L2	3
B	Define wetlands according to Ramsar convention? Give classification of wetlands?	10	3	L1	5
Q4 A	Write short note on cycle of neglect with help necessary sketch? Give any 5 principles of occupational health and safety?	10	2	L2	2
B	Enlist and explain any two water purification techniques using 3 points each? What is eutrophication of lake and give its effects?	10	4	L3	7
Q5 A	What is PSC concept for fault tree ~~tree~~ constructuion? Basic Events G1, G2 & G3 (refers to failure of respective generator) will lead to system top level event 'TE' (partial loss of power). Draw fault tree diagram for above case, then convert it into an equivalent AND & OR gate. Also calculate probability of occurrence of top level event if each basic event's probability of occurrence is equal to 0.25.	10	1	L3	4
B	Draw neat schematic sketch which enlist's elements ~~which~~ are important for safety engineers knowledge base as Primary elements and as Secondary elements? Explain any one primary element in details?	10	3	L2	1
Q6 A	Explain why to conserve wetlands? Write short note on Convention on Biological Diversity (CBD)?	10	3	L2	5
B	What are the *industry* and *vehicle* specific air pollution control strategies can be adopted and implemented in metro city like Mumbai?	10	4	L1	7
Q7 A	What is sustainable development and give its need?	10	3	L2	6
B	Give impact of waste on health, climate and socio-economic condition if not managed wisely?	10	4	L3	6

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ENDSEM Examinations - December 2022

T.Y. B. Tech (M)

Program: B. Tech in Mechanical Engineering	**Duration: 3 Hrs**
Course Code: PC – BTM515	**Maximum Points: 100**
Course Name: Computer Aided Machine Drawing	**Semester: V**

Note:

1. Question no. 1 is Compulsory
2. Answer **any Three** out of remaining Five questions.
3. Assume suitable data if necessary.

Important Instructions:

1. All drawings (In AutoCad) should be submitted in a Title sheet layout with title block filled with respective details. Make Separate File for each question.
2. Create Folder Name as given in e.g. **M201001_ENDSEM DEC 2022**
3. Create File name as given in e.g. M201001_Q1a and save it in the same folder only.
4. After the exams, the folder consisting the answered files will be uploaded on Server. **Students to make sure their folders are properly uploaded before leaving the Hall.**
5. All Free Hand Sketches and Calculation of limits to be answered on the given blank sheets and submit in person.
6. Save Your Work Regularly in AutoCad.

SET A

Q. No.		Points	CO/ MO	BL	PI
Q.1	Given in the **Figure 1** is the Front View Details of Sleeve and Cotter Joint. a) Create 3d- models of parts, b) Assemble the 3d model parts in their functional positions. c) Plot drawings in layout as given below: i. Sectional Front View. ii. Side View. iii. Bill of Material.	05 07 08	01/01 03/01 04/01	03	5.2.2
Q.1	(d) Draw Free Hand Sketches of the following: (i) Flange Nut. (ii) Square Neck Stud.	05	02/02	01	1.4.1

Q.2	A vertical square pyramid, base 60 mm side and axis 100 mm is resting on its base on the H.P. with all sides of base equally inclined to V.P. A horizontal cylinder, diameter 40 mm, having its axis parallel to both the V.P. and H.P. penetrates the pyramid. The axis of the solids intersects each other at right angle and cylinder axis is 35 mm above the pyramid base. a) Create 3d-models of both solids. b) Assemble them in their given positions. c) Plot drawings in layout as given below i. Front view ii. Top View iii. Side View	07 05 08	01/01 03/01 04/01	03	5.2.2
Q.2	(d) Draw Free Hand Sketches of the following: (i) BA Thread (ii) Buttress Thread	05	02/02	01	1.4.1
Q.3	Given in **Figure 2** is the Details of Plummer Block Bearing. a) Create 3d- models of parts, b) Assemble the 3d model parts in their functional positions. c) Plot drawings in layout as given below: i. Sectional Front View. ii. Bill of Material.	10 05 05	01/04 03/04 04/04	03	5.2.2
Q.3	(d) Draw Free Hand Sketches of the **Gib Headed Key.**	05	02/03	01	1.4.1
Q.4	Given in **Figure 3** is Assembly of Fast and Loose Pulley. (a) Create 3d part model of Loose Pulley (b) Plot Detail Drawing of Loose Pulley as given below: (i) Sectional Front View (ii) Side View (c) Create 3d part model of Collar (d) Plot Detail Drawing of Collar as given below: (i) Front View (ii) Side View	08 07 05 05	01/05 04/05 01/05 04/05	03	5.2.2
Q.5	Given in **Figure 4** is Details of Expansion Joint. a) Create 3d- models of parts, b) Assemble the 3d model parts in their functional positions. c) Plot drawings in layout as given below: i. Sectional Front View. ii. Bill of Material. d) Calculate the limits of Ø170 H7, g6	05 10 05 05	01/06 03/06 04/06 02/02	03	5.2.2 1.4.1

Q.6	Given in **Figure 5** is Assembly of Drill Jig.			03	5.2.2
	(a) Create 3d part model of Base Plate	10	01/07		
	(b) Plot Detail Drawing of Base Plate as given below:	10	04/07		
	(i) Sectional Front View (ii) Top View				
	(c) Calculate the Limits between Base plate and Stem	05	02/02		1.4.1
	**********				

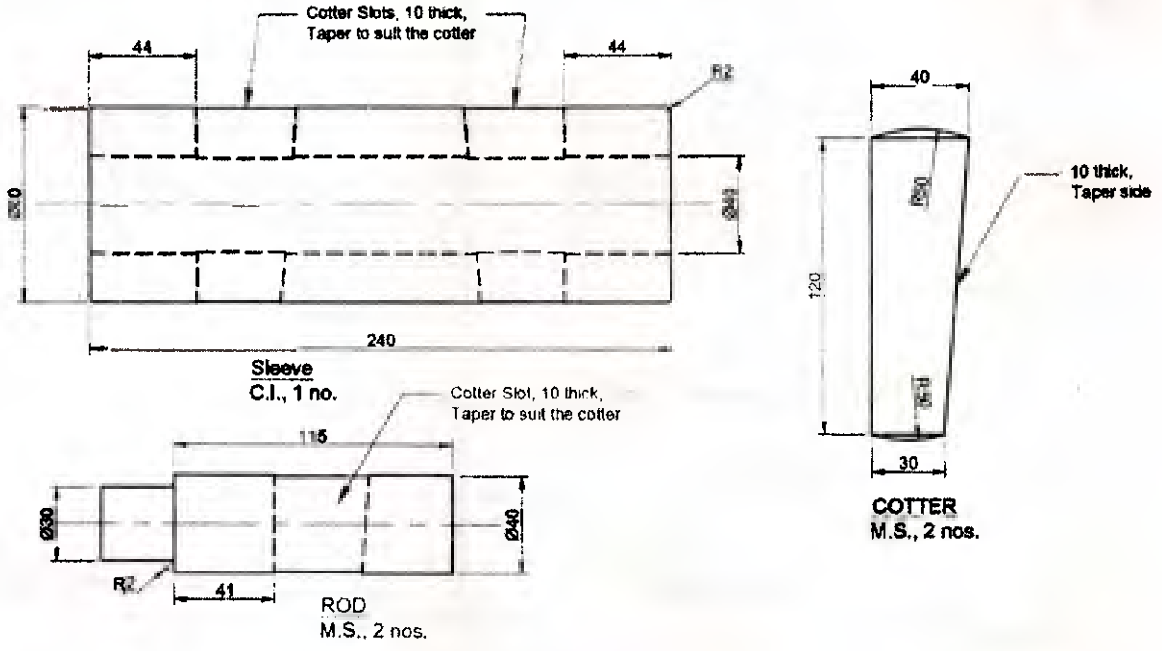

Figure 1: Details of Sleeve and Cotter Joint

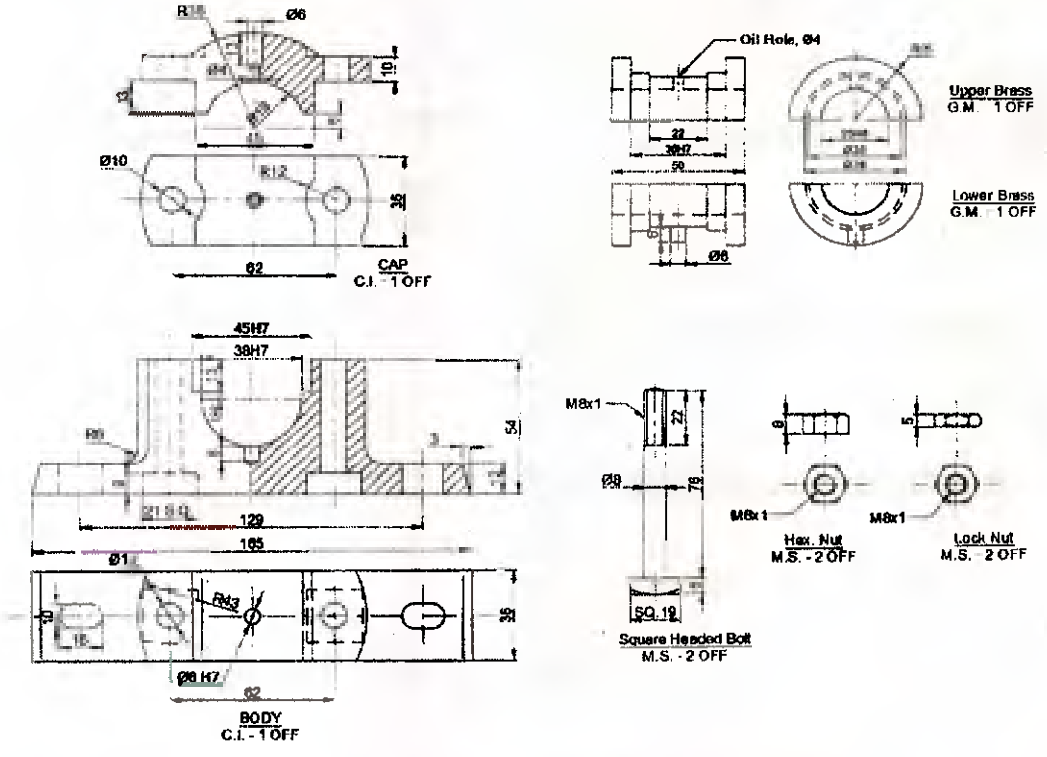

Figure 2: Details of Plummer Block Bearing

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ENDSEM Examinations - December 2022

T.Y. B.Tech (M) Sem V

Program: B. Tech in Mechanical Engineering	**Duration: 3 Hrs**
Course Code: PC – BTM515	**Maximum Points: 100**
Course Name: Computer Aided Machine Drawing	**Semester: V**

Note:

1. Question no. 1 is Compulsory
2. Answer **any Three** out of remaining Five questions.
3. Assume suitable data if necessary.

Important Instructions:

1. All drawings (In AutoCad) should be submitted in a Title sheet layout with title block filled with respective details. Make Separate File for each question.
2. Create Folder Name as given in e.g. **M201001_ENDSEM DEC 2022**
3. Create File name as given in e.g. M201001_Q1a and save it in the same folder only.
4. After the exams, the folder consisting the answered files will be uploaded on Server. **Students to make sure their folders are properly uploaded before leaving the Hall.**
5. All Free Hand Sketches and Calculation of limits to be answered on the given blank sheets and submit in person.
6. Save Your Work Regularly in AutoCad.

SET B

Q. No.		Points	CO/ MO	BL	PI
Q.1	Given in the **Figure 1** is the Details of Simple Flange Coupling. a) Create 3d- models of parts, b) Assemble the 3d model parts in their functional positions. c) Plot drawings in layout as given below: i. Sectional Front View. ii. Side View. iii. Bill of Material.	 05 07 08	 01/04 03/04 04/04	03	5.2.2
Q.1	(d) Draw Free Hand Sketches of the following: (i) Dome Nut. (ii) Plain Washer	05	02/02	01	1.4.1

Q.2	A vertical square pyramid, base 60 mm side and axis 100 mm is resting on its base on the H.P. with all sides of base equally inclined to V.P. A horizontal square prism, base 30 mm, having its axis parallel to both the V.P. and H.P. penetrates the pyramid. The faces of the horizontal square prism are equally inclined to H.P. The axis of the solids intersects each other at right angle and cylinder axis is 35 mm above the pyramid base. a) Create 3d-models of both solids. b) Assemble them in their given positions. c) Plot drawings in layout as given below i. Front view ii. Top View iii. Side View	07 05 08	01/01 03/01 04/01	03	5.2.2
Q.2	(d) Draw Free Hand Sketches of the following: (i) BSW Thread (ii) Square Thread	05	02/02	01	1.4.1
Q.3	Given in the **Figure 2** is Details of Gib and Cotter Joint. a) Create 3d- models of parts, b) Assemble the 3d model parts in their functional positions. c) Plot drawings in layout as given below: i. Sectional Front View. ii. Bill of Material.	10 05 05	01/03 03/03 04/03	03	5.2.2
Q.3	(d) Draw Free Hand Sketches of the **Parallel and Taper Rectangular Key.**	05	02/03	01	1.4.1
Q.4	Given in **Figure 3** is Assembly of V-Belt Pulley. (a) Create 3d part model of V-Belt Pulley (b) Plot Detail Drawing of V-Belt Pulley as given below: (i) Sectional Front View (ii) Side View (c) Create 3d part model of Shaft (d) Plot Detail Drawing of Shaft as given below: (i) Front View (ii) Side View	08 07 05 05	01/05 04/05 01/05 04/05	03	5.2.2
Q.5	Given in **Figure 4** is Details of Expansion Joint. a) Create 3d- models of parts, b) Assemble the 3d model parts in their functional positions. c) Plot drawings in layout as given below: i. Sectional Front View. ii. Bill of Material. d) Calculate the limits of Ø150 H7, g6	05 10 05 05	01/06 03/06 04/06 02/02	03	5.2.2 1.4.1

Q.6	Given in **Figure 5** is Assembly of Drill Jig.			03	5.2.2
	(a) Create 3d part model of Jig Plate	10	01/07		
	(b) Plot Detail Drawing of Jig Plate as given below:	10	04/07		
	(i) Sectional Front View (ii) Top View				
	(c) Calculate the Limits between Base plate and Stem	05	02/02		1.4.1
	**********				

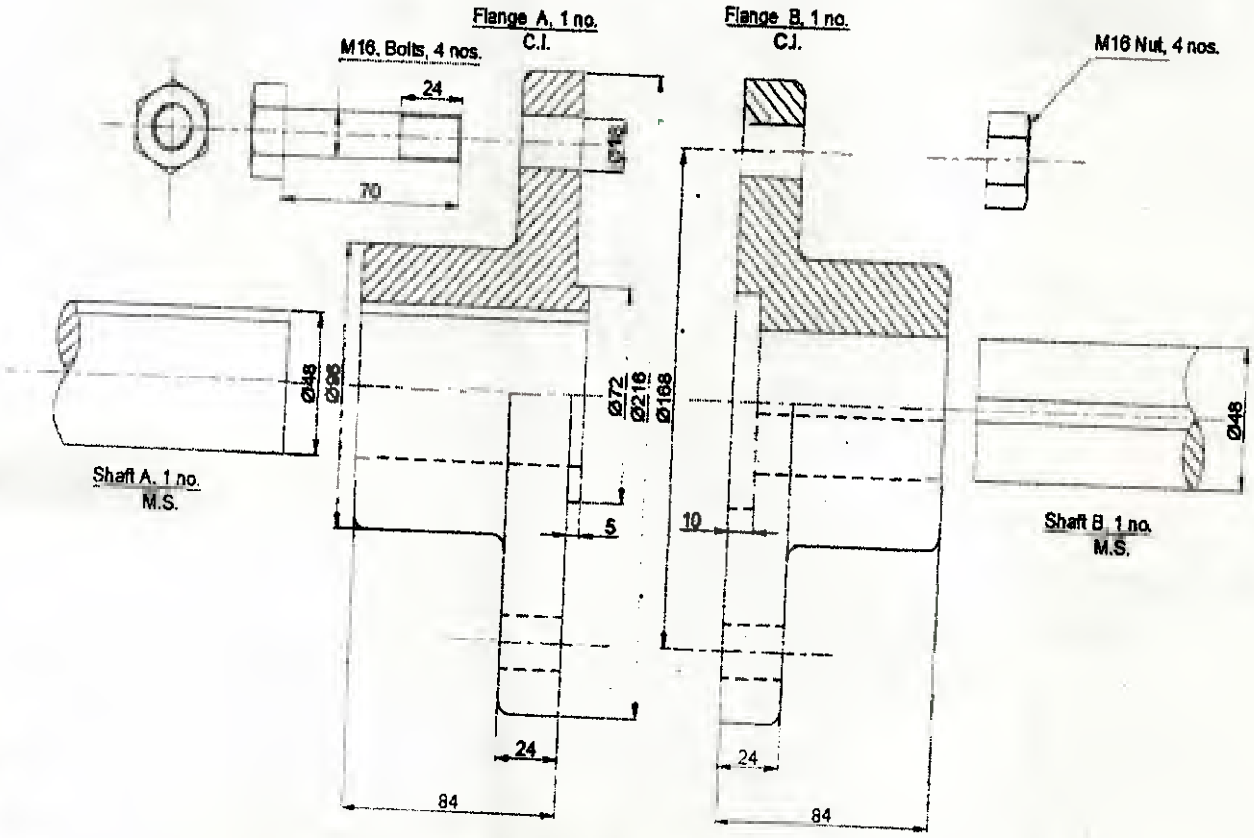

Figure 1: Details of Simple Flange Coupling

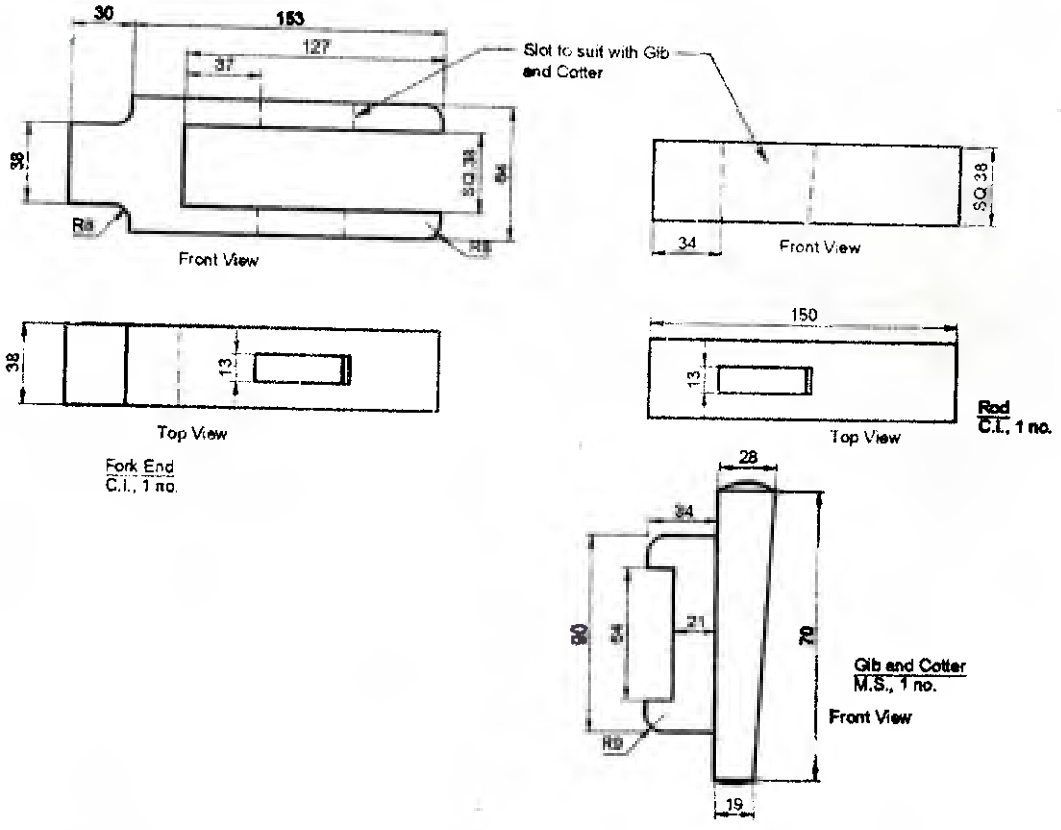

Figure 2: Details of Gib and Cotter Joint

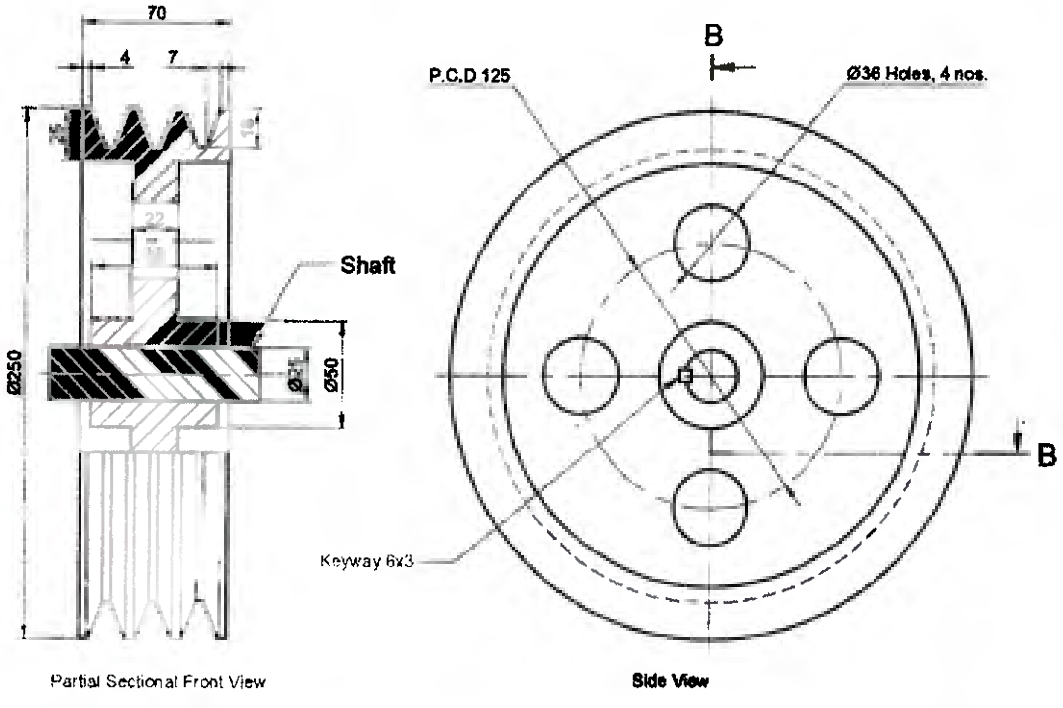

Figure 3: Assembly of V-Belt Pulley

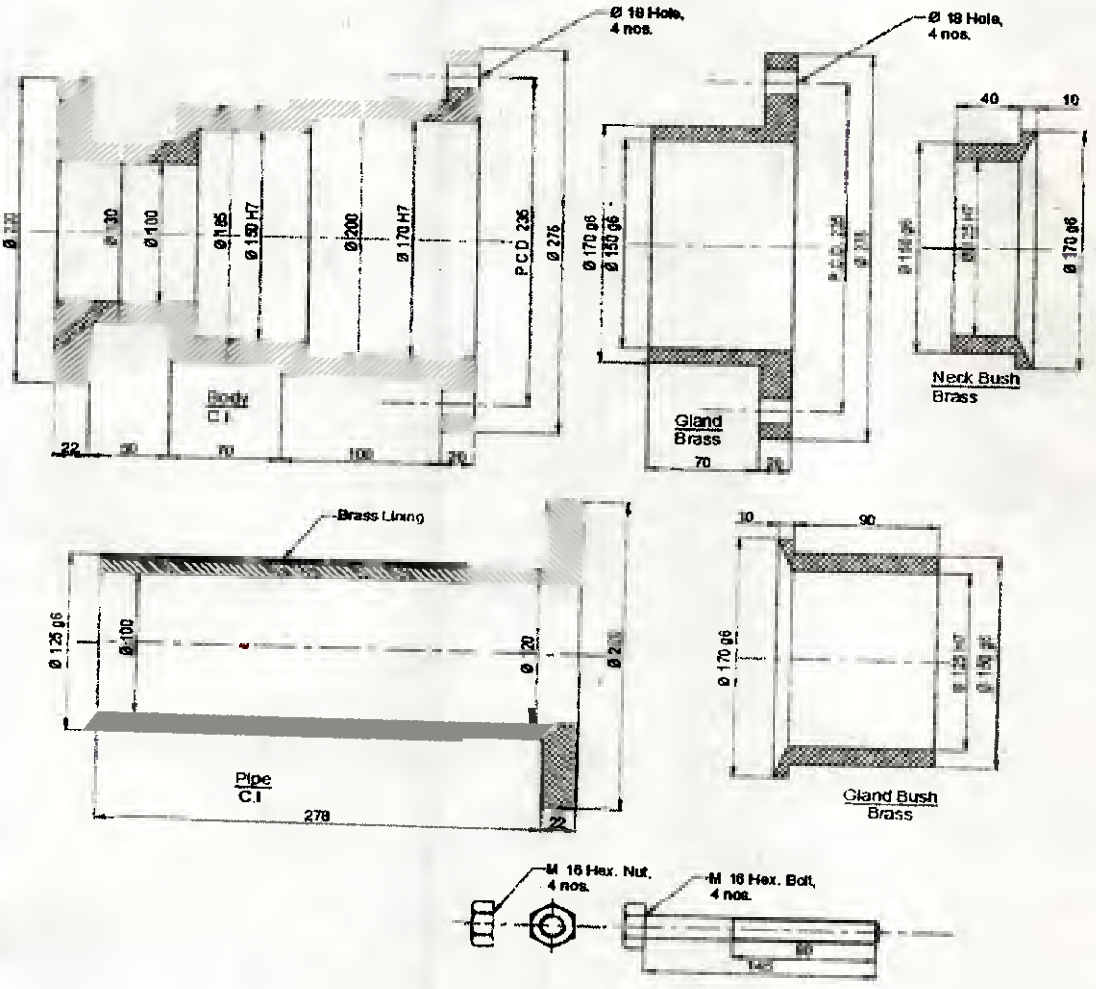

Figure 4: Details of Expansion Joint

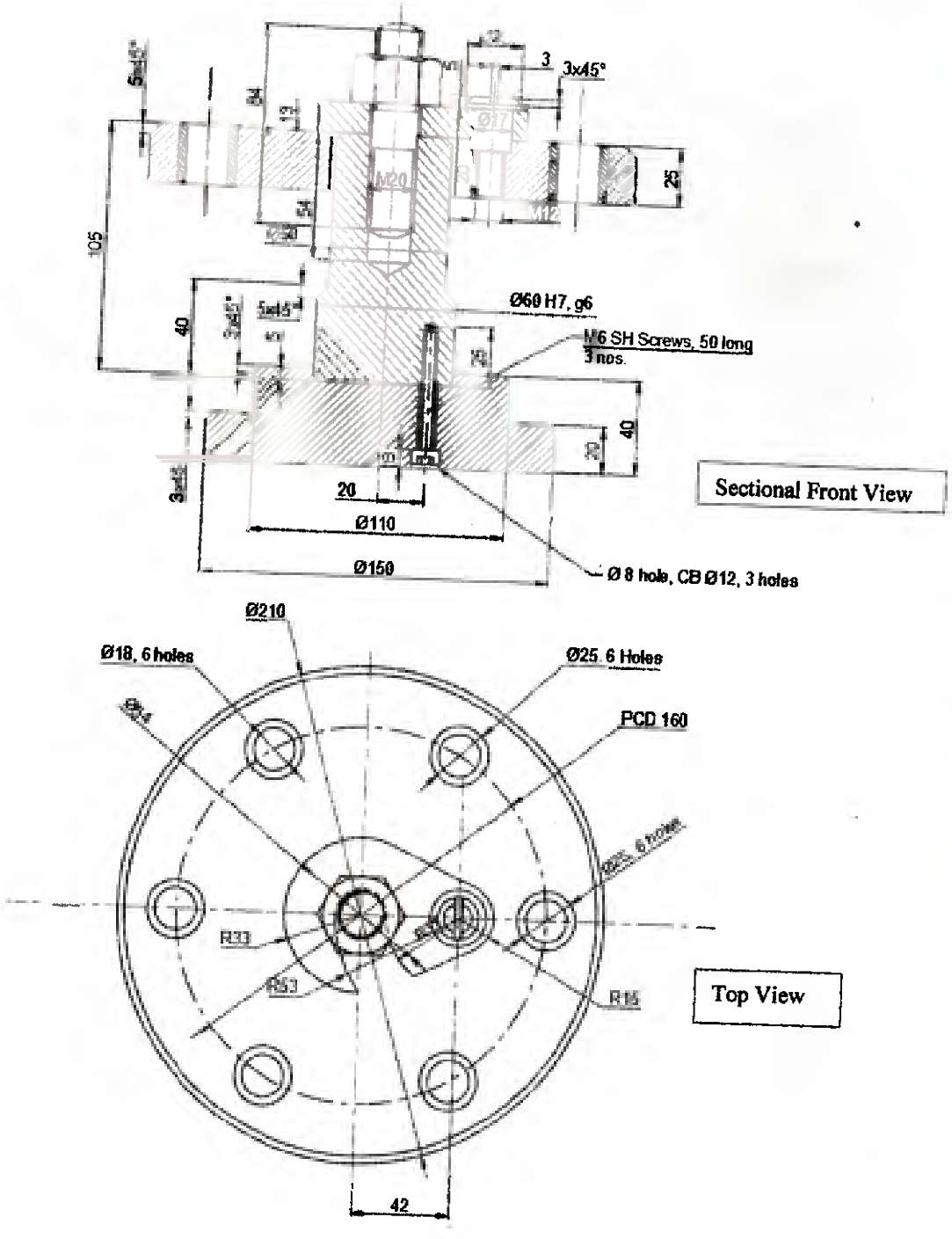

Figure 5: Assembly of Drill Jig

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End Sem - DEC 2022 Examinations

Program: Mechanical T.Y. (M) Sem V

Course Code: PC-BTM503

Course Name: Mechatronics

Notes: Question **No.1 is compulsory**

Duration: 3 Hrs

Maximum Points: 100

Semester: V

Solve any **Four** questions out of **SIX**

Q.No.	Questions	Points	CO	BL	PI
1	**a) Enlist** different applications of Mechatronics in Home, Office and in Industry **b) Discuss** the architecture of 8085 **c) Explain** different types of control valves **d) Discuss** the different components of Fluid power **e) Explain** the concept of stability	20	1to4	I,III,V	1.5.1
2a	**Enlist** the different applications of Hydraulic and Pneumatic systems	10	2	I	1.6.1
2b	**Draw** the architecture of 8051 and **explain** the SFRs	10	2	VI	5.4.1
3a	**Draw** and **explain** i) Clamping circuit using an accumulator, and ii) Sequencing circuit	10	1	III	1.6.1
3b	**Derive** the steady state error and obtain the effect of all standard test inputs on steady state error and static error coefficients *Kp, Kv* and *Ka.*	10	2	V	5.4.1
4a	**Develop** a schematic and functional block diagram of temperature control system. Aim is to maintain hot water temperature constant. Water is coming with constant flow rate. Steam is coming from a valve. Pressure thermometer P is used as a feedback element, which sends signal comparison with set point. This error actuates the valve which controls the rate of flow of steam, eventually controlling the temperature of the water.	10	3	VI	1.6.1
4b	**Reduce** the Block diagram and **obtain** the transfer function	10	3	III	5.4.1

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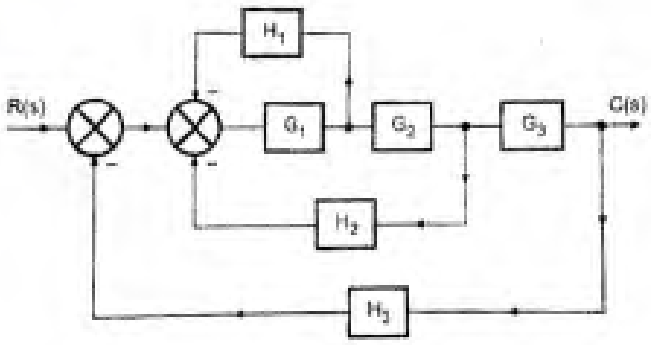
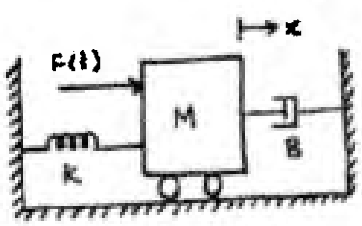
End Sem - DEC 2022 Examinations

					
5a	**Explain** the term time response analysis of control system such as i) Time response ii) Transient response, iii) Steady state response, iv) Steady state error along with explain standard test inputs in details.	10	3	II	1.6.1
5b	**Enlist** the different types of pumps used in hydraulic system also **draw** and **explain** working of each.	10	3	VI	1.6.1
6a	For unity feedback system, $G(s) = \frac{K}{s(s+4)(s+2)}$, **sketch** the nature of the root locus showing all details on it. **Comment** on stability of the system.	10	3	IV	5.4.1
6b	**Sketch** the Bode plot for the system having $G(s)H(s) = \frac{30}{s(1+0.2s)}$	10	3	III	5.4.2
7a	**Obtain** the state model for the mechanical system 	10	4	III	5.1.2
7b	**Obtain** the transfer function for a system having state model $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -2 & -3 \\ 4 & 2 \end{bmatrix} * \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 3 \\ 5 \end{bmatrix} u$	10	4	III	5.1.2

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End Semester Examinations - December 2022

12/12/22

Program: B.Tech T.Y. B.Tech (M) — **Duration: 3 Hours**

Course Code: PC-BTM514 Sem V **Maximum Points: 100**

Course Name: Thermal Systems **Semester: V**

Notes:

1. Question number ONE is compulsory and solve any FOUR questions out of remaining SIX.
2. Steam table and Mollier diagram is allowed to use.
3. All sub questions to be grouped together.
4. Assume suitable data wherever necessary and justify the same.

Q.No.	Questions	Points	CO	BL	Module No
1(a)	A steam power plant has boiler and condenser pressure of 50 bar and 0.1 bar, respectively. Steam coming out of the boiler is dry and saturated. The plant operates on the Rankine cycle. Calculate thermal efficiency of steam power plant working on Rankine cycle.	5	1	1	1
1(b)	Differentiate between Rotary and Reciprocating Compressors.	5	1	1	2
1(c)	Discuss about mountings and accessories of boilers.	5	3	1	3
1(d)	Draw neat sketch of condensing plant and name each component of condensing plant.	5	3	1	4
2(a)	What is surging and chocking in compressors? Explain this phenomenon with neat sketch.	8	1	2	2
(b)	A two stage double acting air compressor operating at 300 rpm takes air in at 1.013 bar and 27^0 C. The diameter and stroke of L.P cylinder are 35 cm and 38 cm respectively. The stroke of H.P cylinder is same as L.P. cylinder and clearance of both the cylinder is 4% of the stroke. The L.P. cylinder discharges air at a pressure of 4.052 bar. The air passes through the intercooler so that it enters the H.P. cylinder at 27^0 C and 3.85 bar. Finally, the air is discharged from the compressor at 15.4 bar. The compression and re-expansion in both the cylinder follows the same law $pv^{1.3}$ =Constant. Determine (i) Heat rejected in intercooler. (ii) The diameter of H.P. cylinder (iii) The power required to drive the H.P. cylinder Take C_p = 1 kJ/kg-K and R = 287 J/kg-K for air.	12	2	3	1

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End Semester Examinations - December 2022

3(a)	Draw neat sketches of root blower and vane-type blower and explain the working of these compressors in detail. Also write equation for work done.	**10**	3	1	2
(b)	What are boiler accessories? Draw a neat sketch of economiser and air preheater and explain its working.	**10**	1	1	3
4(a)	Draw neat sketch of Babcock-Wilox boiler and explain its working in detail.	**10**	1	1	3
(b)	Superheated steam at a pressure of 10 bars and 300°C enters a convergent divergent nozzle and leaves at 1.0 bar absolute. If the flow is isentropic and corresponding expansion index is 1.3, find the ratio of cross-sectional area at exit and throat for maximum discharge.	**10**	4	3	5
5(a)	Draw neat sketch of evaporative condenser and explain its working in detail.	**10**	3	2	4
(b)	Prove that condition for maximum blade efficiency of a reaction turbine is given by relation: $\eta_b = \frac{2\cos^2\alpha}{1+\cos^2\alpha}$	**10**	3	2	5
6(a)	The following data refer to one stage of an impulse turbine: Isentropic nozzle heat drop = 185 kJ/kg Reheat of steam due to blade friction = 10% of isentropic drop. Nozzle angle = 20° Ratio of blade speed to whirl component of steam speed = 0.5. Velocity coefficient for the blades = 0.95. Take this velocity of steam at the entry of nozzle = 30 m/sec. Evaluate: (a) Blade angle if the steam leaves axially, (b) Work done per kg, (c) Friction loss over the blades and K.E. loss.	**10**	4	3	5
(b)	Draw neat sketches of schematic and T-s diagram for regeneration and reheating for open cycle gas turbine and explain it in detail.	**10**	3	2	6
7(a)	The pressure ratio of an open cycle constant pressure gas turbine plant is 6. The temperature range of the plant is 15°C and 850°C. Using the following data: C_{pa} = 1 kJ/kg-K C_{pg} = 1.075 kJ/kg-K and γ = 1.4 for air and gases C.V. of fuel = 43000 kJ/kg	**12**	4	3	6

	$\eta_c = 0.85$, $\eta_t = 0.90$, η_{com} (Combustion) = 0.95. Estimate: (a) The thermal efficiency of the plant (b) I.P. of the plant if the circulation of air is 5 kg/sec (c) A:F ratio, and (d) Specific fuel consumption. Neglect the losses in the system.				
(b)	Explain the working of Kaplan turbine with neat sketch.	**08**	3	1	7

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END SEMESTER EXAMINATION DECEMBER 2022

Program: B. Tech. Mechanical Engg. **Duration:** 03 Hrs.

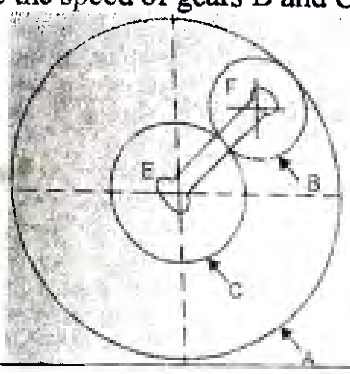
Course Code: PC–BTM512 **Maximum Points:** 100

Course Name: Dynamics of Machinery **Semester:** V

Notes: 1. Attempt any **FIVE** questions
2. Each questions carry equal marks
3. Assume suitable data wherever necessary and justify the same

Q.No.	Questions	Points	CO	BL	Module No.
1	a) Explain Bevis Gibson Torsion Dynamometer. b) Calculate the power of an engine which is running at a constant speed of 500 rpm and carries a rope brake dynamometer. The dead weight on the engine and spring balance readings are 750 N and 150 N respectively. The diameter of flywheel is 2 m that of rope is 20 mm. c) The turning moment diagram for a multicylinder engine has been drawn to a scale of 1 mm = 325 Nm vertically and 1 mm = 3^0 horizontally. The areas above and below the mean torque line are -26, +378, -256, +306, -302, +244, -380, +261 and -225 mm^2 respectively. The engine is running at a mean speed of 600 rpm. The total fluctuation of speed is not to exceed ± 1.8 % of the mean speed. If the radius of flywheel is 0.7m, Find the mass of the flywheel.	05 05 10	1	3	1
2	a) What is the effect of the gyroscopic couple on the stability of an four-wheeler while negotiating a curve. b) Each road wheel of a motorcycle is of 600 mm diameter and has a moment of inertia of 1.1 $kg.m^2$. The motorcycle and rider together weigh 220 kg and the combined centre of mass is 620 mm above the ground level when the motorcycle is upright. The moment of inertia of the rotating parts of the engine is 0.18 kgm^2. The engine rotates at 4.5 times the speed of the road wheels in the same sense. Find the angle of hell necessary when the motorcycle is taking a turn of 35 m radius at a	10 10	1	1,2	2

END SEMESTER EXAMINATION DECEMBER 2022

	speed of 72 km/hr.					
3	a) Describe and Sketch the arrangement for Watt governor. b) In a proell governor, the mass of each ball is 8 kg and the mass of the sleeve 120 kg. Each arm is 180 mm long. The length of extension of lower arm to which the balls are attached is 80 mm. The distance of pivots of arms from axis of rotation is 30 mm and the radius of rotation of the balls is 160 mm when the arms are inclined at 40^0 to the axis of rotation. Determine: (i) The equilibrium speed (ii) The coefficient of insensitiveness if the friction of the mechanism is equivalent to 30 N. (iii) The range of speed when the governor is inoperative.	06 14	1	3	3
4	a) Define the following terms: I. Angle of Obliquity II. Module III. Circular Pitch b) An epicyclic gear consists of three gears A, B and C as shown in Fig. The gear A has 72 internal teeth and gear C has 32 external teeth. The gear B meshes with both A and C and is carried on an arm EF which rotates about the centre of A at 18 rpm. If the gear A is fixed, determine the speed of gears B and C.  	06 14	1	3	4

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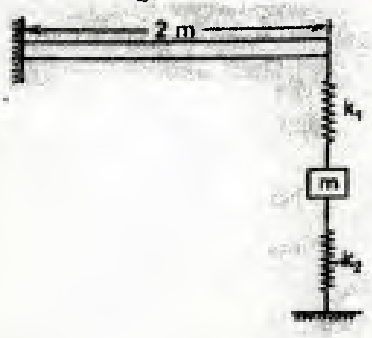
END SEMESTER EXAMINATION DECEMBER 2022

5	a) Find the natural frequency of the system shown in Figure. Given $k_1 = k_2 = 3 \times 10^5$ N/m, m = 150 kg, E = 210 GN/m^2, I = 4 x 10^{-5} m^4.  b) A spring mass system has spring stiffness of K N/m and mass of m kg. The natural frequency of system is 12 Hz. When an extra 2 kg mass is coupled to m, the natural frequency reduces by 2 Hz. Find the value of k and m.	10 10	3	2,3	5
6	a) Differentiate between Viscous and Coulomb damping. b) Derive an expression for Logarithmic Decrement. c) Explain and Derive the expression for Over damped and Critically damped system.	05 05 10	4	2,3	6
7	a) A rotating shaft carries four unbalanced masses 18 kg, 14 kg, 16 kg and 12 kg at radii 5 cm, 6 cm, 7 cm and 6 cm respectively. The 2nd, 3rd and 4th masses revolve in planes 8 cm, 16 cm and 28 cm respectively measured from the plane of the first mass and are angularly located at 60^0, 135^0 and 270^0 respectively measured anticlockwise from the first mass looking from this mass end of the shaft. The shaft is dynamically balanced by two masses, both located at 5 cm radii and revolving in planes midway between those of 1st and 2nd masses and midway between those of 3rd and 4th masses. Determine the magnitude of the masses and their respective angular positions. b) Explain balancing of four cylinder four stroke in line engine.	12 08	2	3	7

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End Semester Examination December -2022

Program: ~~B.Tech~~ **Mechanical Engineering**
Class: **Third Year B.Tech. (Mechanical)** Sem V
Course Code: **PC-BTM501**
Course Name: **Heat and Mass Transfer**

Date: **16/12/2022**
Duration: **3 hours**
Maximum Points:**100**
Semester: **V**

Instructions:

1. **Q.1 is COMPULSORY.** Solve **any Four questions out of remaining Six.**
2. Use of **heat exchanger data** is allowed.
3. Use of **Reference Data** for **Properties of fluids, Convective heat transfer correlations and Heisler Charts** duly approved by examiner is permitted.
4. Draw **neat sketches** wherever required.
5. Answers to theory questions should be **specific** and in **legible handwriting.**

Q. No.	Questions	Points	CO	BL	Module
1	**Solve any four** out of following questions: (a) State and explain Fourier's law of one dimensional heat conduction. What are the assumptions to be considered for this law? (b) State the examples of mass transfer in day to day life and industrial applications. (c) State and explain Fick's law of diffusion and compare it with Fourier's law of heat conduction. (d) Explain with significance: Biot No. (*Bi*) and Fourier No. (*Fo*). Differentiate: Nusselt No. (*Nu*) from *Bi*. (e) Explain: Thermal boundary layer thickness and significance of Prandtl No. (*Pr*) in deciding relation between hydrodynamic and thermal boundary layer. (f) Define: Irradiation (G) and Hence Prove: $\alpha + \rho + \tau = 1$, defining the terms involved in the equation.	20	1,2	1,2,3	1,6,7; 3,4,5
2(a)	Two slabs, each 120 mm thick, have thermal conductivities of 14.5 W/m°C and 210 W/m°C. These are placed in contact, but due to roughness, only 30 percent of area is in contact and the gap in the remaining area is 0.025 mm thick and is filled with air. If the temperature of the face of the hot surface is at 220°C and the outside side surface of other slab is at 30°C. **Evaluate:**				

	(i) Heat flow through the composite system (ii) The contact resistance and temperature drop in contact. Assume that the conductivity of air is 0.032 W/m°C and that half of the contact (of the contact area) is due to either metal.	**10**	4	1,2,3	2
2(b)	A steam pipe (k = 45 W/m²°C) having 70 mm inside diameter and 85 mm outside diameter is lagged with two insulation layers; the layer in contact with the pipe is 35 mm asbestos (k = 0.15 W/m²°C) and is covered with 25 mm thick magnesia insulation (k = 0.075 W/m²°C). The heat transfer coefficients for inside and outside surfaces are 220 W/m²°C and 6.5 W/m²°C respectively. If the temperature of steam is 350°C and the ambient temperature is 30°C. Estimate (i) The steady loss of heat for 50 m length of the pipe. (ii) The overall heat transfer coefficient based on inside and outside surfaces of the lagged steam main.	**10**	4	1,2,3	2
3(a)	Derive an expression for LMTD of parallel flow heat exchanger.	**10**	2	1,2	6
3(b)	A counter-flow heat exchanger, through which passes 12.5 kg/s of air to be cooled from 540°C to 146°C, contains 4200 tubes, each having a diameter of 30 mm. The inlet and outlet temperatures of cooling water are 25°C and 75°C respectively. If the water side resistance to flow is negligible, calculate the tube length required for this duty. For turbulent flow inside tubes : $Nu = 0.023\ Re^{0.8}\ Pr^{0.4}$ Properties of the air at the average temperature are as follows: $\rho = 1.009$ kg/m³; $c_p = 1.0082$ kJ/kg°C; $\mu = 2.075 \times 10^{-5}$ kg/ms (Ns/m²) and $k = 3.003 \times 10^{-2}$ W/m°C.	**10**	4	1,2,3	6
4(a)	In a gas turbine power plant heat is being transferred in a heat exchanger from the hot gases leaving the turbine at 450°C to the air leaving the compressor at 170°C. The air flow rate is 5000 kg/h and fuel-air ratio is 0.015 kg/kg. The overall heat transfer coefficient for the heat exchanger is 52.33 W/m²°C. The surface area is 50 m² and arrangement is cross-flow (both fluids unmixed). Using NTU method estimate the followings: (i) The exit temperature on the air and gas sides, and (ii) The rate of heat transfer in the heat exchanger. Take $c_{ph} = c_{pc} = 1.05$ kJ/kg°C.	**10**	4	1,2,3	6
4(b)	Hydrogen gas at 25°C and 2.5 atmosphere flows through a rubber tubing of 12 mm inside radius and 24 mm outside radius. The binary diffusion coefficient of hydrogen is 2.1×10^{-8} m²/s and the solubility of hydrogen is 0.055 m³ of rubber	**5**	4	1,2,3	7

	at 1 atmosphere. If the gas constant for hydrogen is 4160 J/kg K and the concentration of hydrogen at the outer surface of tubing is negligible, calculate the diffusion flux rate of hydrogen per meter length of rubber tubing.				
4(c)	A spherical cylinder 3.5 m inner diameter, 40 mm thick, made of nickel, contains gas at 358 K. Molar concentration of hydrogen in Ni at the inner surface is 0.085 kg mole/m^3 and is zero at the outer surface. Determine the mass diffusion rate of hydrogen through the walls of the container. For H_2-Ni at 358 K, take $D_{H2-Ni} = 1.2 \times 10^{-12}$ m^2/s.	5	4	1,2,3	7
5(a)	Derive: Expression for temperature distribution in a solid (θ/θ_i) using lumped parameter analysis and Hence Prove: $(\theta/\theta_i) = exp\ (-Bi\ x\ Fo)$. Draw: Neat sketch of the system and equivalent thermal circuit. A thermocouple junction is in the form a 8 mm diameter sphere. Thermophysical properties of material of thermocouple are $c = 420\ J/kg.K$, $\rho = 8000\ kg/m^3$, $k = 40\ W/m.K$, $h = 40\ W/m^2.K$. Determine: Time constant of thermocouple.	10	2	1,2,3	3
5(b)	State: Criteria of *Bi* value for analysis of transient heat conduction problems. A *50 mm* thick iron plate is initially at *225°C*. In a quenching process, its both the surfaces are suddenly exposed to an environment of *25°C* with the convective heat transfer coefficient of $500\ W/m^2.K$. Thermophysical properties of iron are $c = 460\ J/kg.K$, $\rho = 7850\ kg/m^3$, $k = 60\ W/m.K$. Calculate: i) The centre temperature, 2 min after the start of the exposure. ii) Temperature at a depth of 10 mm from the surface of the plate, 2 min after the start of the exposure.	10	4	1,5	3
6(a)	Explain: Significance of Grashoff No. (*Gr*) and Rayleigh No. (*Ra*). A horizontal pipe carrying steam runs in a large room and is exposed to air at *30°C*. The pipe surface temperature is at *200°C* and the outside diameter of pipe is *20 mm*. Heat loss per meter length of the pipe is 1.9193 kW/m. Nusselt No. (*Nu*) is given by McAdams correlation $\overline{Nu} = 0.53\ (Ra)^{0.25}$. Take required properties of air at mean film temperature. Evaluate: i) Free Convective heat transfer rate from the pipe ii) Emissivity of the pipe surface.	10	3,4	2,5	4,5
6(b)	Define equivalent diameter (D_e). State: Formula of D_e for hollow pipe of inside and outside diameter d and D respectively. A metallic bus bar *25 mm* diameter is cooled by turbulent flow of air at 30°C cross flowing past the bus bar with a velocity of *2.5 m/s*. The surface temperature of the bus bar is 85°C. Nusselt No. (*Nu*) is given by correlation $\overline{Nu} = C.Re^n\ Pr^{1/3}$ for turbulent flow over cylinder where; values of C and n are selected from below as: i) $C = 0.683;\ n = 0.466$ for $40 < Re < 4 \times 10^3$ ii) $C = 0.683;\ n = 0.466$ for $4 \times 10^3 < Re < 4 \times 10^4$	10	4	2,5	4

	Take required properties of air at mean film temperature. Evaluate: Heat dissipation rate for 1 m length of the bar.				
7(b)	State: The following laws of radiation and Express: Mathematical equation/s for each of them. i) Stefan-Boltzmann Law ii) Kirchoff's Law iii) Wien's Displacement Law iv) Lambert's Cosine Law	**10**	3	1,2	5
7(b)	For an industrial furnace in the form of a black body emitting radiations at *2500°C*, Evaluate: i) Monochromatic emissive power at *1.2 μm*. ii) Wavelength at which emission is maximum iii) Maximum emissive power iv) Total emissive power v) Intensity of normal radiation	**10**	3	5	5

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END-SEM-EXAMINATIONS December 2022

T.Y. B.Tech (D) (Mech) 19/12/22

Program T-Y :BTech Mechanical engg **Duration** :3 hr

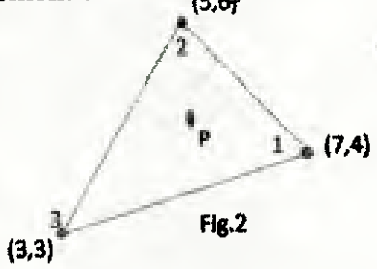
Course Code :PE-BTM511 **Maximum Points** :100

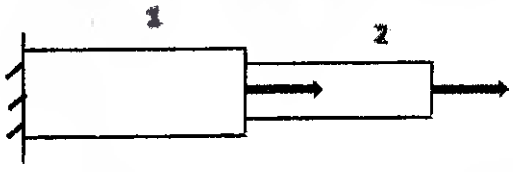
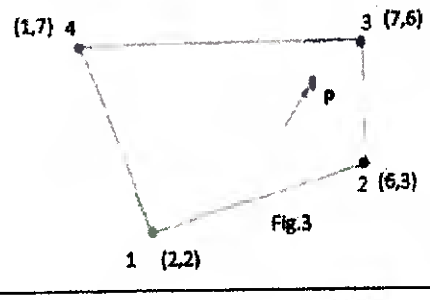
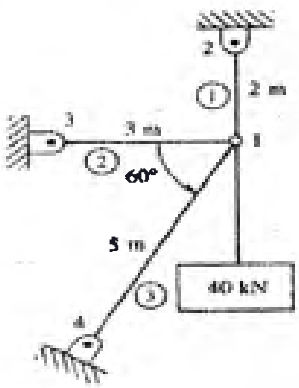
Course Name :Finite Element Methods for Mechanical Engineers.

Semester :V

Instruction : Refer below

1. Question No. 1 is compulsory
2. Solve any four out of remaining six.
3. Answers to each sub-questions are grouped together
4. Use of scientific calculator is allowed
5. Begin answer to each question on new page.
6. Keep some margin on left side of answer paper
7. **Candidates should write the answer legibly (Refer clause 13)**

Q. no.	Description	Points	CO	BL
1	Answer the following: a) Explain step-by-step procedure followed in FEM. b) State and explain the advantages of use of natural coordinates in FEA? c) Describe the Galerkin Weighted residual method. d) What are the characteristics of the stiffness matrix	5x4	1	2,3
2	a) Obtain the shape functions for element shown in fig.2 b) For the element shown in fig.2, calculate temperature at point P(6,5). Given the nodal temperatures $T_1 = 50^0$ C, $T_2 = 45^0$ C, $T_3 = 60^0$ C. c) For the element shown in fig.2, calculate displacement at point P(5,4). Given $u_1=1$, $u_2=2$, $u_3=3$; $v_1=3$, $v_2=2$, $v_3=1$.  Fig.2	10 5 5	1,2	3,4
3	a) Derive the shape function for quadratic bar element using Lagrangian method. (use Cartesian co-ordinate). b) For the stepped bar shown in figure, obtain the following using FEM procedure: • Discretize system using linear bar element and show loading and boundary conditions. • Obtain element level and assembled stiffness matrix. • Calculate nodal displacement.	5 2 6	1,2,3	3,4

	• Stress in each element. Take $P_1 = 90$ kN; $P_2 = 60$ kN, $E_1 = 200$ GPa, $E_2 = 100$ GPa, $L_1 = 1.2$ m, $L_2 = 0.8$ m, $d_1 = 32$ mm, $d_2 = 20$ mm 	4 3		
4	For the quadrilateral element shown in Figure-3, determine: a) Jacobian matrix b) Equivalent nodal forces, if the load of 15 kN in the directions of 45 degrees with horizontal is applied at P (4, 4).  Fig.3	10 10	2	3,4
5	For the truss shown in fig. obtain: a) Elements stiffness matrix b) Displacement of node 1 c) Stress in each element 	10 5 5	2,3	3,4
6	The pin-fin used for heat dissipation, has 50 mm long and circular c/s area of 100π mm². At one end of fin temperature is 200°C. (take k = 100 watt/cm °C, h = 10 watt/cm² °C, use 2 linear elements, neglect convection from free end)Find: a) Conductive and convective matrix for each element b) Final assembled matrix c) Thermal load vector d) Temperature at the other end of pin.	5 5 5 5	1,2,3	3,4
7	a) Explain Cholesky factorization method b) Obtain the weak formulation statement for simply supported beam with UDL.	10 10	1	2,3

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T.Y. B.Tech (Mech) Sem V 19/12/22

T.Y.

END SEM EXAM DEC 2022

Programme : B.Tech.in Mechanical Engineering	Semester : V
Course Name & Code: LGM , PE-B I M534	Session: ~~Afternoon~~ M.
Points :100 Lean & Green Manufacturing	Time 3Hrs

Que 1 is compulsory.
Solve any four questions from remaining

Que		Points	CO	Module
Q1	Explain 7 Problem solving Tools with neat sketches	20	CO1	M1,M2, M3
Q2A	Draw the Cause and effect diagram for supply risk in JIT implementation. Explore the Risk mitigation strategies.	10	CO1, CO2	M3
Q2B	Draw the Kano model. Explain it in detail.	10	CO1	M6, M7
Q3A	Prepare the Framework for Manufacturing Throughput Time per part (MTTP) OR Illustrate the Value Stream Map with suitable example	10	CO2, CO3	M2, M3
Q3B	Prepare Green Supplier Development Process Model and Explain it in detail.	10	CO4	M7
Q4A	Develop the framework for sustainable lean implementation. Draw the neat sketch and explain it in detail.	10	CO1	M3
Q4B	State and explain the green-lean practice bundles.	10	CO1	M3-
Q5A	Draw and explain the UNIDO–ACMA Model approach considering input process result impact.	10	CO1, CO2	M2, M3, M4
Q5B	JIT/lean barriers and manufacturing practice areas High Performance Manufacturing model	10	CO1	M5, M7
Q6A	Prepare the table to show case Human Resource Barriers for Lean Implementation, Strategies and action plan	10	CO1, CO2	M5
Q6B	Prepare and Explain the Blockchain IoT integrated architecture for involving stakeholders in supply chain to make processes green	10	CO4	M6
Q7A	Explore and Explain measures of port lean effectiveness.	10	CO2	M6
Q7B	Explain 11 principles used in Lean Construction practices	10	CO2	M6, M7

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19/12/22

END SEMESTER EXAMINATION DECEMBER 2022

Program: T.Y. B. Tech. (Mechanical Engg.) Sem V

Duration: 3 Hrs

Course Code: PE-BTM552

Maximum Points: 100

Course Name: Hydraulic Machinery

Semester: V

Notes: (1) Q. 1, 2 and 3 are compulsory
(2) Attempt any two questions from Q. 4 to Q.7.
(2) Draw labeled sketches to justify answer.
(3) Clear and readable handwriting is expected.

Q. No.	Questions	Points	CO	BL	Module No.
1	Only draw neat labeled sketches of (i) Pelton wheel Bucket (Front and sectional top views) (ii) Various types of Draft tube (iii) Separate indicator diagram considering alone acceleration and frictional effects for reciprocating pump. (iv) Various types of Impellers of Centrifugal Pumps.	20	1 to 4	5	1,2,3, 5,6,7
2 (a)	In water power site, the available discharge is 340 m^3/s under a net head of 30 m. Assuming a turbine efficiency of 88% and rotational speed of 166.7 rpm, determine the least number of machines, all of the same size, that may be installed if the selection rests with- (i) Francis turbine with Ns not greater than 230. (ii) Kaplan turbine with Ns not greater than 685, What will be the output of each unit? Which of the two installations will be more economical? (Reference Ns given is considering speed in rpm, power in KW, and head in meters).	10	3,4	5	1,2,3,4
2 (b)	A model of Francis turbine one-fifth of full size, develops 3 KW at 306 rpm under a head of 1.77 m. Find the speed and power of full size turbine operating under a head of 5.7 m, if (a) the efficiency of the model and the full size turbine are same. (b) the efficiency of the model turbine is 76% and the scale effect is considered.	10	1,2,4	4	3,4,5
3 (a)	Test on single stage centrifugal pump at 1450 rpm gave the following results:-	10	3,4	5	7

Q (m^3/s)	0	0.006	0.012	0.018	0.024	0.030	0.036

END SEMESTER EXAMINATION DECEMBER 2022

	Hm (m)	22.6	21.9	20.3	17.7	14.2	9.7	3.9			
	When two such identical pumps are connected in parallel, the flow rate through the system is the same as when they are connected in series. Determine the flow rate that the individual pump would deliver if connected to the same system. Assume that the system characteristic is purely resistive with no static lift.										
3 (b)	A single-acting reciprocating pump has a stroke length of 160 mm, suction pipe is 7 m long and the ratio of suction pipe diameter to the piston diameter is 0.75. The water level in the sump is 3 m below the axis of the pump cylinder and the pipe connecting the sump and pump cylinder is 75 mm in diameter. If the crank is running at 75 rpm, determine the pressure head on the piston at the beginning, middle and end of the suction stroke. Take friction factor, f=0.04 (Take $h_f=flv^2/2gd$).								10	3,4	4	6
4	In a hydro-electric scheme a number of Pelton wheels are to be used under following conditions: Total output required 37 MW, gross head 245 m, speed 6.25 rps; 2 jets per wheel, Cv of nozzles 0.97; Speed ratio is 0.46, maximum overall efficiency (based on conditions immediately before the nozzles) 81.5%. "Dimensionless specific speed" not to exceed 0.022 rev (for one jet); head lost to friction in pipe line not to exceed 12 m. Calculate (i) The number of wheels required. (ii) The diameters of jet and wheels (iii) The hydraulic efficiency, if the blades deflects the water through 165^0 and reduce its relative velocity by 15% (iv) The percentage of input power that remains as kinetic energy of the water at discharge. Take the relation for dimensionless specific speed – $\frac{N\sqrt{P}}{\rho^{1/2}(gH)^{5/4}}$, where N is the speed in rps, P is the power in watts, H is the head in meters, and ρ is the density of the water in kg/m^3.								20	4	6	1, 2
5	In a vertical shaft inward flow reaction turbine the sum of the pressure and kinetic heads at entrance to the spiral casing is 135 m and vertical distance between this section and the tail race										5	3

END SEMESTER EXAMINATION DECEMBER 2022

	level is 3 m. The peripheral velocity of the runner at entry is 30 m/s, the velocity of flow is constant at 11 m/s and the discharge from the runner is without whirl. The estimated hydraulic losses are: (a) losses between turbine entrance and exit from guide vanes= 5.8 m, (b) losses in the runner = 7.8 m, (c) losses in the draft tube = 750 mm, (d) kinetic energy rejected to the tail race = 450 mm, Determine: (i) The guide vane angle and the runner blade angle at inlet; (ii) The pressure heads at entry to and exit from the runner.	20	4		
6	A Kaplan turbine installation develops 18 MW under a net head of 14 m. The peripheral speed of the runner at the outermost radius is 40 m/s. The Thoma's cavitation parameter σ is related to the specific speed (power in KW) as given below: σ: 0.5 | 0.75 | 1.25 | 1.8 Ns: 385 | 515 | 685 | 857 What should be the minimum outer diameter of the runner if the turbine is set at 0 m, 3 m and -3 m from the tail water level? Vapour pressure of water at ambient temperature is 0.026 kg/cm^2 (abs) and the atmospheric pressure is 1.03 kg/cm^2. [Use interpolation if required]. Diameters are to be calculated for the nearest synchronous speed.	20	1,2,3	5	4
7	Test on single stage centrifugal pump at 1425 rpm gave the following results:- Q (m^3/s): 0 | 0.006 | 0.012 | 0.018 | 0.024 | 0.030 | 0.036 Hm (m): 22.6 | 21.9 | 20.3 | 17.7 | 14.2 | 9.7 | 3.9 A system is designed where the static head is 5 m and the operating point is Hm=17.7 m and Q= 0.018 m^3/s for the above pump. The system is redesigned, the static head being 5.5 m and the frictional and other losses increased by 20%. Find the new pump speed so that the flow rate of 0.018 m^3/s can be maintained.	20	2,3,4	6	6,7

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END SEMESTER EXAMINATION, DECEMBER 2022

T.Y. B.Tech (M) Sem V 19/12/22

B.Tech. (Mechanical Engineering) Semester - V Duration: **Three Hour**

Course: **COMPRESSIBLE FLUID FLOW (PE BTM 554)** Maximum Points :**100**

Notes

- Answer any FIVE from seven questions,
- Answers to all sub questions should be grouped together for evaluation,
- Make suitable assumption if needed with proper reasoning,
- Data shown under column CO, BL and PI are only for academic evaluation

(CO: Course Outcome, BL: Blooms Taxonomy, PI: Performance Indicator)

		Points	CO	BL
1.	**(A)** Examine the characteristic features of compressible low and identify its basic equations? Write them in their mathematical form.	**[10]**	2,3	4
	(B) For flow through a variable area duct, prove that $\frac{dV}{V} = \frac{dA}{A}\frac{1}{\left[1-M^2\right]}$, Analyze and explain the expression with their physical meaning.	**[10]**	2.3	4,5
2.	**(A)** Differentiate between following. i) Compressible and Incompressible, ii) Subsonic and Supersonic, iii) Stagnation state and actual state of fluid flow. iv) Normal and oblique shock wave	**[10]**	1,2	4
	(B) Define Mach number and critical state of a compressible flow. Derive an expression for the sonic velocity in an arbitrary fluid. Is there any effect of pressure on the sonic velocity?	**[10]**	1	1,4
3	**(A)** What are the two benchmark state to describe the properties of a compressible flow? Derive expressions for the following properties of a flow with Mach number M, in terms of both benchmark states- Pressure, Temperature and Density.	**[10]**	1	1,2
	(B) Air flows steadily through the duct shown from 350 kPa (abs), 60°C, and 183 m/s at the inlet state to M=5 at the outlet, where local isentropic stagnation conditions are known to be 385 kPa (abs) and 350 K. Compute the local isentropic stagnation pressure and temperature at the inlet and the static pressure and temperature at the duct outlet. Locate the inlet and outlet static state points on a Ts diagram, and indicate the stagnation processes.	**[10]**	3,4	3,4
4.	**(A)** Consider a normal shock exist in a one dimensional gas flow. What is the effect of normal shock on following properties (increase/decrease)? Stagnation pressure and temperature, actual pressure and temperature, entropy, velocity and density. Justify your answer.	**[10]**	3,4	1,2

	(B) A normal shock stands in a duct. The fluid is air, which may be considered an ideal gas. Properties upstream from the shock are T_1= 5°C, p_1 = 65.0 kPa (abs.), and V= 668 m/s. Determine properties downstream and s_2- s_1. Sketch the process on a Ts diagram. *(Use Gas Table)*	**[10]**	4	3,4
5.	**(A)** What do you understand by a chocked flow? When does it happens? Explain isentropic flow through a converging nozzle for variable back flow pressure condition. Represent the variation along the nozzle length.	**[10]**	1,3	1,2
	(B) Air flows isentropically in a channel. At section 1 the Mach number is 0.3, the area is 0.001 m^2, and the absolute pressure and the temperature are 650 kPa and 62°C, respectively. At section 2, the Mach number is 0.8. Sketch the channel shape, plot a T-s diagram for the process, and evaluate properties at section 2.	**[10]**	3	4,5
6.	**(A)** Discuss Rayleigh Flow. List down all governing equation required to characterize this flow. Represent it on a Ts diagram and explain its unique feature.	**[10]**	1,3	2,4
	(B) What is a supersonic wind tunnel? What special features does it has compared to subsonic wing tunnels? Explain different types of supersonic wind tunnels with appropriate schematic diagram and discuss their workings.	**[10]**	2,3	1,3, 5
7.	**(A)** What is Fanno flow? Sketch Fanno line on an appropriate property diagram and explain it. Discuss the effect of Fanno flow on following properties: Pressure, temperature, density, enthalpy and velocity of flow.	**[10]**	1,2	1,2
	(B) A long pipe of 25.4 mm diameter has a mean coefficient of friction of 0.003. Air enters the pipe at a Mach number of 2.5, stagnation temperature 310K and static pressure 0.507 bar. Determine for a section at which the Mach number reaches 1.2 *(Use Gas Table)*, (a) static pressure and temperature (b) stagnation pressure and temperature (c) velocity of air (d) distance of section from the inlet, and (e) mass flow rate of the air	**[10]**	3,4	3,4

GAS TABLE

TABLE 4.2

Normal shocks in perfect gases ($\gamma = 1.4$)

M_x	M_y	p_y/p_x	T_y/T_x	p_{0y}/p_{0x}	p_{0y}/p_x
1.00	1.000	1.000	1.000	1.000	1.893
1.02	0.981	1.047	1.013	0.999	1.938
1.04	0.962	1.095	1.026	0.999	1.984
1.06	0.945	1.144	1.039	0.999	2.032
1.08	0.928	1.194	1.052	0.999	2.082
1.10	0.911	1.245	1.065	0.998	2.133
1.12	0.897	1.297	1.078	0.998	2.185
1.14	0.882	1.349	1.090	0..997	2.238
1.16	0.868	1.403	1.103	0.996	2.294
1.18	0.855	1.458	1.115	0.994	2.350
1.20	0.842	1.513	1.128	0.993	2.407
1.22	0.830	1.570	1.141	0.991	2.466
1.24	0.818	1.627	1.153	0.988	2.526
1.26	0.807	1.685	1.166	0.985	2.587
1.28	0.796	1.745	1.178	0.983	2.650
1.30	0.786	1.805	1.191	0.979	2.714
1.32	0.776	1.866	1.204	0.976	2.778
1.34	0.766	1.928	1.216	0.972	2.845
1.36	0.757	1.991	1.229	0.967	2.911
1.38	0.748	2.055	1.242	0.963	2.979
1.40	0.740	2.120	1.255	0.958	3.049
1.42	0.731	2.186	1.267	0.953	3.120
1.44	0.723	2.253	1.281	0.947	3.192
1.46	0.716	2.320	1.294	0.942	3.265
1.48	0.708	2.389	1.307	0.936	3.338
1.50	0.701	2.458	1.320	0.930	3.413
1.52	0.694	2.529	1.334	0.923	3.489
1.54	0.687	2.600	1.347	0.917	3.567
1.56	0.681	2.673	1.361	0.909	3.645
1.58	0.675	2.746	1.374	0.903	3.725
1.60	0.668	2.820	1.388	0.895	3.805

TABLE 4.2

Normal shocks in perfect gases ($\gamma = 1.4$)

M_x	M_y	p_y/p_x	T_y/T_x	p_{0y}/p_{0x}	p_{0y}/p_x
1.62	0.663	2.895	1.402	0.887	3.886
1.64	0.657	2.971	1.416	0.880	3.969
1.66	0.651	3.048	1.430	0.872	4.053
1.68	0.646	3.126	1.444	0.864	4.138
1.70	0.641	3.205	1.458	0.856	4.224
1.72	0.635	3.285	1.473	0.847	4.315
1.74	0.631	3.336	1.487	0.839	4.443
1.76	0.626	3.447	1.502	0.830	4.533
1.78	0.621	3.530	1.517	0.822	4.578
1.80	0.616	3.613	1.532	0.813	4.670
1.82	0.612	3.698	1.547	0.804	4.762
1.84	0.608	3.781	1.562	0.795	4.855
1.86	0.604	3.870	1.578	0.786	4.947
1.88	0.599	3.957	1.593	0.776	5.043
1.90	0.596	4.045	1.608	0.767	5.142
1.92	0.592	4.134	1.624	0.758	5.239
1.94	0.588	4.224	1.639	0.749	5.338
1.96	0.584	4.315	1.656	0.739	5.438
1.98	0.581	4.407	1.671	0.730	5.538
2.00	0.577	4.500	1.687	0.721	5.641
2.02	0.574	4.594	1.704	0.712	5.743
2.04	0.571	4.688	1.720	0.702	5.847
2.06	0.567	4.784	1.737	0.693	5.953
2.08	0.564	4.881	1.754	0.684	6.058
2.10	0.561	4.978	1.770	0.674	6.166
2.12	0.558	5.077	1.787	0.665	6.274
2.14	0.556	5.176	1.805	0.656	6.383
2.16	0.553	5.276	1.822	0.646	6.493
2.18	0.550	5.378	1.839	0.637	6.604
2.20	0.547	5.480	1.857	0.628	6.716

TABLE 4.2

Normal shocks in perfect gases ($\gamma = 1.4$)

M_x	M_y	p_y/p_x	T_y/T_x	p_{0y}/p_{0x}	p_{0y}/p_x
2.22	0.545	5.583	1.875	0.619	6.829
2.24	0.542	5.687	1.892	0.610	6.945
2.26	0.539	5.792	1.910	0.601	7.060
2.28	0.537	5.898	1.928	0.592	7.176
2.30	0.534	6.005	1.947	0.583	7.294
2.32	0.532	6.113	1.965	0.574	7.412
2.34	0.529	6.222	1.984	0.566	7.532
2.36	0.527	6.331	2.003	0.557	7.653
2.38	0.525	6.442	2.021	0.548	7.775
2.40	0.523	6.553	2.040	0.540	7.897
2.42	0.521	6.666	2.059	0.532	8.027
2.44	0.519	6.780	2.079	0.523	8.145
2.46	0.517	6.894	2.098	0.515	8.271
2.48	0.515	7.008	2.118	0.507	8.398
2.50	0.513	7.125	2.138	0.499	8.526
2.52	0.511	7.242	2.157	0.491	8.655
2.54	0.509	7.360	2.177	0.483	8.785
2.56	0.507	7.479	2.197	0.475	8.916
2.58	0.506	7.599	2.218	0.467	9.145
2.60	0.504	7.720	2.238	0.460	9.181
2.62	0.502	7.842	2.259	0.453	9.315
2.64	0.500	7.965	2.279	0.445	9.451
2.66	0.498	8.088	2.300	0.438	9.587
2.68	0.497	8.213	2.322	0.431	9.724
2.70	0.496	8.338	2.343	0.423	9.863
2.72	0.494	8.465	2.364	0.416	10.002
2.74	0.493	8.592	2.386	0.409	10.142
2.76	0.491	8.721	2.407	0.403	10.283
2.78	0.490	8.849	2.429	0.396	10.426
2.80	0.488	8.980	2.451	0.389	10.569

TABLE 4.2

Normal shocks in perfect gases ($\gamma = 1.4$)

M_x	M_y	p_y/p_x	T_y/T_x	p_{0y}/p_{0x}	p_{0y}/p_x
2.82	0.487	9.111	2.473	0.383	10.714
2.84	0.485	9.243	2.495	0.376	10.859
2.86	0.484	9.376	2.518	0.370	11.006
2.88	0.483	9.510	2.540	0.364	11.154
2.90	0.481	9.645	2.563	0.358	11.302
2.92	0.480	9.781	2.586	0.352	11.452
2.94	0.478	9.917	2.609	0.346	11.603
2.96	0.477	10.055	2.632	0.339	11.754
2.98	0.476	10.194	2.656	0.334	11.907
3.00	0.475	10.333	2.679	0.328	12.061
3.05	0.472	10.686	2.738	0.315	12.450
3.10	0.469	11.045	2.798	0.301	12.846
3.15	0.467	11.409	2.860	0.288	13.247
3.20	0.464	11.780	2.922	0.276	13.656
3.25	0.462	12.156	2.985	0.264	14.071
3.30	0.459	12.538	3.049	0.253	14.492
3.35	0.457	12.926	3.114	0.243	14.920
3.40	0.455	13.320	3.180	0.232	15.354
3.54	0.453	13.791	3.247	0.222	15.795
3.50	0.451	14.125	3.315	0.213	16.242
3.55	0.449	14.536	3.384	0.204	16.700
3.60	0.447	14.953	3.454	0.195	17.156
3.65	0.445	15.376	3.525	0.187	17.715
3.70	0.444	15.805	3.596	0.179	18.095
3.75	0.442	16.239	3.669	0.172	18.575
3.80	0.441	16.680	3.743	0.164	19.060
3.85	0.439	17.126	3.817	0.157	19.553
3.90	0.438	17.578	3.893	0.151	20.051
3.95	0.436	18.036	3.969	0.145	20.556
4.00	0.435	18.500	4.047	0.138	21.068

TABLE 4.2

Normal shocks in perfect gases ($\gamma = 1.4$)

M_x	M_y	p_y/p_x	T_y/T_x	p_{0y}/p_{0x}	p_{0y}/p_x
4.05	0.434	18.969	4.125	0.133	21.586
4.10	0.432	19.445	4.205	0.127	22.111
4.15	0.431	19.926	4.285	0.122	22.642
4.20	0.430	20.413	4.367	0.117	23.179
4.25	0.429	20.906	4.449	0.113	23.723
4.30	0.428	21.405	4.532	0.108	24.273
4.35	0.427	21.909	4.616	0.104	24.829
4.40	0.426	22.420	4.702	0.099	25.393
4.45	0.425	22.936	4.788	0.095	26.078
4.50	0.424	23.458	4.875	0.0917	26.539
4.55	0.423	23.986	4.963	0.088	27.120
4.60	0.422	24.520	5.052	0.085	27.710
4.65	0.421	25.059	5.142	0.081	28.305
4.70	0.420	25.605	5.233	0.078	28.907
4.75	0.419	26.156	5.325	0.075	29.516
4.80	0.418	26.713	5.418	0.072	30.130
4.85	0.417	27.276	5.512	0.069	30.751
4.90	0.4167	27.845	5.607	0.067	31.379
4.95	0.416	28.419	5.703	0.0642	32.013
5.00	0.415	29.000	5.800	0.0617	32.654
6.00	0.404	41.833	7.941	0.0296	46.815
7.00	0.397	57.000	10.469	0.0154	63.552
8.00	0.393	74.500	13.387	0.0085	82.865
9.00	0.389	94.333	16.693	0.005	104.753
10.000	0.388	116.500	20.388	0.003	129.217
∞	0.378	∞	∞	0	∞

TABLE 6.2

Flow of perfect gases with friction (Fanno flow, $\gamma = 1.4$)

M	p/p^*	$c/c^* = \rho^*/\rho$	T/T^*	p_0/p_0^*	F/F^*	$4\bar{f}L_{max}/D$
0.02	54.770	0.022	1.199	28.942	22.834	1778.450
0.04	27.382	0.044	1.199	14.482	11.435	440.352
0.06	18.251	0.066	1.199	9.666	7.643	193.031
0.08	13.684	0.087	1.198	7.262	5.753	106.718
0.10	10.943	0.109	1.197	5.822	4.624	66.922
0.12	9.116	0.131	1.196	4.864	3.875	45.407
0.14	7.809	0.153	1.195	4.183	3.343	32.511
0.16	6.830	0.175	1.194	3.673	2.950	24.197
0.18	6.067	0.196	1.192	3.278	2.643	18.543
0.20	5.455	0.218	1.190	2.964	2.400	14.533
0.22	4.955	0.239	1.188	2.708	2.205	11.596
0.24	4.538	0.261	1.186	2.496	2.043	9.387
0.26	4.185	0.283	1.184	2.317	1.909	7.687
0.28	3.882	0.304	1.181	2.166	1.795	6.357
0.30	3.619	0.326	1.178	2.035	1.698	5.299
0.32	3.388	0.347	1.176	1.922	1.615	4.447
0.34	3.185	0.368	1.172	1.823	1.542	3.752
0.36	3.004	0.389	1.169	1.736	1.479	3.180
0.38	2.842	0.410	1.166	1.658	1.423	2.705
0.40	2.695	0.431	1.163	1.590	1.375	2.308
0.42	2.563	0.452	1.159	1.529	1.332	1.974
0.44	2.442	0.473	1.155	1.474	1.294	1.692
0.46	2.333	0.494	1.151	1.425	1.260	1.451
0.48	2.231	0.514	1.147	1.380	1.230	1.245
0.50	2.138	0.534	1.143	1.340	1.203	1.069
0.52	2.052	0.555	1.138	1.303	1.179	0.917
0.54	1.972	0.575	1.134	1.270	1.157	0.787
0.56	1.897	0.595	1.129	1.240	1.138	0.674
0.58	1.828	0.615	1.124	1.213	1.120	0.575
0.60	1.763	0.635	1.119	1.188	1.105	0.491

TABLE 6.2

Flow of perfect gases with friction (Fanno flow, $\gamma = 1.4$)

M	p/p^*	$c/c^* = \rho^*/\rho$	T/T^*	p_0/p_0^*	F/F^*	$4\bar{f}L_{max}/D$
0.62	1.703	0.654	1.114	1.166	1.092	0.417
0.64	1.645	0.674	1.109	1.145	1.079	0.353
0.66	1.592	0.693	1.104	1.127	1.068	0.298
0.68	1.541	0.713	1.098	1.109	1.058	0.249
0.70	1.493	0.732	1.093	1.094	1.049	0.208
0.72	1.448	0.751	1.087	1.081	1.041	0.172
0.74	1.405	0.770	1.082	1.068	1.035	0.141
0.76	1.365	0.788	1.076	1.057	1.028	0.114
0.78	1.326	0.807	1.069	1.047	1.023	0.092
0.80	1.289	0.825	1.064	1.038	1.018	0.073
0.82	1.254	0.843	1.058	1.031	1.015	0.056
0.84	1.221	0.861	1.051	1.024	1.011	0.042
0.86	1.189	0.879	1.045	1.018	1.008	0.031
0.88	1.158	0.897	1.039	1.013	1.006	0.022
0.90	1.129	0.915	1.003	1.009	1.004	0.015
0.92	1.101	0.932	1.026	1.006	1.003	0.0089
0.94	1.074	0.949	1.020	1.003	1.001	0.005
0.96	1.048	0.966	1.013	1.001	1.0006	0.0020
0.98	1.024	0.983	1.006	1.0003	1.0001	0.0005
1.00	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**0.000**
1.02	0.977	1.016	0.993	1.0003	1.0001	0.00046
1.04	0.955	1.033	0.986	1.0013	1.0005	0.0018
1.06	0.933	1.049	0.979	1.003	1.0012	0.004
1.08	0.913	1.065	0.973	1.005	1.002	0.0066
1.10	0.894	1.081	0.966	1.008	1.003	0.0099
1.12	0.875	1.097	0.959	1.011	1.004	0.0138
1.14	0.856	1.113	0.952	1.015	1.006	0.0182
1.16	0.838	1.128	0.945	1.020	1.007	0.023
1.18	0.821	1.143	0.938	1.025	1.009	0.028
1.20	0.804	1.158	0.932	1.030	1.011	0.034

TABLE 6.2

Flow of perfect gases with friction (Fanno flow, $\gamma = 1.4$)

M	p/p^*	$c/c^* = \rho^*/\rho$	T/T^*	p_0/p_0^*	F/F^*	$4\bar{f}L_{max}/D$
1.22	0.788	1.173	0.925	1.037	1.013	0.039
1.24	0.773	1.188	0.918	1.043	1.015	0.045
1.26	0.757	1.202	0.911	1.050	1.017	0.0517
1.28	0.743	1.217	0.903	1.058	1.019	0.0582
1.30	0.728	1.231	0.897	1.066	1.022	0.065
1.32	0.715	1.245	0.889	1.075	1.024	0.0716
1.34	0.701	1.259	0.883	1.084	1.027	0.0785
1.36	0.688	1.273	0.876	1.094	1.029	0.0855
1.38	0.676	1.286	0.869	1.104	1.032	0.093
1.40	0.663	1.300	0.862	1.115	1.035	0.099
1.42	0.651	1.313	0.855	1.126	1.037	0.107
1.44	0.640	1.326	0.848	1.138	1.040	0.114
1.46	0.628	1.339	0.841	1.150	1.043	0.121
1.48	0.617	1.352	0.834	1.163	1.046	0.128
1.50	0.606	1.364	0.828	1.176	1.048	0.136
1.52	0.596	1.377	0.821	1.189	1.052	0.143
1.54	0.586	1.389	0.814	1.204	1.055	0.151
1.56	0.576	1.401	0.807	1.219	1.057	0.158
1.58	0.566	1.413	0.800	1.234	1.061	0.165
1.60	0.557	1.425	0.794	1.250	1.063	0.172
1.62	0.547	1.437	0.787	1.267	1.067	0.179
1.64	0.538	1.448	0.780	1.284	1.069	0.187
1.66	0.529	1.460	0.774	1.301	1.073	0.194
1.68	0.521	1.471	0.767	1.319	1.075	0.201
1.70	0.513	1.482	0.760	1.340	1.078	0.208
1.72	0.505	1.493	0.754	1.357	1.082	0.215
1.74	0.496	1.504	0.747	1.376	1.085	0.222
1.76	0.489	1.515	0.741	1.397	1.088	0.228
1.78	0.481	1.525	0.735	1.418	1.091	0.235
1.80	0.474	1.536	0.728	1.439	1.093	0.242

TABLE 6.2

Flow of perfect gases with friction (Fanno flow, $\gamma = 1.4$)

M	p/p^*	$c/c^* = \rho^*/\rho$	T/T^*	p_0/p_0^*	F/F^*	$4\bar{f}L_{max}/D$
1.82	0.467	1.546	0.722	1.461	1.096	0.248
1.84	0.459	1.556	0.716	1.484	1.099	0.255
1.86	0.453	1.566	0.709	1.507	1.102	0.262
1.88	0.446	1.576	0.703	1.530	1.105	0.268
1.90	0.439	1.586	0.697	1.555	1.108	0.274
1.92	0.433	1.596	0.691	1.580	1.111	0.281
1.94	0.426	1.605	0.685	1.610	1.114	0.287
1.96	0.420	1.615	0.678	1.633	1.117	0.293
1.99	0.414	1.624	0.673	1.660	1.120	0.299
2.00	0.408	1.633	0.667	1.687	1.123	0.305
2.02	0.402	1.642	0.661	1.716	1.126	0.311
2.04	0.397	1.651	0.655	1.747	1.128	0.317
2.06	0.391	1.659	0.649	1.775	1.131	0.323
2.08	0.386	1.668	0.643	1.806	1.134	0.328
2.10	0.380	1.677	0.637	1.837	1.137	0.334
2.12	0.375	1.685	0.632	1.870	1.139	0.339
2.14	0.369	1.694	0.623	1.902	1.142	0.345
2.16	0.365	1.702	0.621	1.935	1.145	0.350
2.18	0.359	1.710	0.615	1.970	1.147	0.356
2.20	0.355	1.718	0.609	2.005	1.150	0.361
2.22	0.350	1.726	0.604	2.041	1.153	0.366
2.24	0.346	1.733	0.598	2.078	1.155	0.371
2.26	0.341	1.741	0.594	2.115	1.158	0.376
2.28	0.336	1.748	0.588	2.154	1.160	0.381
2.30	0.332	1.756	0.583	2.193	1.163	0.386
2.32	0.327	1.764	0.578	2.233	1.165	0.391
2.34	0.323	1.771	0.573	2.274	1.168	0.396
2.36	0.319	1.778	0.567	2.316	1.170	0.400
2.38	0.315	1.785	0.563	2.360	1.173	0.405
2.40	0.311	1.792	0.557	2.403	1.175	0.409

TABLE 6.2

Flow of perfect gases with friction (Fanno flow, $\gamma = 1.4$)

M	p/p^*	$c/c^* = \rho^*/\rho$	T/T^*	p_0/p_0^*	F/F^*	$4\bar{f}L_{max}/D$
2.42	0.307	1.799	0.553	2.448	1.178	0.414
2.44	0.303	1.806	0.548	2.494	1.179	0.419
2.46	0.299	1.813	0.543	2.540	1.182	0.423
2.48	0.296	1.819	0.538	2.588	1.185	0.427
2.50	0.292	1.826	0.533	2.637	1.187	0.432
2.52	0.289	1.832	0.528	2.687	1.189	0.436
2.54	0.285	1.838	0.524	2.737	1.191	0.440
2.56	0.281	1.845	0.519	2.789	1.193	0.445
2.58	0.278	1.851	0.515	2.842	1.195	0.448
2.60	0.275	1.857	0.510	2.896	1.198	0.453
2.62	0.271	1.863	0.506	2.951	1.200	0.457
2.64	0.268	1.869	0.501	3.007	1.202	0.460
2.66	0.265	1.875	0.497	3.065	1.204	0.464
2.68	0.262	1.881	0.493	3.123	1.206	0.468
2.70	0.258	1.886	0.488	3.183	1.208	0.472
2.72	0.256	1.892	0.484	3.244	1.210	0.476
2.74	0.253	1.898	0.479	3.306	1.212	0.479
2.76	0.250	1.903	0.476	3.370	1.214	0.483
2.79	0.247	1.908	0.471	3.435	1.216	0.486
2.80	0.244	1.914	0.467	3.500	1.218	0.489
2.82	0.241	1.919	0.463	3.567	1.220	0.493
2.84	0.238	1.925	0.459	3.636	1.222	0.497
2.86	0.236	1.929	0.455	3.706	1.224	0.499
2.88	0.233	1.935	0.451	3.780	1.226	0.503
2.90	0.231	1.940	0.447	3.850	1.228	0.506
2.92	0.228	1.945	0.443	3.924	1.229	0.509
2.94	0.226	1.949	0.439	4.000	1.231	0.513
2.96	0.223	1.954	0.436	4.076	1.233	0.516
2.98	0.220	1.959	0.432	4.155	1.235	0.519
3.00	0.218	1.964	0.428	4.235	1.237	0.522

TABLE 6.2

Flow of perfect gases with friction (Fanno flow, $\gamma = 1.4$)

M	p/p^*	$c/c^* = \rho^*/\rho$	T/T^*	p_0/p_0^*	F/F^*	$4\bar{f}L_{max}/D$
3.10	0.207	1.987	0.411	4.657	1.245	0.537
3.20	0.196	2.008	0.394	5.121	1.253	0.550
3.30	0.186	2.028	0.377	5.628	1.260	0.563
3.40	0.177	2.046	0.362	6.184	1.267	0.575
3.50	0.168	2.064	0.348	6.789	1..274	0.586
3.60	0.160	2.081	0.334	7.450	1.281	0.597
3.70	0.153	2.096	0.321	8.169	1.287	0.607
3.80	0.146	2.111	0.308	8.951	1.293	0.616
3.90	0.139	2.125	0.297	9.800	1.298	0.625
4.00	0.134	2.138	0.286	10.720	1.303	0.633
4.10	0.128	2.150	0.275	11.715	1.308	0.641
4.20	0.123	2.162	0.265	12.792	1.312	0.648
4.30	0.117	2.173	0.255	13.955	1.317	0.655
4.40	0.113	2.184	0.246	15.210	1.321	0.662
4.50	0.108	2.194	0.237	16.562	1.325	0.668
4.60	0.104	2.203	0.229	18.018	1.330	0.673
4.70	0.100	2.212	0.221	19.583	1.332	0.678
4.80	0.096	2.220	0.214	21.264	1.335	0.684
4.90	0.093	2.228	0.207	23.070	1.339	0.689
5.00	0.089	2.236	0.200	25.000	1.342	0.694
6.00	0.064	2.295	0.146	53.180	1.366	0.730
7.00	0.047	2.333	0.111	104.14	1.381	0.753
8.00	0.037	2.359	0.087	190.11	1.392	0.768
9.00	0.029	2.377	0.069	327.19	1.399	0.779
10.00	0.024	2.391	0.057	535.94	1.404	0.787