Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute)

Munshi Nagar, Andheri (W) Mumbai – 400058

26/12/22

PREVIOUS SEMESTER EXAMINATION DECEMBER-2022

Program: MECHANICAL S.Y. B.Tech (M) Sem IV

Course Code: BS-BTM401

Course Name: APPLIED MATHEMATICS-IV

Duration: 03 Hours

Maximum Points: 100

Semester: IV

- **Attempt any five out of seven questions**
- **Use of scientific calculator is allowed.**

QNO.	QUESTION	POINTS	CO	BL	Module No.
QI a)	Let X & Y be two independent binomial variates with parameters $(n_1=6,p=1/2)$ and $(n_2=4,p=1/2)$ respectively. Evaluate P(X+Y)=3.	06	1	2	2
QI b)	Find a real root of $x^2-x-1=0$ by regula-falsi method upto third approximation	06	3	3	7
QI c)	Calculate Karl Pearson's coefficient of correlation for the following data:	08	1	1	1
QII a)	The length of time a lady speaks on telephone is found to be a random variable with PDF $f(x)=\begin{cases} Ae^{-x/5}, x\geq 0 \\ 0, x<0 \end{cases}$. Find A and the probability that she will speak for (i) more than 10 minutes (ii)less than 5 minutes(iii) between 5 & 10 minutes.	10	1	2	3
QII b)	Verify Stoke's theorem for the vector field $\vec{F}=(x^2-y^2)\hat{i}+2xy\hat{j}$ over the box bounded by planes x = 0, x = a, y = b, z = C if the face z = 0 is cut.	10	2	2	6
QIII a)	Two cards are drawn simultaneously from a well – shuffled deck of 52 cards. Compute the variance for the number of aces.	06	1	2	2
QIII b)	The sales-data of an article in six shops before and after a special promotional campaign are as under	06	1	2	4

X	78	89	99	60	59	79	68
Y	125	137	156	112	107	136	123

Shops	A	B	C	D	E	F

PREVIOUS SEMESTER EXAMINATION DECEMBER-2022

	Before Campaign	53	28	31	48	50	42				
	After Campaign	58	29	30	55	56	45				
	Can the campaign be judged to be a success at 5% LOS.										
QIII c)	An aptitude test for selecting officers in a bank is conducted on 1000 candidates. The average score is 42 and standard deviation of score is 24. Assuming normal distribution for the scores, find i) The numbers of candidates whose scores exceed 60. ii) The numbers of candidates whose score lie between 30 and 60.							08	1	1	3
QIV a)	A radioactive source emits particles at a rate of 10 per minute in accordance with Poisson law. Each particle emitted has a probability of $\frac{2}{5}$ being recorded. Find the probability that atleast 4 particles are recorded in a 2 minute period.							06	1	3	2
QIV b)	Prove that $\vec{F}=(ye^{xy}\cos z)\hat{i}+(xe^{xy}\cos z)\hat{j}-(e^{xy}\sin z)\hat{k}$ is conservative and find the scalar potential Φ.							06	2	2	6
QIV c)	Find the positive root of $x-\cos x=0$ by Bisection method.							08	3	1	7
QV a)	Seven coins are tossed and number of heads obtained is noted. The experiment is repeated 128 times and following distribution is obtained.							06	1	1	2
	No.of heads	0	1	2	3	4	5	6	7		
	Frequency	7	6	19	35	30	23	7	1		
	Fit a Binomial distribution if the nature of coins is unknown.										
QV b)	In an experiment on pea – breading mendel obtained the following frequencies of seeds. 315 Round and Yellow 101 Wrinkled and Yellow 108 Round and Green 32 Wrinkled and Green According to his theory of heredity the numbers should							06	1	2	5

PREVIOUS SEMESTER EXAMINATION DECEMBER-2022

	be in population 9:3:3:1. Is there any evidence to doubt the theory at 5% Los?				
QV c)	Evaluate $\int_0^1 e^{-x^2} dx$ dividing the range into four equal parts using (i) Trapezoidal rule (ii) Simpson's 1/3rd rule	08	3	2	7
QVI a)	Evaluate by Green's thm $\oint_c e^{-x}(\sin y\,dx + \cos y\,dy)$ where C is the rectangle with vertices (0, 0), (π/0) (π, π/2) & (0, π/2).	06	2	1	6
QVI b)	A die is thrown 264 times with the following results No appeared on die: 1 | 2 | 3 | 4 | 5 | 6 Frequency: 40 | 32 | 28 | 50 | 54 | 60 Show that the die is biased	06	1	3	5
QVI c)	Using Runge-Kutta method IVth order. Solve $\frac{dy}{dx} = \frac{1}{x+y}$; $x_0 = 0$, $y_0 = 1$ for the interval (0, 1) choosing $h = 0.5$.	08	3	1	7
QVI I a)	Using Newton-Raphson method find the root of $x\log_{10} x = 12.34$ with $x_0 = 10$ upto 3 places of decimal.	10	3	3	7
QVI I b)	Verify Divergence Theorem for $\vec{F} = 4x\hat{i} - 2y^2\hat{j} + z^2\hat{k}$ taken over the bounded by the cylinder $x^2 + y^2 = 4$, $z = 0$, $z = 3$	10	2	2	6

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PREVIOUS SEMESTER EXAMINATION DECEMBER 2022
EVEN SEMESTER COURSES

Program: S Y BTech. (Mechanical Engineering) Sem IV
Course Code: PC-BTM403
Course Name: FLUID MECHANICS

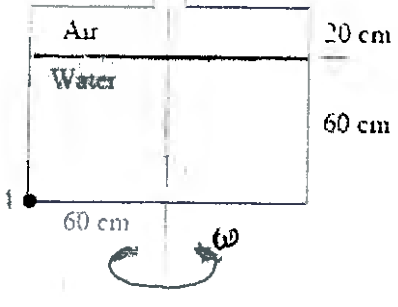
Duration: 3 Hours
Maximum Points: 100
Semester: IV

Notes:

- Attempt any **five** questions from remaining seven questions.
- Answers to all sub questions must be grouped together.
- Figures to the right indicate full marks.
- Make any suitable assumption if needed with proper reasoning.

Q. No.	Questions	Points	CO	BL
1.	**A.** Define and explain following terms: a) Compressible flow, b) Sonic Velocity, c) Mach Number d) Stagnation Properties, e) Shock Wave	10	1	1
	B. Two reservoirs 5.2 km apart are connected with a pipeline which consists of a 225 mm diameter pipe for the first 1.6 km sloping at 5.7 m per km. For remaining distance the pipe diameter is 150 mm laid at a slop of 1.9 m per km. The levels of water above the pipe opening are 6 m in the upper reservoir and 3.7 m in lower reservoir. Taking f=0.024 for both pipes and coefficient of contraction =0.6, calculate the rate of discharge through the pipeline.	10	3	3
2.	**A.** Derive Bernoulli's equation along a streamline starting from Navier-Stokes equation. Briefly discuss the conditions for its validity.	10	2	2
	B. Consider two long, horizontal parallel plates with a viscous incompressible fluid placed between them. The two plates moves in two opposite direction with two different constant velocities. There is no pressure gradient and the only body force due to the weight. Starting with the Navier-Stokes equation, determine an expression for the velocity profile for laminar flow between the two plates.	10	3,4	3,4
3.	**A.** For a given flow field $\vec{V} = 2x\,\vec{i} - yt\,\vec{j}$ m/s where x and y are in meters and t is in seconds. a) What is the dimension of flow? b) Is the flow possible? c) Find the equation of the streamline passing through (2,-1). d) Calculate the acceleration, the angular velocity, the vorticity vector.	10	2	2
	B. Listing all assumption made, derive an expression to estimate the force acting on an inclined plane lamina submerged in liquid. Also find an expression for point of application of this resultant force.	10	4	4

4.	**A.** Listing all features and assumption derive Von Karmon's Integral equation.	**10**	1,4	1,4
	B. A nozzle is attached to a 6-cm-diameter hose but the horizontal nozzle turns the water through an angle of 90°. The nozzle exit is 3 cm in diameter and the flow rate is 500 liter/min. Determine the force components of the water on the nozzle and the magnitude of the resultant force. The pressure in the hose is 400 kPa and the water exits to the atmosphere. Analyze and solve the problem using Reynolds transport theorem.	**10**	3	3
5.	**A.** Differentiate between laminar and turbulent flow. Explain developing and developed flow features in pipe and write empirical relation to estimate developing length in laminar and turbulent.	**10**	2	2
	B. If the velocity distribution in a laminar boundary layer over a flat plate is given by, $\frac{u}{U} = \sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$, calculate displacement and momentum thickness and wall shear stress.	**10**	3	3
6.	**A.** Explain following terms: a) Closure problem of turbulent flow b) Turbulent velocity profile c) Darcy friction factor	**10**	1	1
	B. Explain the concept of flow separation and discuss about various methods to control it.	**10**	3	3
7.	**A.** Explain following with illustration: a) Lagrangian and Eulerian motion of fluid particle b) Viscous and Inviscid flows c) Incompressible and compressible flow d) Uniform and non-uniform flows	**10**	1,2	1,2
	B. The cylinder as shown in following figure is rotated about the central axis. What rotational speed is required so that the water just touches top corner. Also, fine the pressure at point A and force acting at the bottom of the tank.	**10**	3,4	3,4



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Previous Year End Semester – December 2022 Examinations

28/12/22

Program: S.Y.B. Tech. (Mechanical Engineering) Sem IV **Duration: 03 Hrs**

Course Code: PC-BTM404 **Maximum Points: 100**

Course Name: Mechanical Engineering Measurement **Semester: IV**

Notes:

1. **Question number 1 is compulsory**
2. **Solve any 4 questions from question number 2 to 7**
2. **If necessary assume suitable data with justification**
3. **Draw neat labeled sketches wherever required.**

Q. No.	Questions	Points	CO	BL	M. N.
1	With neat labeled sketches explain working principle of (i) Mechanical Tachometer (ii) Nozzle meter (iii) Inductive Tachometer (iv) Piezoelectric accelerometer	20	3	4	3 to 6
2 (A)	It is proposed to develop measurement and control system for maintaining temperature and pressure of a reactor chamber in pharmaceutical applications. Proposed design aimed to retrieved data from system and controlled it remotely using internet network system. Students are instructed to present architecture of such network integrated measurement and control system (explain with neat schematic diagram).	10	2	3	7
2 (B)	Explain generalized measurement system with neat schematic diagram. Further map the different constituents of generalized measurement system with the physical elements of Bourdon Pressure Gauge.	10	1	2	1, 2
3 (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 changes in gauge resistance is found to be 0.145 Ω, calculate the gauge factor. Deflection of the free end $\delta = FL^3/3EI$, where F= Force, L=Length, E= Youngs modulus, I=Moment of Inertia, Take Young's modulus for steel as 200×10^9 N/m^2	10	4	4	3
3 (B)	Following is the calibration data of a pressure transducer: q_i (Mpa): 0 q_o (increasing) (Mpa): 2 q_o (decreasing) (Mpa): -1	10	3	2	1 to 4

	<table><tr><td>10</td><td>8</td><td>12</td></tr><tr><td>20</td><td>17</td><td>23</td></tr><tr><td>30</td><td>26</td><td>34</td></tr><tr><td>40</td><td>39</td><td>41</td></tr><tr><td>50</td><td>49</td><td>49</td></tr></table> Find out: (i) The equation for the best-linear fit. (ii) The standard deviation of input qi, output q0, slope and intercept. (iii) qi if the instrument reads q0=30 after calibration. (iv) Plot Hysteresis curve and find Maximum Hysteresis error and dead band				
4 (A)	The transfer function of a system is given as $\frac{361}{\left(S^2+16S+361\right)}$ Find the following for a unit step input: undamped natural frequency, damping ratio, damped natural frequency, settling time, peak time, rise time, percentage overshoot.	10	2	2	
4 (B)	What are "Desired", "Modifying", and "Interfering" inputs for an instrumentation system? Draw block diagram for showing their influence on the output.	10	4	6	1
5 (A)	A diaphragm pressure gauge is constructed of spring steel to measure differential of 7 MN/m^2. The diameter of diaphragm is 12.5 mm. Calculate the thickness of diaphragm, if the maximum deflection is 0.333 of thickness. Also calculate the natural frequency of diaphragm. Given: Young's modulus=200 GN/m^2, Poisson's ratio-0.28 and density of steel=7800 kg/m^3	10	2	4	4
5 (B)	In laboratory mercury in capillary tube temperature measurement system is available. It was proposed to measure humidity present in the laboratory. Explain step-by-step way to measure humidity. Draw appropriate sketches and flow diagram to explain the procedure	10	2	5	5
6	With neat labeled diagram explain working of (i) optical encoder (ii) stroboscope (iii) eddy current drag-cup tachometer (iv) Saywood Viscometer	20	2	3	2 to 7
7(A)	An orifice meter with orifice diameter 15 cm is inserted in a pipe of 30 cm diameter, the pressure difference measured by a mercury oil differential manometer on the two sides of the orifice meter gives a reading of 50 cm of mercury. Find the rate of oil of specific gravity 0.9 when the coefficient of discharge of the meter = 0.64.	10	4	4	6

7(B)	With neat sketches explain the following terms with respect to the measurement system: (i) Accuracy (ii) Hysteresis (iii) Resolution (iv) Span and Range (v) Drift (vi) Dead zone (vii) Precision	10	3	4	1,2

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Previous Semester Examination Dec 2022

S.Y. B.Tech (ME) Sem IV

29/12/22

Program: B.Tech Second Year Mechanical **Duration: 03 Hrs**

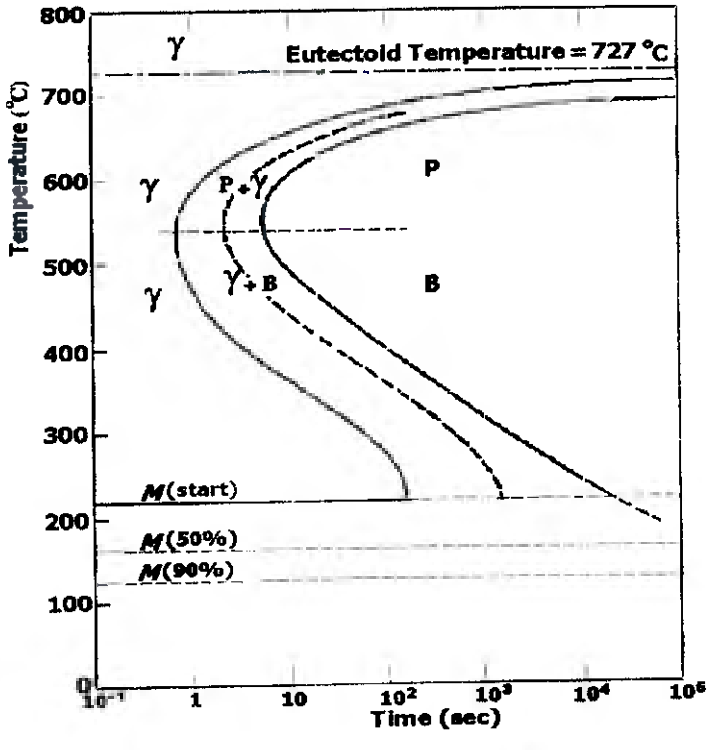
Course Code: PC-BTM406 **Maximum Points: 100**

Course Name: Material Science **Semester: IV**

Notes:

1. **Question no 1 is compulsory**
2. Attempt any **four questions** from the remaining six questions.
3. If necessary **assume suitable** data with justification
4. Draw **neatly labeled sketches** wherever required.

Q. No.	Questions	Points	CO	BL	PI
1A	A FCC crystal yield under a normal stress of 2MPa applied in the [$\bar{1}$ 3 2] system. The slip system is (111) [$\bar{1}$ 0 1]. Determine critical resolved shear stress. Also draw cubic crystals showing, slip plane and slip direction.	06	2	5	3.2.3
1B	Explain the reason behind the Properties changes when engineering Materials are in Bulk and Fiber Forms. [Note: explain by taking some properties and materials]	06	4	3	3.2.3
1C	Derive an equation for finding out the critical size of nucleation. Explain the relationship between critical radius and free energy with the help of a suitable figure.	08	2,3	4	3.8.1
2A	Discuss why it is important to consider the entire life cycle rather than just the first stage of materials.	06	1,4	6	3.2.1
2B	You are appointed as a material engineer in the medical implant industry. Suggest material for total hip replacement. Select suitable material and explain it. Also explain why a particular material is only selected.	06	1,2	6	4.2.1
2C	Draw Fe-C equilibrium diagram and label the temperature, composition, and phases. "Liquid is going to convert into two solid" explain this statement using Fe-C diagram. Also, find the exact amount of components of the given statement.	08	3	4	3.8.1
3 A	What is the full annealing heat treatment process? Explain full annealing in details for hypoeutectoid steel with schematic phase diagram.	08	3	5	3.1.1

3B	Name the material which changes its optical properties. Write an application where such material is used. Explain the working of material with anyone application.	07	1	2	1.3.1
3C	Following are the product specification required from the customer. Suggest the process to achieve the given requirement and procedure. 1. Gear, Steel (0.1% Al, 1.5% Cr,0.3%Mo) surface hardness 1100HV, case depth:0.1 to 0.6mm. Crankshaft, medium carbon steel, case depth:0.7 to 6mm.	05	4,3	5	3.1.1
4A	Discuss each case of the heat treatment process of Fe-0.77% C eutectoid steel rapidly cooled from a preheated temperature of 860^0C (>727^0C) as follows [NOTE: explain, write properties of the final product] 1. Rapidly cool to 400^0 C, hold for 10^4 s and quench to room temperature 2. Rapidly cool to 600°C, hold for 10 s and quench to room temperature; 3 Rapidly cool to 650 °C, hold for 20 s, rapidly cool to 400 °C, hold for 10^3 s and quench to room temperature;  	10	4	6	2.4.1

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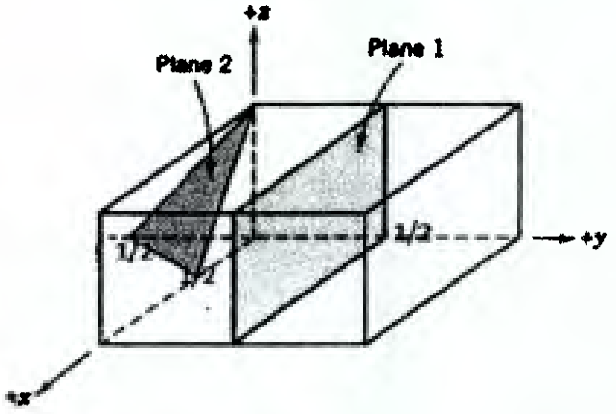
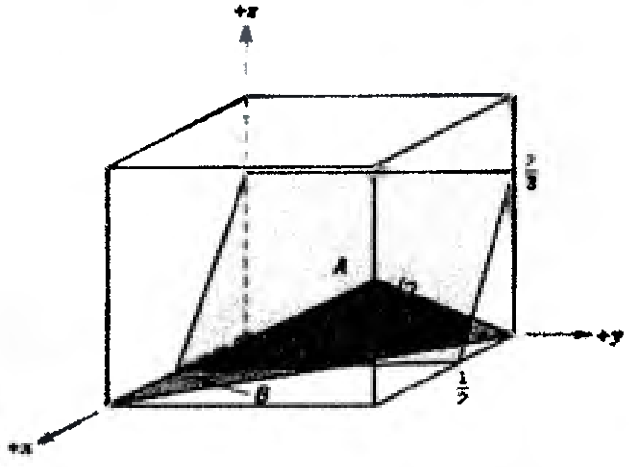
Previous Semester Examination Dec 2022

4B	Explain metallurgical classes of stainless steel. Explain which stainless steel are not heat treatable and the reason behind it.	05	4	2	3.2.2
4C	Why does diamond stay stable at room temperature and not transform to graphite although it is an unstable phase of carbon at room temperature? Explain with a suitable diagram.	05	2	3	2.3.1
5A	Write the effect of alloying elements on the properties of materials when they are added to the material composition. 1. Nickel 2. Molybdenum 3. Vanadium 4. Cobalt 5. lead	06	4		2.2.1
5B	Classify ceramics based on application. Explain electro ceramics in detail.	06	4	4	4.2.2
5C	Determine the Miller indices for the planes shown in the following unit cell: 	08	4	2,6	2.2.2

					
6A	Classify composite based on the form of reinforcement. Explain single layer fibrous composite materials.	08	4	4	4.2.2
6B	Write a composition of the following materials and their application. 1. Muntz metal 2. Nickel gun-metal 3. Cartridge Brass 4. Dow metal	06	3,4	3	3.2.1
6C	Explain the method of plotting a TTT diagram. What information is obtained from this diagram?	06	3	2	2.3.1
7A	From the data given below for the Cu-Ni system, plot the equilibrium diagram to scale and label the diagram. The melting point of Cu: 1,085 °C. the melting point of Ni: 1,455 °C Answer the following for 60%Ni alloy composition: A. What is the composition of the first solid crystallizing out from liquid? B. What is the composition of the last solid formed at the end of the solidification process? C. What is the amount of solid and liquid at 1340 °C.	08	3	3	2.4.1

		Weight % Ni	20	40	60	80				
		Liquidus temp. °C	1200	1275	1345	1440				
		Solidus Temp °C	1165	1235	1310	1380				
7B	Discuss the recycling issue in the materials. Suggest other consumer action for minimal environmental impact than just recycling.						07	1,4	6	3.4.2
7C	Find the theoretical density of copper (FCC) assuming the atom to be a hard sphere. The atomic weight of copper is 63.54gm/mole and radius of atom is 1.278 A^0.						05	2	5	3.2.1

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KT-EXAMINATIONS (Even SEM) DEC 2022

S. Y. B. Tech (M) Sem IV 30/12/22.

Program: **BTech Mechanical engg**

Course Code: **PC-BTM412**

Course Name: **Kinematics of Machinery**

Notes:

Duration: 3.00 hr

Maximum Points: 100

Semester: IV

1. Question number **ONE is compulsory** solve any **four** out of remaining
2. **Question nos. three and five should be solved on drawing sheet.**
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. **Candidates should write the answer legibly**

Q.No.	Questions	Pts	Cos	BL	PI
1	a) Classify the kinematic pairs based on different criterion. b) Describe with neat sketch a quick return motion mechanism (slotted lever-crank) suitable for shaping machine. Show how the ratio of time taken for the two strokes is determined? c) Sketch the Davis steering gear mechanism and show that it satisfies the required condition for correct steering. d) Sketch and describe different types of cam & followers which are used for motion modification.	4x5	1 2 3 4	2,3	2.4.1
2	a) A driving shaft of a Hooke's joint rotates at a uniform speed of 360 rpm. If the maximum variation in the driven shaft is ±4 % of the mean speed, determine the greatest permissible angle between the axes of the shafts. What are the maximum and minimum speeds of the driven shaft? b) State the conditions for straight line generating mechanism. Sketch the Hart's mechanism and prove that the tracing point 'P' describes the straight line.	10 10	2	3	2.3.1

3	a) A crank-rocker linkage has a 100 mm frame, a 25 mm crank, a 90 mm coupler and a 75 mm rocker. For the given mechanism find the minimum and maximum transmission angle. Sketch both the toggle position and find corresponding crank angles and transmission angles. (Solve graphically). b) For the above given mechanism, find the angular velocities of coupler and follower in terms of input angular velocity of crank as ω, for the configuration of minimum and maximum transmission angle.(Use IC method)	8 12	1	3,4	2.3.1
4	a) Explain the meaning of the following terms: circular pitch, diametral pitch, module, pressure angle. Illustrate with sketches where possible. b) A gear set with a module of 4 mm/tooth has involute teeth with 20° pressure angle, and has 19 and 31 teeth, respectively. They have 1.0m for the addendum and 1.5m for the dedendum. (In SI. tooth system modules are given in, m, and a = 1.0m means 1 module, not 1 meter). Tabulate the addendum, dedendum, clearance, circular pitch, base pitch, base circle radius, contact ratio, angle of action for the pinion and wheel.	6 14	4	3	2.3.1
5	a) Use following data in drawing the displacement, velocity, acceleration verses theta (θ) diagram for a cam in which a knife-edged follower is raised with SHM and is lowered with SHM: least radius of cam 40 mm, lift 50 mm, angle of ascent 80^0, angle of descent 60^0, dwell between ascent and descent 40^0, cam rotation 100 rpm. Determine the maximum velocity and acceleration during ascent and descent. b) Deduce the expression for displacement, velocity and acceleration of the follower when it moves with SHM.	14 6	4	3	2.3.1
6	a) Deduce the expression for minimum number of teeth on gear wheel. b) A spur gears with 9 and 36 teeth are to be cut with 20^0 full-depth cutter with module of 8 mm. i. Determine the amount that the addendum of the gear must be decreased in order to avoid the interference. ii. If the addendum of the pinion is increased by the same amount, determine the contact ratio.	10 10	4	4	2.2.3
7	a) State the advantages of gear drive over the belt drive. b) What is interference in gear? How it is avoided? c) Define kinematic pair, link, mechanism (draw suitable sketch). d) State and explain Kennedy's theorem. e) State and prove condition for correct steering.	20	4 4 2 2 2	2	2.3.2

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S. Y. B. Tech (M) Sem IV 21/12/22

PREVIOUS SEMESTE EXAMINATION – DECEMBER 2022

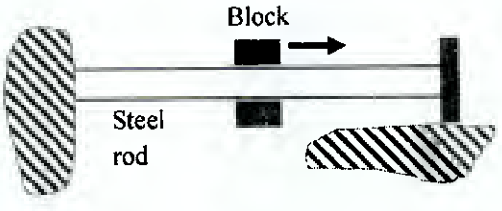
Program: B.Tech. in Mechanical Engineering | **Duration: 3 Hours**

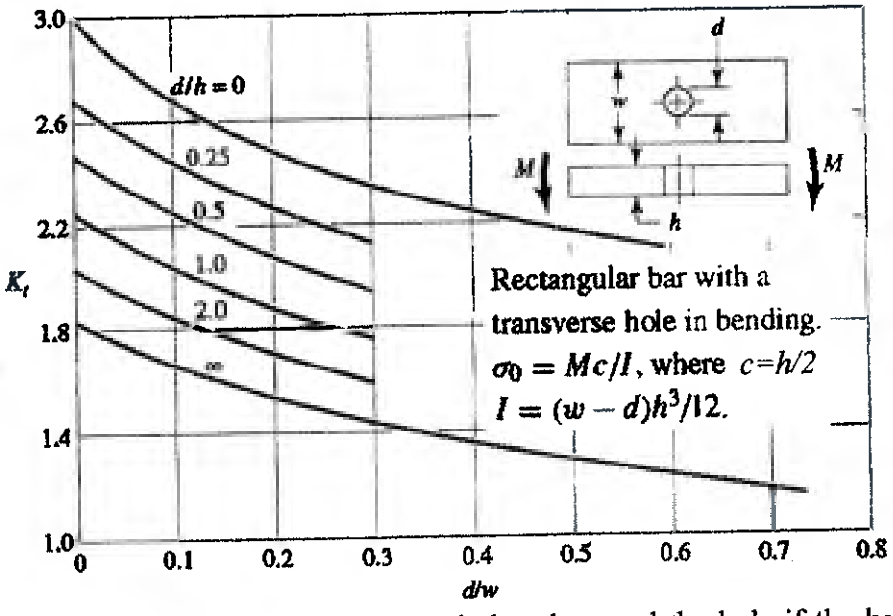
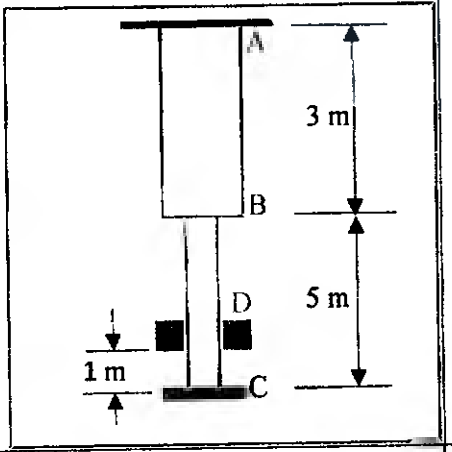
Course Code: PC-BTM415 | **Max. Points: 100**

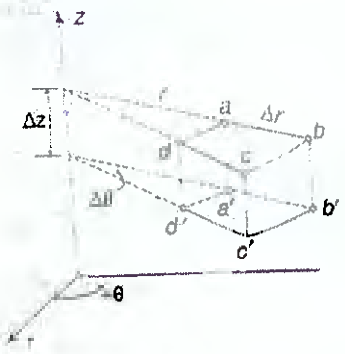
Course Name: Solid Mechanics | **Semester: IV**

Notes:

1. **Question no. 1 is compulsory**, solve any 4 of remaining 6 questions.
2. Assume suitable data if necessary.

Q. No.	Questions	Points	CO	BL	Module
Q1 COMPULSORY	A) Two 50 mm long steel rods of 50 mm diameter are pressed against each other with a force of 100 N. Consider E = 200 GPa, $\nu = 0.3$. Determine the following. i. The width of the contact area ii. The maximum contact pressure iii. The maximum shear stress on the contact surface iv. The maximum shear stress below the surface of contact.	(5)	2	3	4
	B) Given the stress matrix τ_{ij}, determine the magnitude of the normal and shear stress on a plane **parallel to x axis** and **equally inclined** to y and z axes. $\tau_{ij} = \begin{bmatrix} 1 & 3 & 2 \\ 3 & 4 & 5 \\ 2 & 5 & -1 \end{bmatrix}$	(5)	1	3	1
	C) Explain the generalized statement of Hooke's law used for describing behavior of a material.	(5)	2	2	3
	D) A sliding block weighing 200 N slides over a 20 mm diameter 2000 mm long horizontal steel rod at a velocity of 2 m/s as shown in the figure. The block is stopped by its impact with a rigid collar provided at the end of rod. Ignoring friction and bending of bar, find the instantaneous stress induced in the rod. Consider E = 200 GPa. 	(5)	4	3	6
Q2	A) Describe the relation between the true and engineering stress/strain. Discuss the need of these concepts in engineering analysis.	(5)	3	2	1
	B) The displacement field for a body is given by: $\bar{u} = [(xyz + 3xy^2z^2)\bar{\imath} + (yz + xz)\bar{\jmath} + (x^2y^4 + yz^2)\bar{k}]10^{-5}$ What are the strain components at (-1, 1, -1)?	(5)	2	3	2
	C) Describe the concept of plane stress and plane strain conditions used to solve elasticity problems. Give two examples of each type. What is the advantage of this concept?	(5)	3	2	3

	D) A rectangular bar with transverse hole is subjected to bending moment. The geometry parameters and the stress concentration factor for the bar are as shown in the figure.  Calculate the maximum stress induced around the hole if the bar subjected to bending moment of 200 Nm. The dimensions of the bar in mm are: d = 15, w = 50 and h=5.	(5)	2	3	5
Q3	A) A rotor of 500 mm diameter is shrunk fitted on a steel shaft of 75 mm diameter. The interference on diameter is 0.02 mm. Find the rotation speed at which contact pressure is zero. Also calculate the maximum tangential stress at the calculated speed. Consider E = 200 GPa, ν = 0.3 and density = 7850 kg/m^3.	(10)	2	3	4
	B) Collar D of 2 kg mass is released from rest in the position shown in the figure and it is stopped by a small plate attached at end C of the vertical rod ABC. Section AB is of 15 mm diameter and section BC is of 8 mm diameter. E = 210 GPa. Determine the instantaneous stresses in the rod.  	(10)	4	3	6
Q4	A) Derive the following compatibility equation. $$\frac{\partial^2 \varepsilon_x}{\partial z^2} + \frac{\partial^2 \varepsilon_z}{\partial x^2} = \frac{\partial^2 \gamma_{xz}}{\partial x \partial z}$$	(5)	3	4	2

	B) Figure shows a solid element located inside a stressed body and defined in a cylindrical coordinate system. To derive one of the equilibrium equations, it is required to compute all forces acting on this element in z-direction due to stresses acting on its six faces and the body force. Obtain the expressions for the forces acting in **z-direction** on the **two faces bb'c'c and aa'd'd** and for the body force acting on the element in z-direction. 	**(5)**	3	3	4
	C) Discuss how temperature loading is accounted for in the stress-strain relationship. Obtain the stresses for a case wherein an unconstrained solid is uniformly heated.	**(5)**	2	2	5
	D) Describe the Bauschinger effect with the help of load-displacement diagram. In which situations this effect is advantageous?	**(5)**	2	2	7
Q5	A) A thick-walled pipe has an internal radius of 500 mm. It is subjected to internal pressure of 1.0 MPa and external pressure of 0.2 MPa. If $E = 200$ GPa and $\nu = 0.3$, determine the thickness as per the maximum principal stress theory of failure. Consider tensile strength as 400 MPa and factor of safety as 2.0. Also determine the changes in internal and external radii for the pipe with the calculated thickness.	**(10)**	2	3	4
	B) A thin-walled box section of dimensions width = $4a$, breadth = $3a$ and wall thickness = t is to be compared with a solid section of diameter $2a$. Find the thickness t so that the two sections have (a) same maximum stress for the same torque and (b) same torsional stiffness.	**(5)**	2	3	5
	C) Describe the three modes of fracture with neat sketch. Give two examples of each mode from real life situations.	**(5)**	2	2	7
Q6	A) The matrix representation of the stress state at a point is given by the following matrix. Determine the principal stresses and the direction of the **maximum** principal stress. $$[\tau_{ij}] = \begin{bmatrix} 1 & -1 & 3 \\ -1 & 2 & 4 \\ 3 & 4 & 5 \end{bmatrix}$$	**(10)**	1	3	1
	B) Discuss significance of following terms in solid mechanics: (i) Principal strains, (ii) Strain-displacement equations, (iii) strain gauges.	**(5)**	3	2	2
	C) Describe the importance of metal plasticity with suitable examples. Explain the following terms in the context of plasticity: (i) Deviatoric or π plane, (ii) Yield locus.	**(5)**	3	2	7
Q7	A) One of the differential equations of equilibrium is $$\frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} + \gamma_y = 0$$ Derive above equation. (Hint: use force equilibrium for a cubicle element along a coordinate axis.)	**(5)**	3	3	1
	B) Define following terms illustrating their significance in solid mechanics: (i) Stress tensor, (ii) Stress concentration factor, (iii) Stress intensity factor, (iv) Symmetry of cross shears, (v) Shear flow.	**(5)**	1	2	1

	C) Prove that the strain energy stored in a hollow cylinder of length L, polar area moment of intertia J and subjected to torque T is given by $U = \frac{T^2 L}{2JG}$.	(5)	3	3	6
	D) Explain the principle of superimposition. Prove the uniqueness theorem for elastic bodies using the principle of superimposition.	(5)	3	3	3

ANNEXURE: USEFUL FORMULAE

Annexure 1

Stresses for two cylinders in contact with each other

$$p_{max} = \frac{2}{\pi}\frac{F}{bl}$$

$$b = \sqrt{\frac{2F}{\pi l}\left[\frac{\frac{(1-\nu_1^2)}{E_1}+\frac{(1-\nu_2^2)}{E_2}}{\frac{1}{d_1}+\frac{1}{d_2}}\right]}$$

$$\sigma_x = -2\nu p_{max}\left[\sqrt{\left(1+\frac{z^2}{b^2}\right)}-\frac{z}{b}\right]$$

$$\sigma_y = -p_{max}\left[\left(2-\frac{1}{1+z^2/b^2}\right)\sqrt{1+z^2/b^2}-2\frac{z}{b}\right]$$

$$\sigma_z = -p_{max}\left[\frac{1}{\sqrt{1+z^2/b^2}}\right]$$

Stresses in thick pressurized cylinders

$$\sigma_r = \frac{p_a a^2 - p_b b^2}{b^2-a^2} - \frac{a^2 b^2}{r^2}\times\frac{p_a - p_b}{b^2-a^2}$$

$$\sigma_\theta = \frac{p_a a^2 - p_b b^2}{b^2-a^2} + \frac{a^2 b^2}{r^2}\times\frac{p_a - p_b}{b^2-a^2}$$

$\sigma_z = 0$ with both ends open

$\sigma_z = \nu(\sigma_r + \sigma_\theta)$ with both ends closed

Stresses in rotating solid disks

$$\sigma_r = \frac{3+\nu}{8}\rho\omega^2(b^2-r^2)$$

$$\sigma_\theta = \frac{3+\nu}{8}\rho\omega^2 b^2 - \frac{1+3\nu}{8}\rho\omega^2 r^2$$

Stresses in rotating disks with central hole

$$\sigma_r = \frac{3+\nu}{8}\rho\omega^2\left(b^2+a^2-\frac{a^2b^2}{r^2}-r^2\right)$$

$$\sigma_\theta = \frac{3+\nu}{8}\rho\omega^2\left(b^2+a^2+\frac{a^2b^2}{r^2}-\frac{1+3\nu}{3+\nu}r^2\right)$$

SIF for edge cracked plate subjected to axial load P / bending moment M

$(K_I)_P = \frac{P}{Bh}\sqrt{\pi a}\,Y_P$,

$$Y_P = 1.12 - 0.23\alpha + 10.55\alpha^2 - 21.72\alpha^3 + 30.39\alpha^4;\ \alpha = a/h$$

$(K_I)_M = \frac{6M}{Bh^2}\sqrt{\pi a}\,Y_M$

$$Y_M = 1.122 - 1.4\alpha + 7.33\alpha^2 - 13.08\alpha^3 + 14\alpha^4;\ \alpha = a/h$$