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12MMD/MDE/MCM/MEA/MAR/MST11

First Semester M.Tech. Degree Examination, June/July 2014
Applied Mathematics

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

1 a. Define significant figures. State the rule to round-off a number to n significant digits. Round-off the following to four significant figures: 1.6583, 30.0567, 0.859378, 3.14159 **(07 Marks)**

b. Define: Error, truncation error, absolute error, relative error, percentage error. **(05 Marks)**

c. Derive the series: $\log\left(\frac{1+x}{1-x}\right) = 2\left(x + \frac{x^3}{3} + \frac{x^5}{5} + \ldots\ldots\ldots\ldots\right)$

Hence find log 1.2 correct to seven decimal places. **(08 Marks)**

2 a. State the fundamental theorem of Algebra. Explain the bisection method to find a real root of $f(x) = 0$. **(06 Marks)**

b. Using Newton-Raphson method, find a real root of the equation $\sin x = x/2$ in $(\pi/2, \pi)$. **(07 Marks)**

c. Using the secant method, find a real root of the equation $xe^x - 1 = 0$ **(07 Marks)**

3 a. Find a root of the equation $x^3 - x - 1 = 0$ using the Muller's method, root lies between 0 and 2. **(08 Marks)**

b. Explain Bairstow's method to find the complex roots of a polynomial equation

$$a_0x^n + a_1x^{n-1} + \ldots\ldots\ldots + a_{n-1}x + a_n = 0$$ **(08 Marks)**

c. If C_1, C_2, C_3 are the roots of $A_0x^3 + A_1x^2 + A_2x + A_3 = 0$ then write the relation between these roots, roots and coefficients A_0, A_1, A_2, A_3 according to the Graeffe's root-squaring method. **(04 Marks)**

4 a. Use Romberg's method to compute $\int_0^1 \frac{dx}{1+x}$, correct to four decimal places. Hence find $\log_e(1 + x)$ **(07 Marks)**

b. Write the Newton-Cote's closed and open integration formulae. **(06 Marks)**

c. Find $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ for $x = 1.2$. Given

x	1.0	1.2	1.4	1.6	1.8	2.0	2.2
y	2.7183	3.3201	4.0552	4.9530	6.0496	7.3891	9.0250

(07 Marks)

5 a. Using Cholesky method solve:

$x + 2y + 3z = 5$; $2x + 8y + 22z = 6$; $3x + 22y + 82z = -10$

And for large n, write the operational count for Gauss elimination method, Gauss-Jordan method. **(10 Marks)**

b. Solve: $2x - y = 7$; $-x + 2y - z = 1$; $-y + 2z = 1$

using Gauss-Seidel method with

$X^{(k+1)} = -(D + L)^{-1} U X^{(k)} + (D + L)^{-1}b$ **(10 Marks)**

6 a. Define eigen values and eigen vectors of a non-zero square matrix. Using the Rutishauser method find all the eigen values of the matrix

$$A = \begin{bmatrix} 4 & 3 \\ 1 & 2 \end{bmatrix}$$ **(08 Marks)**

b. Using Jacobi method find all the eigen values and corresponding eigen vectors of the matrix

$$A = \begin{bmatrix} 1 & \sqrt{2} & 2 \\ \sqrt{2} & 3 & \sqrt{2} \\ 2 & \sqrt{2} & 1 \end{bmatrix}$$ **(12 Marks)**

7 a. Define the term linear-transformation with a suitable example. With usual notations, prove that $T(0) = 0$,

$T(C_1\alpha_1 + C_2\alpha_2 + \ldots\ldots + C_n\alpha_n) = C_1T(\alpha_1) + C_2T(\alpha_2) + \ldots\ldots + C_nT(\alpha_n)$ **(10 Marks)**

b. If $T : R^3 \to R^2$ be the linear transformation defined by $T(x, y, z) = (2x + y - z, 3x - 2y + 4z)$. Then obtain the matrix representation of T for the following bases.

$B = \{(1, 1, 1), (1, 1, 0), (1, 0, 0)\}$

$B' = \{(1, 3), (1, 4)\}$ **(10 Marks)**

8 a. Use Gram-Schmidt process on the basis $\{(1, 0, 1), (1, 0, 0), (2, 1, 0)\}$ to obtain orthonormal basis of R^3. **(08 Marks)**

b. Find a least square solution of system represented by $Ax = b$, where

$$A = \begin{bmatrix} 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 \end{bmatrix}, \qquad b = \begin{bmatrix} -3 \\ -1 \\ 0 \\ 2 \\ 5 \\ 1 \end{bmatrix}$$ **(12 Marks)**

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12MMD/MDE/MCM/MEA/MTE/MAU12

First Semester M.Tech. Degree Examination, June/July 2014

Finite Element Method

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

1 a. Describe basic steps in finite element analysis of solids and structures. **(10 Marks)**

b. Describe Gaussian elimination algorithm for solution of linear simultaneous equations. **(10 Marks)**

2 For a two-node BAR element answer the following:

a. Basic equations and potential energy functional
b. Admissible displacement function
c. Strain matrix
d. Stress recovery equation
e. Stiffness matrix computation
f. Element equations **(20 Marks)**

3 For a four-noded quadrilateral element answer the following:

a. Admissible displacement functions
b. Strain matrix computation
c. Stress recovery equation
d. Stiffness matrix computation
e. Element equations **(20 Marks)**

4 Sketch an axisymmetric triangular ring element and answer the following:

a. Geometric representation
b. Admissible displacement function
c. Strain matrix
d. Stress recovery equation
e. Stiffness matrix computation **(20 Marks)**

5 A library of three-dimensional continuum elements of different shapes and increasing orders are implemented in FEA software. Among these describe the following with neat sketches including parent element, polynomial approximation for each.

a. Four-noded tetrahedral solid element
b. Eight nodded hexahedral solid element
c. Tetrahedral solid element quadratic in order
d. Hexahedral solid element quadratic in order of the serendipity family. **(20 Marks)**

6 a. For bending analysis of a straight beam using Euler-Bernoulli beam theory, construct the potential energy functional. **(10 Marks)**

b. With neat sketches describe 1-D beam, 2-D beam and 3-D beam elements. Identify the nodal d.o.f. in local and global coordinates. Include material properties and section properties for each. **(10 Marks)**

7 For vibration analysis of solids by the FEM, answer the following:

a. Equations of motion
b. Consistent mass matrix computation
c. Governing matrix equations
d. Solution methods **(20 Marks)**

8 Write short notes on:

a. Weighted residual method for heat transfer analysis
b. Convergence criteria
c. Variational formulation of solid mechanics problems
d. History of finite element method **(20 Marks)**

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12MMD/MDE/MEA13

First Semester M.Tech. Degree Examination, June/July 2014

Theory of Elasticity

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

1 a. Drive equations of equilibrium for a 3-D state of stress and explain their importance. **(08 Marks)**

b. For the following state of stress, determine the magnitude of principal stresses and direction of maximum principal stress.

$$\{\tau_{ij}\} = \begin{bmatrix} 30 & -25 & 20 \\ -25 & 40 & 30 \\ 20 & 30 & -20 \end{bmatrix}$$ **(12 Marks)**

2 a. i) Explain the importance of compatibility conditions.
ii) Write expressions for Cauchy's strain displacement relations. **(06 Marks)**

b. For the following displacement field:

$$u = \left[(x^2 + y^2 + z)i + (3x + 4y^2)j + (2x^3 + 4z)k\right] \times 10^{-4}$$

Determine: i) Strain tensor at P(2, 1, 3)
ii) Principal strains
iii) Volumetric strain
iv) Decompose the strain tensor into spherical and deviatoric component. **(14 Marks)**

3 a. When weight is the only body force, derive the compatibility condition in terms of stresses and explain its significance. **(08 Marks)**

b. What is Airy's stress function? Explain. **(04 Marks)**

c. The state of strain at a point in a stressed member made of steel (E = 207 GPa, G = 80 GPa), determine stress matrix.

$$\{\epsilon_{ij}\} = \begin{bmatrix} 0.001 & 0.004 & -0.002 \\ 0.004 & -0.003 & 0.002 \\ -0.002 & 0.002 & 0.005 \end{bmatrix}$$ **(08 Marks)**

4 a. Investigate whether following functions are stress functions:
i) $\varphi = Ax^3 + By^3$
ii) $\varphi = Ax^2y + Bxy^2$
iii) $\varphi = A(x^4 - y^4)$ **(06 Marks)**

b. Explain St.Venant's principle and its importance. **(04 Marks)**

c. Show that the function $\varphi = \frac{3F}{4C}\left[xy - \frac{xy^3}{3c^2}\right] + \frac{p}{2}y^2$ is a stress function and investigate the problem solved by the function in the region $y = \pm C$ and $x = 0$ to L on the positive side of x. **(10 Marks)**

5 Derive expressions for radial and tangential stresses in a rotating disk of uniform thickness in (i) solid disk, (ii) disk with a circular hole at the centre and show that the stress concentration factor due to hole is 2. **(20 Marks)**

6 Derive expressions for thermal stresses induced in a long circular cylinder when the temperature is symmetrical about the axis and does not vary along the axis in the following cases:
i) Solid cylinder
ii) Hollow cylinder. **(20 Marks)**

7 a. For beam of uniform cross section of span L, simply supported, subjected to a transverse load Q at the midspan and axial compressive force 'P' at the ends, determine deflection at the midpoint. **(15 Marks)**

b. Explain the principle of superposition to obtain resultant deflection when several transverse loads are acting on a beam subjected to compressive loads at the ends. **(05 Marks)**

8 a. Show that the problem of torsion of a solid bar of arbitrary cross section can be solved by a function φ that satisfies $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)\varphi = -2G\theta$ and is constant on the boundary. **(10 Marks)**

b. Using Prandtl stress function for elliptic cross section, obtain the expressions for stresses in the elliptic section. Determine the location of maximum stress and comment on the result. **(10 Marks)**

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12MMD/MDE14

First Semester M.Tech. Degree Examination, June/July 2014

Experimental Stress Analysis

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

1 a. What is gauge factor? Derive an expression for gauge factor for an electrical resistance strain gauge. **(10 Marks)**

b. Explain with neat sketches the bonded wire type and foil type strain gauges and mention their advantages. **(06 Marks)**

c. What is temperature compensation? Explain the method of obtaining temperature compensation. **(04 Marks)**

2 a. Explain the construction of a three element rectangular rosette and derive an expression for the principal stresses and their orientations in terms of strain measurement readings. **(10 Marks)**

b. The following observations were made with a three element delta rosette on a steel specimen:

$\in_A = 400\ \mu m/m$; $\in_B = -200\ \mu m/m$; $\in_C = 200\ \mu m/m$

Determine the principal strains, principal stresses and their orientations. Take Poisson's ratio = 0.3 and $E = 200 \times 10^9\ N/m^2$. **(10 Marks)**

3 a. Sketch and explain any two methods of calibration of photoelastic model material. **(10 Marks)**

b. Explain Friedel's method of compensation used to measure the fractional fringe order. **(10 Marks)**

4 a. Explain the shear difference method of separation of principal stresses in 2-D photoelasticity. **(10 Marks)**

b. What is meant by scaling model – prototype relations? Write the relationship between model to prototype for stress and deflection, for temperature and for dynamic cases. **(10 Marks)**

5 a. Explain stress freezing technique for the determination of stresses in 3-D photoelasticity. **(10 Marks)**

b. Sketch and explain scattered light polariscope. **(10 Marks)**

6 a. Explain birefringent coating technique of stress analysis and explain with a neat sketch working of reflection polariscope. **(10 Marks)**

b. What is brittle coating technique of experimental stress analysis? And list the advantages and applications of brittle coating technique. **(10 Marks)**

7 a. Explain Moire method of analysis in strain measurement and explain different types of gratings. **(10 Marks)**

b. Explain geometrical and displacement approaches to Moire fringe analysis. Discuss geometric approach for pure extension with no rotation. **(10 Marks)**

8 a. Explain the principle of holography in stress analysis. Using schematic diagram, explain the holographic set-up for the construction of hologram. **(10 Marks)**

b. Explain a method of obtaining "Isopachics" in holography. **(10 Marks)**

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12MMD/MDE153

First Semester M.Tech. Degree Examination, June/July 2014

Mechatronics System Design

Time: 3 hrs. Max. Marks:100

Note: 1. *Answer any FIVE full questions.*
2. *Missing data, if any, may be suitably assumed.*

1 a. Define mechatronics and with a block diagram, explain the mechatronics design approach. **(10 Marks)**

b. What do you understand by the term "sequential control"? Explain with a block diagram the working of a microprocessor based washing machine. **(10 Marks)**

2 a. Enumerate the factors considered in the selection of transducers. **(04 Marks)**

b. Explain the characteristics and applications of the following types of sensors:
i) Thermistors ii) Optical encoder iii) Pnuematic proximity sensor **(10 Marks)**

c. Distinguish clearly between static and dynamic characteristics of a sensor. Explain the meaning of the following dynamic characteristics:
i) Response time ii) Time constant **(06 Marks)**

3 a. With a circuit diagram, explain how the control of a double acting pneumatic cylinder is accomplished. **(06 Marks)**

b. Give the symbols for the following types of valves:
i) Pilot operated direction control valve
ii) Pressure sequence valve
iii) 4/2 solenoid operated spring return direction control valve
iv) Variable delivery flow control valve. **(04 Marks)**

c. If one arm of a Wheatstone bridge contains a sensor, prove that the change in output voltage of the bridge is proportional to change in resistance of the sensor. **(06 Marks)**

d. A platinum resistance temperature sensor has a resistance of 100 Ω at 0°C and forms one arm of the Wheatstone bridge. The bridge is balanced at this temperature with the other arms also being at 0°C with a resistance of 100 Ω. If the temperature coefficient of resistance of platinum is 0.0039/K, what will be the output voltage from the bridge per degree change in temperature? **(04 Marks)**

4 a. Explain how a transistor switching circuit can be used to control the speed of a permanent magnet d.c. motor. **(10 Marks)**

b. Discuss Half stepping and required switching sequence, in case of a permanent magnet stepper motor. Also explain a complete switching cycle. **(10 Marks)**

5 a. Discuss the characteristics of hydraulic system building blocks describing their equations and energy/power relations. **(08 Marks)**

b. Derive an expression for the extension or contraction 'x' of bellows with respect to time when there is an input of a pressure P_1. The bellows is shown in Fig.Q5(b). **(12 Marks)**

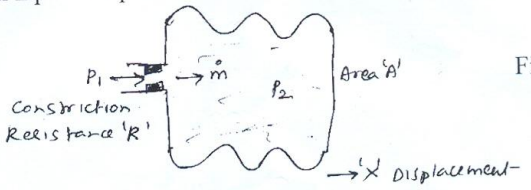

Fig.Q5(b)

6 a. Explain the processes that occur in a signal conditioning. **(04 Marks)**

b. Explain the following:

i) Differential amplifier

ii) Summing up amplifier **(06 Marks)**

c. Explain the functioning of a successive approximation analogue to digital converter. Give the specifications of an analog to digital converter. **(10 Marks)**

7 a. What are MEMS? Explain the applications of MEMS in automotive industry. **(08 Marks)**

b. Discuss the characteristics of silicon as a substrate material. **(06 Marks)**

c. What is photolithography? Briefly explain the procedure for the same. **(06 Marks)**

8 a. Consider a series RLC circuit with R = 100 Ω, L = 2.0 H and C = 20 μF. The current 'i' in the circuit is given by $\frac{d^2i}{dt^2}+\frac{R}{L}\frac{di}{dt}+\frac{1}{LC}i=\frac{V}{LC}$. When there is a step input of 'V' volts, determine:

i) The natural frequency

ii) Damping factor

iii) The solution to the equation when i = 0 at t = 0 and $\frac{di}{dt}=0$ at t = 0. **(10 Marks)**

b. Explain the typical faults that occur in a microprocessor system; enumerate the fault finding techniques that are used with microprocessor based systems. **(10 Marks)**

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