2017-2018
B.TECH.WINTER(IV-SEMESTER) EXAMINATION
(MECHANICAL ENGINEERING)
Numerical Methods & Optimization
AM232
Credits-04

Maximum Marks: 60
Duration: Two Hours

Note: 1. Answer all the questions.
2. Carry all the calculations up to four decimal places

Q1. (a) Approximate a root of the equation $2x - \log_{10} x - 7 = 0$ correct to four decimals by Newton-Raphson method.

OR (a') Determine $p, q$ and $r$ so that the order of the iterative method

$$x_{n+1} = px_n + \frac{aq}{x_n^3} + \frac{ra^2}{x_n^2}$$

for $\sqrt[n]{a}$ becomes as high as possible. Also, determine the order of the iterative scheme for this choice of $p, q$ and $r$.

(b) Perform three iterations of Gauss-Seidel method for the system of linear equations:

$$\begin{pmatrix} 2 & 3 & -5 \\ 3 & -4 & 1 \\ 5 & 1 & -2 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 23 \\ -8 \\ 13 \end{pmatrix}$$

Take initial approximation $(0, 0, 0)^T$.

Q2. (a) Construct the divided difference table for the function

$$f(x) = 2^x - x$$

with arguments $x = 0, 2, 3, 5$ and obtain the interpolating polynomial by using Newton’s divided difference interpolation formula.

(b) Using suitable formula for numerical differentiation approximate $\frac{dy}{dx}$ at $x = 156$ from the following table:

<table>
<thead>
<tr>
<th>x</th>
<th>150</th>
<th>152</th>
<th>154</th>
<th>156</th>
<th>158</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>1837.117</td>
<td>1873.982</td>
<td>1911.090</td>
<td>1948.439</td>
<td>1986.029</td>
</tr>
</tbody>
</table>

OR 2'. (a) Using Newton’s forward interpolation formula obtain the interpolating polynomial which passes through the points $(-3, -54), (-1, -10), (1, 2), (3, 30), (5, 122)$. 

cont'd...
(b) Determine the values of $\lambda_0, \lambda_1$ as a function of $c$ so that the quadrature formula
\[
\int_{-1}^{1} f(x) dx = \lambda_0 f(-1) + \lambda_1 f(-c) + \lambda_1 f(c) + \lambda_0 f(1) + E
\]
has maximum precision. Also what value of $c$ gives the most accurate formula? Apply the formula to evaluate $\int_{-1}^{1} x^2 e^{-x} dx$.

Q3 (a) Solve the initial value problem:
\[
\frac{dy}{dx} = x^2 + 0.1y^2, \quad y(1.3) = 1.02, \quad 1.3 \leq x \leq 1.5,
\]
by
(i) Runge-Kutta method of order 4 in one step.

OR
(ii) Modified Euler's method with $h = 0.2$. Perform three iterations.

(b) Solve, by finite difference method, the boundary value problem:
\[
\frac{d^2y}{dx^2} - 2 \frac{dy}{dx} + xy = e^x
\]
subject to the conditions: $y(0) - 2y'(0) = 1.1, y(0.9) = 2.6$.

Take $h = 0.3$.

Q4 (a) Two products $A$ and $B$ are to be manufactured. One single unit of product $A$ requires 2.4 minutes of punch press time and 5 minutes of assembly time. The profit for the product $A$ is Rs 0.60 per unit. One single unit of product $B$ requires 3 minutes of punch press time and 2.5 minutes of welding time. The profit for the product $B$ is Rs 0.70 per unit. The capacity of punch department available for these products is 1200 min/week. The welding department has capacity 600 min/week and assembly department has 1500 min/week. Company wants to determine the optimum products $A$ and $B$ that maximizes the profit.

(i) Formulate the Linear Programming Model.
(ii) Solve the problem by graphical method.

OR (a') Formulate the dual of the following Linear Programming Problem:
\[
\text{Min } Z = 1250x_1 + 1000x_2 + 900x_3 + 150x_4
\]
Subject to
\[
\begin{align*}
2x_1 + 2x_2 + 2x_3 & \geq 50 \\
x_1 + 5x_2 + 3x_3 + x_4 & \geq 100 \\
x_i & \geq 0, \ i = 1,2,3,4
\end{align*}
\]
and then solve by graphical method showing clearly the feasible solution space.
(b) Solve, by Simplex method, the Linear Programming Problem:

\[ \text{Min } Z = 5x_1 - 4x_2 + 6x_3 - 8x_4 \]

Subject to

\[ x_1 + 2x_2 + 2x_3 + 4x_4 \leq 40 \]
\[ 2x_1 - x_2 + x_3 + 2x_4 \leq 8 \]
\[ 4x_1 - 2x_2 + x_3 - x_4 \leq 10 \]
\[ x_i \geq 0, \quad i = 1,2,3,4. \]
2017-18
B.TECH. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
ELECTRICAL TECHNOLOGY
EE204

Maximum Marks: 60 Credits: 04 Duration: Two Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q. No. Questions

1 (a) Draw and explain the static V-I Characteristics of a Triac. Show the curve for different gate currents having relation I_{g1} > I_{g2} > I_{g0}. [06]

1 (b) Draw the circuit diagram of step-up chopper. A step-up chopper has input and output voltages as 100 V and 300 V respectively. If the non-conducting time of chopper is 100 μs, compute the pulse width of output voltage. [06]

2 (a) Explain the principle of operation of a dc motor. How back emf is produced in it? [06]

2 (b) With the help of suitable diagram explain the operation of a three point starter. [06]

OR

2 (b') Assume that a 25 hp, 250 V, self-excited shunt motor is supplied by a full load line current of 83 A. The armature and field resistances are 0.1 and 108 Ω respectively. If the total brush-contact voltage drop is 2V and the friction and core losses are 650 W, determine the following:
(a) Shunt field winding loss
(b) Armature winding loss
(c) Percent efficiency of the motor. [06]

3 (a) With the help of diagram and necessary equations explain how a rotating magnetic field is produced in three phase induction motor. [06]

3 (b) With the help of diagram explain the torque-speed characteristics of induction motor. Show the curve for various values of rotor resistances (R_{22} > R_{23} > R_{21}). [06]

OR

cont'd... 2.
3 (b') With the help of diagram explain how star-delta starter is used for starting the
induction motor. Also write its advantages and disadvantages.

4 (a) Classify different types of synchronous motors. Explain why a synchronous motor is
not self-starting?

4 (b) What is a stepper motor? Discuss the operation of a variable reluctance stepper
motors. Mention two applications of stepper motor.

OR

4(b') With the help of a neat diagram, discuss the working of Universal motor. Describe its
applications.

5 (a) A 400 turn autotransformer operating in the step-down mode with a 25% tap supplies
a 4 kVA, 0.85 pf lagging load. The input to the transformer is 2 kV, 50 Hz. Neglecting
the small losses and leakage effects, determine: (a) the load current, (b) the incoming
line current, (c) the transformed current, (d) the apparent power conducted and the
apparent power transformed.

5 (b) With the help of diagram explain the working principle of a welding transformer. Also
list the various types of reactors used in a welding transformer.

OR

5 (b') Enumerate different types of tariff in the power system. Also explain how
synchronous condenser is used for improving the power factor.
Maximum Marks: 60  Credits: 04  Duration: Two Hours

Attempt all questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No.  Question  M.M.

1(a)  Differentiate between
      i) Hardness and hot hardness
      ii) Toughness and strength
      iii) Ductility and malleability
      iv) Grey cast iron and white cast iron  [08],CO5

1(b)  Explain the effect of any four alloying elements on properties of steel.  [04],CO4

2  Write a detailed note on ceramic materials emphasizing on the following
      i) Their classification
      ii) Their properties
      iii) Their applications
      iv) Their methods of processing  [12],CO2

2' Write short notes on the following
      i) Galvanizing
      ii) Tinning
      iii) Inorganic coatings
      iv) Organic coatings  [12],CO2

3(a)  Explain the following with sketches
      i) Ferrite  [06],CO4

contd...2.
ii) Austenite

iii) Pearlite

iv) Martensite

3(b) Describe with sketches various line and surface defects found in materials. [06],CO3

OR

3'(b) Calculate the planar density on (100) in polonium, (110) in rhodium and (111) in chromium. Atomic radii of polonium, rhodium and chromium are 1.7 Å, 1.34 Å and 1.24 Å respectively. [06],CO3

4(a) Describe comprehensively Iron-carbon equilibrium diagram of steel. [07],CO4

4(b) Explain the Time-Temperature-Transformation (TTT) diagram of steel. [05],CO4

5(a) Explain the fatigue phenomenon and mechanism of fatigue fracture in materials. [06],CO5

5(b) Explain the importance of material science in manufacturing. [06],CO1

OR

5'(a) Describe strain hardening and Baushinger effect in materials. [05],CO5

5'(b) During a creep test on pure Aluminium at 280 °C under steady stress of 6.85 MPa, the following data were recorded [07],CO7

<table>
<thead>
<tr>
<th>Time t (min)</th>
<th>Strain (mm/mm)</th>
<th>Time t (min)</th>
<th>Strain (mm/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>24</td>
<td>0.094</td>
</tr>
<tr>
<td>1</td>
<td>0.020</td>
<td>32</td>
<td>0.109</td>
</tr>
<tr>
<td>2</td>
<td>0.029</td>
<td>40</td>
<td>0.122</td>
</tr>
<tr>
<td>4</td>
<td>0.041</td>
<td>48</td>
<td>0.136</td>
</tr>
<tr>
<td>8</td>
<td>0.057</td>
<td>60</td>
<td>0.156</td>
</tr>
<tr>
<td>16</td>
<td>0.078</td>
<td>72</td>
<td>0.176</td>
</tr>
</tbody>
</table>

Plot strain-stress curve, and show the extents of primary, secondary and tertiary stages on it. Determine (a) minimum creep rate (b) the creep intercept (c) transient creep law.
Attempt all questions
Assume suitably if any data is missing

Q.No. | Question | M.M.
--- | --- | ---
1(a) | What are the principal stresses, give their expressions. Further discuss the theory of failure used for ductile materials. | [02]
1(b) | Explain any two of the following  
   i) Notch sensitivity  
   ii) Surface strength  
   iii) Soderberg method of Combination of Stresses. | [02]
1(c) | A rotating shaft supported in ball bearings at supports A and B and loaded by a non-rotating force of 8 KN at the mid span is shown in Figure 1. Estimate the life of the shaft if it is made of steel having ultimate tensile strength of 540 N/mm², surface finish factor = 0.85, size factor =0.84, Kc =Kd=1, fatigue stress conc. factor Kf = 1.585. | [08]
2(a) | Explain any two of the following:
   i) Law of Gearing  
   ii) Length of path of contact  
   iii) Interference in involute gears. | [04]
2(b) | Two mating gears of 20° pressure angle have 20 and 40 involute teeth of module 10 mm. The addendum on each wheel is to be made of such a length that the line of contact on each side of the pitch point has half the maximum possible length. Determine (i) The addendum height for each gear wheel (ii) The length of path of contact (iii) The length of Arc of contact (iv) The contact ratio. | [08]
3(a) | What are the different failures in riveted joint? | [03]

contd ... 2.
OR

3 (a') Derive the relations for eccentrically loaded bolted joints.

3 (b) What is the process of making a riveted joint leak proof.

3 (c) A single square thread power screw has an input power of 3kw at a speed of 60 rpm. The screw has a diameter of 36mm and a pitch of 6mm. The coefficients of friction are 0.14 for the thread and 0.09 for the collar, with a collar diameter of 90mm. Find the axial load F and the efficiency of the screw.

4 (a) What are the different types of constrained motions? Explain each type with neat sketches and examples.

4 (b) What is a double slider-crank chain? With a neat sketch explain the first inversion of double slider-crank chain.

OR

4(b') With a neat sketch prove that for Davis steering gear

\[ \tan \alpha = \frac{w}{2l} \]

where \( w, l \) and \( \alpha \) are having their usual meaning.

5 The lengths of crank and connecting rod of a reciprocating engine are 100mm and 400mm respectively. The crank is rotating at a uniform speed of 240 rpm. Using Klien's construction, find (i) velocity of piston (ii) acceleration of piston (iii) angular velocity of connecting rod (iv) angular acceleration of connecting rod, when the crank has turned through 30° from inner dead centre.

OR

5' For a reciprocating engine, prove that the displacement, velocity and acceleration of the piston are given respectively by the expression:

\[ x = r \left[ (1 - \cos \theta) + (n - (n^2 - \sin^2 \theta)^{1/2}) \right] \]

\[ v = r \omega \left[ \sin \theta + (\sin 2\theta / 2n) \right] \]

\[ a = r \omega^2 \left[ \cos \theta + (\cos 2\theta / n) \right] \]

where \( r, l, n \) and \( \theta \) have their usual meaning.

\[ 8 \text{ KN} \]

\[ \text{Figure 1} \]