1(a) Answer any two of the following: 

(i) Evaluate \( L^{-1} \left( \frac{4s+5}{(s-1)^2(s+2)} \right) \) \[8\]

(ii) Evaluate \( L^{-1} \left( \frac{s}{s^2+s^2+1} \right) \)

(iii) Evaluate \( L(t^2 \cos at) \)

(b) Solve the following IVP by using Laplace transforms: 
\( (D^2 - 3D + 2)x = 1 - e^{2t}, \ x_0 = 1, x_1 = 0. \) \[7\]

2(a) Show that the vector field \( \vec{A} = (x^2 - y^2 + x)i - (2xy + y)j \) is irrotational. Find a scalar function \( \phi \) such that \( \vec{A} = \text{grad} \ \phi. \) \[8\]

(b) Show that \( \text{div} (\text{grad} \ r^n) = n(n+1)r^{n-2} \), where \( \vec{r} = xi + yj + zk. \) \[7\]

OR

(b') Find the directional derivative of \( 4xz^3 = 3x^2y^2z^2 \) at \( (2, -1, 2) \) along the \( z \) - axis. \[7\]

3(a) Evaluate \( \iint_S \vec{r} \cdot d\vec{S} \) where \( S \) is the surface of the sphere \( x^2 + y^2 + z^2 = 9. \) \[8\]

OR

(a') Verify Stokes' theorem for the function
\( \vec{F} = x^2i + xyj \)
integrated around the square in the plane \( z = 0 \) and and bounded by the lines \( x = 0, y = 0, x = a \) and \( y = a. \) \[8\]
(b) Use Green's theorem in a plane to evaluate the integral
\[ \int_C [(2x^2 - y^2)dx + (x^2 + y^2)dy], \]
where C is the boundary of the surface in the xy-plane enclosed by the x-axis and the semi circle \( y = \sqrt{1 - x^2}. \)

4. Answer any two of the following:

(a) Determine the analytic function \( w = u + vi \) if \( u = \frac{2\sin2x}{e^{2y}+e^{-2y}-2\cos2x}. \)

(b) If \( f(z) \) is analytic function of \( z \), prove that
\[ \left( \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right) |f(z)|^2 = 4|f'(z)|^2. \]

(c) Use Cauchy's integral formula to evaluate
\[ \int_C \frac{3z^2 + z}{z^2 - 1} \, dz, \]
where C is the circle |z| = 2.

******************************************************************************
2017-18
B.E. (EVENING) WINTER (IV SEMESTER) EXAMINATION
(MECHANICAL ENGINEERING)
NUMERICAL METHODS & OPTIMIZATION
(EAM-232)

Maximum Marks: 60 Credit: 04 Duration: Two Hours

Note: Attempt all the questions. Programming calculator is not allowed.

Q.No. Questions M.M.

1(a) Using the general iteration method, find a real root of the equation \( \cos x - xe^x = 0 \) between 0 and 1 correct to three decimal places. [08]

1(b) Solve the following system of equations by Gauss elimination method:

\[
\begin{align*}
4x + y + z &= 4 \\
x + 4y - 2z &= 4 \\
3x + 2y - 4z &= 6.
\end{align*}
\]
OR

1(b') Perform three iterations of the Gauss-Seidel iteration method for solving the system of equations:

\[
\begin{align*}
4x + 2z &= 6 \\
5x + 4y + 10z &= 11 \\
5y + 2z &= -3.
\end{align*}
\]

2(a) Using Newton's backward interpolation formula, find \( y \) when \( x = 27 \), from the following data:

<table>
<thead>
<tr>
<th>( x )</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>35.4</td>
<td>32.2</td>
<td>29.1</td>
<td>26.0</td>
<td>23.1</td>
</tr>
</tbody>
</table>

OR

2(a') The following table gives the viscosity of an oil as a function of temperature. Use Lagrange's formula to find the viscosity of oil at a temperature of 140\(^\circ\).

Temperature in degrees: 110 130 160 190
Viscosity: 10.8 8.1 5.5 4.8

2(b) Dividing the range into 8 equal parts, find the value of \( \int_0^\pi \sin^3 x \, dx \) by Simpson's one third rule.

Contd... 2.
3(a) Given \( y' = x^2 + y \), \( y(0) = 1 \), determine \( y(0.2) \) and \( y(0.4) \) using modified Euler’s method (take \( h = 0.2 \)).

OR

3(a') Apply the fourth order Runge-Kutta method to find an approximate value of \( y \) when \( x = 0.2 \), given that \( y' + y = 0, y(0) = 1 \) (take \( h = 0.2 \)).

3(b) Solve the boundary value problem

\[
\frac{d^2y}{dx^2} + y + 1 = 0
\]

\[
y(0) = 0, \quad y(1) = 0
\]

by the finite difference method. Compute \( y(0.5) \) (take \( h = 0.25 \)).

4(a) A company produces two types of leather belts, say type \( A \) and \( B \). Belt \( A \) is superior quality and belt \( B \) is lower quality. Profits on the two types of belt are 40 and 30 rupees per belt, respectively. Each belt of type \( A \) requires twice as much time as required by a belt of type \( B \). If all belts were of type \( B \), the company would produce 1000 belts per day. But the supply of the leather is sufficient only for 800 per day. Belt \( A \) requires a fancy buckle and 400 fancy buckles are available for this, per day. For belt of type \( B \) only 700 buckles are available per day. How should the company manufacture the two types of belt in order to have maximum overall profit?

Formulate this as a linear programming problem and solve it by graphical method.

OR

4(a') Obtain the dual of the following LP problem:

Minimum \( z = 1500x_1 + 1500x_2 + 300x_3 + 400x_4 \),

subject to the constraints:

\[
2x_1 + 3x_2 + x_3 \geq 50, \\
3x_1 + 2x_2 + x_4 \geq 60, \\
x_1, x_2, x_3, x_4 \geq 0
\]

and hence solve by graphical method.

4(b') Solve the LP problem by simplex method:

Maximize \( z = 3x_1 + 2x_2 + 5x_3 \),

subject to the constraints:

\[
x_1 + 2x_2 + x_3 \leq 430, \\
3x_1 + 2x_3 \leq 460, \\
x_1 + 4x_2 \leq 420, \\
and \quad x_1, x_2, x_3 \geq 0.
\]
Answer all the questions.  
Assume suitable data if missing.  
Notations used have their usual meaning.

Q. No. Questions
1 (a) Draw the I-V characteristics of a thyristor. Discuss its various modes of operation. [06] [CO1]

1 (b) Draw the circuit of single phase full-bridge inverter with RL-load. Draw and explain the wave shapes of output voltage and output current. [06] [CO1]

OR

1’(b) Explain the working of a step-down chopper. What is chopping frequency? [06]

2 (a) How dc motors are classified? Draw Torque-Current, Speed-Current and Speed-Torque characteristics for each of them. [06] [CO2]

2 (b) A 200 kW, 400 V dc motor runs at 600 rpm. It has 864 lap connected armature conductors. The full load armature copper loss is 10 kW. Calculate the useful flux per pole. [06] [CO2]

OR

2’(a) Derive the EMF equation of DC motor. Which quantities in the expression are constant? [06] [CO2]

2’(b) A 220 V dc shunt motor is operating at a speed of 1440 rpm. The armature resistance is 1 Ω and armature current is 10 A. If the excitation of the machine is reduced by 15%, calculate the value of the extra resistance to be added in the armature circuit to maintain the same speed and torque. [06] [CO2]

3 (a) Draw and explain the torque-speed characteristic of a three phase induction motor for different values of rotor resistances. [06] [CO3]
3 (b) A two-pole, 50 Hz induction motor supplies 15 kW to a load at a speed of 2950 rpm. How much power will be supplied by the motor when the torque is doubled? Assume torque to be linearly dependent on slip.

OR

3’(a) With the help of suitable diagram, explain the working of a ‘direct online starter’ used for 3-phase induction motor.

3’(b) The efficiency of a 400 V, three phase, 6-pole induction motor drawing a line current of 80 A at 0.75 pf and 4% slip is 85%. Calculate the shaft power output and shaft torque.

4 (a) Describe the principle of operation of a synchronous motor.

4 (b) With the help of a suitable diagram, explain the working of a hysteresis motor.

5 (a) Name the various types of tariffs used in a power system. Explain three part tariff.

5 (b) A 15 kVA, 60 Hz, 1200/80 V distribution transformer is reconnected for using as a step-up autotransformer with a 1280 V output and a 1200 V input. Determine the rated primary and secondary currents and the apparent power rating when connected as an autotransformer.
2017-18  
B.E. (WINTER SEMESTER) EXAMINATION  
MECHANICAL ENGINEERING  
MATERIAL SCIENCES  
EME-202

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.  Question  M.M.
1(a)  Describe the different interfacial defects observed in crystal systems and explain any two of them.  [06]
1(b)  What are the indices for the two planes drawn in the sketch below?  [06]

OR

1(b')  Sketch the atomic packing of:  [06]
   (a) (100) plane for the FCC crystal system
   (b) (111) plane for the BCC crystal system
2(a)  What are the different allotropes of Iron? Sketch them on an Iron-Carbon diagram.  [08]
2(b)  Describe the steps involved in determination of composition of a binary system using inverse lever rule.  [04]

OR

2 (b')  Explain the following heat treatment processes: (a) Annealing & (b) Normalizing.  [04]

cont'd...
3(a) Explain the concept of steady state diffusion, its mechanism and modelling as it applies to solids.

3(b) A sheet of steel 2.5 mm thick has nitrogen atmospheres on both sides at 900°C and is permitted to achieve a steady-state diffusion condition. The diffusion coefficient for nitrogen in steel at this temperature is $1.2 \times 10^{-10}$ m$^2$/s, and the diffusion flux is found to be $1.0 \times 10^{-7}$ kg/m$^2$.s. Also, it is known that the concentration of nitrogen in the steel at the high-pressure surface is 2 kg/m$^3$. How far into the sheet from this high pressure side will the concentration be 0.5 kg/m$^3$? Write the assumptions involved.

OR

3(b') Describe briefly the following strengthening mechanisms in solids (a) Grain size reduction, (b) Solid solution strengthening, and (c) Precipitation hardening

4(a) What is a true stress-strain curve? Explain the Holloman-Ludwig power law equation.

4(b) Describe the stages involved in plastic deformation of a tensile specimen with the help of a schematic macroscopic diagram.

OR

4(a') Differentiate between ductile and brittle fracture.

4(b') Describe the deformation under creep, the creep curve and steady state creep rate. What are the effects of temperature and stress on creep behaviour?

5(a) What are the different types of corrosions? What common factors influences the occurrence of corrosion?

5(b) Write short notes on:

(i) Degradation of polymers

(ii) Corrosion of ceramics
2017-18
B.E. (AUTUMN SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
Mechanics of Solids (EME213)

Maximum Marks: 60
Credits: 04
Duration: Two Hours

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

Q.No. Question

1 (a) Derive stress equilibrium equations in 3D rectangular coordinate system.

1 (b) The displacements in micro units for a solid is given by
   \[
   u = (x^2 + y) i + (3 + z) j + (x^2 + 2y) k
   \]
Calculate at (3, 1, -2)
   i) Strain matrix.
   ii) Strain in the direction \( n_x = n_y = n_z = 1/\sqrt{3} \).
   iii) Principal strains.

OR

1 (b’) The strains determined using the strain rosette shown in Fig. 1 during the test of a machine is given by
   \( \varepsilon_1 = 600 \mu, \varepsilon_2 = 450 \mu, \varepsilon_3 = -75 \mu \)
Determine (a) \( \varepsilon_x, \varepsilon_y \) and \( \gamma_{xy} \), in-plane principal strains, and in-plane maximum shearing strain.

2 State and explain generalized Hooks Law for an anisotropic material and reduced it for an isotropic material.

\[\text{contd... 2.}\]
2' Derive the expressions for radial and hoop stresses in a thin rotating disk of uniform thickness.

3 (a) Derive the expressions for the hoop and longitudinal stresses developed in a thin cylindrical pressure vessel subjected to an internal pressure.

3 (b) A cylindrical storage tank used to transport gas under pressure has an inner diameter of 600 mm and a wall thickness of 18 mm. Strain gages attached to the surface of the tank in transverse and longitudinal directions indicate strains of $255 \times 10^{-6}$ and $60 \times 10^{-6}$ mm/mm respectively. Knowing that a torsion test has shown that the modulus of rigidity of the material used in the tank is $G = 81$ GPa, determine (a) the gage pressure inside the tank, (b) the principal stresses and the maximum shearing stress in the wall of the tank.

OR

3 (b') An external pressure of 10 MN/m$^2$ is applied to a thick cylinder of internal diameter 160 mm and external diameter 320 mm. If the maximum hoop stress permitted on the inside wall of the cylinder is limited to 30 MN/m$^2$, what maximum internal pressure can be applied assuming the cylinder has closed ends? What will be the change in outside diameter when this pressure is applied? $E = 207$ GPa $v = 0.3$.

4 Using double integration method, find the maximum deflection and slope at point A for the beam shown in Fig. 3.

Fig. 3
5 (a) Derive expression for Euler's buckling load for a thin column having one end fixed and other end pinned.

5 (b) State Castigliano's theorem. Using this, find the vertical and horizontal deflections at point A for the curved beam shown in Fig. 4.

Fig. 4.
2017-18
B.E. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
Kinematics and Design of Machines (EME215)

Maximum Marks: 60          Credits: 04          Duration: Two Hours

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

Q.No.   Question                                           M.M.

1 (a)  The length of the fixed link of a crank and slotted-lever mechanism is 250 mm and that
        of the crank is 100 mm. Determine the
        1) inclination of the slotted lever with the vertical in the extreme position,
        2) ratio of the time of cutting stroke to the time of return stroke, and
        3) length of the stroke, if the length of the slotted lever is 450 mm and the line of
        stroke passes through the extreme positions of the free end of the lever.

1 (b)  Prove that a point on one of links of a Hart mechanism traces a straight line on the
        movement of its links.                                (09)

OR

1’     Derive an expression for the ratio of angular velocities of the shafts of a Hooke’s joint
        and also the conditions for the ratio to be unity, maximum and minimum.   (12)

2     Fig 1 shows a mechanism in which OA = QC = 100 mm, AB
        = QB = 300 mm and CD = 250 mm. The crank OA rotates at 150 rpm in the clockwise direction.
        Determine the
        1) velocity of the slider at D
        2) angular velocities of links QB and AB
        3) rubbing velocity at the pin B which is 40 mm in diameter

OR

\[\text{contd... \#2}\]
2. One cylinder of a rotary engine is shown in the configuration diagram shown in Fig. 2. OA is the fixed crank, 200 mm long, OP is the connecting rod and is 520 mm long. The line of stroke is along AR and at the instant is inclined at 30° to the vertical. The body of the engine consisting of cylinders rotates at a uniform speed of 400 rpm about the fixed centre A. Determine the
1) acceleration of piston (slider) inside the cylinder
2) angular acceleration of the connecting rod

3 (a) Two involute gears in a mesh have a module of 8 mm and a pressure angle of 20°. The larger gear has 57 while the pinion has 23 teeth. If the addenda on pinion and gear wheels are equal to one module, find the
1) contact ratio (the number of pairs of teeth in contact)
2) angle of action of the pinion and the gear wheel
3) ratio of the sliding to rolling velocity at the
   a. beginning of contact
   b. pitch point
   c. end of contact

3 (b) A gear train shown in Fig. 3 in which gears D-E and F-G are compound gears. D gears with A and B; E gears with F; and G gears with C. The numbers of teeth on each gear are A = 60, B = 120, C = 135, D = 30, E = 75, F = 30, G = 60. If the wheel A is fixed and the arm makes 20 revolutions clockwise, find the revolutions of B and C.

4 (a) What do you understand by Machine Design. Illustrate the different phases in a designing process.

4 (b) A forged steel bar, 50 mm in diameter, is subjected to a reversed bending stress of 250 N/mm². The bar is made of steel 40C8 (Sₘₐₓ = 600 N/mm²). Calculate the life of the bar.
for a reliability of 90%. (Required data may be obtained from tables and charts provided at the end of this paper)

OR

4. A cantilever beam made of cold drawn steel 40C8 (S
$_{yr}$ = 600 N/mm$^2$ and S$_{iy}$ = 380 N/mm$^2$) is shown in Fig. 4. The force P acting at the free end varies from -50 N to +150 N. The expected reliability is 90% and the factor of safety is 2. The notch sensitivity factor at the fillet is 0.9. Determine the diameter 'd' of the beam at the fillet cross-section. (Required data may be obtained from tables and charts provided at the end of this paper)

5 (a) A bracket for supporting the travelling crane is shown in Fig. 5. The bracket is fixed to the steel column by means of four identical bolts, two at A and two at B. The maximum load that comes on the bracket is 5 kN acting vertically downward at a distance of 250 mm from the face of the column. The bolts are made of steel 40C8 (S$_{yr}$ = 380 N/mm$^2$) and the factor of safety is 5. Determine the major diameter of the bolts on the basis of maximum principal stress. Assume (d$_c$ = 0.8d)

5 (b) A brake band attached to the hinge by means of a riveted joint is shown in Fig. 6. Determine the size of the rivets needed for the load of 10 kN. Also, determine the width of the band. The permissible stresses for the band and rivets in tension, shear and compression are 80, 60 and 120 N/mm$^2$ respectively. Assume, margin (m) = 1.5d and transverse pitch ($p_t$) = p. Also find the pitch of the rivets.
Chart 1

Surface finish factor $K_s$

- Polished
- Ground
- Machined and cold drawn
- Hot rolled
- Forged

Tensile strength N/mm²

<table>
<thead>
<tr>
<th>Reliability R (%)</th>
<th>$K_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1.000</td>
</tr>
<tr>
<td>90</td>
<td>0.897</td>
</tr>
<tr>
<td>95</td>
<td>0.868</td>
</tr>
<tr>
<td>99</td>
<td>0.814</td>
</tr>
</tbody>
</table>

Table 1

$D/d$ values:
- $D/d = 1.1$
- $D/d = 1.2$
- $D/d = 1.5$
- $D/d = 2.0$

Chart 2

$K_t$

$K_b$

<table>
<thead>
<tr>
<th>Diameter (d) (mm)</th>
<th>$K_b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$d \leq 7.5$</td>
<td>1.00</td>
</tr>
<tr>
<td>$7.5 &lt; d \leq 50$</td>
<td>0.85</td>
</tr>
<tr>
<td>$d &gt; 50$</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Table 2