Q1 (a) Find an interval of unit length which contains a real root of the equation \( x^3 + x^2 - 1 = 0 \). Obtain the initial root \( x_0 \) by bisection method and then use it to approximate the root correct to three decimal places by general iteration method.

OR

(a') Using Newton Raphson method, establish the iterative formula \( x_{n+1} = \frac{1}{3} \left( x_n + \frac{a}{x_n} \right) \) for computing the cube root of \( a \) and hence evaluate \( \sqrt[3]{2} \) correct to four decimal.

(b) Determine the values of \( p \) and \( q \) so that rate of convergence of the iterative scheme \( x_{n+1} = px_n + \frac{4q}{x_n} \) for computing \( 4^{1/3} \) becomes as high as possible.

(c) Solve the following system of linear equations by Gauss Seidel iteration method:

\[
\begin{pmatrix}
2 & -8 & 1 \\
1 & -2 & 9 \\
3 & 1 & -1 \\
\end{pmatrix}
\begin{pmatrix}
x \\
y \\
z \\
\end{pmatrix} =
\begin{pmatrix}
-5 \\
8 \\
3 \\
\end{pmatrix}
\]

Perform three iterations with initial approximate solution \( (1.0, 0.5, 0.8)^T \).

Q2 (a) Form the difference table for the function \( f(x) = 2^x - 5 \) with the arguments \( x = 1, 2, 4, 5 \). Use this table to find the interpolating polynomial that fits the data and hence find \( f''(2) \).
(a') Using Lagrange's interpolation find the root of the equation \( f(x) = 0 \) given that \( f(30) = -30, \ f(34) = -13, \ f(38) = 3, \ f(42) = 16. \)

(b) Use Newton's forward interpolation formula to find the interpolating polynomial which takes the values:

\[
y(0) = 1, \ y(1) = 0, \ y(2) = 1, \ y(3) = 10.
\]

(c) Derive two point Gauss formula

\[
\int_a^b f(x) \, dx = h \left[ f \left( \frac{a + b}{2} + \frac{h}{\sqrt{3}} \right) + f \left( \frac{a + b}{2} - \frac{h}{\sqrt{3}} \right) \right] + E
\]

where \( h = \frac{b-a}{2} \). Apply this formula to evaluate \( \int_{-2}^{2} \left( \frac{e^{-x^2}}{1+x^2} \right) \, dx \).

---

Q 3  
(a) Using Taylor's series (up to four degree), solve the initial value problem:

\[
\frac{dy}{dx} = x - y^2, \quad y(0) = 1
\]

and find if \( f' \) at \( x = 0.1 \).

---

Q 3 (a) Solve the initial value problem:

\[
\frac{dy}{dx} = 3x + \frac{1}{2} y, \quad y(1.2) = 3.1 \text{ and find if at } x = 1.4
\]

by Modified Euler's method, taking \( h = 0.2 \). Perform three iterations.

(b) Solve, by finite difference method, the boundary value problem:

\[
\frac{d^2y}{dx^2} = y, \quad y'(0) = 0, \quad y(1) = 1.
\]

Take \( h = \frac{1}{3} \).

---

Q 3 (a) Solve the following linear programming problems graphically:

(i) \( \text{Max } z = 5x_1 + 3x_2 \)

Subject to the constraints:
(ii) \( \text{Min } z = 2x_1 + 3x_2 \)
Subject to the constraints:
\[
\begin{align*}
3x_1 + 5x_2 & \leq 15 \\
5x_1 + 2x_2 & \leq 10 \\
x_1, x_2 & \geq 0
\end{align*}
\]

\[
\begin{align*}
x_1 + x_2 & \leq 4 \\
6x_1 + 2x_2 & \geq 8 \\
x_1 + 5x_2 & \geq 4 \\
x_1, x_2 & \geq 0
\end{align*}
\]

OR

(a') Construct the dual of the following linear programming problem:
\[
\text{Min } z = 1250x_1 + 1000x_2 + 900x_3 + 150x_4
\]
Subject to the constraints:
\[
\begin{align*}
2x_1 + 2x_2 + 2x_3 & \geq 50 \\
x_1 + 5x_2 + 3x_3 + x_4 & \geq 100 \\
x_1, x_2, x_3, x_4 & \geq 0
\end{align*}
\]
and then solve the problem graphically.

(b) Solve by Simplex method the linear programming problem:
\[
\text{Max } Z = x_1 + 2x_2 + x_3
\]
Subject to the constraints:
\[
\begin{align*}
2x_1 + x_2 - x_3 & \leq 2 \\
-2x_1 + x_2 - 5x_3 & \geq -6 \\
4x_1 + x_2 + x_3 & \leq 6 \\
x_i & \geq 0, \quad i = 1, 2, 3.
\end{align*}
\]
1. (a) Differentiate between necessities and luxuries. Explain the law of supply and demand with suitable examples. [06]

1. (b) An investment of Rs. 1,05,815.4 can be made in a project that will produce a uniform annual revenue of Rs. 53,000 for 5 years and then have a salvage value of Rs. 30,000. Annual disbursements will be Rs. 30,000 each year for operation and maintenance costs. The company's minimum attractive rate of return is 10%. Show whether it is a desirable investment by using the present worth method. [06]

OR

1. (b') The machines shown below have been proposed for a certain manufacturing operation. Determine which should be selected if the company's MARR is 19% per year and the decision is to be based on a comparison of their equivalent uniform annual costs. [06]

<table>
<thead>
<tr>
<th></th>
<th>Machine I</th>
<th>Machine II</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Cost,$</td>
<td>15,000</td>
<td>29,000</td>
</tr>
<tr>
<td>Annual Cost,$/year</td>
<td>7,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Life, yrs.</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Salvage value,$</td>
<td>3,500</td>
<td>4,200</td>
</tr>
</tbody>
</table>

2. Attempt any two questions from the following [06]

2. (a) What is Inflation? List its causes.
Ten years ago, a chemical company installed a heat exchanger in its plant for $10,000. The company is considering replacing the heat exchanger because maintenance costs have been increasing. The estimated maintenance costs for the next 5 years are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1,000</td>
</tr>
<tr>
<td>2.</td>
<td>1,200</td>
</tr>
<tr>
<td>3.</td>
<td>1,400</td>
</tr>
<tr>
<td>4.</td>
<td>1,600</td>
</tr>
<tr>
<td>5.</td>
<td>1,800</td>
</tr>
</tbody>
</table>

Whenever the heat exchanger is replaced, the cost of removal will be $1,500 more.
than the heat exchanger is worth as scrap metal. The replacement the company is considering has an equivalent annual cost \((EAC) = $900\) at its most economic life. Should the heat exchanger be replaced now or not if the company's minimum attractive rate of return \(MARR\) is 20%?

2. (b) What are the various criteria for performing a cost benefit analysis? Cash flows of a 4-year project are represented in the table below

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investments $</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent Costs $</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Income $</td>
<td>200</td>
<td>250</td>
<td>300</td>
<td>350</td>
<td></td>
</tr>
</tbody>
</table>

Conduct a cost-benefit analysis to conclude whether this project should be approved or not if discounted with a 10% interest rate?

2. (c) What is meant by depreciation? Give the reasons for declining value of an asset. An asset has a first cost of $25000 and an expected salvage value of $4000 after 12 years. Calculate using double declining methods, the depreciation for the fourth year and the book value at the end of fifth year.

3. (a) Explain the classical and the administrative model of decision making. What are the similarities and differences between them? Use a suitable example from the industry to illustrate your point.

3. (b) A farmer wants to buy a new combine harvester rather than hire a custom harvester. The total fixed costs for the desired combine are $21,270 per year. The variable costs (not counting the operator's labor) are $8.75 per hour. The farmer can harvest 5 acres per hour. The custom harvester charges $16.00 per acre. How many acres must be harvested per year to break-even?

4. What do you understand by the term “Job design”? Explain the job characteristic approach of job design.

OR

4'. Explain Maslow's theory of motivation. Suppose you are a manager at an automobile company. How would you ensure that the various needs (as identified by Maslow) of your subordinates are met?

5. Suppose you are a project manager at Infosys. In your team there are six engineers. Knowledge of a new software package is necessary for completing your project. You are tasked with designing a training program. What different steps would you take to ensure that the training program you designed would be successful? You can show those steps in the form of a flow chart.
Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning. Draw neat sketches to support your answers.

1(a) Explain why it is generally undesirable to allow temperature rise excessively in machining operations. Give the measures taken to restrict the temperature rise in machine mild steel components.

1(b) A dry turning operation was performed using a tool with the signature $0^\circ, -5^\circ, 6^\circ, 7^\circ, 0^\circ, 0^\circ, 8^\circ$. The cutting and its normal forces measured were 1300 N and 740 N respectively. When a cutting fluid was employed, these forces were 1200 N and 710 N respectively. What is change in the friction angle resulting from the use of a cutting fluid?

2(a) What is meant by radial rake angle of a straight edge plain milling cutter? Locate the radial rake angle with help of a neat sketch. Enumerate the parameters for milling a mild steel cubical block to secure orthogonal cutting process.

2(b) A titanium alloy rod having a through hole of 55 mm diameter and 150 mm length is machined to a final diameter of 60 mm. The spindle speed is 300 mm and the tool travels at an axial velocity of 200 mm/min. Calculate mean cutting speed, material removal rate, time of cut, power required and the cutting force if the specific energy is 3.7 W-s/mm$^3$.

OR

2’(a) Discuss the following:

(i) Die and punch.

(ii) Progressive die

(iii) Cleaning of surfaces

2’(b) What is meant by a jig? Give its application in drilling operation.

Give details with the figure of a jig for the mass production of following products requiring drilling of 10 mm diameter (4 holes as mentioned in the figure below).
The thickness of the products is approximately 7 mm. Give the details of the materials of the parts incorporated in the jig.

All dimensions are in mm.

3 Write short notes on any three of the following:
   a) Electrical discharge machining
   b) Plasma arc machining
   c) Electron beam machining
   d) Laser beam machining

4(a) Define and explain the following terms with neat sketches with reference to dimensional metrology:
   i. Tolerance and Allowance
   ii. Limits and Fits
   iii. Fundamental Deviation and Fundamental Tolerance unit

4(b) Write a short note on selective assembly.

4(c) What are limit gauges? Describe the Taylors’s principle of design of “GO” and “NO GO” gauges. Find the maximum and minimum dimensions for GO and NO GO plug/snap gauges required for controlling the dimensions of holes in the fits designated by 25H8/e8. Given that the tolerance value for a nominal diameter of 25 mm in IT8 is 33 microns and the fundamental deviation of e shaft is -40 microns. Sketch the gauge and mark the dimensions on it.

OR

4*(a) Enumerate the relative advantages and disadvantages of the line standards, end standards and wavelength standards.

4*(b) Describe any one method of determining the taper angle of a plug gauge.

4*(c) Explain the working principle of an autocollimator and briefly explain its applications.
5 Answer any 3 of the following

(a) What are acceptance tests? Explain their significance. Name some tests that may be
carried out on a lathe machine for testing the main spindle for true running. Explain
any one of them in detail.

(b) Sketch the fringes that you may expect in the following cases when tested with an
optical flat under a monochromatic source of light:

i. When the edges of the optical flat are worn out and the middle surface is
optically flat

ii. When the optical flat is resting along its length on an optically flat surface of
a slip gauge and inclined across its width

Two slip gauges of 10mm width, measuring 1.000mm and 1.002mm are kept side
by side in contact with each other lengthwise. An optical flat is kept on the slip
gauges. Monochromatic light of wavelength 0.0058928mm is used in inspection.
Find the total number of straight fringes that can be observed on both slip gauges.

(c) Calculate the dimensions over pins in the following case of gear measurement:
number of teeth = 31; module = 3; and pressure angle = 20°. Also indicate the
diameter of pins to be used.

(d) Derive an expression for the best size wire in thread measurement in terms of the
known thread parameters
Maximum Marks: 60  
Credits: 04  
Duration: Three Hours

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

Q.No.  
Question  
M.M.

1(a)  What do you mean by inversion of a mechanism? Explain with neat sketches any two inversion of single slider crank chain.  
[06]

1(b)  What do you mean by steering gear? Derive an expression for the fundamental equation of correct gearing.  
[06]

OR

1(b') A Hooke's joint is used to connect two shafts. The driving shaft is rotating uniformly with a speed of 400 rpm. The maximum speed of the driven shaft is 420 rpm. Determine the greatest permissible angle between the two shafts. Also find the minimum speed of the driven shaft.  
[06]

2  The oscillating link OAB of a mechanism shown in figure 1 is pivoted at O and is moving at 90 rpm anticlockwise. If OA=150 mm, AB=75 mm and AC=250 mm, calculate: (i) the velocity of the block C, (ii) angular velocity of link AC.  
[12]

OR

2'  The lengths of the crank and connecting rod of a reciprocating engine are 200 mm and 800 mm respectively. The crank is rotating at a uniform speed of 480 rpm. Using Klein's construction find: (i) the acceleration of the piston and (ii) angular acceleration of the connecting rod when the crank has turned through 45° from I.D.C. position.  
[12]

3  Design a slider crank mechanism so that displacement of the slider is proportional to  
[12]

Contd...
cube of the crank rotation in the interval of $30^\circ \leq \theta \leq 100^\circ$. Assume initial distance of the slider equal to 150 mm and final distance to be 100 mm (Refer figure 2).

4(a) If interference between two involute gears is to be avoided prove that the maximum length of arc of contact will be equal to $(r + R) \sin \phi$,

where $r =$ pitch radius of pinion

$R =$ pitch radius of gear(wheel), and

$\phi =$ pressure angle

OR

4(a') A spur gear has a module of 2 mm and its pitch line velocity is 0.6283 m/s. If the number of teeth of this spur gear is 30, find the speed of gear. Also determine its circular pitch.

4(b) A simple gear train consist of two gears only. The first gear is driving the second gear. The speed of first gear is 600 rpm. The number of teeth on first and second gears are 20 and 60 respectively. Determine (i) speed ratio of gear train (ii) train value of gear train (iii) speed of the second gear and (iv) direction of rotation of the second gear if first gear is rotating clockwise

5 Draw the displacement, velocity and acceleration diagrams for a follower when it moves with uniform acceleration and uniform retardation. Derive expression for velocity and acceleration during outstroke and return stroke of the follower.
Fig. 1

Fig. 2
2014-15

B.TECH. (WINTER SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
MACHINE DESIGN
ME- 317

Maximum Marks: 60
Credits: 04
Duration: Three Hour

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.
Charts/Tables is allowed.

Q.No. Question
1.(a) What are permanent joints? Give their example with suitable sketch. [06]
1.(b) A plate 75 mm wide and 10 mm thick is joined with another steel plate by means of single transverse and double parallel fillet welds. as shown in fig 1., the joint is subjected to maximum tensile force of 55 kN. The permissible tensile and shear stresses in the weld material are 70 and 50 N/mm² respectively. Determine the required length of each parallel fillet weld. [06]

2.(a) What is the difference between the clutch and brake. State different types of brake and give one practical application of each. [06]
2.(b) A centrifugal clutch consists of four shoes, each having a mass of 1.5 kg. In the engaged position, the radius to centre of gravity of each shoe is 110 mm, while the inner radius of drum is 140 mm. The coefficient of friction is 0.3. The pre-load in the spring is adjusted in such a way that the spring force at the beginning of engagement is 700 N. The running speed is 1440 rpm, calculate
   (i) The speed at which the engagement begins.
   (ii) The power transmitted by the clutch at 1440 rpm. [06]

OR

2'. Fig. 2 shows an internal expanding brake with four identical shoes. Each hinge pin supports a pair of shoes. The actuating mechanism is designed in such a way that it produces the same force P on each of the four shoes. The face width of the friction lining is 50 mm and the maximum intensity of normal pressure is limited to 1 N/mm². the coefficient of friction is 0.3, calculate

contd...
3. A helical compression spring subjected to a maximum force of 1250 N. The
deflection of the spring corresponding to the maximum force is 30 mm. Take spring
index as 6. The spring is made of patented and cold drawn steel wire. The ultimate
tensile strength and modulus of rigidity of the material are 1090 N/mm², and 81370
N/mm² respectively. The permissible shear stress for the spring wire should be
taken as 50% of the ultimate tensile strength. Calculate the following
(i) Wire diameter and mean coil diameter.
(ii) Number of active coils and total number of coils.
(iii) Free length of the spring and pitch of the coil.
(iv) Draw the neat sketch of the spring showing various dimensions.

OR

3'(a) Derive the relation for the deflection in full length and graduated leaves of a semi
elliptical spring in terms of usual notation.

3'(b) A semielliptical leaf spring used for the automobile suspension consists of 3 extra
full length leaves and 15 graduated leaves, including the master leaf. The center to
center distance between the two eyes of the spring is 1 m. The maximum force that
acts on the spring is 75kN. For each leaf, the ratio of width to the thickness is 9:1.
The modulus of elasticity of the leaf spring is 207GPa. The leaves are pre-stressed
in such a way that when the force is maximum the stress induced in all leaves are
same and is 450MPa. Determine
(i) Width and thickness of the leaves.
(ii) Initial nip and initial preload required to close the gap between extra full
length leaves and graduated leaves.

4(a) Why ball and roller bearings are called antifriction bearings?
Draw line sketches of rolling contact bearings with all the details.

4(b) Draw and explain:
(i) Stable hydrodynamic lubrication diagram
(ii) Curve for bearing characteristic number vs. coefficient of friction as
obtained by McKee’s brothers.

5.(a) Write five assumptions for deriving Reynolds’s equation of hydrodynamic
lubrication. Enumerate the desirable properties of a good bearing material.

5.(b) Derive the Lewis bending strength equation for a spur gear tooth. [06]

OR

5.(b′) A pair of spur gear consists of 20 teeth pinion meshing with a 120 teeth gear. The module is 4 mm, calculate the centre distance, the pitch circle diameter of pinion and gear, addendum and dedendum, the tooth thickness and gear ration. [06]

Fig 1

Fig 2.
1. A sample of natural gas has the following volumetric analysis: 72% CH₄, 9% H₂, 14% N₂, 2% O₂ and 3% CO₂. Stoichiometric combustion reaction occurs with air which enters the combustion chamber at 20°C, 1 atm (101,325 kPa) and 80% relative humidity. Assuming complete combustion and 1 atm pressure everywhere, determine the dew point temperature of the products.

OR

1'(a) Define equilibrium constant \( K_p \), express it in terms of standard state Gibbs function change \( \Delta G^\circ \), partial pressures, number of moles and molar concentration.

1'(b) A gaseous mixture of 1 kmol of CH₄ and 3 kmol of O₂ contained in a rigid vessel at 1 atm and 25°C is ignited and burns completely (\( CH_4 + 3O_2 \rightarrow CO_2 + 2H_2O(g) + O_2 \)). If the final temperature is 1000 K, determine the final pressure and the heat transferred from the vessel. Briefly discuss the procedure for the case when initial pressure is much higher (initial mixture is non-ideal).

2(a) In a steam power plant working on an ideal reheat-regenerative cycle, steam enters a high pressure (HP) turbine at 8MPa, 480°C. A fraction of steam 'y' is extracted at 2MPa and fed to a closed feedwater heater (CFWH). The rest '1-y' is extracted at 0.7 MPa and reheated to 440°C at the same pressure and then fed to a LP turbine. Both the turbines are connected through a common shaft. Another fraction 'z' is bled off from the LP turbine at 0.3 MPa and is taken into an open feedwater heater (OFWH). The remaining '1-y-z' is condensed at 0.008 MPa in the condenser. The first pump...
compresses this condensate and sends it to the OFWH at 0.3 MPa, whereas the second pump compresses the saturated liquid water coming out from the OFWH at 0.3 MPa to 8MPa and delivers it to the CFWH, the feedwater leaving the CFWH at 8MPa is then taken to the steam generator. The drained saturated liquid fraction 'y' at 2MPa from the CFWH is fed through a trap 'T' (where throttling occurs) to the OFWH which is at 0.3 MPa. Draw the plant layout of the problem and label the state points.

2(b) What kind of boiler is employed in a supercritical power plant. Explain in brief its principle of operation. Draw layout of an ideal, double reheat supercritical Rankine cycle power plant (with no feedwater heating) together with T-s diagram.

OR

2' Briefly mention the advantages and disadvantages of mercury in a binary vapour cycle. In a binary vapour Hg-Steam cycle, saturated Hg vapours enter the turbine at 1250 kPa \( (h_g = 361.2 \text{ kJ/kg}, s_g = 0.5024 \text{ kJ/kgK}) \) and exhausts at 14 kPa \( (h_r = 36.0 \text{ kJ/kg}, h_f = 294.2 \text{ kJ/kg}, s_f = 0.0923 \text{ kJ/kgK}, s_f = 0.5491 \text{ kJ/kgK}) \). The mercury condenser/steam generator produces saturated steam at 3.8 Mpa. The steam turbine exhausts at 7 kPa. Determine (i) the work done by Hg and steam turbines, (ii) for a steam flow rate of 25 kg/s, find the Hg flow rate, (iii) combined cycle and individual efficiencies of steam and Hg cycles. Assume sensible heating of water is done in the Hg condenser/steam generator, and no Hg pump work. Draw the cycle on a T-s plot.

3 A fluid with negligible velocity expands isentropically in a convergent nozzle from 6.9 bar, 93°C to 3.6 bar. Determine the mass flow rate at the exit, when (i) the fluid is helium \( (\text{mol wt} = 4 \text{ kg/kmol}, C_p = 5.19 \text{ kJ/kgK}) \), (ii) fluid is ethane \( (\text{mol wt} = 30 \text{ kg/kmol}, C_p = 1.88 \text{ kJ/kgK}) \). Which of the cases represent over expansion and under expansion. Is the nozzle correctly designed?

Contd...
4 A reaction turbine expands 34000 kg/h of steam from 20 bar, 400°C to a pressure of 0.2 bar. The turbine is designed such that the steam leaving is just dry-saturated. The reheat factor is 1.05 and the overall isentropic efficiency is 72%. There are 14 stages and the enthalpy drop is the same in each. All the blades have an exit angle of 22° and the mean value of blade speed ratio is 0.82. Calculate the stage efficiency, the diagram power, the drum diameter, and the blade height for the last row of moving blades. The turbine speed is 2400 rev/min. Make a sketch on the h-s diagram showing the last stage expansion.

5(a) Define the term vacuum efficiency of a condensing plant? How it varies with barometric pressure?
(b) What are non-mixing types of condensers? Why they are preferred over mixing type? Describe briefly the central flow surface condenser with neat sketch.
(c) A turbine consumes 14000 kg of steam per hour while developing 2500 kW. Steam is supplied at 30 bar and 300°C. The exhaust from the turbine is condensed in a condenser at a vacuum of 725 mm of Hg and the barometer reads 758 mm of Hg. The condensate is removed from the condenser at temperature of 28°C. The temperature of cooling water increases from 7°C to 27°C. Assuming no radiation losses, find: the dryness fraction of steam entering the steam condenser and the mass of circulating water per hour.
(d) Explain the working of forced draught cooling tower with a neat diagram.
Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No.  Question  M.M.
1(a)  Compare the Otto, Diesel and Limited pressure cycles for constant maximum pressure and same heat input.  [5]
1(b)  A Morse test conducted on a 4-stroke, 4-cylinder petrol engine and the following data were obtained:

Brake power with all 4 cylinders = 14.9 kW  
Brake power with 1 cylinder cut-off = 10.4 kW  
Brake power with 2 cylinder cut-off = 10.3 kW  
Brake power with 3 cylinder cut-off = 10.2 kW  
Brake power with 4 cylinder cut-off = 10.1 kW  

Fuel consumption per minute = 0.091 kg, Bore = 80 mm, Stroke = 120 mm, Calorific value of the fuel = 45000 kJ/kg and Clearance volume = 8x10^4 mm^3.

Calculate,
   i) Mechanical efficiency  
   ii) Indicated thermal efficiency  
   iii) Brake thermal efficiency  
   iv) Air standard efficiency  
   v) Relative efficiency.

OR

1'(a) What are the main constituents of exhaust emission from petrol engines? Classify internal combustion engines on the basis of:
(i) Type of ignition  (ii) Engine cycle  (iii) Position and number of cylinders  
(iv) Applications.

1'(b) Explain with suitable sketches the following Scavenging systems:
(i) Uniflow scavenging  (ii) Cross-flow scavenging and (iii) Loop or reverse scavenging.

2(a) What is meant by carburetion? A simple jet carburettor is to supply 6 kg/min of air and 0.44 kg/min of petrol of specific gravity 0.74. The air is initially at 1 bar and 27°C. Calculate, (i) the diameter of venturi if the air speed is 90 m/s and the velocity coefficient for venturi is 0.85 and (ii) the diameter of the jet if the pressure drop at the jet is 0.8 times the pressure drop at the venturi and the discharge coefficient for the jet is 0.66.

2(b) Which engine is more suitable for super charging SI or CI engine? Why? Describe with sketches the different methods for supercharging?

3(a) Explain the phenomenon of Detonation in SI engines. Discuss the effect of various engine variables on detonation. How does SI engine knocking differ from CI engine knock?

3(b) Explain briefly the following terms:
(i) Cetane number  (ii) Octane number  (iii) Sensitivity and HUCR

4(a) Discuss the following in case of an actual 4-stroke cycle engine
(i) Time loss  (ii) Exhaust blowdown loss  (iii) Pumping loss

4(b) The air-fuel ratio in a diesel engine is 29:1. If the compression ratio is 16:1 and the temperature at the end of compression is 900 K, find at what cylinder volume the combustion is completed? Express this volume as a percentage of stroke. Assume that the combustion begins at TDC and takes place at constant pressure. Take calorific value of fuel as 42 MJ/kg, \( R = 0.287 \frac{kJ}{kgK} \) and \( C_v = 0.709 + 28 \times 10^{-6} T \) kJ/kgK

OR

4'(a) What do you understand by Fuel-Air cycles? What assumptions are made in Fuel-Air cycle analysis? Discuss the effect of variation in specific heat and effect of dissociation.
4'(b) Following data is referred to a 4-stroke, 4-cylinder petrol engine, developing 40 kW,
Cylinder dia=90 mm, Stroke length=100 mm, Engine speed=2000 rpm, A/F ratio=15:1, Comp. Ratio=6:1. The engine fuel is Octane (C8H18) having calorific value 44800 kJ/kg. The initial pressure and temperature are 1 bar & 27 °C respectively. Find out (i) Percentage molecular change (ii) Pressure and temperature at the end of combustion Without and With molecular change.

Take Cv = 0.71 kJ/kgK, and the law of Compression as $Pv^{1.3} = \text{constant}$

5(a) With the help of neat sketches, describe the working of a Turbofan engine.

5(b) A test plant of an open cycle gas turbine consisting of compressor, combustor and a turbine delivers 1475 kW, when operating under the following conditions;
Compressor inlet temperature and pressure = 15.5 °C and 1 bar
Isentropic efficiency of the compressor = 0.85
Conditions at turbine inlet = 620 °C and 4 bar
Efficiency of the plant = 20 %
Estimate the isentropic efficiency of the turbine and mass flow rate of air.

OR

5'(a) Explain the advantages of Regeneration in a Gas Turbine Plant. Obtain the expression for Thermal efficiency of such a plant taking into account all component efficiencies.

5'(b) A jet engine in which all compressions and expansions are isentropic, is operating at an altitude where the entrance pressure is 83 kPa and the entrance temperature is 230 K. The aircraft is moving at a velocity of 305 m/s. Fuel is added so the maximum temperature is 1400 K and the compressor discharge pressure is 480 kPa. Neglect the mass of the fuel, assuming air as the substance throughout. Determine, (i) the exit velocity of the combustion gas from the engine (ii) the specific thrust and (iii) propulsive efficiency.
1(a) Explain why it is generally undesirable to allow temperature rise excessively in machining operations. Give the measures taken to restrict the temperature rise in machine mild steel components.

1(b) A dry turning operation was performed using a tool with the signature $0^\circ, -5^\circ, 6^\circ, 7^\circ, 0^\circ, 0^\circ, 8^\circ$. The cutting and its normal forces measured were 1300 N and 740 N respectively. When a cutting fluid was employed, these forces were 1200 N and 710 N respectively. What is change in the friction angle resulting from the use of a cutting fluid?

2 (a) What is meant by radial rake angle of a straight edge plain milling cutter? Locate the radial rake angle with help of a neat sketch. Enumerate the parameters for milling a mild steel cubical block to secure orthogonal cutting process.

2(b) A titanium alloy rod having a through hole of 55 mm diameter and 150 mm length is machined to a final diameter of 60 mm. The spindle speed is 300 mm and the tool travels at an axial velocity of 200 mm/min. Calculate mean cutting speed, material removal rate, time of cut, power required and the cutting force if the specific energy is 3.7 W-s/mm$^3$.

OR

2’ (a) Discuss the following:
   (i) Die and punch.
   (ii) Progressive die
   (iii) Cleaning of surfaces

2’(b) What is meant by a jig? Give its application in drilling operation.

Give details with the figure of a jig for the mass production of following products requiring drilling of 10 mm diameter (4 holes as mentioned in the figure below). The thickness of the products is approximately 7 mm. Give the details of the materials of the parts incorporated in the jig.
3(a) Differentiate between absolute and incremental mode of programming in NC/CNC machines.

3(b) Give G-M code of any four of the following:

(i) Incremental dimensioning system
(ii) Linear interpolation
(iii) Feed rate in mm/rev
(iv) Spindle stop
(v) Dimensions in millimetres
(vi) Coolant off

3(c) Develop a program to turn a bar of 50 mm diameter 100 mm long to the following product. Give the details of each code used:

All dimensions are in millimetres.

4(a) Define and explain the following terms with neat sketches with reference to dimensional metrology:

i. Tolerance and Allowance
ii. Limits and Fits
iii. Fundamental Deviation and Fundamental Tolerance unit

4(b) Write a short note on selective assembly.
4(c) What are limit gauges? Describe the Taylors' principle of design of "GO" and "NO GO" gauges. Find the maximum and minimum dimensions for GO and NO GO plug/snap gauges required for controlling the dimensions of holes in a fit designated by 25H8/e8. Given that the tolerance value for a nominal diameter of 25mm in IT8 is 33 microns and the fundamental deviation of e shaft is -40 microns. Sketch the gauge and mark the dimensions on it.

OR

4'(a) Enumerate the relative advantages and disadvantages of the line standards, end standards and wavelength standards.

4'(b) Describe any one method of determining the taper angle of a plug gauge.

4'(c) Explain the working principle of an autocollimator and briefly explain its applications.

5. Answer any 3 of the following:

(a) What are acceptance tests? Explain their significance. Name some tests that may be carried out on a lathe machine for testing the main spindle for true running. Explain any one of them in detail.

(b) Sketch the fringes that you may expect in the following cases when tested with an optical flat under a monochromatic source of light:

i. When the edges of the optical flat are worn out and the middle surface is optically flat

ii. When the optical flat is resting along its length on an optically flat surface of a slip gauge and inclined across its width

Two slip gauges of 10mm width, measuring 1.000mm and 1.002mm are kept side by side in contact with each other lengthwise. An optical flat is kept on the slip gauges. Monochromatic light of wavelength 0.0058928mm is used in inspection. Find the total number of straight fringes that can be observed on both slip gauges.

(c) Calculate the dimensions over pins in the following case of gear measurement: Number of teeth=31; module= 3; and pressure angle $\psi = 20^\circ$. Also indicate the diameter of pins to be used.

(d) Derive an expression for the best size wire in thread measurement in terms of the known thread parameters.
Question

1(a) Consider the superposition of a uniform stream having velocity $U_o$ and line vortices of strengths $-\Gamma$ and $+\Gamma$ located symmetrically on the y-axis at $(0, +a)$ and $(0, -a)$ respectively, as shown in figure below. Obtain:

(i) location of the stagnation point(s) for $\Gamma/(\pi U_o a) > 1$
(ii) location of the stagnation point(s) for $1/(\pi U_o a) < 1$

![Diagram showing superposition of a uniform stream and line vortices](image)

1(b) Consider air (density $= 1.2 \text{ kg/m}^3$) flowing at $U_o = 20 \text{ m/s}$ past a 30 cm diameter circular cylinder as shown in figure below. If the cylinder is imparted rotation such that the stagnation points lie on the lower-half of the cylinder surface (neglecting the thin viscous layer), estimate using potential flow theory:

(i) the range of rotational speed in r.p.m for the stagnation point(s) to lie on the...
lower-half surface of the cylinder.

(ii) the sideways / transverse force (magnitude and direction) per unit length of the cylinder corresponding to the maximum rotational speed in part (i).

\[ \mathbf{f}_t = \mathbf{f}_x + \mathbf{f}_y \]

2(a) A symmetrical wedge with a 12° included angle is placed in an airflow in which the Mach Number is 2.3 and the pressure is 60 kPa. If the centreline of the wedge is at an angle of 4° to the direction of flow as shown in figure below, find the pressure difference between the two surfaces of the wedge. \((\gamma = 1.4, \ C_p = 1.004 \text{ kJ / kg})\)

[Image of a symmetrical wedge with angles labeled]

\[ \mathbf{M}_a = 2.3 \]
\[ \phi = 4^\circ \text{ kPa} \]

2(b) Air flows out of a pipe with a diameter of 0.3 m at a rate of 1000 m³/min at a pressure and Temperature of 150 kPa and 293 K respectively. If the pipe is 50 m long, find:

(i) Mach number at inlet

(ii) pressure and temperature at pipe inlet.

(Take \( f = 0.005, \gamma = 1.4, \ C_p = 1.004 \text{ kJ / kg} \))

OR

2'(a) Air flowing at a Mach number of 2.0 passes over a wedge that turns the flow through an angle of 5° as shown in figure below. Find the pressure ratio \( p_2 / p_1 \) across the oblique shock. If this shock is reflected from a plane surface, find the overall pressure ratio \( p_3 / p_1 \) and the Mach number \( M_3 \).

[Image of an airflow over a wedge with an angle of 5°]
2' (b) Air at a temperature of 60°C with a pressure of 200 kPa enters a constant area duct (area = 8 cm²) at a velocity 220 m/s. Neglecting effects of friction, determine:

(i) The maximum amount of heat that can be transferred to the air flow per unit mass of air and corresponding exit temperature.

(ii) The maximum temperature achievable by heat transfer and the corresponding amount of heat transfer in kW for the given inlet conditions. \( \gamma = 1.4, C_p = 1.004 \text{ kJ/kg} \).

3(a) What is the difference between "ensemble average" and "time average" of a turbulent flow variable?

3(b) Consider the flow of air (density = 1.2 kg / m³, absolute viscosity = \( 18 \times 10^{-6} \) N.s/m²) past a sphere of diameter 50 cm in cross flow as shown in figure below. The approaching stream has a uniform velocity of 50 m/s. Estimate the largest and the smallest length and time scales in the turbulent flow past the cylinder.

\[ U_0 = \frac{\tau_0}{\sqrt{\nu_f}} \]

3(c) Consider the momentum equations in Cartesian coordinates for an incompressible, isothermal turbulent flow expressed as,

\[ \rho \left[ \frac{\partial u_i}{\partial t} + \frac{\partial u_i u_j}{\partial x_j} \right] = \frac{\partial \tau_{ij}}{\partial x_j} + B_i \quad i=1,2,3 \text{ and } j=1,2,3 \]

Apply Reynold's decomposition and time averaging to the momentum equations to obtain the momentum equations for the mean flow. How many additional unknowns are introduced in the momentum equations for the mean flow?

4(a) Using the Navier-Stokes's equations for the flow in two dimensions, obtain the transformations of these equations into the vorticity transport form as given below.
\[ \frac{\partial \omega}{\partial t} + u \frac{\partial \omega}{\partial x} + v \frac{\partial \omega}{\partial y} = \nu \left( \frac{\partial^2 \omega}{\partial x^2} + \frac{\partial^2 \omega}{\partial y^2} \right) \]

4(b) Obtain the governing equations of motion of a fluid near a suddenly moving plane surface (Stokes's first problem) with a velocity of \( U_0 \) in its own plane. Using appropriate transformations, change the equation into an ODE and obtain the solution in the following form:

\[ u = U_0 \left[ 1 - \left( \frac{2}{\sqrt{\pi}} \right) \int_0^\eta \exp(-\eta^2) d\eta \right], \text{ where } \eta = \frac{y}{2\sqrt{vt}} \]

OR

4(b') In the case of viscous flow of a fluid between two parallel plates with the lower plate fixed and the upper plate moving with a speed of 15 m/s, obtain the value of the pressure gradient for zero flow rate. The separation between the plates is 10 cm. Take the viscosity of the fluid, \( \mu = 6.0 \times 10^{-3} \text{ kg/m/s} \).

5(a) Sketch clearly the shape of the boundary layer profiles subjected to favourable and adverse pressure gradients and justify your answer using the boundary layer equation.

5(b) Using the Blasius transformation of the boundary layer equation for the flat plate at zero angle of incidence, obtain the expression for \( u \) and \( v \) velocity components in the boundary layer.

5(e) For a boundary layer flow over a flat plate of length 1.0 m with mainstream velocity of 15 m/s, find the axial velocity \( u \) at a point \( y = 0.001 \text{ m} \) away in \( y \)-direction at a distance of \( x = 0.25 \text{ m} \) from the leading edge. Take \( v = 15 \times 10^{-6} \text{ m}^2/\text{s} \) and \( f'(2) = 0.63 \).

OR

5'(a) Obtain the following form of the von Karman's momentum-integral equation of the boundary layer:

\[ \tau_\delta / \rho = d \left( U_\infty^2 \delta_2 \right) / dx + \delta_1 U_\infty dU_\infty / dx \]

5'(b) Using an approximate \( u \)-velocity profile in the boundary layer over a flat plate at zero angle of incidence of the form:

\[ u / U_\infty = A + B(y/\delta) + C (y/\delta)^2 + D(y/\delta)^n \]

obtain the following:

(i) \( \delta, \delta_1 \text{ and } \delta_2 \)

(ii) skin friction coefficient and drag coefficient

(iii) transverse velocity, \( v \)
Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. | Question | M.M.
--- | --- | ---
1(a) | John is currently working a total of 12 hours per day to produce 250 switches. He thinks that by changing the material he can increase his production to 360 switches per day. Total material cost for each switch is approximately $4.00; he has to invest $20 in the necessary supplies (expendables) per day; energy costs are assumed to be only $3.00 per day; and he values his time at $10 per hour for his work. Viewing this from a total (multifactor) productivity perspective, what is his productivity (switches per dollar) at present and with the new material? Also calculate the percent change in productivity. | [06]
1(b) | The concept of product and process life cycles has implications for technological changes. Discuss these implications. | [06]

OR

1'(a) | How a job shop production system is different from an assembly line system? | [04]
1'(b) | Name and explain the various stages of product development. | [04]
1'(c) | What is value engineering? What objectives may be achieved using value engineering approach? | [04]

2(a) | Explain the following (i) group technology (ii) flexible manufacturing system and (iii) cellular manufacturing | [06]
2(b) | A project has the following activities and other characteristics. | [06]

<table>
<thead>
<tr>
<th>Activity</th>
<th>Preceding activity</th>
<th>Optimistic time</th>
<th>Most likely time</th>
<th>Pessimistic time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
<td>3</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>C</td>
<td>A</td>
<td>6</td>
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<tr>
<td>D</td>
<td>A</td>
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<tr>
<td>F</td>
<td>D</td>
<td>3</td>
<td>6</td>
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</tr>
<tr>
<td>G</td>
<td>B</td>
<td>3</td>
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</tr>
<tr>
<td>I</td>
<td>G</td>
<td>4</td>
<td>19</td>
<td>28</td>
</tr>
</tbody>
</table>

i) Draw the PERT network.
ii) Find the slack and critical path.
3(a) What is capacity planning? What is the modeling alternatives used for capacity planning? Describe, using numerical example, any one model used for capacity planning.

3(b) Differentiate between forward and backward operation scheduling. A company has received two job orders, P and Q, both of which require processing at machines M₁ and M₂. The last come first served rule is used to sequence the jobs. Job Q arrived in advance of job P. The sequence of routing for the two jobs, both of which are due in 12 hours is given below. Each machine is available for 12 hours every day and no other jobs are currently scheduled for them. Develop schedules using forward and backward operation scheduling procedures.

Route sheet : Job P

<table>
<thead>
<tr>
<th>Routing sequence</th>
<th>Machine</th>
<th>Processing time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M₁</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>M₂</td>
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</tr>
<tr>
<td>3</td>
<td>M₁</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>M₂</td>
<td>3</td>
</tr>
</tbody>
</table>

Route sheet : Job Q

<table>
<thead>
<tr>
<th>Routing sequence</th>
<th>Machine</th>
<th>Processing time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
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<td>M₁</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>M₂</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>M₁</td>
<td>3</td>
</tr>
</tbody>
</table>

3'(a) What is aggregate output planning? Explain the procedure of developing a suitable aggregate output (production) plan.

3'(b) Discuss the role of human factors in the design of production environment. Use a practical example.

3'(c) Using any one work measurement technique, set a detailed time standard in a manufacturing environment.

4(a) Differentiate between MRP and MRP II. Using numerical example, explain how a detailed MRP schedule is established?

4(b) The daily demand for an item is normally distributed with a mean 120 and standard deviation of 14. The source of supply of the items is reliable and maintains a constant lead-time of four days. If the cost of placing an order is Rs. 600 and annual holding charges are Rs. 10 per unit, find the order quantity and reorder level so that the probability of a stock-out is not more than 2.5% (Use Z=2).
5(a) What is the basic quality control tools used to identify problems in an organization? Differentiate between single sampling plan and double sampling plan.

5(b) Differentiate between single sampling plan and double sampling plan.

A quality characteristic for a manufacturing process making plastic insulated cables was the breakdown voltage. In order to monitor and control, an SPC study was undertaken. Five cables from each daily batch were measured for their breakdown voltage (sample size = 5). The mean values, range and standard deviation for the sample for the first 10 batches are presented in the Table. Calculate control limits and draw X-bar and R-charts. (For sample size 5, \( A_2 = 0.577 \), \( D_3 = 0 \), \( D_4 = 2.115 \))

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Mean</th>
<th>Range</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.794</td>
<td>0.44</td>
<td>0.170</td>
</tr>
<tr>
<td>2</td>
<td>3.005</td>
<td>0.41</td>
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</tr>
<tr>
<td>3</td>
<td>2.968</td>
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<tr>
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<td>2.930</td>
<td>0.45</td>
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<tr>
<td>9</td>
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<td>0.42</td>
<td>0.156</td>
</tr>
<tr>
<td>10</td>
<td>3.267</td>
<td>0.53</td>
<td>0.203</td>
</tr>
</tbody>
</table>

OR

5'(a) Explain the concept of inspection. What are the parameters of measuring instruments that are used to ensure correct device selection?

5'(b) Starting from the initial trial solution \((X_1, X_2) = (0, 0)\), apply the gradient search procedure to solve the following problem. Select an error tolerance to perform only three iterations.

Maximize \( f(X) = X_1 X_2 + 3X_2 - X_1^2 - X_2^2 \)