B.TECH. (AUTUMN SEMESTER) EXAMINATION
(MECAHANICAL ENGINEERING)
MANUFACTURING SCIENCE
ME 303

Maximum Marks: 60 Credits: 05 Duration: Two Hours

Answer all the questions.
Assume suitable data if missing.

1a. The following data has been recorded during orthogonal turning of a mild steel rod: [08]
    Tube diameter = 30mm
    Cutting speed = 12 m/min
    Feed force = 70 kg
    Length of continuous chip in one revolution = 45 mm
    Rake angle = 30°
    Feed = 0.1 mm/revolution
    Cutting force = 180 kg

    Determine the (i) Coefficient of friction between tool and chip
    (ii) Shear plane angle
    (iii) Velocity of chip along the tool face
    (iv) Chip thickness.

b. Define tool life. With the help of suitable diagrams explain the features of the different [04] kinds of tool wear.

2. Answer any TWO questions:

   a. In a slab milling operation, the surface of a brass workpiece is machined using a 60 [06] mm plain milling cutter, spindle speed = 382 rpm, table speed = 50 cm/min, length of the workpiece = 150 mm, width of cutter = 100 mm, width of the workpiece = 90 mm, depth of cut = 3 mm, helix angle = 30° and the number of cutter teeth = 8. Calculate the material removal rate and machining time.

   b. Discuss the following: [06]

      (i) Progressive die
      (ii) Shot peening and laser peening

   c. What is the major difference between a fixture and a jig? Give the major applications of a jig in drilling operation. Name the different types of drill jigs and explain any one of them with suitable diagrams. [06]

3. Answer any TWO questions:

   a. Discuss the important process parameters that affect the material removal rate in [06] ultrasonic machining.
b. List the characteristic requirements of a good electrode material in EDM. Also, discuss what makes graphite suitable as an electrode material for EDM process.  [06]

c. Explain the working principle of electrochemical machining. Discuss the major factors that affect the surface finish in ECM.  [06]

4a. Explain the following terms (i) Tolerance (ii) Allowance  [04]

b. Design the general type GO and NO-GO gauge for components having 20H7-f8 fit, given that:
   (i) 20mm falls in the diameter step of 18mm to 30mm
   (ii) Upper deviation of ‘f’ shaft = 5.5 D^{0.41}
   (iii) IT7 = 16i  (iv) IT8 = 25i

OR

4'a. Calculate the angle of taper and minimum diameter of an interval taper from the following readings:
   (i) Diameter of the bigger ball = 10.25 mm
   (ii) Diameter of the smaller ball = 6.07 mm
   (iii) Height of top of bigger ball from datum = 30.13 mm
   (iv) Height of top of smaller ball from datum = 10.08 mm

b. With the help of a neat diagram explain the working of a differential screw micrometre.  [06]

5. Answer any TWO of the following:

a. What is a comparator? Why is it important to have a proper magnification system in a comparator? With the help of a neat diagram, explain the working principle of an optical comparator.  [06]

b. Explain the principle of measurement by light wave interference method. 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.

c. Define effective diameter of a screw thread? What is its importance in the functioning of a screw? Derive a relationship to determine the effective diameter using the two wire method.  [06]
Q.No. | Question                                                                                                                                                                                                 | M.M. |
---|---|---|
1(a) | Define design factor. How it is different from factor of safety?                                                                                                                                         | [03] |
1(b) | A welded connection, as shown in fig. 1 is subjected to an eccentric force of 60 kN in the plane of the welds. Determine the size of the welds, if the permissible shear stress for the weld is 100 N/mm². Assume static conditions. All dimensions are in mm. | [09] |

![Fig. 1](image_url)

OR

1(b)* What are the advantages of welded joints over riveted joints? State and explain the types of welded joints.

A plate, 75 mm wide and 10 mm thick, is joined with other steel plate by means of single transverse and double parallel fillet welds, as shown in Fig. 2. The joint is subjected to a 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.

Fig. 2

2(a) A single row deep groove ball bearing is subjected to a pure radial force of 3000 N from a shaft that rotates at 600 rpm. The expected rating life of the bearing is 30,000 hours. Calculate dynamic load and capacity.

2(b) State and explain the types of bearings on the basis of lubrication mechanism. Derive the classical Reynold’s equation for long bearing in terms of usual notations.

OR

2(b)* Enumerate the various steps for selection of rolling contact bearing from manufacturer’s catalogue. A taper roller bearing has a dynamic load capacity of 25 KN. The desired life for 90% of the bearings is 8000 hour and the speed is 300 rev/min. Calculate the equivalent radial load that the bearing can carry.

3(a) State whether the following statements are true or false with specific reason:

(i) Multi disk wet clutches are used in trucks.
(ii) Axial force necessary for engaging the clutch is given by:

\[ W_a (\sin \alpha + 0.5 \mu \cos \alpha) \]

(iii) A brake commonly used in Indian Railway trains is internal expanding brake.

3(b) A centrifugal clutch is to be designed to transmit 15 kW at 900 rpm. The shoe are four in number. The speed at which the engagement begins is 3/4th of the running speed. The inside radius of the pulley rim is 150 mm. The shoe are lined with ferrodo for which the coefficient of friction may be taken as 0.25. Determine:

(i) Mass of the shoes.
(ii) Size of the shoes.

4(a) Derive the expression for stiffness of the helical torsion spring in terms of usual notations.
4(a) Define nip in leaf spring. What is the objective of nipping?

4(b) A helical compression spring subjected to a force of 500 N. The deflection of the spring corresponding to this force is approximately 20 mm. The spring index is 6 and it is made of cold-drawn steel wire with ultimate tensile strength of 1000N/mm². The permissible shear stress for the spring wire can be taken as 50% of the ultimate tensile strength and modulus of rigidity is 81370 N/mm². Design the spring and calculate:

(i) Wire diameter,
(ii) Mean coil diameter,
(iii) Number of active coils,
(iv) Total number of coils,
(v) Free strength of the spring, and
(vi) Pitch of the coils.

Assume a gap of 1 mm between adjacent coils under maximum load conditions. Assume the spring has square and ground ends.

5(a) Differentiate between bevel and worm gear. Draw suitable sketches in support of your answer.

5(b) A gear drive is required to transmit a maximum power of 22.5 kW. The velocity ratio is 1:2 and the speed of pinion is 200 rpm. The appropriate centre distance between the shafts may be taken as 600 mm. The teeth has 20° stub involute profile. The static stress for the gear material may be taken as 60 MPa and the face width as 10 times the module. Find the module, face width and number of teeth on each gear. Check the design for dynamic load. The dynamic factor in the Buckingham equation may be taken as 80.

OR

5(b)' A helical cast steel gear with 30° helix angle has to transmit 35 kW at 1500 rpm. If
the gear has 24 teeth, determine the necessary module, pitch diameter and face width for 20° full depth teeth. The static stress for cast steel may be taken as 56 MPa. The width of face may be taken as 3 times the normal pitch. What would be the end thrust on the gear? The tooth factor for 20° full depth involute gear may be taken as \(0.154 - \frac{0.912}{T_E}\), where \(T_E\) represents the equivalent number of teeth.
Q.No. 1  Calculate lower and higher heating values for propane at 25°C, 0.1MPa on both kilomole and kilogram basis with (i) liquid propane with gaseous water in the products, (ii) gaseous propane with liquid water in the products. Define internal energy of combustion with a suitable example. 

OR

1’  A rigid tank contains a mixture of 1 kmol of H₂ and 0.5 kmol of O₂ at 1 atm, 25°C. After ignition, the final pressure and temperature are 5 atm and 2800 K, with combustion products consisting of H₂O, O₂ and H₂. The equilibrium relation among the products can be expressed as: H₂O ↔ H₂+1/2O₂. Calculate equilibrium constant K_p and express it in the form of number of moles and pressure P. (Take Gibb's function of formation $\bar{g}_f$ (kJ/kmol) for H₂, O₂ and H₂O as 0, 0, -89031 respectively.)

2  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 'γ'...
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.

OR

2' What type 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 its T-s diagram.

3 Write down the basic relations for fluid flow through a convergent-divergent nozzle for (i) an ideal gas, (ii) equilibrium steam, (iii) supersaturated steam. Briefly explain the equilibrium expansion of steam on a T-s plot.

4 Differentiate between impulse and reaction turbines. At a particular stage of a reaction turbine, the mean blade speed is 150 m/s. The exit angles of the fixed and moving blades are 20°. The inlet angles of the fixed and moving blades are 30°. The stage efficiency is 80%. The pressure at entry to the stage is 15 bar and the temperature is 200°C. Determine (i) the specific enthalpy drop across the stage in kJ/kg, (ii) the drum diameter and the blade height if the blade height is 1/10 th of the drum diameter and the steam flow is 100 kg/s.

5 Explain the working principle of Jet and Surface condensers. Wet steam at 34°C and 2620 kg/hr enters a surface condenser and leaves as saturated liquid at 29°C. Cooling water enters at 17°C and exits at 31°C with a flowrate of 102000 kg/hr. Determine the dryness fraction of the entering steam.
2016-17
B.TECH. (AUTUMN SEMESTER) EXAMINATION
MECHANICAL ENGINEERING
HEAT AND MASS TRANSFER
ME 323

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 An electrical conductor of copper with a diameter of 1mm is covered with a plastic insulation of thickness 1mm. The temperature of its surroundings is 20°C. Find the maximum current carried by the conductor so that no part of the plastic is above 80°C. Assume thermal conductivities of copper as 400 W/mK and that of the plastic equal to 0.5 W/mK. Take h=8 W/m²K and specific electric resistance of copper, ρ=3x10⁻⁸ ohm-m. Discuss the effect of increase or decrease of insulation on the current carrying capacity of the conductor.

OR

1' A rod is connected to two plates at its ends having temperatures T₁ and T₂. The rod is exposed to an environment with convection coefficient h and temperature Tₐ. Obtain an expression for temperature distribution in the rod and hence, the location where there will be minimum temperature.

2 Air at 30°C flows with a velocity of 12 m/s over a 2m long flat plate, which is maintained at 150°C. Find the local heat transfer coefficients at a distance of 0.5 m from the leading edge and at the trailing edge. Identify the type of flow at these two sections? Find the location on the plate where the flow pattern changes. The properties of air at the mean temperature of 90°C are:

\[ C_p = 1.01 \text{ kJ/kg °C}, \ \rho = 0.962 \text{ kg/m}^3, \ \mu = 2.131 \times 10^{-5} \text{ kg/m.s}, \ k = 0.031 \text{ W/mK].} \]
The heat transfer equation for laminar flow is \( \text{Nu} = 0.332 \text{ Re}^{1/2} \text{ Pr}^{1/3} \) and that for the turbulent flow is \( \text{Nu} = 0.0296 \text{ Re}^{4/5} \text{ Pr}^{1/3}. \)

OR

2' Define and differentiate between sub-cooled and saturated boiling. With neat diagram explain the different regimes of pool boiling of water over a heated nichrome wire.
3(a) Define solid angle and intensity of radiation. Show that the emissive power:
\[ E_b = \pi l_b \]

3(b) Write short notes on radiation shield and radiation through gasses.

OR

3' Explain radiation shape factor and obtain its relation between two bodies. Using the relation for shape factor between the sun and earth, find the value of solar constant if the sun emits 90% radiation. Take the diameters of earth and sun equal to 12.8 x 10^6m and 13.76 x 10^8m, respectively and their mean distance as 14.86 x 10^{10}m. Estimate temperature of the sun using Wein’s displacement law, if the maximum solar radiation entering the earth’s atmosphere is at wavelength of 0.5 \( \mu \)m.

4 Explain fouling of heat exchangers giving factors affecting them. A counter flow heat exchanger, having 20m² surface area is used for cooling oil at 300 °C by water entering at 25 °C. If the mass flow rate and specific heat of oil and water are as given in the table below and the overall heat transfer coefficient, \( U = 300 \text{ W/m}^2 \text{ K} \), estimate the outlet temperatures of oil and water by using NTU method.

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Mass flow rate in kg/h</th>
<th>Specific heat in kJ/kg K</th>
</tr>
</thead>
<tbody>
<tr>
<td>oil</td>
<td>10,000</td>
<td>1.9</td>
</tr>
<tr>
<td>Water</td>
<td>3,000</td>
<td>4.187</td>
</tr>
</tbody>
</table>

5(a) Define and differentiate between diffusion and convective mass transfers.

5(b) Obtain the expression for total mass transfer during isothermal evaporation from a surface of water in a deep tank and subsequent diffusion through a stagnant air layer.
2016-17
B.TECH. (WINTER SEMESTER) EXAMINATION
(MECHANICAL ENGINEERING)
I.C. ENGINES
ME-324

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)  Compare the thermal efficiencies of Otto, Diesel and Dual cycles for the following [06]
cases
(i) For the same compression ratio
(ii) For the same peak pressure and temperature
Inlet conditions are same for all the above cases. Give reasons of your conclusion.

1(b)  What do you understand by scavenging in 2-stroke engines? Define Delivery Ratio Scavenging Efficiency. [06]

2(a)  Discuss the type of mixture requirements of a SI engine from no load to full load [06]
under steady state operation.

2(b)  Determine the air-fuel ratio at 4570 m altitude in a carburettor adjusted at sea level [06]
for a 15.2:1 ratio. At sea level, air temperature is 20 °C and pressure 1.01325 bar.
The temperature of the air decreases with altitude given by the expression
\[ t = t_s - 0.0065 \cdot h \]
where \( h \) = height in m and \( t_s \) = sea level temperature in °C. The air
pressure decreases with altitude as per relation \( h = 19220 \ln (1.013/p) \)
where \( p \) is in bar. State any assumptions made.

OR

2'(a)  With the help of neat sketches, describe various systems of Mechanical [05]
supercharging and Turbocharging.
2'(b) The entire output of a supercharged 4-stroke cycle oil engine is used to drive an air compressor. The air enters the compressor at 20 °C and is delivered to a cooler which removes heat at the rate of 1335 kJ/min. The air leaves the cooler at 62 °C and 1.72 bar. Part of this air flow is used to supercharge the engine which has a volumetric efficiency of 0.70 based on induction manifold conditions of 62 °C and 1.72 bar. The engine which has six cylinders of 90 mm bore and 100 mm stroke runs at 2000 rpm and delivers an output torque of 150 Nm. The mechanical efficiency of the engine is 0.75. Determine (i) the engine indicated mean effective pressure (ii) the air consumption in kg/min (iii) air flow into compressor in kg/min.

3(a) Explain the normal combustion phenomena in CI engines by specifying various stages of combustion.

3(b) What do you understand by ‘Octane Number’ of a SI engine fuel. Discuss the test conditions and method of its determination.

4(a) Explain the advantages of Regeneration in a Gas Turbine Plant.

4(b) A closed cycle gas turbine uses helium as the working substance. The gas enters the compressor at 4 bar & 320 K and discharges at 16 bar & 590 K. It then enters a regenerator of effectiveness 70%. From the regenerator, it goes to another heat exchanger where further heat is added from combustion gases. The helium then enters the turbine at 15.5 bar & 1400 K and leaves the turbine at 4.2 bar & 860 K to enter the regenerator. From the regenerator, it goes to the compressor through a cooler where heat is rejected before compression. Determine, (i) the compressor and turbine efficiencies (ii) the thermal efficiency of the cycle (iii) the heat rejected in the cooler before compression (iv) the helium flow rate for a net power output of 100 MW. Take \( C_p \) and \( \gamma \) for helium as 5.2 kJ/kg K and 1.67 respectively.

OR

4'(a) With the help of neat sketches, describe the working of Liquid propellant and Solid propellant rocket engines.

4'(b) A turbojet aircraft flies with a velocity of 260 m/s at an altitude where the air is at 35 kPa and -40 °C. The compressor has a pressure ratio of 10 and the temperature of
gases at the turbine inlet is 1100 °C. Air enters the compressor at a rate of 45 kg/s. Assuming steady operating conditions with constant specific heats, determine
(i) the temperature and pressure of the gases at the turbine exit
(ii) the velocity of the gases at the nozzle exit
(iii) propulsive efficiency of the cycle

5(a) Discuss the Exhaust blowdown losses and pumping losses in an actual 4-stroke cycle engine.

5(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 kJ/kgK and C_v = 0.709 + 2.8x10^-6 T kJ/kgK
B.TECH. (AUTUMN SEMESTER) EXAMINATION
(MECAHANICAL ENGINEERING)
MANUFACTURING TECHNOLOGY II
ME 325

Maximum Marks: 60 Credits: 04 Duration: Two Hours

Answer all the questions. Assume suitable data if missing.

1a. The following data has been recorded during orthogonal turning of a mild steel rod:
   Tube diameter = 30mm
   Cutting speed = 12 m/min
   Feed force = 70 kg
   Length of continuous chip in one revolution = 45 mm
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   Determine the (i) Coefficient of friction between tool and chip
   (ii) Shear plane angle
   (iii) Velocity of chip along the tool face
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b. Define tool life. With the help of suitable diagrams explain the features of the different kinds of tool wear.

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   a. In a slab milling operation, the surface of a brass workpiece is machined using a 60 mm plain milling cutter, spindle speed = 382 rpm, table speed = 50 cm/min, length of the workpiece = 150 mm, width of cutter = 100 mm, width of the workpiece = 90 mm, depth of cut = 3 mm, helix angle = 30° and the number of cutter teeth = 8. Calculate the material removal rate and machining time.

b. Discuss the following:
   (i) Progressive die
   (ii) Shot peening and laser peening

c. What is the major difference between a fixture and a jig? Give the major applications of a jig in drilling operation. Name the different types of drill jigs and explain any one of them with suitable diagrams.

3a. What is an industrial robot? What are the characteristic situations where a robot may substitute humans? Explain with the help of suitable examples.

OR

a'. What are qualified tools? Explain their importance in CNC machines.

3b. 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:

Contd...
All dimensions are in millimetres.

4a. Explain the following terms (i) Tolerance (ii) Allowance

b. Design the general type GO and NO-GO gauge for components having 20H7/f8 fit, given that:
   (i) 20 mm falls in the diameter step of 18mm to 30mm
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b. With the help of a neat diagram explain the working of a differential screw micrometre.

5 Answer any TWO of the following:

a. What is a comparator? Why is it important to have a proper magnification system in a comparator? With the help of a neat diagram, explain the principle of magnification in an optical comparator.

b. Explain the principle of measurement by light wave interference method. 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.

c. Define effective diameter of a screw thread? What is its importance in the functioning of a screw? Derive a relationship to determine the effective diameter using the two wire method.
1. Steady Uniform ($U$) flow over a flat plate exists. The flat surface is porous in nature and fluid is being drawn off into the porous surface such that the normal velocity at the surface is $V$. Fluid (kinematic viscosity, $v$) may be assumed as Newtonian and viscous, but also incompressible. Using the configuration shown in Figure 1, solve the Navier-Stokes equation by explicitly stating the assumptions made to show that the velocity distribution is $u(y) = U(1 - e^{-\frac{y}{v^2}})$.

![Figure 1](image.png)

$v(x,0)=-V$

2. For a flow over a flat plate with zero pressure gradient, the velocity profile within the boundary layer is assumed as $u = U_\infty \tanh\left(\frac{y}{\delta}\right)$. Show that the skin friction on the plate is given by $\frac{f_w}{\rho U_\infty^2} = 0.3125 \left[\frac{U_{\infty}}{v}\right]^{\frac{1}{2}}$.

OR

2'(a) Following are parametric forms of three velocity profiles over a stationary surface:

(i) $\frac{u}{U_\infty} = \frac{3}{2} \frac{y}{\eta} - \frac{1}{2} \left(\frac{y}{\eta}\right)^3$ ; (ii) $\frac{u}{U_\infty} = -\frac{3}{2} \frac{y}{\eta} + \frac{1}{2} \left(\frac{y}{\eta}\right)^3 + \left(\frac{y}{\eta}\right)^4$ ; (iii) $\frac{u}{U_\infty} = \left(\frac{y}{\eta}\right)^2 + \left(\frac{y}{\eta}\right)^3 - 2 \left(\frac{y}{\eta}\right)^4$

Check whether the above boundary layers adheres to or detaches from the surface.

Contd...
2'(b) Water with a uniform free stream velocity of 2 m/s flows past a flat plate of length L = 10 cm. Find the thickness of the velocity boundary layer at a location x = 5 cm. At the same location, find the fluid velocity at a distance y = 0.0225 cm away from the surface. Calculate drag on the plate per meter depth into the plane of the paper. For water \( \rho = 983.1 \text{ kg/m}^3, v = 0.4748 \times 10^{-6} \text{ m}^2/\text{s} \).

\[
\eta = \frac{y}{\sqrt{\frac{\nu x}{U_\infty}}}
\]

<table>
<thead>
<tr>
<th>( \eta )</th>
<th>( f )</th>
<th>( f'(\eta) = \frac{u}{U_\infty} )</th>
<th>( f''(\eta) )</th>
</tr>
</thead>
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<tr>
<td>0</td>
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<td>5.0</td>
<td>3.28329</td>
<td>0.99155</td>
<td>0.01591</td>
</tr>
</tbody>
</table>

3. Explain Reynolds Decomposition of Turbulent flow and derive Reynolds Averaged Navier-Stokes Equation.

4(a) Explain the operation of the converging-diverging nozzles under the effect of the back pressure. Show with graph the pressure distribution inside the nozzle for different back pressure.

4(b) Air flows isentropically in a converging-diverging nozzle with a throat area of 3 cm\(^2\). At section 1, the pressure is 101 kPa, \( T_1 = 300 \text{ K} \), and \( V_1 = 868 \text{ m/s} \). (a) Is the nozzle choked? Determine (b) \( A_1 \); and (c) the mass flow

in a)

OR

4(b') A pitot static tube is placed in subsonic air flow. The static pressure and temperature in the flow are 96 kPa and 27°C respectively. The difference between the pitot and static pressures is measured and found to be 32 kPa. Find the air velocity (a) assuming an incompressible flow and (b) assuming compressible flow

5(b) Air flows at a Mach number of 1.8 with a pressure of 90 kPa and temperature of 15°C down a wide channel. The upper wall of this channel turns through an angle of 5° away from the flow leading to the generation of an expansion waves. Find pressure, Mach number and temperature behind this expansion wave.

5(b') Air enters a duct sub-sonically at section 1 at 1.2 kg/s. When 650 kW of heat is added, the flow chokes at the exit at \( P_2 = 95 \text{ kPa} \) and \( T_2 = 700 \text{ K} \). Assuming frictionless heat addition, estimate (a) the velocity; and (b) the stagnation pressure at section 1.
Answer the following questions.
Assume suitable data if missing.
Notations used have their usual meaning.

Q.No. Question M.M.
1(a) Differentiate between partial factor and total factor productivity. [5]

As a part of new assignment, Parag of Pop-Corn Products was asked to identify areas for productivity improvements. He collected data on all inputs and outputs of previous year’s operations being transferred into equivalent of money units. The table below gives details with all figures in lakh rupees. Calculate the partial factor productivity for him.

<table>
<thead>
<tr>
<th>Input</th>
<th>Amount</th>
<th>Units produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Capital</td>
<td>300</td>
<td>1000</td>
</tr>
<tr>
<td>Energy</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

1(b) Explain the forced choice model of strategic planning for operations. [7]

2(a) Differentiate between part design attributes and part manufacturing attributes. [4]

2(b) A project consists of following activities, whose time estimates are given as under [8]

<table>
<thead>
<tr>
<th>Activity</th>
<th>Optimistic time (day)</th>
<th>Most likely time (day)</th>
<th>Pessimistic time (day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>3</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>1-3</td>
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<td>2-5</td>
<td>2</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>2-6</td>
<td>5</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>3-6</td>
<td>3</td>
<td>6</td>
<td>15</td>
</tr>
</tbody>
</table>
4-7 | 3 | 9 | 27
5-7 | 1 | 4 | 7
6-7 | 4 | 19 | 28

(i) Find the variance of each activity.
(ii) Determine the critical path and the expected project duration.

OR

2'(a) Differentiate between cellular layout and product layout. Draw a process type of layout for a product of your own choice. [5]

2'(b) The following tasks must be performed on an assembly line in the sequence specified in the table. [7]

<table>
<thead>
<tr>
<th>Task</th>
<th>Task time (min)</th>
<th>Task that must precede</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>23</td>
<td>A</td>
</tr>
<tr>
<td>C</td>
<td>17</td>
<td>B</td>
</tr>
<tr>
<td>D</td>
<td>42</td>
<td>B</td>
</tr>
<tr>
<td>E</td>
<td>15</td>
<td>B</td>
</tr>
<tr>
<td>F</td>
<td>37</td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>5</td>
<td>D, E</td>
</tr>
<tr>
<td>H</td>
<td>12</td>
<td>F, G</td>
</tr>
<tr>
<td>I</td>
<td>34</td>
<td>H</td>
</tr>
<tr>
<td>J</td>
<td>27</td>
<td>H</td>
</tr>
<tr>
<td>K</td>
<td>18</td>
<td>I, J</td>
</tr>
<tr>
<td>L</td>
<td>7</td>
<td>K</td>
</tr>
</tbody>
</table>

(i) What is the theoretical minimum number of stations required to meet a demand of 500 units/day when the time available/day is 480 minutes?
(ii) What is the efficiency of the balanced line?
3. What is the role of work study in the design of an automated manufacturing environment? A company has received two job orders, A and B, both of which require processing at machines $M_1$ and $M_2$. The last come first served rule is used to sequence the jobs. Job B arrived in advance of job A. 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 A**

<table>
<thead>
<tr>
<th>Routing sequence</th>
<th>Machine</th>
<th>Processing time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$M_1$</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>$M_2$</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>$M_1$</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>$M_2$</td>
<td>2</td>
</tr>
</tbody>
</table>

**Route sheet : Job B**

<table>
<thead>
<tr>
<th>Routing sequence</th>
<th>Machine</th>
<th>Processing time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$M_1$</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>$M_2$</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>$M_1$</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>$M_2$</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>$M_1$</td>
<td>2</td>
</tr>
</tbody>
</table>

4. Explain the JIT system of manufacturing. The gross requirements for a component in first, third, fifth, seventh and eighth period are 80, 90, 110, 90 and 80 respectively. The scheduled receipts for the first, third, fifth and seventh periods are 70, 100, 40 and 100 respectively. Sixty uncommitted items are available and the lead time is four periods duration. Establish a detailed material requirement planning (MRP) schedule.

OR

4'. Describe the concept of ‘Re-order Point Level’ in the stochastic inventory control models. Derive the relationship for ‘Economic Order Quantity’ for a ‘Gradual Replacement’ deterministic inventory control model.
5(a) What are the basic tools of Quality? Differentiate between Ishikawa diagram and Pareto’s analysis.

5(a)* How many types of sampling plans do you know? Explain any two.

5(b) Apply one dimensional search procedure to solve the following non-linear programming problem. Select an error tolerance to perform only five iterations.

Maximize \( f(X) = 12X - 3X^4 - 2X^6 \)
Attempt any two part from each question. 
Assume suitable data if missing. 
Notations used have their usual meaning.

Q.No.  Question                                               M.M.
1(a)   For the linear translational system shown in Fig-1, find out the transfer function \( X_2(s)/F(s) \). 

1(b)   For the electrical system shown in Figure 2, find out the transfer function \( V_o(s)/V_i(s) \).
1(c) Explain the working principle of AC servomotors.

2(a) Obtain the transfer function for the signal flow graph given in Figure 3 using Mason’s gain formula.

![Figure 3](image)

2(b) Draw block diagram for the signal flow graph given in Figure 3 above.

2(c) State any six rules of block diagram reduction technique.

3(a) Derive the relationship between transfer function and state space model of a control system.

3(b) Obtain the state space model for the given transfer function.\[ G(s) = \frac{Y(s)}{U(s)} = \frac{10}{(s^2 + 5s + 4)} \]

3(c) Find state space equation for the electrical circuit shown in Figure 4.

![Figure 4](image)

4(a) Define rise time, peak time, peak overshoot and settling time and write respective formulas for the time response of a second order system to unit step input.
4(b) Find breakaway point and centroid for root locus of a control system having open loop transfer function \( G(s)H(s) = \frac{K}{s(s^2+1)(s+2)}. \)

4(c) The forward path transfer function of unity feedback system is given as \( \frac{96}{s(s^2+4s+8)} \). Find the static error coefficient and steady state error of the system when subjected to unit ramp input.

5(a) A unity feedback control system characterized by open loop transfer function \( G(s) = \frac{K(s+13)}{s(s^2+10s+21)}. \) Using Routh array criterion, calculate the range of \( K \) for the system to be stable.

5(b) Draw Bode magnitude plot for the transfer function given below.
\( G(s) = \frac{1000}{s(s+10)}. \)

5(c) Draw Nyquist plot for the system whose open-loop transfer function given below.
\( G(s)H(s) = \frac{10}{(s+1)(s+2)}. \)
1(a) What are various types of chips formed during metal cutting? Discuss the mechanism of their formation. [04]

1(b) Enumerate the characteristics of an ideal tool material. [03]

1(c) Following data were obtained while turning with right hand turning tool: [05]

- Depth of cut = 2.0 mm
- Chip thickness = 2.5 mm
- Cutting force = 1200 N
- Feed = 3.0 mm/revolution
- Tool signature = 0°, -5°, 6°, 7°, 25°, 0°, 5 mm
- Force normal to cutting force = 900 N

Calculate the following:

(i) Shear angle of the work material
(ii) Friction force and the force normal to it.
(iii) Friction angle.

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. [05]

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/mm³. [07]

OR

2'(a) Write short notes on the following: [06]

(i) Die and punch.
(ii) Shot peening
(iii) Honing

2'(b) What is meant by a jig? Give its application in drilling operation. [06]

Give details with the figure of a jig for the mass production of the product (shown in... Contd....2.
figure) requiring drilling of 4 holes of 10 mm diameter each. The thickness of the product is approximately 7 mm. Give the details of the materials of the parts incorporated in the jig.

![Diagram of a jig with dimensions]

All dimensions are in mm.

**NOTE:** Q. No. 3 is for students appearing for ME303 & 3' for students appearing for ME325

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

3'(a) What is the need of a DNC? How can it benefit CNC shop floor manufacturing? [04]

3'(b) Define the work envelope of a robot. How does it differ from one type of robot to another? [04]

3'(c) Write a part program, to turn a bar of 42 mm diameter to the component shown in figure. [04]

The machining parameters are given below:
- Cutting speed: 800 rpm
- Feed = 200 mm/min
- Depth of cut should not exceed 2mm.

![Diagram of a machined component with dimensions]

All dimensions are in mm.

4(a) Determine and sketch the limits for a 25mm shaft and hole pair designated H7-f8. The basic size lies in the range of 18-30mm. The tolerance for grade 7 and 8 are 16i and 25i

Contd……3.
respectively. The fundamental deviation for the shaft is -5.5 D 0.43 microns. Determine the type of fit produced.

Also design the GO and NO-GO gauges for the hole. Sketch the gauge(s) and mark the dimensions on it.

4(b) With reference to dimensional metrology, explain the following terms. Draw neat diagrams where necessary:
   i. Tolerance and Allowance
   ii. Limits and Fits
   iii. Fundamental Deviation and Fundamental Tolerance unit

OR

4'(a) Explain the principle and working of an autocollimator. List some of its practical uses. [04]
4'(b) Differentiate between line standards and end standards [04]
4'(c) Explain the basic principle of a vernier scale. In a vernier calliper, the main scale reads in millimetres with a least count of 0.5mm. Twenty divisions on the vernier scale correspond to 19 divisions on the main scale. Determine the least count of the calliper. [04]

Answer any 3 of the following:

a. Explain the principle of measurement by light wave interference method. 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

b. What is the best size wire for measuring the effective diameter of a screw thread? Calculate the same for measuring the effective diameter of a screw thread using two-wire method given that the distance across 10 threads is 12.5mm.

c. With a suitable diagram explain the construction and working principle of a mechanical optical comparator.

d. What is the need for acceptance tests of machine tools? Explain the significance of the true running of spindle. With the help of a neat diagram explain how the test may be carried out.