

SECTION – A

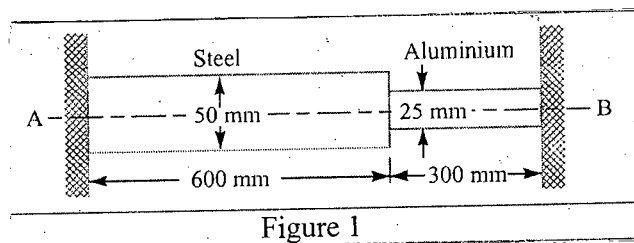
There are **FOUR** questions in this section. Answer any **THREE**.

The text book titled "Shigley's Mechanical Engineering Design" is supplied.

1. (a) A composite bar made of aluminium and steel is held between the supports as shown in Fig. 1. The bars are stress free at a temperature of 37°C . What will be the stress in the two bars when the temperature is 20°C , if
- the supports are unyielding; and
 - the supports yield and come nearer to each other by 0.10 mm ?

(20)

(It can be assumed that the change of temperature is uniform all along the length of the bar. Take $E_s = 210\text{ GPa}$, $E_a = 74\text{ GPa}$, $\alpha_s = 11.7 \times 10^{-6}/^{\circ}\text{C}$ and $\alpha_a = 23.4 \times 10^{-6}/^{\circ}\text{C}$.)



- (b) A helical compression spring is to be made of oil-tempered wire of 4-mm diameter with a spring index of $C = 10$. The spring is to operate inside a hole, so buckling is not a problem and the ends can be left plain. The free length of the spring should be 80 mm. A force of 50 N should deflect the spring 15 mm.

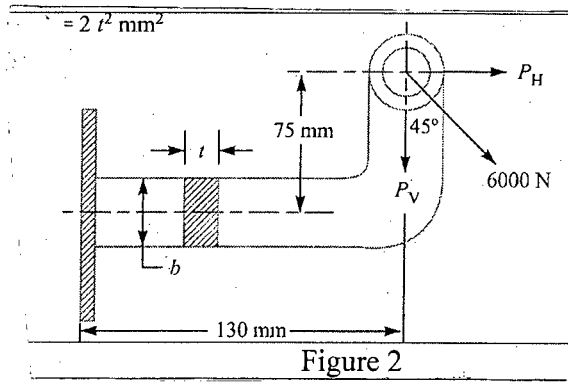
(15)

- Determine the spring rate.
 - Determine the minimum hole diameter for the spring to operate in.
 - Determine the total number of coils needed.
 - Determine the solid length.
 - Determine a static factor of safety based on the yielding of the spring if it is compressed to its solid length.
2. (a) A mild steel bracket as shown in Fig. 2, is subjected to a pull of 6000 N acting at 45° to its horizontal axis. The bracket has a rectangular section whose depth is twice the thickness. Find the cross-sectional dimensions of the bracket, if the permissible stress in the material of the bracket is limited to 60 MPa.

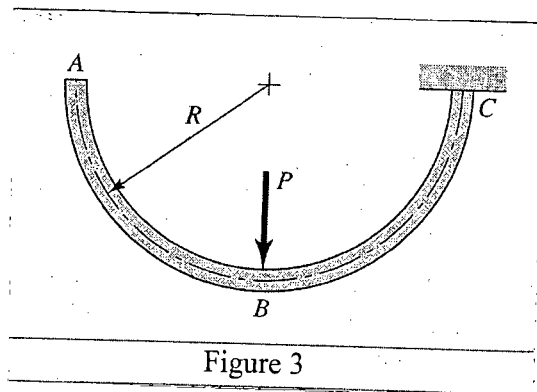
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(b) The steel curved bar shown in Fig. 3 has a rectangular cross section with a radial height $h = 6$ mm, and a thickness $b = 4$ mm. The radius of the centroidal axis is $R = 40$ mm. A force $P = 10$ N is applied as shown. Find the vertical deflection at B. Use Castigliano's method for a curved flexural member, and since $R/h < 10$, do not neglect any of the terms. (20)



3. (a) A 50 mm diameter shaft is made from carbon steel having ultimate tensile strength of 630 MPa. It is subjected to a torque which fluctuates between 2000 N-m to -800 N-m. Using Soderberg method, calculate the factor of safety. Assume suitable values for any other data needed. Assume the yield stress (σ_y) for carbon steel in reversed bending as 510 N/mm², surface finish factor as 0.87, size factor as 0.85 and fatigue stress concentration factor as 1. (15)

(b) Two plates of 10 mm thickness each are to be joined by means of a single riveted double strap butt joint. Determine the rivet diameter, rivet pitch, strap thickness and efficiency of the joint. Take the working stresses in tension and shearing as 80 MPa and 60 MPa respectively. (20)

4. (a) Design and make a neat dimensioned sketch of a muff coupling which is used to connect two steel shafts transmitting 40 kW at 350 r.p.m. The material for the shafts and key is plain carbon steel for which allowable shear and crushing stresses may be taken as 40 MPa and 80 MPa respectively. The material for the muff is cast iron for which the allowable shear stress may be assumed as 15 MPa. (15)

(b) A light pressure vessel is made of 2024-T3 aluminum alloy tubing with suitable end closures. This cylinder has a 3.5 inch OD, a 0.065 inch wall thickness, and $\nu = 0.334$. The purchase order specifies a minimum yield strength of 46 kpsi. Using the distortion-energy theory, determine the factor of safety if the pressure-release valve is set at 500 psi. (20)

SECTION – B

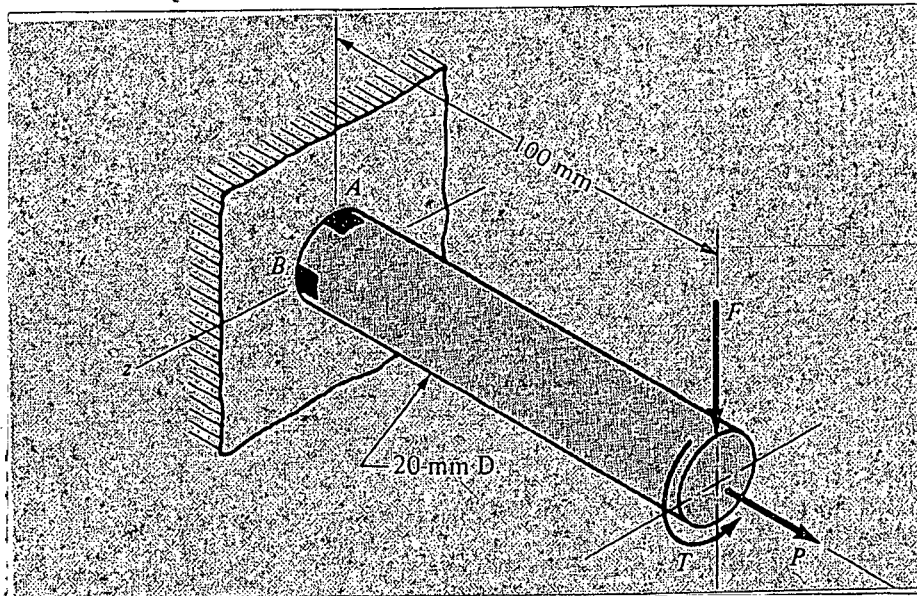
There are **FOUR** questions in this section. Answer any **THREE**.

- 5. (a) How does establishment of the 'design driver variables' help in understanding the economic and technical feasibility of a new product development? (10)
(b) Describe the 'Kano diagram' of customer satisfaction. (10)
(c) Briefly describe different customer need gathering methods with their relative merits and demerits. (15)

- 6. (a) Mention various steps of the house of quality. (10)
(b) What are the purposes for different prototypes? (10)
(c) Compare different types of design team structures. (15)

- 7. (a) Describe the 'FAST method' for functional decomposition. (10)
(b) Briefly describe the key elements of ISO 14001 relating to an environmental management system. (10)
(c) What are the reasons for adopting concurrent engineering system? (15)

- 8. (a) The following problem illustrates that the factor of safety for a machine element depends on the particular point selected for analysis. Compute factor of safety, based upon the distortion energy theory, for stress elements at A and B of the member shown in the figure. This bar is made of AISI 1006 cold-drawn steel and is loaded by the forces $F = 0.55 \text{ kN}$, $P = 8.0 \text{ kN}$, and $T = 30 \text{ N.m}$. (15)



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Table 1. Size of rivet diameters for rivet hole diameter as per IS : 1928 - 1961 (Reaffirmed 1996).

Basic size of rivet (mm)	12	14	16	18	20	22	24	27	30	33	36	39	42	48
Rivet hole diameter (min) (mm)	13	15	17	19	21	23	25	28.5	31.5	34.5	37.5	41	44	50

Table 2. Values of constant C.

Number of rivets per pitch length	Lap joint	Built joint (single strap)	Built joint (double strap)
1	1.31	1.53	1.75
2	2.62	3.06	3.50
3	3.47	4.05	4.63
4	4.17	-	5.52
5	-	-	6.00

Table 3. Proportions of standard parallel, tapered and gib head keys.

Shaft diameter (mm) upto and including	Key cross-section		Shaft diameter (mm) upto and including	Key cross-section	
	Width (mm)	Thickness (mm)		Width (mm)	Thickness (mm)
6	2	2	85	25	14
8	3	3	95	28	16
10	4	4	110	32	18
12	5	5	130	36	20
17	6	6	150	40	22
22	8	7	170	45	25
30	10	8	200	50	28
38	12	8	230	56	32
44	14	9	260	63	32
50	16	10	290	70	36
58	18	11	330	80	40
65	20	12	380	90	45
75	22	14	440	100	50

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) What is time-variable computation? Provide an example. (6)
 (b) The following information is available for a bank account: (15)

Date	Deposits	Withdrawals	Interest	Balance
5/1				1512.33
6/1	220.13	327.26		
7/1	216.80	378.61		
8/1	450.25	106.80		
9/1	127.31	350.61		

Note that the money earns interest which is computed as

$$\text{Interest} = i B_i$$

Where i = the interest rate expressed as a fraction per month, and B_i the initial balance at the beginning of the month.

- (i) Use the conservation of cash to compute the balance on 6/1, 7/1, 8/1, and 9/1 if the interest rate is 1% per month ($i = 0.01/\text{month}$). Show each step in the computation.
- (ii) Write a differential equation for the cash balance in the form $dB/dt = f(D(t), W(t), i)$ where t = time (months), $D(t)$ = deposits as a function of time (\$/month), $W(t)$ = withdrawals as a function of time (\$/month). For this case, assume that interest is compounded continuously; that is, interest = $i B$.
- (iii) Use Euler's method with a time step of 0.5 month to simulate the balance. Assume that the deposits and withdrawals are applied uniformly over the month.
- (iv) Develop a plot of balance versus time for (i) and (iii).
- (c) Briefly discuss the consequences of *normalization* in the floating-point representation of numbers. (6)
- (d) What is a numerically unstable computation? How can you possibly detect a numerically unstable computation? (8)

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2. (a) Derive an expression for the Lagrange form of the remainder of the Taylor series. **(10)**

(b) Discuss a procedure for approximating the error in $f(x)$ given the derivative of a function and an estimate of the error in a independent variable. Use appropriate sketches. **(10)**

(c) Determine the number of terms necessary to approximate $\cos x$ to 8 significant figures using the Maclaurin series approximation. **(15)**

$$\cos x = 1 - \frac{x^2}{2} + \frac{x^4}{4!} - \frac{x^6}{6!} + \frac{x^8}{8!} - \dots$$

Calculate the approximation using a value of $x = 0.3\pi$. Also, write a pseudocode to determine your result.

3. Discuss the limitations of naive Gauss elimination method. How can you circumvent these limitations? **(10)**

(b) Show that the Gauss elimination itself can be expressed as an LU decomposition. **(8)**

(c) Perform Crout decomposition on **(12)**

$$\begin{aligned} 2x_1 - 5x_2 + x_3 &= 12 \\ -x_1 + 3x_2 - x_3 &= -8 \\ 3x_1 - 4x_2 + 2x_3 &= 16 \end{aligned}$$

Then, multiply the resulting $[L]$ and $[U]$ matrices to determine that $[A]$ is produced.

(d) How can you solve a non-linear system of equations using elimination method? **(5)**

4. (a) How can you interpret the elements of the matrix inverse as a measure of ill-conditioning? **(5)**

(b) Derive three simultaneous equations for the four unknown constants for second-order Runge-Kutta methods and prove that there is a family of second-order methods rather than a single version. **(15)**

(c) Solve the following problem over the interval from $t = 0$ to 2 using a step size of 0.5 where $y(0) = 1$. Display all your results on the same graph and then compared them. **(15)**

$$\frac{dy}{dt} = -2y + t^2$$

Obtain your solutions with (i) Heun's method without iterating the corrector, (ii) Heun's method with iterating the corrector until $\epsilon_s < 0.1\%$, (iii) midpoint method, and (iv) Ralston's method.. **(15)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) The *divide and average* method, an old-time method for approximating the square root of any positive number a , can be formulated as: (5)

$$x_{i+1} = \frac{x_i + \frac{a}{x_i}}{2}$$

Prove that this is equivalent to the *Newton-Raphson* algorithm.

- (b) The *normal probability distribution* is defined as (15)

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}; \quad -\infty \leq x \leq +\infty$$

where μ is the mean, and σ is the standard deviation. If x is distributed in this fashion, then the probability that $a \leq x \leq b$ is given by the following expression.

$$P(a \leq x \leq b) = \int_a^b f(x) dx$$

Suppose, the *Young's modulus* (E) of a mechanical component is under consideration. Past data reveals that the mean E is 29576 ksi with a standard deviation of 1507 ksi. Assume that E is normally distributed.

Find the probability of E having a value between 28,000 ksi and 29,500 ksi. Use *Simpson's 3/8 rule* while determining the integral. Divide the whole interval into 16 subintervals.

- (c) Solve the following system of nonlinear equations: (15)

$$\begin{aligned} -2x^3 + 3y^2 + 42 &= 0 \\ 5x^2 + 3y^3 - 69 &= 0 \end{aligned}$$

Use the *fixed-point iteration* method. Start at $x = 1, y = 1$, and carry out the first four iterations.

6. (a) Draw the graph of a single function f which satisfies all of the following: (8)

- (i) f is defined and differentiable for all x ;
- (ii) There is a unique root $x_r > 0$;
- (iii) *Newton-Raphson* method will converge for any $x_0 > x_r$;
- (iv) *Newton-Raphson* method will diverge for any $x_0 < 0$.

Note that the requirement here is to find a single function that satisfies all of these conditions at the same time.

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Contd... Q. No. 6

(b) If the *composite trapezoidal* rule is to be used to compute. (7)

$$\int_0^1 e^{-x^2} dx$$

with an error of at most $\frac{1}{2} \times 10^{-4}$, how many points should be used?

(c) Suppose we wish to find a root of the following polynomial: (20)

$$f(x) = x^7 + 3x^6 + 7x^5 + x^4 + 5x^3 + 2x^2 + 5x + 5.$$

Carry out the first three iterations of the *Müller's* method with initial guesses of 0, -0.2 and -0.1. Compute the approximate percent relative errors after each iteration.

7. (a) If one borrows L dollars at an annual interest rate of r , for a period of m years, then the size of the monthly payment, M , is given by the annuity equation (15)

$$\frac{1}{M} = \frac{12}{L \times r} \left[1 - \left(1 + \frac{r}{12} \right)^{-12m} \right]$$

Suppose, you need to borrow \$150,000 to buy a new house, and you can only afford to pay \$600 per month. Assuming a 30 year mortgage, use the *Regula -Falsi* method to determine what interest rate you can afford to pay. Use $r_1 = 2.4\%$ and $r_u = 2.7\%$ as your initial guesses. Perform 3 iterations and calculate the approximate percent relative errors. Use four significant figures in all your calculation.

(b) In 1973, the horse *Secretariat* became the first (and, so far, only) winner of the *Kentucky Derby* to finish the race in less than two minutes, running the 1.25 miles distance in 1 minute and 59.4 seconds. Remarkably, he ran each quarter mile faster than the previous one, as the following table of data shows. Here t is the elapsed time (in seconds) since the race began and x is the distance (in miles) that *Secretariat* has traveled. (20)

x (mile)	0	0.25	0.5	0.6	0.75	0.9	1	1.25
t (second)	0	25.0	49.4	58.9	73	87.04	96.4	119.4

- (i) Use *Newton's* interpolating polynomial to determine t at $x = 0.7$ mile. Note that a polynomial will yield an exact value. Your solution should prove that your result is exact.
- (ii) Use this polynomial to estimate *Secretariat's* speed in miles per hour at the finish of the race.

IPE 329

8. (a) Show that, the formula for the
- secant*
- method can also be written as

(5)

$$x_{n+1} = \frac{x_{n-1}f(x_n) - x_n f(x_{n-1})}{f(x_n) - f(x_{n-1})}$$

Explain why it is inferior to the original formula for the *secant* method in a computer program.

- (b) 'Multiple roots pose some difficulties for many of the root-finding numerical methods' — explain.

(10)

- (c) If the
- bisection*
- method generates intervals
- $[a_0, b_0]$
- ,
- $[a_1, b_2]$
- , and so on, and the midpoints of the successive intervals are denoted as
- c_0, c_1, c_2
- , and so on, which of these inequalities are true and which of these are false for the root
- r
- that is being calculated?

Justify your answers.

(20)

(i) $\left| r - \frac{1}{2}(a_n + b_n) \right| \leq 2^{-n-2}(b_0 - a_0)$

(ii) $|r - b_n| \leq 2^{-n-1}|b_0 - a_0|$

(iii) $|r - c_n| < |r - c_{n-1}|$

(iv) $a_n \leq r \leq c_n$

(v) $\left| \frac{1}{2}(a_n + b_n) - \frac{1}{2}(a_{n-1} + b_{n-1}) \right| \geq 2^{-n-1}(b_0 - a_0)$

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Exponential smoothing is an averaging process in which unequal weights are assigned to the observations. Justify the comment. (15)
 (b) Explain the trend effects in moving average method and exponential smoothing method. (10)
 (c) Define time series. Explain the four components of a time series. (10)

2. (a) Explain the following terms related to inventory: (12)
 (i) EOQ (ii) Effective lead time (iii) Shortage cost.
 (b) An item sells for \$25 a unit, but a 10% discount is offered for lots of 150 units or more. A company uses this item at the rate of 20 units per day. The setup cost for ordering a lot is \$50, and the holding cost per unit per day is \$0.30. (23)
 (i) Determine the optimal order quantity.
 (ii) Should the company take the advantage of the discount?

3. (a) Define production planning and control. Differentiate between continuous and intermittent manufacturing with respect to the following: (15)
 (i) Factory layout (ii) Cycle time
 (iii) Flexibility (iv) Operator's skill
 (b) What are the functions of shop-floor control? Explain. (12)
 (c) Explain the terms 'make-to-order' and 'assemble-to-order' and the appropriateness of their application in a manufacturing organization. (8)

4. (a) MRP is more than an inventory system. What additional capabilities does MRP possess? (10)
 (b) The following table shows a partially completed inventory record for the rotor subassembly. (25)

	Week							
	1	2	3	4	5	6	7	8
Gross requirements	65	15	45	40	80	80	80	80
Schedule receipts	150							

Holding cost = \$2.50/unit/week, setup cost = \$150, lead time = 2 weeks, projected on-hand inventory = 20. Develop an EOQ solution and calculate total relevant costs for the data in the given table.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) How can you distinguish "Standard Elemental Time" from "Predetermined Time Study"? Which one do you think is more accurate and why? (5)
- (b) Briefly explain the alternatives to be considered once the capacity is saturated. (10)
- (c) Discuss the four building blocks in JIT system implementation. (8)
- (d) Select the best out of three following machines with the conditions of (i) No loss allowed and (ii) Need to satisfy market demand: (12)

D = 400 ~ 500 unit

R = Tk 30/unit

V = Tk 10/unit

m/c #	FC (Taka)	Capacity (unit)
1	8000	400
2	9000	450
3	10000	500

6. (a) Briefly explain two demand options and two capacity options in balancing demand and capacity. (10)
- (b) What are the factors that separate "design capacity" from "effective capacity" and "effective capacity" from "actual output"? (4)
- (c) For the following activity table, calculate line efficiency to have a desired output rate of 90 units in 2 hrs. Also assign the activities to required minimum number of workstation. (12)

Activity	Successor	Time (sec)
A	C	45
B	C	40
C	D, E	30
D	F	35
E	F	22
F	G, I	28
G	H, J	20
H	–	25
I	–	30
J	–	35

- (d) From the following table of produced parts in an hour time, calculate Normal time and Standard time with a performance rating of 1.20 using an allowance of 15% of normal time: (9)

Worker	A	B	C	D	E	F	G	H
No. of pcs	26	28	27	25	24	28	26	27

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7. (a) "Productivity can be increased even with same machine efficiency" — Discuss. **(8)**
 (b) How can you distinguish "push system" from "pull system"? Provide example for both. **(6)**
 (c) Complete the following production plans and calculate Total costs for both plans: **(21)**

	January	February	March	April	May	June
Beginning Inventory	350					
Demand Forecast	1740	1560	1380	1160	1240	1420
Safety Stock (0.2 X Demand)						
Production Requirement						
Working days per month	22	19	21	21	22	20
Ending Inventory						

Plan 1: Constant workforce - Vary inventory & Stockout

Average No of workers =

Beginning Inventory	350					
Working days per month						
Available hrs per month (8hrs/day)						
Actual Production (5hrs/unit)						
Demand Forecast	1740	1560	1380	1160	1240	1420
Ending Inventory						
Shortage cost (\$5/unit)						
Safety stock						
Unit excess						
Inventory cost (\$1.5/unit)						
Straight time cost (\$4/hr)						

Plan 2: Constant low workforce - Subcontract

Minimum No of workers =

Production Requirement						
Working days per month						
Production requirement per day						
Available hrs per month (8hrs/day)						
Actual Production (5hrs/unit)						
Units subcontracted						
Subcontracting cost (\$20/unit)						
Straight time cost (\$4/hr)						

8. (a) Explain forward scheduling and backward scheduling. **(5)**
 (b) What are the objectives of work-center scheduling? **(5)**
 (c) Use Johnson's rule to find the optimum sequence for processing the jobs shown through two work centers. Times of each center are as follows: **(25)**

Job	Work Center 1 (hrs)	Work Center 2 (hrs)
A	6	12
B	3	7
C	18	9
D	15	14
E	16	8
F	10	15

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Discuss the guidelines required to plan a maintenance organization. What are the benefits and drawbacks of centralized maintenance? (4+7=11)
- (b) Describe the nine-step approach for managing a maintenance program. (12)
- (c) Briefly describe the strategies for reducing the system-level Corrective Maintenance time. (12)

2. (a) Define the following terms used in engineering maintenance: (6)
 - (i) Mean time to repair (MTTR)
 - (ii) Maintenance Plan
 - (iii) Reliability
 - (iv) Quality
- (b) Distinguish between 'Mean Preventive Maintenance Time (MPMT)' and 'Median Preventive Maintenance Time (MDPMT)'. (7)
- (c) Describe the steps that are to be followed in establishing a Preventive Maintenance program in an organization. (10)
- (d) An engineering system can either fail completely or undergo periodic preventive maintenance. Given that, system failure rate, $\lambda = 0.005$ failures per hour; rate of system down for PM, $\lambda_p = 0.007$ per hour; system repair rate, $\mu = 0.008$ repairs per hour and rate of system PM performance, $\mu_p = 0.008$ per hour. Calculate the system steady- state availability. Also calculate the probability of system failure and probability of system down for preventive maintenance at steady state. (12)

3. (a) Develop a Corrective Maintenance mathematical model for a system that can either be operating normally or failed in two mutually exclusive failure modes. (15)
- (b) What do you understand by Proactive Maintenance? Mention some techniques that can be employed by Proactive Maintenance to extend equipment life. (10)
- (c) What are the Predictive Testing and Inspection (PTI) technologies? Write down some application areas for Nondestructive testing? (6+4=10)

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4. (a) With a neat sketch show different components of a screw conveyor. (9)
- (b) Write down the advantages of screw conveyor. (4)
- (c) Classify 'screw' of a screw conveyor. Give neat sketches. Write down the purpose of using them. (10)
- (d) Mention the name of couplings used in screw conveyor. Write down the use of couplings. (2)
- (e) For a horizontal screw conveyor carrying free flowing non-abrasive material, capacity, $Q = 70$ tons/hr, bulk weight, $\gamma = 0.66$ tons/m³, length of conveying run, $L = 30$ m, rotating at a speed of 60 rpm, loading efficiency, $\Psi = 40\%$, resistance to motion factor, $\omega_0 = 2.8$ and efficiency of transmission 87%. Find- (4×2½=10)
- (i) Diameter of the screw.
- (ii) Required motor power.
- (iii) Torque transmitted to the screw.
- (iv) Load transfer rate.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Describe the factors involved in selection of conveying equipment with relevant examples. (12)
- (b) Define resistance to motion factor. (2)
- (c) What are the basic requirements of a pulling member of conveying machines? Differentiate between the pulling members of belt conveyor and apron conveyor. (4+10=14)
- (d) Write down the characteristics that should be possessed by intermediate supports of a conveying machine. What are the types of intermediate supports used in different conveying machines? (4+3=7)
6. (a) Write down the advantages of belt conveyor. For an inclined belt conveyor, what should be the angle of inclination to prevent spillage? (5+2=7)
- (b) What are the necessary properties that a conveyor belt should possess? Discuss the function of rubber and fabric plies in rubberized textile belt. (3+4=7)
- (c) A flanged apron conveyor (Fig. 6c) is designed to deliver hot castings of a diameter 650 mm, a height of 300 mm and a piece weight $G = 200$ kg. The conveyor capacity Z is 250 pieces per hour with an irregularity factor $K' = 2.5$. If apron width is 900 mm, $A = 150$, minimum load spacing $a = 1000$ mm and resistance to motion factor, $\omega' = 0.13$, find the tensions at different points. Here, $H = 4.5$ m and $\alpha = 17^\circ$. (21)

IPE 311

7. (a) Suppose in a building construction work, you need to elevate gravels to a height of 20m from ground with a bucket elevator. What type of charging and discharging methods are you going to select for this purpose? Explain with neat sketches. **(10)**
- (b) For a bucket elevator derive the equation of Pole Distance (l) in terms of rotational speed (n). **(10)**
- (c) Write down the use of different types of buckets with necessary justification. **(10)**
- (d) In a continuous V-type bucket elevator coal (bulk weight, $\gamma = 0.68 \text{ tons/m}^3$) is elevated at a speed of 0.75 m/s. The volume of each bucket is 90 liters and height is 60 cm. If loading efficiency is 70%, find the capacity of the bucket elevator. **(5)**

8. (a) Classify roller conveyors. How motion is transferred in these conveyors? What is a gravity conveyor? **(2+2+2=6)**
- (b) For a powered roller conveyor prove that required motor power, **(12)**

$$N = \frac{(Z_0 G \omega' + z p \omega_1) v}{102 \eta_g} \text{ kW}$$

- (c) What are the four basic types of layout? Compare process layout with product layout. What is cellular layout? Write down some advantages of cellular layout. **(4+6+2+5=17)**

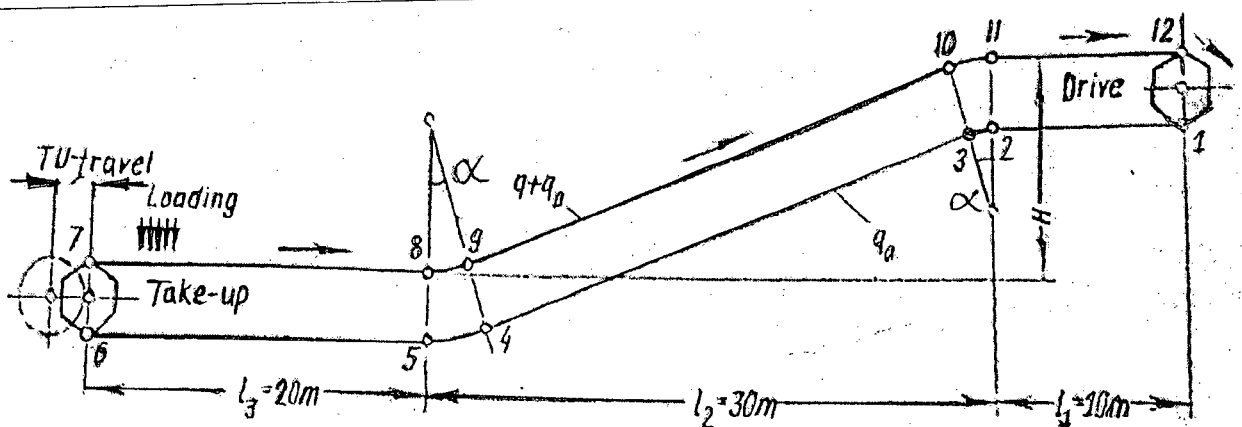


Fig. for question 6c.

SECTION – AThere are **FOUR** questions in this section. Answer any **THREE**.

1. (a) What are the most commonly used Quality Assurance Systems? Write down their full names along with their application areas. (15)
- (b) Juran defined "Zone of Perfectionism" and "Zone of Improvement Projects". What are those? (15)
- (c) Shewhart developed "Learning and Improvement Cycle", having four steps. What are those? Write in brief. (5)
2. (a) Write a short note on "Deming Prize" evaluation criteria. (15)
- (b) What is ABC analysis? What is its background theory? (15)
- (c) Who relates quality to Kaizen by stating that "in its broadest sense, quality is anything that can be improved, and that needs improvement"? What else did he say? (5)
3. (a) What was Motorola's plan/effort while they started 6σ (six sigma) implementation? (15)
- (b) A company uses Taguchi Loss Function. They manufacture water pumps, with target output rotational speed value of 240 rpm. In case of any deviation from the target output rpm value, recalibration is required with certain costs associated. It is estimated that the average cost of recalibration is 400 \$ for a deviation of 9 rpm. The record shows that population standard deviation of rotational speed is 2 rpm. Several measurements of rpm values for multiple pumps were recorded. It was found that average or mean output speed is 220 rpm. (20)
- For multiple units, what is the loss for nominal-the-best situation?
4. (a) What is the reliability of a parallel system, where it is a function of time? Explain with appropriate mathematical equations. (15)
- (b) For a Multi-Vari chart, the table shows the measured values of defect rates. Calculate the possible variations and identify the Red X? (20)

Time →	8.00 am			1.00 pm			4.00 pm		
Floor No. →	1	2	3	1	2	3	1	2	3
Production of defects for five different workers at five machines of the same specifications	28	27	22	30	32	30	36	38	35
	27	20	22	32	33	31	35	36	33
	28	20	29	32	31	38	30	32	37
	25	29	26	35	35	38	32	37	36
	24	26	24	31	34	33	34	35	34

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) What is meant by the term FMEA? State the benefits of FMEA. (18)
(b) Briefly describe BPR. How does BPR differ from TQM? (17)
6. (a) Before manufacturing of a product starts, what are the decisions that need to be resolved? (8)
(b) Define C_p , C_{pk} and k . Mention the relationship equation among these indices. (10)
(c) For a process, from the past record it has been found that, $\mu = 20$ mm, $\sigma = 0.2$ mm. For statistical quality control sample of size 8 are taken every day. The sample mean was obtained as 20.2 mm and significance level for the test is 0.05. (17)
(i) Has the process mean really shifted?
(ii) Calculate the probability of Type II error?
7. (a) What are the types of variable charts? When $\bar{X} - S$ chart should be used rather than $\bar{X} - R$ chart? (10)
(b) A computer manufacturer collects data from the final test of its product starting from the end of January and all through February. Each day sample inspected for non conformities are different in size. The number of items in the sample that 'do not conform' to specifications is recorded. The data is shown below: (25)

Subgroup number (day)	Number Inspected	Number Defective
1	2000	55
2	1000	18
3	2000	50
4	1500	42
5	1500	39
6	2000	52
7	2000	47
8	1500	34
9	1000	29
10	2000	53
11	2000	45
12	1500	26

Develop a u-chart with three-sigma control limits and evaluate whether the process is in statistical control.

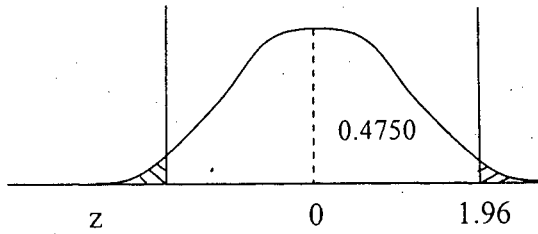
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8. (a) Describe the basics of control charts. (10)
- (b) Explain the performance advantages of CUSUM and Weighted average charts relative to Shewhart control chart. (10)
- (c) For 'Weighted moving average' chart calculate control limits from the following data, with $w = 4$. (15)

Sample Number	Observations (bottle volume in ounces)				Average	Range
	1	2	3	4	\bar{x}	R
1	15.85	16.02	15.83	15.93	15.91	0.19
2	16.12	16.00	15.85	16.01	15.99	0.27
3	16.00	15.91	15.94	15.83	15.92	0.17
4	16.20	15.85	15.74	15.93	15.93	0.46
5	15.74	15.86	16.21	16.10	15.98	0.47

= 4 =

Table A. Standard Normal Distribution Values (Areas under the normal curve).



z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0/09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

= 5 =

Table B. Factors used in 3σ Quality Control Charts.

Sample size n	\bar{X} charts			S charts					R charts					
	Factors for control limits			Factors for central line	Factors for control limits				Factors for central line	Factors for control limits				
	A	A ₂	A ₃	c ₄	B ₃	B ₄	B ₅	B ₆	d ₂	d ₃	D ₁	D ₂	D ₃	D ₄
2	2.121	1.880	2.659	0.7979	0	3.267	0	2.606	1.128	0.853	0	3.686	0	3.267
3	1.732	1.023	1.954	0.8862	0	2.568	0	2.276	1.693	0.888	0	4.358	0	2.574
4	1.500	0.729	1.628	0.9213	0	2.266	0	2.088	2.059	0.880	0	4.698	0	2.282
5	1.342	0.577	1.427	0.9400	0	2.089	0	1.964	2.326	0.864	0	4.918	0	2.114
6	1.225	0.483	1.287	0.9515	0.030	1.970	0.029	1.874	2.534	0.848	0	5.078	0	2.004
7	1.134	0.419	1.182	0.9594	0.118	1.882	0.113	1.806	2.704	0.833	0.204	5.204	0.076	1.924
8	1.061	0.373	1.099	0.9650	0.185	1.815	0.179	1.751	2.847	0.820	0.388	5.306	0.136	1.864
9	1.000	0.337	1.032	0.9693	0.239	1.761	0.232	1.707	2.970	0.808	0.547	5.393	0.184	1.816
10	0.949	0.308	0.975	0.9727	0.284	1.716	0.276	1.669	3.078	0.797	0.687	5.469	0.223	1.777
11	0.905	0.285	0.927	0.9754	0.321	1.679	0.313	1.637	3.173	0.787	0.811	5.535	0.256	1.744
12	0.866	0.266	0.886	0.9776	0.354	1.646	0.346	1.610	3.258	0.778	0.922	5.594	0.283	1.717
13	0.832	0.249	0.850	0.9794	0.382	1.618	0.374	1.585	3.336	0.770	1.025	5.647	0.307	1.693
14	0.802	0.235	0.817	0.9810	0.406	1.594	0.399	1.563	3.407	0.763	1.118	5.696	0.328	1.672
15	0.775	0.223	0.789	0.9823	0.428	1.572	0.421	1.544	3.472	0.756	1.203	5.741	0.347	1.653
16	0.750	0.212	0.763	0.9835	0.448	1.552	0.440	1.526	3.532	0.750	1.282	5.782	0.363	1.637
17	0.728	0.203	0.739	0.9845	0.466	1.534	0.458	1.511	3.588	0.744	1.356	5.820	0.378	1.622
18	0.707	0.194	0.718	0.9854	0.482	1.518	0.475	1.496	3.640	0.739	1.424	5.856	0.391	1.608
19	0.688	0.187	0.698	0.9862	0.497	1.503	0.490	1.483	3.689	0.734	1.487	5.891	0.403	1.597
20	0.671	0.180	0.680	0.9869	0.510	1.490	0.504	1.470	3.735	0.729	1.549	5.921	0.415	1.585
21	0.655	0.173	0.663	0.9876	0.523	1.477	0.516	1.459	3.778	0.724	1.605	5.951	0.425	1.575
22	0.640	0.167	0.647	0.9882	0.534	1.466	0.528	1.448	3.819	0.720	1.659	5.979	0.434	1.566
23	0.626	0.162	0.633	0.9887	0.545	1.455	0.539	1.438	3.858	0.716	1.710	6.006	0.443	1.557
24	0.612	0.157	0.619	0.9892	0.555	1.445	0.549	1.429	3.895	0.712	1.759	6.031	0.451	1.548
25	0.600	0.153	0.606	0.9896	0.565	1.435	0.559	1.420	3.931	0.708	1.806	6.056	0.459	1.541