BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations (January 2020 Term)

Sub: **IPE 303** (Product Design I)

Full Marks: 180 Section Marks: 90 Time: 2 Hours (Sections A + B)

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

Machine design book is provided.

Assume reasonable value for any missing data.

1. (a) The purpose of using transmission shafts in electromechanical drive systems is to transmit power and torque from one location to another. A transmission shaft with a uniformly distributed load of 10 N/mm is shown in Figure 1. The modulus of elasticity of the shaft material and maximum allowable deflection of the shaft are 207000 N/mm^2 and 2.4 mm, respectively. Using Castigliano's theorem, determine the shaft diameter d. **(25)**

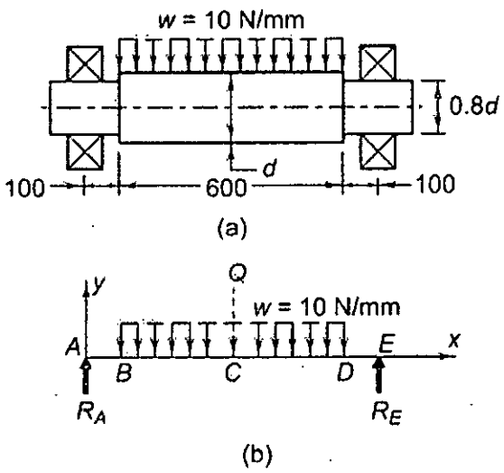


Figure 1

(b) A helical compression spring is to be made of no. 32 music wire. The spring has an outside diameter of 38 mm with plain ground ends. It is expected to operate inside a hole, so buckling is not a problem. The free length of the spring should be 80 mm. A force of 50 N should deflect the spring 15 mm. Determine: **(20)**

i. the spring rate
ii. the total number of coils needed
iii. the solid length
iv. the torsional yield strength of the wire considering 'after set removed' condition.

2. (a) Consider, the section in Figure 2(a) is transmitting a positive bending moment $M_z = 2.13$ kN.m about z axis. If all the dimensions are in mm, find- **(20)**

   i. the second moment of area,

   ii. the location of the neutral axis,

   iii. the distances from the neutral axis to the top and bottom surfaces.

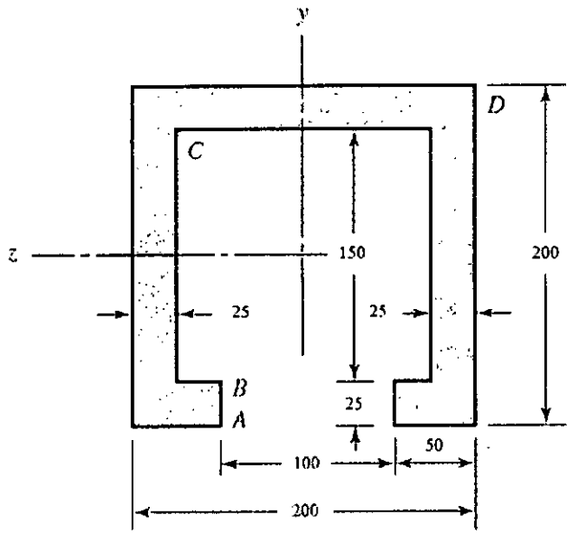


Figure 2(a)

(b) A pair of mating steel spur gears with 18 mm face width transmits a load of 200 N. For estimating the contact stresses, make the simplifying assumption that the teeth profiles can be treated as cylindrical with instantaneous radii at the contact point of interest of 11 mm and 15 mm, respectively. Estimate maximum contact pressure and maximum shear stress experienced by either gear. **(25)**

3. (a) A solid round bar with diameter of 50 mm has a groove cut to a diameter of 45 mm, with a radius of 2.5 mm. The bar is not rotating. The bar is loaded with a repeated bending load that causes the bending moment at the groove to fluctuate between 0 and 2825 Nm. The bar is hot-rolled AISI 1095, but the groove has been machined. Determine the factor of safety for fatigue based on infinite life using the modified Goodman criterion, and the factor of safety for yielding. **(30)**

   (b) The ultimate tensile and compressive strengths of a brittle material are 210 MPa and 630 MPa, respectively. Using the brittle-Coulomb-Mohr and modified-Mohr theories, determine the factor of safety for the following state of plane stress: **(15)**

   $\sigma_x = -98$ MPa,

   $\sigma_y = -65$ MPa,

   $\tau_{xy} = -98$ MPa.

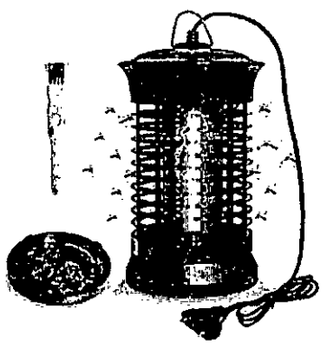
SECTION – B

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

Machine design book is provided.

Assume reasonable value for any missing data.

4. (a) Draw a "Functional Analysis System Technique (FAST)" diagram for the following product: **(25)**

Product Name	Product Description	Product Image
Mosquito killer machine	It is built with electrically charged, high-voltage metal grids that electrocute insects immediately they make contact with it. It uses ultraviolet light to attract insects. It is thin and has a modern style that makes it look great.	

(b) Discuss the roles of "Early (alpha) prototypes" and "Later (beta) prototypes" in development of a product. **(12)**

(c) What are the challenges that can be faced by a product development team? Discuss them with appropriate examples. **(8)**

5. (a) In context of a single product, explain different types of customer requirements according to Kano model. Include necessary diagrams and examples. **(20)**

(b) With appropriate examples, explain how the following factors affect the selection of suitable and economical production process for a product: **(12)**

i. The production quantities involved
ii. Utilization of existing equipment
iii. Selection of jigs and fixtures and other production aids
iv. Limitation of skill

(c) A 1 in-8 UNC × 3 in SAE grade 4 bolt is subjected to a load P in a tension joint. The initial bolt tension is $F_i = 32$ kip. The bolt and joint stiffnesses are $k_b = 4$ and $k_m = 12$ Mlbf/in, respectively. **(8+5)**

i. Is the bolt able to sustain a given load of $P = 15$ kip? Justify your answer with respect to the SAE minimum proof strength of the bolt.
ii. Determine the maximum load (P_{max}

6. (a) Explain the Figure Q6(a) in context of value engineering in product design. **(8)**

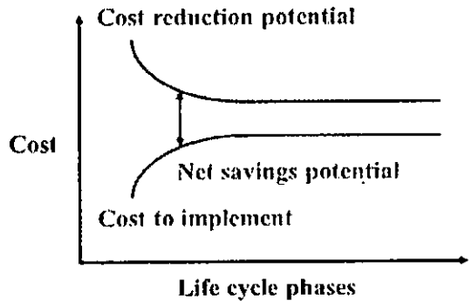


Figure: Q6(a)

(b) The AISI 1050 HR forged steel strap of Figure Q6(b) has a repeatedly applied load of 2500 lbf ($F_a = F_m = 1250$ lbf). Determine the fatigue factor of safety for the weldment. **(12)**

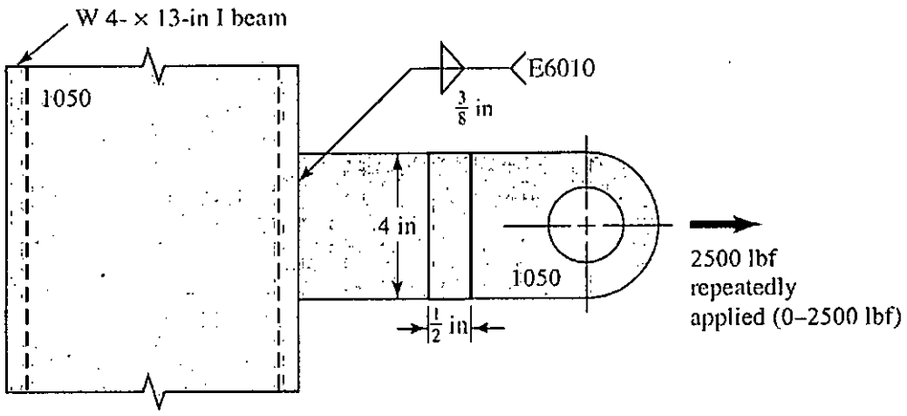


Figure: Q6(b)

(c) A square-thread power screw has a major diameter of 42 mm and a thread depth of 3 mm with double threads, and it is to be used in an application similar to that in Figure Q6(c). The given data include $f = f_c = 0.085$, $d_c = 50$ mm, and $F = 7000$ N per screw. **(25)**

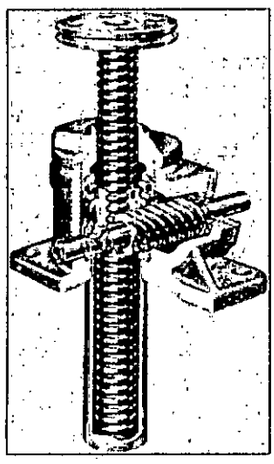


Figure: Q6(c)

i. Find the pitch diameter, minor diameter, and lead.
ii. Find the torque required to raise the load.
iii. Find the torsional and compressive stresses.
iv. Find the thread bending stress at the root of the thread.
v. Determine the maximum shear stress at the root of the thread.

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations (January 2020 Term)

Sub: **IPE 311** (Material Handling and Maintenance Management)

Full Marks: 180 Section Marks: 90 Time: 2 Hours (Sections A + B)

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

Include further instructions (if any)

1. (a) What is maintenance index? In your opinion, what is the most important maintenance index? **(05)**

   (b) Assume the failure rate of a manufacturing system is defined by $\lambda(n) = fe^{-n}$, where f is the system failure rate at the inspection frequency, $n = 0$. Develop an expression for the optimal value of n using the profit maximization model. **(10)**

   (c) A mechanical system can be in one of two states: operating normally or failed. Its constant failure and repair rates are λ_m and μ_m, respectively. Draw the system state space diagram and obtain expressions, by using the Markov method, for system time-dependent and steady-state availabilities and unavailabilities. Also, what are the assumptions associated with the Markov method? **(15)**

   (d) Three independent and identical machines form a parallel system. Each machine's times to failure are exponentially distributed with a mean time to failure of 250 h. The periodic preventive maintenance (PM) is performed after every 120 h. Calculate the system mean time to failure with and without the performance of periodic PM. If the three machines form a series system, calculate the system mean time to failure with and without the performance of periodic PM. **(15)**

2. (a) Briefly describe the strategies for reducing the system-level corrective maintenance time. **(10)**

   (b) An operating system can fail either fully or partially, and from the partially operating state it fails completely. The fully operational system undergoes periodic PM. More specifically, the system can be in either of four states: operational, partially operational, down for PM, or failed. The system is repaired from partially and fully failed states to the normal operating state. Use Markov model to derive expressions for system availability, probability of system down for PM, and probability of system failure. Explicitly mention all the assumptions that are associated with your model. **(35)**

3. (a) Distinguish between bulk weight and specific weight. **(10)**

   (b) Suppose, you have to convey a bulk load over a distance of 1 km with significant change in elevation. Now, mention the technical factors that will govern your choice of the most suitable conveying equipment. **(15)**

(c) Show that, **(20)**

For vertical devices-

$$N = \frac{QH}{270}(1 + \omega)\ \text{kW},$$

where the symbols carry their usual meaning.

SECTION – B

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

Include further instructions (if any)

4. (a) Draw a neat, labeled diagram of a belt conveyor. Mention the purpose of each major component. **(20)**

(b) Discuss (with proper diagrams) the different types of drive arrangements for belt conveyors. Contrast the drives based on their suitable applications. **(25)**

5. (a) Show that, for bucket elevator when-

$$l < r_b$$

and the pole lies within circumference of pulley, the discharge is centrifugal. Here, the symbols carry their usual meaning. **(25)**

(b) Contrast between the different types of buckets popularly used in bucket elevator (with neat and labeled diagram). What are their relative advantages and disadvantages? **(20)**

6. (a) Discuss the different types of resistances present in a screw conveyor. Now, obtain the total power required in a screw conveyor while taking into consideration the different types of resistances present. **(35)**

(b) Mention the applications where only roller conveyor can be used, i.e., there is no suitable replacement when designing the material handling system. **(10)**

L-3/T-II/IPE Date: 13/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-II B. Sc. Engineering Examinations (January 2020 Term)

Sub: **IPE 315** (Operations management)

Full Marks: 180 Section Marks: 90 Time: 2 Hours (Sections A + B)

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

1. (a) Productivity can be increased with the same machine efficiency – how? **(5)**

(b) What are the three elements that need to be reliable for a good forecast? Discuss. **(8)**

(c) In balancing demand and capacity, you need to choose the alternative that best satisfies your objectives, not the one with the lowest cost - why? **(7)**

(d) How can poor-quality raw materials affect company's performance? **(5)**

(e) From the following table and data, decide the machine you want to buy and explain the reason to support your decision. **(20)**

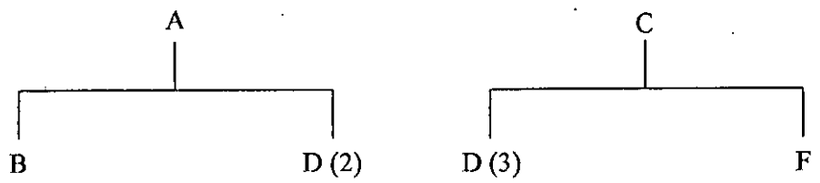
Machine	Fixed Cost (Tk)	Capacity (unit)
1	10000	500
2	15000	750
3	20000	1000

Revenue, R = Tk. 30/unit
Variable cost, V = Tk 10/unit
Total Demand D = 650~850 unit

Conditions to be applied:
1. No loss allowed
2. Need to satisfy market demand

2. (a) "Process quality is directly proportional to quantity" – do you think the statement is correct? How? If not, what should be the correct statement and why? **(5)**

(b) Complete the inventory database tables for following BOM: **(25)**



Week No.	1	2	3	4	5	6
Gross requirements A				80		
Gross requirements C						50

For A (LT = 1 wk; lot size = 70)

Week No.	1	2	3	4	5	6
Gross requirements						
Scheduled receipt	70					
Projected on-hand inventory (17)						
Planned receipt						
Planned order release						

For C (LT = 1 wk; lot for lot)

Week No.	1	2	3	4	5	6
Gross requirements						
Scheduled receipt						
Projected on-hand inventory						
Planned receipt						
Planned order release						

For D (LT = 1 wk, Lot size = 100)

Week No.	1	2	3	4	5	6
Gross requirements						
Scheduled receipt	100					
Projected on-hand inventory (25)						
Planned receipt						
Planned order release						

(c) For the following task table, calculate the minimum required number of stations and efficiency to have a desired output of 360 units in 3 hrs. Also assign the jobs into required work stations. **(15)**

Task	Successor	Duration (sec)
C	----	16
D	G	13
B	F, C	18
H	A, B, I	14
F	----	16
G	B, I	16
E	H	15
A	F	17
I	C	18

3. (a) Including or excluding material cost provides the same EOQ when there is no quantity discount – why? **(6)**

(b) FOQ and L4L are two different types of ordering scheme. Out of these two, application of FOQ is the most economic. Why? **(6)**

(c) Master Production Schedule (MPS) is exactly opposite to Aggregate Planning – Discuss with examples. **(8)**

(d) Government barrier and trade block are not included in factor rating scale for location selection – why? **(7)**

(e) Find the EOQ for the following data: **(18)**

Annual Demand = 1000 unit
Ordering cost = $ 15 per order
Holding cost = $ 4 per unit per year
Cost per unit = $ 20 for lot size 1~99
= $ 19.75 for lot size 100~199
= $ 19.60 for lot size 200~299
= $ 19.40 for lot size 300~399
= $ 19.25 for lot size 400~up

What will be the total cost for this amount of order quantity including material price?

SECTION – B

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

4. (a) Why "Effective Capacity" is always less than "Available Capacity" for a machine? **(20)**

   (b) Each of seven jobs needs to go through work centers 1 (machine 1) and 2 (machine 2). Find the optimum sequence of jobs using Johnson's rule. **(25)**

	Job Times (Hours)	
Job	Work Center A	Work Center B
1	3.2	4.2
2	4.7	1.5
3	2.2	5.0
4	5.8	4.0
5	3.1	2.8
6	6.7	3.3
7	5.5	4.3

5. (a) Based on classification of manufacturing systems, what type of systems do these industries (Apparel, Furniture, Cement) follow, or belong to? Justify your answer. **(20)**

   (b) Describe the role of bottleneck in a mass production system. **(25)**

6. (a) Out of 7 wastes described in "Lean Manufacturing System", probably "Inventory waste" is the most serious one in the context of Bangladesh. Why? **(20)**

   (b) "Examine" step of 'Method Study' uses questioning technique, especially on "Purpose, Place, Sequence, Person, and Means". Explain "Purpose and Person" in the context of any practical example. **(25)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations (January 2020 Term)

Sub: **IPE 319** (Quality Management)

Full Marks: 180 Section Marks: 90 Time: 2 Hours (Sections A + B)

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

1. a) What is Chebyshev's theory? How is it related to Statistical Quality Control? (20)
   b) Describe the linkage between Process Capability analysis and Motorola's Six-Sigma program (25)

2. a) Describe the core concept of Design of Experiment. What major barriers a company in Bangladesh may face if they decide to implement this? Write point-by-point. (20)
   b) A drilling machine is producing drills (holes) in a flat thick sheet for a customer. The design specifies that the inside diameter of the drills must be within 10 to 14 mm. The quality inspector takes a sample of 5 components every day, for a period of 15 days, to measure the diameter. The average range of diameters of the 15 samples (of size 5 each) of components produced in 15 days is 4.2 mm. Measure the process capability of this drilling operations. For a sample size 5, $d_2 = 2.326$. (25)

3. a) What do you understand by a compliance system? Compare ISO9000 QMS and TQM in improving quality. (20)
   b) There are different types of quality losses, namely Smaller-the-better, Bigger-the-better, Nominal-the-best, as per Taguchi Loss function. For a garments product, identify three quality characteristics. Which type of quality loss is suitable for those 3 quality characteristics (25)

SECTION – B

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

4. a) Describe and differentiate between Juran's quality cost model and the alternative quality cost model. (20)
   b) Describe the typical histogram shapes and their meanings. (15)
   c) How RPN is calculated in FMEA? Explain. (10)

5. a) Explain how BPR differs from TQM. What are the risks and barriers to BPR? (20)
   b) Describe the distinguishing characteristics of TQM. (15)
   c) Construct a table that summarizes the main contributions of the quality gurus. (10)

6. a) What are the policies and goals of Kaizen? List the major losses and their categories that Kaizen activities sought to eliminate in an organization. (20)

b) Which basic tool of TQM is used for ABC analysis? Describe it with a suitable example. (15)

c) Which award system is different from the other two award systems on its focus on application of statistical techniques? List the main evaluation criteria of this award system. (10)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations (January 2020 Term)

Sub: **IPE 329** (Numerical Analysis)

Full Marks: 180 Section Marks: 90 Time: 2 Hours (Sections A + B)

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

1. (a) The Taylor polynomial of degree n for $f(x) = e^x$ is $\sum_{i=0}^{n}\left(\frac{x^i}{i!}\right)$. Use the Taylor polynomial of degree nine and three-digit chopping arithmetic to find an approximation to e^{-5} by each of the following methods. **(15)**

(i) $e^{-5} \approx \sum_{i=0}^{9}\frac{(-5)^i}{i!} = \sum_{i=0}^{9}\frac{(-1)^i(5)^i}{i!}$

(ii) $e^{-5} = \frac{1}{e^5} \approx \frac{1}{\sum_{i=0}^{9}\frac{(5)^i}{i!}}$

(iii) An approximate value of e^{-5} correct to three digits is 6.74×10^{-3}. Which formula, (i) or (ii), gives the most accuracy, and why?

(b) (i) How many multiplications and additions are required to determine a sum of the form $\sum_{i=1}^{n}\sum_{j=1}^{i} a_j b_j$? **(10)**

(ii) Modify the sum in part (i) to an equivalent form that reduces the number of computations.

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

(d) Use the forward-difference formulas and backward-difference formulas to determine each missing entry in the following table. **(10)**

x	$f(x)$	$f'(x)$
0.5	0.4794	
0.6	0.5646	
0.7	0.6442	

2. (a) Let $f(x) = (x+2)(x+1)x(x-1)^3(x-2)$. To which zero of f does the Bisection method converge when applied on the following intervals? **(20)**
(i) $[-3, 2.5]$, (ii) $[-2.5, 3]$, (iii) $[-1.75, 1.5]$, (iv) $[-1.5, 1.75]$.

(b) An object falling vertically through the air is subjected to viscous resistance as well as to the force of gravity. Assume that an object with mass m is dropped from a height s_0 and that the height of the object after t seconds is **(10)**

$$s(t) = s_0 - \frac{mg}{k}t + \frac{m^2g}{k^2}(1 - e^{-kt/m}),$$

where, $g = 32.17$ ft/s^2 and k represents the coefficient of air resistance in lb-s/ft. Suppose $s_0 = 300$ ft, $m = 0.25$ lb, and $k = 0.1$ lb-s/ft. Use fixed-point iteration to find, to within 0.01 s, the time it takes this quarter-pounder to hit the ground.

(c) (*i*) Find approximations to within 10^{-5} to all the zeros of the following polynomial by first finding the real zeros using Newton's method and then reducing to polynomials of lower degree to determine any complex zeros. **(15)**

$$f(x) = x^4 + 5x^3 - 9x^2 - 85x - 136$$

(*ii*) Repeat (*i*) using Müller's method.

3. (a) Use Newton's method to approximate, to within 10^{-4}, the value of x that produces the point on the graph of $y = x^2$ that is closest to (1, 0). **(10)**

(b) $f(x) = 10x^3 - 8.3x^2 + 2.295x - 0.21141 = 0$ has a root at $x = 0.29$. Use Newton's method with an initial approximation $x_0 = 0.28$ to attempt to find this root. Explain what happens. **(08)**

(c) The fourth-degree polynomial, $f(x) = 230x^4 + 18x^3 + 9x^2 - 221x - 9$, has two real zeros, one in $[-1, 0]$ and the other in $[0, 1]$. Attempt to approximate these zeros to within 10^{-6} using the method of false position. **(10)**

(d) Consider the following linear system **(17)**

$$\begin{aligned} 1.19x_1 + 2.11x_2 - 100x_3 + x_4 &= 1.12. \\ 14.2x_1 - 0.122x_2 + 12.2x_3 - x_4 &= 3.44. \\ 100x_2 - 99.9x_3 + x_4 &= 2.15. \\ 15.3x_1 + 0.110x_2 - 13.1x_3 - x_4 &= 4.16. \end{aligned}$$

Actual solution [0.176, 0.0126, −0.0206, −1.18].

(*i*) Use Gaussian elimination and three-digit rounding arithmetic to solve the above linear system, and compare the approximations to the actual solution.

(*ii*) Repeat (*i*) using Gaussian elimination with partial pivoting and three-digit rounding arithmetic.

SECTION – B

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

4. (a) Given the data **(18)**

x	1	2	3	5	7	8
$f(x)$	3	6	19	99	291	444

(i) Calculate $f(4)$ using Newton's interpolating polynomials of order 1 through 4. Choose your base points to attain good accuracy. What do your results indicate regarding the order of the polynomial used to generate the data in the table?

(ii) Employ inverse interpolation to determine the value of x that corresponds to $f(x) = 300$ for the given data.

(b) Compare between Newton and Lagrange polynomials. **(10)**

(c) Idealized spring-mass systems have numerous applications throughout engineering. **(17)** Figure 4(c) shows an arrangement of four springs in series being depressed with a force of 2000 kg. The k's are spring constants. Spring constants k_1 through k_4 are 150, 50, 75, and 225 N/m, respectively.

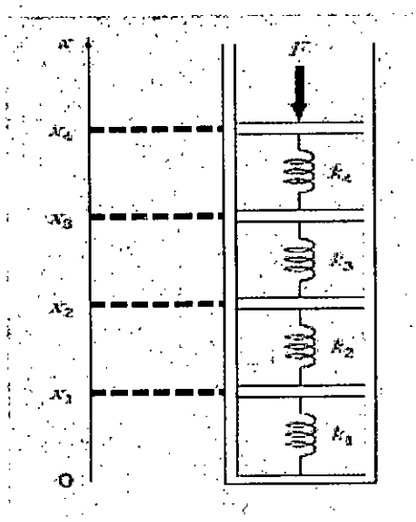


Figure: 4(c)

(i) At equilibrium, develop the force-balance equations defining the interrelationships between the springs.

(ii) Compute the x's.

5. (a) $A=\begin{bmatrix} 0.15 & 0.25 & 0.5 & 1 \\ 0.55 & 0.65 & 0.25 & 1 \\ 3.5 & 2 & 1.5 & 1 \\ 0.5 & 0.25 & 0.45 & 1 \end{bmatrix}$ **(18)**

(i) Use LU Decomposition algorithm to find the inverse of this matrix.

(ii) Find the condition number of this matrix.

(b) Prove that the number of multiply and divide flops involved in the decomposition phase of LU Decomposition algorithm is $\frac{n^3}{3}-\frac{n}{3}$ by writing a pseudo code for the particular algorithm. **(15)**

(c) Discuss about the features of the LU Decomposition algorithm. **(04)**

(d) Write a short note on stimulus-response computation. **(08)**

6. (a) Evaluate the following integral: **(20)**

$$\int_{-2}^{4}(1-2x-5x^3+2x^4)$$

Use,

(i) Composite trapezoidal rule, with n=2

(ii) Single application of Simpson's 1/3 rule

(iii) Multiple application of Simpson's 1/3 rule with n=4

(iv) Simpson's 3/8 rule

(v) Simpson's 1/3 rule in conjunction with Simpson's 3/8 rule for n=5.

In each case, compute the true error and indicate which provides the highest accuracy.

(b) Use Euler's method to numerically integrate the following equation: **(10)**

$$\frac{dy}{dx} = -3x^3 + 12x^2 - 25x + 9.5$$

From $x = 0$ to $x = 1$ with a step size of 0.5. The initial condition at $x = 0$ is $y = 1$. Find the true error at each iteration.

(c) 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)**