

(3 Hours)

Total Marks: 80

N.B. : (1) Question No. 1 is compulsory.

(2) Attempt any three questions out of remaining five questions

Q.1. (a) By using matrices, Solve the following system of linear equation (5)

$$x+y+z=9, \quad 2x+5y+7z=52, \quad 2x+y-z=0.$$

(b) Differentiate between Simple Random Sampling and Stratified Random Sampling (5)

(c) Explain Scatter plots. (5)

(d) Compare constrained and non constrained optimization Techniques (5)

Q.2. (a) Find Singular Value of Decomposition of matrix $A = \begin{bmatrix} 1 & 1 \\ 0 & 1 \\ -1 & 1 \end{bmatrix}$ (10)

(b) A company gave an intensive training to its salesmen to increase the sales. A random sample of 10 salesmen was selected and the value (in lakhs of Rupees) of their sales per month, made before and after the training is recorded in the following table. (10)

Salesman	1	2	3	4	5	6	7	8	9	10
Before	15	22	6	17	12	20	18	14	10	16
After	17	23	16	20	14	21	18	20	10	11

Test whether there is any increase in mean sales at 5% level of significance.

Table Values: $t(\alpha, df, \text{test type})$

$$t(0.05, 10, \text{one-tailed}) = 1.812$$

$$t(0.05, 9, \text{one-tailed}) = 1.833$$

$$t(0.05, 10, \text{two-tailed}) = 2.228$$

$$t(0.05, 9, \text{two-tailed}) = 2.262$$

Q.3. (a) A survey was conducted with 500 female students of which 60% were intelligent, 40% had uneducated fathers, while 30% of the not intelligent female students had educated fathers. Test the hypothesis that the education of fathers and intelligence of female students are independent at 5% level of significance. (Given $\chi^2(1, 0.05) = 3.841$) (10)

(b) What is a Graph? Explain any four types of Graph along with its uses. (10)

Q.4. (a) Explain types of data. Compare and contrast quantitative and qualitative data. (10)

(b) Discuss the need for exploratory data analysis and explain types of Exploratory data analysis. (10)

Q.5. (a) Minimize the function $f(x_1, x_2) = 4x_1 + 8x_2 - x_1^2 - x_2^2$ (10)
subject to $x_1 + x_2 = 4, \quad x_1, x_2 \geq 0$ (b) Find the minimizer of $f(x) = x^2 + \frac{54}{x}$ using bisection method in (2,5) within a range of 0.3 (10)

- Q.6. Write short notes on (any four) **(20)**
- (a) Four Fundamental Subspaces **(5)**
 - (b) Principal Component Analysis (PCA) algorithm. **(5)**
 - (c) Benefits of Dimensionality Reduction. **(5)**
 - (d) 5 Number Summary (the box and whisker plot.) **(5)**
 - (e) Gradient based optimization Techniques **(5)**
 - (f) Exponential function and their graph. **(5)**
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Time:3 Hours

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- NB:-
- 1) Draw neat sketches whenever necessary.
 - 2) **Q.No.1** is compulsory.
 - 3) Solve any **Three** questions from the remaining **Five** questions.
 - 4) Assume suitable data wherever necessary.

- Q.1** Solve any **five** from following six questions : **20**
- a) With a help of neat sketch explain Catalytic converter
 - b) Justify - variation in specific heat is responsible for changes in efficiency of air standard efficiency of engine.
 - c) In air standard Otto-cycle, the compression ratio is 10. The condition at the beginning of the compression process is 100 kPa and 27 °C. Heat added at constant volume is 1500 KJ/Kg, while 700 kJ/kg of heat is rejected during the other constant volume process in the cycle. Specific gas constant for air = 0.287 kJ/kg K. Find the mean effective pressure (In kPa) of the cycle.
 - d) Explain effects of spark advancement and retardation on the engine performance.
 - e) Explain that the requirement of air motion and swirl in CI engine combustion chamber is much more stringent than in an SI Engine.
 - f) Explain why turbocharged engines may have inferior values of power output and fuel consumption than naturally aspirated engines especially at low speed.
- Q.2 a)** Calculate the diameter of fuel orifice of 4 stroke engine which develops 25 kW per cylinder at 2500 rpm. The specific fuel consumption is 0.3 kg/kW h and fuel is injected at a pressure of 150 bar over a crank travel of 25°. The pressure in the combustion chamber is 40 bar. Coefficient of velocity is 0.875 and specific gravity is 0.8762 **10**
- b)** A single jet carburetor is to supply 6 kg/ min of air & 0.44 kg/min of petrol of specific gravity 0.74. The air is initially at 1 bar & 27 °C. Assuming an isentropic coefficient of 1.35 for air, determine the diameter of the venturi if the air speed is 90 m/s and the velocity coefficient of venturi is 0.85 (ii) the dia of the jet, if the pressure drops at the jet is 0.8 times the pressure drop at the venturi, and the coefficient of the discharge for the jet is 0.66. **10**
- Q.3 a)** A test on a single-cylinder, 4 stroke oil engine having a bore of 15 cm and stroke 30 cm gave the following results: speed 300 rpm; brake torque 200 Nm; Indicated mean effective pressure 7 bar; fuel consumption 2.4 kg/h; cooling water flow 5 kg/min; cooling water temperature rise 35°C; air-fuel ratio 22; exhaust gas temperature 410°C; barometer pressure 1 bar; room temperature 20°C. The fuel has a calorific value of 42 MJ/kg and contains 15% by weight of hydrogen. Take latent heat of vaporization as 2250 kJ/kg. Determine the Indicated thermal Efficiency and volumetric efficiency based on atmospheric conditions. Also draw up a heat balance sheet in terms of kJ/min. Take C_p for dry exhaust gas as 1 kJ/kg-k and superheated steam $C_p = 2.1$ kJ/kg-k; $R = 0.287$ kJ/kg K **10**
- b)** What are the different functions of lubricating system? State the different lubricating systems used for I C Engines. Explain any one of them.

- Q.4 a)** A test of one hour duration was conducted on a single cylinder engine having a bore of 300 mm and stroke of 450mm. fuel consumed is 8.8 kg at an average speed of 200rpm. The mean effective pressure of the engine 5.8bar and calorific value of fuel is 41800 kJ/kg. The brake friction load is 1860N for a brake wheel of diameter of 1.22m. Quantity of cooling water consumed during the test is 650 kg with a rise in temperature of 22°C. Draw the heat balance sheet on hourly and percentage basis and also Calculate: i) Mechanical efficiency, ii) Brake thermal efficiency **10**
- b)** Explain the types of combustion chambers used in SI engines and compare them. Why maximum diameter of SI engine combustion chambers is limited? **10**
- Q.5 a)** In a test of a single cylinder 4 stroke diesel engine with bore 400mm and stroke 450mm, the following observations were made: **10**
- Duration of test=1hr
Fuel Consumption= 7.5kg
Indicated mean effective press=3.75bar
Calorific value of fuel = 44500 KJ/Kg
Total Air consumption=361kg
Total Revolutions =12000
Net brake load=1500N
Brake drum diameter =180 cm
Rope diameter=3cm
Quantity of cooling water used = 600 kg Temperature rise=42⁰C
Exhaust gas temperature=300⁰ C
Room Temperature =20⁰C
Cp for exhaust gases=1.01 KJ/KgK
Calculate:
1) Mechanical Efficiency 2) Indicated and Brake thermal Efficiency 3) Draw heat balance sheet on minute basis.
- b)** With neat sketch explain compression induced swirl and divided combustion chamber. Also state its advantages and disadvantages. **10**
- Q.6 a)** Write short note on (Any four): **20**
- Thermo-syphon cooling system
 - Exhaust gas re-circulation
 - Turbo charging v/s supercharging
 - Alternative fuels in IC Engine
 - Air box method
 - VCR Engine

[Time: 03 Hours]

[Total marks: 80]

N.B.

- 1) Question No.1 is compulsory
- 2) Attempt any three out of remaining questions
- 3) Draw neat sketches to illustrate your answers
- 4) Figures to the right indicate full marks.
- 5) Use of **Standard Data Book** is permitted

Q1 Answer any **four** of the following

20

- a) Draw and explain different types of fatigue cycles.
- b) What is S-N Diagram? Draw the S-N diagram for ferrous and non-ferrous materials.
- c) What is spring index of coil spring? Give its significance in the design.
- d) Explain the surface finish factor and size factor with respect to machine element subjected to variable load
- e) Explain ergonomic consideration in design with suitable examples

Q2 Design a rigid type of flange coupling to connect two shafts. The input shaft transmits 40

10

- a) kW power at 220 rpm to the output shaft through the coupling. The service factor for the application is 1.5. Select suitable materials for various parts of the coupling, design the coupling and specify the dimensions of its components.
- b) Write the expression of Beam strength equation and Estimation of module based on beam strength defining each term.

10

Q3 i) Distinguish between design synthesis and design analysis.

10

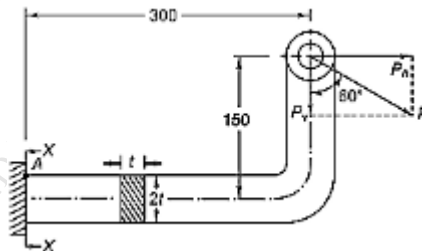
- a) ii) What are preferred numbers? Give R2 series for 1000mm shaft.

- a)
- b) It is required to design a cotter joint to connect two steel rods of equal diameter. Each rod is subjected to an axial tensile force of 60 kN. Design the joint and specify its main dimensions.

10

Q4 A wall bracket with a rectangular cross-section is shown in Figure. The depth of the cross-section is twice of the width. The force P acting on the bracket at 60 degree to the vertical is 6 kN. The material of the bracket is grey cast iron FG 200 and the factor of safety is 3.5. Determine the dimensions of the cross-section of the bracket. Assume maximum normal stress theory of failure.

10



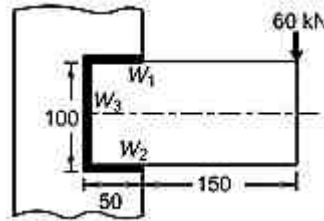
- a)
- b) A propeller shaft is required to transmit 59 kW power at 500 rpm. It is a hollow shaft, having an inside diameter 0.6 times of outside diameter. The shaft is made of steel with an ultimate tensile strength of 730 MPa and yield strength of 580 MPa. Determine the shaft diameter using the ASME code if, $k_b = 1.5$ and $k_t = 1.0$

10

- Q5 a) A helical compression spring, made of circular wire, is subjected to an axial force, which varies from 2.7 kN to 3.7 kN. Over this range of force, the deflection of the spring should be approximately 5 mm. The spring index can be taken as 5. The spring has square and ground ends. The spring is made of patented and cold-drawn steel wire with ultimate tensile strength of 1050 N/mm² and modulus of rigidity of 81370 N/mm². The permissible shear stress for the spring wire should be taken as 50% of the ultimate tensile strength. Design the spring and calculate:
- (i) wire diameter;
 - (ii) mean coil diameter;
 - (iii) number of active coils;
 - (iv) total number of coils;
 - (v) Free length of the spring;
 - (vi) pitch of the coil.
 - (vii) required spring rate; and
 - (viii) actual spring rate

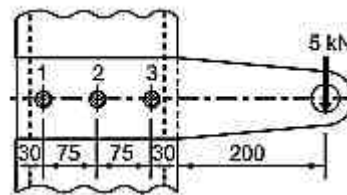
Draw a neat sketch of the spring showing various dimensions.

- b) A welded connection, as shown in Figure, 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



- Q6 a) It is required to design a pair of spur gears with 20° full-depth involute teeth based on the Lewis equation. The velocity factor is to be used to account for dynamic load. The pinion shaft is connected to a 12 kW, 1540 rpm motor. The starting torque of the motor is 150% of the rated torque. The speed reduction is 4 : 1. The pinion as well as the gear is made of plain carbon steel 40C8 (Sut = 600 N/mm²). The factor of safety can be taken as 1.5. Design the gears, specify their dimensions.

- b) A steel plate subjected to a force of 5 kN and fixed to a channel by means of three identical bolts is shown in Figure. The bolts are made from plain carbon steel 45C8 (Syt = 380 N/mm²) and the factor of safety is 3. Specify the size of bolts.



- N.B:** 1) Question No. 1 is **compulsory**.
 2) Attempt any **THREE** questions out of remaining **FIVE** questions
 3) Assume suitable data wherever necessary.
 4) Use of Graph paper is allowed.
 5) Figures to the right indicate full marks

1. Answer the following questions.

20

- i) Distinguish between Line, End and Wavelength Standard.
- ii) Distinguish between open loop and closed loop control system with suitable examples.
- iii) Explain working LVDT with neat sketch.
- iv) While measuring the speed of steam turbine with stroboscope, stationary image was observed for three consecutive stroboscope settings of 3000, 4000 and 5250 flashes per minute. Calculate the rotational speed of turbine.

2. (A) Reduce the following block diagram and find the transfer function.

10

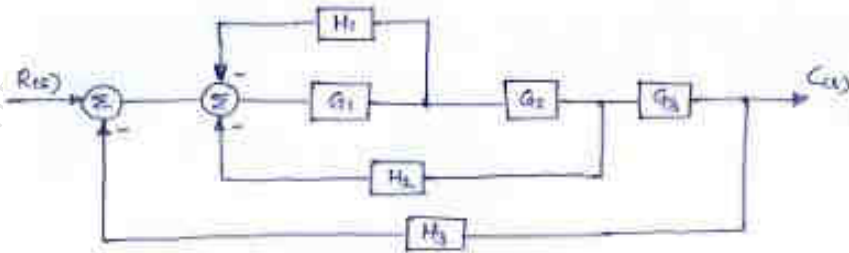


Fig.1

- (B) What is Taylors principle, explains in detail? Write note on Hole Basis System and Shaft Basis System.

10

3. (A) For a particular unity feedback system

10

$$G(s) = \frac{10}{S(S + 1)(S + 5)}$$

Sketch the Bode Plot, Find ω_{gc} , ω_{pc} , GM and PM. Comment on stability.

- (B) b) A unity feedback system characterized by an open loop transfer function

10

$$G(s) = \frac{K}{S(S + 2)(S^2 + 4S + 5)}$$

Determine the gain K. so that the system will be stable.

4. (A) Explain principle of interference. How flatness can be checked with help of optical interferometer. **10**

(B) What are desired, Modifying, Interfering input? Explain with example of each. Also suggest method to minimize the effect of Modifying & Interfering inputs. **10**

5. (A) Draw the Root-Locus of the system having **10**

$$G(s)H(s) = \frac{K}{s(s+5)(s+10)}$$

(B) Draw neat labelled diagram of Taylor Hobson Talysurf and briefly explain working principle. State one major advantage and disadvantage of this instrument over Tomlinson surface meter. **10**

6. (A) What are the different elastic transducers used for pressure measurement? Illustrate working principle of any one transducer in detail. **10**

(B) Write short note on (any Two) **10**

- i) Parkinson's gear tester
- ii) Two wire method
- iii) Optical encoder

(3 Hours)

Total Marks: 80

Note:

1. Question No. 1 is compulsory.
2. Attempt any **THREE** out of the remaining **FIVE** questions.
3. Assume suitable data if necessary.
4. Use of Statistical Tables are allowed

Q. 1. Write short notes on **any FOUR** questions. (20)

- (a) Explain parametric and non-parametric test
- (b) Explain spearman's rank correlation
- (c) Describe any one type of sampling with example
- (d) Explain level of significance and confidence level
- (e) Explain types of correlations

Q. 2. (a) An ambulance service claims that it takes on an average 8.9 min for ambulance to reach its destination in emergency calls. To check on this claim the agency that licenses ambulance service has timed them on 50 emergency calls getting mean of 9.3 min with standard deviation of 1.6 min. What can they conclude at 5% level of significance. (10)

(b) To access the significance of possible variation in performance in a certain test between the convent school of a city, a common test was given to a few students taken at random from the senior fifth class of each of the four schools concerned. The results are given below, make an analysis of variance of data (10)

A	B	C	D
8	12	18	13
10	11	12	9
12	9	16	12
8	14	6	16
7	4	8	15

Q. 3. (a) Find from the following values of the demand and the corresponding price of a commodity, the degree of correlation between the demand and price by computing Karl Pearson's coefficient of correlation (10)

Demand in quintals	65	66	67	67	68	69	70	72
Price in paise per kg	67	68	65	68	72	72	69	71

(b) Fit a second-degree parabolic curve to the following data (10)

X :	1	2	3	4	5	6	7	8	9
Y :	2	6	7	8	10	11	11	10	9

- Q. 4.** (a) 7 fair dice are thrown 729 times. How many times do you expect at least four dice to show three or five? (10)
- (b) Explain different types of sampling with example (10)

- Q. 5.** (a) Fit a straight line to the following data (10)

X :	1	2	3	4	5	6
Y :	49	54	60	73	80	86

- (b) The following table give the number of breakdowns in a factory in various days of a week. Using Chi- Square Test check whether breakdown is uniformly distributed or not (10)

Days	Mon	Tue	Wed	Thu	Fri	Sat	Sun
No of Breakdowns	14	22	16	18	12	19	11

- Q. 6.** (a) Explain steps in Two-way ANOVA with example (10)
- (b) If discrete random variable has values (10)

X	1	2	3	4	5	6	7
P (X = x)	K	2K	3K	K^2	$K^2 + K$	$2K^2$	$4K^2$

Find

- i. K
- ii. Mean
- iii. Variance
- iv. $P(X \leq 6)$
- v. $P(X \geq 2 / X \leq 5)$