



**K. K. Wagh Institute of Engineering Education and Research,
Nashik**

(An Autonomous Institute from A. Y. 2022-23)

Model Answer key

Exam Seat No.:

End-Sem Examination-I

Academic Year: 2025-26

Class: F.Y

Branch Code: MCA

Name of Course: Research Methodology

Max. Marks: 60

Winter 2025

Sem: I

Program: MCA

Pattern: 2024

Course Code: 2409507

Duration: 2:30 Hrs.

Instructions: Candidates should read carefully the instructions printed on the Question Paper and on the cover page of the Answer Book, which is provided for their use.

1. This question paper contains TWO page(s).
2. Answer to each new question is to be started on a new page.
3. Assume suitable data wherever required but justify it.
4. Draw the neat, labelled diagrams, wherever necessary.
5. The last columns indicates the Course Outcome

Q. No.	Details	Max. Marks	CO No.	BT Level
Q.1	<p>a) Define research and identify the different types of research classified according to their application. [6Marks]</p> <p>Answer:</p> <p>Definition:</p> <p>Research is a systematic and organized effort to investigate a problem, generate new knowledge, or validate existing facts. It involves a logical approach to identify, collect, analyze, and interpret data to answer a specific question or test a hypothesis.</p> <p>Objectives of Research:</p> <ul style="list-style-type: none">➤ To explore new knowledge.➤ To solve practical problems.➤ To validate or test theories.➤ To provide a basis for decision making. <p>Types of Research (based on application):</p> <p>1. Basic Research:</p> <p>Conducted to gain fundamental knowledge without immediate practical application.</p>	[12]	CO ₁	L2



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<p>Example: Studying the genetic makeup of plants to understand resistance to pests.</p> <p>2. Applied Research:</p> <p>Solves specific practical problems.</p> <p>Example: Developing a pesticide to control a crop disease.</p> <p>3. Descriptive Research:</p> <p>Observes and describes phenomena as they exist.</p> <p>Example: Surveying consumer preferences for organic foods.</p> <p>4. Experimental Research:</p> <p>Tests cause-effect relationships under controlled conditions.</p> <p>Example: Studying the effect of fertilizer type on crop yield by controlling other factors.</p> <p>Importance:</p> <p>Helps in decision making and policy formulation.</p> <p>Provides a structured approach to problem-solving.</p> <p>Bridges the gap between theory and practice.</p> <p>Example:</p> <p>For instance, applying applied research in agriculture helps farmers choose the best crop varieties for higher yields under specific conditions.</p> <p style="text-align: center;">OR</p> <p>b) Explain experimental research with an example. [6Marks]</p> <p>Answer:</p> <p>Definition:</p> <p>Experimental research is a type of research where the investigator manipulates one or more independent variables to observe the effect on a dependent variable while controlling other influencing factors.</p> <p>Characteristics:</p> <ul style="list-style-type: none">➤ Has a clear hypothesis.➤ Involves manipulation of independent variables.➤ Uses controlled conditions to ensure reliability.➤ Results are measurable and analyzable.			
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<p>Steps in Experimental Research:</p> <ol style="list-style-type: none"> 1. Formulate the research problem and hypothesis. 2. Identify independent, dependent, and control variables. 3. Design the experiment (select experimental and control groups). 4. Conduct the experiment under controlled conditions. 5. Collect, record, and analyze data. 6. Draw conclusions and interpret results. <p>Example:</p> <p>A laboratory study testing the effect of sunlight exposure on plant growth:</p> <p style="padding-left: 20px;">Independent variable: Hours of sunlight per day.</p> <p style="padding-left: 20px;">Dependent variable: Plant height/growth rate.</p> <p style="padding-left: 20px;">Controlled variables: Soil type, water, temperature, fertilizer.</p> <p>Discussion:</p> <p>By systematically manipulating sunlight while keeping other factors constant, researchers can determine the precise effect of sunlight on plant growth.</p> <p>So, Experimental research provides empirical evidence, validates hypotheses, and allows prediction of outcomes in controlled environments.</p>			
<p>c) Discuss the importance of sample design in research. [6Marks]</p> <p>Answer:</p> <p>A sample design is a framework that outlines how to select a subset (sample) from the population for research. It is an essential step because it ensures that the sample accurately represents the entire population, which allows researchers to generalize findings reliably.</p> <p>Importance of Sample Design:</p> <p>Representativeness: A well-designed sample reflects the characteristics of the population, reducing bias.</p> <p>Cost and Time Efficiency: Studying a sample is more practical than collecting data from the entire population.</p> <p>Accuracy of Results: Proper sampling reduces errors and improves the reliability of conclusions.</p> <p>Feasibility: Enables research in situations where studying the entire</p>		CO 1	L2



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<p>population is impossible.</p> <p>Supports Statistical Analysis: Proper sampling allows use of statistical techniques to infer population parameters.</p> <p>Example: In a college survey to assess student satisfaction, selecting 100 students using stratified random sampling ensures representation across departments, years, and genders.</p> <p>As per study, a carefully designed sample ensures valid, accurate, and generalizable research results while optimizing resources.</p> <p style="text-align: center;">OR</p> <p>d) Describe the different methods used to collect primary data and explain when each method is most appropriately applied. [6Marks]</p> <p>Answer:</p> <p>Primary data refers to original data collected firsthand by the researcher. There are several methods to collect primary data:</p> <p>Surveys / Questionnaires:</p> <p>Collects structured responses from a large number of participants.</p> <p>Use: Best for gathering opinions, attitudes, or demographic information.</p> <p>Example: Surveying students about cafeteria food preferences.</p> <p>Interviews:</p> <p>Involves direct interaction with respondents to get detailed information.</p> <p>Use: Suitable for in-depth understanding, especially for sensitive or complex issues.</p> <p>Example: Interviewing farmers to understand challenges in crop production.</p> <p>Observations:</p> <p>Researcher observes and records behavior or events as they occur naturally.</p> <p>Use: Best when real behavior needs to be studied without relying on self-reports.</p> <p>Example: Observing customer movement patterns in a supermarket.</p> <p>Experiments:</p> <p>Manipulation of variables to study cause-and-effect relationships.</p> <p>Use: Ideal for testing hypotheses under controlled conditions.</p> <p>Example: Testing the effect of different fertilizers on plant growth in a</p>			
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	<p>lab or field experiment.</p> <p>Choosing the appropriate primary data collection method depends on research objectives, type of data needed, resources, and the nature of the study. Proper selection ensures reliability, accuracy, and relevance of research findings.</p>			
<p align="center">Q.2</p>	<p>a) How would you use different literature review sources for building a strong background for your research? [6Marks]</p> <p>Answer:</p> <p>A literature review is a systematic examination of existing research and publications related to a topic. It helps to identify research gaps, avoid duplication, and provide a theoretical foundation for your study.</p> <p>Steps to Use Different Sources:</p> <p>Identify Relevant Sources: Use journals, books, conference proceedings, patents, theses, and online databases (Scopus, Google Scholar, PubMed).</p> <p>Categorize Information: Group findings by themes, methods, results, and gaps in knowledge.</p> <p>Critical Analysis: Evaluate the credibility, relevance, and limitations of each source.</p> <p>Synthesize Knowledge: Combine insights from multiple sources to form a coherent understanding of the topic.</p> <p>Identify Research Gaps: Highlight areas where further study is needed or existing results are inconsistent.</p> <p>Example: For a study on improving crop yield, reviewing research articles on fertilizer types, irrigation methods, and pest control strategies can help design the experiment effectively.</p> <p>Using diverse literature review sources ensures a strong research foundation, supports hypothesis formulation, and guides methodology planning.</p> <p align="center">OR</p> <p>b) How would you plan laboratory experiments for validating your research ideas? [6Marks]</p> <p>Answer:</p> <p>Laboratory experiments test hypotheses under controlled conditions to validate research ideas.</p>	<p align="center">[12]</p>	<p align="center">CO 2</p>	<p align="center">L3</p>



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<p>Steps to Plan Experiments:</p> <p>Define Objectives: Clearly state what the experiment intends to validate or measure.</p> <p>Identify Variables: Determine independent variables (factors to manipulate), dependent variables (outcomes to measure), and control variables (kept constant).</p> <p>Design Experiment: Decide on sample size, number of trials, and method of measurement. Use appropriate experimental designs like factorial or randomized designs.</p> <p>Conduct the Experiment: Follow the protocol carefully, record observations accurately, and maintain consistency.</p> <p>Analyze Results: Apply statistical techniques to interpret the data and determine if the hypothesis is supported.</p> <p>Draw Conclusions: Compare findings with expectations, literature, and research objectives.</p> <p>Example: Testing the effect of different fertilizer concentrations on plant growth in pots under controlled light and water conditions to identify the optimal level.</p> <p>Properly planned laboratory experiments validate research ideas, provide empirical evidence, and help refine hypotheses for further study.</p>			
<p>c) Using public health as an example, show how you would apply research prioritization to choose the most important problem—such as low childhood vaccination rates. [6Marks]</p> <p>Answer: Scenario: Low childhood vaccination rates.</p> <p>Definition: Research prioritization is the systematic process of identifying, ranking, and selecting research problems based on their significance, feasibility, and potential impact.</p> <p>Steps:</p> <ol style="list-style-type: none"> 1. Identify Problems: Collect data on childhood vaccination coverage and prevalence of preventable diseases. 2. Assess Significance: Consider the severity of the health issue, number of affected children, and potential social/economic impact. 3. Review Feasibility: Check availability of resources, expertise, and time for research. 		CO 2	L3



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<p>4. Rank Problems: Use scoring or ranking criteria to select the most critical issue.</p> <p>5. Select Priority Problem: Choose the problem with high impact and feasible intervention.</p> <p>Justification/Example:</p> <p>By prioritizing low vaccination rates, public health researchers can design targeted interventions such as awareness campaigns, mobile vaccination drives, or policy recommendations, which could prevent outbreaks and improve child health outcomes.</p> <p>Prioritization ensures efficient use of resources, addresses the most critical health issues, and enhances the societal impact of research.</p> <p style="text-align: center;">OR</p> <p>d) How would you frame a hypothetical proposal for improving an existing system or process? [6Marks]</p> <p>Answer:</p> <p>A hypothetical proposal is a structured plan that outlines how to enhance an existing system or process, even before actual implementation. It demonstrates logical reasoning, feasibility, and expected outcomes.</p> <p>Steps to Frame the Proposal:</p> <p>Identify the Problem: Clearly define the inefficiency, limitation, or challenge in the current system or process.</p> <p>Example: A university cafeteria wastes a large amount of leftover food daily.</p> <p>Set Objectives: Determine the goals of the improvement.</p> <p>Example: Reduce food waste by 30%, optimize portion sizes, and improve cost efficiency.</p> <p>Review Existing Practices: Analyze how the current system operates and identify areas for improvement.</p> <p>Example: Observe food consumption patterns, menu choices, and peak hours in the cafeteria.</p> <p>Propose Hypothetical Solutions: Suggest strategies or interventions that could address the problem.</p> <p>Example: Introduce smaller serving portions, allow customizable meals, implement a digital pre-order system, or educate students on reducing waste.</p> <p>Outline Methodology: Describe how the proposed solution can be tested</p>			
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	<p>or implemented, including tools, resources, and steps.</p> <p>Example: Conduct a 2-week pilot with smaller portions and track leftover food quantities.</p> <p>Predict Expected Outcomes: Estimate the benefits or improvements if the proposal is implemented.</p> <p>Example: Reduction in leftover food, cost savings for the cafeteria, and increased awareness among students.</p> <p>Emphasize feasibility, potential impact, and how the proposal contributes to system efficiency or sustainability.</p> <p>Framing a hypothetical proposal involves problem identification, goal setting, reviewing current practices, suggesting solutions, outlining methodology, and predicting outcomes. This structured approach helps in decision-making, planning, and preparing for real-world implementation.</p>			
Q.3	<p>a) Apply the process of simulation model formulation to design a traffic signal timing system. [6Marks]</p> <p>Answer: A traffic signal timing system can be modeled using simulation to optimize traffic flow and reduce congestion.</p> <p>Steps to Apply Simulation Model Formulation:</p> <p>Define the System: Identify key components such as intersections, traffic lanes, vehicle arrival rates, and traffic signals.</p> <p>Identify Objectives: Determine what the simulation should achieve—e.g., minimizing waiting time, reducing congestion, or optimizing signal timing.</p> <p>Determine Input Variables: Inputs include vehicle arrival rates, traffic density, pedestrian crossing times, and signal cycle durations.</p> <p>Formulate the Model: Represent the system mathematically or through flow diagrams. Include rules such as green-light duration based on traffic volume.</p> <p>Validate the Model: Compare the simulation output with real-world traffic patterns to ensure accuracy.</p> <p>Run Simulation & Analyze Results: Test different signal timings to find optimal durations for green, yellow, and red lights.</p> <p>Implement Findings: Apply the best timing configuration to improve traffic flow and reduce waiting time.</p> <p>Example: Using a simulation software like VISSIM, the timing for a</p>	[12]	CO 3	L3



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<p>busy city intersection can be optimized by adjusting the green-light duration based on peak and off-peak hours.</p> <p>Simulation modeling allows safe testing of multiple scenarios without disrupting actual traffic, enabling efficient signal design and better traffic management.</p> <p style="text-align: center;">OR</p> <p>b) Demonstrate how graphs can be applied to model a communication network and explain each step. [6Marks]</p> <p>Answer:</p> <p>A graph-based model represents a communication network as a set of nodes (devices) and edges (connections), helping to analyze network structure and performance.</p> <p>Steps to Model a Communication Network Using Graphs:</p> <p>Identify Nodes: Each node represents a device in the network, such as computers, routers, or servers.</p> <p>Define Edges: Edges represent communication links between devices, which can be directed (one-way) or undirected (two-way).</p> <p>Assign Weights: If needed, assign weights to edges to represent distance, bandwidth, or latency.</p> <p>Construct the Graph: Draw the network graphically, showing nodes and connecting edges.</p> <p>Analyze Graph Properties: Study connectivity, shortest paths, network flow, and bottlenecks.</p> <p>Use for Decision Making: Optimize routing, identify critical nodes, or plan for network expansion.</p> <p>Example: Modeling a corporate LAN where servers and workstations are nodes and Ethernet connections are edges; shortest-path algorithms can optimize data routing.</p> <p>Graph-based modeling provides a clear visual and analytical representation of communication networks, helping design, optimize, and troubleshoot efficiently.</p>			
<p>c) Develop an ODE-based model to illustrate population growth using the logistic growth equation. [6Marks]</p> <p>Answer: Definition:</p> <p>An Ordinary Differential Equation (ODE) is a mathematical equation</p>	CO 3	L3	



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	<p>involving derivatives of a function that describes how the function changes over time.</p> <p>Application in Population Growth:</p> <p>Logistic growth model: $dP/dt = rP(1 - P/K)$</p> <p>P = population at time t</p> <p>r = intrinsic growth rate</p> <p>K = carrying capacity</p> <p>Steps to Formulate Model:</p> <ol style="list-style-type: none"> 1. Identify variables: P (population) as dependent, t (time) as independent. 2. Define growth mechanism: population grows proportionally to current population but slows near carrying capacity. 3. Write ODE: $dP/dt = rP(1 - P/K)$ 4. Solve ODE to obtain population over time. <p>Explanation:</p> <p>Initially, population grows exponentially.</p> <p>As it approaches K, growth slows and stabilizes.</p> <p>Example:</p> <p>Studying bacterial population growth in a lab culture where resources are limited.</p> <p>ODE models help predict population trends, assess resource requirements, and make decisions in ecology, public health, and agriculture.</p> <p style="text-align: center;">OR</p> <p>d)Apply the classification of mathematical models to categorize a city's population growth system and justify the type of model selected. [6Marks]</p> <p>Answer:</p>			
Q.4	<p>a) Apply the general model of a process to develop a model for a food-processing unit converting raw fruits into packaged juice. [6Marks]</p> <p>Answer: A food-processing unit converts raw fruits into packaged juice through several stages, including washing, sorting, pulping, pasteurization,</p>	[12]	CO 4	L3



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<p>packaging, and storage. The general model of a process helps to represent the input, output, and transformations in a structured manner.</p> <p>Steps to apply the general model:</p> <ol style="list-style-type: none">1. Identify Inputs: Raw fruits, water, sugar, energy, and labor.2. Define Process Stages: Map all steps such as washing, sorting, pulping, heating, and packaging.3. Determine Process Variables: Controllable variables like temperature, pulp consistency, and processing time; uncontrollable variables like fruit quality or ambient temperature.4. Identify Outputs: Packaged juice, yield quantity, and quality indicators (taste, color, shelf life).5. Formulate Relationships: Define equations or models that relate input and process variables to outputs. <p>Example: Predicting juice yield based on type of fruit and processing time allows optimization of resources and minimizes waste.</p> <p>This modeling approach helps streamline the production process, ensures consistent product quality, and aids in decision-making for efficiency improvements.</p> <p style="text-align: center;">OR</p> <p>b) Demonstrate how dependent and independent variables apply to modelling the output of a chemical reactor. [6Marks]</p> <p>Answer:</p> <p>In chemical reactor modeling, independent variables are those that can be controlled or manipulated, such as temperature, pressure, concentration of reactants, and flow rate. The dependent variable is the output or result influenced by the independent variables, such as reaction yield, conversion rate, or selectivity.</p> <p>Steps:</p> <ol style="list-style-type: none">1. Identify the independent variables affecting the reactor performance.2. Identify the dependent variable to be measured or predicted.3. Design experiments or simulations to study how changes in independent variables affect the dependent variable.4. Analyze data to establish cause-effect relationships. <p>Example: Increasing temperature (independent) in an esterification reaction can increase the reaction yield (dependent) up to an optimal point.</p>			
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<p>Understanding and modeling these relationships allows engineers to optimize reactor conditions for maximum efficiency and product quality.</p>			
<p>c) Develop a first-order design to study the effect of temperature and pressure on fuel efficiency of an engine. [6Marks] Answer: A first-order design (factorial design) studies the effect of independent variables (temperature and pressure) on a dependent variable (fuel efficiency).</p> <p>Steps:</p> <ol style="list-style-type: none"> 1. Select Factors: Temperature and pressure. 2. Define Levels: High and low settings for each factor. 3. Design Experiments: Use a factorial combination (e.g., $2 \times 2 = 4$ runs) to test all combinations. 4. Conduct Experiments: Measure fuel efficiency for each combination. 5. Analyze Data: Calculate main effects and determine which factor has the greatest influence on efficiency. <p>Example: Observing how high temperature and low pressure affect fuel consumption and engine performance.</p> <p>This design identifies the most influential variables, providing insight into optimizing engine performance efficiently.</p> <p style="text-align: center;">OR</p> <p>d) Apply Taguchi parameter design to develop a robust process for smartphone battery testing. [6Marks]</p> <p>Answer: The Taguchi method is a systematic approach to optimize process parameters to improve robustness and reduce variation.</p> <p>Steps:</p> <ol style="list-style-type: none"> 1. Identify Control Factors: Charging current, operating temperature, number of cycles. 2. Define Levels: Specify 2–3 levels for each factor. 3. Select Orthogonal Array: Use a Taguchi array (e.g., L9) to design experiments efficiently. 4. Conduct Experiments: Run tests according to the array combinations. 5. Analyze Results: Use Signal-to-Noise (S/N) ratio to determine 	CO 4	L3	



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	<p>optimal settings.</p> <p>6. Validate: Test the optimized parameters for consistent performance.</p> <p>Example: Optimizing charging profile to extend smartphone battery life while maintaining safety.</p> <p>Taguchi parameter design ensures batteries perform consistently under varying conditions, improving product reliability and reducing testing costs.</p>			
<p style="text-align: center;">Q.5</p>	<p>a) Demonstrate how classifying different data types can guide the development of an effective analysis plan for a consumer behavior study [6Marks]</p> <p>Answer: Classifying data is crucial for selecting appropriate analysis techniques. Common data types include:</p> <p>Nominal: Gender, location (categorical, no order)</p> <p>Ordinal: Satisfaction ratings (ranked order)</p> <p>Interval: Temperature preferences (differences meaningful, no true zero)</p> <p>Ratio: Spending amounts (true zero, allows all arithmetic operations)</p> <p>Steps:</p> <ol style="list-style-type: none"> 1. Identify the type of data collected. 2. Choose statistical tools based on data type: frequency tables for nominal, median for ordinal, mean and standard deviation for interval/ratio, regression for relationships. 3. Develop analysis plan specifying which test applies to each variable. <p>Example: Analyzing customer ratings (1–5) to understand satisfaction trends and determine factors affecting loyalty.</p> <p>Proper classification ensures correct statistical analysis, leading to accurate insights for business decisions.</p> <p style="text-align: center;">OR</p> <p>b) Demonstrate how the steps for preparing a research report can be applied to present the findings of a machine learning project [6Marks]</p> <p>Answer: A research report communicates findings systematically.</p> <p>Steps:</p>	<p style="text-align: center;">[12]</p>	<p style="text-align: center;">CO 5</p>	<p style="text-align: center;">L3</p>



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<p>1. Title & Abstract: Summarize research problem and key findings.</p> <p>2. Introduction: Define problem, objectives, and significance.</p> <p>3. Literature Review: Summarize previous work and identify research gaps.</p> <p>4. Methodology: Describe dataset, preprocessing, model selection, and evaluation metrics.</p> <p>5. Results: Present model performance using tables, graphs, and metrics like accuracy or F1-score.</p> <p>6. Discussion: Interpret results, compare with existing studies.</p> <p>7. Conclusion & Recommendations: Highlight contributions and suggest future work.</p> <p>Example: ML model predicting student performance based on study habits; the report includes data preprocessing steps, model accuracy, and actionable insights for educators.</p> <p>A structured report ensures clarity, reproducibility, and effective communication of results.</p>			
<p>c) Apply error analysis techniques to evaluate accuracy of experimental readings in a physics experiment. [6Marks]</p> <p>Answer: Error analysis identifies and quantifies deviations in measurements.</p> <p>Steps:</p> <ol style="list-style-type: none"> 1. Identify Errors: Systematic (instrumental/calibration), random (environmental), human. 2. Measure & Record: Take repeated readings and note deviations. 3. Calculate Metrics: Mean, standard deviation, and percentage error. 4. Propagate Errors: If multiple variables are combined, calculate combined error. 5. Interpret Results: Assess reliability and accuracy. <p>Example: Measuring acceleration due to gravity using a pendulum; compare measured value with theoretical 9.8 m/s^2 and calculate error.</p> <p>Error analysis improves reliability of results and helps refine experimental methodology.</p> <p>OR</p>		CO 5	L3



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<p>d)How would be you use the interpretation techniques to analyse statistical results in a research study. [6Marks]</p> <p>Answer:</p> <p>Statistical interpretation involves making meaningful conclusions from collected data.</p> <p>Steps:</p> <ol style="list-style-type: none">1. Select Appropriate Test: Based on variables and research objectives (t-test, ANOVA, regression, chi-square).2. Apply Test: Perform calculations using statistical software or formulas.3. Interpret Outputs: Evaluate p-values, confidence intervals, correlation coefficients, and effect sizes.4. Draw Conclusions: Identify significant differences, relationships, or trends. <p>Example: Using a t-test to compare test scores of students taught by two different teaching methods; significant p-value indicates method effectiveness.</p> <p>Proper interpretation ensures valid conclusions, guides decision-making, and supports evidence-based research outcomes.</p>			
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