



What is Research?

- Finding solutions to problems
- Knowing the unknown
- Finding facts
- Discover new information on a topic
- Increase understanding of a topic.
- Developing new methods/processes/devices/algorithms for various applications

To sum up

- Research is a detailed and careful study of something to find out more information about it

In other words, Research is

- Investigation – finding answers to various questions – How? Why? When? What? What if? What if not?

Examples

Covid 19 Epidemic Outbreak – A lot of research was undertaken

Reason for the outbreak?

How to control?

How to prevent?

After-effects? Vaccine development? etc

Research Methodology

- Research should be carried out systematically
- Research should follow a structured approach
- Research should be carried out using definite principles, procedures, and techniques
- This systematic and structured approach of conducting research is called Research Methodology

Intellectual Property Rights

- ☐ Many Research work lead to innovation and inventions.
- ☐ An invention is a creation of the mind
- ☐ Other examples of creation of mind – Literary and art work (like music, articles, books), novel designs (for product appearance), symbols (logos) used in business etc.
- ☐ Any such creations of mind are referred to as Intellectual Property.

Examples of creations of mind

1. A new formula to prepare a drug (medicine)
2. A unique manufacturing process
3. A new music composition
4. A computer program
5. A novel
6. A movie screenplay
7. Logos of any brand (Ex.: Nike)
8. Name of a product (Ex.: Coca-Cola)
9. Coco-cola formula
- 10.KFC recipe
- 11.Design of a car (or any product)

Any Intellectual Property is an asset which is intangible (difficult to describe, understand or measure). This intellectual property (assets) should be legally protected (protected by law).

Intellectual property is protected by law through

- Patents
- Copyrights
- trademarks

Patents protect inventions (Examples 1 & 2)

Copyrights protect original works of authorship (Examples 3, 4, 5 & 6)

Trademarks protect brand names and logos (Examples 7 & 8)

- ❖ This legal protection allows creators to earn recognition or financial benefit from their creations. This further encourages creators to indulge in more innovation and creativity.
- ❖ Laws like patents, copyrights, and trademarks grant exclusive rights to creators, allowing them to control the use of their creations for a specific period.
- ❖ This legal protection of intellectual property is called Intellectual Property Rights (IPR).

Why Should Engineering Students Study RM?

Career Options for an engineering graduate

- Working professional in an industry
- Entrepreneurship
- Research
- Government Jobs (Especially in Public Sector Unions)
- Higher Studies (M.E., M. Tech., PhD) , teaching

In career options an engineering graduate chooses, basically he/she is expected to solve engineering problems, innovate and invent. They are required to develop new methods/processes/devices. To do all these, a systematic and structured approach is necessary. This is explained in Research Methodology. Hence RM is included in engineering curriculum to enable graduates to succeed in their career paths.

- The usefulness of this course may be different for different career paths. This is because the extent of research carried out may vary from one career path to other. Example: A pure researcher will only do research, whereas, an industry professional or an entrepreneur will do a decent amount of research based on the type of domain in which he works. But basic research is carried out in any field, an engineering graduate steps in.
- Even in higher education or teaching field doing research is mandatory.
- So, it is imperative these days that an engineering graduate should have knowledge on the systematic and structured approach of doing research which is dealt in RM.

A few outcomes of studying RM in the professional life of students

- Solving engineering problems systematically.

In their profession they will know

- ✓ How to identify and formulate a problem
 - ✓ What are the relevant data pertaining to the problem and how to collect them
 - ✓ What are the methods available to analyze the collected data and how to analyze it
 - ✓ From the findings of the analyzed data, what decision to make
- Critical thinking and analysis – RM Will enable engineers to develop the skills of thinking critically, evaluate an information properly and take a right decision.
 - Effective Communication – RM will enable engineers to clearly and effectively communicate research findings with their colleagues and stakeholders.
 - Reducing Errors – RM will help engineers minimize errors and thereby ensure the reliability of their research.

Why Should Engineering Students Study IPR?

- ✓ In any career path chosen by the engineering graduates, they are required to innovate and invent (i.e. do some amount of research).
- ✓ The findings of the research, may be small or big, is the creation from their mind. So, the research findings are their intellectual property.
- ✓ Their research findings (intellectual property) may be unauthorizedly used or reproduced by someone else.
- ✓ This unauthorized use and reproduction of someone's research findings (intellectual property) should be safeguarded.

- ✓ Further, the intellectual property should provide commercial benefit to the inventors.
- ✓ Engineers (inventors) should know how to commercialize their inventions.
- ✓ They should know how to establish their own company to develop the product from their inventions.
- ✓ They should know what the procedure is to get different licenses and agreements to be made to establish a company.
- ✓ Intellectual Property Rights (IPR) deals with all these. Hence, engineering students are made to study this.

Students should note that this subject is common to all branches of engineering.

Course Objectives

CO1. To Understand the knowledge on basics of research and its types.

CO2. To Learn the concept of Literature Review, Technical Reading, Attributions and Citations.

CO3. To learn Ethics in Engineering Research.

CO4. To Discuss the concepts of Intellectual Property Rights in engineering.

Module-1 (5 Hours)

Introduction: Meaning of Research, Objectives of Engineering Research, and Motivation in Engineering Research, Types of Engineering Research, Finding and Solving a Worthwhile Problem.

Ethics in Engineering Research, Ethics in Engineering Research Practice, Types of Research Misconduct, Ethical Issues Related to Authorship.

Teaching- Learning Process

Chalk and talk method / PowerPoint Presentation.

Module-2 (5 Hours)

Literature Review and Technical Reading, New and Existing Knowledge, Analysis and Synthesis of Prior Art Bibliographic Databases, Web of Science, Google and Google Scholar, Effective Search: The Way Forward Introduction to Technical Reading Conceptualizing Research, Critical and Creative Reading, Taking Notes While Reading, Reading Mathematics and Algorithms, Reading a Datasheet.

Attributions and Citations: Giving Credit Wherever Due, Citations: Functions and Attributes, Impact of Title and Keywords on Citations, Knowledge Flow through Citation, Citing Datasets, Styles for Citations, Acknowledgments and Attributions, What Should Be Acknowledged, Acknowledgments in, Books Dissertations, Dedication or Acknowledgments.

Teaching-Learning Process

Chalk and talk method / PowerPoint Presentation

Module-3(5 Hours)

Introduction To Intellectual Property: Role of IP in the Economic and Cultural Development of the Society, IP Governance, IP as a Global Indicator of Innovation, Origin of IP History of IP in India. Major Amendments in IP Laws and Acts in India.

Patents: Conditions for Obtaining a Patent Protection, To Patent or Not to Patent an Invention. Rights Associated with Patents. Enforcement of Patent Rights. Inventions Eligible for Patenting. Non-Patentable Matters. Patent Infringements. Avoid Public Disclosure of an Invention before Patenting. Process of Patenting. Prior Art Search. Choice of Application to be Filed. Patent Application Forms. Jurisdiction of Filing Patent Application. Publication. Pre-grant Opposition. Examination. Grant of a Patent. Validity of Patent Protection. Post-grant Opposition. Commercialization of a Patent. Need for a Patent Attorney/Agent. Can a Worldwide Patent be Obtained. Do I Need First to File a Patent in India. Patent Related Forms. Fee Structure. Types of Patent Applications. Commonly Used Terms in Patenting. National Bodies Dealing with Patent Affairs. Utility Models.

Process of Patenting. Prior Art Search. Choice of Application to be Filed. Patent Application Forms. Jurisdiction of Filing Patent Application. Publication. Pre-grant Opposition. Examination. Grant of a Patent. Validity of Patent Protection. Post-grant Opposition. Commercialization of a Patent. Need for a Patent Attorney/Agent. Can a Worldwide Patent be Obtained. Do I Need First to File a Patent in India. Patent Related Forms. Fee Structure. Types of Patent Applications. Commonly Used Terms in Patenting. National Bodies Dealing with Patent Affairs. Utility Models.

Module-4(5 Hours)

Copyrights and Related Rights: Classes of Copyrights. Criteria for Copyright. Ownership of Copyright. Copyrights of the Author. Copyright Infringements. Copyright Infringement is a Criminal Offence. Copyright Infringement is a Cognizable Offence. Fair Use Doctrine. Copyrights and Internet. Non-Copyright Work. Copyright Registration. Judicial Powers of the Registrar of Copyrights. Fee Structure. Copyright Symbol. Validity of Copyright. Copyright Profile of India. Copyright and the word 'Publish'. Transfer of Copyrights to a Publisher. Copyrights and the Word 'Adaptation'. Copyrights and the Word 'Indian Work'. Joint Authorship. Copyright Society. Copyright Board. Copyright Enforcement Advisory Council (CEAC). International Copyright Agreements, Conventions and Treaties. Interesting Copyrights Cases.

Trademarks: Eligibility Criteria. Who Can Apply for a Trademark. Acts and Laws. Designation of Trademark Symbols. Classification of Trademarks. Registration of a Trademark is Not Compulsory. Validity of Trademark. Types of Trademark Registered in India. Trademark Registry. Process for Trademarks Registration. Prior Art Search. Famous Case Law: Coca-Cola Company vs. Bisleri International Pvt. Ltd.

Module-5(5 Hours)

Industrial Designs: Eligibility Criteria. Acts and Laws to Govern Industrial Designs. Design Rights. Enforcement of Design Rights. Non-Protectable Industrial Designs India. Protection Term. Procedure for Registration of Industrial Designs. Prior Art Search. Application for Registration. Duration of the Registration of a Design. Importance of Design Registration. Cancellation of the Registered Design. Application Forms. Classification of Industrial Designs. Designs Registration Trend in India. International Treaties. Famous Case Law: Apple Inc. vs. Samsung Electronics Co.

Geographical Indications: Acts, Laws and Rules Pertaining to GI. Ownership of GI. Rights Granted to the Holders. Registered GI in India. Identification of Registered GI. Classes of GI. Non-Registerable GI. Protection of GI. Collective or Certification Marks. Enforcement of GI Rights. Procedure for GI Registration Documents Required for GI Registration. GI Ecosystem in India.

Case Studies on Patents. Case study of Curcuma (Turmeric) Patent, Case study of Neem Patent, Case study of Basmati patent. **IP Organizations In India. Schemes and Programmes**

Teaching- Learning Process

Chalk and talk method / PowerPoint Presentation

Course Outcomes (Course Skill Set)

At the end of the course the student will be able to:

- CO 1. To know the meaning of engineering research.
- CO 2. To know the procedure of Literature Review and Technical Reading.
- CO 3. To know the fundamentals of patent laws and drafting procedure.
- CO 4. Understanding the copyright laws and subject matters of copyrights and designs
- CO 5. Understanding the basic principles of design rights.



Research is a kind of study on a particular subject or an issue where the researcher utilizes scientific techniques.



Research

Research is a **systematic and organized process of collecting, analyzing, and interpreting information** to answer questions, solve problems, or generate new knowledge. It involves inquiry, careful study, and the use of scientific methods to understand a subject more deeply or to discover something new.

Key Points in Research:

- It starts with a **problem or question**.
- Involves **collection of data/information**.
- Requires **analysis and interpretation**.
- Leads to **new knowledge, solutions, or insights**.

Example of Research

Topic: *Does daily exercise improve memory in college students?*

- **Problem/Question:** Many students face memory issues due to stress. Does regular exercise help improve memory?
- **Hypothesis:** Students who exercise daily will perform better in memory tests compared to those who do not.
- **Data Collection:** Select 100 students. Divide them into two groups — one group does 30 minutes of daily exercise, the other does none.
- **Analysis:** After 3 months, conduct memory tests on both groups and compare results.
- **Conclusion:** If the exercise group performs better, the research supports the idea that exercise improves memory.

This way, research provides **evidence-based answers** instead of assumptions.

• Research Cycle

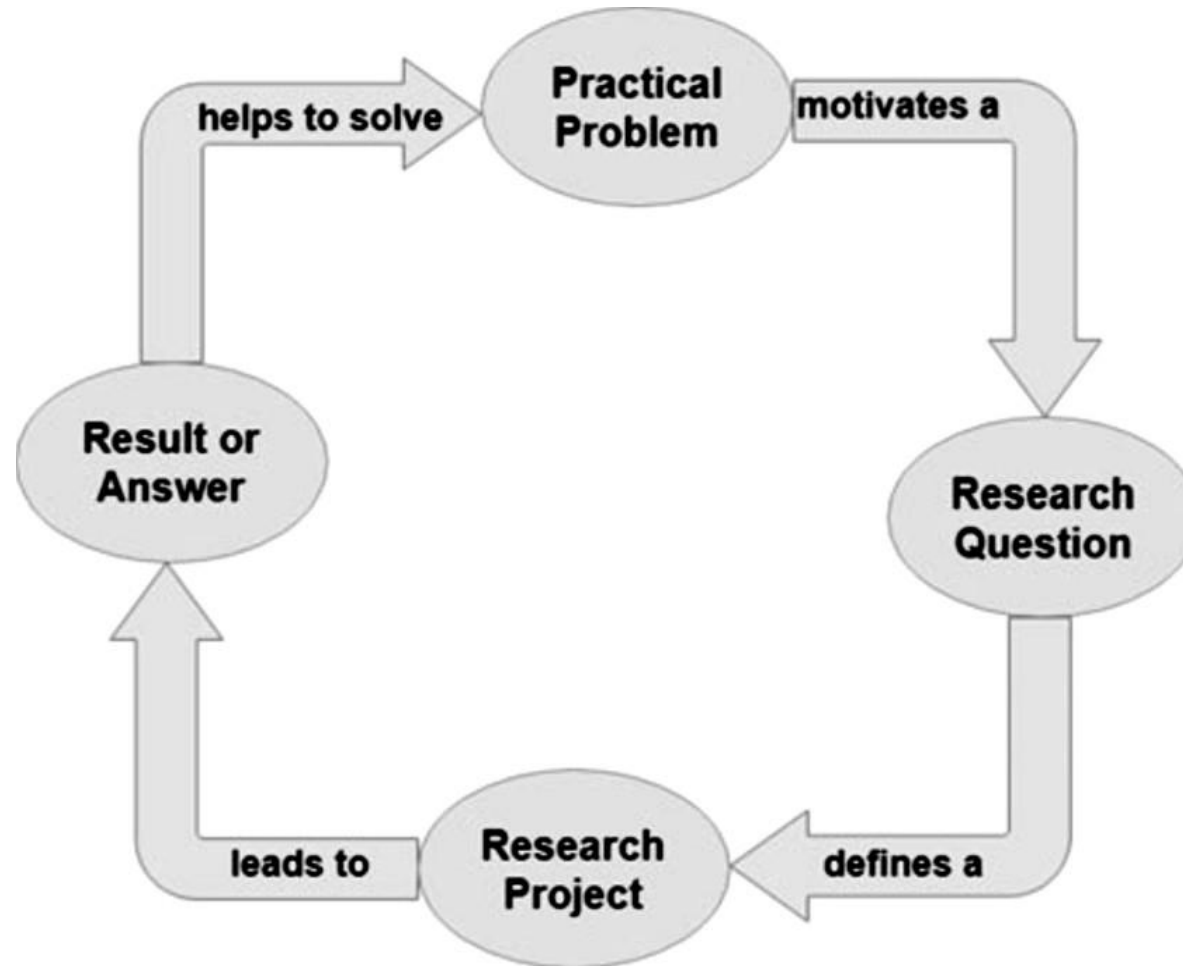


Fig. 1.1 The research flow diagram

Stage in Research Cycle	Meaning	Example (Student Concentration Problem)
Practical Problem	A real-life issue that needs a solution.	Students find it hard to concentrate in online classes.
Research Question	A focused question arising from the problem.	Does reducing screen time before class improve concentration?
Research Project	The systematic investigation (planning, data collection, analysis).	Two groups of students: one reduces screen time, the other doesn't; measure their focus during class.
Result or Answer	Findings from the project that address the research question.	Students with reduced screen time showed 20% better concentration.
Helps to Solve Practical Problem	Applying the results to solve the original issue.	Recommendation: Students should avoid screens 1 hour before class for better focus.

Building background Knowledge:

Building background knowledge means **collecting, studying, and understanding existing information** about a topic before starting your own research. It helps you know:

- What is already known,
- What gaps still exist,
- What methods have been used earlier,
- How your work will add something new.

Technical Example: Improving Battery Life in Smartphones

Background Knowledge	Source	Research Gap Identified
Smartphone batteries use Lithium-ion technology .	Electronics textbooks, manufacturer datasheets.	Well-known chemistry, but efficiency reduces over time.
Average smartphone battery lasts 8–12 hours with normal use.	Consumer reports, tech websites.	Battery drains quickly with heavy apps (gaming, video calls).
High screen brightness and background apps consume more power.	Articles on Android/iOS power management.	Many studies suggest reducing brightness, but less work on smart background app control.
Fast charging reduces charging time but generates heat which degrades battery health.	IEEE papers on battery charging.	Need better charging algorithms that balance speed and battery lifespan.
Existing research focuses on hardware improvements (better batteries).	Research papers, company whitepapers.	Less focus on software-based solutions to improve battery performance.

Research Problem After Building Background Knowledge:

“How can a smart background-app management system be designed to extend smartphone battery life without affecting user experience?”

Ways of Developing Knowledge

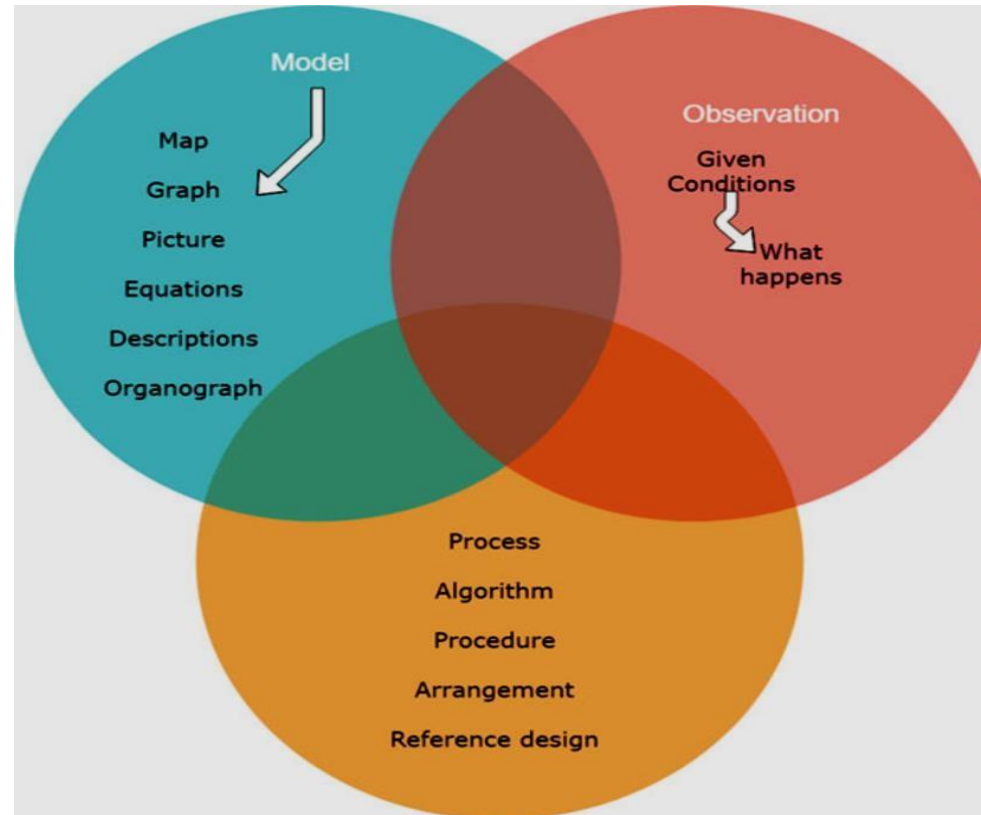


Fig. 1.2 The categories of knowledge in research

1. Observation (Red Circle)

- **What it means:**
Gaining knowledge by carefully watching and recording what happens under certain conditions.
- **Tools/Methods:**
Experiments, surveys, field studies, case studies.
- **Example:**
Observing how plants grow under different amounts of sunlight → leads to knowledge about photosynthesis.

2. Model (Blue Circle)

- **What it means:**
Representing reality using simplified forms such as graphs, equations, maps, or diagrams. Models help explain or predict phenomena.
- **Tools/Methods:**
Maps, graphs, pictures, equations, organographs (organizational charts).
- **Example:**
Using Newton's equations of motion to model how a car accelerates → helps predict speed at any given time.

3. Process (Orange Circle)

- **What it means:**
Developing knowledge by designing systematic steps, procedures, or algorithms to explain or achieve results.
- **Tools/Methods:**
Process flow, algorithm design, procedures, arrangements, reference designs.
- **Example:**
Designing an algorithm for fingerprint authentication in smartphones → provides a step-by-step way of applying knowledge in practice

Intersection of All Three

•When **Observation + Model + Process** are combined, deeper and more reliable knowledge is created.

Example:

- **Observation:** Measure data of virus spread in a city.
- **Model:** Create a mathematical model (graph/equations) of infection rates.
- **Process:** Develop algorithms for vaccination schedules.
→ Together, they give a complete understanding and solution.

In short:

Observation = What happens

Model = How we represent/explain it

Process = How we systematically use/apply it

Objectives of Engineering Research



To gain familiarity with a phenomenon or to achieve new insights into it.(studies with this object in view are termed as exploratory or formulative research studies).



To portray accurately the characteristics of a particular individual, situation or a group (studies with this object in view are known as descriptive research studies), very common in social science , behavioral science.



To determine the frequency with which something occurs or with which it is associated with something else (studies with this object in view are known as diagnostic research studies)



to test a hypothesis of a causal relationship between variables(such studies is known as hypothesis testing research studies)

Motivation in Engineering Research

The intention of doing research may be one or more of the following:

Extrinsic Views(Behaviorist approach) – people are motivated by external rewards and punishments; this is also called carrot and stick approach.

Intrinsic Views(cognitive or humanist approach) – people are motivated by internal capacities, such as aspirations , perceptions, attitudes or thoughts that can be motivating or demotivating.

Intrinsic vs Extrinsic Motivation – With Examples

Context	Intrinsic Motivation	Extrinsic Motivation
Education	Studying because you enjoy learning and are curious	Studying to get good grades or avoid punishment
Work	Working on a project because it's challenging and interesting	Working to earn a bonus, raise, or promotion
Sports	Playing a sport because you love the game and it makes you feel good	Playing to win medals, trophies, or gain recognition
Art	Painting for self-expression and personal fulfillment	Painting to sell your work or gain followers on social media
Volunteering	Helping out because you value kindness and want to make a difference	Volunteering to earn a certificate or improve your resume
Personal Goals	Learning a new language because you enjoy it	Learning a new language to get a better job or pass an exam
Music	Playing an instrument because it relaxes you and brings joy	Playing to perform on stage or win a competition

Types of Research

1. **Descriptive research** is a type of research method used to **describe** the characteristics, behaviors, or situations of a population or phenomenon **as they exist** — without manipulating variables.

It focuses on **what is happening**, rather than **why** or **how** it happens.

- It answers questions like:
 - *What are the characteristics of the group?*
 - *How often does something occur?*
 - *What is the current status of a situation?*

Key points:

- It provides an accurate picture of the subject.
- It uses methods like surveys, observations, and case studies.
- It is usually **quantitative** **but** can also include qualitative descriptions.

Example:

Imagine you want to study “**the eating habits of college students in Bangalore**”.

In descriptive research, you might:

Conduct a **survey** asking students how many meals they eat per day, what types of food they consume, and where they eat.

- **Collect data** from 500 students.
- **Summarize** findings like:

- ✓ 65% eat fast food at least twice a week.
- ✓ 40% skip breakfast regularly.
- ✓ Average monthly food spending is ₹3,500.

Here, you are **describing** the current eating habits without trying to change them or test a cause-effect relationship.

Another ex: screen time of children





2. Analytical research is a research approach where the focus is on **analyzing and interpreting information** to understand **why** something happens, determine **relationships** between variables, or test a **hypothesis**.



It goes **beyond just describing** a situation (like descriptive research) — it tries to **explain causes, patterns, and connections** using critical thinking and data analysis.



Answers **“Why?”**, **“How?”**, and **“What does this mean?”** questions.

Steps in Analytical Research: Example



Research Question:

Does high social media usage negatively affect students' grades?



Data Collection:

Survey 500 students about the number of hours they spend daily on social media.

Collect their recent semester GPA/marks.



Analysis:

Use statistical tools (like correlation or regression) to check if there's a relationship between hours spent on social media and academic performance.

Compare performance between heavy users (4+ hours/day) and light users (<1 hour/day).



Interpretation:

You find that students spending more than 4 hours/day on social media have GPAs 15% lower on average than those spending less than 1 hour/day.

You interpret this as possible evidence that excessive social media usage may distract from study time or reduce sleep.



Conclusion:

The research doesn't just *describe* how many hours students spend on social media — it **analyzes** the data to explain the relationship between social media use and grades.

Aspect

Descriptive Research

Analytical Research

Research Question

What is the level of air pollution in the city?

How does air pollution affect the health of residents in the city?

Purpose

To measure and describe the current status of air quality.

To examine the relationship between pollution levels and health problems.

Data Collected

Air Quality Index (AQI), pollutant levels (PM_{2.5}, CO₂, NO₂).

Same pollution data **plus** hospital records on respiratory illnesses.

Method

Observation, survey, environmental monitoring.

Statistical analysis, correlation, regression between pollution & health.

Outcome

"AQI is poor for 70% of the year, PM_{2.5} is above safe limits."

"Higher PM_{2.5} levels are strongly linked with increased asthma and lung infections."

Research Topic: Traffic Congestion in urban areas

Descriptive Research

- **Objective:** Describe the current state of traffic congestion in a specific urban area.
- **Methodology:** Conduct surveys and collect data on traffic patterns, peak hours, and congestion levels. Use traffic cameras and sensors to gather real-time information. Analyze historical data to identify trends.
- **Findings:** Present a detailed description of the current traffic congestion situation, including statistics on peak congestion times, affected areas, and common causes.

Analytical Research

- **Objective:** Analyze the factors contributing to traffic congestion and propose potential solutions.
- **Methodology:** Use statistical methods to identify correlations between variables such as population growth, urban development, and traffic congestion. Analyze the impact of specific interventions or traffic management strategies. Compare the effectiveness of different approaches through modeling and simulation.
- **Findings:** Provide insights into the root causes of traffic congestion and propose analytical solutions. For example, the research may suggest optimizing traffic signal timings, implementing public transportation improvements, or introducing congestion pricing.

Fundamental Research (also called Basic or Pure Research):

It is a type of research that focuses on **gaining new knowledge and understanding** rather than solving an immediate practical problem. The main goal is to **expand theories, principles, and concepts** that can later be applied in practice.

➤ **Key Features of Fundamental Research:**

- **Purpose:** To increase scientific knowledge and understanding.
- **Nature:** Theoretical and exploratory.
- **Focus:** Explains “why” things happen, not just “how.”

➤ **Application:** Not aimed at immediate use but can provide the foundation for applied research in the future.

➤ **Timeframe:** Long-term impact.

➤ **Examples:**

- Studying how the human brain stores memories.
- Investigating the behavior of electrons in different conditions.
- Exploring the relationship between genetics and intelligence.
- Understanding the origin of the universe in physics.

Applied Research

- Applied research is a type of research that is **conducted to solve practical, real-world problems** by applying existing theories, methods, and knowledge. Unlike **fundamental (basic) research**, which focuses on generating new theories or expanding knowledge without immediate use, **applied research** aims to **find solutions or improvements** that can be directly used in industry, technology, healthcare, or society.

Characteristics of Applied Research

- Problem-oriented (focuses on a specific issue).
- Practical application of theories and concepts.

Examples of Applied Research

- Developing a new medicine based on existing biological theories.
- Applying wireless power transfer concepts to build charging stations for electric vehicles.

Comparison between applied and fundamental research

Eg:Electricity & Wireless Charging

Fundamental research

- **Objective :** To understand the basic principles of how electricity and electromagnetic fields work.
- **Research Question:** “What is the nature of electromagnetic induction?”
- **Outcome:** New theory or explanation of natural phenomena (e.g., Faraday’s law of electromagnetic induction).
- **Usefulness:** Expands scientific knowledge but not immediately applied.

Applied Research

- **Objective:** To use the knowledge of electromagnetic fields to design **wireless charging systems** for mobile phones or electric vehicles.
- **Research Question:** “How can electromagnetic induction be used to wirelessly charge a battery efficiently
- **Outcome :** A practical solution or product (e.g., wireless charging pad).
- **Usefulness:** Directly applicable to solve real-world problems.

Quantitative Research

- Quantitative research is a type of research that focuses on **collecting and analyzing numerical data**. It deals with **measurements, statistics, and quantities** to test hypotheses, find patterns, and make predictions.

It answers “**what**,” “**how many**,” “**how often**,” or “**to what extent**.”

- Characteristics of Qualitative Research**

Data is **numerical** (numbers, scores, percentages).

Uses structured tools: surveys, questionnaires, experiments, statistical analysis.

Results are **objective, measurable, and generalizable**.

Often involves large sample sizes.

Used to test hypotheses or relationships between variables.

Examples of Qualitative Research

Education – Measuring the impact of study hours on students’ exam scores.

Healthcare – Testing the effectiveness of a new drug on 500 patients.

Qualitative Research

- Qualitative research is a type of research that focuses on **understanding human experiences, behaviors, opinions, and social phenomena** through **non-numerical data** such as words, observations, interviews, and case studies. Instead of numbers and statistics, it explores **meanings, patterns, and deeper insights**.

Characteristics of Qualitative Research

- Data is **descriptive** (words, images, videos) rather than numerical.
- Seeks to answer “**why**” and “**how**” rather than “how many.”
- Uses open-ended, flexible methods (interviews, focus groups, observations).
- Results are **interpretive and explanatory**, not generalized to large populations.
- Often used in social sciences, psychology, education, and market research.

Examples of Qualitative Research

- **Education** – Studying how students feel about online learning through interviews.
- **Healthcare** – Exploring patient experiences with a new treatment.
- **Business/Marketing** – Understanding consumer preferences through focus groups.
- **Sociology** – Observing community interactions to study cultural practices.

Example: Online Learning Impact on Students

Qualitative Research Question:

- “How do students feel about online learning, and what challenges do they face?”
- Method: Interviews with 20 students.
- Data: Students say they feel isolated, find it hard to focus, but enjoy flexibility.

Quantitative Research Question:

- “Does online learning improve or reduce students’ grades compared to classroom learning?”
- Method: Collect GPA data of 200 students in online vs. offline classes.
- Data: 65% of students scored higher in traditional classes, 35% in online classes.

Finding and Solving a Worthwhile Research Problem

1. Finding a Research Problem

The first step in research is to identify a **problem or question** that needs investigation.

Sources for finding problems:

- Gaps in existing literature.
- Real-life issues in society/industry.
- Personal experience or curiosity.
- Suggestions from experts.
- Reviewing recent technological developments.

Example: You notice that online learning apps consume too much battery → possible research problem: *How to optimize mobile apps for better battery efficiency?*

2. Skills Needed

To find and solve a research problem, a researcher should have:

- **Critical thinking** – to question and analyze existing knowledge.
- **Literature review skills** – to search and evaluate past work.
- **Creativity** – to think of new solutions.
- **Technical knowledge** – subject expertise, research methods.
- **Problem-solving ability** – breaking a big problem into smaller parts.
- **Communication** – to present findings clearly.

3. Identifying a Problem

Steps:

- Look at practical issues in daily life, industry, or environment.
- Read research papers to find **knowledge gaps**.
- Discuss with peers, mentors, or experts.
- Use brainstorming or mind-mapping.
- Evaluate feasibility (time, cost, resources).

Example: In agriculture, farmers lose crops due to irregular rainfall → Problem: *Can low-cost IoT sensors predict soil moisture and help irrigation?*

4. Attributes or Characteristics of a Worthwhile Research Problem

A good research problem should be:

- **Relevant** → solves a real or scientific need.
- **Original** → not just repeating what's already done.
- **Feasible** → possible within time, resources, skills.
- **Clear & Specific** → not vague or too broad.
- **Researchable** → can be studied using data, experiments, or analysis.
- **Ethical** → should not harm people, animals, or society.
- **Significant** → contributes new knowledge or practical applications.

5. Decision to Tackle a Problem

- After listing possible problems, decide based on:
 - **Interest & Motivation** → Are you passionate about solving it?
 - **Relevance** → Will it benefit society, industry, or academia?
 - **Resources available** → Do you have tools, data, and funds?
 - **Time constraints** → Can it be completed in your research duration?
 - **Scope for innovation** → Does it allow creativity and new solutions?
- **Example Decision:** Between “battery optimization in phones” vs “developing new battery chemistry.”
 - As a student with limited lab facilities, you may **choose optimization** (software-based), because it's feasible within your resources.

Finding and solving a worthwhile problem = **Spotting a gap → Having skills → Identifying the right problem → Checking characteristics → Deciding feasibility**

Objectives of Engineering Research



To gain familiarity with a phenomenon or to achieve new insights into it.(studies with this object in view are termed as exploratory or formulative research studies).



To portray accurately the characteristics of a particular individual, situation or a group (studies with this object in view are known as descriptive research studies). Eg: very common in social science , behavioral science, want to study the effect of digital media on children, cocomelon



To determine the frequency with which something occurs or with which it is associated with something else (studies with this object in view are known as diagnostic research studies) eg: cholera ,water quality, industry which is releasing their effluence. Eg: smoker lung cancer, medical or clinical research,



to test a hypothesis of a causal relationship between variables(such studies is known as hypothesis testing research studies) casual – cause n effect, hypothesis testing sweeden digital content cause – introduction of digital media , effect – loss of some skills

- **Observation** is the most fundamental way of obtaining information from a source. Observation takes different forms from something like measurements in a laboratory to a survey among a group of subjects to the time it takes for a firmware routine to run.

The observational data often needs to be processed in some form and this leads to the second category of knowledge, the model.

- **Models** are approximated, often simplified ways of describing sometimes very complex interactions in the form of a statistical relationship, a figure, or a set of mathematical equations. (Map, graphs, pictures, equations, etc).
- The final category is a way of **arranging** or doing things through processes, algorithms, procedures, arrangements, or reference designs, to get a certain desired result.

Eg: How plants respond to sunlight -

Research

- Research refers to a careful, well-defined (or redefined), objective, and systematic method of search for knowledge, or formulation of a theory that is driven by inquisitiveness for that which is unknown and useful on a particular aspect so as to make an original contribution to expand the existing knowledge base.
- Research involves formulation of hypothesis or proposition of solutions, data analysis, and deductions; and ascertaining whether the conclusions fit the hypothesis.
- Research is a process of creating or formulating knowledge that does not yet exist. Thus, research is an art of scientific investigation.
- It involves setting a clear goal, asking questions, forming hypothesis, analyzing data and making sure your conclusions match your initial ideas.
- *Eg: Imagine you are curious about why plants in your garden grow differently. Your search could involve observing, making guesses, collecting data about sunlight, soil and water and then figuring out why plants grow differently.*

Building background Knowledge:

- **Research** is not just about reading a lot of books and gathering a lot of existing information. **It is instead contributing to that existing body of knowledge.**
- So, research is about how one **poses a question** which has relevance to the world that we are living in, and **while looking for that answer** one has to **be as systematic as one can be.**
- Good research questions develop throughout the project actually and one can even keep modifying them.
- ***Eg: Before fixing your garden, you might learn about soil types, sunlight needs, and plant nutrition. Instead of just gathering facts, you aim to contribute something new and specific***

- **Good research involves systematic collection and analysis of information and is followed by an attempt to infer a little bit beyond the already known information in a way that is a significant value addition.**
- Usually, engineering research is a journey that traverses from a research area (example: Control Systems), to the topic (example: Control of Microbial Fuel Cells) and finally onto the problem (example: AdaptiveControl of Single Chamber Microbial Fuel Cells)
(Area – Topic – Problem).
- **Getting a good problem to solve is more than half the work done.** However, sometimes the journey can be reverse, for example, the traversal from **(Problem -- Topic -- Area)**. This can happen when one is led to a problem through a connection to another problem whose top structure is different.

❖ **Influences** from others like competition, collaboration, commitment, and encouragement are also motivating factors in research. For example: My friends are all doing research and so should I, or, a person that I dislike is doing well and I want to do better.

Personal motivation in solving unsolved problems, intellectual joy, service to community, and respectability are all driving factors.

Several other factors like **government directives**, **funding opportunities** in certain areas, and terms of employment, can motivate people to get involved in engineering research.

- The following factors would be a mix of extrinsic and intrinsic aspects:
 - (i) Wanting to do better than what has been achieved in the world,
 - (ii) improve the state of the art in technology,
 - (iii) Contribute to the improvement of society,
 - (iv) Fulfillment of the historical legacy in the immediate sociocultural context.
- Several other factors like government directives, funding opportunities in certain areas, and terms of employment, can motivate people to get involved in engineering research.

4. Interpretation:

- You find that students spending more than 4 hours/day on social media have GPAs 15% lower on average than those spending less than 1 hour/day.
- You interpret this as possible evidence that excessive social media usage may distract from study time or reduce sleep.

5. Conclusion:

The research doesn't just *describe* how many hours students spend on social media — it **analyzes** the data to explain the relationship between social media use and grades

- (ii) **Applied versus Fundamental:** Research can either be applied research or fundamental (basic or pure) research. Applied research seeks to **solve an immediate problem** facing the organization, whereas fundamental research is **concerned with generalizations and formulation of a theory**. Research concerning **natural phenomena or relating to pure mathematics** are examples of fundamental research.
- (iii) **Quantitative versus Qualitative:** Quantitative research uses **statistical observations of a sufficiently large number of representative cases** to draw any conclusions, while qualitative researchers rely on a **few nonrepresentative cases or verbal narrative in behavioral studies** such as clustering effect in intersections in **Transportation engineering** to make a proposition.

1.4 Finding and Solving a Worthwhile Problem

- The recommended steps to solve a research problem are
 - (i) Understand the problem, restate it as if its your own, visualize the problem by drawing figures, and determine if something more is needed.
 - (ii) One must start somewhere and systematically explore possible strategies to solve the problem or a simpler version of it while looking for patterns.
 - (iii) Execute the plan to see if it works, and if it does not then start over with another approach. Having delved into the problem and returned to it multiple times, one might have a flash of insight or a new idea to solve the problem.
 - (iv) Looking back and reflecting helps in understanding and assimilating the strategy, and is a sort of investment into the future.

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Ethics in Engineering Research







Ethics generally refers to a set of rules **distinguishing acceptable and unacceptable conduct, distinguishing right from wrong, or wise aphorisms** like the sayings of Chanakya.

- Most people learn such norms in their formative years, but moral development continues through different stages of growth.

Government bodies, and universities worldwide have adopted certain codes for research ethics. Research ethics and the responsible conduct of research are often erroneously used interchangeably.

- Research ethics examines the appropriate application of research outcomes,
- while responsible conduct of research deals **with the way the work is undertaken.**

1. Ethics in Engineering Research Practice

- The reason that ethics matter in data used in engineering research is usually because there is impact on humans.
- Certain practices may be acceptable to certain people in certain situations, and the reasons for unacceptability may be perfectly valid.
- Engineering ethics gives us the rule book; tells us, how to decide what is okay to do and what is not.

Researchers make many choices that matter from an ethical perspective and influence the effects of technology in many different ways:

- (i) By setting the ethically right requirements at the very outset, engineering researchers can ultimately influence the effects of the developed technology.

(ii) Influence may also be applied by researchers through design (a process that translates the requirements into a blueprint to fulfill those requirements). During the design process, decision is to be made about the priority in importance of the requirements taking ethical aspects into consideration.

(iii) Thirdly, engineering researchers have to choose between different alternatives fulfilling similar functions.

5.2 Types of Research Misconduct

- Engineering research should be conducted to improve the state-of-the-art of technologies. Research integrity encompasses dealing fairly with others, honesty about the methods and results, replicating the results wherever possible so as to avoid errors, protecting the welfare of research subjects, ensuring laboratory safety, and so forth. In order to prevent mistakes, peer reviews should take place before the research output is published.
- **Fabrication** (Illegitimate creation of data): Fabrication is the act of conjuring data or experiments with a belief of knowledge about what the conclusion of the analysis or experiments would be, but cannot wait for the results possibly due to timeline pressures from supervisor or customers.
- **Falsification** (Inappropriate alteration of data): Falsification is the misrepresentation or misinterpretation, or illegitimate alteration of data or experiments, even if partly, to support a desired hypothesis even when the actual data received from experiments suggest otherwise.

- **Falsification and fabrication** of data and results, hamper engineering research, cause false empirical data to percolate in the literature, wreck trustworthiness of individuals involved, incur additional costs, impede research progress, and cause actual and avoidable delays in technical advancement. Misleading data can also crop up due to poor design of experiments or incorrect measurement practices.
- **Plagiarism (Taking other's work sans attribution):** Plagiarism takes place when someone uses or reuses the work (including portions) of others (text, data, tables, figures, illustrations or concepts) as if it were his/her own without explicit acknowledgement. Verbatim copying or reusing one's own published work is termed as self-plagiarism and is also an unacceptable practice in scientific literature. The increasing availability of scientific content on the internet seems to encourage plagiarism in certain cases, but also enables detection of such practices through automated software packages.
- A commonly used tool among researchers is **iThenticate**: <http://www.ithenticate.com/>.
- iThenticate is a plagiarism detection service for the corporate market, from Turnitin, LLC, which also runs Plagiarism.org.

How are supervisors, reviewers or editors alerted to plagiarism?

- (i) **Original author comes to know and informs everyone concerned.**
- (ii) **Sometimes a reviewer finds out about it during the review process.**
- (iii) **Or, readers who come across the article or book, while doing research.**

(iv) Other Aspects of **Research Misconduct**: Serious deviations from accepted conduct could be construed as research misconduct. When there is both deception and damage, a fraud is deemed to have taken place. Sooner or later ethical violations get exposed. Simultaneous submission of the same article to two different journals also violates publication policies.

5.3 Ethical Issues Related to Authorship

- Academic authorship involves communicating scholarly work, establishing priority for their discoveries, and building peer-reputation, and comes with intrinsic burden of acceptance of the responsibility for the contents of the work. **It is the primary basis of evaluation for employment, promotion, and other honors.**
- Credit for research contributions is attributed in three major ways in research publications:
- By **authorship** (of the intended publication), **citation** (of previously published or formally presented work), and through a **written acknowledgment** (of some inputs to the present research). Authorship establishes both accountability and gives due credit. A person is expected to be listed as an author only when associated as a significant contributor in research design, data interpretation, or writing of the paper.

- Including **“guest” or “gift”** (coauthorship bestowed on someone with little or no contribution to the work) authors dilutes the contribution of those who actually did the work, inappropriately inflates credentials of the listed authors, and is ethically a red flag highlighting research misconduct.
- There is also an unfortunate malpractice of coauthorship that can be described as **“Career-preservation authorship”** wherein a head of the department, a dean, a provost, or other administrators are added as Coauthors because of **quid pro quo** arrangement wherein the principal author benefits from a “good relation” with the superiors and the administrator benefits from authorship without doing the required work for it.
- **Double submission** is an important ethical issue related to authorship, which involves submission of a paper to two forums simultaneously. The motivation is to increase publication possibility and possibly decrease time to publication. Reputed journals want to publish original papers, i.e., papers which have not appeared else- where, and strongly discourage double submission.

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MODULE-I

1. What is Research? With the help of neat diagram explain Research Flow?
2. Explain categories of knowledge research with a diagram?
3. Mention and explain the objective of Engineering Research?
4. Explain the motivation of Engineering Research?
5. Mention the different types of Research?
6. Explain analytical, descriptive, and applied research?
7. What is Ethics? Explain Ethics in Engineering Research Practice?
8. Explain different types of Research Misconduct?
9. What are the ethical issues related to Authorship?