VISVESVARAYA TECHNOLOGICAL UNIVERSITY

JNANA SANGAMA, BELGAVI -590 014

"RESEARCH METHODOLOGY & IPR (22BRMK557)"

(Theory)

(Effective from the academic Year 2025-2026)

Study Material

ODD SEMESTER – V

Subject Code: 22BRMK557

(Choice Based Credit System)

Prepared by:	HOD
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Department oF Electronics & Communication Engineering

Akshaya Institute of Technology

(Recognized by AICTE, New Delhi and Affiliated to Visvesvaraya Technological , University, Belagavi)

Akshaya Institute of Technology lingapura, Obalapura post, Koratagere Road, Tumakuru-distric-572106, Karnataka State, INDIA.

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Akshaya Institute of Technology lingapura, Obalapura post, Koratagere Road,
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STUDENT'S NAME: ……

USN: ……

BRANCH: ……

SECTION: …… **YEAR:** ……

AKSHAYA INSTITUTE OF TECHNOLOGY

Lingapura, Obalapura Post, Koratagere Road, Tumakuru - 572106

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VISION

To produce competent engineering professionals in the field of Electronics and Communication Engineering by imparting value based quality technical education to meet the societal needs and to develop socially responsible citizens.

MISSION

M1: To provide strong fundamentals and technical skills in the field of Electronics and Communication Engineering through effective teaching learning process.

M2: Enhancing employability of the students by providing skills in the fields of VLSI, Embedded systems, Signal processing, etc., through Centre of Excellence.

M3: Encourage the students to participate in co-curricular and extra-curricular activities that creates a spirit of social responsibility and leadership qualities.

Program Specific Outcomes (PSOs)

After Successful Completion of Electronics and Communication Engineering Program Students will be able to

1. Apply fundamental knowledge of core. Electronics and Communication Engineering in the analysis, design and development of Electronics Systems as well as to interpret and synthesize experimental data leading to valid conclusions.
2. Exhibit the skills gathered to analyze, design, develop software applications and hardware products in the field of embedded systems and allied areas.

Program Educational Objectives (PEOs)

PEO1: Graduates exhibit their innovative ideas and management skills to meet the day to day technical challenges.

PEO2: Graduates utilize their knowledge and skills for the development of optimal solutions to the problems in the field of Electronics and Communication Engineering..

PEO3: Graduates exhibit good interpersonal skills, leadership qualities and adapt themselves for life-long Learning

V Semester

RESEARCH METHODOLOGY & IPR			
Course Code:	**BRMK557**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

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.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer methods (L) need not be only the traditional lecture methods, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video to explain various concepts on IPR.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher Order Thinking) questions in the class, which promotes critical thinking.
5. Introduce Topics in manifold representations.
6. Show the different ways to analyze the research problem and encourage the students to come up with their own creative ways to solve them.
7. Discuss how every concept can be applied to the real world - and when that's possible, it helps Improve the students' understanding.

Module-1 (8 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 (8 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 (8 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.

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.

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Teaching- Learning Process	Chalk and talk method / PowerPoint Presentation.

Module-4 (8 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(8 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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.

Marks scored shall be proportionally reduced to 50 marks.

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Course Outcomes (Course Skill Set)

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

CO1. To know the meaning of engineering research.

CO2. To know the procedure of the literature Review and Technical Reading

CO3. To understand the fundamentals of the patent laws and drafting procedure

CO4. Understanding the copyright laws and subject matters of copyrights and designs

CO5. Under standing the basic principles of design rights

Suggested Learning Resources:

Textbook

1. Dr. Santosh M Nejakar, Dr. Harish Bendigeri "Research Methodology and Intellectual Property Rights", ISBN 978-93-5987-928-4, Edition: 2023-24.

Reference Book:

1. David V. Thiel "Research Methods for Engineers" Cambridge University Press, 978-1-107-03488-4
2. Intellectual Property Rights by N.K.Acharya Asia Law House 6th Edition. ISBN: 978-93-81849-30-9

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quizzes
- Assignments
- Seminars

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MODULE 1: INTRODUCTION

Syllabus

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.

MEANING OF 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

OBJECTIVES OF ENGINEERING RESEARCH

The purpose of research is to discover answers to questions through the application of scientific procedures. The main aim of research is to find out the truth which is hidden and which has not been discovered as yet. Though each research study has its own specific purpose, we may think of research objectives as falling into a number of following broad groupings:

1. Exploratory or Formulative research studies: To gain familiarity with a phenomenon or to achieve new insights into it
2. Descriptive research studies: To portray accurately the characteristics of a particular individual, situation or a group

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3. Diagnostic research studies: To determine the frequency with which something occurs or with which it is associated with something else
4. Hypothesis-testing research studies: To test a hypothesis of a causal relationship between variables

The objective of engineering research is

- To solve new and important problems, and since the conclusion at the end of one‘s research outcome has to be new, but when one starts, the conclusion is unknown.
- Research objectives can sometimes be convoluted and difficult to follow. Knowing where and how to find different types of information helps one solve engineering problems, in both academic and professional career.
- Lack of investigation into engineering guidelines, standards, and best practices result in failures with severe repercussions. As an engineer, the ability to conduct thorough and accurate research while clearly communicating the results is extremely important in decision making.
- The main aim of the research is to apply scientific approaches to seek answers to open questions, and although each research study is particularly suited for a certain approach
- The objectives of engineering research should be to develop new theoretical or applied knowledge and not necessarily limited to obtaining abilities to obtain the desired result.
- The objectives should be framed such that in the event of not being able to achieve the desired result that is being sought, one can fall back to understanding why it is not possible, because that is also a contribution toward ongoing research in solving that problem.

MOTIVATION IN ENGINEERING RESEARCH

The possible motives may be the result of one or more of the following desires:

- Studies have shown that intrinsic motivations like interest, challenge, learning, meaning, purpose, are linked to strong creative performance;
- Extrinsic motivating factors like rewards for good work include money, fame, publish praise, and status are very strong motivators, but may block creativity. Extrinsic

Research outcome may enable obtaining a patent which is a good way to become rich and famous.

- 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.

The following factors would be a mix of extrinsic and intrinsic aspects:

- Wanting to do better than what has been achieved in the world
- Improve the state of the art in technology
- Contribute to the improvement of society
- Fulfillment of the historical legacy in the immediate socio-cultural 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.

TYPES OF ENGINEERING RESEARCH

Descriptive versus Analytical:

- Descriptive research includes comparative and co relational methods, and fact-finding inquiries, to effectively describe the present state of art. The researcher holds no control over the variables; rather only reports as it is.
- Descriptive research also includes attempts to determine causes even though the variables cannot be controlled.
- On the contrary, in analytical research, already available facts for analysis and critical evaluation are utilized. Some research studies can be both descriptive and analytical

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.
- Research to identify social or economic trends, or those that find out whether certain communications will be read and understood are examples of applied research.
- The primary objective of applied research is to determine a solution for compelling problems in actual practice, while basic research is aimed at seeking information which could have a broad base of applications in the medium to long term.

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 non representative cases or verbal narrative in behavioral studies such as clustering effect in intersections in Transportation engineering to make a proposition.

Conceptual vs. Empirical

- Conceptual research is that related to some abstract idea(s) or theory.
- It is generally used by philosophers and thinkers to develop new concepts or to reinterpret existing ones.
- On the other hand, empirical research relies on experience or observation alone, often without due regard for system and theory.
- It is data-based research, coming up with conclusions which are capable of being verified by observation or experiment. We can also call it as experimental type of research.
- In such a research it is necessary to get at facts firsthand, at their source, and actively to go about doing certain things to stimulate the production of desired information.
- In such a research, the researcher must first provide himself with a working hypothesis or guess as to the probable results. He then works to get enough facts (data) to prove or disprove his hypothesis.

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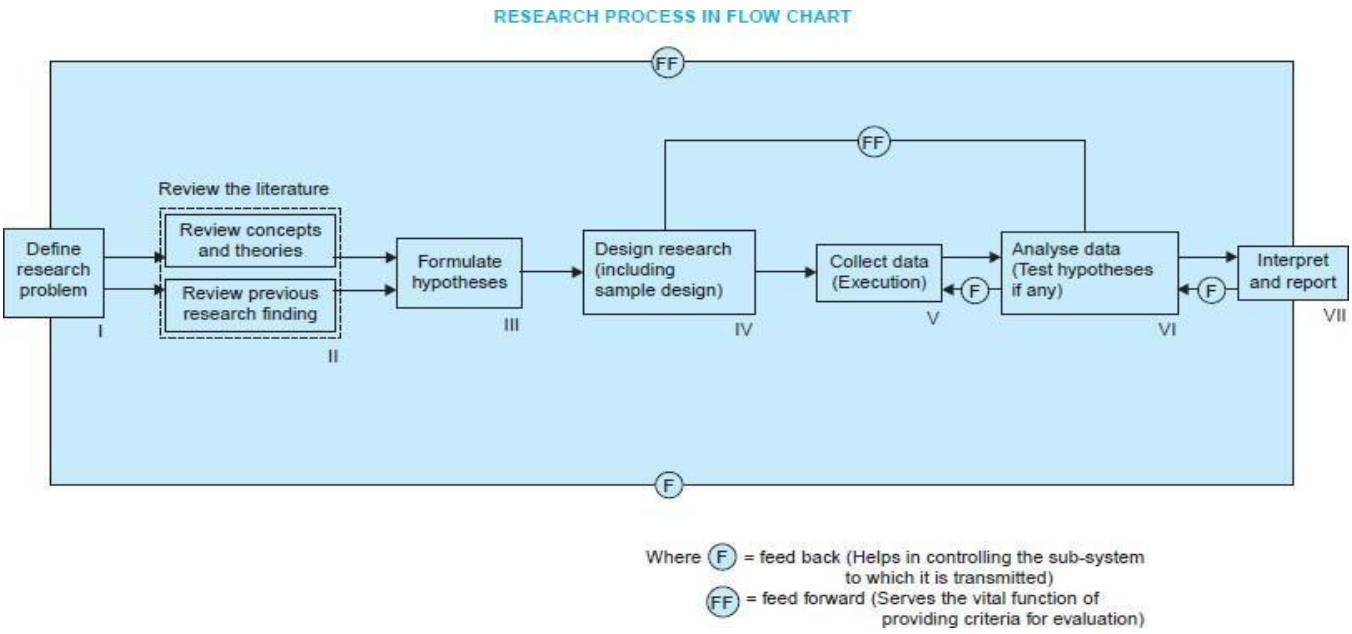
- He then sets up experimental designs which he thinks will manipulate the persons or the materials concerned so as to bring forth the desired information.
- Such research is thus characterized by the experimenter‘s control over the variables under study and his deliberate manipulation of one of them to study its effects.
- Empirical research is appropriate when proof is sought that certain variables affect other variables in some way. Evidence gathered through experiments or empirical studies is today considered to be the most powerful support possible for a given hypothesis.

ENGINEERING RESEARCH PROCESS

Research process consists of series of actions or steps necessary to effectively carry out research and the desired sequencing of these steps.



The chart indicates that the research process consists of a number of closely related activities, as shown through I to VII. But such activities overlap continuously rather than following a strictly prescribed sequence

1. **Formulating the research problem**: There are two types of research problems, viz., those which relate to states of nature and those which relate to relationships between

variables. At the very outset the researcher must single out the problem he wants to study, i.e., he must decide the general area of interest or aspect of a subject-matter that he would like to inquire into.

2. **Extensive literature survey**: Once the problem is formulated, a brief summary of it should be written down. It is compulsory for a research worker writing a thesis for a Ph.D. degree to write a synopsis of the topic and submit it to the necessary Committee or the Research Board for approval. At this juncture the researcher should undertake extensive literature survey connected with the problem.
3. **Development of working hypotheses**: After extensive literature survey, researcher should state in clear terms the working hypothesis or hypotheses. Working hypothesis is tentative assumption made in order to draw out and test its logical or empirical consequences.

   Hypothesis should be very specific and limited to the piece of research in hand because it has to be tested. The role of the hypothesis is to guide the researcher by delimiting the area of research and to keep him on the right track. It sharpens his thinking and focuses attention on the more important facets of the problem.
4. **Preparing the research design**: The research problem having been formulated in clear cut terms, the researcher will be required to prepare a research design, i.e., he will have to state the conceptual structure within which research would be conducted. The preparation of such a design facilitates research to be as efficient as possible yielding maximal information. In other words, the function of research design is to provide for the collection of relevant evidence with minimal expenditure of effort, time and money.
5. **Determining sample design:** The researcher must decide the way of selecting a sample or what is popularly known as the sample design. In other words, a sample design is a definite plan determined before any data are actually collected for obtaining a sample from a given population. Sampling can be done choosing a particular unit, random unit selection, systematic pattern, homogenous group (stratified sampling), quota, cluster or area, multi stages and sequential.
6. **Collecting the data**: In dealing with any real life problem it is often found that data at hand are inadequate, and hence, it becomes necessary to collect data that are appropriate. There are several ways of collecting the appropriate data which differ considerably in

context of money costs, time and other resources at the disposal of the researcher. Primary data can be collected either through experiment or through survey. If the researcher conducts an experiment, he observes some quantitative measurements, or the data, with the help of which he examines the truth contained in his hypothesis. But in the case of a survey, data can be collected by any one or more of the following ways by observation, through personal interview, through telephonic interview, by mailing the questionnaire etc

7. **Execution of the project**: It is a very important step in the research process. If the execution of the project proceeds on correct lines, the data to be collected would be adequate and dependable. The researcher should see that the project is executed in a systematic manner and in time. A careful watch should be kept for unanticipated factors in order to keep the survey as much realistic as possible.
8. **Analysis of data:** After the data have been collected, the researcher turns to the task of analyzing them. The analysis of data requires a number of closely related operations such as establishment of categories, the application of these categories to raw data through coding, tabulation and then drawing statistical inferences. The unwieldy data should necessarily be condensed into a few manageable groups and tables for further analysis. Thus, researcher should classify the raw data into some purposeful and usable categories.
9. **Hypothesis-testing**: After analyzing the data as stated above, the researcher is in a position to test the hypotheses, if any, he had formulated earlier. Do the facts support the hypotheses or they happen to be contrary? This is the usual question which should be answered while testing hypotheses. Various tests, such as Chi square test, t-test, F-test, have been developed by statisticians for the purpose. The hypotheses may be tested through the use of one or more of such tests, depending upon the nature and object of research inquiry. Hypothesis-testing will result in either accepting the hypothesis or in rejecting it.
10. **Generalizations and interpretation**: If a hypothesis is tested and upheld several times, it may be possible for the researcher to arrive at generalization, i.e., to build a theory. As a matter of fact, the real value of research lies in its ability to arrive at certain generalizations

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11. **Preparation of the report or the thesis**: Finally, the researcher has to prepare the report of what has been done by him. Writing of report must be done with great care keeping in view the following:

- The layout of the report should be as follows: (i) the preliminary pages; (ii) the main text, and (iii) the end matter.
- In its preliminary pages the report should carry title and date followed by acknowledgements and foreword. Then there should be a table of contents followed by a list of tables and list of graphs and charts, if any, given in the report.
- The main text of the report should have the following parts:

  (a) Introduction: It should contain a clear statement of the objective of the research and an explanation of the methodology adopted in accomplishing the research. The scope of the study along with various limitations should as well be stated in this part.

  (b) Summary of findings: After introduction there would appear a statement of findings and recommendations in non-technical language. If the findings are extensive, they should be summarized.

  (c) Main report: The main body of the report should be presented in logical sequence and broken-down into readily identifiable sections.

  (d) Conclusion: Towards the end of the main text, researcher should again put down the results of his research clearly and precisely. In fact, it is the final summing up.
- At the end of the report, appendices should be enlisted in respect of all technical data. Bibliography, i.e., list of books, journals, reports, etc., consulted, should also be given in the end. Index should also be given specially in a published research report.

FINDING AND SOLVING A WORTHWHILE PROBLEM

- A researcher may start out with the research problems stated by the Supervisor or posed by others that are yet to be solved. Alternately, it may involve rethinking of a basic theory, or need to be formulated or put together from the information provided in a group of papers suggested by the Supervisor.
- Research scholars are faced with the task of finding an appropriate problem on which to begin their research. Skills needed to accomplish such a task at the outset, while taking care of possible implications are critically important but often not taught.

- Once the problem is vaguely identified, the process of literature survey and technical reading would take place for more certainty of the worthiness of the intended problem.
- However, an initial spark is ideally required before the process of literature survey may duly begin.
- Sometimes, an oral presentation by somebody which is followed by asking questions or introspection provides this perspective which reading papers do not.
- At other times, a development in another subject may have produced a tool or a result which has direct implications to the researcher‘s subject and may lead to problem identification.
- A worthwhile research problem would have one or more attributes.
- It could be non-intuitive/counterintuitive even to someone who knows the area, something that the research community had been expecting for some time, a major simplification of a central part of the theory, a new result which would start off a new subject or an area, provides a new method or improves upon known methods of doing something which has practical applications, or a result which stops further work in an area.
- The researcher has to be convinced that the problem is worthwhile before beginning to tackle it because best efforts come when the work is worth doing, and the problem and/or solution has a better chance of being accepted by the research community.
- Not all problems that one solves will be great, and sometimes major advancements are made through solutions to small problems dealt with effectively. Some problems are universally considered hard and open, and have deep implications and connections to different concepts.
- The reality is that most researchers in their lifetime do not get into such problems. However, hard problems get solved only because people tackle them.
- The question a researcher has to grapple with whether the time investment is worth it given that the likely outcome is negative, and so it is a difficult personal decision to make.
- At the same time, even in the case of failure to solve the intended hard problem, there may be partial/side results that serve the immediate need of producing some results for

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the dissertation. George Pólya (1887–1985) suggested a 4-step procedure for mathematical problem-solving, which is relevant to engineering researchers as well.

The recommended steps to solve a research problem are

- Understand the problem, restate it as if it‘s your own, visualize the problem by drawing figures, and determine if something more is needed.
- One must start somewhere and systematically explore possible strategies to solve the problem or a simpler version of it while looking for patterns.
- 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.
- Looking back and reflecting helps in understanding and assimilating the strategy, and is a sort of investment into the future.

ETHICS IN ENGINEERING RESEARCH

- Ethics generally refers to a set of rules distinguishing acceptable and unacceptable conduct, distinguishing right from wrong as such
- Most people learn such norms in their formative years, but moral development continues through different stages of growth. Although everyone recognizes some common ethical norms, but there is difference in interpretation and application.
- Ethical principles can be used for evaluation, proposition or interpretation of laws. Although ethics are not laws, but laws often follow ethics because ethics are our shared values.
- International norms for the ethical conduct of research have been there since the adoption of the Nuremberg Code in 1947.
- According to Whitbeck, the issues related to research credit dates back to the establishment of the British Royal Society (BRS) in the seventeenth century to refine the methods and practices of modern science. This event altered the timing and credit issues on the release of research results since BRS gave priority to whoever first submitted findings for publication, rather than trying to find out who had first discovered.

- Whitbeck raised two simple but significant questions to address the tricky issue of authorship in research:
    - Who should be included as an author and
    - The appropriate order of listing of authors.
- In an increasingly interconnected world, the issue of co-authorship is very relevant to all researchers. There are issues around individuals who may be deeply involved during the conduct of the research work, but may not contribute in the drafting phase
- 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.

ETHICS IN ENGINEERING RESEARCH PRACTICE

- Technological developments raise a whole range of ethical concerns such as privacy issues and data related to surveillance systems, and so engineering researchers need to make ethical decisions and are answerable for the repercussions borne out of their research as outcomes.
- 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.
- We have unprecedented access to data today, and unprecedented options for analysis of these data and consequences in engineering research related to such data. Are there things that are possible to do with this data, that we agree we should not do?
- Engineering ethics gives us the rule book; tells us, how to decide what is okay to do and what is not. Engineering research is not work in isolation to the technological development taking place.
- Researchers make many choices that matter from an ethical perspective and influence the effects of technology in many different ways:

● By setting the ethically right requirements at the very outset, engineering plays a ultimately influence the effects of the developed technology.

  - 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.
  - Thirdly, engineering researchers have to choose between different alternatives fulfilling similar functions.
- Research outcomes often have unintended and undesirable side effects. It is a vital ethical responsibility of researchers to ensure that hazards/risks associated with the technologies that they develop, are minimized and alternative safer mechanisms are considered.
- If possible, the designs should be made inherently safe such that they avoid dangers, or come with safety factors, and multiple independent safety barriers, or if possible a supervisory mechanism to take control if the primary process fails.

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.

There may be different types of research misconduct as described, which can be summarized as follows:

- **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.

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Falsification and fabrication of data and results, hamper engineering research and 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. 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.

  Although there are many free tools and also paid tools available that one can procure institutional license of, one cannot conclusively identify plagiarism, but can only get a similarity score which is a metric that provides a score of the amount of similarity between already published content and the unpublished content under scrutiny.

  However, a low similarity score does not guarantee that the document is plagiarism free. It takes a human eye to ascertain whether the content has been plagiarized or not.

  It is important to see the individual scores of the sources, not just the overall similarity index. Setting a standard of a maximum allowable similarity index is inadequate usage of the tool. Patchwork plagiarism is more difficult to evaluate.

  There are simple and ethical ways to avoid a high similarity count on an about to be submitted manuscript. Sometimes, certain published content is perfect for one's research paper, perhaps in making a connection or fortifying the argument presented. The published material is available for the purpose of being used fairly.

One is not expected to churn out research outcomes in thin air.

However, whatever is relevant can be reported by paraphrasing in one‘s own words, that is, without verbatim copy.

One can also summarize the relevant content and naturally, the summary invariably would use one‘s own words. In all these cases, citing the original source is important. However, merely because one has cited a source, it does not mean that one can copy sentences (or paragraphs) of the original content verbatim.

A researcher should practice writing in such a way that the reader can recognize the difference between the ideas or results of the authors and those that are from other sources. Such a practice enables one to judge whether one is disproportionately using or relying on content from existing literature.

- **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.

  Another issue is that when mistakes are found in an article or any published content, they are generally not reported for public access unless a researcher is driven enough to build on that mistake and provide a correct version of the same which is not always the primary objective of the researcher.

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.
- There is several important research conduct and ethics related issues connected to authorship of research papers and are summarized herewith in the context of engineering research.
- 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‖ (co-authorship 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.
- Sometimes, the primary author dubiously bestows co-authorship on a junior faculty or a student to boost their chances of employment or promotion, which can be termed as Career-boost authorship.
- There is also an unfortunate malpractice of co-authorship 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. Sometimes, an actual contributor abstains from the list of authors due to no disclosed conflict of interest within the organization. Such co-authorships can be termed as ghost co-authorship. Full disclosure of all those involved in the research is important so that evaluation can happen both on the basis of findings, and also whether there was influence from the conflicts.
- In another type of questionable authorship, some researchers list one another as coauthors as a reciprocal gesture with no real collaboration except minimal reading and editing, without truly reviewing the work threadbare.
- Some authors, in trying to acquire a sole-authored work, despite relying on significant contribution to the research work from others, recognize that effort only by an acknowledgment, thereby misrepresenting the contributions of the listed authors.
- The unrecognized ―author‖ is as a consequence, unavailable to readers for elaboration.
- All listed authors have the full obligation of all contents of a research article, and so naturally, they should also be made aware of a journal submission by the corresponding author.

- It is imperative that their consent is sought with respect to the content and that they be agreeable to the submission.
- In case of misconduct like inappropriate authorship, while the perpetrator is easier to find, the degree of appropriate accountability of the coauthors is not always obvious. Being able to quantify the contributions so as to appropriately recognize and ascertain the degree of associated accountability of each coauthor, is appealing.
- 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 elsewhere, and strongly discourage double submission.

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