

# **Ph.D. MECHANICAL ENGINEERING**

## **CURRICULUM AND SYLLABUS**

**(2024 AND ONWARDS)**

**Department of Mechanical Engineering**  
**FACULTY OF ENGINEERING**



**KARPAGAM ACADEMY OF HIGHER EDUCATION**

**(Deemed to be University)**

**(Established Under Section 3 of UGC Act, 1956)**

**(Accredited with A+ Grade by NAAC in the Second Cycle)**

**Pollachi Main Road, Eachanari Post, Coimbatore – 641 021, Tamil Nadu, India.**

**Phone : 0422 – 2980011 – 14 , Email : info@kahedu.edu.in**

**Regulations**  
for  
**Ph.D., Full Time (FT) / Part Time (PT)**

As per the UGC (Minimum Standards and Procedures for Award of Ph.D., Degree)  
Regulations, 2022

The Regulation will be effective from 7<sup>th</sup> November, 2022  
(The research scholars admitted from January, 2023 onwards will be governed by this regulation)



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## Regulations for Ph.D., Full Time (FT) / Part Time (PT)

### 1.0 Preamble

The Degree of Doctor of Philosophy (Ph.D.,) is awarded to a candidate who has submitted a thesis on the basis of original and independent research work done in any particular discipline or involving more than one discipline (inter-disciplinary), that make a contribution to the advancement of knowledge, which is approved by Board of Examiners as per the requirement.

### 2.0 Eligibility Criteria for admission to the Ph.D., Programme:

- 2.1 A 1-year/2-semester master's degree programme after a 4-year/8-semester bachelor's degree programme or a 2-year/4-semester master's degree programme after a 3-year bachelor's degree programme or qualifications declared equivalent to the master's degree by the corresponding statutory regulatory body, with at least 55% marks in aggregate or its equivalent grade in a point scale wherever grading system is followed

or equivalent qualification from a foreign educational institution accredited by an assessment and accreditation agency which is approved, recognized or authorized by an authority, established or incorporated under a law in its home country or any other statutory authority in that country to assess, accredit or assure quality and standards of the educational institution.

- 2.2 Candidate seeking admission after a 4-year/8-semester bachelor's degree programme should have a minimum of 75% marks in aggregate or its equivalent grade on a point scale wherever the grading system is followed. A relaxation of 5% marks or its equivalent grade may be allowed for those belonging to SC/ST/OBC (non-creamy layer)/Differently-Abled, Economically Weaker Section (EWS) and other categories of candidates as per the decision of the Commission from time to time.

Candidates who have completed the M.Phil. programme with at least 55% marks in aggregate or its equivalent grade in a point scale wherever grading system is followed or equivalent qualification from a foreign educational institution accredited by an assessment and accreditation agency which is approved, recognized or authorized by an authority, established or incorporated under a law in its home country or any other statutory authority in that country to assess, accredit or assure quality and standards of educational institutions, shall be eligible for admission to the Ph.D. programme. A relaxation of 5% marks or its equivalent grade may be allowed for those belonging to SC/ST/OBC (non-creamy layer)/Differently-Abled, Economically Weaker Section (EWS) and other categories of candidates as per the decision of the Commission from time to time

- 2.3 The Part Time research scholars have to report to the guide once in a month till they submit their Synopsis/Thesis.

**3.0 Admission**

Admission for Ph.D. programme shall be made on half yearly basis viz. January and July. The admission shall be based on the criteria notified by the Institution, keeping in view the guidelines/norms issued by the UGC and other statutory bodies concerned and taking into account the reservation policy of the Central / State Government and the number of vacancies available with each recognized guide of the Department concerned.

**4.0 Selection Procedure**

4.1 The candidates will be selected for admission to Ph.D., programme based on the performance in the **Entrance Test** and **Interview** conducted to assess the aptitude of the candidate for research, subject to satisfying the eligibility conditions.

The candidates who have qualify for fellowship/scholarship in UGC-NET//UGC-CSIRNET/GATE/CEED and similar National level tests based on an interview. And/or The candidates who have qualified from “Karpagam Academy of Higher Education entrance test” conducted at the level of our Institution. The Entrance Test syllabus shall consist of 50% of research methodology, and 50% shall be subject-specific.

Students who have secured 50% marks in the entrance test are eligible to be called for the interview. A relaxation of 5 % marks will be allowed in the entrance examination for the candidates belonging to SC/ST/OBC/differently-abled category, Economically Weaker Section (EWS), and other categories of candidates as per the decision of the Commission from time to time.

KAHE may decide the number of eligible students to be called for an interview based on the number of Ph.D. seats available.

- 4.2 The candidates selected for admission to the Ph.D., programme shall be required to submit attested copy of the certificates with 3 passport size recent Photo. The original certificates brought during interview will be returned immediately after verification.
- 4.3 Provided that for selection of candidates, a weightage of 70% to the entrance test and 30% to the performance in the interview shall be given.
- 4.4 The Karpagam Academy of Higher Education shall maintain the list of all the Ph.D., registered students on its website year-wise. The list shall include the name of the registered candidate, topic of his/her research, name of his/her supervisor / co-supervisor and date of enrolment /registration.
- 4.5 Admission of International students in Ph.D., programme is also based on Entrance test and Interview keeping in view the guidelines/norms in this regard issued by statutory/regulatory bodies concerned from time to time.

**5.0 Eligible Degrees for Ph.D., Registration:**

Master's degree / M.Phil., Degree in the relevant disciplines or 4-Year Bachelor's Degree in the relevant disciplines, approved by Central and State approval authority.

**6.0 Duration of the Programme**

Ph.D. Programme shall be for a minimum duration of three (3) years, including coursework, and a maximum duration of six (6) years from the date of admission to the Ph.D. programme.

A maximum of an additional two (2) years can be given through a process of re-registration as per the Statute/Ordinance of the Higher Educational Institution concerned; provided, however, that the total period for completion of a Ph.D. programme should not exceed eight (8) years from the date of admission in the Ph.D. programme.

Provided further that, female Ph.D. scholars and Persons with Disabilities (having more than 40% disability) may be allowed an additional relaxation of two (2) years; however, the total period for completion of a Ph.D. programme in such cases should not exceed ten (10) years from the date of admission in the Ph.D. programme.

Female Ph.D. Scholars may be provided Maternity Leave/Child Care Leave for up to 240 days in the entire duration of the Ph.D. programme.

Ph.D. programmes through part-time mode will be permitted, provided all the conditions stipulated in these Regulations are fulfilled.

The Higher Educational Institution concerned shall obtain a “No Objection Certificate” through the candidate for a part-time Ph.D. programme from the appropriate authority in the organization where the candidate is employed, clearly stating that:

- i. The candidate is permitted to pursue studies on a part-time basis.
- ii. His/her official duties permit him/her to devote sufficient time for research.
- iii. If required, he/she will be relieved from the duty to complete the course work.

**7.0 Conversion from Full Time Ph.D. to Part Time Ph.D. and Vice-versa**

- i. Conversion from Full time to Part time or vice versa is permitted on recommendation of the Research Supervisor
- ii. A conversion fee of ₹2000 has to be paid towards the conversion.

**8.0 Modification of Topic**

Modification of topic of research by the candidate is permitted. A fee of ₹ 2000 has to be paid for a change of topic of research. The time limit fixed for modification of topic of research in Ph.D., programme is up to final DCM prior to submission of synopsis.

**9.0 Language**

The Ph.D., Part I course work and Part II synopsis / thesis must be written in English for subjects other than languages.

**10.0 Eligibility criteria to be a Research Supervisor:**

Permanent faculty members working as Professor/Associate Professor with a Ph.D., and at least five research publications in peer-reviewed or refereed journals and permanent faculty members working as Assistant Professors with a Ph.D., and at least three research publications in peer-reviewed or refereed journals may be recognized as a Research Supervisor in the university where the faculty member is employed. Such recognized

research supervisors cannot supervise research scholars in other institutions, where they can only act as co-supervisors. Ph.D. awarded by a university under the supervision of a faculty member who is not an employee of the university would be in violation of these Regulations.

For Ph.D. scholars working in Central government/ State government research institutions whose degrees are given by Higher Educational Institutions, the scientists in such research institutions who are equivalent to Professor/Associate Professor/Assistant Professor can be recognized as supervisors if they fulfill the above requirements.

Provided that in areas/disciplines where there is no, or only a limited number of peer-reviewed or refereed journals, the Higher Educational Institution may relax the above condition for recognition of a person as Research Supervisor with reasons recorded in writing.

Adjunct Faculty members shall not act as Research Supervisors and can only act as co-supervisors.

However, Co-Supervisor can be allowed in inter-disciplinary areas from other departments of the same institute or from other institutions with the approval of the Doctoral Committee.

In case of interdisciplinary/multidisciplinary research work, if required, a Co-Supervisor from outside the University may be appointed.

A Research Supervisor who is a Professor, at any given point of time, can guide a maximum of 8 Ph.D., scholars only. An Associate Professor upto a maximum of 6 Ph.D., scholars and an Assistant Professor upto a maximum of 4 Ph.D., scholars.

In case of relocation of a female Ph.D. scholar due to marriage or otherwise, the research data shall be allowed to be transferred to the Higher Educational Institution to which the scholar intends to relocate, provided all the other conditions in these Regulations are followed, and the research work does not pertain to a project sanctioned to the parent Institution/Supervisor by any funding agency. Such scholar shall, however, give due credit to the parent institution and the supervisor for the part of research already undertaken.

Faculty members with less than three years of service before superannuation shall not be allowed to take new research scholars under their supervision. However, such faculty members can continue to supervise Ph.D. Research scholars who are already registered until superannuation and as a co-supervisor after superannuation, but not after attaining the age of 70 years.

#### **11.0 Admission of International students in Ph.D., programme.**

Each supervisor can guide up to two international research scholars on a supernumerary basis over and above the permitted number of Ph.D. scholars as specified.

#### **12.0 Change of Research Supervisor**

Transfer of Ph.D., scholars from one Research supervisor to another Research supervisor shall be permitted under the following conditions:

- i. If the Research Supervisor resigns and leaves the institution.
- ii. If the Research Supervisor expresses unwillingness to guide the candidate
- iii. If the Research Scholar expresses his/her unwillingness to work under a specific Research Supervisor.

- iv. By mutual consent.
- v. A fee of ₹2000 has to be paid towards the change of Research Supervisor, if the change is requested by the Research scholar.

### 13.0 Doctoral Committee (Research Advisory Committee as per UGC)

There shall be a Doctoral Committee (Research Advisory Committee as per UGC) for every Ph.D., scholar to monitor the progress of his/her research work. The Research Supervisors in consultation with Head of the Department shall furnish a panel of minimum five experts with doctoral qualification in their respective research field, from the other Academic Institutions / National Laboratories and established research laboratories. From this list one will be nominated as a external expert for each Ph.D research scholar. The Research Supervisor of the research scholar shall be the convener of the Doctoral Committee. The Co- Supervisor, if applicable, shall also be a member. In the absence of Research Supervisor, the Co-Supervisor can be the convenor of the Doctoral Committee. **The Doctoral Committee Meeting shall be conducted in presence of Ph.D Research Supervisor and the nominated external expert.** If a Doctoral Committee member is away from his/her place of work for a longer period, the Research Supervisor shall request for an alternate member from the Panel of experts submitted.

#### 13.1 Functions of Doctoral Committee (Research Advisory Committee as per UGC):

The Research Supervisor of the Ph.D. scholar concerned shall be the Convener of this committee, and this committee shall have the following responsibilities:

- i. To review the research proposal and finalize the topic of research.
- ii. To guide the Ph.D. scholar in developing the study design and methodology of research and identify the course(s) that he/she may have to do.
- iii. To periodically review and assist in the progress of the research work of the Ph.D. scholar.

Each semester, a Ph.D. scholar shall appear before the Doctoral Committee in the Karpagam Academy of Higher Education campus to make a presentation and submit a brief report on the progress of his/her work for evaluation and further guidance. The Doctoral Committee shall submit its recommendations along with a copy of Ph.D. scholar's progress report to The Registrar, Karpagam Academy of Higher Education. A copy of such recommendations shall also be provided to the Ph.D. scholar.

The first Doctoral Committee meeting of a scholar which shall be conducted within one month from the date of registration shall decide the topic of research, work plan and the course work to be undertaken by the scholar. The Doctoral Committee shall also submit a Panel of three Experts from recognized institutes (other than Parent Institution) along with their CV for question paper setting and evaluation relating to Part –I Examinations.

The scholar shall be permitted for pre-submission presentation after recommended by the Final Doctoral Committee Meeting. The synopsis to be submitted only after the successful completion of pre-submission presentation. The time gap between the date of pre-submission and the date of submission of synopsis shall be atleast one month.

**14.0 Submission of Progress Report:**

Progress report is to be submitted every half-year period during the entire duration of Ph.D., programme

**15.0 Course of Study:**

The course of study of Ph.D., programme consists of Part I Course work and Part II Research work.

**15.1 Part I: Course Work**

Course work comprises the following three theory papers.

- |           |                                     |
|-----------|-------------------------------------|
| Paper I   | : Research Methodology and Pedagogy |
| Paper II  | : Research and Publication Ethics   |
| Paper III | : Special Paper (Research Area)     |

- 15.2 The course work shall be treated as a prerequisite for Ph.D., preparation. The credit assigned to the Ph.D. course work shall be 12 credits.

Paper I on Research Methodology and Pedagogy a minimum of four credits shall be assigned which could cover areas such as quantitative methods, computer applications, research ethics and review of published research in the relevant field, training, field work, etc.

Paper II Research and Publication Ethics and Paper III Special Paper carry 4 credits each. The total number of special papers in each discipline shall be 10. The candidate has to select one among the 10, in consultation with the Research Supervisor.

The Credit requirement for the Ph.D. coursework is a minimum of 12 credits, including a "Research and Publication Ethics" course as notified by UGC vide D.O. No. F.1- 1/2018(Journal/CARE) in 2019 and a research methodology course. The Research Advisory Committee can also recommend UGC recognized online courses as part of the credit requirements for the Ph.D. programme.

Ph.D. scholars, irrespective of discipline, shall be trained in teaching / education / pedagogy / writing related to their chosen Ph.D. subject during their doctoral period. Ph.D. scholars will also be assigned 4-6 hours per week of teaching/research assistantship for conducting tutorial or laboratory work and evaluations.

The Full-Time scholar is required to write all the three courses within six months and for Part time the research scholar has to write within one year, from the date of registration, but has to pass all the courses within a maximum of one and half years (three attempts). If the scholar fails to complete course work within one and half years (three attempts) his/her registration will stand automatically cancelled.

- 15.3 A Ph.D., scholar has to obtain a minimum of 55% of marks or its equivalent grade in the UGC 10 point scale in the course work in order to be eligible to continue the programme and submit the dissertation/thesis.



The pattern of question paper for course work for Ph.D., programme is given below.

**Pattern of Question Paper** (Common for FASCM /FoE/FoP)(For Course Work in Ph.D, Programme)

**Part – A** (5 X 7 = 35 marks - Answer any FIVE out of Seven)

**Part – B** (5 X 10 = 50 marks - Answer any FIVE out of Ten)

**Part – C** (1 X 15 = 15 marks - Compulsory Question)

#### **15.4. Part II: Research Work**

Upon satisfactory completion of course work and obtaining the marks/grade prescribed, the Ph.D., scholar shall be required to undertake research work. The Ph.D., candidates shall select an original research topic within the chosen area of research specialization. At the end of the minimum period of duration the candidates are eligible to submit the thesis.

#### **16.0 Publication of Articles**

Before sending the articles for publication, the article/manuscript is to be submitted to Scrutiny Committee for language and technical scrutiny with a fee of ₹450 per article. After publication, the candidate has to submit the copy of his/her article to the members of the Doctoral Committee.

#### **16.1 Publication of a minimum of two articles is mandatory for submission of a thesis.**

16.2 Condition for submission of thesis:

It is Mandatory for the Ph.D., Scholars to publish two research articles for submission of his/her of Ph.D., thesis as mentioned below:

- (i) Engineering, Science and Pharmacy: One article should be in SCI / SCIE / Web of Science and another one in Scopus
- (ii) Commerce, Management, Arts: One in Scopus and another one in Peer reviewed / UGC care listed Journals
- (iii) To attend at-least two timeline presentations and two annual research congress

#### **17.0 Pre-Submission Presentation**

The Pre-submission will be permitted only when the research scholar has either published his/her article or it has been accepted for publication provided the date of publication of the article is given in the acceptance letter for publication in an approved Journal. All the published papers by the scholar shall have name of the Research Supervisor and Karpagam Academy of Higher Education. Papers without the name of the Research Supervisor and Karpagam Academy of Higher Education will not be accounted. The Research Scholar should be one among the first two authors in the paper.

Prior to submission of the synopsis, the scholar shall make Pre-submission presentation and it is open to all faculty members and research students, and their feedback and comments if any may suitably be incorporated in the draft synopsis and thesis in consultation with Doctoral Committee. A notification may be issued to all the Departments regarding the same. The report in the prescribed format shall be forwarded

by the Research Supervisor to the Research section on the same day along with the certificate of bonafide research work done.

**18.0. Plagiarism (Turnitin Software):**

18.1 The research scholar has to submit his/her synopsis and thesis for checking plagiarism on payment of prescribed fee. If the percentage of plagiarism is more than 10% the thesis will not be accepted for submission. Same is the case for manuscripts and synopsis.

18.2 Further while submitting for evaluation, the thesis shall have an undertaking from the research scholar and a certificate from the Research Supervisor attesting the originality of the work, vouching that the plagiarism is less than 10% and that the work has not been submitted for the award of any other degree/diploma of the same Institution where the work was carried out, or any other Institution.

18.3 In any case if scholars have committed an act of plagiarism with more than 10%, his/her Thesis / degree shall be withdrawn and his / her registration shall be cancelled and also, he / she shall be debarred to register for any other programme in the Karpagam Academy of Higher Education. Appropriate legal action shall also be initiated.

18.4 Research Supervisor ship of the Supervisor will also be withdrawn.

**19.0. Submission of synopsis**

The research scholar who has successfully completed the course work alone is eligible to submit the synopsis. He/she shall be permitted to submit the synopsis during the last quarter of the eligible minimum period on the recommendation of the Final Doctoral Committee Meeting and after Pre-submission Presentation. The research scholar shall submit five copies of synopsis with a soft copy along with prescribed application through the Research Supervisor to the Controller of Examinations. Synopsis shall be accepted only when the Panel of Examiners is submitted to Controller of Examinations. In case the panel is exhausted, the Vice Chancellor can either call for a fresh panel of examiners from the Research Supervisor or nominate examiner(s).

**19.1 Submission of thesis**

Five copies of thesis with flexible cover along with soft copy (PDF format) shall be prepared in accordance with the format and specifications prescribed. Thesis shall be submitted together with the prescribed application form along with the prescribed fee, within three months from the date of submission of the synopsis.

All the Ph.D., scholars are encouraged to submit their thesis within the stipulated time period. However, for those candidates who have submitted synopsis but unable to submit the thesis within the stipulated period, an extension of three months will be allowed on payment of ₹ 2000/- as extension fee. If the candidate fails to submit within the extension period of three months, he / she has to pay full year fee for all the years till he / she submits the thesis.

**20.0 Evaluation of the Thesis**

- 20.1 The Ph.D. thesis submitted by a Ph.D. scholar shall be evaluated by his/her Research Supervisor and atleast two external examiners who are experts in the field. Such examiner(s) should be academics with a good record of scholarly publications in the field. Wherever possible, one of the external examiners should be chosen from outside India. The viva-voce board shall consist of the Research Supervisor and at least one of the two external examiners and may be conducted offline.
- 20.2 The viva-voce of the Ph.D. scholar to defend the thesis shall be conducted if both the external examiners recommend acceptance of the thesis after incorporating any corrections suggested by them. If one of the external examiners recommends rejection, the Institution concerned shall send the thesis to an alternate external examiner from the approved panel of examiners, and the viva-voce examination shall be held only if the alternate examiner recommends acceptance of the thesis. If the alternate examiner does not recommend acceptance of the thesis, the thesis shall be rejected, and the Ph.D. scholar shall be declared ineligible for the award of a Ph.D.
- 20.3 Each member of the Board shall adjudicate the thesis and shall submit a detailed report as given in the prescribed form on the merits and demerits of the thesis and finally explicitly indicate whether the thesis is Recommended or Recommended for Resubmission or Not Recommended within a period of 6 months.
- 20.4 If the evaluation report from the examiner is not received within 6 Months, another examiner will be appointed from the panel of examiners.
- 20.5 As soon as the reports of evaluation are received from the examiners by Controller of Examinations, they shall be sent to the Research Supervisor (Convener) for consolidation of the reports.
- 20.6 If the examiners insist on corrections to be made in the thesis, the same shall be made before appearing for the Public viva-voce examination, along with a certificate as given below from the Research Supervisor that the corrections have been satisfactorily carried out.

A Ph.D. scholar shall submit the thesis for evaluation, along with (a) an undertaking from the Ph.D. scholar that there is no plagiarism and (b) a certificate from the Research Supervisor attesting to the originality of the thesis and that the thesis has not been submitted for the award of any other degree/diploma to any other Higher Educational Institution.

<p><b>CERTIFICATE</b></p> <p>This is to certify that all corrections, modifications suggested by the examiners of the thesis entitled, “.....”submitted by Mr./Ms ..... have been incorporated and resubmitted. The thesis may be accepted.</p> <p style="text-align: right;"><b>Signature of the Research Supervisor</b></p>
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- 20.7 In case of a thesis, which has not been specifically ‘recommended’ or ‘not recommended’ but revision and resubmission is suggested, the thesis shall be

revised and the thesis duly certified by the Research Supervisor be sent to the same examiner who has suggested the revision for obtaining the recommendation.

- 20.8 The time-limit to resubmit the revised thesis, as per the suggestions for revision and resubmission of thesis by the examiner(s) shall not exceed twelve full months. A candidate shall not ordinarily be permitted to submit the thesis for the degree or to take the public viva-voce examination on more than two occasions.
- 20.9 The viva-voce shall be conducted by the Research Supervisor and atleast by one of the two external examiners, on the critiques given in the evaluation report. It is open to DC Members, all faculty members, research scholars and other interested experts/researchers.
- 20.10 The first notification for Ph.D., viva-voce shall be issued only after the Research Supervisor of the candidate, receives the approval from the authorities to issue the first notice.
- 20.11 15 clear days' notice may be required to be given for issue of the second notification from the date of the first notification. Similarly, 15 clear days are required to be given for conducting the public viva-voce from the date of issue of the second notification.
- 20.12 The Research Supervisor shall fix the date and time of the viva-voce in consultation with the External Examiner and Head of the Department concerned. After conducting the public viva-voce, the Research Supervisor shall convey to the Controller of Examination, the result of such examination endorsed by the External Examiner along with list of participants, recommending for the award of Ph.D.,
- 20.13 A candidate who is not successful in the Public viva-voce may be permitted to undergo the Public viva-voce second time, within a period of three months but not before one month after the first viva-voce.
- 20.14 The entire process of evaluating a Ph. D. thesis, including the declaration of the viva-voce result, within a period of six (6)months from the date of submission of the thesis.

### **21.0 Award of the Degree**

A candidate who has successfully completed the public viva-voce shall be declared to have qualified for the award of Ph.D., degree of Karpagam Academy of Higher Education. Viva voce evaluation of the thesis shall be conducted offline. Prior to actual award of the degree, provisional certificate shall be issued after approval by the Board of Management.

Issuing a Provisional certificate:

Prior to the actual award of the Ph.D. degree, the degree- awarding Higher Educational Institution shall issue a provisional certificate to the effect that the Ph.D. is being awarded in accordance with the provisions of these Regulations.

Award of Ph.D. degrees:

Award of degrees to candidates registered for the Ph.D. programme on or after November,07, 2022 shall be governed by University Grants Commission (Minimum Standards and Procedures for Award of Ph.D. Degree) Regulations, 2022.

**Depository with INFLIBNET:**

Following the successful completion of the evaluation process and before the announcement of the award of the Ph.D. degree(s), the Karpagam Academy of Higher Education shall submit an electronic copy of the Ph.D. thesis to INFLIBNET, for hosting the same so as to make it accessible to all the Higher Educational Institutions and research institutions.

**22.0. Cancellation of Registration**

The registration of a research scholar shall stand cancelled if -

- The research scholar has not paid the prescribed fee within the stipulated time;
- The Full-Time candidate has not completed his course work within one and half years (three attempts) and Part-Time candidates within two years (three attempts)
- The progress report is not submitted consecutively or the progress reports are not satisfactory as decided by the Doctoral Committee;
- The maximum period stipulated for the programme exceeded; and
- The research scholar withdraws from the course voluntarily.

In all the above cases, the fees paid by the research scholar shall be forfeited. However, such candidates may be permitted for fresh registration.

**23.0 Publication of the thesis**

The candidate may publish his/her thesis on the recommendation of the Research Supervisor in the format as given below and after getting permission from the Karpagam Academy of Higher Education. At least ten copies of the published work should be given to the Karpagam Academy of Higher Education at free of cost Permission for publication of the thesis should be obtained within FIVE years of the award of the degree. All the publications arising out of the research work shall have the name of Karpagam Academy of Higher Education. Due credit shall be given to the Institution and Research Supervisor if any patent is filed out of the work undertaken during the period of research.

**[CERTIFICATE]**

This is to certify that the thesis entitled, “.....” submitted by Mr. / Ms. .... does not contain any objectionable material and is a record of original and independent research work done by him/her. Hence the thesis is fit for publication, if the candidate so desires.

**Signature of the Research Supervisor**

**24.0 Conferment of the Degree**

Candidates who qualify for the Ph.D., degree shall be awarded the degree in the discipline in which he/she has registered.

**25. Preparation and Submission of Synopsis and Thesis**

**25.1 Preparation of Synopsis**

Synopsis should outline the research problem, the methodology adopted and the summary of the findings. The synopsis should not exceed 10 pages from the first page to the last page including the List of Publications. The sequence in which the Synopsis should be arranged is as follows:

- i. Cover Page and Title page (as shown in the Annexure I) (Page No.17& Page No.18)
- ii. Text divided into suitable Headings (numbered consecutively)
- iii. References
- iv. List of Publications (those published / accepted for publication in Journals and papers presented in Conferences / Symposia)
- v. Standard A4 size (297mm x 210mm) paper shall be used for preparing the copies.

Top edge: 30 mm

Bottom edge: 30 mm

Left side: 35 mm

Right side : 25 mm

The Synopsis should be prepared on good quality white bond paper preferably not lower than 80 gsm. One and a half spacing should be used for typing the general text. The general text shall be typed in Font Style Times New Roman and Font Size 12. All page numbers (Arabic numbers) should be typed without punctuation on the upper right hand corner. Synopsis should be bound using flexible cover of thick white art paper. The cover should be printed in black letters and the text for printing should be identical to what has been prescribed for the title page. References, if any cited in the text of the Synopsis, should be listed at the end of the Synopsis under the heading "REFERENCES" as per the following format:

### References

#### I. References cited from published research papers should be in the following format:

##### a. Single author

Wattenberg, L.W.,2008.Chemoprevention of cancer. Cancer Research., 45:1-8.

##### b. Two authors

Defendi, V. and B. Pearson, 2012. Quantitative estimation of succinic dehydrogenase activity in a single microscopic tissue section. Journal, Histochemistry, Cytochemistry, 3: 61-64.

##### c. More than two authors

Kristan K., M. Kotnik, M. Oblak and U.J. Urleb, 2009. New high throughput fluorimetric assay for discovering inhibitors of UDP-N-acetylmuramyl-l-alanine: d-glutamate (MurD)lLigase.Biomol. Screen, 14: 412-418.

#### II. References cited from a published book

Vuković-Gačić, B. and D.Simić, 2010. Identification of natural antimutagens with modulating effects on DNA repair, In: Antimutagenesis and anti-carcinogenesis mechanisms III (Eds. G.Bronzzeti, H. Hayatsu, S. De Flora, M.D. Waters and D.M. Shankel), Plenum Press, New York,269-277.

#### III. References cited from approved Thesis / Dissertation

Ratnakar, P., 2012. Biochemical studies of *Allium sativum* Linn. (Garlic). Ph.D.,Thesis, DelhiUniversity. P. 87.

### 25.2 Preparation of Thesis

**A. General**

In general, the Thesis shall be presented, in an organized and scholarly fashion, the original research work of the research scholar.

**B. Size of Thesis**

The size of the Thesis should not exceed 250 pages of typed matter reckoned from the first page of Chapter 1 to the last page of the Conclusion Chapter exclusive of tables, photographs, figures, references & appendices.

**C. Sequence of the Contents of the Thesis**

The sequence in which the Thesis material should be arranged is as follows:

- i. Cover Page and Title page (as shown in Annexure II Page 19& Page 20)
- ii. Bonafide Certificate (as shown in Annexure III Page 21)
- iii. Declaration and Certificate from the Research Supervisor and co-Research Supervisor (if any)(as shown in Annexure IV Page 22& V Page 23)
- iv. Acknowledgement
- v. Table of Contents
- vi. List of Symbols and Abbreviations.
- vii. Abstract
- viii. Chapters
- ix. References
- x. Appendices
- xi. List of Publications- only title of the paper with ISSN and other details.

**D. Page Dimensions and Margin**

The dimensions of the final bound Thesis report (5 copies) should be 290 mm x 205mm. Page margins: Tables and Figures should conform to the margin specifications. Large sized figures may be as it is or otherwise reduced to the appropriate size before insertion.

**E. Bonafide Certificate**

The Bonafide Certificate shall be typed in **double line spacing** using Font Style Times New Roman and Font Size 12 as per the format shown in Annexure III. The certificate shall carry the Supervisor's signature and shall be followed by the Supervisor's name, academic designation, department and full address of the institution where the Research Supervisor has guided the research scholar.

**F. Acknowledgement**

It should be brief and should not exceed two pages when typed in double spacing. The scholar's signature shall be made at the bottom right end above his / her name typed in capitals.

**G. Table of Contents**

The Table of contents should list all captions from items v to xi following it. The title page, Bonafide Certificate and Declaration Certificate will not find a place among the items listed in the Table of Contents but the page numbers must be typed in lower case Roman letters in all the pages (excepting No. i on the Title page). One and a half spacing should be adopted for typing the matter under Table of Contents.

## **H. List of Symbols and Abbreviations**

One and a half spacing should be adopted for typing the matter under this head. Standard symbols, abbreviations, etc. should be used. The list should be arranged alphabetically with respect to the contents on the right side.

## **I. Abstract**

Abstract should be an essay type of narration not exceeding four pages outlining the research problem, methodology used for solving it and a summary of the findings. This shall be typed in double line spacing using Font Style Times New Roman and Font Size 12.

## **J. Chapters**

The chapters may be broadly divided into Introduction, Review of Literature, Material and Methods, Results, Discussion, Summary and References.

- a. Each chapter should be given an appropriate title.
- b. Tables and Figures in a chapter should be placed in the immediate vicinity of the reference where they are cited.
- c. Footnotes should be used sparingly. They should be typed single space and placed directly underneath in the very same page which refers to the material they annotate.

## **K. List of References**

The listing of references cited in the text should be typed in single line spacing starting from 4lines spaces below the heading "REFERENCES". The reference material should be listed in the alphabetical order of the first author of each reference. The name of the author / authors should be immediately followed by the other details and year. The cited references in the Text should be listed "REFERENCES" as per the specified format:

## **L. Appendices**

Appendices are provided to give supplementary information's relevant to the research work done by the candidate.

## **M. List of Publications**

Reprints / Photostat copies of research papers already published / accepted for publication in Journals are to be attached in chronological orders and these pages need not be numbered. The heading "List of Publications" alone must find a place in the Table of Contents without page numbers for this item only.

## **N. Tables and Figures**

"Table" means tabulated numerical data in the body of the Thesis as well as in the appendices. All other non-verbal material used in the body of the Thesis and appendices such as charts, graphs, maps, photographs and diagrams may be designated as Figures.

- a. A Table or Figure including caption should be accommodated within the prescribed margin limits and appear on the page following the page where their first reference is made.
- b. Tables and Figures on half page or less in length may appear on the same page along with the text. However, they should be separated from the text both above and below by triple spacing.



- c. All Tables and Figures should be prepared on the same paper or material used for the preparation of the rest of the Thesis.
- d. Two or more small Tables or Figures may be grouped, if necessary, in a single page.
- e. Wherever possible, the photograph(s) shall be reproduced on a full sheet of photographic paper or colour xerox.
- f. More than one photograph can be included in a page.
- g. Samples of Fabric, Leather, etc., if absolutely necessary may be attached evenly in a page and fixed/pasted suitably and should be treated as Figures.

## **O. Typing Instructions**

### **General**

This section includes additional information for final typing of the Thesis. The impressions on the typed / photo-stated / printed copies should be black in colour.

A sub-heading at the bottom of a page must have at least two full lines below it or else it should be carried over to the next page.

The last word of any page should not be split using a hyphen. One and a half spacing should be used for typing the general text. The general text shall be typed in Font Style Times New Roman and Font Size 12. Single spacing should be used for typing:

- (i) Long Tables
- (ii) Long quotations
- (iii) Foot notes
- (iv) Multiline captions
- (v) References

All quotations exceeding one line should be typed in an indented space – the indentation being 15 mm from either side of the margin.

## **P. Page Numbering**

All page numbers (small case Roman numerals or Arabic numbers) should be typed without punctuation on the **upper right hand corner** 20 mm from the top with the last digit of the number in line with the right hand margin. The preliminary pages of the Thesis (such as Title page, Bonafide Certificate, Declaration and Certificate, Table of Contents, Acknowledgement, List of Symbols and Abbreviations and Abstracts) should be numbered in lower case Roman numerals. The Title page will be numbered as (i) but this should not be typed on the page. The page immediately following the Title page shall be numbered as (ii) and it should appear **at the top right hand corner** as already specified. Pages of main text, starting with Chapter 1 should be consecutively numbered using Arabic numerals.

## **Q. Numbering of Chapters, Divisions and Sub-Divisions**

The numbering of chapters, divisions and sub-divisions should be done using Arabic numerals only and further decimal notation should be used for numbering the divisions and sub-divisions within a chapter. For example, sub-division 4 under division 3 belonging to chapter 2 should be numbered as 2.3.4. The caption for the sub-division should immediately follow the number assigned to it.

Every chapter beginning with the first chapter should be serially numbered using Arabic numerals. Appendices, included if any, should also be numbered in an identical manner starting with Appendix 1.

**R. Numbering of Tables and Figures**

Tables and Figures appearing anywhere in the Thesis should bear appropriate numbers. The rule for assigning such numbers is illustrated by an example. Thus, if a Figure in Chapter 3, happens to be the fourth then assign 3.4 to that Figure. Identical rules apply for Tables except that the word Figure is replaced by the word Table. If Figures (or Tables) appear in appendices, then Figure 3 in Appendix 2 will be designated as Figure A 2.3. If a table is to be continued into the next page this may be done, but no line should be drawn underneath an unfinished Table. The top line of the Table continued into the next page should, for example read Table 2.1 (continued) placed centrally and underlined.

**S. Numbering of Equations**

Equations appearing in each Chapter or Appendix should be numbered serially, the numbering should commence afresh for each Chapter or Appendix. Thus, for example, an equation appearing in Chapter 3, if it happens to be the eighth equation in that Chapter should be numbered as (3.8) thus (3.8) While referring to this equation in the body of the Thesis it should be referred to as Equation (3.8).

**T. Binding Specifications**

Thesis should be bound with **black calico cloth** and using flexible cover of thick white art paper. The cover should be printed in black letters and the text for printing should be identical to what has been prescribed for the title page.

Soft copy of the Thesis (PDF format) written in CD (2 Nos.) should be submitted for Karpagam Academy of Higher Education archives.

**Revision of Regulation:**

The Karpagam Academy of Higher Education may from time to time, amend the Regulations based on UGC Regulations if found necessary.

**ANNEXURE I**

**Specimen of Cover Page and Title Page**

<Font Style Times New Roman>

**ANTIOXIDANT ACTIVITY OF INDIAN MEDICINAL PLANTS FROM WESTERN GHATS**

Font Size 18><1.5 line spacing>

**SYNOPSIS**

<Font Size 14>

***Submitted by***

<Font Size 14><Italic>

**RAGHAVENDRA S A**

<Font Size 16>

***in partial fulfilment of the requirements for the award of the degree of***

<Font Size 14><Italic><1.5 line spacing>

**DOCTOR OF PHILOSOPHY**

<Font Size 16>

IN

**BIOTECHNOLOGY**

<Font Size 14>



**DEPARTMENT OF BIOTECHNOLOGY**

**Karpagam Academy of Higher Education**

(Deemed to be University) (Established Under Section 3 of UGC Act, 1956)

(Accredited with A+ Grade by NAAC in the Second Cycle)

Pollachi Main Road, Eachanari Post, Coimbatore – 641 021, Tamil Nadu, India

<Font Size 16><1.5 line spacing>

**December, 2022**

<Font Size 14>

**ANTIOXIDANT ACTIVITY OF INDIAN MEDICINAL PLANTS FROM  
WESTERN GHATS**

**SYNOPSIS**

*Submitted by*

**RAGHAVENDRA S A**

*in partial fulfilment of the requirements for the*

*award of the degree of*

**DOCTOR OF PHILOSOPHY  
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Pollachi Main Road, Eachanari Post, Coimbatore – 641 021, Tamil Nadu, India

**December, 2022**

**ANNEXURE II**

**Specimen of Cover Page and Title Page**

<Font Style Times New Roman>

**ANTIOXIDANT ACTIVITY OF INDIAN MEDICINAL PLANTS FROM WESTERN  
GHATS**

<Font Size 18><1.5 line spacing>

**THESIS**

<Font Size 14>

***Submitted by***

<Font Size 14><Italic>

**RAGHAVENDRA S A**

<Font Size 16>

***in partial fulfilment of the requirements for the award of the degree of***

<Font Size 14><Italic><1.5 line spacing>

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<Font Size 16>

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<Font Size 16><1.5 line spacing>

**December, 2022**

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**December, 2022**



**ANNEXURE IV**

**Specimen of Declaration**

<Font Style Times New Roman>

**DECLARATION**

<Font Size 16>

<Font Size 12>

I \_\_\_\_\_ hereby declare that the thesis entitled  
“ \_\_\_\_\_ ”  
submitted to the Karpagam Academy of Higher Education, in partial fulfillment of the  
requirements for the award of the Degree of Doctor of Philosophy in  
\_\_\_\_\_ is a record of bonafide and  
independent research work done by me during the period from \_\_\_\_/\_\_\_\_/\_\_\_\_ to \_\_\_\_-  
\_\_\_\_/\_\_\_\_/\_\_\_\_ under the supervision and guidance of  
Dr. \_\_\_\_\_, Department of  
\_\_\_\_\_ at Karpagam Academy of Higher Education, and it has not  
formed the basis for the award of any Degree / Diploma / Associate ship / Fellowship or other  
similar title to any candidate in Karpagam Academy of Higher Education so far.

**Signature of the Research Scholar**



**ANNEXURE V**

**Specimen of Certificate**

<Font Style Times New Roman>

**CERTIFICATE**

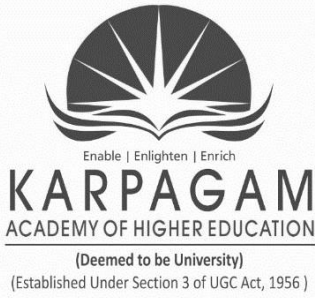
<Font Size 16>

<Font Size 12>

This is to certify that the thesis entitled “\_\_\_\_\_” submitted to the Karpagam Academy of Higher Education, in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy in \_\_\_\_\_ is a record of bonafide research work done by Mr. / Ms. \_\_\_\_\_ during the period from \_\_\_\_/\_\_\_\_/\_\_\_\_ to \_\_\_\_/\_\_\_\_/\_\_\_\_ of his / her study in the Department of \_\_\_\_\_ at Karpagam Academy of Higher Education, under my supervision and guidance and the thesis has not formed the basis for the award of any Degree / Diploma / Associate ship / Fellowship or other similar title to any candidate of Karpagam Academy of Higher Education so far.

**Countersigned**  
**Head of the Department**

**Signature of the Research Supervisor**



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Phone: 0422 - 2980011- 14 | Email : info@kahedu.edu.in

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## FORMAT I

### Progress Report of Research Scholar

(To be submitted once in six months)

1. Programme : Ph.D., FT/PT
2. Subject :
3. Name & Regn.No. of the Research scholar:
4. Title of Ph.D., Research work :
5. Report No./Month/Year :

No.	Month	Year

6. Brief report about the work carried

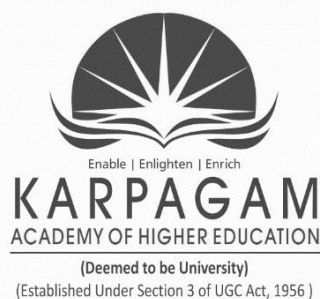
out by the Research scholar :

- a. Article/s published \_\_\_\_\_ No's (Attach copies)
- b. Seminars/Conferences attended \_\_\_\_\_ (Attach certificate copies)
- c. Course work: Completed / Not Completed (Attach copy of Mark sheet)
- d. Course fee: Paid till \_\_\_\_\_(copies of receipts)

7. Research Guide's Comment :

Signature of the Research Scholar  
(with Name & address)  
Mobile No.:  
E-mail id:

Signature of the Research Supervisor  
(with Name & address)  
Mobile No.:  
E-mail id:



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## FORMAT II

### Request for Pre-submission presentation

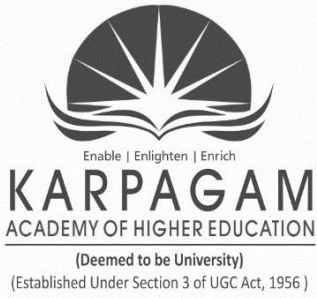
#### Check list

1. Name of the research scholar with Registration Number :
2. Name of the Research Supervisor :  
Designation :  
Department :
3. (a) Whether the minimum period completed? : Yes/No (Refer Registration Communication)  
(b) If extension obtained, attach particulars :
4. Whether course fee paid for all the years : Yes/No (Attach No Dues Certificate)
5. Title of Ph.D. Research work :
6. Details of the Part I Course work :  
(Enclose necessary documents)
7. Number of DC Meetings attended (Annually 2) :
8. Total No. of 6 months performance reports submitted : 6/8/10/12
9. (a) No. of Time-line presentations attended :  
(b) No. of Annual Research Congress attended :
10. (a) Minimum No. of Research articles to be published : 2 as per KAHE regulation  
(b) No of articles published by the scholar :  
(Attach photocopies of reprints)
11. Whether submission of thesis is recommended  
at the Final Doctoral Committee Meeting and  
date of DCM :
12. Communication skill\* : Good/Satisfactory/Need improvement  
(To be judged based on the DC Meeting, (Tick whichever is applicable)  
Time line Presentation and  
Annual Research Congress)

**Signature of the Research Scholar  
Supervisor**

**Signature of the Research**

\*The Guide/HOD shall give specific remarks about the communication skill of the scholar. At the time of Pre-submission Presentation, if it is found that the Communication skill of the scholar is less than average, the period of submission may be extended for one more year and the scholar shall be advised to improve his/her Communication skill and may be presented again.



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## FORMAT III

KAHE / RS / Rx /Ph.D./Dept./ Pre-Sub / xxxx / 2022/

Date: \_\_\_\_\_

### Pre-Submission presentation of the Ph.D. research - Notification

I am by direction to inform you that a Pre-submission Presentation of the Ph.D., thesis is arranged for the candidate \_\_\_\_\_ working under the supervision of \_\_\_\_\_, Designation, Department of \_\_\_\_\_, Karpagam Academy of Higher Education, Coimbatore – 641 021.

**Ph.D. Thesis Title:** “ \_\_\_\_\_ ”.

All members of faculty, experts and all interested persons are requested to attend the aforesaid Pre-submission Presentation.

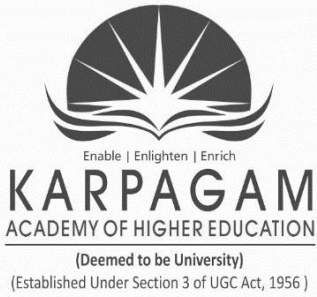
Venue :  
Date :  
Time :

**Registrar**

**To**

All Head of the Department of \_\_\_\_\_, requested to make necessary arrangement to conduct the programme.

Kindly circulate to Dean / Director / Research Supervisor / Research Scholars



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**FORMAT - IV**

DEPARTMENT OF \_\_\_\_\_  
**Pre-submission Presentation Report**

- |   |   |
|---|---|
|   | Date:   |
| 1. Name of the Research Scholar   | :   |
| 2. Register Number of the Research Scholar  | :   |
| 3. Ph.D., programme in  | :   |
| 4. Department   | :   |
| 5. Name of the Research Supervisor  | :   |
| Designation   | :   |
| Department  | :   |
| 6. Presentation date & Venue  | :   |
| 7. No. of articles published by the scholar   | :   |
| 8. Number of members present in<br>the presentation (enclose the<br>attendance sheet)                     | :   |
| 9. A report on the Question & Answer Session<br>(in the enclosed format)                                  | :   |
| 10. Comments of the Supervisor  | :   |
| (a) On the composition of the Thesis chapters   | : Adequate/Needs to be revised.   |
| (b) On the Communication skill*<br>(additional sheets may be used)  | : Good/Satisfactory/Needs improvement<br>(Tick whichever is applicable)       |
| 11. After the Pre-submission<br>Presentation whether the scholar<br>may be permitted to submit the Thesis | : Permitted/Extended for one year<br>(Strike out whichever is not applicable) |

**Signature:**

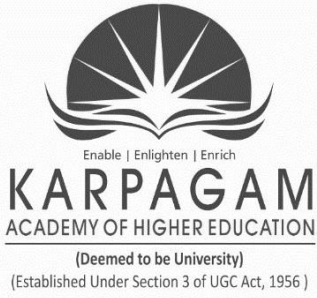
**Research Scholar**

**Research Supervisor**

**HOD**

**Dean**

\*(At the time of Pre-submission Presentation, if it is found that the Communication skill of the scholar is less than average and needs improvement, the period of submission may be extended for one more year and the scholar shall be advised to improve his/her Communication skill and may be presented again.)



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**FORMAT – IV Annexure**

**Pre-submission Presentation: A brief report on the Question & Answer Session**

Answers should be brief and relevant to the question. If needed, additional sheets may be used

**Topic of the Research work:**

**Q1.**

**Answer:**

**Q2.**

**Answer:**

**Q3.**

**Answer:**

**Q4.**

**Answer:**

**Q5:**

**Answer:**

**Signature of**

**Research Scholar**

**Research Supervisor**



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**FORMAT V**

## **Pre-submission presentation**

### **Certificate**

**Name & Reg. No. of the research scholar :**

**Subject :**

**Date of Presentation :**

Certified that the above research scholar under my guidance has presented his/her research work during Pre-submission Presentation and his/her presentation is \_\_\_\_\_ . All the suggestions made by the participants are taken into consideration and important suggestions will be included in the thesis entitled:

“ \_\_\_\_\_ ”.

**Place :**

**Date :**

**Signature of the Research Supervisor**  
(Name & Address)

**Counter Signed:**

**HOD**  
(Name & Seal)



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*This is a Format only (Neatly typed, aligned and duly signed form to be submitted)*

**FORMAT - VI**

## Submission of Ph.D., Thesis: Check List

1. Name of the research scholar with Registration Number :
2. Name of the Research Supervisor :  
Designation :  
Department :
3. (a) Whether the minimum period completed? : Yes/No (Refer Registration Communication)
4. (b) If extension obtained, attach particulars :
5. Whether course fee paid for all the years : Yes/No (Attach No Dues Certificate)
6. Title of Ph.D. Research work :
7. Details of the Part I Course work :
8. (Enclose necessary documents)
9. Number of DC Meetings attended (Annually 2) :
10. Total No. of 6 months performance reports submitted : 6/8/10/12  
(a) No. of Time-line presentations attended :  
(b) No. of Annual Research Congress attended :
11. (a) Minimum No. of Research articles to be published : 2 as per KAHE regulation  
(b) No of articles published by the scholar :
12. Whether submission of thesis is recommended at the Final Doctoral Committee Meeting and date of DCM :
13. Date of Pre-Submission Presentation made :  
(Attach a certificate from the supervisor duly countersigned by the HOD)
14. Probable date of submission of Synopsis :
15. Expected date of submission of Thesis :

**Signature of:**

**Research Scholar**

**Research Supervisor**

**HOD**

**For Office of the Research use:**

1	2	3	4	5	6	7	8	9	10	11	12	13	14
---	---	---	---	---	---	---	---	---	----	----	----	----	----

Recommendation for submission: **Recommended / Not recommended**

**Addl. Director, Research**

**Director, Research**





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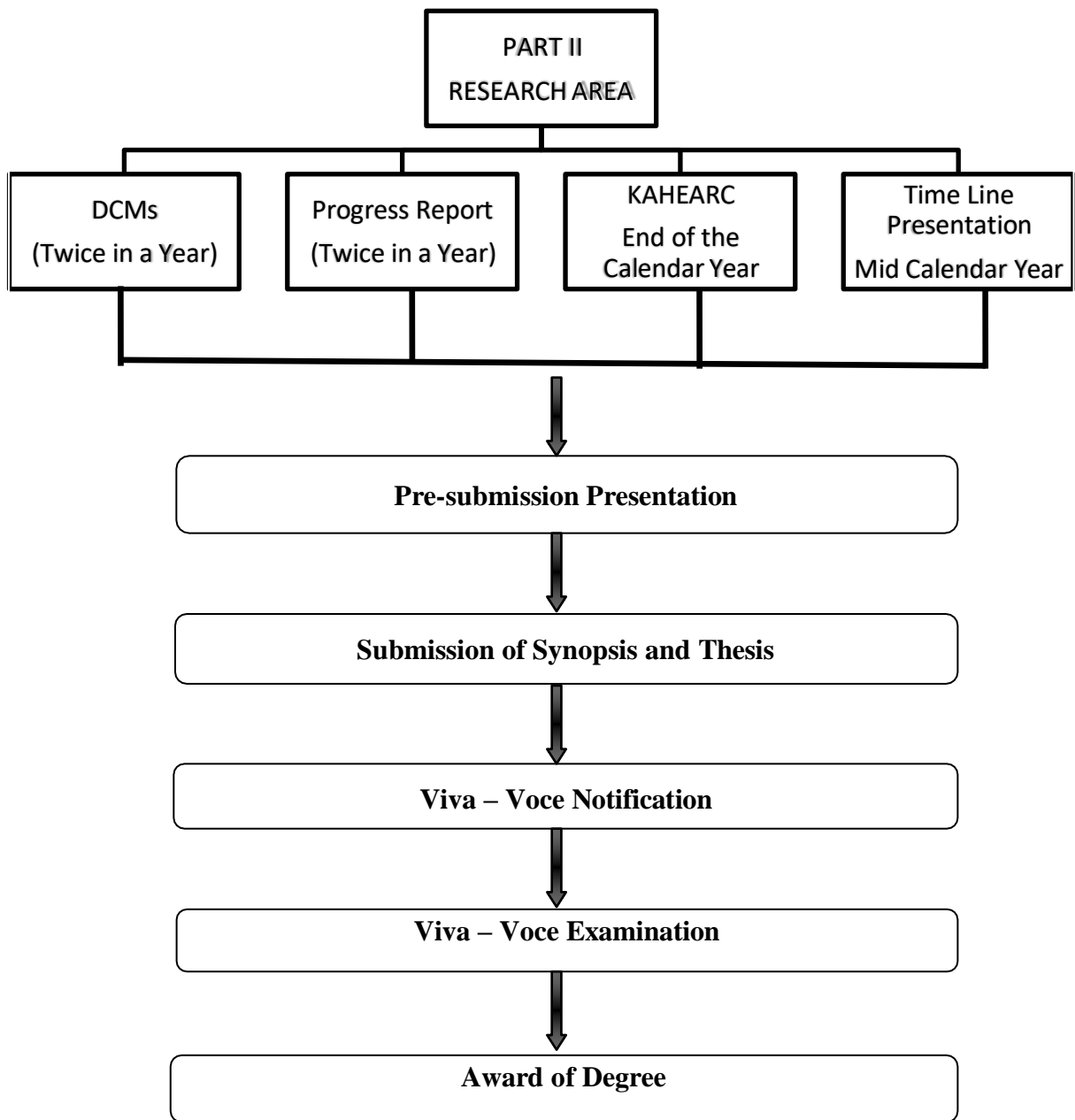
## Certificate of Plagiarism

Certified that the thesis entitled “\_\_\_\_\_” for  
the award of Ph.D., degree has undergone Plagiarism check through Turnitin software and the  
level of plagiarism is \_\_\_\_\_.

Signature of the Research Scholar

Signature of the Research Supervisor

Professor in- charge for Plagiarism Test



## Publications terminology

### 1. Impact Factor

The Impact Factor of an academic journal is a measure which reflects the average number of citations to recent articles published in that Journal.

- It is a measure of the relative importance of a journal in a given field.
- It was devised by **Mr. Eugene Garfield**, the founder of the **Institute for Scientific Information**.
- Impact factor is calculated yearly starting from 1975 for those journals which are indexed in the **Journal Citation Reports**.
- Normally, the impact factor for 2021 is published in 2022.
- It is a journal metric and not to be used to assess an individual researcher or research institution.

### Calculation

Example: If a Journal has an impact factor of 3 in the year 2022; it means that each paper published in that journal during the years 2020 and 2021 had received an average of 3 citations in 2022.

Let A= The number of times that articles published in that journal in and 2021, were cited by articles in indexed journals during 2022.

B= The total number of “citable items” (usually, articles, reviews and proceedings) published in that journal in 2020 and 2021.

Then, Impact factor (in 2022) =  $\frac{A}{B}$

### 2. HIndex

The h-index is an index that attempts to measure both the productivity and impact of the published work of a scientist or scholar. The index is based on the set of the scientist's most cited papers and the number of citations that they have received in other publications. The index can also be applied to the productivity and impact of a group of scientists, such as a department or university or country, as well as a scholarly journal. The index was suggested by Jorge E. Hirsch, a physicist at UCSD (University of California, San Diego), as a tool for determining theoretical physicists' relative quality and is sometimes called the Hirsch index or Hirsch number. The h-index serves as an alternative to more traditional journal impact factor metrics in the evaluation of the impact of the work of a particular researcher.

### 3. Scopus

**Scopus**, officially named **SciVerse Scopus**, is a bibliographic database containing abstracts and citations for academic journal articles. It covers nearly 20,500 titles from over 5,000 international publishers, of which 19,500 are peer-reviewed journals in the scientific, technical, medical, and social sciences (including arts and humanities). It is owned by **Elsevier** and is available online by subscription. Since Elsevier is the owner of Scopus, and is also one of the main international publishers of scientific journals, Elsevier established the independent and international Scopus Content Selection and Advisory Board to prevent a potential conflict of interest in the choice of the periodicals to be included in the database and to maintain an open and transparent content coverage policy. The board consists of scientists and subject librarians from all scientific disciplines and geographical areas, whose interest is to access any relevant information regardless of the publishers.

**SciVerse**

**SciVerse** is a platform for accessing scientific information from certain databases and the web. It is published by **Elsevier**. It provides access to 2,500 journals and 11,000 books with about 500 thousand additions each year.

"**SciVerse**" globally indexes articles, books, theses, abstracts, patents and sifts through web results, from publishers, universities and professional organizations.

**4. International Standard Serial Number**

An **International Standard Serial Number (ISSN)** is a unique eight-digit number used to identify a print or electronic periodical publication. Periodicals published in both print and electronic form may have two ISSNs, a **print ISSN (p-ISSN)** and an **electronic ISSN (e-ISSN or eISSN)**. The ISSN system was first drafted as an ISO international standard in 1971 and published as ISO 3297 in 1975. The ISO subcommittee is responsible for the standard.

**Code format**

The format of the ISSN is an eight-digit number, divided by a hyphen into two four-digit numbers. The last digit, which may be 0–9 or an X, is a check digit. The ISSN of the journal *Hearing Research*, for example, is 0378-5955, the check digit is 5.

**Code assignment**

ISSN codes are assigned by a network of ISSN National Centres, usually located at national libraries and coordinated by the ISSN International Centre based in Paris. The International Centre is an intergovernmental organization created in 1974 through an agreement between UNESCO and the French government. The International Centre maintains a database of all ISSNs assigned worldwide, the ISSN Register.

**Availability**

The ISSN Register is not freely available for interrogation on the web but is available by subscription. There are several routes to the identification and verification of ISSN codes for the general public.

- the print version of a periodical typically will include the ISSN code as part of the publication information
- most periodical websites contain ISSN code information
- derivative lists of publications will often contain ISSN codes; these can be found through on-line searches with the ISSN code itself or periodical title.

**5. Peer Review**

**Peer review** is the evaluation of work by one or more people of similar competence to the producers of the work (peers). It constitutes a form of self-regulation by qualified members of a profession within the relevant field. Peer review methods are employed to maintain standards of quality, improve performance, and provide credibility. In academia peer review is often used to determine an academic paper's suitability for publication.

**Professional peer review**

Professional peer review focuses on the performance of professionals, with a view of improving quality, upholding standards, or providing certification. Professional peer review activity is widespread in the field of health care, where it is best termed as **Clinical peer review**.

## Scholarly peer review

Scholarly peer review (also known as **refereeing**) is the process of subjecting an author's scholarly work, research, or ideas to the scrutiny of others who are experts in the same field, before a paper describing this work is published in a journal. The work may be accepted, considered acceptable with revisions, or rejected. Peer review requires a community of experts in a given (and often narrowly defined) field, who are qualified and able to perform impartial review

### 6. Web of Science

Single research destination to explore the citation universe across subjects and around the world. Web of Science provides access to the most reliable, integrated, multidisciplinary research connected through linked content citation metrics from multiple sources within a single interface. Since Web of Science adheres to a strict evaluation process, one can be assured only the most influential, relevant, and credible information is included - allowing to uncover next big idea faster.

### 7. Science Citation Index

- The Science Citation Index (SCI) is a citation index originally produced by the Institute for Scientific Information (ISI) and created by Eugene Garfield and was officially launched in 1964. The larger version (Science Citation Index Expanded) covers more than 8,500 notable and significant journals, across 150 disciplines, from 1900 to the present. These are alternatively described as the world's leading journals of Science and Technology, because of a rigorous selection process.
- The index is made available online through different platforms, such as the Web of Science and SciSearch.

### 8. International Standard Book Number

The **International Standard Book Number (ISBN)** is a unique numeric commercial book identifier based upon the 9-digit **Standard Book Numbering (SBN)** code created by Gordon Foster, Emeritus Professor of Statistics at Trinity College, Dublin, for the booksellers and stationers. The 10-digit ISBN format was developed by the International Organization for Standardization (ISO) and was published in 1970 as International Standard ISO. ISO has appointed the International ISBN Agency as the registration authority for ISBN worldwide and the ISBN Standard is developed under the control of ISO Technical Committee.

#### ISBN issuance

International Standard Book Numbers issuance is country-specific, in that ISBNs are issued by the ISBN Registration Agency that is responsible for that country or territory. The ranges of ISBNs assigned to any particular country are based on the publishing profile of the country concerned.

# FACULTY OF ENGINEERING

## DEPARTMENT OF MECHANICAL ENGINEERING

### Ph.D. Course Work Subjects (Effective from the academic year 2024-2025)

S.No.	Course Code	Course Title	Page No.
<b>Group - I</b>			
1.	24RME101	RESEARCH METHODOLOGY	01
<b>Group - II</b>			
2.	24RME201	RESEARCH PUBLICATION AND ETHICS	03
<b>Group - III</b>			
3.	24RME301	TRIBOLOGY IN DESIGN	05
4.	24RME302	ADVANCED MANUFACTURING PROCESSES	07
5.	24RME303	PHYSICS OF SOLAR ENGINEERING	08
6.	24RME304	ADVANCED HEAT AND MASS TRANSFER	10
7.	24RME305	INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS	12
8.	24RME306	REFRIGERATION SYSTEMS DESIGN	14
9.	24RME307	COMPOSITE AND POLYMER MATERIALS	15
10.	24RME308	ADVANCES IN CASTING AND WELDING PROCESSES	17
11.	24RME309	SUPPLY CHAIN MANAGEMENT	19
12.	24RME310	ENGINEERING METALLURGY	21
13.	24RME311	SMART MANUFACTURING	22
14.	24RME312	INTELLIGENT INDUSTRIAL AUTOMATION AND ITS APPLICATION	24
15.	24RME313	ALTERNATIVE FUELS FOR IC ENGINES	26
16.	24RME314	ENERGY CONSERVATION AND MANAGEMENT	27
17.	24RME315	FUEL CELL TECHNOLOGY	28
18.	24RME316	MICRO-MACHINING AND PRECISION ENGINEERING	29
19.	24RME317	OPTIMIZATION TECHNIQUES	31
20.	24RME318	COMPUTATIONAL METHODS	33
21.	24RME319	FINITE ELEMENT ANALYSIS	35

**Ph.D. COURSE WORK SYLLABUS**  
**MECHANICAL ENGINEERING**  
**RESEARCH METHODOLOGY**  
(Effective from the academic year 2024-2025 onwards)

**CODE: 24RME101**

**UNIT I**

**INTRODUCTION TO RESEARCH**

Research Methodology: An Introduction –Meaning of research—Objectives of Research-Motivation in Research—Types of Research. -Concept of Applied and Basic research – Quantitative and Qualitative Research Techniques – Need for theoretical frame work – Hypothesis development – Hypothesis testing with quantitative data. Research design – Purpose of the study: Exploratory, Descriptive, Hypothesis Testing. Impact Factor--Citation and Citation Index.

**UNIT II**

**EXPERIMENTAL DESIGN**

Laboratory and the Field Experiment – Internal and External Validity – Factors affecting Internal validity. Measurement of variables – Scales and measurements of variables. Developing scales – Rating scale and attitudinal scales – Validity testing of scales – Reliability concept in scales being developed – Stability Measures.

**UNIT III**

**DATA COLLECTION, ANALYSIS AND INFERENCE**

Binomial, Poisson, Normal, Exponential, Weibull and Geometric Distributions. Random sampling, stratified sampling, systematic sampling and cluster sampling. Student-t-test, F-test and  $\chi^2$  test and their applications in research studies. Forecasting methods. Factor analysis, Cluster Analysis and Discriminant Analysis (Basic ideas only). Completely Randomized Design Randomized Block Design and Latin Square Design. Accuracy, Precision and error analysis.

**UNIT IV**

**MULTIVARIATE STATISTICAL TECHNIQUES**

Data Analysis – Factor Analysis – Cluster Analysis – Discriminant Analysis – Multiple Regression and Correlation – Canonical Correlation – Application of Statistical (SPSS) Software Package in Research.

**UNIT V**

**RESEARCH REPORT AND ETHICS IN RESEARCH**

Significance of Report Writing- different steps in report writing-Layout of Research Report—Types of Reports-- Integral parts of a report – Precautions for writing a research report—Oral Presentation. Policy on academic Honesty and Integrity—academic cheating and Plagiarism. Opportunities to carry out research projects with funding/assistance from government agencies.

## **SUGGESTED BOOKS:**

1. Donald R. Cooper and Ramela S. Schindler, "Business Research Methods", Tata McGraw-Hill, Publishing Company Limited, New Delhi, 2000.
2. Uma Sekaran, "Research Methods for Business", John Wiley and Sons Inc., New York, 2000.
3. C.K.Kothari, "Research Methodology, methods and techniques", New Age International, New Delhi, 2001.
4. Donald H.McBurney, "Research Methods", Thomson Asia Pvt. Ltd. Singapore, 2002.
5. G.W.Ticehurst and A.J.Veal, "Business Research Methods", Longman, 1999.
6. Ranjit Kumar, "Research Methodology", Sage Publications, London, New Delhi, 1999.
7. Garg, B.L.Karadia, R.Agarwal, & F.Agarwal, U.K. 2002. "An Introduction to Research Methodology", RBSA Publishers.
8. Panneerselvan.R., "Research Methodology", Prentice hall of India, New Delhi, 2004.
9. Ganesan R, "Research Methodology for Engineers", MJP Publishers, Chennai. 2011
10. Walpole R.A, Myers R.H, Myers S.L. and Ye King: "Probability & Statistics for Engineers and Scientists", Pearson Prentice Hall, Pearson Education, Inc. 2007.
11. Graziano, A.M.and Raulin, M.,L.: "Research Methods – A Process of Inquiry", Sixth Edition, Pearson, 2007.
12. Leedy, P.D."Practical Research – Planning and Design", Eighth Edition, Pearson.2005.



**RESEARCH PUBLICATION AND ETHICS**  
(Effective from the academic year 2024-2025 onwards)

**CODE: 24RME201**

**UNIT I: PHILOSOPHY AND ETHICS**

Introduction to Philosophy: Definition, nature and scope, concept, branches- Ethics: Definition, moral Philosophy ,nature of moral judgments and reactions.

**UNIT II: SCIENTIFIC CONDUCT**

Ethics with respect to science and research – Intellectual honesty and research integrity – scientific misconduct: Falsification – Fabrication and plagiarism (FFP) – Redundant Publications: duplicate and overlapping publications – salami slicing – Selective reporting and misrepresentation of data.

**UNIT III: PUBLICATION ETHICS**

Publication Ethics: Definition, introduction and importance – Best practices / standards setting initiatives and guidelines : COPE , WAME, etc,-Conflicts of interest -Publication Misconduct: definition, concept, problems that lead to unethical behavior and vice versa, type-Violation of publication ethics,

Authorship and contributorship – Identification of publication misconduct, complaints and appeals- Predatory publishers and journals

**UNIT IV: PUBLICATION MISCONDUCT**

Group Discussions: Subject specific ethical issues, FFP, authorship- Conflicts of interest- Complaints and appeals: examples and Fraud from India and abroad.

Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools

**UNIT V: DATABASE AND RESEARCH METRICS**

Database : Indexing database-Citation database: Web of Science, Scopus, etc

Research Metrics: Impact Factor of journal as per journal citation Report, SNP, SJR,IPP, Cite score- Metrics:h-index, I10 index, altmetrics.

**UNIT VI: DEVELOPMENT OF E-CONDUCT & IPR**

Integrated Library Management System (ILMS) : e-journals-e-books- e- shodhsindushodhganga- Database –e-content Development –Learning Management system(LMS) –e-PG-Pathshala-CEC(UG) SWAYAM-MOOCs-NPTEL-NMEICT.

IPR: Patent-Copyrights-Trademark-Geographical Indication.

## **PRACTICE**

### **Open ACCESS Publishing**

Open access publications and initiatives –SHERPA/ROMEO online resource to check publisher copyright & self-archiving policies-Software tool to identify predatory publications developed by SPPU –journal finder/Journal suggestion tools viz, JANE Elsevier Journal Finder, Springer Journal Suggester, etc.

### **SUGESSTED READINGS**

1. Best Practice Guidelines on Publishing Ethics: A Publisher's Perspective, Second Edition, 2014 John Wiley & Sons, Ltd.
2. Wager E. The Committee on Publication Ethics (COPE): Objectives and achievements 1997- 2012. Presse Med. 2012.
3. Carlson RV, Boyd KM, Webb DJ. The revision of the Declaration of Helsinki: Past, present and future. Br J Clin Pharmacol. 2004.
4. Kambadur Muralidhar, Amit Ghosh,& Ashok Kumar Singhvi "ETHICS in Science Education,Research and Governance",
5. Indian National Science Academy, New Delhi 2019.
6. Publishing Ethics: Academic Research, Cambridge University Press ,Version 2.0, May 2019.

**TRIBOLOGY IN DESIGN**  
(Effective from the academic year 2024-2025 onwards)

**CODE: 24RME301**

**UNIT I**

**SURFACE INTERACTION AND FRICTION**

Topography of Surfaces – Surface features-Properties and measurement – Surface interaction – Adhesive Theory of Sliding Friction –Rolling Friction-Friction properties of metallic and non-metallic materials – friction in extreme conditions –Thermal considerations in sliding contact

**UNIT II**

**WEAR AND SURFACE TREATMENT**

Types of wear – Mechanism of various types of wear – Laws of wear –Theoretical wear models- Wear of Metals and Non metals – Surface treatments – Surface modifications – surface coatings methods- Surface Topography measurements –Laser methods – instrumentation - International standards in friction and wear measurements

**UNIT III**

**LUBRICANTS AND LUBRICATION REGIMES**

Lubricants and their physical properties- Viscosity and other properties of oils –Additives-and selection of Lubricants- Lubricants standards ISO, SAE, AGMA, BIS standards – Lubrication Regimes –Solid Lubrication-Dry and marginally lubricated contacts- Boundary Lubrication- Hydrodynamic lubrication — Elasto and plasto hydrodynamic - Magneto hydrodynamic lubrication – Hydro static lubrication – Gas lubrication.

**UNIT IV**

**THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION**

Reynolds Equation, -Assumptions and limitations-One and two-dimensional Reynolds Equation- Reynolds and Sommerfeld boundary conditions- Pressure wave, flow, load capacity and friction calculations in Hydrodynamic bearings-Long and short bearings-Pad bearings and Journal bearings- Squeeze film effects-Thermal considerations-Hydrostatic lubrication of Pad bearing-Pressure, flow, load and friction calculations-Stiffness considerations- Various types of flow restrictors in hydrostatic bearings

**UNIT V**

**HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION**

Rolling contacts of Elastic solids- contact stresses – Hertzian stress equation- Spherical and cylindrical contacts-Contact Fatigue life- Oil film effects- Elasto Hydrodynamic lubrication theory-Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication- - Film shape in thin and outside contact zones-Film thickness and friction calculation- Rolling bearings- stresses and deflections-Traction drives

## **SUGGESTED BOOKS:**

1. Rabinowicz.E, “Friction and Wear of materials”, John Willey & Sons ,UK,1995
2. Cameron A. “Basic Lubrication Theory”, Ellis Herward Ltd., UK, 1981
3. Halling J. (Editor) – “Principles of Tribology “, Macmillian – 1984.
4. Williams J.A. “Engineering Tribology”, Oxford Univ. Press, 1994.
5. S.K.Basu, S.N.Sengupta & B.B.Ahuja ,“Fundamentals of Tribology”, Prentice –Hall of India Pvt Ltd , New Delhi, 2005.
6. G.W.Stachowiak& A.W .Batchelor , “Engineering Tribology”, Butterworth - Heinemann, UK,2005.

**ADVANCED MANUFACTURING PROCESSES**  
**(Effective from the academic year 2024-2025 onwards)**

**CODE: 24RME302**

**UNIT I**

**NEW MACHINING PROCESSES**

(Non thermal energy) – Abrasive machining – water jet machining - ultrasonic machining – chemical machining – electro chemical machining – construction working principle – steps - types – process parameters – derivations – problems, merits, demerits and applications.

**UNIT II**

**NEWER MACHINING PROCESS**

Wire cut EDM - Electro chemical machining – ECG - Electric discharge machining – construction – principle – types – control - circuits – tool design – merits, demerits & applications.

**UNIT III**

**NEWER MACHINING PROCESS**

Laser beam machining – Electron beam machining – Plasma arc machining – Ion beam machining – construction working principle types – process parameter – derivations – problems, merits, demerits and applications.

**UNIT IV**

**FABRICATION OF MICRO DEVICES**

Semiconductors – films and film depurification – Oxidation - diffusion – ion implantation – etching – metallization – bonding – surface and bulk machining – LIGA Process – Solid free form fabrication.

**UNIT V**

**MICROFABRICATION TECHNOLOGY**

Wafer preparation – monolithic processing – moulding – PCB board hybrid & mcm technology – programmable devices & ASIC – electronic material and processing. – steriolithography SAW devices, Surface Mount Technology.

**SUGGESTED BOOKS:**

1. Serope kelpekijian & Stevan R. Schmid- “Manufacturing process and Engineering materials” – 2003
2. “Micro sensors Mems & smart devices”- Julian W.Hardner – 2002
3. Brahem T. Smith, “Advanced machining”, I.F.S. UK 1989.
4. Jaeger R.C., “Introduction to microelectronic fabrication”, Addison Wesley, 1988.
5. Nario Taniguchi – “Nano technology” – Oxford University Press 1996.
6. Pandey P.C. & Shan HS, “Modern Machining Processes”, Standard Publishing Co., 1980
7. More Madon, “Fundamentals of Micro fabrication”, CRC Press, 1997

**PHYSICS OF SOLAR ENGINEERING**  
(Effective from the academic year 2024-2025 onwards)

**UNIT I**

**CODE:24RME303**

**INTRODUCTION**

Basics of solar energy - Brief History of solar energy utilization - Various approaches of utilizing solar energy - Blackbody radiation- Relation between radiation field energy density and radiation spectrum - Planck's formula in energy unit - Maximum spectral density - Planck's formula in wavelength unit - Wien displacement law - Stefan - Boltzmann law - Photoelectric effect - Einstein's theory of photons - Einstein's derivation of the black-body formula.

**UNIT II**

**ORIGIN OF SOLAR ENERGY, TRACKING SUNLIGHT & ATMOSPHERIC INTERACTION**

Basic parameters of the Sun - Measurement of the solar constant - The structure of the Sun - The origin of solar energy - Rotation and orbital motion of the Earth around the Sun - Solar time, sidereal time, universal standard time, local standard time - Equation of time - Intensity of sunlight on an arbitrary surface at any time - Interaction with the atmosphere - Absorption of the molecules - Air mass - Rayleigh scattering - Direct and scattered sunlight.

**UNIT III**

**SOLAR CELLS**

Formation of a pn – junction - Space charge and internal field - Quasi - Fermi levels - The Shockley diode equation - Structure of a solar cell - The solar cell equation - Fill factor and maximum power - Various electron - hole-pair recombination mechanisms - Crystalline silicon solar cells - Thin film solar cells: CIGS, Cite and a – silicon - Tandem solar cells - Dye - sensitized solar cells - Organic solar cells

**UNIT IV**

**CONCENTRATION OF SOLAR ENERGY**

Three types of imaging optics: trough or linear collectors, central receiver with heliostats, and parabolic dish concentrator with on - axis tracking- Solar thermal electricity using Stirling engine or Rankine engine - Solar photovoltaic's with concentration.

**UNIT V**

**ENERGY STORAGE**

Necessity of storage for solar energy- Chemical energy storage - Thermal energy storage - Thermal Flywheels - Compressed air- Rechargeable batteries.

## **SUGGESTED BOOKS:**

1. Duffie, J.A., and Beckman, W.A. "Solar Energy Thermal Process", John Wiley and Sons, New York, Jui Sheng Hsieh, Solar Energy Engineering, Prentice-Hall, 2007.
2. M. Stix, "The Sun An Introduction", Second Edition, Springer 2002.
3. Nelson, "The Physics of Solar Cells". Imperial College Press, 2003.
4. Rai, G.D., "Solar Energy Utilization", Khanna Publishers, N. Delhi, 2010.
5. Sukhatme S.P., "Solar Energy", Tata McGraw Hills P Co., 3rd Edition, 2008.
6. B.G. Streetman and S. Banerjee, "Solid State Electronic Devices", Sixth Edition, Prentice Hall, 2006.

**ADVANCED HEAT AND MASS TRANSFER**  
**(Effective from the academic year 2024-2025 onwards)**

**CODE: 24RME304**

**UNIT I**

**CONDUCTION AND RADIATION HEAT TRANSFER**

One dimensional energy equations and boundary condition - three-dimensional heat conduction equations - extended surface heat transfer - conduction with moving boundaries - radiation in gases and vapour. Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection.

**UNIT II**

**TURBULENT FORCED CONVECTIVE HEAT TRANSFER**

Momentum and energy equations - turbulent boundary layer heat transfer - mixing length concept - turbulence model –  $k-\epsilon$  model - analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube - high speed flows.

**UNIT III**

**PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER**

Condensation with shears edge on bank of tubes - boiling – pool and flow boiling - heat exchanger –  $\epsilon$  -- NTU approach and design procedure - compact heat exchangers.

**UNIT IV**

**NUMERICAL METHODS IN HEAT TRANSFER**

Finite difference formulation of steady and transient heat conduction problems – discretization schemes – explicit - Crank Nicolson and fully implicit schemes - control volume formulation –steady one-dimensional convection and diffusion problems - calculation of the flow field – SIMPLER Algorithm.

**UNIT V**

**MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION**

Mass transfer - vaporization of droplets - combined heat and mass transfers - heat transfer correlations in various applications like I.C. engines - compressors and turbines.



## **SUGGESTED BOOKS:**

1. Yunus A.Cengel, "Heat and Mass Transfer – A practical Approach", 3rd edition, Tata McGraw Hill, 2007.
2. Holman.J.P, "Heat Transfer", Tata Mc Graw Hill, 2002.
3. Ozisik. M.N., "Heat Transfer – A Basic Approach", McGraw-Hill Co., 1985
4. Incropera F.P. and DeWitt. D.P., "Fundamentals of Heat & Mass Transfer", John Wiley & Sons, 2002.
5. Nag.P.K, "Heat Transfer", Tata McGraw-Hill, 2002
6. Ghoshdastidar. P.S., "Heat Transfer, Oxford University Press, 2004
7. Yadav, R., "Heat and Mass Transfer", Central Publishing House, 1995.

**INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS**  
(Effective from the academic year 2024-2025 onwards)

**CODE:24RME305**

**UNIT 1**

**INTRODUCTION AND ROBOT KINEMATICS**

Definition need and scope of Industrial robots – Robot anatomy – Work volume – Precision movement – End effectors – Sensors. Robot Kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators – Robot dynamics – Methods for orientation and location of objects.

**UNIT-II**

**ROBOT DRIVES AND CONTROL**

Controlling the Robot motion – Position and velocity sensing devices – Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves – Electro hydraulic servo valves, electric drives – Motors – Designing of end effectors – Vacuum, magnetic and air operated grippers.

**UNIT-III**

**ROBOT**

Transducers and Sensors – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image Representation - Image Grabbing –Image processing and analysis – Edge Enhancement – Contrast Stretching – Band Rationing - Image segmentation – Pattern recognition – Training of vision system.

**UNIT-IV**

**ROBOT CELL DESIGN AND APPLICATION**

Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple Robots and machine interference – Robot cycle time analysis. Industrial applications of Robots.

**UNIT-V**

**ROBOT PROGRAMMING, ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS**

Methods of Robot Programming – Characteristics of task level languages lead through programming methods – Motion interpolation. Artificial intelligence – Basics – Goals of artificial intelligence – AI techniques – problem representation in AI – Problem reduction and solution techniques - Application of AI and KBES in Robots.

## **SUGGESTED BOOKS:**

1. K.S.Fu, R.C. Gonzalez and C.S.G. Lee, "Robotics Control, Sensing, Vision and Intelligence", Mc Graw Hill, 1987.
2. Yoram Koren," Robotics for Engineers' Mc Graw-Hill, 1987.
3. Kozyrey, Yu. "Industrial Robots", MIR Publishers Moscow, 1985.
4. Richard. D, Klafter, Thomas, A, Chmielewski, Michael Negin, "Robotics Engineering-An Integrated Approach", Prentice-Hall of India Pvt. Ltd., 1984.
5. Deb, S.R." Robotics Technology and Flexible Automation", Tata Mc Graw-Hill, 1994.
6. Mikell, P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey, "Industrial Robotics Technology, Programming and Applications", Mc Graw-Hill, Int. 1986.
7. Timothy Jordanides et al, "Expert Systems and Robotics", Springer-Verlag, NewYork, May 1991.

**REFRIGERATION SYSTEMS DESIGN**  
(Effective from the academic year 2024-2025 onwards)

**CODE:24RME306**

**UNIT I**

**REFRIGERATION CYCLES - ANALYSIS**

Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapor compression cycle, Multipressure Systems , Cascade Systems-Analysis.

**UNIT II**

**MAIN SYSTEM COMPONENTS**

Compressor- Types, performance, Characteristics of Reciprocating Compressors, Capacity Control, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behavior with fluctuating load.

**UNIT III**

**REFRIGERANTS**

Classification of Refrigerants, Refrigerant properties, Oil Compatibility, Environmental Impact- Montreal / Kyoto protocols-Eco Friendly Refrigerants. Different Types of Refrigeration Tools, Evacuation and Charging Unit, Recovery and Recycling Unit, Vacuum Pumps.

**UNIT IV**

**SYSTEM BALANCING & CONTROLS**

Estimation of Cooling Load, System Equilibrium and Cycling Controls, Electric Circuits in- Refrigerators, Window A/C, Types of motors, Relays.

**UNIT V**

**OTHER REFRIGERATION CYCLES**

Vapor Absorption Systems-Aqua Ammonia & LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration and Air Refrigeration cycles.

**SUGGESTED BOOKS:**

1. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version (2001).
2. Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989.
3. Jordan and Priester , Refrigeration and Air conditioning 1985.
4. Goshnay W.B., Principles and Refrigeration, Cambridge, University Press, 1985.
5. Langley , Billy C., ‘Solid state electronic controls for HVACR’ pentice-Hall 1986.

**COMPOSITE AND POLYMER MATERIALS**  
(Effective from the academic year 2024-2025 onwards)

**CODE:24RME307**

**UNIT I**

**PROPERTIES OF POLYMERS**

Chemistry and Classification of Polymers – Properties of Thermo plastics – Properties of Thermosetting Plastics – Applications – Merits and Disadvantages.

**UNIT II**

**PROCESSING OF POLYMERS**

Extrusion – Injection Moulding – Blow Moulding – Compression and Transfer Moulding – Casting – Thermo Forming General Machining properties of Plastics – Machining Parameters and their effect – Joining of Plastics – Mechanical Fasteners – Thermal bonding – Press Fitting.

**UNIT III**

**INTRODUCTION TO FIBRES AND COMPOSITE MATERIALS**

Fibres – Fabrication, Structure, properties and applications - Glass, Boron, carbon, organic, ceramic and metallic fibers whiskers– Matrix materials structure – polymers, – metals and ceramics – Physical and chemical properties.

**UNIT IV**

**PROCESSING OF POLYMER MATRIX COMPOSITES**

Open mould process, bag moulding, compression moulding with BMC and SMC filament winding – pultrusion – centrifugal casting – injection moulding – structure, properties and application of PMC's – Carbon Matrix Composites - Interfaces – Properties – recycling of PMC.

**UNIT V**

**PROCESSING OF METAL MATRIX COMPOSITES AND CERAMIC MATRIX COMPOSITES**

Solid state fabrication techniques – diffusion bonding – powder metallurgy techniques plasma spray, chemical and physical vapour deposition of matrix on fibres Chemical vapour infiltration – Sol gel – liquid state fabrication methods – infiltration – squeeze, casting – rheo casting – compocasting - Interfaces properties– application of MMC and ceramic matrix composites.

## **SUGGESTED BOOKS:**

1. Krishnan K Chawla, "Composite Materials Science and Engineering", International Edition, Springer, 2006
2. Harold Belofsky, "Plastics, Product Design and Process Engineering", Hanser Publishers, 2002.
3. Bera.E and Moet.A, "High performance polymers", Hanser Publishers, 2001.
4. Rauwendaal,C., "Polymer extrusion", Hanser publishers, 2000.
5. Rosatao, D.V. "Blow moulding", Hand Book, Hanser Publishers, 1989.
6. Seamour, E.B. "Modern Plastics Technology", Prentice Hall, 2002
7. Mallick, P.K. and Newman.S., "Composite Materials Technology", Hanser Publishers, 2003

**ADVANCES IN CASTING AND WELDING PROCESSES**  
**(Effective from the academic year 2024-2025 onwards)**

**CODE: 24RME308**

**UNIT I**

**CASTING DESIGN**

Heat transfer between metal and mould — Design considerations in casting – Designing for directional solidification and minimum stresses - principles and design of gating and risering

**UNIT II**

**CASTING METALLURGY**

Solidification of pure metal and alloys – shrinkage in cast metals – progressive and directional solidification — Degasification of the melt-casting defects – Castability of steel, Cast Iron, Al alloys , Babbit alloy and Cu alloy.

**UNIT III**

**RECENT TRENDS IN CASTING AND FOUNDRY LAYOUT**

Shell moulding, precision investment casting, CO<sub>2</sub> moulding, centrifugal casting, Die casting, Continuous casting, Counter gravity low pressure casting, Squeeze casting and semisolid processes. Layout of mechanized foundry – sand reclamation – material handling in foundry pollution control in foundry — Computer aided design of casting.

**UNIT IV**

**WELDING METALLURGY AND DESIGN**

Heat affected Zone and its characteristics – Weldability of steels, cast iron, stainless steel, aluminum, Mg , Cu , Zirconium and titanium alloys – Carbon Equivalent of Plain and alloy steels Hydrogen embrittlement – Lamellar tearing – Residual stress – Distortion and its control . Heat transfer and solidification - Analysis of stresses in welded structures – pre and post welding heat treatments – weld joint design – welding defects – Testing of weldment.

**UNIT V**

**RECENT TRENDS IN WELDING**

Friction welding, friction stir welding – explosive welding – diffusion bonding – high frequency induction welding – ultrasonic welding – electron beam welding – Laser beam welding –Plasma welding – Electroslag welding- narrow gap, hybrid twin wire active TIG – Tandem MIG- modern brazing and soldering techniques – induction, dip resistance, diffusion processes – Hot gas, wave and vapour phase soldering. Overview of automation of welding in aerospace, nuclear, surface transport vehicles and under water welding.

## **SUGGESTED BOOKS:**

1. ASM Handbook, Vol 15, "Casting", 2004
2. ASM Handbook vol.6, "Welding, Brazing & Soldering", 2003
3. Parmer R.S., "Welding Engineering and Technology", Khanna Publishers, 2002
4. Srinivasan N.K., "Welding Technology", Khanna Tech Publishers, 2002
5. Heineloper & Rosenthal, "Principles of Metal Casting", Tata McGraw Hill, 2000.
6. Jain P.L., "Principles of Foundry Technology", Tata McGrawHill Publishers, 2003
7. Carry B., "Modern Welding Technology", Prentice Hall Pvt Ltd., 2002
8. Iotrowski – "Robotic welding – A guide to selection and application" – Society of Mechanical Engineers, 1987.
9. Schwariz, M.M. – "Source book on innovative welding processes" – American Society for Metals (OHIO), 1981
10. Cornu.J. "Advanced welding systems" – Volumes I, II and III, JAICO Publishers, 1994.
11. Lancaster.J.F. – "Metallurgy of welding" – George Alien & Unwin Publishers, 1980



**SUPPLY CHAIN MANAGEMENT**  
**(Effective from the academic year 2024-2025 onwards)**

**CODE:24RME309**

**UNIT I**

**INTRODUCTION AND SUPPLY CHAIN NETWORK DESIGN**

Definition, house of supply chain – customer satisfaction, integration, coordination - decision phases in a supply chain, objectives of SCM, examples of supply chains, supply chain drivers, supply chain performance measures. SUPPLY CHAIN NETWORK DESIGN- Data collection – data aggregation, transportation modes and rates, mileage estimation, warehouse costs, warehouse capacity, potential warehouse locations, service level requirements and future demand. Network design in the supply chain – factors influencing the network design, framework for network design decisions, models for facility location and capacity allocation – capacitated plant location model, gravity location model, allocating demand to production facilities, simultaneous location of plants and warehouses – impact of uncertainty on network design.

**UNIT II**

**INVENTORY MANAGEMENT AND STRATEGIC ALLIANCE**

Single warehouse inventory model - cycle inventory – economies of scale to exploit fixed costs, quantity discounts, short term discounting, multi-echelon inventory, example problems. managing uncertainty – safety inventory in the supply chain –safety level estimation, impact of supply uncertainty, impact of aggregation, impact of replenishment policies, managing safety inventory in multi echelon supply chain, managing safety inventory in practice – product availability – optimal level, affecting factors, supply chain contracts – risk pooling – examples. value of information – Bullwhip effect, information and supply chain technology. STRATEGIC ALLIANCE - Framework for strategic alliance - 3PL and 4PL – retailer-supplier partnerships – distribution integration – procurement and outsourcing – benefits, make/buy decisions, E-Procurement, supplier relationship management – supplier scoring and assessment, supplier selection and contracts – E-Business and the supply chain. design for logistics- Reverse logistics –Cases in Paper industry – Furniture industry – supplier integration into new product development – mass customization.

**UNIT III**

**DISTRIBUTION NETWORK DESIGN AND STRATEGIES**

Role of distribution in supply chain – distribution network design – factors influencing distribution network design. push strategy – pull strategy – Kanban replenishment systems, types, implementation, and push–pull strategy – demand driven strategy – impact of internet on supply chain strategy. distribution networks in practice – direct shipment, cross docking, warehousing, transshipment.

**UNIT IV**

**CUSTOMER VALUE AND GLOBAL SUPPLY CHAINS**

Customer value – dimensions, strategic pricing, customer value measures, information technology and customer value – customer relationship management. global supply chains – introduction, driving factors, risks and advantages, issues, regional differences in logistics.

## **UNIT V**

### **INFORMATION TECHNOLOGY FOR SCM**

Goals – standardization – infrastructure – interface devices, communications, databases, system architecture – system components – integrating the supply chain information technology - DSS for supply chain management.

#### **SUGGESTED BOOKS:**

1. Simchi – Levi Davi, Kaminsky Philip and Simchi-Levi Edith, “Designing and Managing the Supply Chain”, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2003.
2. Chopra S and Meindl P, “Supply Chain Management: Strategy, Planning, and Operation”, Prentice Hall India Pvt. Ltd, New Delhi, 2007.
3. Robert B Handfield and Ernest L Nichols, “Introduction to Supply Chain Management”, Prentice Hall, Inc. New Delhi, 1999.
4. Sahay B S, “Supply Chain Management”, Macmillan Company, 2000.
5. David Brunt and David Taylor, “Manufacturing Operations and Supply Chain Management : The Lean Approach”, Vikas Publishing House, New Delhi, 2001.
6. Hartmud Stadler and Christoph Kilger, “Supply Chain Management and Advanced Planning: Concepts, Models, Software”, Springer-Verlag, 2000.
7. David F Ross, “Introduction to E-Supply Chain Management”, CRC Press, 2003

**ENGINEERING METALLURGY**  
(Effective from the academic year 2024-2025 onwards)

**CODE:24RME310**

**UNIT I**  
**SPECIAL STEEL**

High strength low alloy (HSLA) steel, Dual phase steel, Duplex stainless steel, TRIP steel, Maraging steel, High speed steel, Stainless steel: ferritic, austenitic and martensitic. Precipitation & dispersion hardenable materials.

**UNIT II**  
**AGE HARDENABLE ALLOYS**

Al-Cu alloys, Al-Fe-V-Si alloys. Super alloys: Ni, Fe and Co based super alloys, Ti based alloys & their thermo mechanical treatment, Nano materials: Synthesis, properties and applications. ; Non-structural materials: Dielectric materials; dielectric constant and polarization, linear dielectric materials, capacitors and insulators, non-linear dielectrics, pyro, piezo and ferro-electrics properties;

**UNIT III**  
**SEMICONDUCTOR**

Direct and indirect band gap, band diagrams, applications of semiconductors, degenerate and non-degenerate semiconductors, extrinsic and intrinsic semiconductors. Superconducting materials, Optical & Photoionic materials, electron-hole-recombination.

**UNIT IV**  
**BIOMATERIALS**

Property requirements for biomaterials, concept of biocompatibility, important biometallic alloys; Ti based, stainless steel. Intelligent materials.

**SUGGESTED BOOKS:**

1. W.F. Smith, "Principles of Materials Science and Engineering", McGraw Hill, New York (1994).
2. W.D. Callister, "An Introduction Materials Science & Engineering", John Wiley & Sons (2007).
3. V. Raghavan, "Material Science and Engineering", Prentice Hall of India, 2004.
4. R.Sharma, Sharma, "Heat Treatment: Principles and techniques", Prentice Hall of India, (2004).

**SMART MANUFACTURING**  
(Effective from the academic year 2024-2025 onwards)

**CODE:24RME311**

**UNIT I**  
**INTRODUCTION**

Overview, and components of manufacturing systems, Design, operation, and control of manufacturing systems.

**UNIT II**  
**TYPES OF MANUFACTURING SYSTEMS**

Single station cells, manual assembly lines, automated production lines, transfer lines, analysis automated assembly systems.

**UNIT III**  
**PERFORMANCE OF MANUFACTURING SYSTEM**

Productivity, quality, reliability, agility, responsiveness, sustainability, utilization & availability, flexibility, reconfigurability, resiliency, efficiency and effectiveness of manufacturing system, metrics and key performance indicators.

**UNIT IV**  
**GROUP TECHNOLOGY AND CELLULAR MANUFACTURING**

Flexible manufacturing systems, changeable manufacturing systems, Just-In-Time and lean production, automation. Agile/demand driven manufacturing, Quick response manufacturing, world class manufacturing and holonic manufacturing systems.

**UNIT V**  
**COMPUTER INTEGRATED MANUFACTURING**

Enterprise Integration (ISA-95 and other standards), Digital Manufacturing and smart manufacturing systems.

**SUGGESTED BOOKS:**

1. M. P. Groover, "Automation, Production systems and Computer Integrated Manufacturing". 3rd edition, Pearson Education, 2015. ISBN: 978-9332549814.
2. N. Singh, "Systems Approach to Computer Integrated Design and Manufacturing", 1st edition, Wiley India, 2011. ISBN: 978-8126530410.
3. G. Chryssolouris, "Manufacturing Systems: Theory and Practice". 2nd edition, Springer, 2006. ISBN: 978-1441920676.
4. W. J. Hopp, M. L. Spearman, "Factory Physics", 3rd edition, Waveland Press, 2011.

5. E. Turban, L. Volonino, “Information Technology for Management: Transforming Organizations in the Digital Economy”, 7th edition, Wiley India Private Limited, 2010. ISBN: 978-8126526390.
6. R. Askin and C. Standridge, “Modeling and Analysis of Manufacturing Systems”, 1st edition, John Wiley, 1992. ISBN: 978-0-471-51418-3.

**INTELLIGENT INDUSTRIAL AUTOMATION AND ITS APPLICATION**  
**(Effective from the academic year 2024-2025 onwards)**

**CODE:24RME312**

**UNIT I**

**INTRODUCTION TO INDUSTRIAL AUTOMATION**

Intelligent Systems, Hydraulic Actuators for Industrial Automation, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Flow lines & Transfer Mechanisms, Fundamentals of Transfer Lines. (SLE: Analysis of Transfer Lines)

**UNIT II**

**MATERIAL HANDLING AND IDENTIFICATION TECHNOLOGIES**

Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods. (SLE: Material Identification Methods)

**UNIT III**

**AUTOMATED MANUFACTURING SYSTEMS**

Components, Classification and Overview of Manufacturing Systems, Manufacturing Cells, GT and Cellular Manufacturing, FMS, FMS and its Planning and Implementation. Quality Control Systems: Traditional and Modern Quality Control Methods, SPC Tools, Inspection Principles and Practices, Inspection Technologies. (SLE: Usage of SPC tools using excel or Minitab).

**UNIT IV**

**CONTROL TECHNOLOGIES IN AUTOMATION**

Industrial Control Systems, Process Industries Versus Discrete-Manufacturing Industries, Continuous Versus Discrete Control, Computer Process and its Forms. Introduction & Automatic Process Control, Building Blocks of Automation Systems: LAN, Analog & Digital I/O Modules, SCADA Systems & RTU. Distributed Control System: Functional Requirements, Configurations & some popular Distributed Control Systems. (SLE: Display Systems in Process Control Environment.)

**UNIT V**

**AUTOMATION AND INDUSTRIAL CONTROL APPLICATIONS**

Electric Drives, Sensors and Vision used for automation, Trajectory planning, Automation Algorithm, Programming and flow control for automation. Modeling and Simulation for Plant Automation: Introduction, need for system Modeling, Building Mathematical Model of a Plant, Modern Tools & Future Perspective. Industrial Control Applications: Cement, Thermal, Water Treatment & Steel Plants. (SLE: Cases Studies minimum one for Cement, Thermal, Water Treatment & Steel Plants applications).

## **SUGGESTED BOOKS:**

1. Automation, “Production Systems and Computer Integrated Manufacturing”,M.P.Groover, Pearson Education.5th edition, 2009.
2. “Computer Based Industrial Control”- Krishna Kant, EEE-PHI,2nd edition,2010
3. “An Introduction to Automated Process Planning Systems”- Tiess Chiu Chang & Richard A. Wysk.
4. “Performance Modeling of Automated Manufacturing Systems”, -Viswanandham, PHI, 1st edition, 2009.
5. G.S. Hegde, “A Textbook on Industrial Robotics”, University Science Press, Second Edition 2008, ISBN 978-81-318-051803

**ALTERNATIVE FUELS FOR IC ENGINES**  
**(Effective from the academic year 2024-2025 onwards)**

**CODE:24RME313**

**UNIT I**

**ALTERNATE FUELS**

Estimation of petroleum reserve - Need for alternate fuel - Availability and properties of alternate fuels – general use of alcohols - LPG - Hydrogen - Ammonia, CNG and LNG - Vegetable oils and Biogas – Solar – Merits and demerits of various alternate fuels;

**UNIT II**

**PROPERTIES OF ALCOHOLS AND CNG**

Properties, alcohols and gasoline blends, performance in SI engine. Methanol and gasoline blends - Combustion characteristics in engines - emission characteristics – Engine modifications; Availability of CNG, properties, modification required to use in engines - performance and emission characteristics of CNG using LPG in SI & CI engines.

**UNIT III**

**ENGINE MODIFICATION AND PERFORMANCE**

Performance and emission for LPG – Hydrogen – Storage and handling, performance and safety aspects; Various vegetable oils for engines – Single and dual fuel use – Engine modifications - SVO - Esterification - Performance in engines - Performance and emission characteristics;

**UNIT IV**

**LAYOUT OF AN ELECTRIC VEHICLE**

Layout of an electric vehicle - Advantage and limitations - Specifications - System component.

**UNIT V**

**VEHICLE SYSTEM**

Electronic control system - High energy and power density batteries - Hybrid vehicle - Solar powered vehicles.

**SUGGESTED BOOKS:**

1. M. Dayal, “Energy today & tomorrow”, I & B Horishr India, 1982.
2. Nagpal, “Power Plant Engineering”, Khanna Publishers, 1991.
3. “Alcohols and motor fuels progress in technology”, Series No.19, SAE Publication USA 1980  
SAE PaperNos. 840367, 841156, 841333, 841334
4. “The properties and performance of modern alternate fuels” - SAE Paper No.841210. SAE Handbook



**ENERGY CONSERVATION AND MANAGEMENT**  
**(Effective from the academic year 2024-2025 onwards)**

**CODE:24RME314**

**UNIT I**

**ENERGY SOURCES**

Classification and characterization of fuels (fossil and bio-fuel), conversion and utilization, environmental and economic issues, optimum use of energy resources,

**UNIT II**

**BOILERS, ICE and GAS TURBINES**

Thermodynamic cycles, Principles of thermal energy conversion in boilers, internal combustion engines and gas turbines, cogeneration and combined cycle power generation.

**UNIT III**

**ENERGY MANAGEMENT**

Fuel cells and MHD technology, solar, wind and nuclear power, utilization of industrial heat, Energy management in industry.

**UNIT IV**

**POLLUTION CONTROL**

Environmental and economic evaluation advanced pollution control technology.

**SUGGESTED BOOKS:**

1. R. Gold Stick and A. Thumann, "Principles of Waste Heat Recovery", PHI, 1986.
2. D. Y. Goswami, F. Kreith, "Energy Conversion"- CRC Press, 2007
3. V. Kadambi, and M. Prasad, "Introduction to energy conversion turbo machinery: Energy conversion cycle"-Wiley Eastern, New Delhi, 1974,

**FUEL CELL TECHNOLOGY**  
(Effective from the academic year 2024-2025 onwards)

**CODE:24RME315**

**UNIT I**  
**INTRODUCTION**

Overview of current fuel cell technology. Operating principles, fundamental thermodynamics and electrochemistry.

**UNIT II**  
**TYPES OF FUEL CELLS AND APPLICATIONS**

Proton exchange membrane fuel cells; components; performance; testing. Micro fuel cells. High temperature fuel cells. Modelling of transport phenomena in fuel cells.

**UNIT III**  
**HYDROGEN PRODUCTION AND STORAGE.**

Fuel cell systems and ancillaries. Overview and status of various fuel cell technologies. Fundamentals: fuel cell thermodynamics; electrode kinetics; performance and efficiency; transport processes.

**UNIT IV**  
**FUELLING ISSUES**

Proton Exchange Membrane Fuel Cells (PEMFCs). Solid Oxide Fuel Cells (SOFCs). Fuelling issues. Fuel cell systems and applications.

**SUGGESTED BOOKS:**

1. A.V. Da Rosa, 2005, "Fundamentals of Renewable Energy Processes", Elsevier academic press.
2. W. Vielstich, A. Lamm and H.A. Gastieger, 2003, "Handbook of Fuel Cells", vol. 1-4, John Wiley.
3. G. Hogen ed. 2003, "Fuel Cell Technology Handbook", CRC press.

**MICRO-MACHINING AND PRECISION ENGINEERING**  
(Effective from the academic year 2024-2025 onwards)

**CODE:24RME316**

**UNIT I**

**INTRODUCTION TO MICROMACHINING TECHNOLOGIES**

Introduction to micromachining technologies, bulk micromachining, LIGA, Surface Micromachining, Characterization of micro-machining, Tool making, Micromachinability of materials.

**UNIT II**

**DIAMOND MICRO-MACHINING**

Machining principles, diamond turning, diamond grinding, accuracy and dimensional control, molecular dynamics simulation of the atomic processes in micro-machining, principles of molecular dynamics, atomistic forces of chip formation and surface generation, future trends in ultrahigh speed machining.

**UNIT III**

**MICROELECTRO DISCHARGE MACHINING**

Principles of micro-EDM, micro-EDM by Die-sinking and WEDG, micro-WEDM, micro-WEDG, micro-ECM, Principles of micro-turning, micro-drilling and micro-milling, hybrid micro-machining method, on-line measurement by machine vision and integrated probe.

**UNIT IV**

**ABRASIVE MICROMACHINING AND MICRO GRINDING**

Abrasive micromachining mechanisms, micro-grinding mechanism, micro-machining rate, micro-machining cooling media. ; Laser micromachining: Principles of laser material removal, laser micro-drilling, laser micro-adjustment, laser surface structuring, laser micro-cutting.

**UNIT V**

**MICRO-MACHINING BY FINISHING TECHNIQUES**

Micro-lapping, micro-machining, magneto-abrasive micromachining and finishing (MAF), ELID Grinding.; Measuring Techniques in micro-machining: stylus instruments, scanning tunneling microscopes, atomic force microscope, measurement of micromoles and slots using optical method, vibro-scanning method, elastic transmission method, computer aided measurement testing and diagnostics, surface integrity and other related measurements.

## **SUGGESTED BOOKS:**

1. J. M. Geough, “Micro-machining of Engineering Materials”, Edited by Marcel Dekker, 2002.
2. R.W. Johnstone, M. Parameswaran, “An introduction to surface-micromachining”, Kluwer Academic Publishers, 2004.
3. N. P Mahalik. “Micro-manufacturing and nano-technology”, edited by, Springer Publication, 2006.
4. M. P. Groover, “Automation, Production Systems and Computer-Integrated Manufacturing”, 2003.

**OPTIMIZATION TECHNIQUES**  
(Effective from the academic year 2024-2025 onwards)

**CODE: 24RME317**

**UNIT I**

**NONLINEAR OPTIMIZATION**

Introduction – unconstrained optimization - one-dimensional optimization – elimination methods – Fibonacci method, golden section methods – interpolation methods – quadratic, direct route method – multivariable optimization - direct search methods – pattern search methods – univariate method, hooks and jeeves method, simplex method – descent methods – steepest descent, Newton methods.

**UNIT II**

**CONSTRAINED NONLINEAR OPTIMIZATION**

Direct methods – the complex method, cutting plane method – indirect methods – interior and exterior penalty function methods, Khun-Tucker conditions, Lagrangian method.

**UNIT III**

**INTEGER AND DYNAMIC PROGRAMMING**

Introduction to integer programming – solution techniques - graphical method, the branch and bound technique, gomary’s cutting plane method, examples on the application in manufacturing / design systems – introduction to dynamic programming - bellman’s principle of optimality, examples on the application on routing problem, inventory problem.

**UNIT IV**

**NETWORK OPTIMIZATION MODELS**

Terminology of networks – the shortest route problem – the minimum spanning tree problem – the maximum flow problem – the minimum cost flow problem – the network simplex method.

**UNIT V**

**NON TRADITIONAL OPTIMIZATION MODELS**

Introduction to non-traditional optimization, computational complexity – NP-hard, NP-complete, no free lunch theorem – working principles of simulated annealing, Tabu search, and neural networks, simple applications. Introduction to Genetic Algorithms, Ants Colony Algorithm, Particle Swarm Algorithm, Hybrid Algorithms, Simple Applications.

## **SUGGESTED BOOKS:**

1. Singiresu S Rao, "Engineering Optimization: Theory and Practice", Wiley-Interscience, Third Edition, 1996.
2. Kalyanmoy Deb, "Optimization for engineering design", Prentice Hall India Pvt. Ltd., New Delhi, 2000.
3. David E Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning",
4. Addison Wesley Pub Co., 1989.
5. Marco Dorigo and Thomas Stutzle, "Ant Colony Optimization", Prentice Hall of India, 2005.
6. Maurice Clerc, "Particle Swarm Optimization", ISTE, 2007
7. Dimitri P Bertsekas, "Dynamic Programming: Deterministic and Stochastic Models", Prentice Hall, 1987.
8. Stephen G Nash and Ariela Sofer, "Linear and Nonlinear Programming", McGraw Hill College Div., 1995.
9. Fred Glover, Manuel Laguna and Fred Laguna, "Tabu Search", Kluwer Academic Publishers, 1997.

**COMPUTATIONAL METHODS**  
(Effective from the academic year 2024-2025 onwards)

**CODE: 24RME318**

**UNIT I**

**INTRODUCTION TO COMPUTATIONAL METHODS**

Examples, solving sets of equations, Gauss elimination method, Choleski method, Iterative methods, Relaxation method, system of non-linear equations- Newton Raphson method, computer programs.

**UNIT II**

**NUMERICAL INTEGRATION**

Newton-Cotes integration formulas, Trapezoidal rule, Simpson's rules, Gaussian quadrature, adaptive integration, cubic spline functions - Bezier curves and B-splines, computer programs. Boundary value problems and characteristic value problems: Shooting method, solution through a set of equations, derivative boundary conditions, Rayleigh-Ritz method, characteristic value problems, solution using characteristic polynomial method, Jacobi method, power method and Inverse power method.

**UNIT III**

**NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS**

Laplace's equations, representations as a difference equation, Iterative methods for Laplace's equations, Poisson equation, derivative boundary conditions, irregular and non-rectangular grids, Matrix patterns, Sparseness, ADI method, applications to heat flow problems, computer programs.

**UNIT IV**

**PARABOLIC PARTIAL DIFFERENTIAL EQUATIONS**

Explicit method, Crank-Nicholson method, derivative boundary condition, stability and convergence criteria, Parabolic equations in two or more dimensions, applications to heat flow problems, computer programs. Hyperbolic Partial differential equations: Solving wave equation by finite differences, stability of numerical method, method of characteristics, Wave equation in two space dimensions, computer programs.

**UNIT V**

**CURVE FITTING AND APPROXIMATION OF FUNCTIONS**

Least square approximation, fitting of non-linear curves by least squares, regression analysis, computer programs.

## **SUGGESTED BOOKS:**

1. Curtis F Gerald and Patrick O Wheatley, “Applied Numerical Analysis”, Pearson Education, 2002.
2. Rajasekaran S, “Numerical Methods in Science and Engineering – A Practical Approach”, Wheeler Publishing, 1999, Second Edition.
3. Douglas J Faires and Riched Burden, “Numerical Methods”, Brooks/Cole Publishing Company, 1998, Second Edition.
4. Steven C Chapra and Raymond P Canale, “Numerical Methods for Engineers with Software and Programming Applications”, Tata McGraw Hill Edition, 2004.
5. John H Mathews and Kurtis D Fink, “Numerical Methods using MATLAB”, Prentice Hall, 1998.
6. Ward Cheney and David Kincaid, “Numerical Mathematics and Computing”, Brooks/Cole Publishing Company, 1999, Fourth Edition.



**FINITE ELEMENT ANALYSIS**  
(Effective from the academic year 2024-2025 onwards)

**CODE:24RME319**

**UNIT I**

**BENDING OF PLATES AND SHELLS**

Review of Elasticity Equations – Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements - Conforming and Non-Conforming Elements – C0 and C1 Continuity Elements – Degenerated shell elements- Application and Examples.

**UNIT II**

**NON-LINEAR PROBLEMS**

Introduction – Iterative Techniques – Material non-linearity – Elasto Plasticity – Plasticity – Visco Plasticity – Geometric Non linearity – large displacement Formulation –Solution procedure- Application in Metal Forming Process and Contact Problems.

**UNIT III**

**DYNAMIC PROBLEM**

Direct Formulation – Free, Transient and Forced Response – Solution Procedures – Eigen solution- Subspace Iterative Technique – Response analysis-Houbolt, Wilson, Newmark – Methods – Explicit & Implicit Methods- Lanchzos, Reduced method for large size system equations.

**UNIT IV**

**FLUID MECHANICS AND HEAT TRANSFER**

Governing Equations of Fluid Mechanics – Solid structure interaction - Inviscid and Incompressible Flow – Potential Formulations – Slow Non-Newtonian Flow – Metal and Polymer Forming – Navier Stokes Equation – Steady and Transient Solution.

**UNIT V**

**ERROR ESTIMATES AND ADAPTIVE REFINEMENT**

Error norms and Convergence rates – h-refinement with adaptivity – Adaptive refinement.

**SUGGESTED BOOKS:**

1. Zienkiewicz, O.C. and Taylor, R.L., “The Finite Element Method”, Fourth Edition, Volumes 1 & 2, McGraw Hill International Edition, Physics Services, 1991.
2. Cook R.D., “Concepts and Applications of Finite Element Analysis”, John Wiley and Sons Inc., New York, 1989.
3. Bathe K.J., “Finite Element Procedures in Engineering Analysis”, Prentice Hall, 1990.