Master of Technology
(Wireless Communication)

Regulations, Curriculum and Syllabus
(Non CBCS)

(with effect from academic year 2018-2019)
i) Regulations for (Non – CBCS) M.Tech. (Wireless Communication)

Besides the Non - CBCS regulations specified by Pondicherry University in respect of engineering post graduate degree admission, evaluation and awarding degree, the following norms are applicable for this programme.

1. Name of the Programme : M.Tech. (Wireless Communication)

2. Nature of the Programme : Regular, Coming under Engineering Department.

3. Programme Duration : Two years (Four Semesters). However, one can complete the programme within maximum of eight semesters.

4. Eligibility Criteria : Candidates for admission to the first semester of four semester M.Tech (Wireless Communication) should have passed B.E / B.Tech in Electronics and communication Engineering / Telecommunication Engineering / Communication Engineering / Electronics and Telecommunication / Information Technology and other related branches, through regular course of study from an AICTE approved institution or an examination of any University or authority accepted by the Pondicherry University as equivalent thereto, with at least 55% marks in the degree examination or equivalent CGPA.

Note:
   i. Candidates belonging to SC/ST who have a mere pass in the qualifying examination are eligible (as per university norms).
   ii. There is no age limit for M.Tech programmes.

5. Admission Criteria : The admission policy for various M.Tech programmes will be decided by the respective institutes offering M.Tech programmes subject to conforming to the relevant regulations of the Pondicherry University.

6. Intake : As per the sanctioned strength to the Institute by the Pondicherry University.

7. Teaching and Learning Methods : Lectures, tutorials and seminars are the main methods of course delivery, which would be supplemented by individual practical work, project work, simulation assignment, seminars and industrial visits.
8. Structure of M.Tech Programme:

8.1 The M.Tech Programmes is of semester pattern with 16 weeks of instruction in a semester.

8.2 The programme of instruction for each stream of specialization will consist of:
   i. Core courses (Compulsory)
   ii. Electives
   iii. Laboratory
   iv. Online course
   v. Internship
   vi. Project work

8.3 Credits will be assigned to the courses based on the following general pattern:
   i. One credit for each lecture period
   ii. One credit for each tutorial period
   iii. One credit for Project literature survey
   iv. Two credits for practical course
   v. Two credits for Online course
   vi. Two credits for Internship
   vii. Twelve credits for Project work
   viii. One teaching period shall be of 60 minutes duration including 10 minutes for discussion and movement.

8.4 Regulations, curriculum and syllabus of the M.Tech programme shall have the approval of Board of Studies and other Boards /Committees / Councils, prescribed by the Pondicherry University. The curriculum should be so drawn up that the minimum number of credits and other requirements for the successful completion of the programme will be as given in Table 1.

Table 1: Curriculum Details of the Programme

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Requirements M.Tech (Full-Time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of Semesters</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Min. No. of credits of the Programme</td>
<td>74</td>
</tr>
<tr>
<td>3</td>
<td>Max. No. of credits of the Programme</td>
<td>74</td>
</tr>
<tr>
<td>4</td>
<td>Min. Cumulative Grade Point Average for pass</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Min. period of completion of the Programme (consecutive Semesters)</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Max. period for completing the Programme (consecutive Semesters)</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>Number of core and elective courses</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>Online course</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>Project work (semesters)</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>Internship</td>
<td>1</td>
</tr>
</tbody>
</table>
8.5 A core course is a course that a student admitted to the M.Tech. programme must successfully complete to receive the degree. A student must register for all the core courses listed in the curriculum.

8.6 Elective courses are required to be chosen from the courses offered by the department(s) in that particular semester from among the approved courses. A core course of one department may be chosen as an elective by a student from other department ***.

*** Note: A candidate should successfully complete 7 electives for the award of degree. However, it is mandatory that the electives for each semester should be from the group of electives listed in curriculum.

8.7 Project work is envisaged to train a student to analyze independently any problem posed to him/her. The work may be analytical, experimental, design or a combination of both. The project report is expected to exhibit clarity of thought and expression.

8.8 The medium of instruction, examination, seminar and project work will be in English.

9. Requirements to appear for University Examination:

9.1 A candidate shall be permitted to appear for university examinations at the end of any semester only if he/she secures not less than 75% overall attendance arrived at by taking into account the total number of periods in all subjects put together offered by the institution for the semester under consideration. Candidates who secure overall attendance greater than 60% and less than 75% have to pay a condonation fee as prescribed by the University along with a medical certificate obtained from a medical officer not below the rank of Assistant Director to become eligible to appear for the examinations.

9.2 His/Her conduct should be satisfactory as certified by the Head of the institution.

10. Evaluation:

10.1 Theory Courses: 40% of marks for internal and 60% for end semester examinations.

The end semester question paper will have Part A (6 × 2 = 12 Marks) consisting of six two mark questions and Part B (4 × 12 = 48 Marks) consisting of six twelve mark descriptive questions of which one of them is compulsory and totally a candidate has to answer four out of six. For the end semester examination (University Semester Examination), the questions will be chosen only from the first four units of every theory subject of the programme to account end semester marks of 60 and internally (cumulatively) to assess a candidate’s depth of knowledge in the concerned subject for 40 marks, a minimum of two internal tests (30 marks) shall be conducted. Further, the content of the fifth unit in each subject shall be considered to conduct seminars, tutorials, simulations, assignments, development of hardware models etc. for 10 marks as it is formulated at system level for all subjects of the programme. The question paper setter will be appointed by the Competent Authority of the University. However, the evaluation shall be a central evaluation that shall be carried out by Controller of Examinations, Pondicherry University.
10.2 Practical Courses: 50% of marks for internal and 50% for the end semester examinations.

10.3 Internship / Seminar / Workshop / Conference / FDP / Short term course / NPTEL/GIAN/MOOC Course: 100% of marks through internal assessment only.

It is optional to undergo internship in established industry or esteemed institution / Seminar / Workshop / Conference / FDP / Short term course / NPTEL/GIAN/MOOC Course for a period of four weeks (20 working days) either in single or multiple spans by a candidate. Further, a presentation should be given regarding the training or programme underwent during the period with the submission of a report. There shall not be any end semester evaluation. However, the internal evaluation is done by the committee comprising of internal members and one external member from other department of the same institute constituted by Head of the Department for the award of appropriate grade to the candidate based on the performance. The distribution of marks will be decided by the committee. The internship / Seminar / Workshop / Conference / FDP / Short term course / NPTEL/GIAN/MOOC Course can be completed at any period of the duration of M.Tech. programme to fulfill the partial requirements for the award of M.Tech. degree.

10.4 NPTEL/GIAN/MOOC Course:

It is mandatory to undergo one course related to the chosen programme for the minimum period of 30 hours either from NPTEL or GIAN or MOOC that is to be completed at any period of the duration of M.Tech. programme to fulfill the partial requirements for the award of M.Tech. degree. Absolute grade shall be awarded to a candidate based on the marks given in the certificate issued by the competent authority (NPTEL or GIAN or MOOC) for the chosen course.

10.5 Project - Literature Survey

100% of marks through internal assessment only.

It is mandatory to undergo a complete literature survey by a candidate on the area of project work in the third semester regularly. There will be two reviews for the candidate on the literature survey carried out. There shall not be any end semester evaluation. However, the internal evaluation is based on the presentation of the candidate with the submission of a report about the literature survey. It will be done by the committee comprising of internal members and one external member from other department of the same institute constituted by Head of the Department for the award of appropriate grade to the candidate based on the performance. The distribution of marks for the literature survey will be decided by the committee.

10.6 Project and Viva Voce

50% of marks for internal and 50% for end semester examinations.

The Project work shall be evaluated for a maximum of 100 marks. There shall be three assessments during the fourth semester by a review committee. The Head of the Department shall constitute the
review committee consisting of supervisor, project coordinator and another faculty member from the Department for the internal assessment (30 marks). The contribution by the respective supervisor of a student for 20 marks shall be accounted for the internal marks of 50. The end semester Project Viva Voce (for 50 marks) shall be conducted by the external member nominated by the competent Authority of the University. The distribution of the marks is shown in the Table given below.

Table 2: Allocation of marks

<table>
<thead>
<tr>
<th>Allocation of Marks for Project and Viva Voce (100 Marks)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal (50 Marks)</strong></td>
</tr>
<tr>
<td>Review Committee (30 Marks)</td>
</tr>
<tr>
<td>First Review</td>
</tr>
<tr>
<td>10 Marks</td>
</tr>
<tr>
<td>Second Review</td>
</tr>
<tr>
<td>10 Marks</td>
</tr>
<tr>
<td>Third Review</td>
</tr>
<tr>
<td>10 Marks</td>
</tr>
<tr>
<td>Supervisor (20 Marks)</td>
</tr>
<tr>
<td>20 Marks</td>
</tr>
<tr>
<td><strong>External (50 Marks)</strong></td>
</tr>
<tr>
<td>50 Marks</td>
</tr>
<tr>
<td><strong>Total (100 Marks)</strong></td>
</tr>
<tr>
<td>100 Marks</td>
</tr>
</tbody>
</table>

10.7 Publication: Mandatory requirement for the completion of the programme.

It is mandatory to have a minimum of one submitted manuscript / accepted publication in reputed journal during the M.Tech. programme. However, the submitted manuscript / accepted paper is subject to the recommendation of the evaluating committee comprising of internal members from same Department constituted by Head of the Department and one external member (examiner) from other institute nominated by competent Authority of University for the acceptance of the quality of the manuscript /paper of the candidate. The publication can be made at any period of the duration of M.Tech. programme. However, it does not contribute any credits to the programme but mandatory to fulfill the partial requirements for the award of M.Tech. degree. This evaluation process may be carried out along with even end semester examination depending up on the status of the students.

10.8 The end-semester examination shall be conducted by the Pondicherry University for all the courses offered by the department. A model question paper, as approved by the Chairperson, BOS (ECE), Pondicherry University, for each course offered under the curriculum should be submitted to the University.

10.9 The University shall adopt the double valuation procedure for evaluating the end-semester examinations, grading and publication of the results. Each answer script shall be evaluated by two experts. If the difference between the total marks awarded by the two examiners is not more than 15% of end-semester examination maximum marks, then the average of the total marks awarded by the two examiners will be reckoned as the mark secured by the candidate; otherwise, a third examiner is to be invited to evaluate the answer scripts and his/her assessment shall be declared final.

10.10 Continuous assessment of students for theory courses shall be based on two tests (15 marks each) and one assignment (10 marks). A laboratory course carries an internal assessment mark of 50.
distributed as follows: (i) Regular laboratory exercises and records – 20 marks (ii) Internal laboratory test– 20 marks and (iii) Internal viva-voce – 10 marks.

10.11 All eligible students shall appear for the University examination.

11. Grading

11.1 The assessment of a course will be done on absolute marks basis. However, for the purpose of reporting the performance of a candidate, letter grades, each carrying stipulated points, will be awarded as per the range of total marks (out of 100) obtained by the candidate, as detailed below in Table 3.

Table 3: Letter Grade and the Corresponding Grade Point

<table>
<thead>
<tr>
<th>Range of Total Marks</th>
<th>Letter Grade</th>
<th>Grade Point</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 to 100</td>
<td>S</td>
<td>10</td>
<td>Excellent</td>
</tr>
<tr>
<td>80 to 89</td>
<td>A</td>
<td>9</td>
<td>Very Good</td>
</tr>
<tr>
<td>70 to 79</td>
<td>B</td>
<td>8</td>
<td>Good</td>
</tr>
<tr>
<td>60 to 69</td>
<td>C</td>
<td>7</td>
<td>Above Average</td>
</tr>
<tr>
<td>55 to 59</td>
<td>D</td>
<td>6</td>
<td>Average</td>
</tr>
<tr>
<td>50 to 54</td>
<td>E</td>
<td>5</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>0 to 49</td>
<td>F</td>
<td>0</td>
<td>Failure</td>
</tr>
<tr>
<td>-</td>
<td>FA</td>
<td>-</td>
<td>Failure due to lack of attendance</td>
</tr>
<tr>
<td>-</td>
<td>AB</td>
<td>-</td>
<td>Failure by absence</td>
</tr>
</tbody>
</table>

11.2 A student is deemed to have completed a course successfully and earned the appropriate credit if and only if, he /she receives a grade of E or above. The student should obtain 40% of marks in the University examination in a subject to earn a successful grade. A candidate shall be declared to have passed the examination in a subject of study only if he/she secures not less than 50% of the total marks (Internal assessment plus university examination marks).

11.3 A candidate who has been declared “Failed” in a course may reappear for that subject during the subsequent semester and secure a pass.

11.4 The internal assessment marks secured by a student in a theory course shall be considered only during the first appearance. For the subsequent attempts, the marks secured by the student in the University examination shall be scaled up to the total marks. Further, the marks secured by the student in the University examination in the latest attempt shall alone remain valid in total suppression of the University examination marks secured by the student in earlier attempts.
12. Declaration of Results, Rank and Issue of Grade Card

12.1 The results will be declared and the grade cards will be issued to the students after completing the valuation process.

12.2 The grade cards will contain the following details:
   i. The college in which the candidate is studying/has studied.
   ii. The list of courses enrolled during the semester and the grades scored.
   iii. The Grade Point Average (GPA) for the semester and the Cumulative Grade Point Average (CGPA) of all enrolled subjects from first semester onwards.

12.3 GPA is the ratio of the sum of the products of the number of Credits (C) of courses registered and the corresponding Grade Point (GP) scored in those courses, taken for all the courses and the sum of number of credits of all the courses

\[
GPA = \frac{\text{Sum of (C × GP)}}{\text{Sum of C}}
\]

The sum will cover all the courses the student has taken in that semester, including those in which he/she has secured F.

12.4 CGPA will be calculated in a similar manner, considering all the courses enrolled from first semester. FA grades are to be excluded for calculating GPA and CGPA. If a student has passed in a course after failing in earlier attempts, the grade secured by the student in the successful attempt only will be taken into account for computing CGPA.

12.5 To convert CGPA into percentage marks, the following formula shall be used:

\[
\% \text{ Mark} = (\text{CGPA} - 0.5) \times 10
\]

12.6 A candidate who satisfies the course requirements for all semesters and passes all the examinations prescribed for all the four semesters within a maximum period of eight (8) semesters reckoned from the commencement of the first semester to which the candidate was admitted, shall be declared to have qualified for the award of degree.

12.7 A candidate who qualifies for the award of the degree shall be declared to have passed the examination in FIRST CLASS with DISTINCTION upon fulfilling the following requirements:

   i. Should have passed all the subjects pertaining to semesters 1 to 4 in his/her first appearance in 4 consecutive semesters starting from first semester to which the candidate was admitted.
   ii. Should not have been prevented from writing examinations due to lack of attendance.
   iii. Should have secured a CGPA of 8.50 and above from semesters 1 to 4.

12.8 A candidate who qualifies for the award of the degree by passing all the subjects relating to semesters 1 to 4 and secure CGPA not less than 6.5 shall be declared to have passed the
examination in FIRST CLASS. All other candidates who qualify for the award of degree shall be declared to have passed the examination in SECOND CLASS.

12.9 A student with CGPA less than 5.0 is not eligible for the award of degree.

12.10 For the award of University rank and gold medal, the CGPA secured from 1st to 4th semester should be considered and it is mandatory that the candidate should have passed all the subjects from 1st to 4th semester in the first appearance and he/she should not have been prevented from writing the examination due to lack of attendance and should not have withdrawn from writing the University examinations.

13. Provision for Withdrawal : A candidate may, for valid reasons, and on the recommendation of the Head of the Institution be granted permission by the University to withdraw from writing the entire semester examination as one UNIT. The withdrawal application shall be valid only if it is made earlier than the commencement of the last theory examination pertaining to that semester. Withdrawal shall be permitted only once during the entire programme. Other conditions being satisfactory, candidates who withdraw are also eligible to be awarded DISTINCTION whereas they are not eligible to be awarded a rank/gold medal.

14. Temporary Discontinuation from the Programme : If a candidate wishes to temporarily discontinue the programme for valid reasons, he/she shall apply through the Head of the Institution in advance and obtain a written order from the University permitting discontinuance. A candidate after temporary discontinuance may rejoin the programme only at the commencement of the semester at which he/she discontinued, provided he/she pays the prescribed fees to the University. The total period of completion of the programme reckoned from the commencement of the first semester to which the candidate was admitted shall not in any case exceed 4 years, including the period of discontinuance.

15. Revision of Regulations and Curriculum : The University may from time to time revise, amend or change the regulations of curriculum and syllabus as and when requirement for the same arises.

16. Power to Modify : 15.1 Notwithstanding anything contained in the foregoing, the Pondicherry University shall have the power to issue directions/orders to remove any difficulty.

15.2 Nothing in the foregoing may be construed as limiting the power of the Pondicherry University to amend, modify or repeal any or all of the above.

17. Minimum number of credits to be acquired for successful completion of the programm : 74 (Seventy Four) Credits
### ii) Curriculum for M.Tech. (Wireless Communication)

#### I Semester

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>H/S</th>
<th>L-T-P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WCENG 510</td>
<td>Advanced Communication Laboratory - I</td>
<td>H</td>
<td>0-0-4</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>WCENG 511</td>
<td>Advanced Coding Techniques</td>
<td>H</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>WCENG 512</td>
<td>Advanced Engineering Mathematics</td>
<td>H</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>WCENG 513</td>
<td>Advanced Radiation Systems</td>
<td>H</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>WCENG 514</td>
<td>Advanced Wireless Communication</td>
<td>H</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Elective I</td>
<td>S</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Elective II</td>
<td>S</td>
<td>2-1-0</td>
<td>3</td>
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</tbody>
</table>

Total Credits for Semester I: **24**

(H – Hard Core Course; S – Soft Core Course)

#### II Semester

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>H/S</th>
<th>L-T-P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>WCENG 520</td>
<td>Advanced Communication Laboratory - II</td>
<td>H</td>
<td>0-0-4</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>WCENG 521</td>
<td>Advanced Digital Signal Processing</td>
<td>H</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>WCENG 522</td>
<td>RF System Design</td>
<td>H</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>WCENG 523</td>
<td>Modeling and Simulation of Wireless</td>
<td>H</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Communication Systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>WCENG 524</td>
<td>Wireless IP Networks</td>
<td>H</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Elective III</td>
<td>S</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Elective IV</td>
<td>S</td>
<td>2-1-0</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credits for Semester II: **24**

(H – Hard Core Course; S – Soft Core Course)
### III Semester

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>H/S</th>
<th>L-T-P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.</td>
<td></td>
<td>Elective V</td>
<td>S</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>16.</td>
<td></td>
<td>Elective VI</td>
<td>S</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>17.</td>
<td></td>
<td>Elective VII</td>
<td>S</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>18.</td>
<td>WCENG 610</td>
<td>Internship/ Seminar/ Workshop / Conference / FDP / Short term course / NPTEL/GIAN/MOOC Course</td>
<td>H</td>
<td>0-0-2</td>
<td>2</td>
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<tr>
<td>19.</td>
<td>WCENG 611</td>
<td>NPTEL/GIAN/MOOC Course</td>
<td>H</td>
<td>0-2-0</td>
<td>2</td>
</tr>
<tr>
<td>20.</td>
<td>WCENG 612</td>
<td>Project – Literature Survey</td>
<td>H</td>
<td>0-0-1</td>
<td>1</td>
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</table>

**Total Credits for Semester III** 14

(H – Hard Core Course; S – Soft Core Course)

### IV Semester

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>H/S</th>
<th>L-T-P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.</td>
<td>WCENG 620</td>
<td>Project and Viva Voce</td>
<td>H</td>
<td>0-0-12</td>
<td>12</td>
</tr>
<tr>
<td>22.</td>
<td>WCENG 621</td>
<td>Publication</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total Credits for Semester IV** 12

(H – Hard Core Course; S – Soft Core Course)

Total number of credits required to complete M.Tech. in Wireless Communication : 74 credits
### Semester I – List of Electives

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Name of the Course</th>
<th>L-T-P</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>WCENG 530</td>
<td>Advanced Embedded System Design</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>WCENG 531</td>
<td>Advanced Image Processing</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>WCENG 532</td>
<td>Advanced Optical Communication</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>WCENG 533</td>
<td>Advanced Satellite Communication</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>WCENG 534</td>
<td>Communication Protocols</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>6.</td>
<td>WCENG 535</td>
<td>Electromagnetic Interference and Compatibility</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>7.</td>
<td>WCENG 536</td>
<td>Microwave Communication</td>
<td>2-1-0</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>WCENG 537</td>
<td>Mobile Communication System</td>
<td>2-1-0</td>
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<td>9.</td>
<td>WCENG 538</td>
<td>Optimization Techniques</td>
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<td>10.</td>
<td>WCENG 539</td>
<td>Smart Antenna</td>
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### Semester II - List of Electives

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<tbody>
<tr>
<td>1.</td>
<td>WCENG 550</td>
<td>Advanced Technologies in Wireless Networks</td>
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<td>2.</td>
<td>WCENG 551</td>
<td>Antennas for Personal Area Communication</td>
<td>2-1-0</td>
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<td>3.</td>
<td>WCENG 552</td>
<td>Cognitive Radio Technology</td>
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<td>4.</td>
<td>WCENG 553</td>
<td>Free Space Optical Communication</td>
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<td>WCENG 554</td>
<td>Green Radio Communication Techniques</td>
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<td>6.</td>
<td>WCENG 555</td>
<td>High Performance Communication Networks</td>
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<td>7.</td>
<td>WCENG 556</td>
<td>Information and Network Security</td>
<td>2-1-0</td>
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<td>WCENG 557</td>
<td>Internet of Everything Things</td>
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<td>WCENG 558</td>
<td>Multicarrier Wireless Communication</td>
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<td>10.</td>
<td>WCENG 559</td>
<td>Statistical Theory of Communication</td>
<td>2-1-0</td>
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# Semester III - List of Electives

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<tbody>
<tr>
<td>1.</td>
<td>WCENG 630</td>
<td>Advanced Technologies in Wireless Reception</td>
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<td>2.</td>
<td>WCENG 631</td>
<td>Convergence Technologies</td>
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<td>3.</td>
<td>WCENG 632</td>
<td>Heterogeneous Network</td>
<td>2-1-0</td>
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<td>4.</td>
<td>WCENG 633</td>
<td>High Speed Switching Architecture</td>
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<td>WCENG 634</td>
<td>Internetworking Multimedia Communication</td>
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<td>6.</td>
<td>WCENG 635</td>
<td>Micro and Nano Electronic Engineering</td>
<td>2-1-0</td>
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<td>7.</td>
<td>WCENG 636</td>
<td>MIMO Communication Systems</td>
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<td>WCENG 637</td>
<td>Multimedia Compression Techniques</td>
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<td>WCENG 638</td>
<td>Network Routing Algorithm</td>
<td>2-1-0</td>
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<td>WCENG 639</td>
<td>Pattern Recognition and Artificial Intelligence</td>
<td>2-1-0</td>
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<td>11.</td>
<td>WCENG 640</td>
<td>RF System Design for Wireless Communication</td>
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<td>WCENG 641</td>
<td>Soft Computing</td>
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<td>13.</td>
<td>WCENG 642</td>
<td>Audio Signal Processing</td>
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<td>WCENG 643</td>
<td>Ultra Wideband Communication Systems</td>
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<td>WCENG 644</td>
<td>Vehicular Ad-Hoc Networks (VANET)</td>
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<td>VLSI for Wireless Communication</td>
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<td>WDM Optical Networks</td>
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<td>18.</td>
<td>WCENG 647</td>
<td>5G Wireless Networks</td>
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### Syllabus for M.Tech. (Wireless Communication)

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<thead>
<tr>
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<th>Credits</th>
<th>Total Hours</th>
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<tbody>
<tr>
<td>WCENG 510</td>
<td>ADVANCED COMMUNICATION LABORATORY-I</td>
<td>L 0</td>
<td>T 0</td>
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</tr>
</tbody>
</table>

**Objective**: Hands on experience on hardware experiments in order to acquire sufficient knowledge and understand practical nuances / implications of various communication techniques.

**LIST OF EXPERIMENTS** (Given list is only the minimum, however, the course teacher can decide the level of experiments)

1. Microcontroller Based Experiments
   - a. Various Logic Operations
   - b. Level and Edge Triggering Interrupts
   - c. ADC/DAC
   - d. Real time digital clock and alarm realization

2. DSP Based Experiments
   - a. Wave form generation
   - b. Linear and Circular convolution
   - c. FIR filter implementation
   - d. IIR filter implementation

3. Communication Based Experiments
   - a. Design and analysis of GMSK modulator and demodulator
   - b. Multiplexing, BER measurement and data transmission through optical fiber
   - c. Characterization of Directional Coupler using micro strip trainer kit
   - d. Characterization of power divider using microstrip trainer kit
   - e. Measurement of radiation pattern of microstrip patch antenna
   - f. Study of DPCM and ADPCM using Advanced Digital Modulator trainer kit

4. VLSI Based Experiments
   - a. Synthesis of 8-bit adders
   - b. Synthesis of 4-bit multiplier
   - c. Synthesis of mod-13 counter
   - d. Synthesis of FSM

WCENG 510
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<tr>
<td>WCENG 511</td>
<td>ADVANCED CODING TECHNIQUES</td>
<td>L T P</td>
<td>4</td>
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**Prerequisite:** Knowledge in probability, calculus, Information theory and Coding.

**Objective:** To understand the concepts of various coding techniques with their applications.

**Outcome:** Students will be able to incorporate the various coding techniques in the field of wireless communications.

**Unit I: Convolutional code**  
12 Hours

**Unit II: Decoders**  
12 Hours

**Unit III: TCM and Turbo Codes**  
12 Hours
M-ary signaling – One and Two-dimensional TCM – Multiple TCM – Decoding and performance analysis – Implementation considerations.  

**Unit IV: ARQ Protocols**  
12 Hours

**Unit V: Instructional Activities**  
12 Hours
Simulation of minimum of five coding techniques using related tools.
Reference Books:

Hyperlinks:
1. nptel.ac.in/courses/117102062/
3. https://digitalcommons.lsu.edu/cgi/viewcontent.cgi?article=2897&context=gradschool_dissertations

WCENG 511
Prerequisite: Probability Theory

Objective: To make the students understand various mathematical concepts implied to Wireless Communication Engineering.

Outcome: The students will be able to apply these mathematical concepts to various applications of Wireless Communication Engineering.

Unit I: Random Variables 12 Hours
Random variables: Probability axioms - Conditional probability - Discrete and continuous random variables, Cumulative Distribution Function (CDF) - Probability Mass Function (PMF) - Probability Density Function (PDF) - Conditional PMF/PDF - Expected value - Variance; Functions of a random variable; Expected value of the derived random variable.

Unit II: Multiple Random Variables 12 Hours
Multiple random variables: Joint CDF/PMF/PDF - functions of multiple random variables - multiple functions of multiple random variables - independent/uncorrelated random variables - sums of random variables - moment generating function - random sums of random variables.

Unit III: Stochastic Processes 12 Hours

Unit IV: Finite Difference Time Domain Method 12 Hours

Unit V: Instructional Activities 12 Hours
Response of LTI system’s - probability distribution and density functions- Weiner and Shot noise process- Practical applications of wave scattering in FDTD using related platforms.
Reference Books:

Hyperlinks:
1. http://users.ece.utexas.edu/~gustavo/ee381j.html
2. http://www2.math.uu.se/research/telecom/software.html
3. http://www.ifp.illinois.edu/~hajek/Papers/randomprocesses.html

WCENG 512
Course Code | Name of the Course | Periods | Credits | Total Hours
---|---|---|---|---
WCENG 513 | ADVANCED RADIATION SYSTEM | L T P | 4 | 60

Prerequisite: Electromagnetic and antenna theory.

Objective: To learn the antenna radiation concepts, different types of antenna and their design methodology.

Outcome: Students will be able to design different types of antenna for various applications.

**Unit I: Concepts of Radiation and Antenna Fundamentals**  
12 Hours

Physical Concept of Radiation: Radiation from surface and line current distributions - fundamental parameters of antennas - Friss Transmission Equation - radiation integrals and auxiliary potential functions - Near and Far Field regions - Reciprocity and Reaction Theorems - radiation hazards and solutions

**Unit II: Aperture and Reflector Antennas**  
12 Hours

Huygens’s principle - radiation from rectangular and circular apertures - design considerations - Babinets principle - radiation from sectoral - pyramidal - conical and corrugated Horns - design concepts of parabolic reflectors and cassegrain antennas.

**Unit III: Broadband Antennas**  
12 Hours


**Unit IV: Microstrip Antennas**  
12 Hours

Microstrip Antennas: Radiation mechanism - parameters and applications - feeding methods - design of rectangular and circular patch - impedance matching of microstrip antennas - broadband - compact and tunable microstrip antennas.

**Unit V: Instructional Activities**  
12 Hours

Design, simulation and analysis of different antennas for wireless applications using related simulation tools.
Reference Books:

Hyperlinks:
1. http://www.nptel.ac.in/courses/117107035/
2. http://www.nptel.ac.in/courses/108101092/
3. http://www.nptel.ac.in/courses/108104099/
4. http://www.nptel.ac.in/courses/108104087/

WCENG 513
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<th>Course Code</th>
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<th>Periods</th>
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<tr>
<td>WCENG 514</td>
<td>ADVANCED WIRELESS COMMUNICATION</td>
<td>L  T   P</td>
<td>4</td>
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</table>

**Prerequisite:** Basics of analog, digital and wireless communication.

**Objective:** To impart the new concepts in Advanced Wireless Communications.

**Outcome:** Students will able to understand the latest technologies used in advanced wireless communication systems.

**Unit I: Introduction**

Introduction about wireless communication - technical challenges of wireless communication-applications; Cellular architecture - frequency reuse - channel assignment - handoff - coverage and capacity improvement; Multiple access - FDMA/CDMA/TDMA/SDMA

**Unit II: Propagation principles**

Propagation Principles: Propagation mechanisms - channel modeling methods - radio channels-indoor channels - outdoor channels - fading channels ; Mobile Radio Propagation : Large scale path loss – path loss and propagation models - small scale fading - types of small scale fading-parameters of mobile multipath channels - statistical models for multipath fading channels

**Unit III: Modulation and Detection**

Digital modulation: Structure of a wireless communication link - linear and constant envelope modulation techniques for wireless communication - error performance in fading channel; Transmission System; combined fast and slow fading - Equalization - different detection techniques used in wireless communication.

**Unit IV: MIMO Systems**

Types of MIMO Systems: Beam forming - spatial multiplexing - basic space time code design principles- Alamouti scheme - orthogonal and quasi orthogonal space time block codes- space time trellis codes - representation of space - performance analysis for space-time trellis codes - comparison of space-time block and trellis codes.

**Unit V: Instructional Activities**

Simulation of minimum of (2) modulation and multiple access technique for wireless communication using related simulation tools.
Reference Books:

Hyperlinks:
3. https://videoken.com/search-results

WCENG 514
<table>
<thead>
<tr>
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<th>Name of the Course</th>
<th>Periods</th>
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<tr>
<td>WCENG 520</td>
<td>ADVANCED COMMUNICATION LABORATORY-II</td>
<td>L 0</td>
<td>T 0</td>
<td>P 4</td>
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</table>

**Objective**: Hands on experience on various simulation tools to design and analyse the various communication techniques.

**LIST OF EXPERIMENTS**: (Given the list is minimal, however, the course teacher can decide the level of experiments)

1. **Simulation using MATLAB**
   a. Direct sequence spread spectrum system
   b. Channel coding
   c. Line coding
   d. Filters
   e. Modulation schemes
   f. Security algorithm and authentication protocols

2. **Simulation using VHDL/ Verilog**
   a. Flip Flops
   b. Synchronous/ Asynchronous Counters
   c. Registers
   d. ROM/RAM
   e. PRBS generator

3. **Simulation using PSPICE**
   a. Analog circuits
   b. Digital circuits
   c. Communication circuits

4. **Simulation using NetSim**
   b. Design and analyse the Spanning tree algorithm.
   c. Performance analysis of WiMAX/ WiFi network.
   d. Performance analysis of convergence networks (WiMAX and LTE networks)

**WCENG 520**
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<tr>
<td>WCENG 521</td>
<td>ADVANCED DIGITAL SIGNAL PROCESSING</td>
<td>L</td>
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**Prerequisite:** Knowledge in Signal and Systems, and Digital Signal Processing.

**Objective:** To make the students to understand the concepts in signal processing mechanisms and power spectrum estimation methods

**Outcome:** Students will be able to analyze and implement advanced signal processing techniques for various applications

**Unit I: Fundamentals of Signal Processing** 12 Hours

Introduction: Basic elements of Digital Signal Processing System - advantages of digital over analog signal processing; Classification of signals: Deterministic vs Random signals - Multi channel and Multi-dimensional signals; Down Sampling - decimation - up sampling - interpolation.

**Unit II: Power spectrum estimation** 12 Hours


**Unit III: Adaptive Signal processing** 12 Hours

FIR adaptive filters - steepest descent adaptive filter - LMS algorithm - convergence of LMS algorithms; Applications: Noise cancellation - channel equalization; Adaptive recursive filters - recursive least square estimation.

**Unit IV: Wavelet Transform** 12 Hours

Introduction: Continuous Wavelet Transform - basic properties of wavelet transforms - Discrete Wavelet Transform: Haar scaling functions and function spaces - nested spaces - Haar wavelet function - orthogonality of φ(t) and ψ(t) - normalization of Haar bases at different scales; Daubechies wavelets - support of wavelet system.

**Unit V: Instructional Activities** 12 Hours

EEG/ECG signal analysis for the real time environment; Echo cancellation using adaptive filters; Voice recognition and speech-to-text conversion using related tools.
Reference books:

Hyperlinks:
2. http://ar.book.org/s/?q=DSP+PROAKIS&yearFrom=&yearTo=&language=&extension=&t=0

WCENG 521
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<td>WCENG 522</td>
<td>RF SYSTEM DESIGN</td>
<td>L 3</td>
<td>T 1</td>
<td>P 0</td>
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</table>

Prerequisite: Microwave engineering.

Objective: To impart RF system design for different applications.

Outcome: Students will be able to design different types of RF active components, devices and circuits.

Unit I: RF Passive Components and Transmission Line Analysis 12 Hours
High Frequency Components: Resistors- capacitors and inductors; Transmission line analysis - line equation - microstrip line - SWR - voltage reflection co-effcient - propagation constant - phase constant - phase velocity - Smith chart - parallel RL and RC circuits - ABCD parameters and S parameters.

Unit II: RF Device and Circuit 12 Hours
RF amplifier design- power gain equations - maximum gain design, low noise amplifier design, high power amplifier design- stability considerations; RF oscillator design -one – port and two – port negative resistance oscillators - oscillator design using large – signal measurements; RF Mixer Design: Single ended mixer – double ended mixer.

Unit III: RF feedback systems and Power amplifiers 12 Hours
Stability of feedback systems: Gain and phase margin- root– locus techniques -time and frequency domain considerations - compensation ; General model – Class A, AB, B, C, D, E and F amplifiers - power amplifier linearization techniques - efficiency boosting techniques - ACPR metric- design considerations.

Unit IV: PLL and frequency synthesizers 12 Hours
Linearised Model - noise properties - phase detectors - loop filters and charge pumps- integer-N frequency synthesizers - direct digital frequency synthesizers

Unit V: Instructional Activities 12 Hours
Simulation of the frequency response of amplifier, oscillator and mixer for different applications using related tools.
References Books:

Hyperlinks:
1. http://nptel.iitm.ac.in/syllabus/117105029

WCENG 522
Course Code | Name of the Course | Periods | Credits | Total Hours |
---|---|---|---|---|
WCENG 523 | MODELING AND SIMULATION OF WIRELESS COMMUNICATION SYSTEMS | L T P | 4 | 60 |

**Prerequisite**: Knowledge of MATLAB programming, Digital Signal Processing and Digital Communication

**Objective**: To understand the modeling of wireless communication systems through simulation.

**Outcome**: Students will able to design and analyse the various concept of wireless communication systems.

**Unit I: Introduction**


**Unit II: Generating and Processing Random Signals**

Staciónary and Ergodic Processes: Uniform random number generators - mapping uniform random variables to an arbitrary PDF - generating uncorrelated and correlated Gaussian random numbers - PN sequence generators; Establishing a PDF and PSD Post Processing: Basic graphical techniques - estimation - coding.

**Unit III: Methodology for Simulating a Wireless System**

Fundamental Concepts of Monte Carlo Simulation - applications and integration - two Monte Carlo examples; Semi Analytic Techniques System: Level simplifications and sampling rate considerations - overall methodology; Modeling and Simulation of Nonlinearities: Modeling and simulation of memory less nonlinearities - modeling and simulation of nonlinearities with memory - techniques for solving nonlinear differential equations.

**Unit IV: Modeling and Simulation of Time-Varying Systems**


**Unit V: Instructional Activities**

Simulation of Generating PDF for the Gaussian and non-Gaussian distributions and Simulation of linear and non-linear systems using different techniques with the help of simulation tools.
Reference Books:

Hyperlinks:

WCENG 523
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<tr>
<td>WCENG 524</td>
<td>WIRELESS IP NETWORKS</td>
<td>L 3</td>
<td>T 1</td>
<td>P 0</td>
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</table>

**Prerequisite:** Wireless Networks.

**Objective:** To learn the next generation wireless network concepts, different types networks and their application.

**Outcome:** Students will be able to understand the different type of wireless networks and various applications.

**Unit I: Wireless IP Network Architectures**

12 Hours

Evolution of Wireless Networks - Introduction to 1G/2G/3G/4G Terminology - Current Wave of Mobile Data Services: High Speed and Multimedia Mobile Internet Services. IP-Based Wireless Networks - 3GPP, 3GPP2.


**Unit II: IP Multimedia Subsystems and Application**

12 Hours

Signaling in IP Networks - Session Initiation Protocol (SIP) - Session Description Protocol (SDP)

3GPP IP Multimedia Subsystem (IMS) - IMS Architecture 3.2.2 Mobile Station Addressing for Accessing the IMS - Reference Interfaces - Service Architecture - Registration with the IMS - Deregistration with the IMS - End-to-End Signaling Flows for Session Control - 3GPP2 IP Multimedia Subsystem (IMS)

**Unit III: Mobility Management**

12 Hours

Basic Issues in Mobility Management - Mobility Management in IP Networks - Mobility Management in 3GPP Packet Networks - Mobility Management in 3GPP2 Packet Data Networks - Mobility Management in MWIF Networks - Comparison of Mobility Management in IP, 3GPP, and 3GPP2 Networks.

**Unit IV: Quality of Service**

12 Hours


**Unit V: Instructional Activities**

12 Hours

Design, simulation and analysis of different wireless networks and their QoS service applications using related simulation tools.
Reference Books:

Hyperlink:
1. http://www.ebookee.com/Next1Generation1Mobile1Systems13G1amp1Beyond1repost1_330093.html
2. http://www.ebookee.com/Advanced1Wireless1Communications14G1Technologies1Rrepost1_343539.html
3. http://nptel.ac.in/courses/117102062/

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<td>WCENG 530</td>
<td>ADVANCED EMBEDDED SYSTEM DESIGN</td>
<td>L T P</td>
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**Prerequisite:** Fundamentals of Embedded system

**Objective:** To teach the fundamentals on design attributes of Hardware software partitioning in system design strategies for processor Communications and discuss on Co-Designs

**Outcome:** Understand the timing and interrupt in processor and apply co design methodology Solve the Co-Synthesis problem understand the memories and communication protocol in embedded field.

**Unit I: Introduction to Embedded Hardware and Software**

9 Hours

**Unit II: System Modeling and Co-Synthesis**

9 Hours

**Unit III: Memory and Interfacing**

9 Hours

**Unit IV: Concurrent Process Models and Co-Design**

9 Hours

**Unit V: Instructional Activities**

9 Hours
Simulation study of any (five) Embedded system design and their application using related tools.
References Books:

Hyperlinks:
1. www.vectorindia.org/embedded_coursecontent.html
2. www.cetpainfotech.com
3. http://nptel.ac.in/courses/117106030/35

WCENG 530
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<td>WCENG 531</td>
<td>ADVANCED IMAGE PROCESSING</td>
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**Prerequisite:** Fundamentals of Signals and Systems

**Objective:** Make the students to understand the concepts used in image processing techniques and its analysis.

**Outcome:** Students will be able to work with various image processing techniques for real time applications

**Unit I: Digital Image Fundamentals**

9 Hours

Image fundamentals: Image acquisition - sampling and quantization - image resolution; basic relationship between pixels - color images - RGB, HSI and other models; Transform based models (DFT, DCT, DWT); Image Enhancement: Spatial and frequency averaging - smoothening and sharpening filters.

**Unit II: Segmentation and Denoising**

9 Hours

Image Segmentation: Edge detection - edge linking via Hough transform - thresholding - region based segmentation; Denoising: Maximum likelihood estimation - Bayesian estimators - model selection (MDL principle) - transform based denoising - adaptive wiener filtering - soft shrinkage and hard thresholding.

**Unit III: Image Compression**

9 Hours

Image compression: Basics of source coding theory (lossless and lossy) - Vector quantization - codebook design - transform and sub band coding.

**Unit IV: Image Security and Forensic**

9 Hours

Image Security: cryptography and steganography techniques- Chaos based and Non-Chaos based methods; Image Forensics: Key photographic techniques-detection techniques for crime scene analysis.

**Unit V: Instructional Activities**

9 Hours

Simulation of preprocessing techniques-implementation of image processing techniques for real time applications-forensic analysis using related tools.
Reference Books:

Hyperlinks:
1. www.imageprocessingplace.com/DIP-3E/dip3e_main_page.html

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<tr>
<td>WCENG 532</td>
<td>ADVANCED OPTICAL COMMUNICATION</td>
<td>L 2</td>
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</table>

**Prerequisite:** Sound knowledge on basic optics, optical communication, various modulation and detection schemes in optical communication

**Objective:** To impart the concepts of multilevel modulation schemes, OFDM and MIMO for optical communication systems and nonlinear optics.

**Outcome:** Students will able to understand the potential of physical layer of optical system and its applications.

**Unit I: Introduction**  
9 Hours
Prologue: Historical perspective - light sources - modulators, fiber losses - signal dispersion - signal propagation - multi channel propagation - optical solutions- photonic crystal and Photonic Band Gap (PBG); Introduction to second order nonlinear optics: Second Harmonic Generation (SHG) - Sum Frequency Generation (SFG) - Difference Frequency Generation (DFG); Third order nonlinear optics: Third Harmonic Generation (THG) - Four Wave Mixing (FWM) - Self Focusing (SF).

**Unit II: Modulation schemes**  
9 Hours
Noise sources - channel impairments - optical transmission system - advanced modulation formats - multilevel modulation schemes - OFDM for optical communications - MIMO optical communication - polarization multiplexing - constrained (line or modulation) coding - soliton based communication.

**Unit III: Detection schemes**  
9 Hours
Coherent detection of optical signals - optical coherent detection schemes - optical heterodyne detection - optical homodyne detection - optical intradyne detection - DPSK photonic systems - optical channel equalization - coherent optical OFDM detection - optical MIMO detection.

**Unit IV: Optical Channel Estimation**  
9 Hours
Optical channel capacity - calculation of information capacity - information capacity of systems with direct detection - capacity of optical OFDM systems - capacity of optical MIMO systems.

**Unit V: Instructional Activities**  
9 Hours
Simulation of two dimensional photonic crystal, ring resonator and Y-shaped waveguide using 32-bit OPTIFDTD (freeware); Also analyze second order nonlinearity and four-wave mixing through simulation using the same FDTD tools.
Reference Books:

Hyperlinks:
1. http://nptel.iitm.ac.in/courses/117101002.html

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**Prerequisite:** Basics of digital and satellite communication

**Objective:** To impart the orbital mechanics, space craft sub-systems and satellite link design

**Outcome:** Students will be able to analyze the advanced technical details behind the satellite link.

**Unit I: Introduction and Satellite Access:**  
9 Hours  
Orbits of Satellite: Low - medium – geo synchronous - angle period - returning period – orbital spacing - delay transponder - earth stations - antennas and earth coverage - altitude and eclipses; Multiple Access: Demand assigned FDMA - spade system - TDMA - satellite switched TDMA - CDMA.

**Unit II: Space Segment and Earth Segment**  
9 Hours  
Space Segment: Power supply - altitude control - station keeping - thermal control - TT and C subsystem - transponders; Earth Segment: Receive only home TV system - outdoor unit - indoor unit - master antenna TV system - community antenna TV system.

**Unit III: Satellite Link Design**  
9 Hours  
Link Design: System noise temperature and G/T ratio - C/N design of uplink and downlink - error control for digital satellite link.

**Unit IV: VSAT Systems**  
9 Hours  
VSAT Systems: Network architectures – access control protocols - earth station engineering - antennas - link margins - system design procedure.

**Unit V: Instructional Activities**  
9 Hours  
Simulation of link budget for two satellite systems - simulation of Transponders and Antenna system using related tools.
Reference Books:

Hyperlinks:

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<tr>
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Prerequisite: Fundamentals of communication

Objective: This subject aims to teach various communications Protocol for wireless communication.

Outcome: Understand the fundamental of communication protocols in wireless communication for real time application.

Unit I: Network Reference Model and Specifications 9 Hours

Unit II: Verification and Validation 9 Hours
Protocol verification - Verification of a protocol using finite state machines - Protocol validation - protocol design errors - Protocol validation approaches - SDL based protocol verification and validation.

Unit III: Conformance and Performance Testing 9 Hours
Conformance testing – methodology - frame work – architectures - Test sequence generation - Distributed architecture - Conformance testing with TTCN - RIP, SDL based tools for conformance testing, SDL based: conformance testing of MPLS - performance testing of TCP and OSPF-Interoperability testing - SDL based interoperability testing of CSMA/CD and CSMA/CA protocol.

Unit IV: Protocol Synthesis and Implementation 9 Hours

Unit V: Instructional Activities 9 Hours
Simulation study of any (five) communication protocols and their application using related tools.
Reference Books:

Hyperlinks:

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**Prerequisite:** Electromagnetic theory.

**Objective:** To expose the students on the fundamentals of electromagnetic interference and compatibility in the electronic system design.

**Outcome:** Students will able to know the EMI environment, coupling principles, specifications, standards and limits, measurements and control techniques, and EMC design of PCBs.

**Unit I: EMI Environment**

EMI/ EMC Concepts and Definitions: Sources of EMI - conducted and radiated EMI - transient EMI - time domain vs frequency domain EMI - units of measurement parameters.

**Unit II: EMI Coupling Principles and Standards**


**Unit III: EMI Measurements**

EMI Test Instruments/ Systems: EMI shielded chamber - open area test site - TEM cell - sensors/ Injectors/ Couplers - test beds for ESD and EFT.

**Unit IV: EMI Control Techniques**


**Unit V: Instructional Activities**

Simulation of minimum of two EMI coupling methods and controlling techniques with their performance analysis using related tools.
**Reference Books:**


**Hyperlinks:**


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Prerequisite: Fundamentals of Electronics and communication

Objective: To enable the student to understand the basic principles of microwave amplifiers and oscillators, passive component characteristics, resonators and filters, antennas and microwave radio link characterization.

Outcome: The student would be able to design a microwave system taking into account the path losses and fading channel characteristics, carry out measurements and interpret results obtained.

**Unit I: Microwave Active Devices**  
9 Hours

**Unit II: S Parameters**  
9 Hours
S Parameters: Scattering parameters, properties of S matrix, Conversion of ABCD and S matrix, S matrix representation of Waveguide corners, bends, twists, Directional couplers, Circulators, Isolators, Attenuators, Wave guide Tee, Hybrid Tee, Hybrid rings (rat-race) and Terminator

**Unit III: Microwave Measurements**  
9 Hours
Microwave Measurements: VSWR, power, impedance, insertion loss, scattering parameters and dielectric constant measurement. And Antenna Measurements: Radiation pattern, gain, directivity, phase and polarization measurement

**Unit IV: Satellite Microwave Systems**  
9 Hours
Satellite Microwave Systems: Satellite orbits and dynamics, Frequency allocation and satellite footprints, Earth stations and satellite transponders, Noise considerations. Link budget calculations. Multiple access methods, Mobile satellite systems, their uses and illustrative systems.

**Unit V: Instructional Activities**  
9 Hours
Simulation study of any (five) microwave communication circuits or standards using related tools.
Reference Books:
6. Combes, Graffewil and Sauterean “Microwave Components, Devices and Active Circuits”. John wiley.198

Hyperlinks:

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<td>MOBILE COMMUNICATION SYSTEM</td>
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Prerequisite: Fundamentals of analog and digital communication systems.

Objective: To learn the architecture and working principles of mobile communication systems

Outcome: The students will be able to understand the design principles and techniques of Mobile Communication Systems.

Unit I: Introduction to cellular concepts  
9 Hours
Evolution of mobile radio communications - trends in cellular radio and personal communication; Basics of cellular concepts – Types and components of mobile communication - Operation of cellular system Systems- handoff – radio channel characterization - Multiple Access schemes.

Unit II: Mobile standards  
9 Hours

Unit III: Mobile IP network and transport layer  
9 Hours

Unit IV: Diversity Schemes  
9 Hours

Unit V: Instructional Activities  
9 Hours
Simulation study of any (five) mobile communication standards using related tools.
References Books:

Hyperlinks:
2. https://www.digitaltrends.com/mobile/4g-vs-lte

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<td>WCENG 538</td>
<td>OPTIMIZATION TECHNIQUES</td>
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</table>

**Prerequisite**: Fundamentals of optimization and communication

**Objective**: This subject aims to teach various optimization techniques for wireless communication.

**Outcome**: Understand the fundamental of optimization techniques in wireless communication for real time application.

**Unit I: Introduction / Linear Programming**  
9 Hours
Linear Programming: Graphical method, simplex method, Non-Simplex Method, revised simplex method, Big-M method, 2-phase method, alternate optimal solutions, unbounded LPs, degeneracy and convergence, duality in linear programming, sensitivity analysis, dual simplex method, Transportation, assignment and other applications.

**Unit II: Non-Linear Programming**  
9 Hours

**Unit III: Dynamic Programming**  
9 Hours
Dynamic Programming Multistage decision process, Concept of sub optimization and principle of optimality, computational procedure in dynamic programming

**Unit IV: Optimization Methods**  
9 Hours
Optimization Methods 09 Simulated annealing, Particle Swarm optimization, Ant colony optimization, Bee colony optimization, Cuckoo Search, Bat Algorithms, Firefly Algorithms

**Unit V: Instructional Activities**  
9 Hours
Simulation study of any (five) optimization techniques in wireless communication using related tools.
References Books:

Hyperlinks:
1. http://apmonitor.com/me575/
2. https://www.mat.univie.ac.at/~neum/glopt/techniques.html

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Prerequisite: Fundamentals of Antenna

Objective: This subject aims to teach Propagation and modeling, spatial processing, techniques for CDMA system and RF positioning for the smart antennas.

Outcome: Understand the fundamental parameters of antenna and use of cellular concepts and able to integrate smart antenna technology with overall communication system design, principle and its performance.

Unit I: Introduction / DOA Estimation 9 Hours
Need for Smart Antennas, Smart Antenna Configurations, Switched-Beam Antennas, Adaptive Antenna Approach, Space Division Multiple Accesses (SDMA), Architecture of a Smart Antenna System, Receiver, Transmitter, Benefits and Drawbacks, Mutual Coupling Effects.

Unit III: Beam forming fundamentals 9 Hours

Unit IV: Space–Time Processing 9 Hours
Introduction, Discrete Space–Time Channel and Signal Models, Space–Time Beam forming, Intersymbol and Co-Channel Suppression, ISI Suppression, CCI Suppression, Joint ISI and CCI Suppression, Space–Time Processing for DS-CDMA, Capacity and Data Rates in MIMO Systems, Single-User Data Rate Limits, Multiple-Users Data Rate Limits, Data Rate Limits Within a Cellular System, MIMO in Wireless Local Area Networks

Unit V: Mobile Stations Smart Antennas 9 Hours

Unit V: Instructional Activities 9 Hours
Simulation study of any (five) smart antennas design and their application using related tools.
Reference Books:
2. Ahmed El Zooghby, Smart Antenna Engineering, Artech House
3. M.J. Bronzel, Smart Antennas, John Wiley, 2004

Hyperlinks:
1. http://nptel.ac.in/syllabus/117105083/
2. http://nptel.iitm.ac.in/syllabus/117105029/
4. journal.utm.edu.my/index.php/jtec/article/view/836
5. downloads.hindawi.com/journals/ijap/2013/746920.pdf

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<td>ADVANCED TECHNOLOGIES IN WIRELESS NETWORKS</td>
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**Prerequisite:** Basics knowledge of computer and wireless networks

**Objective:** To learn about the advanced topics in wireless networks with their architectures

**Outcome:** Students will able to understand the various technologies in wireless networks.

**Unit I: Wireless Area Networks**

WPAN: System model - protocol stack of IEEE 802.15; Bluetooth: Network architecture - operation - specification and application models; Radio Frequency Identification (RFID): Types and specifications; ZIGBEE and WBAN: Standard and architecture; WLAN: Network architecture - protocol stack of IEEE 802.11 - physical layer and MAC layer mechanism; WiMAX: BWA - issues and challenges of WiMAX - network architecture - protocol stack of IEEE 802.16 - differences between IEEE 802.11 and IEEE 802.16

**Unit II: Wireless Internet**


**Unit III: Wireless Sensor Network**


**Unit IV: Wideband Wireless Technologies**


**Unit V: Instructional Activities**

Simulation of minimum of five wireless networks standards using related tools.
Reference Books:


Hyperlink:

2. www.tutorialspoint.com/wimax/

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<td>ANTENNAS FOR PERSONAL AREA</td>
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**Prerequisite:** Fundamentals of Antenna and communication

**Objective:** To understand about Wearable Antennas, Printed Antennas, Integrated Antennas and to apply the Reconfigurability function in Antenna Design and to study about different array technique

**Outcome:** Antenna Theory is central for all Radio Systems, and this course will enable the learners to understand different Radio Antennas and their usage.

**UNIT I: Printed Antennas**

9 Hours


**UNIT II: Wearable Antennas**

9 Hours


**UNIT III: Active Integrated Antennas**

9 Hours


**UNIT IV: Reconfigurable and Array Antennas**

9 Hours

Reconfigurable methodologies, Design Considerations for Reconfigurable systems, Reconfigurable Planar/printed antenna configurations, Active reconfigurable systems. Linear and planar array fundamentals, Mutual Coupling in Arrays, Multidimensional Arrays, Switched beam and Phased Arrays, Array Feeding Techniques, Array optimization techniques

**Unit V: Instructional Activities**

9 Hours

Simulation of minimum of five personal area communication with suitable antenna using related tools
Reference Books:

Hyperlinks:

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**Prerequisite:** Fundamentals in Wireless Networks

**Objective:** To understand the requirements in designing software defined radios and cognitive radio and its functionalities

**Outcome:** Students will be able to design the wireless network based on cognitive radio technology

**Unit I: Introduction**

9 Hours

Fundamentals of Communication Networks: New challenges - multiple access schemes - cross layer design and optimization; Multicarrier modulation and equalization - ISI; RF spectrum and regulation: Regulatory issues of cognitive access.

**Unit II: SDR Architecture**

9 Hours


**Unit III: CR Architecture**

9 Hours

Cognitive radio network architectures: Architectures for spectrum sharing - network optimization - topology aware CRN architectures - Haykin dynamic spectrum architecture.

**Unit IV: CRN Security**

9 Hours

Primary user emulation attacks - security vulnerabilities in IEEE 802.22 - security threats to the radio software.

**Unit V: Instructional Activities**

9 Hours

Simulation of CR & SDC network using related tools.
Reference Books:

Hyperlinks:

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**Prerequisite:** Basics knowledge of optics and communication

**Objective:** To learn about the advanced topics in optical communication

**Outcome:** Students will able to understand the various technologies in optical communication.

**Unit I: Fundamentals of FSO Technology and Networks**
9 Hours

**Unit II: Long Distance FSO Communication**
9 Hours
The FSO model – Applications – System descriptions and design – Introduction to Laser Satellite Communications – Characteristics, Modulation Techniques and Radiation effects – Laser Sources.

**Unit III: Optical Components**
9 Hours
Optical Components for FSO Optical waveguides – Optical Filters, Couplers, Amplifiers, Switches, Antennas, Interconnecting Equipments, and etc – Optical integrated circuits – semiconductor integrated optic devices.

**Unit IV: Optical Signal Processing**
9 Hours
Analog and Discrete systems – Noise and Stochastic processes – Filters – Power spectra estimation – Ambiguity function, Wigner distribution function and triple correlations.

**Unit V: Instructional Activities**
9 Hours
Simulation of minimum of five free space optical communication standards using related tools.
Reference Books:

Hyperlinks:

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Prerequisite: Fundamentals of computer communication and wireless networks.

Objective: To impart the importance of energy conservation, CO₂ emission and inculcate green concepts for designing energy efficient next generation wireless networks.

Outcome: Students will be able to design green radio communication networks with energy efficient techniques.

Unit I: Introduction 9 Hours

Unit II: Green Modulation and Co-operative Techniques 9 Hours

Unit III: Base Station Power Management Techniques 9 Hours
Base station power management techniques: Opportunistic spectrum and load management - energy saving techniques in cellular wireless base stations - power management for base stations in a smart grid environment.

Unit IV: Wireless Access Techniques 9 Hours

Unit V: Instructional Activities 9 Hours
Survey about minimum of four green communication networks and carry out simulation of those networks.
References Books:


Hyperlinks:


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**Prerequisite**: Fundamentals of computer networks and wireless networks.

**Objective**: To learn the architecture and uniqueness of high performance networks.

**Outcome**: Students will be able to understand the various topologies, services offered by broadband, WiFi, WiMAX, UWB and LTE networks.

**Unit I: Introduction**


**Unit II: MANET**

Multihop wireless broadband networks - mesh networks; MANET architecture - classification of routing protocols in MANET - routing metrics; packet scheduling algorithms - power control mechanism.

**Unit III: Internet and TCP / IP Networks**

Internet Protocol (IP): Technology trends in IP networks - IP packet communications in mobile communication networks; TCP and UDP - performance of TCP/ IP networks; Circuit Switched Networks: SONET- DWDM - fiber to the home - DSL; Intelligent Network (IN) scheme - comparison with conventional systems - merits of the IN scheme; CATV and layered network - services over CATV.

**Unit IV: Enabling Networks**

WiFi: overview - architecture - PHY and MAC layer; WiMAX overview - system architecture - frame structure - PMP mode - mesh mode - multihop relay mode; UWB overview - time hopping UWB - direct sequence UWB - multiband UWB; LTE and LTE- A overview - system model - frame structure - comparison with broadband technologies.

**Unit V: Instructional Activities**

Simulation of WiFi network - Simulation of WiMAX network in mesh mode and multihop relay mode - Simulation of integration of LTE - A and WiMAX network with single IP network.


**Reference Books:**


**Hyperlinks:**

1. [http:// www.ece.gmu.edu/.../high performance communication networks_1.pdf](http:// www.ece.gmu.edu/.../high performance communication networks_1.pdf)

WCENG 555
Course Code | Name of the Course | Periods | Credits | Total Hours
---|---|---|---|---
WCENG 556 | INFORMATION AND NETWORK SECURITY | L T P | 3 | 45

**Prerequisite**: Analog and Digital Communication

**Objective**: To study the various security attacks- data security and network security algorithms and wireless security mechanism.

**Outcome**: Students will understand the various symmetric and asymmetric cryptographic techniques- authentication mechanism and network security.

**Unit I: Introduction to Cryptography**  
9 Hours
Security issues: Security problems in computing - attacks - security services - security mechanism - OSI security architecture - standard setting organizations; Need for Cryptographic techniques- Substitution - Transposition - Block ciphers

**Unit II: Data Security and Authentication**  
9 Hours
Triple DES with two keys - stream cipher- RC4 - RSA algorithm - elliptical curve cryptography algorithm; MD5 - HASH algorithm-SHA 512 logic–digital signatures standards.

**Unit III: Network Security**  
9 Hours

**Unit IV: System Security**  
9 Hours
Intruders and intrusion detection: Malicious software - viruses and related threats - virus counter measures - distributed denial of service attack - firewalls design principles- trusted systems.

**Unit V: Instructional Activities**  
9 Hours
Simulation of minimum of three public key and private key cryptography algorithms using related simulation tools.
Reference Books:


Hyperlinks:

1. https://www.cl.cam.ac.uk/teaching/1314/InfoTheory

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<td>INTERNET OF EVERYTHING THINGS</td>
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Prerequisite: Basics of computer communication networks and wireless sensor networks

Objective: To study the architecture and security principles of IOE

Outcome: Students will be able to design efficient IOE based projects.

Unit I: Introduction

IoT: Architectural overview - main design principles - standards considerations; M2M and IoT technology fundamentals: devices and gateways - data management - business processes in IoT - everything as a service (XaaS) - M2M and IoT analytics - knowledge management.

Unit II: IoE Sensors

Sensors for IoE: Wireless sensor structure - energy storage module - power management module - RF Module - sensing module.

Unit III: IoE Security

Security requirements in IoE architecture - security in enabling technologies - security concerns in IoE applications: Architecture - insufficient authentication/authorization - insecure access control - threats to access control, privacy, and availability - attacks Specific to IoE.

Unit IV: IoE Testbed

ACOEM Eagle - EnOcean Push Button - NEST Sensor - Ninja Blocks Focus on wearable electronics.

Unit V: Instructional Activities

Simulation of (minimum of any five) IoE applications - home and office infrastructures - security - Home appliances and other IoT electronic equipment - interfacing of sensor with sensor Node using any Embedded target boards (Raspberry Pi / Intel Galileo/ARM Cortex/ Arduino).
Reference Books:

Hyperlink:
2. https://www.codeproject.com/Learn/IoT/
3. https://www.edureka.co/blog/iot-tutorial/

WCENG 557
<table>
<thead>
<tr>
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<tr>
<td>WCENG 558</td>
<td>MULTICARRIER WIRELESS COMMUNICATION</td>
<td>L T P</td>
<td>3</td>
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</table>

**Prerequisite:** Fundamentals of communication systems.

**Objective:** To impart OFDM transmitter and receiver system

**Outcome:** Students will be able to understand the importance of OFDM techniques for wireless systems

**Unit I: OFDM Principles** 9 Hours
System Model: Block diagram of OFDM system - generation of sub carrier using IFFT - guard time - cyclic extensions - windowing - choice of OFDM parameters - signal processing - bandwidth efficiency - peak to average power ratio - peak power problem - PAPR properties of OFDM signals; PAPR reduction techniques: Signal distortion techniques - multiple signaling and probabilistic techniques - coding techniques.

**Unit II: OFDM Time and Frequency Domain Synchronization** 9 Hours
System performance with frequency and timing errors; Synchronization algorithms - comparison of frequency acquisition algorithms - BER performance with frequency synchronization

**Unit III: Adaptive Single and Multiuser OFDM Techniques** 9 Hours
Adaptive modulation for OFDM : Adaptive OFDM speech system - pre-equalization ; Comparison of adaptive techniques - near optimum power and bit allocation in OFDM - multiuser AOFDM - Multiuser systems - Maximum likelihood enhanced sphere decoding of MIMO OFDM.

**Unit IV: Channel Estimation in OFDM systems** 9 Hours
Pilot Based OFDM Channel Estimation-Example; Comb Type Pilot (CTP) Transmission - example; Channel estimation in time/ frequency domain; Frequency Domain Equalization (FDE).

**Unit V: Instructional Activities** 9 Hours
BER Vs Eb/N0 for OFDM in AWGN channel- OFDM channel estimation using LS, LMMSE, and lower complexity LMMSE methods.
Reference Books:


Hyperlinks:

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<td>STATISTICAL THEORY OF COMMUNICATION</td>
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Prerequisite: Representation of Random Processes

Objective: To develop decision, estimation and modulation theories to demonstrate how they can be used to solve a practical problems in many diverse physical situations.

Outcome: The course presents a unified approach to the problem of detection, estimation and modulation theory, which are common tools used in many applications of communication systems, signal processing and system theory.

Unit I – Detection and Estimation Theory  9 Hours

Unit II – Detection and Estimation of Signal Parameters  9 Hours

Unit III – Estimation of Continuous Waveforms  9 Hours
Derivation of Estimator equations – A Lower bound on the mean square estimation error – Multidimensional waveform estimation – Non random waveform estimation.

Unit IV - Linear Estimation  9 Hours

Unit V: Instructional Activities  9 Hours
Develop the design steps for RADAR signal detection and estimation by various prediction techniques and filters. Comment on the same by simulating the design using MATLAB.
**Reference Books:**


**Hyperlinks:**

1. http://nptel.ac.in/syllabus/117105083/
3. http://www.ece.iisc.ernet.in

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<td>WCENG 630</td>
<td>ADVANCED TECHNIQUES FOR WIRELESS RECEPTION</td>
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**Prerequisite:** Fundamentals of Wireless techniques in receiver side of wireless communication

**Objective:** To teach the advanced techniques for wireless reception.

**Outcome:** The students will come out with a complete knowledge of advanced techniques in wireless reception for real-time application.

**Unit I: Blind Multiuser Detection** 9 Hours


**Unit II: Space-Time MUD** 9 Hours

Adaptive array processing in TDMA systems. Optimum space-time multiuser detection. Sub-space based training algorithm and extension to dispersive channels Turbo multiuser detection for synchronous and turbo coded CDMA.

**Unit III: NBI Suppression** 9 Hours


**Unit IV: Signal Processing for Wireless Reception** 9 Hours


**Unit V: Instructional Activities** 9 Hours

Design the steps of Monte Carlo sampling methods for Bayesian filtering. Develop a general variational Bayesian framework for iterative data and parameter estimation for coherent detection is introduced as a generalization of the EM-algorithm.
Reference Books:
5. A. Paulraj et.al, Introduction to Space-time Wireless Communications, Cambridge

Hyperlinks:
1. docwiki.cisco.com/wiki/Wireless Technologies
2. http://dl.acm.org/citation.cfm?id=1593080

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<td>WCENG 631</td>
<td>CONVERGENCE TECHNOLOGIES</td>
<td>L 2</td>
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**Prerequisite:** Basics of wireless networks, elementary concepts in probability, optimization related to communication systems.

**Objective:** To gain expertise in the convergence technologies in respect of network design and performance measures.

**Outcome:** Students will be able to enumerate the functions and importance of internetworking/interoperability of advanced wireless technologies.

**Unit I: Introduction**  
Evolution towards convergence: Next generation network concept - framework for examining next generation and evolving networks - examples of application of framework - enabling mobile network technologies - opportunities and threats to the mobile converging service market

**Unit II: Switching Networks and convergence standards**  

**Unit III: IP Telephony**  
IP Telephony: Network architecture - IP Voice - VoIP call signaling protocols - IP cablecom - media networking - broadband infrastructure - IP TV - cloud computing - interoperability among multicasting/broadcasting systems - QoS.

**Unit IV: Software Methodologies for Converged Networks and Services**  
Development of software methodologies for ICT: Software processes in the NGN framework - high level design and analysis methods - enterprise and business modeling notation - object and data definition language - dynamic modeling notations - component and interface notations - distributed systems - creating a unified framework

**Unit V: Instructional Activities**  
Simulation of minimum four convergence technologies for various applications using related tools.
Reference Books:


Hyperlinks:

1. www.radio-electronics.com/info/wireless/
2. www.radio-electronics.com/info/telecommunication_networks/

WCENG 631
Course Code | Name of the Course          | Periods | Credits | Total Hours |
-------------|-----------------------------|---------|---------|-------------|
WCENG 632    | HETEROGENEOUS NETWORK       | L       | T       | P           |
             |                             | 2       | 1       | 0           |
             |                             |         |         | 3           |
             |                             |         |         | 45          |


Objective: The objective of this course is based on understanding Overview, Technology, Management and Application of Heterogeneous networks.

Outcome: Students will be able to understand the concepts and functionality of heterogeneous communication systems and its applications.

Unit I: Introduction and overview
Motivations for Heterogeneous Networks-Definitions of Heterogeneous Networks-Heterogeneous Networks Use Scenarios-Aspects of Heterogeneous Network Technology-Heterogeneous cellular network nodes-Introduction to 3GPP LTE advanced heterogeneous cellular networks.

Unit II: Multi-tier Network Architecture

Unit III: interference, Mobility Management
Introduction-Conventional inter-cell interference Coordination-Enhanced inter-cell Interference Coordination-Interference Scenarios. Mobility Management in RRC- connected state-Mobility Management in RRC-idle state-Mobility Management in heterogeneous cellular networks.

Unit IV: Cell Selection Modes

Unit V: Instructional Activities
Survey minimum of four heterogeneous networks concepts for wireless communication networks and carry out simulation of those networks.
References Books:
1. Heterogeneous Cellular Networks.–Rose Qing Hu, Yi Qian–Wiley Publication, IEE Press
2. Heterogeneous Cellular Networks –Theory, Simulation and Deployment, By: Xiaoli Chu, David Lopez-Perez, Yang Yang, Fedrik Gunnarsson-Cambridge University Press.

Hyperlinks:
3. https://link.springer.com/chapter/10.1007/978-3-319-18038-0_3

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<td>WCENG 633</td>
<td>HIGH SPEED SWITCHING ARCHITECTURE</td>
<td>L T P</td>
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</table>

**Prerequisite:** Fundamentals of Computer Network and Communication

**Objective:** To impart High Speed Switching Architecture Concepts

**Outcome:** Students will be able to understand the importance of High Speed Switching Network wireless systems

**Unit I: Basic Switching Concepts** 9 Hours


**Unit II: LAN Switching Technology** 9 Hours

Switch Forwarding Techniques, Switch Path Control, LAN Switching, Cut through Forwarding, Store and forward, and Virtual LANs.

**Unit III: Architectures and Signaling Standards** 9 Hours


Signaling – SS7 Signaling - Traffic and queuing models – Performance analysis of Input, Output & Multiple shared Queuing.

**Unit IV: IP Switching** 9 Hours

Addressing Model, IP switching types, Flow driven and topology driven solutions, IP over ATM, Address and next hop resolution, Multicasting, IP v6 over ATM.

**Unit V: Instructional Activities** 9 Hours

Simulation of minimum four High Speed Network Architectures Algorithm for various applications using related tools.
Reference Books:

Hyperlinks:
1. http://nptel.ac.in/syllabus/117105083/

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<td>WCENG 634</td>
<td>INTERNETWORKING MULTIMEDIA COMMUNICATION</td>
<td>L 2</td>
<td>T 1</td>
<td>P 0</td>
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</table>

**Prerequisite:** Fundamentals of Communication and interworking

**Objective:** To familiarize the salient approaches in multimedia communication based on internetworking

**Outcome:** Students will be able to apply concepts of internetworking in multimedia communication

**Unit I: Multimedia Networking** 9 Hours

Digital sound, video and graphics, basic multimedia networking, multimedia characteristics, evolution of Internet services model, network requirements for audio/video transform, multimedia coding and compression for text, image, audio and video.

**Unit II: Broad Band Network Technology** 9 Hours

Broadband services, ATM and IP, IPV6, High speed switching, resource reservation, Buffer management, traffic shaping, caching, scheduling and policing, throughput, delay and jitter performance.

**Unit III: Multicast and Transport Protocol** 9 Hours

Multicast over shared media network, multicast routing and addressing, scalping multicast and NBMA networks, Reliable transport protocols, TCP adaptation algorithm, RTP, RTCP.

**Unit IV: Media - On – Demand** 9 Hours

Storage and media servers, voice and video over IP, MPEG over ATM/IP, indexing synchronization of requests, recording and remote control.

MIME, Peer-to-peer computing, shared application, video conferencing, centralized and distributed conference control, distributed virtual reality, light weight session philosophy.

**Unit V: Instructional Activities** 9 Hours

Simulation of Internetworking Multimedia Communication concepts using related tools
Reference Books:

Hyperlinks:
1. https://www.cl.cam.ac.uk/~jac22/out/mm.pdf

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<td>MICRO AND NANO ELECTRONICS</td>
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<td>ENGINEERING</td>
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**Prerequisite:** Knowledge in basic sensors, actuators and various fabrication techniques

**Objective:** To teach the principles in respect of micro and nano electronics, and MEMS/NEMS.

**Outcome:** The students will come out with a complete knowledge of micro and nano fabrication concepts, micro and nano sensors. MEMS/NEMS for real-time application.

**Unit I: MEMS**

Introduction: Need for miniaturization technology - from perception to realization - overall MEMS market size - MEMS market character - MEMS based on Si- Non-Silicon MEMS - MEMS versus Traditional Precision Engineering.

**Unit II: Micro Sensors and Actuators**

Sensing and actuation - case studies of real devices; Sensing mechanisms: piezoelectric - piezoresistive - capacitive; Actuation mechanisms: piezoelectric - electrostatic - magnetic and thermal; Physical sensors - opto– fluids - sensors for turbulence measurement and control – micro– actuators for flow control.

**Unit III: Nanomaterials and Nanodevices**

Introduction to nanomaterials : properties of nanomaterials - role of size in nanomaterials and nanoparticles - semiconducting nanoparticles; Nanowires - nanoclusters - quantum wells - conductivity - Carbon Nanotube (CNT): structure of CNT and its properties; Nanosensors-structure- applications

**Unit IV: Micro and Nano Fabrication Techniques**

Introduction to Lithography: Pattern transfer with different techniques - E beam lithography; Micromachining: Size effect in micromachining - mechanical micromachining; Oxidation - CVD of nanostructures - CVD diamond technology for NEMS and MEMS applications - nano crystals - nanowires - nanolithography - etching techniques.

**Unit V: Instructional Activities**

Simulation of minimum of five MEMS/ NEMS using related tools.
References Books:


Hyperlink:


WCENG 635
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<tr>
<td>WCENG 636</td>
<td>MIMO COMMUNICATION SYSTEMS</td>
<td>L 2</td>
<td>T 1</td>
<td>P 0 3</td>
</tr>
</tbody>
</table>

Prerequisite: Fundamentals of Information Theory and Wireless Communication.

Objective: To study the MIMO concepts of communication systems, the various types STBC and STTC codes for wireless communication.

Outcome: Students will be able to understand the concepts of MIMO communication systems and its applications.

**Unit I: Information Theoretic aspects**  
9 Hours  
Review of SISO fading communication channels, MIMO channel models, Classical i.i.d. and extended channels, Frequency selective and correlated channel models, Capacity of MIMO channels, Ergodic and outage capacity, Capacity bounds and Influence of channel properties on the capacity.

**Unit II: Diversity and Spatial Multiplexing**  
9 Hours  
Sources and types of diversity, analysis under Rayleigh fading, Diversity and channel knowledge. Alamouti space time code, MIMO spatial multiplexing. Space time receivers. ML, ZF, MMSE and Sphere decoding, BLAST receivers and Diversity multiplexing trade-off.

**Unit III: Space Time Block Codes**  
9 Hours  
Space time block codes on real and complex orthogonal designs, Code design criteria for quasi-static channels (Rank, determinant and Euclidean distance), orthogonal designs, Generalized orthogonal designs, Quasi-orthogonal designs and Performance analysis.

**Unit IV: Space Time Trellis Codes**  
9 Hours  
Representation of STTC, shift register, generator matrix, state-transition diagram, trellis diagram, Code construction, Delay diversity as a special case of STTC and Performance analysis.

**Unit V: Instructional Activities**  
9 Hours  
Survey minimum of four MIMO concepts for wireless communication networks and carry out simulation of those networks.
**References Books:**


**Hyperlinks:**

4. https://onlinecourses.nptel.ac.in/noc16_ec11/preview

    WCENG 636
<table>
<thead>
<tr>
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<tr>
<td>WCENG 637</td>
<td>MULTIMEDIA COMPRESSION TECHNIQUES</td>
<td>L 2</td>
<td>T 1</td>
<td>P 0</td>
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</table>

**Prerequisite:** Basics of Information theory

**Objective:** To expose the students on the fundamentals of source coding and Compression techniques.

**Outcome:** The students will able to know the different multimedia compression techniques so far used in the Practical wireless communication.

**Unit I: Introduction**
9 Hours

**Unit II: Data Compression / Audio Compression**
9 Hours

**Unit III: Image Compression**
9 Hours

**Unit IV: Video Compression**
9 Hours

**Unit V: Instructional Activities**
9 Hours
Simulation of minimum of five multimedia compression techniques using related tools.
References Books:


Hyperlinks:

1. http://nptel.ac.in/syllabus/117105083/

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<td>WCENG 638</td>
<td>NETWORK ROUTING ALGORITHM</td>
<td>L 2 T 1 P 0</td>
<td>3</td>
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</table>

**Prerequisite:** Fundamentals of Computer Network and Communication

**Objective:** To impart Network Routing Algorithm

**Outcome:** Students will be able to understand the importance of Network Routing Algorithm for wireless systems

**Unit I: Network Routing** 9 Hours


**Unit II: Routing in IP Networks** 9 Hours

Routing IP Networks-IP Routing and Distance vector routing Protocol family, OSPF and Integrated IS-IS, IP traffic Engineering, BGP, Internet Routing Architectures.

**Unit III: Routing in PSTN** 9 Hours

Routing in the PSTN- Hierarchical and Dynamic Call routing, Traffic engineering, SS7, PSTN architecture and routing.

**Unit IV: Router Architectures / Next Generation Routing** 9 Hours


**Unit V: Instructional Activities** 9 Hours

Simulation of minimum four Network Routing Algorithm for various applications using related tools
Reference:

Hyperlinks:
1. http://nptel.ac.in/syllabus/117105083/

WCENG 638
Course Code | Name of the Course                    | Periods | Credits | Total Hours |
-------------|--------------------------------------|---------|---------|-------------|
WCENG 639    | PATTERN RECOGNITION AND ARTIFICIAL INTELLIGENCE | L T P   | 3       | 45          |

Prerequisite: Basic concepts of probability theory and random process.

Objective: To help the students to gain in-depth knowledge in pattern recognition and artificial intelligence

Outcome: Students will be able to apply pattern recognition and artificial intelligence techniques for signal and image processing application.

Unit I: Introduction to Pattern Recognition 9 Hours
Introduction: Probability- statistical decision making- nonparametric decision making- patterns and features - training and learning in pattern recognition - pattern recognition approach- different types of pattern recognition.

Unit II: Clustering 9 Hours
Unsupervised learning: Hierarchical clustering- graph theories approach to pattern clustering- fuzzy pattern classifier- application of pattern recognition in medicine.

Unit III: Artificial Intelligence 9 Hours

Unit IV: Basic solving methods 9 Hours

Unit V: Instructional Activities 9 Hours
Range images generation- extraction of geometric elements- automatic scene generation- scene recognition- geometrical hashing using related tools.
Reference Books:


Hyperlinks:


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<td>WCENG 640</td>
<td>RF SYSTEM DESIGN FOR WIRELESS COMMUNICATION</td>
<td>L 2 T 1 P 0</td>
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</table>

**Prerequisite**: Fundamentals of radio frequency concepts and wireless communication

**Objective**: To learn the RF system design for wireless communication

**Outcome**: Students will be able to understand the RF system design in wireless communication for real time applications.

**Unit I: Fundamentals of System Design** 9 Hours

**Unit II: Radio Architectures and Design** 9 Hours

**Unit III: Receiver System Analysis and Design** 9 Hours
Introduction - Sensitivity and Noise Figure of Receiver - Intermodulation Characteristics - Single Tone Desensitization - Adjacent/Alternate Channel Selectivity and Blocking Characteristics - Receiver Dynamic Range and AGC System - System Design and Performance Evaluation

**Unit IV: Transmitter System Analysis and Design** 9 Hours

**Unit V: Instructional Activities** 9 Hours
Simulation of minimum of five RF system design for wireless communication with suitable application using related tools
Reference Books:

Hyperlinks:
1. http://www.nptel.iitm.ac.in

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<td>WCENG 641</td>
<td>SOFT COMPUTING</td>
<td>L 2</td>
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</table>

**Prerequisite:** Computer Networks

**Objective:** To familiarize the salient approaches in soft computing based on artificial neural networks, fuzzy logic, and genetic algorithms

**Outcome:** Students will be able to apply concepts of artificial neural networks, fuzzy logic, and genetic algorithm for real time application

**Unit I: Neural Network**

**Unit II: Fuzzy Sets & Logic**

**Unit III: Genetic Algorithm**
- Role of GA - fitness function - selection of initial population - cross over (different types) - mutation - inversion - deletion - constraints handling and applications of travelling salesman and graph coloring.

**Unit IV: Hybrid Systems**
- Hybrid Systems: GA based BPNN (Weight determination) - Neuro fuzzy systems - Fuzzy BPNN - fuzzy neuron - architecture - learning - Fuzzy logic controlled genetic algorithm.

**Unit V: Instructional Activities**
- Simulation of PSD - HSA and ACO related to either wireless networking or Antenna or Image Processing using related tools.
References Books:

Hyperlinks:

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<td>WCENG 642</td>
<td>AUDIO SIGNAL PROCESSING</td>
<td>L 2</td>
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**Prerequisite:**  
Fundamentals of Speech and Audio signal

**Objective:**  
To study the basic concepts of speech and audio and to analysis of various M-band filter banks for audio coding and to learn various transform coders for audio coding.

**Outcome:**  
The students will come out with a complete knowledge of Speech and Audio signal processing.

**Unit I: Mechanics of Speech**  
9 Hours  

**Unit II: Time and Frequency Domain Methods for Speech Processing**  
9 Hours  

**Unit III: Linear Predictive Analysis of Speech**  
9 Hours  

**Unit IV: Application of Speech and Audio Signal Processing**  
9 Hours  

**Unit V: Instructional Activities**  
9 Hours  
Simulation of minimum of five speech and audio signal processing techniques using related tools.
Reference Books:

Hyperlinks:
2. https://dl.acm.org/citation.cfm?id=2073536

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Prerequisite: Communication theory and wireless communications

Objective: To impart the concepts of the UWB communication systems.

Outcome: Students will be able to design sub-modules of UWB system.

Unit I: UWB Signals and Systems


Unit II: UWB Pulse Generation and Processing


Unit III: UWB Channel Modeling


Unit IV: UWB Antennas and Filters


Unit V: Instructional Activities

Simulation of UWB: Pulse generation and processing – channel modeling – antennas using EM – MIMO for UWB systems using related tools.
Reference books:


Hyper Links:


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**Prerequisites:** Wireless communications and network, and mobile ad-hoc networks

**Objective:** To introduce the students with the emerging technologies and their standards with applications for vehicular communication systems.

**Outcome:** Students will able to understand the basic principles, standards, and system architecture of Vehicular Ad-hoc Networks.

**Unit I: Introduction**

Basic principles and challenges - past and ongoing VANET Activities; Cooperative vehicular safety applications: Introduction - enabling technologies - cooperative system architecture.

**Unit II: Vehicular Mobility Models**

Introduction - notation description - random models - flow models - traffic models - behavioral models - trace or survey based models - integration with network simulators - design framework for realistic vehicular mobility models.

**Unit III: Routing Protocols**


**Unit IV: Security**

Requirement - challenges - adversaries - VANET supporting properties - message authentication and integrity using digital signatures - detection of malicious data and secure position verification.

**Unit V: Instructional Activities**

Simulation of Vehicle to Vehicle Communication - Vehicle to infrastructure and infrastructure to vehicle communication using related tools.
Reference Books:

Hyperlinks:
1. http://www.irma-international.org/viewtitle/43163/

WCENG 644
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<td>WCENG 645</td>
<td>VLSI FOR WIRELESS COMMUNICATION</td>
<td>L 2 T 1 P 0</td>
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**Prerequisite:** Fundamentals of VLSI and Wireless Communication.

**Objective:** To study the design concepts of low noise amplifiers, the various types of mixers and design PLL and VCO for wireless communication.

**Outcome:** Students will be able to design VLSI circuits for wireless communication applications.

**Unit I Components and Devices**


**Unit II Mixers**


**Unit III Frequency Synthesizers**


**Unit IV Sub Systems and Implementations**

Data converters in communications, adaptive Filters, equalizers and transceivers


**Unit V: Instructional Activities**

Survey minimum of four VLSI Circuit design for wireless communication networks and carry out simulation of those networks.
References Books:


Hyperlinks:

4. https://pdfs.semanticscholar.org/19e2/81a115e4023e915e0f416bae74475b8f1c43.pdf

WCENG 645
<table>
<thead>
<tr>
<th>Course Code</th>
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<tr>
<td>WCENG 646</td>
<td>WDM OPTICAL NETWORKS</td>
<td>L 2</td>
<td>T 1</td>
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**Prerequisite:** Fundamentals of optics

**Objective:** To expose the students on the fundamentals of optical network

**Outcome:** The students will able to know the different optical network and techniques used in the Practical wireless communication

**Unit I: Optical Networks** 9 Hours
Optical Networks: Why optical networks? Conventional optical networks, SONET/SDH, FDDI, IEEE 802.3, DQDB, Multiple access optical networks, WDM optical networks architectures and issues in wavelength routed networks

**Unit II: Optical Fibers & Signal Degradation/Digital Transmission Systems** 9 Hours

**Unit III: WDM Base Optical Communication System** 9 Hours

**Unit IV: Passive Components for WDM Based Systems** 9 Hours

**Unit V: Instructional Activities** 9 Hours
Simulation study of any (five) optical networks design using related tools
Reference Books:
1. G. Keiser, Optical Fiber Communications, McGraw Hill
4. J.M. Senior, Optical Fiber Communications, Prentice Hall, India

Hyperlink:

WCENG 646
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<tr>
<td>WCENG 647</td>
<td>5G WIRELESS NETWORKS</td>
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**Prerequisite**: Fundamentals of Information Theory and Wireless Networks.

**Objective**: To study the concepts of wireless networks for the future communication systems.

**Outcome**: Students will be able to understand the concepts of next generation communication systems and its applications.

**Unit I: Multi-gigabit wireless networks** 9 Hours
Next generation (5G) wireless technologies- Upper Gigahertz and Terahertz wireless communications: Millimeter wave networking- Directionality and beam forming- Mobility and signal blockage- IEEE 802.11ad (60 GHz WLAN) MAC and PHY overview: Visible light communication- High-speed networking using LEDs - IEEE 802.15.7 PHY and MAC overview Sensing through visible light- Visible light indoor localization and positionning

**Unit II: Indoor localization and RF sensing** 9 Hours
Smartphone localization - WiFi fingerprinting - protocols and challenges - Non-WiFi localization - Device-free sensing with radio frequency - Mining wireless PHY channel state information- Device-free localization and indoor human tracking - Activity and gesture recognition through RF.

**Unit III: Low-power networking** 9 Hours
Backscatter communication - Radio Frequency Identification (RFID) technology overview - Energy harvesting tags and applications- Internet-of-Things (IoT) - IoT protocol overview - CoAP and MQTT - IPv6 networking in low-power PANs (6LoWPAN)

**Unit IV: Future mobile networks** 9 Hours
Drone networking - Multi-UAV networks, architectures and civilian applications-Communication challenges and protocols for micro UAVs- Connected and autonomous cars - Wireless technologies for Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) communications - Automotive surrounding sensing with GHz and THz signals.

**Unit V: Instructional Activities** 9 Hours
Survey minimum of four 5G wireless networks for wireless communication and carry out simulation of those networks.
References Books:

Hyperlinks:
2. https://www.theiet.org/resources/books/telecom/5gwire.cfm?
5. https://www.intechopen.com/books/how-to-link/towards-5g-wireless-networks-a-physical-layer-perspective

WCENG 647

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