**Program Name** : **Electronics Engineering Programme Group**

**Program Code** : **DE/EJ/ET/EN/EX/EQ**

**Semester** : **Sixth**

**Course Title** : **Optical Network and Satellite Communication**

**Course Code** : **22647**

## 1. RATIONALE

Optical communication technology is developing at very fast pace. Cost trends for fiber vs copper, better transmission quality, high data rate, large band width and reduction in fiber maintenance expense are the major reasons for fast adaptation of this mode of communication. Today in different communication scenarios satellite applications plays important role. The knowledge of satellite communication systems and equipment is very essential. This course will facilitate students to apply the basic principles of optical communication system and satellite communication system to maintain different types of applications based on it.

## 2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain optical communication networks.**
- **Maintain satellite communication systems.**

## 3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a) Interpret the functions of the various blocks of optical fiber communication system.
b) Measure the optical fiber cable parameters.
c) Select relevant architecture of optical networks for the given application.
d) Select uplink and downlink frequencies for various satellite services.
e) Maintain Satellite services.

## 4. TEACHING AND EXAMINATION SCHEME

| Teaching Scheme | | | Credit (L+T+P) | Examination Scheme | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | | | | | | | Practical | | | | |
| L | T | P | | Paper Hrs. | ESE | | PA | | Total | | ESE | | PA | | Total | |
| | | | | | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min |
| 3 | - | 2 | 5 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 25@ | 10 | 25 | 10 | 50 | 20 |

*(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.*

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

## 5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

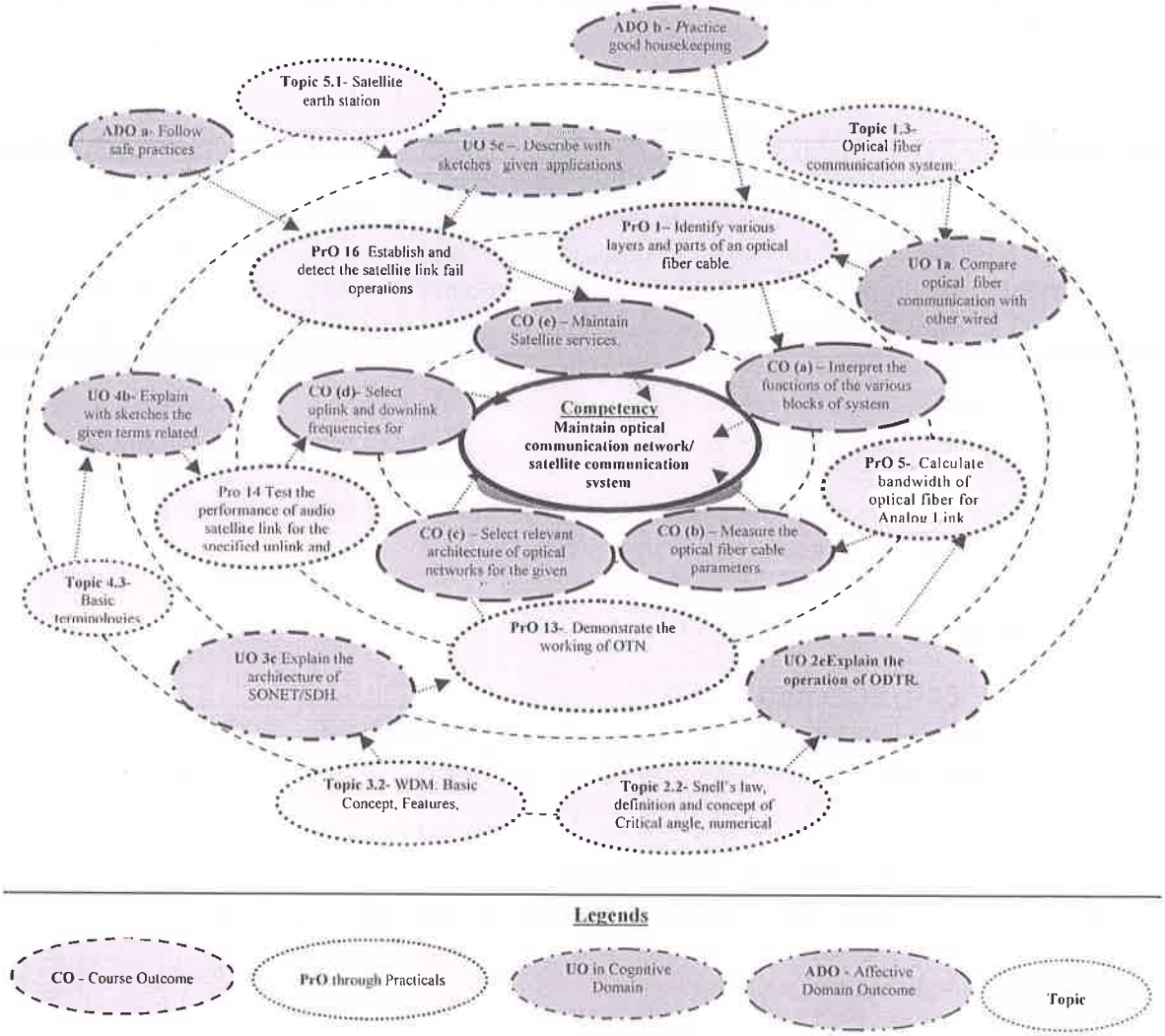


**Figure 1 - Course Map**

## 6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 1 | Identify various layers and parts of an optical fiber cable. | I | 02* |
| 2 | Test the performance of Pulse width modulator and demodulator (PWM) where optical fiber cable is used as transmission media. | I | 02* |
| 3 | Test the performance of the given photo-diode (Detector) use LED as an optical source. | I | 02 |
| 4 | Test performance of given photo-diode (Detector) use LASER as optical source. | I | 02* |
| 5 | Calculate bandwidth of optical fiber for Analog Link. | II | 02 |
| 6 | Observe the change in power level of optical fiber due to cleaning | II | 02 |

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| | effects in the fiber. | | |
| 7 | Calculate Numerical Aperture (NA) and acceptance angle for the given optical fiber cable. | II | 02* |
| 8 | Connect the given Optic cable with relevant optical connector and test the performance of cable. | II | 02 |
| 9 | Measure attenuation losses for the given length of optical fiber cable. | II | 02 |
| 10 | Measure bending losses of the given optical fiber optic cable. | II | 02* |
| 11 | Demonstrate attenuation losses for the given length of optical fiber cable with the help of OTDR. (Virtual lab/ Demonstration in industry/videos can be used in case of non-availabity of the splicing machine in the lab) | II | 02 |
| 12 | Join optical fiber cables using Splicing machines. (Virtual lab/ Demonstration in industry/ videos can be used in case of non-availabity of the splicing machine in the lab) | II | 02 |
| 13 | Demonstrate the working of OTN. (Virtual lab/ Demonstration in industry/ videos can be used in case of non-availabity in the lab) | III | 02* |
| 14 | Test the performance of audio satellite link for the specified uplink and downlink frequency. | IV | 02* |
| 15 | Develop a program using a relevant simulation tool to calculate the time period of a satellite for the given velocity and altitude based on Kepler's third law. | IV | 02 |
| 16 | Detect the satellite link fail operations and re-establish the link. | V | 02 |
| 17 | Establish a link to transmit and receive three separate signals (audio, video, tone) simultaneously through satellite link. | V | 02 |
| | | **TOTAL** | **34** |

***Note***

*i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

*ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

| S.No. | Performance Indicators | Weightage in % |
|---|---|---|
| a. | Preparation of experimental set up | 20 |
| b. | Setting and operation | 20 |
| c. | Safety measures | 10 |
| d. | Observations and Recording | 10 |
| e. | Interpretation of result and Conclusion | 20 |
| f. | Answer to sample questions | 10 |
| g. | Submission of report in time | 10 |
| | **Total** | **100** |

The above PrOs also comprise of the following social skills/ attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
a) Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year

## 7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 1. | CRO/Digital storage oscilloscope: 60MHz/100MHz/200MHz bandwidth, 500MS/s to 1GS/s real-time sample rate, 50GS/s sample rate for repetitive waveforms, High resolution color LCD display | **2,3,4,5** |
| 2. | DMM: DC, 0-1.5/3Amp, 0-2.5/5 Amp, 0-5/10Amp, 0-150/300V, 0-250/500V, 0-75/150V AC-0-1000V , 0-10A | **2,3,4,5** |
| 3. | Power Supply Type: DC, 0- 30 V, 0 - 3A | **2,3,4,5** |
| 4. | Fiber Optic Trainer kit | **1,2,3,4,5,7** |
| 5. | Fiber optic cable tester | **2,3,4,5** |
| 6. | Optical fiber Power meter | **6,8,9** |
| 7. | Lux meter: Display: 3 1/2 digit 18mm (0.7") /LCD •Ranges: 1 to 50,000 LUX /Over-input: indication of " 1 " /Sampling Time: 0.5 second /Repeatability: ±2% /Temperature Characteristic: ±0.1%/? •Accuracy: ±4%rdg ±0.5%f.s | **3,4,5** |
| 8. | OTDR-Attenuation resolution-0.001 dB, Attenuation measurement linearity 0.05 dB, Distance measurement accuracy ± (0.5 + resolution + 5 × 10-5 × L) m | **8,9,10, 11,12** |
| 9. | PC - Processor - dual core @ 2.4 GHz (i5 or i7 Intel processor or equivalent AMD),RAM - 4 GB, Hard Drive - 320 GB 5400 RPM hard drive,OS- win7/10 | **11,12, 13** |
| 10. | Spectrum Analyzer- frequency range- 2.4 to 2.495GHz, Resolution – 26KHz to 3MHz, resolution BW-58.036 to812.500KHz | **14,15,16,17** |
| 11. | Splicing, Cutting and trimming tool of plastic fiber optic cables | **6,12** |
| 12. | Fiber optic cleaning kit . | **6** |
| 13. | Satellite Trainer Kit (ST2272)/ (STC 24): Up linking frequency 2414- | **15,16,17,18** |

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| | /2432/2450/2468 MHz, 4 MHz clock frequency, PIC16F84 - 8 Bit RISC processor based PLL, 16 MHz Bandwidth, FM Modulation of Audio and Video 5/ 5.5/ 8 MHz Audio and Video Modulation, Detachable Dish Antenna, Radiated Power output 25 mW (approx.), 4 downlink frequencies 2414 /2432/2450/2468 MHz | |
| 14. | RF Signal Generator, 9 kHz to 3 GHz, Output Power @1 GHz, -127 dBm to +13 dBm AM, FM, PM Analog I/Q Input Pulse, Frequency Modulation-Maximum Deviation @1 GHz, 20 Hz to 100 kHz | 2 |

## 8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| **Unit –I Fundamentals of Fiber Optic Communication** | 1a.Describe construction and features of Optical fiber.<br>1b. Compare working of optical fiber for given mode and index profile.<br>1c. Explain the block diagram of Optical fiber communication system.<br>1d. Explain the working principle of given optical source and detector. | 1.1Optical fiber communication: Advantages, Disadvantages, applications<br>1.2 Construction of fiber optic cable<br>1.3 Classification based on modes of propagation of light and index profile.<br>1.4 optical fiber communication system: Block diagram.<br>1.5 Optical components: Sources and Detectors |
| **Unit– II Optical Losses** | 2a. Explain the given terms related to optical theory.<br>2b. Calculate acceptance angle, critical angle and numerical aperture of the given optical fiber cable.<br>2c. Explain the step by step procedure of given splicing techniques<br>2d. Describe the different types of Optical fiber losses.<br>2e. Explain the operation of ODTR. | 2.1 Reflection, refraction, Total internal reflection (TIR), Snell's law, critical angle, numerical aperture, acceptance angle and acceptance cone - (numerical on above concepts)<br>2.2 Splicing techniques- Fusion splice, V-groove splice and elastic tube splice<br>2.3 Losses in optical fiber: Absorption loss, scattering loss, dispersion loss, radiation loss, coupling loss.<br>2.4 OTDR: Working Principle, Block diagram, Specification, Application |
| **Unit-III Optical network.** | 3a. Describe working principle of the optical network components.<br>3b. Explain the concept of WDM.<br>3c. Explain the architecture of SONET/SDH.<br>3d. Describe the given type of Ethernet standard. | 3.1 Optical Network Components Use and Features: Amplifiers, Splitter, Optical Switches,<br>3.2 WDM: Basic Concept, Features.<br>3.3 SONET/SDH: Architecture and Hierarchy.<br>3.4 Ethernet standards of Optical network features: IEEE 802.3j, 802.3y, 802.3z |

| | | |
|---|---|---|
| **Unit –IV Overview of Satellite Systems.** | 4a. Describe with sketches the working principles of the given type of satellite.<br>4b. Explain with sketches the given terms related to satellite and orbit.<br>4c. Explain the parameters with respect to the given type of satellite orbit.<br>4d. Explain Kepler's law of planetary motion with respect to the given criteria. | 4.1 Working principle, concepts and basic components of Satellite system : Earth segment, Space segment, active and passive satellite, geostationary and geosynchronous satellites<br>4.2 Frequency allocations for satellite services, Uplink and downlink frequency, satellite frequency bands<br>4.3 Basic terminologies used in satellite communication: latitude, longitude, look angle, elevation angle, station keeping, propagation delay time , velocity, look angle and footprint<br>4.4 Communication Satellite orbits and its types: LEO, MEO, elliptical orbit and GEO, parameters and characteristics of various orbits<br>4.5 Kepler's law, Apogee and Perigee Heights, Orbit Perturbations, Effects of a non spherical earth, Atmospheric drag, effect of eclipse on satellite motion |
| **Unit-V Satellite segments and Services** | 5a. Describe with sketches the functions of the given sub-system of the satellite earth station.<br>5b. Describe the given type of control systems associated with the Satellite.<br>5c. Describe with sketches given applications | 5.1Satellite earth station: Block diagram; Antenna subsystem, LNA, Power subsystem, Telemetry Tracking and Command (TTAC) subsystem, Attitude Control, Spinning satellite stabilization, Momentum wheel stabilization, Station Keeping, Thermal control<br>Transponder: Single, double conversion and regenerative type<br>5.2 Space link: Equivalent Isotropic Radiated Power(EIRP), Transmission Losses : Free-space transmission loss, Feeder losses, Antenna misalignment losses, Fixed atmospheric and ionosphere losses<br>5.3 Satellite Applications:<br>GPS: : Global positioning system (GPS) : concept, working principle, transmitter and receiver<br>VSAT: Overview, architecture, working principle, applications |

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

| Unit No. | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|---|---|---|---|---|---|---|
| | | | R Level | U Level | A Level | Total Marks |

| Unit No. | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|---|---|---|---|---|---|---|
| | | | R Level | U Level | A Level | Total Marks |
| I | Fundamentals of Fiber Optic Communication | 08 | 02 | 04 | 06 | 12 |
| II | Optical Losses | 12 | 04 | 06 | 06 | 16 |
| III | Optical network | 08 | 02 | 06 | 06 | 14 |
| IV | Overview of Satellite Systems | 08 | 02 | 04 | 06 | 12 |
| V | Satellite segments and Services | 12 | 02 | 06 | 08 | 16 |
| **Total** | | **48** | **12** | **26** | **32** | **70** |

***Legends:*** *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note****: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Visit any industry nearby to your house/college and observe the use of optical devices.
b) List out the specification of various optical devices used in the industries.
c) Undertake Internet survey for various optical fiber cables available in market.
d) Observe various splicing techniques used in industries.
e) Visit any earth station nearby to your house/college and observe the function of different components of satellite system and submit report on it.
f) Write report on various antennas and modulation techniques used for television signal transmission.
g) Visit ISRO website and collect the information related to satellite launching and submit report on it.
h) Collect the information related to Indian satellites program.
i) Prepare report on satellite applications.

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.

f) Virtual lab or videos can be use in case of non availability of equipment for mentioned experiments.
g) Correlate subtopics with application of instrumentation.
h) Use proper equivalent analogy to explain different optics concepts.
i) Use Flash/Animations to explain the process of light transmission through various types of fiber optic cable
j) Use open source models to explain working of the fiber optic connectors.
k) Use Flash/Animations to explain satellite communication.
l) Use different websites to explain satellite communication systems

## 12. SUGGESTED MICRO-PROJECTS

***Only one micro-project*** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. For all semesters, the micro-project are group-based to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a) Using LED as optical source, photodiode as optical detector and plastic fiber cable make prototype optical communication system.
b) Make flow diagram of Fiber to Home (FTH).
c) Test the performance of PWM using copper cable and compare it with result of experiment no 02.
d) Prepared survey report to compare technical specification of different types of optical sources and detectors.
e) Undertake a survey for different types of optical cables, give its specification and application.
f) Undertake a survey of different OTDRs available in market, along with their specifications.
g) Prepared report on splicing techniques used at RailTel, Reliance and BSNL or any other such organization.
h) Monitor an optical networking used for cable service provider (TV and internet) and prepared report.
i) Prepare an Internet based report on the different types of launch vehicles used for satellite launching.
j) Prepare the chart to indicate applications of various satellite frequency bands (L, S, C, X, Ku and Ka band).
k) Prepare a survey report on the different types of antennas used for Satellite communication.
l) Conduct an Internet survey and prepare a detail report on GPS and its applications.
m) Prepare a report on VSAT communication based on visit and Internet survey.
n) Visit a satellite centre/ pool lab having satellite set up and prepare a report on all the components and its functions.

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | Electronic communications Systems: Fundamentals Through Advanced | Tomasi, Wayne | Pearson Education India, New Delhi **ISBN-13:** 978-8131719534 |
| 2 | Fiber Optic Communication | Kolimbiris, Harold | Pearson Prentice Hall, New Delhi,2004; ISBN 978-81-317-1588-8 |
| 3 | The ABCs of Fiber Optic Communication | Warier, Sudhir | ARTECH HOUSE, Canton street Norwood, MA, ISBN 9781630814144 |
| 4 | Fiber Optic Communication | Kieser, Gerd | Mc Graw Hill Higher Education, New Delhi ,2013, ISBN: 9781259006876, |
| 5 | Data Communications and Networking | Forouzan, Behrouz A. | Mc Graw Hill Higher Education, New Delhi, 2013, ISBN: 9781259064753, |
| 6 | Optical Fiber Communications Principles and practice | Senior, John M. | Pearson Education Limited, New Delhi, 2010, ISBN: 9788131732663, |
| 7 | Satellite Communications | Roddy Dennis | Tata McGraw-Hill, New Delhi, fourth edition ,2017 **ISBN-13:** 978-0070077850 |
| 8 | Satellite Communication | Katiyar, Sapna | Katson publications, 3rd edition 2013 ISBN-978-93-5014-481-7 |
| 9 | Satellite communication concepts and applications | Rao Raja K. N. | PHI learning Private limited ,New Delhi , second edition, 2012 ISBN-978-81-203-4725-0 |
| 10 | Satellite communication systems, techniques and technology | Gerard Maral, Bousquet Michel, Zhili Sun | Wiley publication, New Delhi n 5th Edition,2009 ISBN: 978-0-470-71458-4 |

## 14. SOFTWARE/LEARNING WEBSITES

a) Optical wavelength bands: http://www.bbcmag.com/2008issues/june08/BBP_June08_OtoL.pdf
b) For virtual lab :- http://iitg.vlab.co.in/?sub=59&brch=269
c) For virtual lab :- http://vlab.co.in/
d) LED data sheet:-http://www1.futureelectronics.com/doc/EVERLIGHT%C2%A0/334-15__T1C1-4WYA.pdf
e) For fiber cleaning video :https://www.youtube.com/watch?v=MMmRdFs96JY
f) http://www.netes.com.tr/upload_x/dosyalar/93DA75C4C94A4B78E5E09EDBB038F0AA.pdf
g) https://recommendedforyou.xyz/books/g4/25739?q=Satellite%20communication%20lab%20manual
h) http://istc.co.in
i) https://www.isro.gov.in/
j) https://www.nasa.gov/
k) http://www.satcoms.org.uk/satellite/vsat-tutorials.asp?