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**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

TEST 1

Winter Semester: 2021 - 22

Course Code: ECE 319

Course Name: Photonics

Program & Sem: B.Tech & 6th Semester

Date: 26th April 2022

Time: 01:30 PM to 02:30PM

Max Marks: 30

Weightage: 15%

Instructions:

1. Read the all questions carefully and answer accordingly.
2. Scientific and non-programmable calculators are permitted.
3. All the questions are compulsory.

Part A [Memory Recall Questions]

Answer all the Questions. Each question carries TWO marks.

(5Qx 2M= 10M)

1. The bending of light when it passes from one medium to another is called Refraction. When a beam of light strikes the water, a part of the light is _____, and some part of the light is refracted. If, $\theta > \theta_c$ and the phenomenon is called as _____.
(C.O.No.1) [Knowledge]
2. Scattering is the redirection of light caused by the light's interaction with matter. If the reemitted light has a longer wavelength, the molecule is left in an excited state, and the process is called _____ and if the reemitted light has the same wavelength as the incident light, the process is called _____.
(C.O.No.1) [Knowledge]
3. A photonic integrated circuit (PIC) is a device that integrates multiple (at least two) photonic functions and as such is similar to an electronic integrated circuit. _____ will have an integrated IC in one package containing several photonic devices of similar functionality. _____ will have a single IC of optical devices with different functionality.
(C.O.No.1) [Knowledge]
4. Planar waveguides, also called _____ waveguides, are waveguides with a planar geometry, which guide light only in one dimension. They are often fabricated in the form of a thin transparent film with increased _____ on some substrate, or possibly embedded between two substrate layers.
(C.O.No.2) [Knowledge]
5. The different waveguide modes have different properties and therefore it is necessary to ensure that the correct mode for any waveguide is excited and others are suppressed as far as possible. Waveguide mode stands for a unique distribution of _____ and _____ components of the electric and magnetic fields.
(C.O.No.2) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each question carries FOUR marks.

(3Qx4M=12M)

6. When two or more light waves having the same frequency, same wavelength and same amplitude meet together in a medium at a point. Clarify in detail this property of the light with neat diagram. (C.O.No.1) [Comprehension]
7. Polarization is a phenomenon induced by the wave nature of electromagnetic radiation, according to physics. Sunlight is an example of an electromagnetic wave since it travels through the vacuum to reach the Earth. Because an electric field interacts with a magnetic field, these waves are known as electromagnetic waves. Polarization is the process of converting non-polarized light into polarized light, elaborate with the neat figure. (C.O.No.1) [Comprehension]
8. A light ray can be guided inside the slab by total internal reflection in the zigzag fashion. Only certain reflection angle " θ " will constructively interfere in the waveguide and hence only certain waves can exist in the waveguide. Mention the two different cases of reflection angle with respect to the compliment of critical angle. (C.O.No.1) [Comprehension]

Part C [Problem Solving Questions]

Answer the Questions. Question carries EIGHT marks.

(1Qx8M=8M)

9. (a) A beam of light is modeled as a stream of photons, each carrying a well-defined energy that is dependent upon the wavelength of the light. What will be the wavelength of the photons in a pale blue light, if the energy of the photon is $3.97 \times 10^{-19} \text{ J}$. [2M] (C.O.No.1) [Comprehension]
- (b) The waveguide propagation constant defines the phase and amplitude of each component or waveguide mode for the wave as it propagates along the waveguide. The factor for each component of the wave can be expressed as? State the number of rules of thumb and common points that may be used when dealing with waveguide modes. [2M+4M] (C.O.No.2) [Comprehension]



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**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

TEST-2

Winter Semester: 2021 - 22

Course Code: ECE 319

Course Name: Photonics

Program & Sem: B.Tech & 6th Semester

Date: 1st June 2022

Time: 1:30 PM to 2:30 PM

Max Marks: 30

Weightage: 15%

Instructions:

4. Read the all questions carefully and answer accordingly.
5. Scientific and non-programmable calculators are permitted.
6. All the questions are compulsory.

Part A [Memory Recall Questions]

Answer all the Questions. Each question carries Two marks.

(5Qx 2M= 10M)

10. Grating is basically a varying arrangement of different materials or structures on certain surface, usually periodic. Either _____ or _____ creates refractive index variation. **(C.O.No.2) [Knowledge]**
11. The modulator is a familiar electro-optic device. The modulator works via the _____ effect; the electric field alters the refractive index of the electro-optic material, which in turn causes a _____ to any transiting optical signal **(C.O.No.2) [Knowledge]**
12. Photoelectric effect has found use in electronic devices specialized for light detection. It is a phenomenon in which electrically charged particles are released from or within a material when it absorbs _____. **(C.O.No.3) [Knowledge]**
13. A Photoresistor is generally made of a semiconductor material that is used as resistive element without any PN junction. _____ have semiconductor material with some impurity or we can say they are doped, for better efficiency. **(C.O.No.3) [Knowledge]**
14. Photomultiplier tubes (PMTs) are electron multiplier tubes that utilize the multiplication of electrons by secondary emission to measure _____. **(C.O.No.3) [Knowledge]**

Part B [Thought Provoking Questions]

Answer both the Questions. Each question carries Six marks.

(2Qx6M=12M)

15. PMT was the first device to detect light at the single-photon level, invented more than 80 years ago. They are widely used to this day, particularly in biological and medical applications. Mention the technique to detect light entering a photomultiplier tube to generate an output signal. **(C.O.No.3) [Comprehension]**

16. The light is split into the two interferometer arms with the splitter and later joined in the combiner after the interferometer arms. Obtain the equations which imply that, the light can be switched between the two output ports with the change in the phase from zero to π in Mach Zehnder interferometer. **(C.O.No.2) [Comprehension]**

Part C [Problem Solving Questions]

Answer the Question. The question carries Eight marks.

(1Qx8M=8M)

17. Suppose d is the thickness of a photodetector material and I_0 is the intensity of the incoming radiation. The number of photons absorbed per unit volume of sample is known. What is the thickness of a Ge and $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ crystal layer that is needed for absorbing 90% of the incident radiation at $1.5\mu\text{m}$. Assume the absorption coefficient $\alpha = 6 \times 10^5 \text{ m}^{-1}$ for Ge and $\alpha = 7.5 \times 10^5 \text{ m}^{-1}$ for InGaAs. **(C.O.No.3) [Comprehension]**



**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

END TERM

Winter Semester: 2021 - 22

Course Code: ECE 319

Course Name: Photonics

Program & Sem: B.Tech & VI Semester

Date: 30th June 2022

Time: 9:30 AM to 12:30 PM

Max Marks: 100

Weightage: 50%

Instructions:

7. Read the all questions carefully and answer accordingly.
8. Scientific and non-programmable calculators are permitted.
9. All the questions are compulsory.

Part A [Memory Recall Questions]

Answer all the Questions. Each question carries TWO marks.

(10Qx 2M= 20M)

18. Light has a dual nature known as the wave-particle duality. Photonics is defined as the _____, _____ and _____ of light information and energy whose quantum unit is the photon. (C.O.No.1) [Knowledge]
19. What matter does with the energy from light depends on what kind of light it is and there is a whole spectrum of light called the Electromagnetic Spectrum. What are the 4 major ways light and matter can interact? (C.O.No.1) [Knowledge]
20. Ray optics is the simplest theory of light. Ray optics is concerned with the _____ and _____ of light rays. It is therefore useful in studying image formation-the collection of rays from each point of an object. (C.O.No.1) [Knowledge]
21. Electromagnetic waves can travel along waveguides using a number of different modes. For each waveguide mode there is a definite _____. Below this frequency no signals can propagate along the waveguide, this is known as the _____. (C.O.No.2) [Knowledge]
22. Microwaves propagate through microwave circuits, components and devices, which act as a part of Microwave transmission lines. A _____ is a structure that guides waves, such as electromagnetic waves or sound, with minimal loss of energy by restricting the transmission of energy to _____ direction. (C.O.No.2) [Knowledge]
23. The term "Waveguide dispersion" is the distribution of energy occurring from different speeds or RIs. Waveguide dispersion occurs because light travels in both the _____ and _____ of a single-mode fiber at an effective velocity. (C.O.No.2) [Knowledge]

24. Photodetectors also called photo sensors, are sensors of light or other electromagnetic radiation. In a photodetector, the _____ is converted into voltage or current. A photoresistor is a sensor that changes its resistance when light shines on it. Photoresistor is a variable resistor whose resistance varies inversely with the _____.
(C.O.No.3) [Knowledge]
25. One of the most important components of integrated optics is the waveguide coupler that allows the controlled exchange of optical energy between _____. The operating principle is to use the evanescent field of one waveguide to produce a _____ in the other.
(C.O.No.3) [Knowledge]
26. Machine-learning algorithms are widely used in many areas of engineering and science, with particular strengths in classification, pattern recognition. Mention any two general considerations when applying machine-learning models. (C.O.No.4) [Knowledge]
27. In comparison of machine-learning tuning approaches in ultrafast fibre lasers. Mention two types of Laser system which uses Genetic algorithms. (C.O.No.4) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each question carries EIGHT marks. (7Qx8M=56M)

28. Light is an electromagnetic wave phenomenon described by the theoretical principles that govern all forms of electromagnetic radiation? Because the wavelength of light is relatively short, the techniques used for waves have traditionally differed from those used for electromagnetic waves of longer wavelength. Compared to other low frequency waves, light waves interact with small bodies exhibiting phenomena like diffraction and interference. Can you mention the nature of each of this phenomenon (reflection, refraction, diffraction and interference) accompanied by a short description. (C.O.No.1) [Comprehension]
29. An optical amplifier is a device which receives some input signal and generates an output signal with higher optical power. The amplification occurs in a so-called gain medium, which has to be pumped from an external source. Elucidate the reverse operation of optical attenuator with a neat diagram. (C.O.No.1) [Comprehension]
30. Electromagnetic energy is transmitted in waves. Like sound, it may propagate equally in all directions, the wave energy radiating in concentric shells corresponding to amplitude. Or it may be directional, focused to form a light beam. Depending upon the dimensions of the waveguide transporting the wave, several modes of operation are possible. Mention all such modes along with their characteristics. (C.O.No.2) [Comprehension]
31. An optical waveguide is a physical structure that guides electromagnetic waves in the optical spectrum. They are used as components in integrated optical circuits, as the transmission medium in long distances for light wave communications. Elaborate the configuration of a typical planar dielectric waveguide and classify the waveguide according to different methods. (C.O.No.2) [Comprehension]
32. Photoresistor is the combination of words "photon" (meaning light particles) and "resistor". A photo-resistor is a device or a resistor dependent on the light intensity or light dependent resistors. What happens when light falls on the photoresistor? Similarly, what happens to the photoresistor in absence of light? (C.O.No.3) [Comprehension]

33. If Alexa is asked to design a photodetector, what are the parameters she needs to consider while designing? How is the photodetector implemented at the receiver side of the communication system? (C.O.No.3) [Comprehension]
34. Illustrate machine-learning strategies for optimization and self-tuning of ultrafast fibre lasers using control of intracavity elements via a feedback loop and control algorithm with training procedure and machine assisted operation. (C.O.No.4) [Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each question carries TWELVE marks. (2Qx12M=24M)

35. (a) A beam of light is modeled as a stream of photons, each carrying a well-defined energy that is dependent upon the wavelength of the light. Photons in an orange light have a wavelength of 600nm. What is the energy of this photon?
 (b) The light is split into the two interferometer arms with the splitter and later joined in the combiner after the interferometer arms. Obtain the equations which imply that, the light can be switched between the two output ports with the change in the phase from zero to π in Mach Zehnder interferometer. (C.O.No.1, 2) [Comprehension]
36. Suppose d is the thickness of a photodetector material and I_0 is the intensity of the incoming radiation. The number of photons absorbed per unit volume of sample is known.
- What is the thickness of a Ge and $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ crystal layer that is needed for absorbing 90% of the incident radiation at $1.5\mu\text{m}$. Assume the absorption coefficient $\alpha = 6 \times 10^5 \text{ m}^{-1}$ for Ge and $\alpha = 7.5 \times 10^5 \text{ m}^{-1}$ for InGaAs.
 - Suppose that each absorbed photon liberates an electron in a unity quantum efficiency photodetector and that the photogenerated electrons are immediately collected. Thus, the rate of charge collection is limited by rate of photogeneration. What is the external photocurrent density for the photodetectors in (a) if the incident radiation is $100\mu\text{W mm}^{-2}$? (C.O.No.3) [Comprehension]