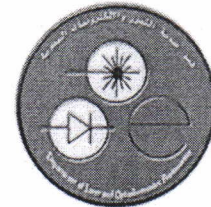




Ministry of Higher Education & Scientific Research
University of Technology
Laser & Optoelectronic Eng. Department
Branch: Optoelectronic Engineering
Class: 3rd Year
Subject: Infrared technology

Final Examination
Time: Three Hours
Date: 1 / 6 / 2016
Examiner: Dr. Suad M. Kadhim
Code: OPE 3306
Academic Year 2015-2016



Attempt Five questions only

- Q1) a) Give the Planck radiation law in terms of power per unit area per unit wavelength interval.
b) Calculate the wavelength of the peak radiation emitted by an object at 200°C. (12 marks)
- Q2) a) Define: Emissivity, Irradiance, Radiant flux, Threshold frequency.
b) The photoelectric threshold wavelength of a tungsten surface is 272nm. Calculate the maximum kinetic energy of the electrons ejected from this tungsten surface by ultraviolet radiation of frequency 1.45×10^{15} Hz. (12 marks)
- Q3) A germanium rod of (10*10*10 mm) with resistance 120Ω. Calculate the density of majority and minority carriers, then calculate the conductivity caused by the minority carriers. Knowing that the rod is p-type and $\mu_h = 0.19 \text{ m}^2/\text{V.s}$, $n_i = 2.5 \times 10^{19} \text{ atom/m}^3$, $\mu_e = 0.39 \text{ m}^2/\text{V.s}$. (12 marks)
- Q4) Explain a typical of an infrared system and state the function of each element. (12 marks)
- Q5) a) Several sources are available for use in infrared system. What are the sources of infrared, and explain two of them.
b) There are two important ways of describing the amount of radiant energy collected by an optical system. State that. (12 marks)
- Q6) a) Explain the Golay pneumatic detector.
b) Practically all optical systems deploy optical filters to optimize their performance. List these optical filters. (12 marks)

Constants

$$q = 1.6 \times 10^{-19} \text{ C}$$

$$h = 6.63 \times 10^{-34} \text{ J.s}$$

$$\text{mass of electron} = 9.1 \times 10^{-31} \text{ kg}$$

Good luck

1

" Infrared technology,
3rd years

Solution

Q1/a

$$M(\lambda) = \frac{C_1}{\lambda^5} \frac{1}{e^{c_2/\lambda T} - 1}$$

b/ $\lambda_{\max} = \frac{2.898 \text{ mm} \cdot \text{K}}{T}$

$$= \frac{2.898 \text{ mm} \cdot \text{K}}{(200 + 273) \text{ K}} = \frac{2.898 \text{ mm} \cdot \text{K}}{473 \text{ K}}$$

$$= 6126 \text{ nm}$$

Q2/a)

① Emissivity :- Is a function of wavelength, temperature, body material and surface conditions of the radiating body.

$$\epsilon(\lambda, T) = \frac{M(\lambda, T)_{\text{source}}}{M(\lambda, T)_{\text{blackbody}}}$$

2- Irradiance ϕ It is the radiant flux incident on a surface of unit area. The unit in which it is measured $\text{W}\cdot\text{m}^{-2}$ are the same as those used for radiant emittance. $H = \frac{J}{d^2}$

3- Radiant flux ϕ It is the measure of the time rate of transfer of radiant energy and is given in watt.

4- Threshold frequency ϕ It is a minimum frequency, when the frequency of ~~incident~~ light incident is less than from threshold frequency no photoelectrons at all were emitted from surface.

$$\begin{aligned}
 b/ \quad E &= hf - \phi = hf - \frac{hc}{\lambda_0} \\
 &= h \left[1.45 \times 10^{15} \text{ Hz} - \frac{3 \times 10^8}{272 \times 10^{-9}} \right] \\
 &= 2.3 \times 10^{-19} \text{ J}
 \end{aligned}$$

Q3/

$$\textcircled{1} \alpha = \frac{1}{R} \cdot \frac{L}{A}$$

$$= \frac{10 \times 10^{-3}}{120 \times 10 \times 10 \times 10^{-6}} = 0.83 (\Omega \cdot m)^{-1}$$

$$P = \frac{\alpha}{q \mu_n} = \frac{0.83}{1.6 \times 10^{-19} \times 0.19} = 2.7 \times 10^{19} / m^3$$

$$\textcircled{2} n = \frac{n_i^2}{P} = \frac{(2.5 \times 10^{19})^2}{2.7 \times 10^{19}} = 2.3 \times 10^{19} / m^3$$

$$\alpha = n e \mu_n = 2.3 \times 10^{19} \times 1.6 \times 10^{-19} \times 0.39$$

$$= 1.4 (\Omega \cdot m)^{-1}$$

Q4/

1- The target :- Is the object of interest, usually the real reason for the existence of the system, it's assumed that the target radiates energy somewhere in the infrared portion of the spectrum.

2- Attenuating atmosphere :- If the radiation from the target passes through any portion of the earth's atmosphere, it will be attenuated because the atmosphere is not perfectly transparent.

2.2

1. The first part of the problem is to find the value of $\frac{1}{x}$ when $x = 1.01$.

$$\frac{1}{1.01} = \frac{1}{1 + 0.01} = 1 - 0.01 + 0.01^2 - 0.01^3 + \dots$$

2. The second part of the problem is to find the value of $\frac{1}{x}$ when $x = 1.02$.

$$\frac{1}{1.02} = \frac{1}{1 + 0.02} = 1 - 0.02 + 0.02^2 - 0.02^3 + \dots$$

~~$$1.01 \times 1.02 = 1.0302$$~~

3. The third part of the problem is to find the value of $\frac{1}{x}$ when $x = 1.03$.

2.3

The above results show that the value of $\frac{1}{x}$ is approximately 1 when x is close to 1. This is because the function $f(x) = \frac{1}{x}$ is continuous at $x = 1$. The function $f(x)$ is continuous at $x = 1$ because the limit of $f(x)$ as x approaches 1 is equal to $f(1)$.

The above results also show that the value of $\frac{1}{x}$ is approximately 1 when x is close to 1. This is because the function $f(x) = \frac{1}{x}$ is continuous at $x = 1$. The function $f(x)$ is continuous at $x = 1$ because the limit of $f(x)$ as x approaches 1 is equal to $f(1)$.

3-Optical receiver:- The optical receiver which is closely analogous to a radar antenna, collects some of the radiation from the target and delivers it to an optical modulation.

4-Optical modulation:- It is coded with information concerning the direction to the target or information to assist in the differentiation of the target from unwanted details in the background.

5-The detector:- which converts the information into an electrical signal.

Q5/a

- 1- The Nernst Glower
- 2- Glowbar Lamp
- 3- Tungsten Filament Lamp
- 4- Carbon Arc Lamp
- 5- The Laser

Carbon Arc Lamp:-

- A- Low-intensity arc Lamps
- B- Flame arc Lamp
- C- High-intensity arc Lamps

1. The first step is to identify the problem and its scope. This involves understanding the current situation and the goals that need to be achieved. It is important to involve all relevant stakeholders at this stage to ensure that the problem is well-defined and that the goals are realistic and achievable.

2. The second step is to develop a plan of action. This involves identifying the specific steps that need to be taken to address the problem and achieve the goals. The plan should be detailed and specific, outlining the tasks, responsibilities, and timelines for each step. It is also important to consider potential risks and contingencies in the plan.

3. The third step is to implement the plan. This involves putting the plan into action and monitoring progress. It is important to communicate the plan to all relevant stakeholders and to ensure that they understand their roles and responsibilities. Regular communication and reporting are essential to ensure that the plan is being followed and that progress is being made.

4. The fourth step is to evaluate the results. This involves assessing the outcomes of the plan and determining whether the goals have been achieved. Evaluation should be based on objective criteria and should involve all relevant stakeholders. If the goals have not been achieved, it is important to identify the reasons for this and to develop a new plan or modify the existing one.

5. The fifth step is to document the results. This involves recording the outcomes of the plan and the lessons learned. Documentation is important for future reference and for sharing the results with others. It should include a clear description of the problem, the plan, the implementation, and the results.

1. The first step is to identify the problem and its scope.
2. The second step is to develop a plan of action.
3. The third step is to implement the plan.
4. The fourth step is to evaluate the results.
5. The fifth step is to document the results.

6. The sixth step is to review the process. This involves reflecting on the entire process and identifying areas for improvement. It is important to consider what worked well and what did not, and to use this information to inform future planning and implementation. Review should be a continuous process, with regular opportunities for reflection and improvement.

b/ Radiant energy :- This term is used to describe the entire amount of energy radiant from a source in given time interval.

It also describes the energy received by an accumulative or integration type of detectors, such as the photographic plate.

Q6/a

Golay Pneumatic detectors.

These detectors are in fact rather complex instruments that were first described by Golay in 1977. The responsivity of this detectors is specified as $(1.5 - 3 \times 10^6 \text{ V/W})$. The maximum input is specified as $2.3 \times 10^{-6} \text{ W}$ and NEP as $7 \times 10^{-11} \text{ W}$. This value is lower than NEP of the ideal thermal detector.

- b/
- 1- Band-Pass Filters (BPFs)
 - 2- Low-Pass Filters (LPFs) and High-Pass Filters (HPFs)
 - 3- Add-Drop Filters
 - 4- IR Absorbing Filters
 - 5- Dielectric Heat Rejection Filters (DHRFs)
 - 6- Dielectric Hot-Mirror Filters (DHMFs)
 - 7- Tunable Filters :-
 - A- Fiber Optic Tunable Filters (FOTFs)
 - B- Tunable Filters for Military and commercial Applications.

