

M. Sc. (Physics) 1st Semester Examination 2020 (CBCS)
PHY 414 (Electronics and Instrumentation)
Full Marks – 50 Time: 2.5 Hours

(2 hours for answering and 30 minutes for downloading, scanning and uploading)

Instructions:

(a) Write your Examination Roll Number and Registration Number (if you have received it) at the top of your answer script.

(b) Do not write your name or class roll number anywhere.

(c) Write page number on top of each page.

(d) Scan the complete answer script into a single pdf file and mail it to the e-mail from where you got this question paper.

(e) The answer script file for the paper PHYAAA (where AAA is the paper code like 411, 412, 413 and 414) must be named as instructed. Note that your Examination Roll Number is of the form $ZZZ/PHY/XXXXXX$, where ZZZ is the college identifier (like C91, 031, etc.), and $XXXXXX$ is a 6-digit number like 201099.

--- For CU students, the filename for the paper PHYAAA must be $XXXXXXPHYAAA.pdf$. For example, the script of PHY414 coming from C91/PHS/201099 must be named 201099PHY414.pdf.

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Answer any five of the following questions

1. Derive expressions for the electron and hole concentration in an intrinsic semiconductor. Using these two expressions show that the position of Fermi energy level is halfway between the valence band and conduction band. Also find an expression to show the temperature dependence of band gap energy. **3+3+2+2**

2. Write down the continuity equation in a P- type and in a N- type semiconductor. Hence derive expressions for the emitter current (I_E) and collector current (I_C) for a P-N-P transistor in the Ebers-Moll form. How can these expressions be represented in a matrix form? **1+8+1**

- 3.(a) Draw schematic diagram of a Smith chart and discuss its properties. **1+3**
 (b) Show that the impedance or admittance at any point of a short-circuited transmission line is always reactive. **2**
 (c) Derive an expression for the line impedance on a transmission line in terms of its load impedance and the characteristic impedance. Also show, how it can be written in terms of reflection coefficient at that point. **3+1**

4.(a) A metal-semiconductor junction is formed at temperature T, with a metal and n-type semiconductor, where ϕ_m (work function of the metal) > ϕ_s (work function of the semiconductor). Comment on the nature of the I-V curve. Draw the equilibrium band diagram after contact and indicate the position of the barrier height (ϕ_B) and built-in potential (V_{bi}). **2+3**

(b) Show that, for a Light Emitting Diode (LED) high injection efficiency (η_i) can be ensured by making an asymmetric junction. **5**

5. (a) Draw the tunnel diode characteristic curve. Explain the curve with the help of band diagram for various biasing condition: i) small reverse bias ii) small forward bias and iii) increased forward bias. **5**

(b) Draw the I-V curve of a p-n junction diode under illumination. Obtain the expression for short circuit current (I_{SC}) and open circuit voltage (V_{OC}) of a solar cell. **1+4**

6. (a) Give the circuit diagram of a class B power amplifier using two transistors and explain why the even harmonics are absent at its output. Calculate the maximum efficiency of a class B amplifier. **1+2+4**

(b) Obtain an expression for the Butterworth polynomial of a first order low pass filter. **3**

7.(a) ^{137}Cs has a half-life of 27 years. Show that, the probability of observing x decays can be expressed by Poisson distribution. **3**

(b) State the working principle of a Pirani Gauge. **3**

(c) x and y are directly measured independent variables whose standard deviations are σ_x and σ_y , respectively. If the derived variable $u = xy$ has the standard deviation σ_u , then show that

$$\left(\frac{\sigma_u}{u}\right)^2 = \left(\frac{\sigma_x}{x}\right)^2 + \left(\frac{\sigma_y}{y}\right)^2 \quad \mathbf{4}$$