

MAHATMA GANDHI UNIVERSITY, KOTTAYAM
MGU-UGP (HONOURS) Exam Type EXAMINATION Month YYYY
Semester 5

Discipline Specific Elective (DSE)- MG5DSEPHY300 –
SEMICONDUCTOR OPTOELECTRONIC DEVICES

(2024 ADMISSION ONWARDS)

Duration: 2 hours

Maximum Marks: 35

Record: 5 Marks

Attempt the question marked 'X'. Change of question is not allowed. (30 Marks).

Error analysis should be done wherever possible.

Remember(K), Understand(U), Apply(A), Analyse(An), Evaluate(E), Create(C), Skill(S), Interest(I)
and Appreciation(Ap)

1. Study the V-I characteristics of LEDs emitting two different wavelengths and compare their turn-on voltages. [S]/[CO5]
2. Study the V-I characteristics of a LED. Find the DC and AC resistances. Also find the turn-on voltage [S]/[CO5]
3. Determine Planck's constant using at least 3 LEDs. [S]/[CO5]
4. Graphically determine Planck's constant using at least 3 LEDs. [S]/[CO5]
5. Design a LED driver circuit employing a constant current source using an op-amp and transistor and study its performance. [S]/[CO5]
6. Determine the diameter of a thin wire using laser diffraction. [S]/[CO5]
7. Measure the divergence of an edge-emitting diode laser beam by measuring the dimensions of the beam projected onto a screen at different distances. [S]/[CO5]
8. Measure the diameter (beam spot size) of the laser beam. [S]/[CO5]
9. Study the optical modulation in a fibre optic communication link. [S]/[CO5]
10. Study the modulation characteristics of a Light Emitting Diode. [S]/[CO5]
11. From the given absorption/transmission data, plot the graph (using suitable software) and obtain the bandgap of a semiconductor. [S]/[CO5]
12. From the given absorption/transmission data, plot the graph (using suitable software) and obtain the absorption coefficient (of a semiconductor). [S]/[CO5]
13. Determine the wavelength of the given laser. A wire of known thickness is given. [S]/[CO5]
14. Compare the divergence of a He-Ne laser and a semiconductor laser. [S]/[CO5]
15. From the data obtained from the diffraction pattern of a thin wire using a laser, plot a graph and find the thickness of the wire. [S]/[CO5]

QP Code: _____

Reg. No.:

Name :

MAHATMA GANDHI UNIVERSITY, KOTTAYAM MGU-UGP (HONOURS) EXAMINATION

Semester 5: MODEL QUESTION PAPER(PRACTICAL)

Computational Physics: Python

MG5DSEPHY301

Time: 2.00 Hours

Maximum Marks: 30

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1. **Freely Falling Body** Write a Python program to simulate the motion of a freely falling body dropped from a height $h = 100$ m. Plot (i) Position Vs Time, (ii) Kinetic Energy Vs height, (iii) Potential Energy Vs height, and (iv) KE, PE, and Total Mechanical Energy Vs height on the same graph. Take mass $m = 1$ kg and $g = 9.8$ m/s². Verify the conservation of mechanical energy from the plot.
 2. **Variation of Acceleration due to Gravity with Altitude** Write a Python program to calculate and plot the variation of acceleration due to gravity g with altitude (h) ranging from 0 to 1000 km above the Earth's surface. Use the values: $g_0 = 9.8$ m/s², radius of Earth $R = 6371$ km. From the plot, find the altitude at which g reduces to half its surface value.
 3. **Simple Harmonic Motion:** Write a Python program to simulate simple harmonic motion of a particle of mass $m = 1$ kg, spring constant $K = 4$ N/m, and amplitude $A = 1$ m. Plot (i) the displacement-time trajectory, (ii) the phase space trajectory (velocity Vs displacement), and (iii) variation of KE, PE, and total energy with position. Verify energy conservation from the plots.
 4. **Projectile Motion** Write a Python program to simulate projectile motion for initial velocity $u = 20$ m/s and projection angle $\theta = 45^\circ$. Plot (i) the trajectory (y Vs x), (ii) the phase space plot (v_y Vs v_x), and (iii) KE, PE, and total mechanical energy as a function of time. Find the maximum height, range, and time of flight from the simulation and compare with analytical values.
 5. **Damped Harmonic Motion** Write a Python program to numerically solve the equation of motion of a damped harmonic oscillator with mass $m = 1$ kg, spring constant $K = 4$ N/m, for three damping coefficients $b = 0.5$ (underdamped), $b = 4$ (critically damped), and $b = 8$ (overdamped). Plot (i) displacement Vs time for all three cases, (ii) the phase space trajectory (velocity Vs displacement), and (iii) variation of KE, PE, and total energy with position for the underdamped case. Compare the nature of oscillations in each case.
 6. Determine the accuracy and processing time for different step sizes by solving algebraic equations using the Bisection and Newton-Raphson methods. Then, plot the error vs step size.
 7. Solve the differential equation of a simple pendulum numerically (using the Euler and Runge-Kutta techniques), compare the result with analytical solutions, and plot the results for various initial conditions.
 8. Use the Trapezoidal Rule, Simpson's 1/3-Rule, and Simpson's 3/8-Rule to fine-tune the definite integral of a given function. Then, compare the accuracy to the analytical solution. Plot the error vs. step size while repeating the experiment with various step sizes.

9. Find the maximum height of a projectile, its horizontal range, and its time of flight for varying initial velocities and projection angles.
10. Examine how the diffraction pattern varies with the slit width and wavelength of a monochromatic light source while examining diffraction patterns caused by a single slit.
11. Plot the intensity pattern for the Fresnel and Fraunhofer diffraction of monochromatic light by a single slit for different slit widths and screen distances.
12. Trace the 3-dimensional trajectory of an electron travelling in a homogeneous perpendicular electric and magnetic field
13. Examine the trajectory and phase space trajectory of a damped harmonic oscillator for various damping coefficients, (solve the differential equation numerically) and compare it with the analytical solutions.
14. Using two oscillatory functions of varying frequency and amplitude, illustrate various kinds of Lissajous figures.
15. Using the Monte Carlo method obtain the value of π (pi).
16. Using Monte Carlo technique, calculate the value of the given integral. Compare your result with the value obtained by analytical method.
17. Solve radioactive decay law to plot the number of nuclei remaining without disintegration (N) after a time t for a sample of known decay constant. From this evaluate the activity of the given sample. or similar codes suggested by the instructor.

MAHATMA GANDHI UNIVERSITY, KOTTAYAM
MGU-UGP (HONOURS) MODEL QUESTION PAPER (PRACTICAL)
SEMESTER FIVE
PHYSICS OF ATMOSPHERE
(2024 ADMISSION ONWARDS)

Duration: 2 hrs

Maximum Marks: 30

Analyse (An), Evaluate (E)

All listed practicals are examination options. The examiner shall assign one practical; the assigned practical carries 30 marks. [CO4]

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| 1. Analyse the variation in ground level air temperature at a location over a period of time from an automatic weather station and estimate basic statistics. | [An, E]
[CO4] |
| 2. Analyse the variation in ground level humidity at a location over a period of time from an automatic weather station and estimate basic statistics. | [An, E]
[CO4] |
| 3. Analyse the variation in ground level wind speed and direction at a location over a period of time from an automatic weather station and estimate basic statistics. | [An, E]
[CO4] |
| 4. Analyse the variation in rainfall at a location over a period of time from an automatic weather station and estimate basic statistics. | [An, E]
[CO4] |
| 5. Analyze the air quality index at a location from the Central Pollution Control Board and monitor air quality over a period of time. | [An, E]
[CO4] |
| 6. Study and interpret meteorological charts (identification of isobaric patterns, signs and symbols) from the India Meteorological Department (IMD). | [An, E]
[CO4] |
| 7. Analyze monsoon charts from the India Meteorological Department (IMD) and identify the features/trends. | [An, E]
[CO4] |
| 8. Using radiosonde data over any location, analyse the vertical profile of temperature and estimate various geophysical parameters (tropopause height, boundary layer height, lapse rate) over a period of time. | [An, E]
[CO4] |
| 9. Using radiosonde data over any location, analyse the vertical profile of humidity to identify the cloud layers for a period of time and compute their statistics. | [An, E]
[CO4] |
| 10. Estimate convective available potential energy and convective inhibition, and analyse them for different events (clear days, cloud days, cyclone events, etc.). | [An, E]
[CO4] |
| 11. Study and interpret Doppler weather radar graphs over any location from the India Meteorological Department (IMD). | [An, E]
[CO4] |
| 12. Analyze any five climate indices and interpret the observations. | [An, E]
[CO4] |
| 13. Plot the tracks of any five cyclone storms over the Indian subcontinent (https://rsmcnewdelhi.imd.gov.in/report.php?internal_menu=MjY) and analyse the observations. | [An, E]
[CO4] |
| 14. Intercompare the rainfall data from numerical weather prediction models over the Indian region with satellite data. | [An, E]
[CO4] |
| 15. Measure atmospheric pressure using different instruments and analyze the data. | [An, E]
[CO4] |
| 16. Measure ground-level ozone concentration and analyze its variation. | [An, E]
[CO4] |
| 17. Measure the surface albedo at different locations and analyze its spatial variation. | [An, E]
[CO4] |

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| 18. Analyze aerosol properties using available solar radiometer data. | [An, E]
[CO4] |
| 19. Analyze aerosols using available satellite-based sensor data. | [An, E]
[CO4] |
| 20. Analyse the variation of surface temperature at different locations using infrared thermometer/remote sensing technique. | [An, E]
[CO4] |
| 21. Measure the spectral response of various bodies using a spectrometer. | [An, E]
[CO4] |
| 22. Examine the difference between radiation fluxes computed with and without aerosols using a radiative transfer model (e.g., SBDART). | [An, E]
[CO4] |
| 23. Investigate how surface irradiance depends on the combined effects of cloud optical depth and surface albedo using a radiative transfer model. | [An, E]
[CO4] |
| 24. Compute the spectral surface irradiance in the thermal IR for three cases: clear skies, and high-altitude clouds of optical depth 1 and 5. | [An, E]
[CO4] |
| 25. Estimate the future change in any two atmospheric variables for a given warming scenario using IPCC WG1 Interactive Atlas Simple Climate Futures (https://interactive-atlas.ipcc.ch/). | [An, E]
[CO4] |

QP CODE:

Reg. No. :.....
Name :.....

MAHATMA GANDHI UNIVERSITY, KOTTAYAM
MGU-UGP (HONOURS) MODEL QUESTION PAPER (THEORY)
SEMESTER FIVE
MG5DSEPHY303– Laser, Non-linear Optics and Fiber Optics
(2024 ADMISSION ONWARDS)

Duration: 1.5 hrs

Maximum Marks: 50

***Remember(K), Understand(U), Apply(A), Analyse (An), Evaluate(E), Create(C), Skill(S),
Interest(I) and Appreciation (Ap)***
*Students should attempt at least one question from each course outcome to enhance their overall
outcome attainability.*

Part A

Short Answer Type Questions
Answer any **10** questions
Each question carries **2** Mark

1. Distinguish between a two-level and three-level laser system. [A][1]
2. What is the function of a resonator in a laser? [U][1]
3. Write down the Schawlow-Townes condition for laser oscillation and explain each term in it. [K][1]
4. Sketch the energy level diagram of a He-Ne laser. [U][1]
5. Define Q-switching and how it can be achieved? [U][2]
6. Compare the intensities of a mode-locked and mode-unlocked laser beam. [U][2]
7. What is meant by third harmonic generation? [U][3]
8. Explain self-focusing of laser beam. [U][3]
9. Distinguish between TE and TM modes in a slab waveguide [A][4]
10. Which are the two low-attenuation transmission windows in a silica glass optical fibre. Which unit is normally used to express the attenuation in an optical fibre. [U][4]
11. Sketch the schematic of a fibre optic communication system. [A][4]
12. Distinguish between step index and graded index optical fibre. [A][4]

[2×10 = 20]

Part B

Short Essay Type Questions

Answer any **6** questions

Each question carries **5** Mark

13. Obtain the expression for the number of resonant frequencies within an open resonator. [U][1]
14. With the help of a proper schematic diagram and energy level diagram, explain the construction and working of a ruby laser. [A][1]
15. Obtain the condition that must be satisfied to get stimulated emission from a semiconductor laser. [U][1]
16. Explain how Q-switching can be achieved in a laser using Kerr effect. [U][2]
17. What is meant by second harmonic generation? Prove that only non-centrosymmetric crystals can exhibit second harmonic generation. [U][2]
18. A laser operating at a pump wavelength of $\lambda_p = 360$ nm pumps a non-linear crystal to produce parametric generation. If the desired signal wavelength is $\lambda_s = 546$ nm: (1) Calculate the frequency of the pump photon ω_p and signal photon ω_s . (2) Determine the idler frequency and its corresponding wavelength [A][2]
19. Obtain the expression for the characteristic penetration depth of an evanescent wave in an optical fibre. [U][3]
20. A Fiber Bragg Grating is to be fabricated to reflect a target centre wavelength $\lambda_0 = 1300$ nm in a silica fibre core with effective refractive index $n = 1.5$. (i) Calculate the required grating pitch/spacing. (ii) Calculate the effective velocity of this wavelength inside the fibre. [A][3]

[5×6 = 30]

QP Code: _____

MAHATMA GANDHI UNIVERSITY, KOTTAYAM

MGU-UGP (HONOURS) REGULAR PRACTICAL EXAMINATION MODEL

QUESTION PAPER

PHYSICS OF ADVANCED MATERIALS

(2024 ADMISSION ONWARDS)

Duration: 2 Hours

Maximum Marks: 35

Record: 5 Marks

1. From the given experimental data, perform the thermal analysis of the material. Plot the appropriate graph, carry out the necessary calculations, and determine the required thermal parameter(s).
[A]/[CO6]
2. Study the variation of resistance with temperature for a carbon film resistor, metal wire, semiconductor and thermistor. Plot suitable graphs and compare their temperature dependence.
[A]/[CO6]
3. Using the given absorption-spectrum data, determine the band gap energy of the material and identify whether the optical transition is direct or indirect using the Tauc relation. Show all relevant calculations and graphical analysis. [A]/[CO6]
4. Determine the absorption coefficient of the given solution and study its dependence on path length and concentration using the supplied experimental data. [A]/[CO6]
5. Determine the specific rotation of the given optically active substance from the experimental observations. Include the relevant formula, observations, calculation and final result with proper units.
[A]/[CO6]
6. Determine the frequency dependence of the dielectric constant of the given material. Tabulate the observations, perform the required calculations and represent the variation graphically. [A]/[CO6]
7. Determine the temperature dependence of the dielectric constant of the given material. Record the observations, calculate the dielectric constant and plot the variation with temperature. [A]/[CO6]
8. Using Lee's disc method, determine the thermal conductivity of the given bad conductor. Include all measurements, formulae, calculations and the final result with proper units. [A]/[CO6]
9. Determine the dielectric constant of the given thin sheet using the prescribed experimental method. Show the observations, calculations and final result. [A]/[CO6]
10. Determine the refractive index of the given glass using the liquid-lens method or spectrometer method. Include the necessary observations, calculations and final result. [A]/[CO6]
11. Using the prescribed bending/elongation method, determine the Young's modulus of the given polymer composite (wood). Include observations, calculations and the final result with proper units.
[A]/[CO6]
12. Draw the B–H hysteresis curve of the given ferromagnetic material and determine its retentivity and coercivity from the curve. Clearly indicate the relevant quantities on the graph. [A]/[CO6]

- 13.** Perform the Hall-effect experiment on the given semiconductor and determine the Hall coefficient, carrier concentration and mobility. Include observations, calculations and final results with proper units. [A]/[CO6]
- 14.** Using the four-probe method, determine the resistivity of the given semiconductor and hence determine its energy band gap from the temperature dependence of resistivity. Show all observations, graphs, calculations and final results. [A]/[CO6]

MAHATMA GANDHI UNIVERSITY, KOTTAYAM
MGU-UGP (HONOURS) V SEMESTER PRACTICAL EXAMINATION
DSE: MG5DSEPHY307 - OP AMP AND LINEAR INTEGRATED CIRCUITS

Duration: 2 hrs

Maximum Marks: 35

Record: 5 Marks

Attempt the question marked 'X'. Change of question is not allowed (30 marks)

1. Design and construct an op-amp based square-wave generator. Generate a square wave of the specified frequency and verify the output waveform using CRO/DSO. [A, An, S, C][5]
2. Design and construct a first-order active low-pass filter using an op-amp. Analyse the variation of gain with frequency by plotting the frequency response graph. [A, An, S, C][5]
3. Design and construct a first-order active high-pass filter using an op-amp. Analyse the variation of gain with frequency by plotting the frequency response graph. [A, An, S, C][5]
4. Construct an op-amp based Pulse Width Modulation (PWM) circuit. Generate a PWM signal and study the variation of pulse width with the input control voltage. [A, An, S, C][5]
5. Construct and test an op-amp based A/D converter. Apply suitable analog input voltages and verify the corresponding digital output. [A, An, S, C][5]
6. Design and construct an op-amp summing amplifier. Apply two or more inputs and verify the relationship between the input voltages and the output voltage. [A, An, S, C][5]
7. Design and construct inverting, non-inverting and buffer amplifiers using op-amp. Obtain the voltage gain for each configuration using AC input voltages. [A, An, S, C][5]
8. Design and construct an op-amp differential amplifier. Apply two input signals and verify the differential amplification by measuring the output voltage. [A, An, S, C][5]
9. Construct an op-amp integrator circuit. Apply a suitable input waveform and observe the integrated output waveform. Verify the theoretical relationship between input and output. [A, An, S, C][5]
10. Construct an op-amp differentiator circuit. Apply a suitable input waveform and observe the differentiated output waveform. Verify the theoretical relationship between input and output. [A, An, S, C][5]
11. Construct an op-amp current-to-voltage (I–V) converter. Verify the current-to-voltage conversion relationship by applying different input currents and measuring the corresponding output voltages. [A, An, S, C][5]
12. Construct and study an op-amp voltage follower. Apply different input voltages and verify that the output voltage follows the input voltage with unity voltage gain. [A, An, S, C][5]