 UG/4th Sem/PHY/19(Pr.)

2019

B.Sc.

4th Semester Examination

PHYSICS (Honours)

Paper - C8P

[Practical]

Full Marks : 20 Time : 3 Hours

The figures in the margin indicate full marks. Candidates are required to give their answers in their own words as far as practicable.

Marks Distribution

[Experiment - 15; LNB - 2; Viva-voce - 3]

Answer any *one* question.

1. Write down the program to obtain a cosine series expansion of the function $f(x)=1+x$ valid in the interval $0 \leq x \leq 2$ hence evaluate

[Turn Over]

$$\frac{1}{1^2}+\frac{1}{3^2}+\frac{1}{5^2}+\ldots=\frac{\pi^2}{8}$$ 8+7

2. (a) Write a Python program to solve the differential equation :

$$\frac{d^2y}{dt^2}+2\frac{dy}{dt}+y=0$$ subject to the conditions

$y(0)=0$ and $y'(0)=1.0$. Show the result.

6+2

(b) Write a Python program to evaluate $\sin\theta$ and show the results for specified values of θ.

5+2

3. (a) Write a Python program to evaluate the Fourier coefficients of the following function :

$$f(x)=\begin{cases}0 & \text{for} \quad -2\le x<0\\ 4 & \text{for} \quad 0\le x<2\end{cases}$$

(b) For the above problem write a Python program to plot f (x). Show the results. 6+5+4

4. (a) Write a Python program to show the orthogonality of Legendre polynomials :

$$\int_{-1}^{+1} P_m(x)\, P_n(x)\, dx = \delta_{m,n}$$

Show the result. 6+2

(b) Write a Python program to make a plot of $P_n(x)$. Show the result. 5+2

5. (i) The differential equations governing the loop current i and charge q on the capacitor of the electric circuit shown are

$$L\frac{di}{dt} + Ri + \frac{q}{c} = E(t),\ \frac{dq}{dt} = i$$

If the applied voltage E is suddenly increased from 0 to 9V, plot the resulting loop current during the first 10 seconds. Use $R = 1.0\,\Omega$, $L = 2\ H$, $C = 0.45F$.

(ii) Analyse a triangular wave as Fourier series. Plot the triangular wave window and the Fourier sum for 10 terms on top of that to show as a reasonable agreement.

6. (i) Do a Fourier transform of a sine wave signal with a pure frequency, $f(t) = \sin(2\pi\nu t)$, sampled for $t = k\Delta t$, with k = 0, 1, 2, ...N – 1. Set N = 8. Print the result.

(ii) Consider the set of measured values :

x	1	2	3	4	5
y	0.5	3.8	7.9	16.5	27.3

Fill the data with a user defined function (Try quadratic). Plot the scattered data along with the fitted line graph over it.

7. (i) The period of a pendulum of length L oscillating at a large angle α is given by

$$T = T_0 \frac{\sqrt{2}}{\pi} \int_0^{\alpha} \frac{d\theta}{(\cos\theta - \cos\alpha)^{1/2}}$$

where $T_0 = 2\pi\sqrt{\frac{L}{g}}$ is the period of the same pendulum at small amplitude. The numerical evaluation of the Integral may fail. Try and explain. If we change the variable, $\sin\theta/2 = \sin\alpha/2\sin\varphi$, we get

$$T = \frac{2T_0}{\pi}\int_0^{\pi/2}\frac{d\phi}{\left(1-\sin^2\alpha/2\sin^2\varphi\right)^{1/2}}$$ which is

a well behaved integral. Now, write a program for Simpson's 1/3 rd rule to solve this integral and also by a Gaussian Quadrature function imported from Scipy.

Calculate the ratio T/T_0 for amplitudes $0° \le \alpha \le 90°$ and plot.

(ii) Evaluate error function *erf* (x) for a set of x-values between [–4, 4] and plot.

8. (a) Write a Python program to find the Fast Fourier Transform of the function, $f(x) = e^{-x^2}$.

(b) Write a program to show the spectrum for the above function. 8+7

[*Turn Over*]

9. (a) Write a Python program to solve the differential equation,

$$\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} + y = 0$$

subject to the conditions as specified by examiner. Show the output. 6+2

(b) Write a Python program to find the two square roots of (–5 + 12j). Show the outputs. 5+2

10. (i) The following function represents the electrostatic potential in spherical polar coordinates due to a ring of charge $q = 1$ and radius $R = 1$ placed in the X-Y plane :

$$\phi(r, \theta) = \sum_{n=0}^{\infty} \frac{r_{min}^{\ n}}{r_{max}^{\ n+1}} P_n(\cos\theta) P_n(0)$$

Where P_n's are the Legendre Polynomials of degree n, and $r_{min} = \min(r, 1)$, $r_{max} = \max(r, 1)$. Use Special function module to evaluate the potential for x and y in the range [–4, 4]. Plot the ϕ vs r.

(ii) Establish numerically, that for any real numbers p and m,

$$e^{2mj\cot^{-1} p}\left(\frac{pj+1}{pj-1}\right)^{m}=1.$$