PHSA - Paper VIIB

Full marks 50 Time 2 hours

Answer any *one* Question

1. (a) Draw the necessary circuit diagram for drawing $B-H$ loop of a specimen given in the form of an anchor ring. For calibration of the galvanometer use standard solenoid.

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Given:

no. of turns per unit length of the primary of the anchor ring	n_1	$440m^{-1}$
no. of turns in the secondary of the anchor ring	n_2	54
no. of turns per unit length of the primary of the solenoid	n_3	$620m^{-1}$
no. of turns in the secondary of the anchor ring	n_4	6000
mean diameter of the core of the anchor ring	D_1	$0.015m$
mean diameter of the primary of the solenoid	D_2	$0.0265m$
mean value of $\frac{I}{d}$ (When current in the primary of the solenoid changes from $+I$ to $-I$, d is the deflection on the galvanometer scale)	$\frac{I}{d}$	$25.4A/m$

(b) Let the values of the magnetic field within the specimen are B_1 and B_2 when magnetizing current (through the primary of the anchor ring) values are I_1 and I_2 respectively. When current changes from I_1 to I_2, galvanometer shows a deflection d_1. Express $(B_1 - B_2)$ in terms of d_1, $\frac{I}{d}$ and the constants, mentioned in the above table.

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(c) Given: $I_1 = 3.5A$

I_2 (A)	d_1 (cm)
-3.5	20.6
3.0	0.4
2.5	0.6
2.0	1.0
1.5	1.6
1.0	2.0
0.5	3.0
0.25	4.1
0.0	4.7
-0.25	7.0
-0.5	11.5

Find B_1, H_1. For all I_2 (given), find B_2, H_2.

(3 + 3) + (6 + 6)

(d) Draw the part of $B-H$ loop with the data you have (use only B_2 and H_2 values that you have calculated).

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(e) i. At which step/steps of the experiment you need to demagnetize the specimen?
ii. Can you perform the experiment of drawing $B-H$ loop without using the solenoid? Justify your answer briefly.

4 + 6

2. (a) i. Write the relationship between fringe width β, separation between virtual sources d, source to screen distance D and wavelength of the light λ used in Fresnel biprism experiment.

ii. What is index error? How the above mentioned relationship will be modified if you incorporate correction for index error x?

iii. How can you remove index error without finding its actual value? Write the necessary formula.

$3 + (3 + 3) + 3$

(b) The following sets of data are obtained in a Fresnel biprism experiment with monochromatic light.

Fringe Position

SET I $D = 75cm$			SET II $D = 60cm$	
Serial no. of fringe	Reading at fringe position cm		Serial no. of fringe	Reading at fringe position cm
1	12.01		1	10.96
2	12.21		2	11.12
3	12.41		3	11.28
4	12.61		4	11.44
5	12.81		5	11.60
6	13.01		6	11.76
7	13.21		7	11.92
8	13.41		8	12.08

Position of real images of the source

lens position	position of left image cm	position of right image cm
near eye piece	9.90	10.75
far from eye piece	9.38	15.24

Calculate fringe widths and separation between virtual sources. Hence find the wavelength of the light used.

$(9 + 9) + 6 + 4$

(c) Let you have a set of data (D_i, β_i) for $i = 1, 2, 3, \cdots$. If β_is are plotted against D_is, how the graph will look like? (Comment and draw.) From the graph how can you find the wavelength of the light used and index error?

$(2 + 2) + (3 + 3)$

3. A parallel beam of light of wavelength λ is incident normally on a plane transmission grating.

(a) Write the condition of getting principal maximum in the diffraction pattern in terms of separation between slits (d), angle of diffraction (θ), wavelength of light (λ) and order number (n)

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(b) Given data:

order number	wavelength nm	reading at left positions of spectral lines degree
2	587.6	224.27
	492.2	216.67
	447.1	214.58
	402.6	212.07
1	587.6	200.67
	492.2	197.63
	447.1	196.48
	402.6	195.70

Direct reading of the telescope : 180.32 degree

Calculate the angle of diffraction (θ) for all the observations.

6 + 6

(c) Plot two $\sin\theta - \lambda$ graphs for the two orders on the same graph paper. From the graph find separation between slits and rulings per unit length of the grating.

(4 + 4) + (3 +3) + (2 + 2)

(d) Instead of visible light, can you perform this experiment with X-ray using the same grating? Justify your answer.

2 + 3

(e) Express resolving power of a grating in terms of order number and total number of rulings. If at the just resolved condition of the sodium D lines in the 1st order you need 0.158 cm width of a grating, find the number of rulings per unit length of that grating.

4 + 5

4. (a) A triangular waveform with time period T and amplitude V_0 is represented by

$$\begin{aligned} V(t) &= \frac{2V_0}{T}t \quad \textbf{for} \quad 0 \leq t \leq \frac{T}{2} \\ &= 2V_0(1 - \frac{t}{T}) \quad \textbf{for} \quad \frac{T}{2} \leq t \leq T \end{aligned}$$

Sketch the wave form as a function of t .Write down the Fourier spectrum of the triangular waveform.

2 +3

(b) Sketch the circuit diagram for generation for half-sinusoidal wave

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(c) Consider a parallel resonant circuit with C and L in parallel with R in series, where r represents the resistance of the inductor coil. (symbols have their usual meanings). Given $C = 0.01\,\mu F$, $R = 100\,K\Omega$, $r = 15.7\,\Omega$, Find out the resonant frequency (f_0), value of L and Dynamic resistance.

3+3+4

(d) Given data for triangular waveform :

Frequency of the input in kHz	Order number of harmonic	Peak-to-peak voltage in mV
8.06	1	1.32
2.68	3	0.148
1.61	5	0.0516
1.15	7	0.026

Calculate the corresponding amplitudes. Make a comparison with the amplitude obtained theoretically.

5+5

(e) Plot a graph between relative amplitudes obtained experimentally and no. of harmonics.

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(f) What is a band-pass filter ?

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(g) What is the resistance and reactance offered by the parallel resonant circuit at resonance ?

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5. (a) Draw the circuit diagram (dc balance) for determination of self-inductance of a coil by Anderson's bridge. Denote P, Q, R, S as the four arms of the bridge with coil in the S arm and r as the variable resistance.

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(b) Write down the ac and dc balanced conditions of the network . How do you balance the circuit for dc and ac ?

5 + 5

(c) Varying the frequency of the oscillator, a graph is plotted between r ($in\ \Omega$) and $\frac{1}{C}$ (C is in μF). How will the graph look like ? If the slope of the graph is given by 150 $\Omega - \mu F$, then find out the value of L (Given : $R = S$ and $R = 100\ \Omega$).

3 +3

(d) If $L_1 = 20.35\, mH$, $L_2 = 30.15\, mH$ and the resultant inductance L of the two inductances L_1 and L_2 is given by $39.5\, mH$, then calculate their mutual inductance M and coefficient of coupling K

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(e) Given data for variation of L with angle ϕ between the coils :

Dial reading, ϕ in degree	L in mH
0	62.4
20	61.5
40	59.8
60	56.5
80	54.8
120	45.5
150	40.0

Plot the variation of L as a function of ϕ.

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(f) How will the graph look like if $L > L_1 + L_2$?

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(g) Can you perform the experiment without using an ac source?

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6. (a) A laser source is placed in front of a crossed grating and diffraction pattern is obtained on the screen, situated at a distance D from the grating. If the nth order fringe is at a distance x_n (perpendicular to D) from the central point, then find the angle of diffraction θ_n if $D >> x_n$.

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(b) Given data :
Distance of the screen from the grating $D = 34.5$ cm

Order no. of the spot	Mean position of the spot along y-axis (cm)	Mean currrent (mA)
3	13.575	2.0
2	11.250	4.0
1	9.00	13.5
0	6.755	33.0
1	4.550	13.4
2	2.322	4.2
3	0.004	2.1

Make a table and calculate (only from the first four rows) the distances of the ordered fringes from the central fringe. Also calculate $\sin\theta_n$ for those fringes.

5 +5

(c) Plot a graph between mean current (mA) vs order number (n).

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(d) Plot a graph between $\sin\theta_n$ vs n.

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(e) Given the wavelength of the laser source $\lambda = 6328A^0$, find out the grating constant from the graph.

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(f) Why should be the screen placed at a large distance away from the crossed grating?

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(g) Draw schematically the fraunhofer diffraction pattern due to single slit.

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7. (a) Write down the ratio of amplitude $\frac{E_{10}}{E_0}$ (where E_0 represent electric field amplitude before reflection and E_{10} represent amplitude after reflection) of the electric vector from a plane interface between two media when
(i) Electric vector is parallel to the plane of incidence
(ii) Electric vector is perpendicular to the plane of incidence.

3+3

(b) Given angle of prism $A = 60^0$, minimum deviation $50^0 15'$ find out refractive index of the prism and Brewster's angle θ_p .

3+3

(c) Given data :
Initial reading of the telescope polaroid when light is extinguished $= X^0 = 123^0$.

Angle of incidence(θ)	Reading of telescope polaroid when light is extinguished	Rotation of polaroid	β_r
80^0	87^0		
60^0	125^0		
50^0	148^0		
40^0	165^0		

Calculate the values in the unfilled columns . β_r represents the angle between the plane of vibration and plane of incidence for reflected wave.

4+4

(d) Calculate the values for θ_2 (angle of refraction) and $(\frac{E_{10}}{E_0})_{||}$

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(e) Plot a graph between $(\frac{E_{10}}{E_0})_{||}$ vs θ. Locate the point where the graph crosses the θ axis.

8+2

(f) When an unpolarized plane light falls on the plane interface at Brewster's angle, what is the state of polarization of the reflected light.

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(g) Comment about the phase change on reflection if the wave is reflected from (i) denser medium (ii) rarer medium.

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