CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN MEDICAL PHYSICS

MPHY 840: PRACTICALS IN THERAPEUTIC RADIOLOGY PHYSICS

STREAMS: MPHY **TIME: 3 HOURS**

DAY/DATE: TUESDAY 09/04/2024 **11.30 A.M. – 2.30 P.M.**

INSTRUCTIONS

- **Answer question ALL Questions**

QUESTION ONE (20 MARKS)

The relationship between the range, thickness and energy is given as:-

$dI = Kdx$ or $I = I_{oe-kx}$ …… (1)

which I: is the initial Intensity of the Alpha, Gamma, which I_{oe} is the intensity at a distance (x), thickness and k is the absorption coefficient of the particular, material 2 , k depends on the type of radiation (alpha, beta, or gamma) and is directly proportional to the density (d) of the material, i.e k = μD.

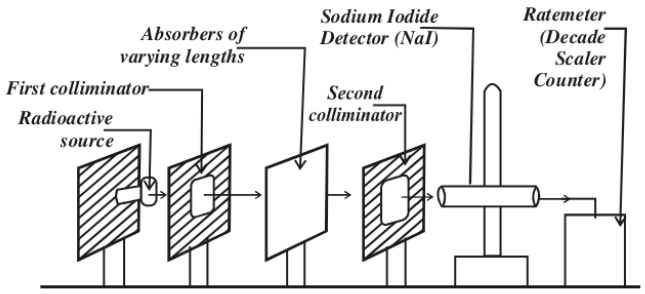

Figure 1: Schematic block diagram of the experimental arrangement

The radioactive source Co ^{60} 5Ci(ϒ) was placed in the holder of the absorption apparatus as shown in Fig.1.

Countrate=Number of counts/Time for the counts (4 minutes) …….(2)

Then, graphs of Log I against thickness were plotted, and the slope of the graph, which is equivalent to the linear absorption coefficient (μ) was calculated.

Table 1 Background Count Rate = 150.75 Gamma – source Co 60 5/uCi(cpm) was used on lead sheet.

Thickness of material absorbers X (cm)	Reading of Counts in front minutes (cpm) 1	2	3	Means counts for 4 minutes (cpm)	Countrate I (cpm)	Countrate with background countrate substrated(I)	Ln I
0.00	5043.00	5042.00	5047.00	5044.00	1261.00	1110.25	7.01
0.10	4825.00	4823.00	4824.00	4824.00		1055.25	
0.15	4840.00	4848.00	4847.00	4847.00		1060.50	
0.25	3915.00	3916.00	39.18.00	39.18.00		827.50	
0.30	3881.00	3882.00	3889.00	3889.00		820.00	
0.35	4526.00	4524.00	4525.00	4525.00		900.00	
0.64	3703.00	3706.00	3703.00	3703.00		775.25	
0.11	3072.00	3070.00	3071.00	3071.00		617.00	
1.34	2775.00	2776.00	2777.00	2776.00		543.00	
1.75	2342.00	2343.00	2347.00	2344.00		435.00	
2.05	1615.00	1613.00	1614.00	1614.00		252.75	
2.06	2074.00	2070.00	2072.00	2072.00		367.25	
3.70	1996.00	1995.00	1994.00	1995.00	498.75	348.00	5.85

Table 2 Background Count rate = 150.75 Gamma – source Co ^{60} 5μCi(cpm) was used on Copper sheet.

Thickness of material absorbers X (cm)	Reading of Counts in front minutes (cpm) 1	2	3	Means counts for 4 minutes (cpm)	Countrate I (cpm)	Countrate with background countrate substrated(I)	Ln I
0.00	5043.00	5042.00	5047.00	5044.00	1261.00	1110.25	7.01
0.15	5618.00	5623.00	5625.00	5622.00			
0.30	5410.00	5400.00	5409.00	5409.00			
0.45	5304.00	5300.00	5302.00	5302.00			
0.65	5213.00	5210.00	5210.00	5211.00			
0.80	5110.00	5110.00	5106.00	5109.00			
0.95	5081.00	5077.00	5082.00	5080.00			
1.10	4910.00	4912.00	4911.00	4911.00			
1.25	4810.00	4809.00	4808.00	4809.00			
1.45	4700.00	4699.00	4701.00	4700.00			
1.61	4612.00	4613.00	4611.00	4612.00	1153.00	1002.25	6.91

a) Complete table 1 and table 2 (8 marks)

b) Plot graphs of Ln I against thickness, and from the slope of the graph, calculate the linear absorption coefficient (μ) of lead (5 marks)

c) Plot graphs of Ln I against thickness, and from the slope of the graph, calculate the linear absorption coefficient (μ) of copper (5 marks)

d) If the density of lead is 11.005gcm $^{-3}$ or 1.1x10^{3} kgm^{-3} calculate the mass absorption coefficient using the equation $\mu m = \mu/\rho$ (2 marks)

QUESTION TWO (20 MARKS)

For each section of table 3, the left column contains i, the sample number (1–150). The right column contains the number of counts for that sample, x i .

i	Xi	i	xi	i	Xi	i	Xi	i	Xi	i	xi
1	4	26	4	51	6	76	7	101	2	126	5
2	6	27	7	52	5	77	3	102	7	127	6
3	5	28	5	53	7	78	7	103	8	128	7
4	7	29	8	54	7	79	8	104	6	129	4
5	9	30	3	55	8	80	5	105	5	130	6
6	9	31	6	56	7	81	5	106	3	131	9
7	7	32	8	57	7	82	6	107	4	132	6
8	9	33	5	58	5	83	9	108	8	133	7
9	6	34	9	59	9	84	3	109	8	134	4
10	4	35	8	60	5	85	7	110	7	135	4
11	4	36	6	61	8	86	3	111	6	136	4
12	7	37	9	62	4	87	9	112	8	137	4
13	7	38	5	63	8	88	5	113	8	138	8
14	6	39	4	64	7	89	3	114	4	139	2
15	6	40	5	65	2	90	2	115	7	140	6
16	5	41	4	66	3	91	6	116	6	141	3
17	5	42	5	67	11	92	5	117	6	142	5
18	5	43	4	68	7	93	7	118	6	143	7
19	5	44	5	69	4	94	7	119	4	144	7
20	5	45	7	70	6	95	6	120	8	145	5
21	6	46	7	71	6	96	9	121	11	146	7
22	6	47	6	72	4	97	4	122	6	147	10
23	5	48	6	73	6	98	4	123	6	148	5
24	8	49	6	74	8	99	8	124	6	149	6
25	7	50	4	75	5	100	6	125	5	150	5

a. Calculate the mean count rate (5 marks)

b. Calculate the standard deviation (5 marks)

c. Plot a histogram development for the 150 Trial Sample (5 marks)

d. Compute the Chi-square for the 20 trial sample used by the Excel spreadsheet

e. for this calculation. (5 marks)

QUESTION THREE (20 MARKS)

DOSE MEASUREMENT OF COBALT-60 RADIOTHERAPY BEAMS IN TREATMENT FIELDS

Radiation therapy is a complex process with multiple steps, each of which has an impact on the quality of treatment. Accurate dosimetry is a critical step during the radiotherapy of cancer patients. The aim of the present study was to measure and evaluate the doses of two cobalt- 60 (^{60} Co) teletherapy units GWXJ80 of NPIC China and Theratron 780 of AECL Canada at various points within fields for different field sizes.

Methods: This cross-sectional descriptive study was done to measure the 60 Co doses in the treatment fields.The dose measurements were done in air and 30×30×30 cm 3 Phantom at 80 cm SSD by using calibrated NE 2570 Farmer Electrometer & NE 2571 Farmer Ionization Chamber and percentage of doses were calculated.

Table-4. Doses (Gy) in phantom at 05 cm depth

Machine	Field Size (cm^2)	Field Mid	Away from Field Center (cm)												
			1	2	3	4	4.5	5	6	7	7.5	8	9	9.5	10
GWXJ80	10×10	1.19		1.19	1.18	1.17	1.04	0.85	0.49						
		100		100	99.2	98.3	87.4	71.4	41.2						
	15×15	1.26		1.26	1.26	1.25	1.23	1.21	1.19	1.61	0.98	0.51			
		%													
	20×20	1.3		1.3	1.3	1.3	1.29	1.28	1.26	1.25	1.23	1.191.158	1.07	0.99	0.54
		%													
Theratron 780	10×10	0.38		0.38	0.37	0.37	0.21	0.16	0.09						
		100		100	97.4	97.4									
		%													
	15×15	0.4		0.4	0.4	0.4	0.4	0.39	0.38	0.37	0.19	0.11			
		%													
	20×20	0.41		0.41	0.41	0.41	0.41	0.41	0.4	0.4	0.39	0.380.36	0.20	0.15	0.13
		%													

Table-5: Doses (Gy) in air

Machine	Field Size (cm 2)		Field Mid	Away from Field Center (cm)													
				1	2	3	4	4.5	5	6	7	7.5	8	9	9.5	10	
GWXJ80	10×10		1.48	1.48	1.47	1.14	1.12	1.06	0.67								
		%	100	100	99.3	77	75.7	71.6	45.3								
	15×15		1.52	1.52	1.52	1.51	1.5	1.49	1.47	1.38	0.97	0.66					
		%															
	20×20		1.55	1.55	1.55	1.54	1.53	1.53	1.511.49		1.46	1.43	1.38	1.17	0.75	0.597	
		%															
Theratron 780	10×10		0.46	0.46	0.46	0.46	0.4	0.32	0.22								
		%															
	15×15		0.47	0.47	0.47	0.47	0.47	0.47	0.470.45		0.36	0.26					
		%															
	20×20		0.48	0.48	0.48	0.48	0.48	0.48	0.480.48		0.47	0.47	0.466	0.42	0.34	0.28	
		%															

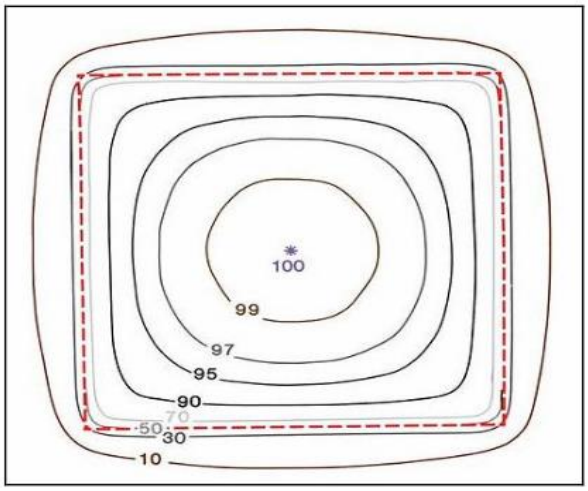

Figure-1: Cross-sectional isodose distribution in a plane perpendicular to the central axis of the beam. Isodose values are normalized to 100% at the centre of field. The dashed line shows the boundary of the field.

a) Plot a graph of Percentage of doses in phantom at 05 cm depth for GWXJ80 against a distance away from Field Center (cm) (4 marks)

b) Plot a graph of Percentage of Doses in phantom at 05 cm depth for Theratron 780 against a distance away from Field Center (cm) (4 marks)

c) Plot a graph of Percentage of doses in air for GWXJ80 against a distance away from Field Center (cm) (4 marks)

d) Plot a graph of Percentage of doses in phantom at 05 cm depth for GWXJ80 against a distance away from Field Center (cm) (4 marks)

e) Discuss the results (4 marks)

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