UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2004/2005

February - March 2005

ZCT 535/4 - Nuclear Medicine and Radiotherapy Physics
[Perubatan Nuklear dan Fizik Radioterapi]

Duration 3 hours
[Masa 3 jam]

Please check that the examination paper consists of **SEVEN** pages of printed material before you begin the examination

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH** muka surat yang bercetak sebelum anda memulakan peperiksaan ini]*

Instruction Answer all **FIVE** questions Students are allowed to answer all questions in Bahasa Malaysia or in English

*[**Arahan** Jawab kesemua **LIMA** soalan Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris]*

SECTION A (90 minutes)
[BAHAGIAN A (90 minit)]

1 (a) Explain what is meant by the following terms
[Huraikan maksud ungkapan berikut]

(i) percentage depth dose along the central axis
[peratusan dos kedalaman sepanjang paksi pusat]

(ii) tissue air ratio (TAR)
[nisbah udara tisu]

(iii) tissue maximum ratio (TMR)
[nisbah maksimum tisu]

(20/100)

(b) Discuss the advantages and disadvantages of replacing a cobalt radiation unit by a linear accelerator under the following terms
[Bincangkan kebaikan dan keburukan dalam penggantian unit sinaran kobalt dengan suatu 'linear accelerator' di bawah ungkapan berikut]

(i) beam energy and output
[tenaga bim dan output]

(ii) beam geometry
[geometri bim]

(iii) protection for the room and personnel
[perlindungan bilik dan pekerja]

(iv) construction and maintenance of the unit
[pembinaan dan penyelenggaraan unit]

(40/100)

(c) A dose of 200 cGy is prescribed to the tumor located at 5 cm depth from field A and 15 cm depth from field B Treatment plan uses parallel opposed isocentric fields The field sizes are 9×10 cm^2 and the SAD is 100 cm and a 10 MV photon beam is used Field A is weighted twice as much as field B
[Suatu dos 200 cGy diberi pada tumor yang letaknya pada kedalaman 5 cm dari medan A dan kedalaman 15 cm dari medan B Rawatannya menggunakan medan bertentangan dan isosentrik Saiz medannya 9×10 cm^2 dan SADnya 100 cm dan 10 MV foton bim digunakan Pemberat pada medan A adalah dua kali daripada medan B]

(i) Calculate the MU required from each field
[Hitungkan MU yang diperlukan dari setiap medan]

(ii) Calculate the D_{max} of field A and field B
[Hitungkan D_{max} bagi medan A dan medan B]

$$Scp\ (9 \times 10\ cm^2) = 0.995$$

(40/100)

2 (a) To determine the tumor/organ position using X-ray machine, orthogonal films are used. Why? Discuss the further steps and information necessary to plan the radiation treatment at the isocentre of tumor using the films.
[Untuk menentukan kedudukan tumor/organ dengan mesin sinar-x, filem orthogonal digunakan. Mengapa? Bincangkan langkah-langkah dan maklumat yang perlu untuk mencadang rawatan sinaran pada isocentre dalam tumor dengan menggunakan filem-filem itu.]

(30/100)

(b) Describe two purposes for which wedges are used in radiotherapy.
[Huraikan dua tujuan untuk baji digunakan di dalam radioterapi.]

(20/100)

(c) Discuss and draw the approximate isodose curves expected when breast cancer is treated with and without wedges. State the positioning of the wedges.
[Bincangkan dan lakarkan isodos secara kasar yang akan didapati dalam rawatan kanser payudara dengan adanya dan tiadanya baji. Nyatakan kedudukan baji.]

(20/100)

(d) A 20 MeV electron beam is used in the treatment of bone metastasis in the spine.
[20 MeV bim elektron digunakan dalam rawatan 'bone metastasis' dalam tulang belakang.]

(i) Draw the central axis depth dose curve to scale and name the axes.
[Lakarkan lengkung kedalaman dos pada paksi pusat dan namakan paksi-paksinya.]

(ii) State the useful portion of the beam. Why?
[Nyatakan bahagian bim yang berguna dalam terapi. Mengapa?]

(iii) State the advantages and disadvantages in using the electron beam for the above treatment
[Nyatakan kebaikan dan keburukan menggunakan bim elektron dalam rawatan ini.]

(iv) If a 'lead cutout' is used to protect part of the spine, determine the thickness of the cutout. Explain.
[Jika suatu 'lead cutout' digunakan untuk melindung sebahagian tulang belakang, tentukan ketebalan 'cutout'nya. Terangkan.]

(30/100)

SECTION B (90 minutes)
[BAHAGIAN B (90 minit)]

3. Briefly explain
[Jelaskan secara ringkas]

(a) why Tc-99m is widely used for imaging
[kenapa Tc-99m digunakan untuk imejan secara menyeluruh]

(10/100)

(b) the operation of Mo-99/Tc-99m generator
[operasi penjana Mo-99/Tc-99m]

(20/100)

(c) four (4) factors that influence the image quality in nuclear imaging
[empat (4) faktor yang mempengaruhi kualiti imej dalam imejan nuklear]

(40/100)

(d) three (3) performance parameters of gamma camera
[tiga (3) parameter prestasi gamma kamera]

(30/100)

4. (a) Explain the advantages of SPECT compare to planar imaging
[Jelaskan kebaikan SPECT jika dibandingkan dengan imejan mensatah]

(20/100)

(b) In SPECT image reconstruction briefly explain the function of filtering
[Dalam pembinaan semula imej SPECT terangkan secara ringkas fungsi turas]

(20/100)

(c) Explain the limitations in using SPECT to determine the activity in a certain volume in the organ
[Terangkan faktor yang menghadkan prosedur SPECT untuk menentukan keaktifan di dalam suatu isipadu organ]

(20/100)

(d) Compare any four (4) aspects of PET versus SPECT
[Bandingkan mana-mana empat (4) aspek berkaitan dengan PET melawan SPECT]

(40/100)

5 (a) Show that cumulative activity = 1 44 A_oT_e in the situation where the uptake of radiopharmaceutical in the organ is instantaneous and the clearance is by both physical and biological excretion
[Buktikan A= 1 44 A_oT_e dalam keadaan di mana pengambilan radiofarmasuetikal oleh organ adalah secara serta-merta dan terdapat penghapusan fizikal dan biologi dari organ]

Te = effective half -- life
[Te = separuh hayat berkesan]

Ao = initial activity
[Ao = keaktifan permulaan di dalam organ]

(30/100)

(b) In liver imaging three (3) millicurie of Tc-99m-Sulphur Colloid was injected into the patient Calculate the dose to the liver if 60% of the injected activity was taken by the liver, 30% by the spleen, and 10% by bone marrow The uptake by the organs is instantaneous with no biological excretion
[Pesakit telah menerima suntikan tiga (3) millicurie Tc-99m-koloid sulfur bagi imejan hati Kira dos sinaran di dalam hati jika 60% keaktifan di dalam hati, 30% di dalam spleen dan 10% di dalam sumsum tulang Andaikan pengambilan oleh organ adalah secara serta-merta dan tidak terdapat pengumuhan biologi]

Given *[Diberikan]*

S (liver <— liver) = 4 6 x 10^5 rad/microCurie hr
[S (hati ← hati) = 4 6 x 10^5 rad/microCurie hr]

S (liver <— spleen) = 9 8 x 10^7 rad /microCurie hr
[S (hati ← limpa) = 9 8 x 10^7 rad/microCurie hr]

S (liver <—bone marrow) = 9 2 x 10^7 rad/microCurie hr
[S (hati ←sumsum tulang) = 9 2 x 10^7 rad/microCurie hr]

(70/100)

Table 11-8 Percentage depth dose table 10 MV x-ray at 100 cm SSD

Eq Sq / Depth (cm)	0.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	22.0	24.0	26.0	28.0	30.0
0.0	10.4	10.5	10.5	11.6	12.6	13.8	14.9	16.1	17.0	17.9	18.8	19.7	20.6	21.4	22.2	23.0	23.8	24.6	25.8	26.9	28.0	29.2	30.4
1.0	77.0	77.0	77.1	78.8	80.6	83.1	86.3	89.1	89.5	89.9	90.2	90.5	90.8	91.1	91.7	91.7	92.0	92.5	92.4	92.5	93.1	93.8	94.4
2.0	94.0	94.0	94.1	94.9	95.6	96.4	97.2	97.9	98.0	98.0	98.1	98.1	98.2	98.2	98.3	98.3	98.4	98.4	98.4	98.5	98.8	99.1	99.3
2.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3.0	96.7	98.0	98.3	98.3	98.3	98.2	98.2	98.2	98.2	98.3	98.3	98.3	98.4	98.3	98.3	98.3	98.3	98.3	98.2	98.2	98.2	98.2	98.2
4.0	91.3	94.7	95.4	95.4	95.5	95.3	95.2	95.1	95.2	95.3	95.5	95.6	95.6	95.6	95.5	95.4	95.4	95.4	95.3	95.3	95.3	95.3	95.3
5.0	86.4	90.3	91.1	91.2	91.4	91.3	91.3	91.4	91.5	91.7	91.8	92.0	92.1	92.0	92.0	92.0	92.0	92.0	92.0	91.9	92.0	92.0	92.0
6.0	81.7	86.0	86.9	87.2	87.5	87.5	87.6	87.1	87.9	88.1	88.3	88.5	88.5	88.6	88.6	88.6	88.7	88.7	88.7	88.7	88.7	88.7	88.7
7.0	77.2	81.9	82.9	83.3	83.7	83.8	83.9	84.1	84.3	84.6	84.8	85.1	85.1	85.2	85.2	85.3	85.3	85.4	85.5	85.5	85.6	85.7	85.7
8.0	73.0	78.1	79.1	79.6	80.1	80.2	80.4	80.7	80.9	81.2	81.5	81.8	81.8	81.9	82.0	82.1	82.1	82.2	82.2	82.3	82.5	82.6	82.6
9.0	69.0	74.1	75.2	75.8	76.3	76.5	76.7	77.0	77.3	77.7	78.0	78.3	78.4	78.5	78.6	78.7	78.8	78.9	79.0	79.1	79.2	79.3	79.3
10.0	65.0	70.5	71.6	72.2	72.8	73.0	73.2	73.5	73.9	74.3	74.7	75.0	75.1	75.2	75.4	75.5	75.6	75.7	75.9	76.0	76.1	76.2	76.2
11.0	61.9	66.9	68.0	68.7	69.3	69.5	69.8	70.2	70.6	71.0	71.4	71.7	71.9	72.1	72.2	72.4	72.5	72.6	72.8	72.9	73.1	73.2	73.2
12.0	58.5	63.6	64.7	65.4	66.0	66.3	66.7	67.0	67.5	67.9	68.3	68.6	68.8	69.0	69.2	69.4	69.5	69.7	69.9	70.0	70.2	70.3	70.3
13.0	55.4	60.3	61.4	62.3	62.9	63.2	63.6	64.0	64.4	64.9	65.3	65.6	65.8	66.0	66.3	66.4	66.6	66.8	67.0	67.2	67.4	67.5	67.4
14.0	52.4	57.3	58.4	59.3	59.9	60.2	60.6	61.0	61.5	62.0	62.5	62.7	63.0	63.2	63.4	63.6	62.8	63.9	64.3	64.4	64.7	64.7	64.7
15.0	49.6	54.3	55.5	56.4	57.0	57.4	57.8	58.3	58.8	59.2	59.7	60.0	60.2	60.5	60.7	60.9	61.1	61.3	61.6	61.8	62.1	62.1	62.0
16.0	47.1	51.6	52.7	53.7	54.3	54.7	55.1	55.6	56.1	56.6	57.1	57.4	57.6	57.9	58.1	58.3	58.5	58.7	59.1	59.3	59.6	59.6	59.5
17.0	44.6	48.9	50.0	50.9	51.5	51.9	52.4	52.9	53.4	53.9	54.4	54.7	55.0	55.2	55.5	55.7	55.9	56.2	56.5	56.8	57.0	57.0	57.0
18.0	42.2	46.4	47.4	48.3	48.9	49.3	49.9	50.4	50.9	51.4	51.9	52.2	52.5	52.7	53.0	53.3	53.5	53.7	54.1	54.4	54.6	54.6	54.6
19.0	40.0	44.0	45.0	45.8	46.3	46.9	47.4	47.9	48.4	49.0	49.4	49.7	50.0	50.3	50.6	50.9	51.1	51.4	51.8	52.1	52.3	52.2	52.2
20.0	37.9	41.7	42.7	43.4	44.0	44.6	45.1	45.6	46.2	46.7	47.1	47.5	47.8	48.1	48.4	48.7	48.9	49.2	49.6	49.9	50.1	50.0	50.0
21.0	35.9	39.6	40.5	41.3	41.8	42.4	42.9	43.4	44.0	44.5	44.9	45.3	45.6	46.0	46.3	46.5	46.9	47.1	47.5	47.8	47.9	47.9	47.9
22.0	34.0	37.6	38.5	39.3	39.9	40.4	41.0	41.5	42.0	42.5	42.9	43.3	43.6	44.0	44.2	44.5	44.8	45.0	45.4	45.8	45.8	45.8	45.8
23.0	32.3	35.8	36.7	37,4	38.0	38.5	39.0	39.5	40.1	40.6	41.0	41.4	41.7	42.1	42.4	42.6	42.9	43.1	43.5	43.9	43.9	43.9	43.8
24.0	30.6	34.0	34.9	35.6	36.1	36.7	37.2	37.7	38.2	38.7	39.1	39.5	39.9	40.2	40.5	40.8	41.0	41.3	41.7	42.0	42.0	42.0	41.9
25.0	29.0	32.7	33.6	34.3	34.8	35.4	35.9	36.4	36.9	37.4	37.8	38.1	38.5	38.9	39.1	39.4	39.7	39.9	40.3	40.6	40.6	40.5	40.5
26.0	27.5	31.4	32.3	33.1	33.6	34.1	34.6	35.1	35.6	36.1	36.5	36.8	37.2	37.5	37.8	38.1	38.3	38.6	38.9	39.2	39.1	39.1	39.1
27.0	26.1	30.3	31.1	31.8	32.3	32.9	33.4	33.8	34.3	34.8	35.2	35.5	35.9	36.2	36.5	36.8	37.1	37.3	37.6	37.9	37.8	37.8	37.8
28.0	24.8	29.2	30.0	30.6	31.2	31.7	32.2	32.7	33.1	33.6	34.0	34.3	34.7	35.0	35.3	35.5	35.8	36.0	36.4	36.5	36.5	36.5	36.5
29.0	23.5	28.1	28.9	29.5	30.0	30.5	31.0	31.5	32.0	32.4	32.8	33.1	33.5	33.8	34.1	34.3	34.6	34.8	35.1	35.3	35.2	35.2	35.2
30.0	22.3	27.0	27.8	28.5	28.9	29.4	29.9	30.4	30.9	31.3	31.6	32.0	32.3	32.6	32.9	33.2	33.5	33.7	33.9	34.0	34.0	34.0	34.0
																			PDD 10 MV				
PSF	1.000	1.001	1.005	1.009	1.012	1.013	1.015	1.016	1.017	1.017	1.018	1.019	1.020	1.021	1.023	1.023	1.024	1.025	1.028	1.031	1.032	1.033	1.034

Table 11-15 10 MV tissue maximum ratio

Eq Sq / Depth (cm)	0 0	4 0	5 0	6 0	7 0	8 0	9 0	10 0	11 0	12 0	13 0	14 0	15 0	16 0	17 0	18 0	19 0	20 0	22 0	24 0	26 0	28 0	30 0
0 0	0 099	0 100	0 100	0 111	0 122	0 133	0 144	0 156	0 165	0 174	0 182	0 191	0 200	0 208	0 216	0 225	0 233	0 241	0 253	0 264	0 276	0 288	0 300
1 0	0 749	0 750	0 750	0 770	0 790	0 816	0 848	0 880	0 884	0 888	0 892	0 896	0 900	0 904	0 908	0 912	0 916	0 920	0 924	0 928	0 934	0 942	0 950
2 0	0 933	0 934	0 934	0 945	0 956	0 967	0 976	0 986	0 987	0 989	0 990	0 991	0 993	0 994	0 996	0 997	0 999	1 001	1 004	1 007	1 011	1 015	1 019
2 5	1 000	1 001	1 001	1 005	1 009	1 012	1 013	1 015	1 016	1 017	1 017	1 018	1 019	1 020	1 021	1 023	1 024	1 025	1 028	1 031	1 032	1 033	1 034
3 0	0 978	0 992	0 995	0 999	1 003	1 006	1 007	1 008	1 009	1 010	1 012	1 013	1 014	1 015	1 016	1 017	1 018	1 019	1 021	1 024	1 025	1 026	1 027
4 0	0 942	0 976	0 985	0 989	0 993	0 995	0 995	0 995	0 997	0 999	1 001	1 003	1 005	1 006	1 006	1 007	1 007	1 008	1 010	1 013	1 014	1 015	1 016
5 0	0 908	0 948	0 958	0 963	0 968	0 972	0 973	0 974	0 976	0 979	0 981	0 984	0 986	0 987	0 988	0 989	0 990	0 991	0 993	0 996	0 998	0 999	1 000
6 0	0 875	0 920	0 931	0 937	0 944	0 949	0 950	0 952	0 955	0 958	0 960	0 963	0 966	0 967	0 969	0 970	0 972	0 973	0 976	0 979	0 981	0 982	0 983
7 0	0 843	0 892	0 904	0 912	0 919	0 924	0 927	0 930	0 933	0 936	0 940	0 943	0 946	0 948	0 949	0 951	0 952	0 954	0 957	0 960	0 963	0 965	0 967
8 0	0 812	0 864	0 878	0 886	0 895	0 901	0 904	0 908	0 912	0 915	0 919	0 922	0 926	0 928	0 930	0 931	0 933	0 935	0 938	0 941	0 944	0 947	0 950
9 0	0 782	0 836	0 849	0 858	0 867	0 874	0 878	0 882	0 886	0 890	0 895	0 899	0 903	0 905	0 907	0 909	0 911	0 913	0 917	0 921	0 924	0 927	0 929
10 0	0 754	0 808	0 822	0 832	0 842	0 849	0 853	0 857	0 862	0 866	0 871	0 875	0 880	0 882	0 885	0 887	0 890	0 892	0 896	0 900	0 903	0 906	0 909
11 0	0 727	0 781	0 794	0 805	0 816	0 823	0 828	0 832	0 837	0 842	0 847	0 852	0 857	0 860	0 862	0 865	0 867	0 870	0 874	0 879	0 883	0 886	0 889
12 0	0 700	0 754	0 768	0 779	0 790	0 798	0 803	0 808	0 813	0 818	0 824	0 829	0 834	0 837	0 840	0 843	0 846	0 849	0 854	0 859	0 863	0 866	0 869
13 0	0 675	0 728	0 741	0 752	0 765	0 774	0 779	0 784	0 789	0 795	0 800	0 806	0 811	0 814	0 817	0 821	0 824	0 827	0 832	0 837	0 842	0 845	0 849
14 0	0 650	0 703	0 716	0 728	0 741	0 750	0 755	0 760	0 766	0 772	0 777	0 783	0 789	0 792	0 795	0 799	0 802	0 805	0 811	0 816	0 821	0 825	0 829
15 0	0 626	0 678	0 691	0 704	0 717	0 726	0 731	0 737	0 743	0 749	0 755	0 761	0 767	0 770	0 774	0 777	0 781	0 784	0 790	0 796	0 801	0 805	0 809
16 0	0 604	0 654	0 667	0 680	0 693	0 703	0 708	0 714	0 720	0 727	0 773	0 740	0 746	0 749	0 753	0 756	0 760	0 763	0 769	0 776	0 781	0 786	0 790
17 0	0 582	0 631	0 643	0 655	0 668	0 677	0 684	0 690	0 696	0 703	0 709	0 716	0 722	0 726	0 730	0 733	0 737	0 741	0 747	0 754	0 759	0 764	0 769
18 0	0 560	0 608	0 620	0 632	0 644	0 653	0 650	0 667	0 674	0 680	0 687	0 693	0 700	0 704	0 708	0 711	0 715	0 719	0 726	0 733	0 739	0 744	0 749
19 0	0 540	0 586	0 597	0 609	0 620	0 630	0 637	0 644	0 651	0 657	0 664	0 670	0 677	0 681	0 685	0 690	0 694	0 698	0 705	0 712	0 719	0 724	0 729
20 0	0 520	0 565	0 576	0 587	0 598	0 607	0 615	0 623	0 630	0 636	0 643	0 649	0 656	0 660	0 665	0 669	0 674	0 678	0 685	0 692	0 699	0 704	0 710
21 0	0 501	0 544	0 555	0 566	0 577	0 586	0 594	0 602	0 609	0 615	0 622	0 628	0 635	0 640	0 644	0 649	0 653	0 658	0 666	0 673	0 680	0 685	0 691
22 0	0 483	0 525	0 536	0 547	0 558	0 567	0 575	0 583	0 590	0 596	0 603	0 609	0 616	0 621	0 625	0 630	0 634	0 639	0 647	0 654	0 661	0 666	0 672
23 0	0 466	0 507	0 518	0 528	0 539	0 548	0 556	0 564	0 571	0 577	0 584	0 590	0 597	0 602	0 607	0 611	0 616	0 621	0 629	0 636	0 643	0 648	0 654
24 0	0 449	0 489	0 499	0 510	0 521	0 530	0 537	0 545	0 552	0 558	0 565	0 571	0 578	0 583	0 588	0 593	0 598	0 603	0 611	0 618	0 625	0 630	0 636
25 0	0 433	0 477	0 488	0 498	0 509	0 518	0 526	0 534	0 540	0 547	0 553	0 560	0 567	0 571	0 576	0 581	0 586	0 591	0 599	0 607	0 613	0 619	0 624
26 0	0 416	0 464	0 476	0 487	0 498	0 507	0 514	0 522	0 529	0 535	0 542	0 548	0 555	0 560	0 565	0 569	0 574	0 579	0 587	0 595	0 602	0 607	0 612
27 0	0 402	0 453	0 466	0 476	0 486	0 495	0 503	0 511	0 518	0 524	0 531	0 537	0 544	0 548	0 553	0 558	0 563	0 568	0 576	0 584	0 590	0 595	0 601
28 0	0 387	0 441	0 455	0 465	0 475	0 484	0 492	0 500	0 506	0 513	0 519	0 526	0 532	0 537	0 542	0 546	0 551	0 556	0 564	0 572	0 579	0 584	0 589
29 0	0 373	0 430	0 444	0 454	0 464	0 473	0 481	0 488	0 495	0 502	0 508	0 515	0 521	0 526	0 530	0 535	0 540	0 545	0 553	0 561	0 568	0 573	0 578
30 0	0 359	0 418	0 433	0 443	0 454	0 463	0 470	0 477	0 484	0 490	0 497	0 503	0 510	0 515	0 519	0 524	0 528	0 533	0 541	0 550	0 556	0 561	0 566

- ooo 0 ooo -