
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 $9 \times 10 \text{ cm}^2$ 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 $9 \times 10 \text{ cm}^2$ 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]

$$Scp (9 \times 10 \text{ cm}^2) = 0.995 \quad (40/100)$$

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 melindungi 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 = $1.44 A_0 T_e$ in the situation where the uptake of radiopharmaceutical in the organ is instantaneous and the clearance is by both physical and biological excretion.

[Buktikan $A = 1.44 A_0 T_e$ dalam keadaan di mana pengambilan radiofarmasetikal oleh organ adalah secara serta-merta dan terdapat penghapusan fizikal dan biologi dari organ.]

T_e = effective half – life

[T_e = separuh hayat berkesan]

A_0 = initial activity

[A_0 = 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 :]*

$$S (\text{liver} \leftarrow \text{liver}) = 4.6 \times 10^{-5} \text{ rad/microCurie.hr}$$

$$[S (\text{hati} \leftarrow \text{hati}) = 4.6 \times 10^{-5} \text{ rad/microCurie.hr}]$$

$$S (\text{liver} \leftarrow \text{spleen}) = 9.8 \times 10^{-7} \text{ rad/microCurie.hr}$$

$$[S (\text{hati} \leftarrow \text{limpa}) = 9.8 \times 10^{-7} \text{ rad/microCurie.hr}]$$

$$S (\text{liver} \leftarrow \text{bone marrow}) = 9.2 \times 10^{-7} \text{ rad/microCurie.hr}$$

$$[S (\text{hati} \leftarrow \text{sumsum tulang}) = 9.2 \times 10^{-7} \text{ rad/microCurie.hr}]$$

(70/100)

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	0.733	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	