THE OPEN UNIVERSITY OF SRI-LANKA
B.Sc DEGREE PROGRAMME: LEVEL - 05
MEDICAL PHYSICS – PHU 3158 / PHE 5158
ANSWER GUIDE FOR HOME ASSIGNMENT 2010

(1) a), b),c) Refer sections 5.1,5.5,5.6 and 5.4.1 – 5.4.4 in module 1

d) When the cavity of laser is confocal type, the spot size of the laser beam $W_{d/2}$ is given by, $W_{d/2} = \sqrt{\frac{\lambda d}{\pi}}$

Where, λ - wave length of the laser beam and d - length of the laser cavity

Here, $W_{d/2}$ = 0.44mm, λ = 633 nm = 633x10^{-6} mm

$$d = \frac{\pi}{\lambda}(w_{d/2})^2 = \frac{22}{7\times 633\times10^{-6}mm} \times (0.4mm)^2 = 794.08 \text{ mm}$$

e) Low power He-Ne laser has no possibility of hazards particularly to the eye. However when powerful laser light has accidentally allowed in to the eye,
Turn the head or blink the eyes immediately.
As a result of exposure of laser in to the eye, the area of retina damaged would be too small to notice and there would be no sensation of pain

(2) a), b), c), d) Refer sections 8.3.3,8.4, 8.5, 8.5.1, 8.7.2 and 8.8 in module 1

e) Doppler Shift $\Delta f = \frac{2fv\,cos\theta}{C}$

Here, $f = 5\ MHz = 5\times10^6 Hz, \theta = 60^0, C = 1.5\ kms^{-1}, \Delta f = 150\ Hz$

$$v = \frac{C.\Delta f}{2f\ cos\theta} = \frac{1.5\times10^{-3}ms^{-1}\times150Hz}{2\times5\times10^6Hz\times cos\ 60^0}$$

$$v = 0.045\ ms^{-1} = 45\ mms^{-1}$$

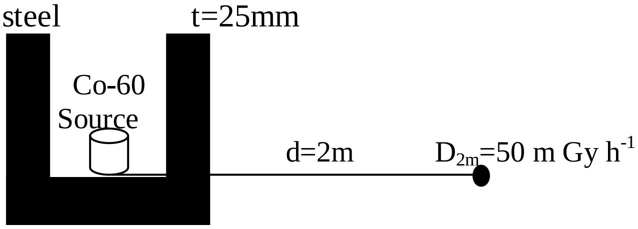
(3) a), b), c) Refer section 10.11 in module 1

Properties of X-rays:
The X-rays are highly penetrating and can pass through several materials which are opaque to light, ionize the gas through which they pass, affect photographic plate, cause fluorescence in several materials, the X-rays are not deflected by electric or magnetic field which show that they are not charged particles, travel in straight lines with the speed of light and the X-rays like visible light consist of electromagnetic waves of very short wavelength and show reflection, refraction, interference, diffraction and polarization in a similar.

b) Tube voltage, Tube current, Target material, Filtration

c) Half value thickness (HVT) The thickness of a material which reduces the radiation intensity to half of its original value
Tenth value thickness (TVT) The thickness of a material which reduces the radiation intensity to one tenth of its original value

d) steel t=25mm



For Co-60 TVT in steel = 6.6cm
Thickness of the steel shield t=25mm
Let the number of TVTs required for Co-60 in 25mm = n

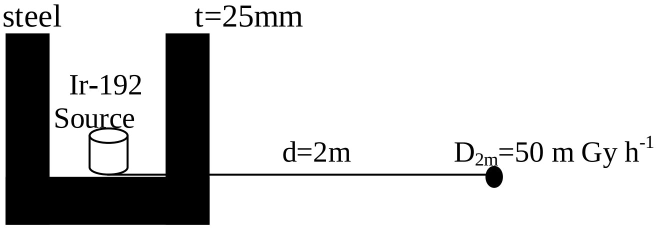
t = n x TVT, n= $\frac{t}{TVT} = \frac{25mm}{66mm}$ = 0.379

Let the Dose rate without steel container = D_0

From the equation $D = \frac{D_0}{10^n}$, $D_0 = D \times 10^n = 50\ mGyh^{-1} \times 10^{0.379} = 119.7\ mGyh^{-1}$

∴ Activity of Co-60, From $D = \frac{\sigma A}{d^2}$, $A_{Co} = \frac{Dd^2}{\sigma_{Co}} = \frac{119.7\ mGy\,h^{-1}\times(2m)^2}{0.31\ mGy\,h^{-1}\ GBq^{-1}m^2}$, A_{Co} = 1544.5 GBq

steel t=25mm



For Ir-192 TVT in steel = 4cm
Thickness of the steel shield t=25mm
Let the number of TVTs required for Ir-192 in 25mm = n

t = n x TVT, n= $\frac{t}{TVT} = \frac{25mm}{40mm}$ = 0.625

Let the Dose rate without steel container = D_0

From the equation $= \frac{D_0}{10^n}$, $D_0 = D \times 10^n = 50\ mGyh^{-1} \times 10^{0.625} = 210.8\ mGyh^{-1}$

∴Activity of Ir-192, From $= \frac{\sigma A}{d^2}$, $A_{Ir} = \frac{Dd^2}{\sigma_{Ir}} = \frac{210.8\ mGy\ h^{-1} \times (2m)^2}{0.114\ mGy\ h^{-1}\ GBq^{-1} m^2}$, A_{Co} = 7398.2 GBq

(4) a), b), c) Refer sections 6.1.1 and 6.1.2 in module 1

d) Using the equation for numerical aperture of the fibre, $n_0 \sin(i_{max}) = \sqrt{(n_f{}^2 - n_c{}^2)}$

Where, n_0 = Refractive index of external medium, n_f = Refractive index of glass fibre core and n_c = Refractive index of glass cladding

$n_0 \sin(i_{max}) = \sqrt{1.51^2 - 1.40^2)} = 0.566$

When the fibre is in air $n_o = 1$

$\therefore \sin(i_{max}) = 0.566,\ i_{max} = sin^{-1}(0.566) = 34.5^0$

e) Rigid endoscopes and flexible endoscopes

f) Refer section 6.2.2 and figure 6.3 in module 1

(5) a) Refer sections 9.3.1, 9.3.2 and 9.3.3 in module 1

b) Refer section 9.6 in module 1

c) Refer section 9.3 in module 1

d) Refer PHU 3158 OBT 2010 Answer guide

e) The field B at the selected slice, B = $B_0 + \Delta B = 1.4\ T + (0.8\ m \times 0.014\ Tm^{-1}) = 1.4112$ T

The frequency required for resonance is given by $f = \gamma \frac{B}{2\pi} = \frac{267.8\ MHz T^{-1}}{2 \times \pi} \times 1.4112\ T = 60.15\ MHz$

(6) a) Refer section 21.2.2 in module 2

b) Refer section 21.2.2 in module 2 for Biological Half-life and for Effective Half-life.

Physical Half- life (Radioactive half life): is the time taken for the activity of a radionuclide to reduce one-half due to physical radioactive decay

c) $\frac{1}{T_{\frac{1}{2}Eff}} = \frac{1}{T_{\frac{1}{2}Bio}} + \frac{1}{T_{\frac{1}{2}Phy}} = \frac{1}{15} + \frac{1}{8}$

$T_{\frac{1}{2}Eff} = \frac{15 \times 8}{15+8}$ = 5.2 days

d) Scintillation detector:

Advantages: High sensitive, less background count, measure low gamma dose rates and beta dose rates (with corrections), can have high light output and good energy resolution

Disadvantages: Somewhat fragile and expensive, not intended for detecting contamination, can give radiation fields only and radiation damage results in change in scintillation characteristics caused by prolonged exposure to intense radiation.

Solid state semiconductor detector:

Advantages: Spectrometry of both heavy charged (alpha) particle and gamma radiation, can be used as pocket electronic (active) dosimeters, Small physical size, can measure high dose rates and high resolution.

Disadvantages: less sensitive, minute-long exposure time, temperature dependence and high cost.

e) Refer section 22.4.3 and figure 22.9 in module 2

(7) a) Refer section 23.3 (page 78) in module 2

b) Refer section 23.4.2.3 (page 81) in module 2

c) Unexplained loss of appetite or loss of weight, Difficulty in swallowing, Indigestion. A lump in the breast or a lump elsewhere, Non healing ulcer, Persistent cough or hoarseness of voice (more than 3 weeks, in a smoker), Persistent Jaundice, A change in a wart or mole, Abnormal bleeding, Bleeding per vagina at times other than the menstrual, Non injury bleeding from the surface of the skin, mouth any other bodily orifice and Unexplained low grade fever.

d) Refer section 27.2.1 in module 2

e) Localization, Immobilization, Shielding, Opposing fields, other field arrangements and CT localization

(8) a) Refer section 25.2.1(page112) in module

b) Tubes = 30

No. of spaces between tube (garbs) = 29

Let the radiation photon energy = E, Radiation photon energy = No. of garbs x V_{Tube}

= 29 x V_{Tube}

∴Voltage across the adjacent tubes = $\frac{E}{29}$

c) Refer section 15.2.5 (page 244 and 245) or section 15.2.6 (page 247) in module 1

d) Refer section 15.2.5 (page 246) in module 1

e) Refer section 16.2 in module 1

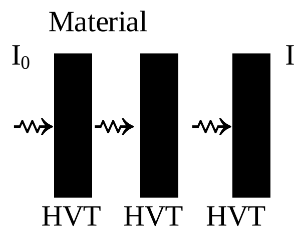
f) (i) From Inverse Square Law, $I_1 {d_1}^2 = I_2 {d_2}^2$

Where, I_1 and I_2 are the intensities corresponding to the distances d_1 and d_2 repectively.

Here, $I_1 = 80\mu Sv\ h^{-1}$, $d_1 = 1\ m$, $I_2 = 25\mu Sv\ h^{-1}$

$$\Rightarrow {d_2}^2 = \frac{80\mu Sv\ h^{-1} \times (1m)^2}{25\mu Sv\ h^{-1}} = 3.2\ \mathrm{m}^2,\ d_2 = 1.79\ m$$

(ii)



$I_0 = 2^n I$

Where, I_0 = Initial intensity of the beam, I = Intensity after attenuation/ absorption, n = no.of.half value layers (HVT) to be inserted.

Here, $I_1 = 80\mu Sv\ h^{-1}$, $I_2 = 25\mu Sv\ h^{-1}$

$$\Rightarrow 2^n = \frac{I_0}{I} = \frac{80\mu Sv\ h^{-1}}{25\mu Sv\ h^{-1}} = 3.2,\ n\ \ln 2 = \ln 3.2,\ \Rightarrow n = \frac{\ln 3.2}{\ln 2} = 1.678$$

HVT in lead for Co-60 is 1.2 cm

Thickness = HVT x n = 1.2 x 1.678 cm = 2.013 cm

∴ 2 cm of lead will give the same protection

(9) a) Refer sections 15.5 in module 1and 28.2 in module 2

b) Refer section 30.6.1 in module 2

c) Let the absorbed dose produced at the lead shield by γ- ray beam is D_0 , then $D = D_0 e^{-\mu x}$

at half value thickness $D = \frac{D_0}{2}$, $\frac{D_0}{2} = D_0 e^{-\mu x_{1/2}}$

$\Rightarrow$HVT = $x_{1/2} = \frac{\ln 2}{\mu}$

HVT in lead = 10 mm, $\Rightarrow 10\ mm = \frac{\ln 2}{\mu}, \therefore \mu = \frac{\ln 2}{10\ mm} \Rightarrow \mu = 0.0693\ mm^{-1}$

Dose equivalent H is given by H = NDQ

Where, D- absorbed dose, Q- Quality factor for type of radiation and N- product of all other appropriate modifying factors that apply to a give situation and in this case it is taken as 1

When the shielding is not present the dose equivalent produced by the neutron beam,

H (neutron) = D × 10× 1

When the shielding is not present the dose equivalent produced by the γ- ray beam,

H (γ- ray) = D_0 × 1× 1

Since the two are equal, H (neutron) = D × 10 = H (γ- ray) = D_0 × 1

$\Rightarrow D_0 = 10D$

But $D_0 = De^{\mu x}$ where $\mu = 0.0693\ mm^{-1}$

$\therefore 10D = De^{0.0693\ mm^{-1} x}$

$\ln 10 = 0.0693\ mm^{-1} x$

$$x = \frac{\ln 10}{0.0693\ mm^{-1}} = \frac{2.3}{0.0693}\ mm$$

$$x = 33.2\ mm$$

∴Thickness of the lead shield = 33.2 mm

d) Repair, Repopulation or regeneration, Redistribution and Reoxygeneration

e) Refer sections 29.1, 29.5, 29.6 in module 2