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76

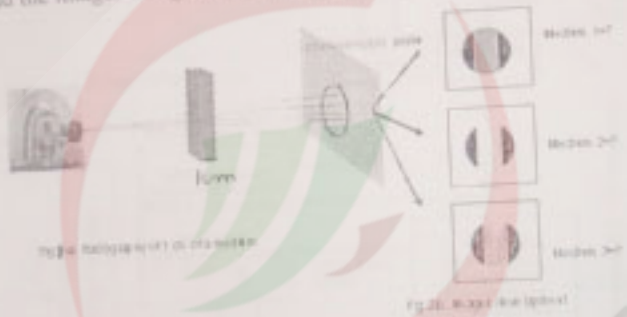
EEN 426-Introduction to Biomedical Engineering
Department of Electrical Engineering
Notre Dame University

Exam II **Instructor: Nasser-Eddin M.**
Duration: 1H30

Problem 1. X-Rays Imaging (25 points)

Figure 1-a is showing the X-Rays radiography of 1 cm of water, 1cm of bone, and 1 cm of lead with a 50 keV beam of x rays. Figure 1-b represents a development of the images for the 3 mediums.

1. Correspond the images of figure 1-b with the radiographed mediums, justify. (3 pts)



2. In practice, the relationship describing the attenuation of the incident beam is given by: $I = I_0 e^{-\mu A}$, where $A = \rho x$, ρ is the density and x is the medium thickness.

$\rho_{water} = 1 g/cm^3$, $\rho_{bone} = 1.92 g/cm^3$, $\rho_{lead} = 11.35 g/cm^3$

$\mu_{water} = 0.227 cm^2/g$, $\mu_{bone} = 0.424 cm^2/g$, $\mu_{lead} = 8.041 cm^2/g$

a- Plot the general relationship between $\frac{I}{I_0}$ and the thickness x for the three mediums. (3.5 pts)

b- Use the curve to find the particular values of $\frac{I}{I_0}$ corresponding to the slices of bone, water, and lead selected on figure 2. [redacted]

Problem 2.(25) pts The figure below shows the first ECG data flow and storage system introduced in the market by Philips in 1990. (i) Explain the global idea of the system and (ii) how could you modify this system in order to meet the 2009's specifications

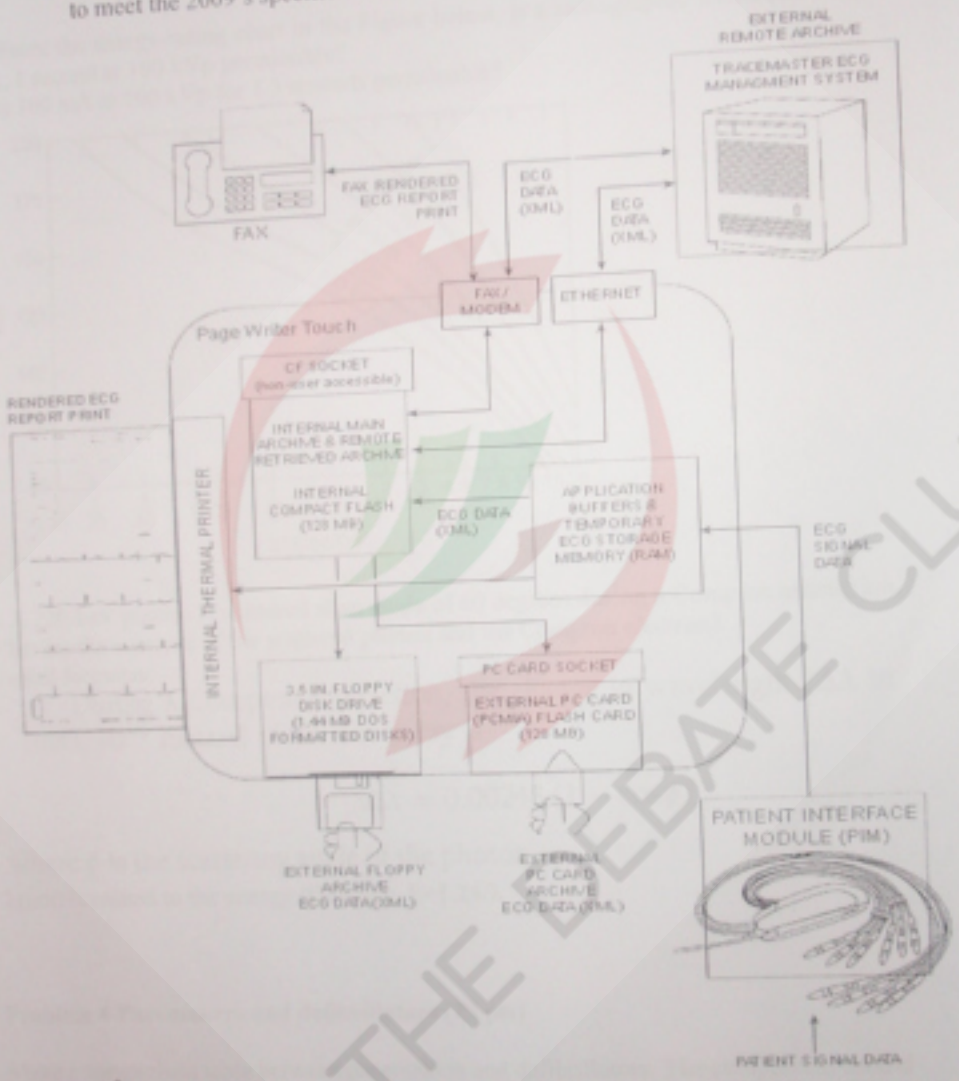
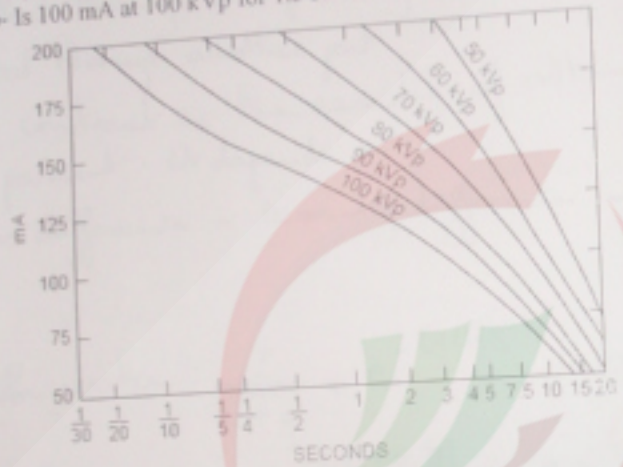


Figure 2. The ECG data flow and storage in PageWriter Touch electrocardiograph. (Courtesy of Philips Medical systems, USA.)

Problem 3. X-Rays (25 points)

a- From the energy-rating chart in the Figure below, is a radiographic technique of 150 mA, 1 second at 100 kVp permissible?
b- Is 100 mA at 100 kVp for 1.5 seconds permissible?



b- A 220-keV photon is scattered at an angle of 60 degrees during a Compton interaction. What are the energies of the scattered photon and the Compton electron?
Usefull formulas:

During a Compton interaction, the change in wavelength [$\Delta\lambda$ in (nm), 10^{-9} meters] of the x or γ ray is

$$\Delta\lambda = 0.00243\,(1 - \cos\phi)$$

where ϕ is the scattering angle of the photon
λ(nm) is related to the energy (KeV) by: E=1.24/λ

Problem 4-Pacemakers and defibrillators (25 pts)

Make a comparison table between pacemakers and defibrillators. The comparison should take into account the physiological conditions, the technical specifications and the design issues of the two systems.

Problem #1

1- Medium 1 is for water
Medium 2 is for lead
Medium 3 is for bone

Radiakia contrast is the difference in x-ray intensity transmitted through one part of the subject or compared to that transmitted through another part

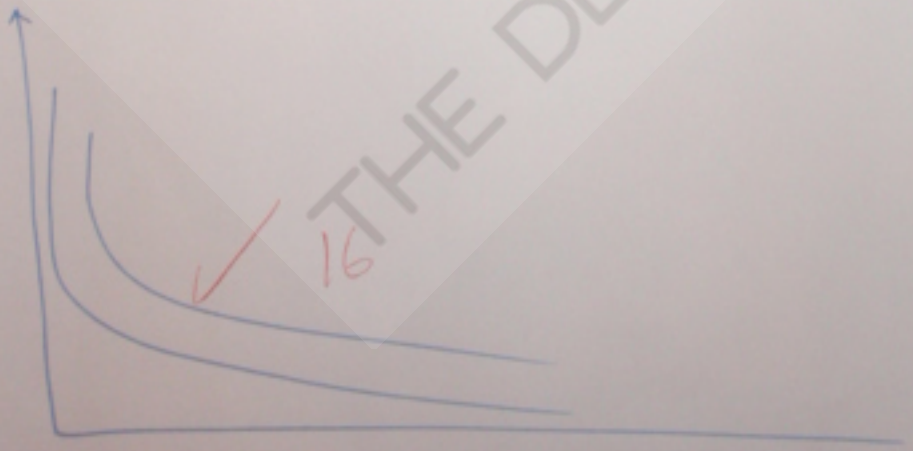
Subject contrast is the result of attenuation of x-ray beam by the patient. it depends on:
Thickness difference - Density difference - Z difference - Radiation fity

2- a - for water: $\frac{I}{I_0} = e^{-(0,172)(1)} = 0,79$

for lead: $\frac{I}{I_0} = e^{-(3,041)(11,35)} = 2,31 \times 10^{-40}$

for bone: $\frac{I}{I_0} = e^{-(0,424)(1,92)} = 0,44$

$\frac{I}{I_0} = e^{-\mu A}$ $\ln \frac{I}{I_0} = -\mu A = -\mu \rho x \Rightarrow x = \frac{\ln(I/I_0)}{-\mu \rho}$



Problem #2

Understand normal activation sequence, conduction velocities, and intrinsic pacemaker rates in the human heart.

Understand the anatomical and physiological basis of the P wave, PR interval, QRS complex, ST segment, T waves, QT interval and U waves

The fax and modem is to send the results whenever we want and the ethernet is to print the result where the machine can be placed

2- to enhance we can send data not with fax we can send wireless and replace the floppy with a CD box

17

Problem #3

a- No, the radiographique technique of 150 mA, 1 sec @ 100 kVp is not permissible because the maximum permit dua to graph is 130 mA

- 100 mA @ 100 kVp for 1,5 sec is permissible it can reach a maximum of 4 sec

(10)

$$E_\gamma' = E_\gamma - E_e = \frac{E_\gamma}{1+\alpha(1-\cos\theta)}$$

$$= \frac{220\ keV}{1+0{,}00143(1-\cos 60)}$$

$$= 219{,}73\ keV$$

(2)

$E_\gamma' = 219{,}73\ keV = E_\gamma - E_e$

$E_e = E_\gamma - E_\gamma' = 220 - 219{,}73$

$= 0{,}27\ keV$ A

Problem #4

A pacemaker is basically a timer that changes its functional states in response to elapsed intervals or sended signals.

Pacemaker restores normal functioning of cardiac rythm which are result of electrical pulses and muscular contraction

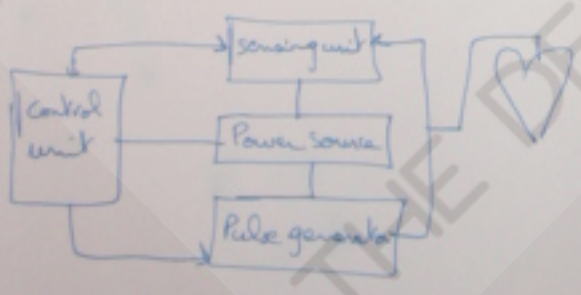
Pacemaker understand heart function, map electrical signals to muscular contractions, mimic electrical signals to ensure normal operation.

Pacemaker works as follows: insulated wires are threaded through a patient's veins to the heart.

It is also an electric stimulator for inducing contraction of the heart

it generates electrical pulses that reach the heart through the leads

Pacemakers charges a capacitor for delivery then discharge the capacitor into the heart



A defibrillator is used to reverse fibrillation of the heart

fibrillation leads to loss of cardiac output and irreversible brain damage a death if not reversed within 5 minutes of onset

~~Defi~~ Defibrillation by electric shock is carried out by passing current through electrodes placed:

- Directly on the heart

A short high-amplitude defibrillation pulse is created ~~using this circuit~~
The clinician discharges the capacitor by pressing a switch when the electrodes are firmly in place
once complete, the switch automatically returns to its original place
the power supply may be lithium silver or lithium iodine used to power low-voltage circuits
The implant is similar in appearance of pacemakers
Defibrillation electrodes are used to detect electrophysiologic signals
Energy storage is necessary to provide stimuli of 5 to 30 joul