Reg. No.											

MANIPAL INSTITUTE OF TECHNOLOGY

(A constituent unit of MAHE, Manipal 576104)

VI SEM B.Tech (BME) GRADE-IMPROVEMENT EXAMINATION, JANUARY 2021.

SUBJECT: MEDICAL IMAGE PROCESSING (BME 3203)
(REVISED CREDIT SYSTEM)
Monday, 4th January 2021, 2 to 5 PM

TIME: 3 HOURS **MAX. MARKS: 50**

Instructions to the Candidates:

1. **Answer ALL the questions.**
2. **Read the questions carefully, and answer concisely (*adequately*, but *to the point*).**

1. (a) (i) Consider a filter defined through the input-output relationship: $y(n) = -x(n-1) + 2x(n) - x(n+1)$. Plot the magnitude and phase of the frequency response associated with this filter.
Sketch the response of this filter on the signal: $x(n) = u(n) + u(n-7) - 2u(n-12)$. (5)
Comment on the results obtained.

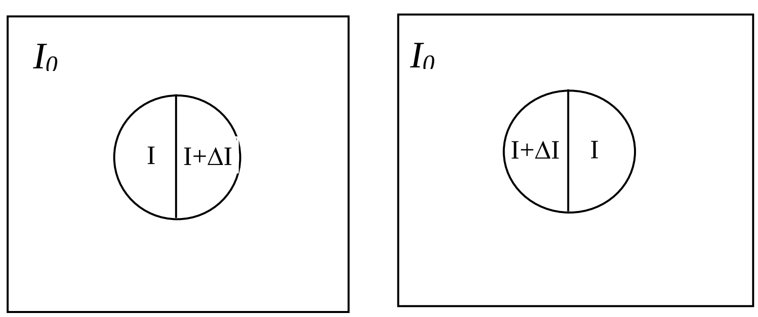
(b) An image is filtered row-by-row, and then column-by column – by the (1D) filter specified in Q.1(a). The results of the two operations are *added* to obtain the output $y(m,n)$. Write the expressions for:

(i) the **overall** input/output response, the 2D impulse response, and the 2D frequency-response of associated with the (overall, 2D) filtering operation. (3)

(ii) the 3×3-point 2D DFT of the sequence $z(m,n)$, where, $z(m,n) = y(m-1,n-1)$. (2)

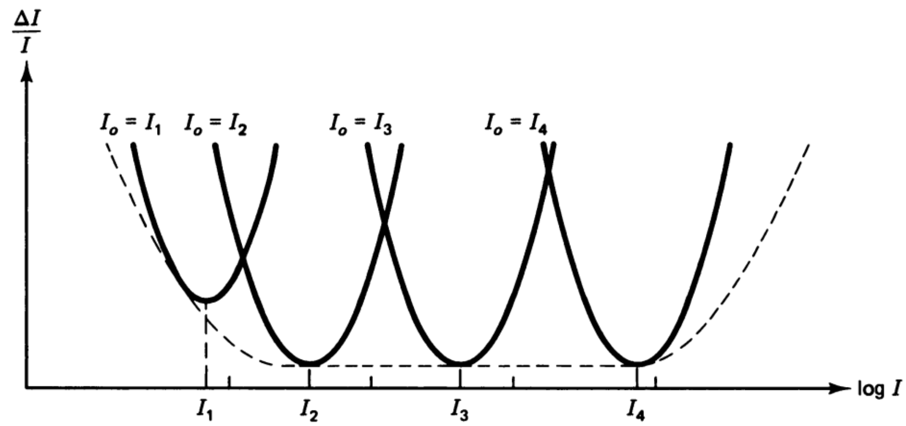
2. (a) Consider the experiment to determine the *adaptability of the human vision system*. The experimental set-up, and the relevant parameters are as shown in Fig. 1(a). "I" is the illumination over the region of interest (ROI, or the "object"), "I_0" is the intensity of the background, and ΔI is the *intensity-difference* with respect to the ROI.

Figure 1 (a)



The results of the experiments are shown in the graph in Fig. 2(b) in the following:

Figure 1 (b)



(5)

In Fig. 1(b), ΔI denotes the *just-noticeable difference*. Explain: (i) the experiment, and (ii) the resulting graph, concisely.

(b) (i) Compute the DCT coefficient-vector $\boldsymbol{c_x}$ associated with the signal-vector $\boldsymbol{x} = [1\ 2\ 5\ 5\ 5]^T$. The formula for the DCT is given by the following:

$$C_x(k) = v(k)\sum_{n=0}^{N-1} x(n)\cos[\frac{\pi}{2N}(2n+1)k], \qquad 0 \le k \le N-1$$ (3)

where: $v(0) = \sqrt{\frac{1}{N}}, \qquad v(k) = \sqrt{\frac{2}{N}}, \qquad 1 \le k \le N-1$

(ii) Let $\boldsymbol{d_x}$ be the *truncated version* of the DCT-coefficient-vector $\boldsymbol{c_x}$ (with only three coefficients retained). Compute the signal-vector $\boldsymbol{y_x}$, 'reconstructed' from $\boldsymbol{d_x}$. (2)

3. (a) (i) With the desire of *flattening* isolated discontinuities in an image (*without blurring*), a student filtered the image in Fig. 2(b), by the mask sketched in Fig. 2(a). Sketch the output that the student would have got. (3)

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1/6	2/6	1/6
	1/6	

Figure 2(a): Filter mask

Figure 2(b): Image

2	10	10	10	20	10	4
10	10	2	10	20	10	10
10	10	10	10	20	10	10
10	10	10	10	20	10	10
1	10	5	5	20	5	5
10	10	5	5	20	5	5
10	10	5	5	20	5	5
10	6	5	5	20	5	6

(ii) Does the student get the output as per his desire? Please answer by pointing out to the *precise results* in the output. (2)

(iii) If you think that the student has made a mistake in the choice of the filter (*i.e.*, felt that he could have a result to satisfy his desire precisely), indicate the type of filter you would suggest. Demonstrate the acorrectness of the choice (compute the output). (3)

(b) Indicate a filter in the continuous time- (or space-) domain, that would accentuate discontinuities. Find its discrete version that would have zero-phase. (2)

4. (a) (i) Prove the formula for reconstructing an image $f\ (x,y)$ from a set of it projections$\{\ p_{\theta}(t)\ \}$:

$$f(x,y) = \int_0^{\pi} \tilde{p}_{\theta}(x\cos\theta + y\sin\theta)d\theta, \quad \forall(x,y)\ \varepsilon\ ROI \quad \text{(ROI: Region of Interest)}$$ (5)

where, $\{\ \tilde{p}_{\theta}(t)\ \}$ are the *filtered versions* of the projections $\{\ p_{\theta}(t)\ \}$ – identify the filter-kernel.

Hint: Start from the Fourier- (central-) slice theorem.

(ii) Write a *pseudo code* to implement the formula on the computer, to reconstruct an image from its projections, over a predefined 2D grid (ROI). (3)

(b) Describe the 3rd generation CT system, and explain its working. (2)

5. (a) (i) In the context of positron emission tomography (PET), explain the concept of electronic collimation, and its utility. (2)

. (ii) Indicate and explain two major sources of errors in PET. (2)

(b) In the context of Magnetic resonance imaging (MRI), answer the following questions <u>concisely</u>:

(i) Explain the action of a 90^{o} pulse, on the protons within an object being imaged? (2)

(ii) What is the shape of the response induced in a coil placed in the vicinity, when a 90^{o} pulse is applied to an object with protons? Explain the reason behind the shape. (2)

(iii) How can a 90^{o} pulse be exploited in distinguishing a tissue *A* with a lower value of T_1, from another tissue *B* with a higher value of T_1? (2)