Reg. No.											

MANIPAL INSTITUTE OF TECHNOLOGY

(A constituent unit of MAHE, Manipal 576104)

VI SEM B.Tech (BME) DEGREE END-SEMESTER EXAMINATIONS, APRIL-MAY 2019.

SUBJECT: MEDICAL IMAGE PROCESSING (BME 3203)
(REVISED CREDIT SYSTEM)
Saturday, 27Th April 2019, 2 to 5 PM

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

Instructions to Candidates:

1. **Answer ALL questions.**
2. **Read all the questions carefully, and answer concisely (*adequately*, but *to the point*).**
3. **Draw labeled diagram wherever necessary**

1. (a) (i) Consider the 1D filter mask given in Fig. 1(a). It is a symmetric mask with the middle coefficient at the origin.

1/3	1/3 ↑	1/3

Figure 1(a)

Find the simplified expression for the frequency-response of the filter, and plot its magnitude. (3)

From the frequency-response, find the *value of the "DC coefficient*". Compare the value with the *sum of the values of the coefficients in the mask*, & comment.

(ii) Observe carefully, the 2D filter mask in the adjacent figure 1(b).

0	1/6	0
1/6	2/6	1/6
0	1/6	0

Figure 1(b)

- Can you use the 1D filter in Fig. 1(a), on a 2D image, to get the precise effect of filtering it using the 2D filter mask in Fig. 1(b)? If so, how would you do that? (2)
- Using the answers to Q (i) and the preceding question (ii), reason-out (predict) the nature of this 2D filter.

(b) (i) How would you compute the 2D DFT using an FFT algorithm? Explain clearly with proper expressions and diagrams. (3)

(ii) Consider filtering a 2D sequence of size 400×700. The size of the filtering kernel is 51×51. Find the number of zeros to be padded to the two sequences, to allow linear filtering by the filter-kernel, using an FFT algorithm. (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 over the background, and ΔI is the *just noticeable difference* with respect to the ROI.

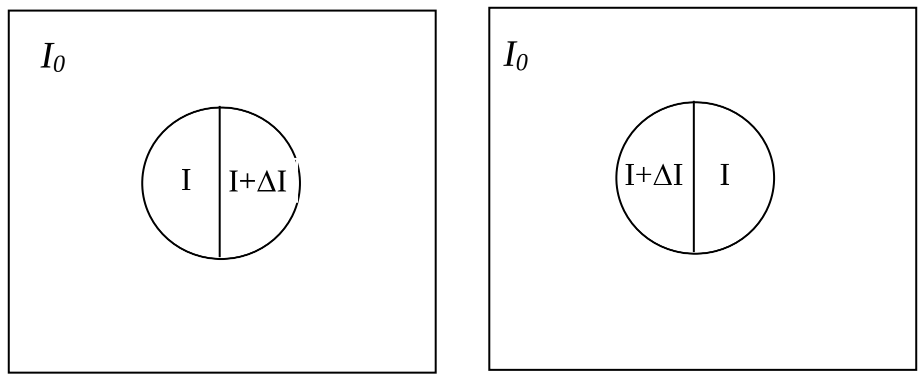


Figure 2 (a)

The results of the experiments are shown in the graph in Fig. 2(b) in the following: (5)

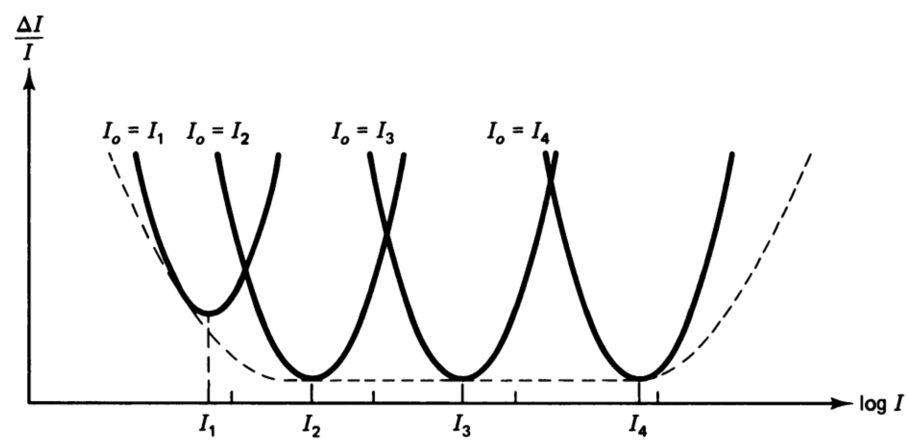


Figure 2 (b)

Explain the experiment, and the resulting graph concisely (& clearly).

(b) (i) What are the essential properties of the DCT, for it to be useful in image compression? Explain each concisely (a line or two per property). (3)

(ii) What are the <u>two main advantages</u> of splitting a large image into smaller blocks, and coding them independently? Explain concisely but clearly. (2)

3. (a) (i) Find the output of a Median Filter (MF) based on a 3×3 cross-shaped neighborhood shown in Fig. 3(a), on the image in Fig. 3(b). (3)

	X	
X	X	X
	X	

Figure 3(a)

Figure 3(b)

5	5	5	5	5	6	6
5	5	12	5	5	6	6
5	0	5	5	5	6	6
5	5	5	5	5	6	12
6	6	6	6	6	12	6
5	6	6	6	12	6	6
6	6	6	12	6	6	6
6	6	12	6	6	6	6

(ii) List the important achievements of the MF (<u>only by pointing out to the relevant pixels</u> in the result. (1)
IMPORTANT: <u>Blind, irrelevant points will fetch *penal marks* (–0.5 per point).</u>

(iii) Do you observe any **drawback** of this median filter-upport? Indicate clearly, by pointing out to the <u>relevant pixels in your result</u>. (1)

(iv) Suggest a support of the MF, to overcome the drawback indicated in (iii). Justify your answer by showing the output at at least two relevant pixels. (1)

(v) Can your support, however, affect something else? If so, show the relevant (affected) pixel. (1)

(b) Find the output of the averaging filter, whose mask is shown In the adjacent figure (Fig. 4), **on the image in Fig. 3(b)**. (3)

Figure 4

	0.5	
0.5	0.5	0.5
	0.5	

4. (a) State the central slice theorem, and illustrate the same using expressions & a suitable diagram. (2)

(b) (i) The formula for computing the backprojection from a set of projections $\{ p_\theta(t) \}$, is given by: $b(x,y) = \int_0^\pi p(x\cos\theta + y\sin\theta)d\theta, \quad \forall(x,y)\ \varepsilon\ ROI$ (Region of Interest)

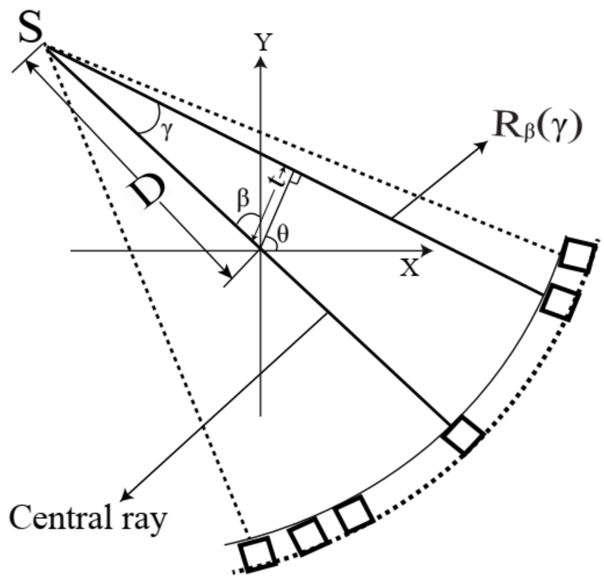
(i) Discretize the formula. (1)

(ii) Write the steps involved in *computing* the backprojection (only). Use the *nearest neighbor method*, in the interpolation-step. You must define all the parameters used. (2)

(iii) Write a *pseudo code* to <u>implement backprojection</u> (only) over a predefined 2D grid, from a set of discrete projections, using the nearest-neighbor method in the interpolation-step. (3)
<u>NOTE: Unnecessary/irrelevant steps (or instructions) will invite *penal marks*.</u>

(c) Derive the relationship between the parameters pertaining to a line, for the purpose of rebinning (resorting the data from the fan-beam geometry (β,γ) to parallel-beam geometry (θ,t). You may wish to refer to the fan-beam scanning geometry in the adjacent Figure (Fig. 5). (2)

Figure 5:



5\. (a) Let N_0 be the number of photons coming out of a *thin homogenous slab* (of a very small width Δx) of attenuating material (coefficient of attenuation = μ), when the input number of photons in a thin beam is N_{in}.

(i) Derive the expression for N_0 in terms of N_{in}. (2)

(ii) If the same beam is input to an connected array of N thin slabs (of equal width Δx) of attenuating materials with coefficients μ_i,, i = 1,2,…., N, what would be the expression for N_0? (1)

(iii) How would the expression modify, if the beam is passed through a *non-homogenous* slab of width L units. (1)

(ii) Explain the system associated with, and the working of – an electron-beam CT. (3)

(b) In the context of Magnetic resonance imaging (MRI): explain T_1-weighted imaging, using a suitable pulse sequence. In other words, explain as to how a tissue A with a lower value of T_1, can be distinguished in the image, from another tissue B with a higher value of T_1. (3)