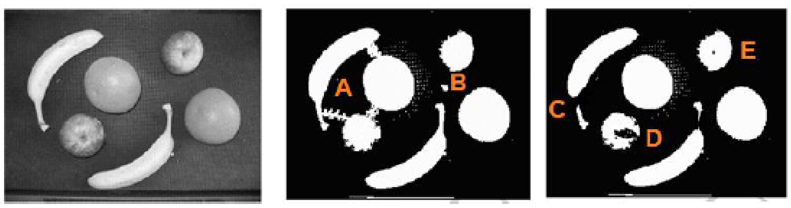
Chapter 4: 4.3, 4.8, 4.12, 4.15, 4.20 (a-c, inclusive)

Prob. 4.2 — ~~Write the set representation of the binary image $\mathcal{A}$, and the array representation of the binary image $\mathcal{B}$.~~

$$\mathcal{A} = \begin{bmatrix} 1 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \qquad \mathcal{B} = \{(1,1),(2,1),(1,2),(2,2),(3,2),(1,3),(3,3)\}.$$

Prob. 4.3 — Apply the set operators of Figure 4.2 to the images $\mathcal{A}$ and $\mathcal{B}$ of the previous question, using $\mathbf{b} = (1,1)$. That is, compute $\mathcal{A} \cup \mathcal{B}$, $\mathcal{A} \cap \mathcal{B}$, $\mathcal{A}_{\mathbf{b}}$, $\check{\mathcal{B}}$, $\neg\mathcal{A}$, and $\mathcal{A} \backslash \mathcal{B}$. Write the results as arrays.

Prob. 4.8 — Recall the fruit image at the beginning of the chapter, which is reproduced below for convenience. On the two thresholded results shown, identify the name that best describes each of the labeled artifacts A–E: lake, bay, channel, cape, isthmus, or island. Which morphological operator (opening or closing) should be applied to the image on the left to remove noise? To the image on the right?



Prob. 4.12 — Which of the labeled pixels below are 4-neighbors of the central pixel c? 8-neighbors? diagonal neighbors?

	a	b
	c	d
e		

Prob. 4.15 — Compute the Euclidean, Manhattan, and chessboard distances from each pixel in a 5×5 image to the central pixel. What shape do the isocontours take in each case?

Prob. 4.20 — Prove each of the following equations for sets $\mathcal{A}$, $\mathcal{B}$, and $\mathcal{C}$:

(a) $\mathcal{A} \ominus (\mathcal{B} \oplus \mathcal{C}) = (\mathcal{A} \ominus \mathcal{B}) \ominus \mathcal{C}$

(b) $\mathcal{A} \check{\ominus} (\mathcal{B} \oplus \mathcal{C}) = (\mathcal{A} \check{\ominus} \mathcal{B}) \check{\ominus} \mathcal{C}$

(c) $\mathcal{A} \oplus (\mathcal{B} \cup \mathcal{C}) = (\mathcal{A} \oplus \mathcal{B}) \cup (\mathcal{A} \oplus \mathcal{C})$

Chapter 5: 5.7, 5.23

Prob. 5.7 — For each of the kernels below, specify whether it is a smoothing or a differentiating kernel.

(a) $\frac{1}{32}\begin{bmatrix} 2 & 4 & 6 & 8 & 6 & 4 & 2 \end{bmatrix}$

(b) $\frac{1}{6}\begin{bmatrix} 1 & 2 & 3 & 2 & 1 & 0 & -1 & -2 & -3 & -2 & -1 \end{bmatrix}$

(c) $\frac{1}{9}\begin{bmatrix} 9 & 1 & -1 & -9 \end{bmatrix}$

(d) $\frac{1}{11}\begin{bmatrix} 1 & 9 & 1 \end{bmatrix}$

Prob. 5.23 — Show that magnitude of the gradient is not isotropic when implemented discretely, by comparing and contrasting the Euclidean, Manhattan, and chessboard versions on the two images below, using the Prewitt, Sobel, and Scharr operators. Which operator, and which metric, yields the most consistent behavior on these two inputs?

$$\begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \end{bmatrix} \qquad \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

Chapter 6: 6.4, 6.19, 6.20

Prob. 6.4 — Explain the difference between the Nyquist rate and the Nyquist frequency.

Prob. 6.19 — Explain why the shifted 2D DFT usually has large values along the horizontal and vertical axes, forming the shape of a plus sign?

Prob. 6.20 — Suppose an image is rotated clockwise by 30 degrees. How does this change the 2D DFT?