

# 6.003: Signal Processing

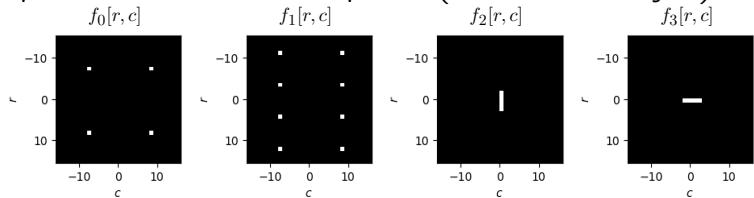
## Two-Dimensional DFT

$$F[k_r, k_c] = \frac{1}{RC} \sum_{r=0}^{R-1} \sum_{c=0}^{C-1} f[r, c] e^{-j\left(\frac{2\pi k_r}{R}r + \frac{2\pi k_c}{C}c\right)}$$

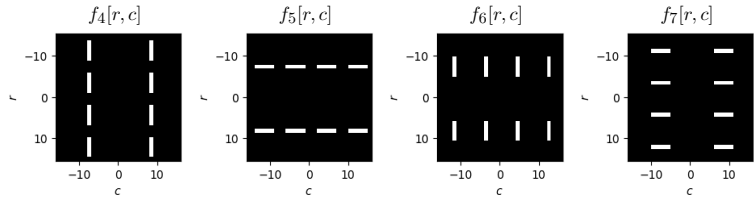
$$f[r, c] = \sum_{k_r=0}^{R-1} \sum_{k_c=0}^{C-1} F[k_r, k_c] e^{j\left(\frac{2\pi k_r}{R}r + \frac{2\pi k_c}{C}c\right)}$$

## 2-D Patterns

Match each 2-D signal below (each  $32 \times 32$  pixels) with its DFT magnitudes. In each image, black represents 0 and white represents the most positive value in that panel (not necessarily 1).



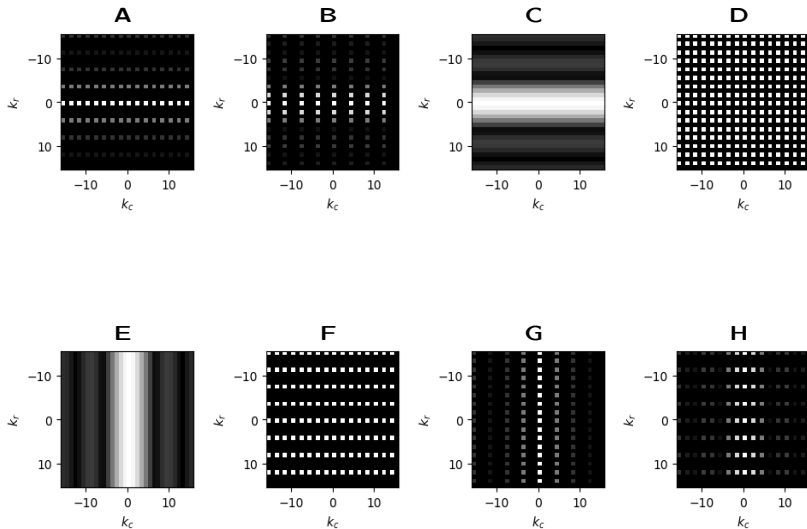
$ F_0[k_r, k_c]  = $ <input type="checkbox"/>	$ F_1[k_r, k_c]  = $ <input type="checkbox"/>	$ F_2[k_r, k_c]  = $ <input type="checkbox"/>	$ F_3[k_r, k_c]  = $ <input type="checkbox"/>
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$ F_4[k_r, k_c]  = $ <input type="checkbox"/>	$ F_5[k_r, k_c]  = $ <input type="checkbox"/>	$ F_6[k_r, k_c]  = $ <input type="checkbox"/>	$ F_7[k_r, k_c]  = $ <input type="checkbox"/>
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## 2-D Patterns

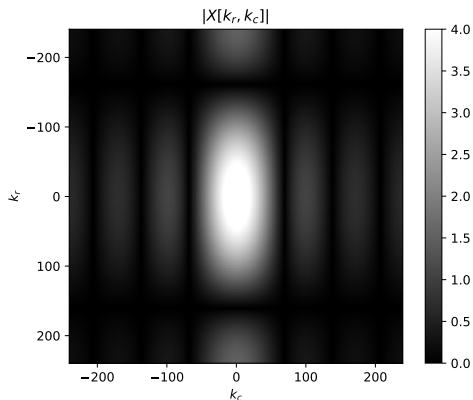
DFT Magnitude Graphs:



## Mystery Photograph

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Below are shown the DFT magnitudes of an image of a single small white object photographed against a black background. The image had dimensions of  $480 \times 480$  pixels and represented an area that was 1.8cm wide and 1.8cm tall.



What did this image look like in the spatial domain, including dimensions?

# Mystery Photograph

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## Cats

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Consider the following image, which we'll refer to as  $f[r, c]$ . This image has height  $R$  and width  $C$ . In this image, black corresponds to a value of 0, and white corresponds to a value of 1.



In addition, consider two other signals (and note that one is specified in the frequency domain, and the other in the spatial domain):

$$H_1[k_r, k_c] = j \sin\left(\frac{10\pi k_c}{C}\right)$$

$$h_2[r, c] = \sin\left(\frac{10\pi c}{C}\right)$$

## Cats

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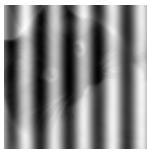
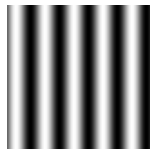
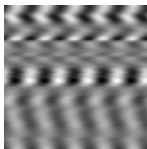
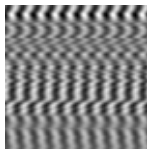
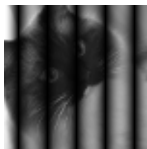
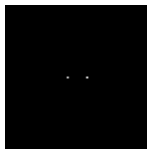
For each of the expressions below, indicate which of the images on the following page is represented by that expression. In each of the images on the following page, black represents the lowest value (not necessarily 0), and white represents the highest value (not necessarily 1). The point  $(r = 0, c = 0)$  is located in the center of each image;  $r$  increases downward, and  $c$  increases to the right.

$$(f \times h_1)[r, c] =$$

$$(f \times h_2)[r, c] =$$

$$(f \circledast h_1)[r, c] =$$

$$(f \circledast h_2)[r, c] =$$

**A****B****C****D****E****F****G****H****I****J****K****L**