1. Spatially filter (convolve) the image on the left with the 3 x 3 mask (kernel) shown. State the assumptions you make for the pixels outside the source image.

```
Assume all pixels outside the image are 0. Output image:
                                  0  1  2  1  0
                                  1  6 10  6  1
                                  2 12 20 12  2
                                  1 10 18 10  1
                                  0  3  6  3  0
```

2. What is the result of mean filtering (averaging pixels with their 8-connected neighbors) for the following image?

```
Round to nearest whole number. Assume all pixels outside the image are 0.
Output image:
                                  4  6 10 13 11
                                 16 19 25 20 17
                                 16 20 25 20 16
                                 17 20 24 19 16
                                  5  7 10 13 10
```

3. What is the result of median filtering (using 8-connected neighbors) for the following image?

```
Round to nearest whole number. Assume all pixels outside the image are 0.
Output image:
                                  0  9  9  9  0
                                  9  9 11 24 24
                                  9 10 12 23 23
                                 10 11 12 22 22
                                  0 10 11 12  0
```

4. What is the result of unsharp masking using an A = 1 (a 5 in the center) mask?

```
                                 31 26  0 68 57
                                 11 14 -9 44 67
                                 18  1 -8 37 51
                                 25 13  8 35 37
                                 28 25  0 53 81
```

5. This question walks through the computational steps for gradient-magnitude edge detection for the following image: (For this question, don't worry about the border pixels.)

(a) What is the result of applying the x-derivative Sobel filter? (Remember to divide by 8.)

(b) What is the result of applying the y-derivative Sobel filter? (Remember to divide by 8.)

(c) What is the gradient magnitude at each pixel?

```
Part A: x-derivative Sobel filter
                                  0.1 7.8 8.4
                                  0.2 7.5 7.6
                                  0.1 6.4 6.5

Part B: y-derivative Sobel filter
                                 -0.9 -0.5 0.1
                                  1.0 0.5 -1.1
                                  0.9 0.1 -0.5

Part C: Sum of x and y
                                  0.9 7.8 8.4
                                  1.0 7.5 7.7
                                  0.9 6.4 6.5
```