[Results]

(a)Gray Scale Dilation
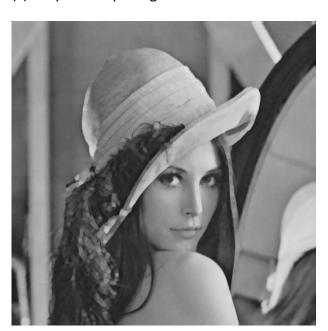

(b) Gray Scale Erosion

(c) Gray Scale Opening

(d) Gray Scale Closing

[Code Fragment & Explanation]

Part-1 Gray Scale Dilation: Find the maximum pixel value of all points in the kernel area for each point in image. Take the maximum pixel value as new pixel value.

```python
 9 def Dilation(img, kernel):
10     imageW, imageH = img.width, img.height
11     new_img = Image.new('L', (imageW, imageH))
12     new_img_pixel = new_img.load()
13     for x in range(imageW):
14         for y in range(imageH):
15             localMaximum = 0
16             for [ex, ey] in kernel:
17                 dest_x, dest_y = x + ex, y + ey
18                 if ( validPixel(dest_x, imageW-1) and validPixel(dest_y, imageH-1) ):
19                     localMaximum = max( localMaximum, img.getpixel((dest_x, dest_y)))
20             new_img_pixel[x, y] = localMaximum
21     return new_img
```

Part-2 Gray Scale Erosion: If kernel pattern fits in the source image, find the minimum of all this pixel values. Take the minimum pixel value as new pixel value.

```python
23 def Erosion(img, kernel):
24     imageW, imageH = img.width, img.height
25     new_img = Image.new('L', (imageW, imageH))
26     new_img_pixel = new_img.load()
27     for x in range(imageW):
28         for y in range(imageH):
29             localMinimum = 255
30             savePixel = True
31             for [ex, ey] in kernel:
32                 dest_x, dest_y = x + ex, y + ey
33                 if ( validPixel(dest_x, imageW-1) and validPixel(dest_y, imageH-1) ): # valid pixel
34                     if img.getpixel((dest_x, dest_y)) == 0: # but no value
35                         savePixel = False
36                         break
37                     else: localMinimum = min( localMinimum, img.getpixel((dest_x, dest_y))) # erosion
38                 else: # non-valid pixel
39                     savePixel = False
40                     break
41             if savePixel: new_img_pixel[x, y] = localMinimum
42     return new_img
```

Part-3 Gray Scale Opening: By definition. Do erosion first and do dilation.

```python
44 def Opening(img, kernel):
45     return Dilation(Erosion(img, kernel), kernel)
```

Part-4 Gray Scale Closing: By definition. Do dilation first and do erosion.

```python
47 def Closing(img, kernel):
48     return Erosion(Dilation(img, kernel), kernel)
```