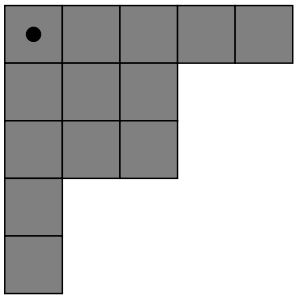
QUIZ 1 SOLUTIONS

1. **Dilation and Erosion (8 points):**

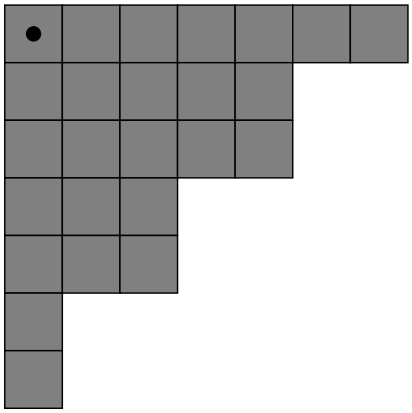
   (a) The dilation of B by B is the set Y which looks like this:



   (b) The smallest set X_1 which could survive a *single* erosion by B is in fact the set B itself. That would leave just a single point behind, located at the origin of B.

   The smallest set X_2 which could survive *two* erosions by B is exactly the set Y which we found in part (a).

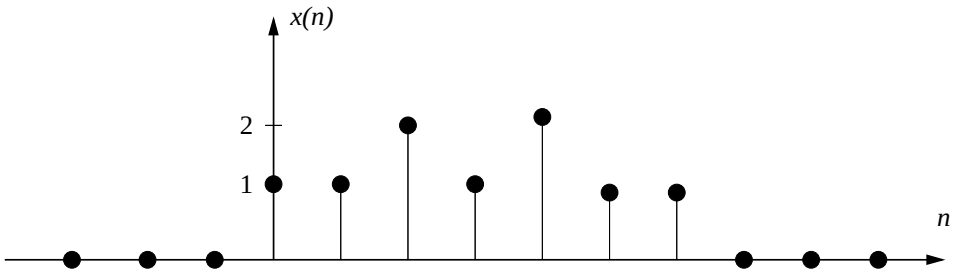
   But we are looking for the smallest set which could survive *three* erosions. By dilating Y by B, we get a set which looks like this:



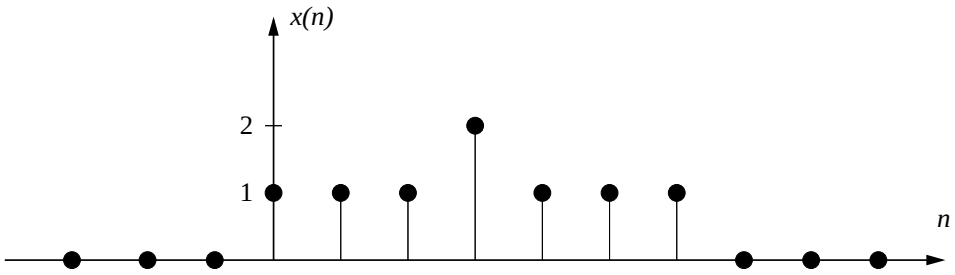
   and this is the smallest set which can survive 3 erosions by B.

2. **Median Filtering (8 points):**

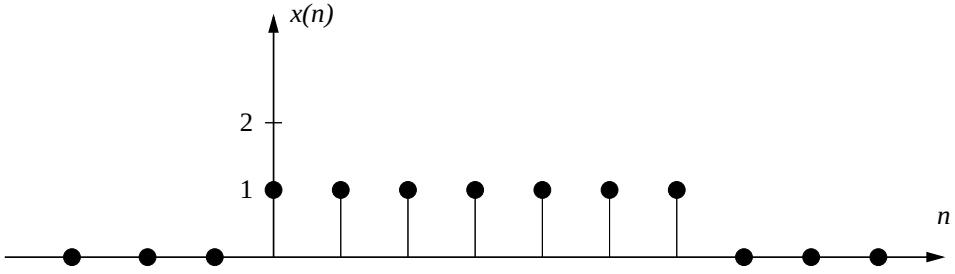
   (a) After one iteration of median filtering, we have:



and after the 2nd we have:



and after the 3rd we have:



which is the root signal, because any subsequent median filtering (with this particular median filter) will cause no further change.

(b) If there are M^2 noise pixels, then there must be at least $M^2 + 1$ good pixels, so that the noise pixels will not constitute the majority in the median operation. So the entire mask must cover at least $2M^2 + 1$ pixels. Thus the mask size must be at least $N \times N$ where N is the next integer larger than sqrt$(2M^2 + 1)$.

3. **Edge Orientation (8 points):**

(a) The direction of the gradient vector is always orthogonal to the direction of the edge. The equation for the direction of the gradient vector at an edge point in terms of G_X and G_Y was given in class, and is also in the textbook as Equation 10.2-11:

$$\alpha(x, y) = \tan^{-1}(G_y/G_x)$$

Since it is OK to specify the direction of an edge by giving the gradient direction, or by giving the edge direction, it is OK to give this answer, and it is also OK to say the answer is 90 degrees off from this value.

(b) This part is a problem from the textbook, 10.12(b). See the separate solution written by Nafi.

4. **Binary Morphological Operators (6 points)**

(a) erosion, (b) thinning, (c) dilation, (d) opening, (e) spur removal, (f) closing.

5. **Edge Classification (5 points):**

1) This is a shadow edge, also called an illumination edge. You get full credit for using one of those words, or for explaining that this type of edge arises from a discontinuity of the intensity of the incident lighting.

2) This is a specular edge, also called a highlight edge. You get full credit for using one of those words, or for explaining that this type of edge arises from a special orientation among light source, object surface, and viewing angle, and depends on material properties.

3) This is an object edge or orientation edge. It arises from a discontinuity of the vector normal of a continuous surface.

4) Edge 4 represents the boundary between the bellpepper and the stem. At that location, there is both an orientation edge (because the stem is not at exactly the same orientation as the main part of the pepper) and there is a reflectance edge. But orientation edge is not the right answer here, because that is already the answer for number 3. A reflectance edge arises from a discontinuity of the reflectance of object surfaces, for example by a change of surface material.

5) Edge 5 is an occlusion edge, which represents the boundary between an object and whatever thing is behind it, as seen by the observer. In this case one bellpepper is partially hidden by the one in front.