

Your Name: _____ Your T-Square ID: _____

- **You must show all work to receive full credit.** Correct answers with no work shown will receive minimal partial credit, while incorrect answers with correct work shown will receive generous partial credit. Illegible answers are wrong answers.
- **Integrity:** By taking this quiz, you pledge that this is your work and you have neither given nor received inappropriate help during the taking of this quiz in compliance with the Academic Honor Code of Georgia Tech.
- **Academic Misconduct:** Academic misconduct will not be tolerated. You are to uphold the honor and integrity bestowed upon you by the Georgia Institute of Technology.
 - Keep your eyes on your own paper.
 - Do your best to prevent anyone else from seeing your work.
 - Do NOT communicate with anyone other than a proctor for ANY reason in ANY language in ANY manner.
 - Do NOT share ANYTHING during the quiz. (This includes no sharing of pencils, paper, erasers or calculators).
 - Do not use notes or books, etc during the quiz.

Problem	Points	Lost	Gained	Running Total	Grader
1	5				
2	8				
3	5				
4	5				
5	5				
6	5				
7	5				
Total:	38				

1. (5 points) What are the benefits of using a pinhole as your optical system? What are the benefits that arise from using a lens (or system of lenses) instead? (In other words, what disadvantages does a pinhole system have that using a lens alleviates?)

Grading: +1 point for each/any of the items below, max of 5.

Pinhole:

- + Infinite depth of focus
- + No lens based distortions (straight lines remain straight)
- + easy to build, takes up minimal space / cost
- Minimal light, requiring long exposures and static scenes
- Size must be carefully chosen, too big gives geometric blurring, too small gives diffraction blurring.

Lens:

- + Lets more light in, allowing faster shutter speeds and allowing for the capture of moving images.
- + Lens systems can have adjustable focus / zoom / field of view
- Can have lens based aberrations (Spherical, Chromatic (color), barrel and pincushion)
- Size, weight & cost.

2. (8 points) For each of the following multiple choice questions, circle the best answer:

- As the focal length of a lens increases, the field of view (FOV)

- a. Gets larger (wider) b. Gets smaller (narrower)

- As the shutter speed gets slower (shutter stays open longer), the exposure:

- a. Goes up (brighter) b. Goes down (darker)

- As the shutter speed gets slower (shutter stays open longer), motion blur:

- a. Becomes more noticeable b. Becomes less noticeable

- As the aperture number goes up (gets bigger, e.g. f/2 to f/8) the area of the aperture:

- a. Gets larger (more light in) b. Gets smaller (less light in)

- The smaller the aperture area:

- a. The smaller the depth of focus b. The larger the depth of focus

- CCD sensors are read:

- a. One line at a time b. One photosite at a time

- CMOS sensors are read:

- a. One line at a time b. One photosite at a time

- a BAYER Filter

- a. Allows cameras to differentiate color information
- b. Has more green sites than red and blue sites
- c. Requires demosaicing
- d. All of the above

3. (5 points) Explain how image pyramids (Gaussian/Laplacian) allow us to perform blending operations at different frequency octaves without using a Fourier transform. Be sure to include an example of what “high frequency” and “low frequency” mean when looking at image data in your explanation.

As your image representation gets smaller and more blurred, each “higher” level in the Gaussian pyramid represents lower frequency (more “big picture”) data about the image. Your largest image contains all of the high frequency information, while the smallest image only has the very general “low frequency” information. For example, the outline of a ball would be low frequency information, while the actual pentagons and hexagons on a soccer ball would be higher frequency information. In the smallest top level images of a Gaussian pyramid, you could see the ball, but in a lower level you could recognize that it was a soccer ball.

By doing operations on specific levels of the Gaussian pyramids (such as merging two pyramids together) we can take different actions at different levels of “frequency information” with respect to the original image, allowing us to blend two images together without ghosting effects.

Grading:

+2 Know that different levels of the pyramids hold different “frequencies” of information.

+1 know that the smaller images have the “lower” frequency information.

+2 Valid example of what “high” and “low” frequency information might mean when looking at an image.

4. (5 points) Explain at a high level how seam carving works, and what is it used for.

Seam carving eliminates a seam or string of contiguous (but not necessarily straight line) pixels from an image stretching from the top to the bottom (or left side to right side). It uses an “energy function” of some sort (e.g. Magnitude of gradients, human perception interest model, eye tracking, etc...) to calculate an “importance” value for each pixel in the image, and then calculates the best path/seam through the image that removes the least important seam of pixels, one seam at a time.

It is typically used to shrink one dimension of an image without changing the other (change the aspect ratio), but can also be used to expand an image (if used to generate new data at seams) or even remove objects from an image (by forcing the seams to go through the objects). You can also calculate the error between two images you want to merge, and carve a seam between them to merge the images at the seam, but this works better with graph cuts.

Grading (Maximum of 5):

+2 for knowledge of removing seams made up of “low interest” pixels

+2 for knowledge of changing image size/aspect ratio.

- +2 for knowledge of carving a seam between two images that you are merging.
- +1 knowledge of “energy function”
- +1 for knowledge of forcing seams to remove objects.

5. (5 points) Under what conditions can a cross-correlation produce the same output as a true convolution?

The kernel must be symmetrical (so that the H&V flip of cross-correlation has no effect) and all data must be real-valued (no complex numbers).

+3 for symmetric kernel

(+2/3 if they say the image has to be symmetrical, example disproving is impulse image.)

(+2/3 if they know that cross-correlation is flipped H&V from correlation, but don't mention symmetric kernel.)

+2 for real valued data.

6. (5 points) What is a separable filter, and what are the advantages of using a separable filter?

A separable filter is one that can be split into a vertical and horizontal component, such that the horizontal and vertical component can be applied independently. Another way to say this is that it is the convolution (or just the outer product) of two vectors.

$$K = H * V$$

$R = I * K$ is equivalent to $R = (I * H) * V$ due to the associativity of convolution.

The advantage of applying H and V separately is that it is much quicker to apply a $1 \times M$ filter and a $M \times 1$ filter than to apply an $M \times M$ filter when M is large.

Grading:

+2 for knowing that the filter can be separated into a horizontal and vertical component (or that $H * V = K$)

+2 for mentioning speed advantage.

+1 for showing formula(s) of equivalence or mentioning associativity. / Or knowing how to detect a filter is separable ($\text{rank}(K) = 1$).

7. (5 points) Explain how the “Anti-Pinhole” camera work by Antonio Toralba and William T. Freeman are able to use an obstruction such as a ball or hand instead of an opening such as a pinhole for imaging purposes.

The primary concept is that we capture a “background” or “reference” image when light falling upon the scene is NOT being obstructed by an object. Then, we capture an image of the scene when light IS being obstructed by an object. By subtracting these two images, we get the light that would have been going through the “anti-pinhole” (if the object were replaced by a pinhole and everywhere the object wasn't was replaced by an opaque light blocking material).

Grading: +1 for a mention that an object blocks light. +1 for mentioning the use of two different images, or tracking “how light changes” as object moves. +3 for explaining the need to subtract the two images to find the difference (light that would have gone through the anti-pinhole).