1. [4] Why can’t the coffers (i.e., sunken square panels) in the vaulted ceiling in Masaccio’s *Trinity* be used to determine the **distance point** for this fresco?

   The coffers are not on a plane and therefore the diagonal lines through them will not intersect at a point corresponding to the distance point for the viewer.

2. [4] How can you tell if a painting, containing a pavimento (tile) floor, that is hung in a gallery, is mounted too high or too low relative to where the painter probably intended you to view it?

   Find the vanishing point where the orthogonals of the pavimenti intersect and this point should be at the same height as your eye.

3. [6] Yes or no: A pair of parallel straight lines that are on a plane in a 3D scene that is **parallel** to the picture plane will project under linear perspective to parallel straight lines (i.e., without a vanishing point) in (a) 1-point perspective? (b) 2-point perspective? (c) 3-point perspective?

   (a) [2] Yes
   (b) [2] Yes
   (c) [2] This was a poor question; interpreted literally, lines parallel to the picture plane will always project to parallel lines, and the answer is yes. But by 3-point perspective we normally mean that the vertical lines in the scene are not parallel to the picture plane, in which case the answer is no. I accepted both answers.

4. [2] True or false: If a drawing is true linear perspective and there are a set of parallel lines in the picture, then those lines must also be parallel in the 3D scene.

   False; there are an infinite number of ways that the lines may occur in 3D and appear parallel in the picture, and most of these are not parallel in 3D.

5. [10] Describe three ways that enhance the perception of depth when viewing a flat picture, as used in Brunelleschi’s peepshow or in trompe l’oeil painting.
View the picture with one eye only, from a great distance away so that marks on the picture surface are not visible, reduce the size of the pupil using a peephole to increase depth of field, restrict viewer’s eye position to the exact position of the center of projection of the picture, view through a mirror so that details are lost, and by squinting so that the picture is blurred and details are lost.

6. [3] Can a drawing contain two horizon lines (aka vanishing lines)? If so, give an example and explanation. If not, explain why not.

Yes, for example in 3-point perspective of a cube there are 3 vanishing points and each pair defines a different “horizon line” as shown below. Notice that there is a separate “horizon line” for each planar face of the cube corresponding to the line where the plane that contains the face vanishes as it gets farther and farther away from the viewer.

7. [4] Why are camera obscuras made using a lens at the aperture rather than just using a small “pinhole”?

Using a small pinhole means that very little light enters and therefore the image formed will be very, very dim. Secondarily, if it is very, very small, then diffraction of light will cause the image to be blurred.

8. [4] Describe what an anamorphic image is in terms of linear perspective, eye position, and the position of the horizon line.

Anamorphic images are distorted images that appear perspectively correct only when viewed under certain unusual circumstances such as at an extremely small angle with respect to the plane of the picture or when reflected in a curved mirror. In extreme viewing angle distortions of planar objects (e.g., Hans Holbein the Younger’s skull) the eye should view the object nearly edge-on so that there is extreme foreshortening. This means that the horizon line associated with the plane of the object will be very close to the edge of the projected plane.
9. [8] Describe what robustness of perspective means, using issues such as the station point paradox and Leonardo’s writings. As part of your answer describe to what extent (i) trompe l’oeil paintings, and (ii) portraits with eyes that follow you, are robust or not, and briefly why.

Robustness of perspective is the idea that even though a picture of a 3D scene created using linear perspective is only geometrically correct from a single viewpoint (the center of projection), there is often a very large range of other viewpoints where the picture still looks 3D the same way it does from the correct viewpoint. This phenomenon is called the station point paradox. Leonardo described that viewing pictures can be made robust by using his “moderate distance rule” which is to “make your view at least 20 times as far off as the greatest width or height of the objects represented.” Trompe l’oeil paintings are often not robust because changing viewpoint destroys the illusion by allowing the viewer to notice 2D picture cues or notice errors in the geometry of objects. (Ceiling trompe l’oeil is often robust, however, because the viewer is forced to be far away.) The illusion of a portrait’s eyes following you as you move around a room is an example of robustness, at least in the sense that though there is foreshortening of the planar eyes in the picture, but the viewer doesn’t see this distortion and believes that the person’s eyes in the picture are always turning to face you as you move.

10. [9] Say you are looking at the center of a flat, rectangular wall in front of you and on it are vertical white and black stripes of equal width that are spaced equally far apart from one another as shown in the following figure.

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(a) [6] If you look at this wall from a close distance, resulting in a wide-angle perspective view, describe two types of distortion caused by linear perspective onto a flat (planar) picture plane that were observed by Leonardo.

As shown in Figure 82 in Kemp’s Science of Art, the heights of the stripes decrease with distance from center (“lateral diminution”) due to the fact that they are farther away from the viewer. The widths of the stripes decrease with distance from the center (“lateral recession”) due to foreshortening. In this case foreshortening does not change the shapes of the stripes as would happen for example when a circular disk appears as an ellipse. This was a tricky question because this is a flat wall, not 3D columns as in the example in the notes. As described in the notes, the projections of 3D columns get fatter with distance from the center.

(b) [3] How can distortions caused by wide-angle perspectives of close-up objects viewed in the periphery be avoided or minimized?
Project onto a cylindrical picture plane, as suggested by Leonardo, or move farther away from the objects, or use multi-perspective views as Raphael did in School of Athens.

11. [6] Suppose there are two identical objects in a scene and they are distance $L=8$ braccia apart, and the closer of the two is distance $L'=8$ from the viewer as shown below. In the figure the picture plane is shown behind the eye (aka center of projection), on the right.

(a) [2] If the picture plane is distance 2 braccia from the eye, what is the relative size of the nearer object to the farther one in the picture?

Using similar triangles, if the objects are each 1 braccio high, the farther object projects to size $1/8$ braccio and the smaller object projects to size $1/4$. Hence the nearer object’s size is twice as big as the farther object.

(b) [2] If the picture plane is moved to distance 4 from the eye, what is the relative size of the nearer object to the farther one in the picture?

Moving the picture plane will change the size of each projected object but their relative sizes remain the same as in (a); hence the nearer object still appears twice as big as the farther.

(c) [2] If the farther object from the eye is moved so that it is 24 (=3$L$) braccia from the closer object, and the closer object stays at distance 8 (=L) from the eye, what is the relative size of the closer object to the farther one when the picture plane is 2 braccia from the eye?

Again, using similar triangles, the farther object now projects to size $1/16$, while the closer object is size $1/4$ as in (a). Therefore the closer object appears 4 times as big as the farther object.

12. [10] (a) [6] Draw the vanishing point(s), horizon line, and distance point for Giovanni Bellini’s Blood of the Redeemer, which is 34 cm wide by 47 cm high.

The vanishing point is at the top of Christ’s head, the horizon line is horizontal passing through the vanishing point, and the distance point is on the horizon line to the right of the picture as shown in the figure.
(b) [4] Where should you position your eye in order to correctly view this painting? That is, how high and how far away in centimeters should a person’s eye be?

Your eye should be at the same height as the vanishing point. Your viewing position should be directly in front of the vanishing point at a distance corresponding to the distance from the centric (vanishing) point and the distance point,