1. Answer the following with true (T) or False (F)  
   1 point each

   F  
   The term “distributed ray tracing” refers to a method for parallel computation of images. \( \times \) In the midterm already

   T  
   One of the things that anti-aliasing helps prevent is the stair-step appearance of rasterized lines.

   T  
   The Z-buffer hidden surface algorithm can be modified to account for transparency by simply adding an \( \alpha \)-buffer.

   F  
   B-spline curves have both the convex hull property and they interpolate control points. \( \times \) The curve having both properties doesn’t exist.

   T  
   Catmull-Clark subdivision is a generalization of B-spline surfaces.

   T  
   Hermite and Bezier bases functions can be used to describe different classes of curves. They describe the same classes of curves by different forms.

   T  
   The Bresenham line drawing algorithm only became practical once fast floating point hardware was commonly available. \( \times \) In the midterm review already.

   T  
   Rotation about an arbitrary axis can be expressed as a series of axis-aligned rotations.

   F  
   The Phong reflectance model can be used to describe any real surface’s reflectance properties.

   F  
   Motion capture is often used for animating smoke, water, and other fluid phenomena. Obviously absurd.

   T  
   Ray tracing can be used to compute global illumination phenomena.

   F  
   In a perspective projection, a sphere can have an outline shaped like an ellipse \( \times \) In the midterm review already.

17. I wish to ray-trace a scene containing a complex space station. The image will be 1000x1000, each pixel with be super sampled on a 10x10 jittered grid. I have two point light sources in the scene (two distant suns). Each bounce will use 10 rays to sample diffuse reflections. I will include shadows. What is the minimum number of rays I will have to trace? Explain why. 3 points

   \[
   \frac{1000 \times 1000 \times 10 \times (1 + 2 + 10 + 10 \times 2)}{16} \]

   Sub-pixel number  Eye ray light rays \( \rightarrow \) Rays from diffuse reflectors to lights \( \rightarrow \) Rays to diffuse reflectors
1. Answer the following with true (T) or False (F)
   (Continued)

   When applying transformations to a 3D scene, the transformation applied to normal vectors should have any translation part doubled. ×
   Most useful cubic basis functions have both the interpolation and convex hull properties.
   The human eye has three types of light receptor.
   Pixel-based image representations have infinite resolution.

   A good scan-conversion algorithm has the property that when given a set of non-overlapping polygons, every pixel “belongs” to at most one single polygon.
   Non-zero winding number and parity testing will produce the same result for a polygon with non-self-intersecting boundary. [I'm doubting it was covered in the lecture]
   A series of transformations which are all 3D rotations can be permuted and the result will not change. Cases in 2D are true.
   Bump-mapping will not change an object’s silhouette.
   Displacement mapping will change ...
   Tensor-product surfaces are built by letting the control points of a curve vary according to some other curves.
   Catmull-Clark subdivision only works on regular meshes.
   Irregular meshes as well, with extraordinary vertices.
   Cubic polynomial basis functions can be used to build interesting $C^5$ curves.

   Particle systems simulate objects such as waterfalls by modeling the interactions between individual molecules. (If crossed out, true)
   Particles can be used to render smoke.

   Motion graphs are plots showing where joints are located in a figure.
   Were motion graphs covered in the lecture?

   The result of applying subdivision to a cubic curve is two quadratic curves. (Cubic still)

   Raytracing can be accelerated using BSP-Trees or K-D Trees.
1. Answer the following with true (T) or False (F)  

T  continuity does not always imply continuity.  
T  The Bezier basis functions are affine invariant.  
T  The Hermite basis functions have local support.  
F  Cubic spline surfaces can be ray-traced without first polygonizing them.  
F  Generating high-quality animations requires either sampling or Aragorn filtering to remove motion blur.  
F  Advanced methods for rendering arbitrary images in constant time exist, but we did not cover them in class.  
F  The fully implicit version of Euler’s method (a.k.a. backwards Euler) is unconditionally stable.  
F  The singular values of a rotation matrix are the amounts of rotation about the X, Y, and Z axes.  
F  The human eye is uniformly sensitive to all frequencies of visible light.  
F  Perspective transformations distort straight lines into circles.  
F  Final gathering can be used with both photon mapping and radiosity.  
F  Some motion capture systems use magnetic fields to determine the location and orientation of tracker objects.  
T  Cubic B-Splines can be exactly converted to quartic B-splines.
For Q8 in final: For Q16 in final: For Q15: Catmull-Clark subdiv.

1. Count the number of edges around a vertex. If it's not 4, the vertex is extraordinary.

2. Count the number of edges of a polygon. If it's not 6, it will produce an additional extraordinary vertex after subdividing.

8. In the context of doing inverse kinematics problems, when is the Jacobian singular? Draw an example using a two-link arm whose links are connected by a rotation joint and whose root link is attached to ground with a rotation joint. Make sure your diagram is clear. Use an X to indicate the goal point. 4 points