Disclaimer: Below you find some example questions, which should help you prepare exam. Note, however, the actual questions at the exam can be very different and ca material presented in the lecture!

a-) It consist of 4 stages :
1- Data acqusation
It is the stage that collection data from sensors, users, or simulations
2- Data filtering/ enchancement
It is the stage that converting raw data to delivered data by using techniques like data reduction, data format conversion. Filling missing value by interpolation, smoothing
3- Data visualization/ mapping. It is the stage that visualize delivered data to renderable representation For example converting scalar field to isosurface or 2D field to height field

4- Rendering. the last stage. It actually generate image/ video from renderable representation

Visualization Pipeline

simulation, databases, sensors

a) Explain the visualization pipeline. What are the four stages?
b) Explain the data acquisition stage. What are three general cases?
c) Explain the filtering/enhancement stage. Give at least two examples.
d) Explain the visualization mapping stage. Give at least two examples.
e) In which stage of the visualization pipeline happens resampling to a regular grid?
f) In which stage of the visualization pipeline are the viewpoint and lighting parameters specified?
g) In which stage of the visualization pipeline happen lighting and shading?
h) In which stage of the visualization pipeline are colors assigned to every voxel?
i) In which stage of the visualization pipeline happen smoothing and noise suppression?

e- filtering/ enchancement
f- rendering
g- rendering
h- Visualization mapping
.
i- filtering/ enhancement

a-) independent variables are Dimension of the domain of the problem like 2D/3D space .
Dependent variables are type and dimension of the data to be visualized like price of something, density values, velocity vectors
b- Independent variables: spatial curve φ in 1D domain $\mathbb{R}$.
Dependent variables: what the curve represents in 3D, for example a location in spatial domain $\mathbb{R}3$.
c- Independent variables: 3D space.
Dependent variables: 3D vector field (i.e. vectors at each point of the 3D space defined by the independent

Data Representation

a) Discuss independent vs. dependent variables in data. Give at least two examples each.
b) What are the independent and dependent variables in a 3D spatial curve $\phi : \mathbb{R} \rightarrow \mathbb{R}^3$
c) What are the independent and dependent variables in a 3D vector field?
d) What type of attribute are the following: categorical, ordinal, or quantitative?
    a. Type of cheese (e.g., Swiss, Brie) — categorical
    b. Tire pressure (e.g., 2.3 bar, 2.5 bar) — quantative
    c. First name (e.g., Alice, Bob) — categorical
    d. Unemployment rate (e.g., 6%, 10%) — quantative
    e. T-Shirt sizes (e.g., medium, large) — ordinal

A cartesian grid is orthogonal, equidistant in all directions, and structured. We need to specify the starting location and the number of vertices in each direction.

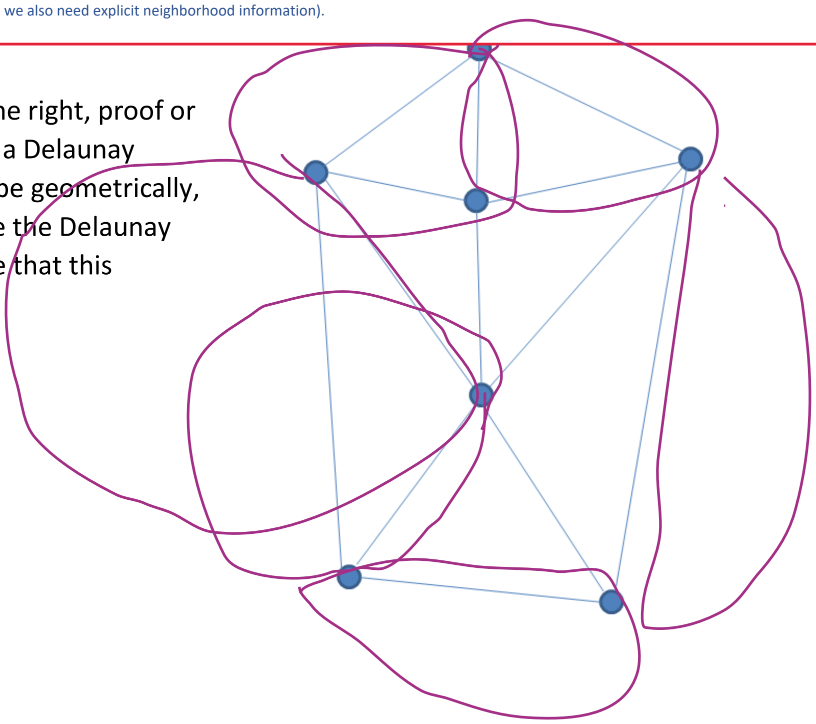
A regular grid is also orthogonal and structured, the nodes are equidistant but for different directions the node distance might be different, i.e. $dx \neq dy$. Therefore the node distance must be explicitly specified, in addition to the information required for a cartesian grid

e) Draw an illustration of a Cartesian grid. Describe how such a grid is different from a regular grid? Which information needs to be specified explicitly for such a grid?
f) What is a curvilinear grid? How is it characterized? How is it different from an unstructured grid? Which information needs to be specified explicitly for such a grid?

One direction of the gridlines follows a certain shape, which makes the cells non-orthogonal. Each grid point's position must be explicitly specified, however there is an implicit neighborhood relationship (unlike for an unstructured grid, where we also need explicit neighborhood information).

Data Interpolation

a) For the triangulation shown on the right, proof or disproof that this triangulation is a Delaunay triangulation. Your proof should be geometrically, meaning that you either illustrate the Delaunay property in the figure or illustrate that this property is violated.



None of circles are inluding a point so we can say this is proof for delaunay triangulation

b) An interpolation function $f(x) = \sum_{i=1}^{N} w_i\, \varphi(\|p_i - x\|)$ is a weighted sum of N *radial functions* $\varphi(r) = e^{-r^2}$ where $\|p_i - x\|$ is the distance between the points p_i and x. Compute the weights w_i such that the function $f(p_i)$ interpolates the data points $p_1 = 1$, $p_2 = 3$, $p_3 = 3.5$ with corresponding scalar values $f_1 = 1$, $f_2 = 0$, $f_3 = \frac{1}{4}$.

The table below shows approximate values for $\varphi(r)$ with respect to different distances r.

r	0	0.5	1	1.5	2	2.5	3
$\varphi(r)$	1	⅘	⅖	⅒	0	0	0

c) Given the interpolation function $f(x)$ from the previous assignment, compute the interpolated value at point $x = 2$.

$$\begin{bmatrix} \varphi(0) & \varphi(3-1) & \varphi(3.5-1) \\ \varphi(1-3) & \varphi(0) & \varphi(3.5-0.5) \\ \varphi(1-3.5) & \varphi(3-3.5) & \varphi(0) \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 1/4 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 4/5 \\ 0 & 4/5 & 1 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix} = \boxed{w_1 = 1}$$

$w_2 + \frac{4}{5} w_3 = 0 \rightarrow w_2 = -\frac{4}{5} w_3$

$\frac{4}{5} w_2 + w_3 = 1/4 \rightarrow \frac{9}{25} w_3 = \frac{1}{4}$

$\boxed{w_3 = \frac{25}{36}}$

$w_2 = -\frac{5}{9}$

$f(2) = \varphi(\|1-2\|) \cdot 1 + \varphi(\|3-2\|) \cdot -\frac{5}{9} + \varphi(\|3.5-2\|) \cdot \frac{25}{36}$

$= \frac{2}{5} + \frac{2}{5} \cdot \frac{-5}{9} + \frac{1}{10} \cdot \frac{25}{36}$

$\frac{2}{5} + \frac{2}{9} + \frac{5}{72} = 0{,}247$