01] Transformations:

A] These 4-component vectors (P_1, P_2, P_3 and P_4) represent 3D points in homogeneous coordinates. Compute their respective coordinates in 3D. Which 3D point(s) represent these 4-component vectors?

[Computation: 5 points]

$P_1 = [8, 4, 6, 2]$

$P_2 = [2.8, 1.4, 2.1, 0.7]$

$P_3 = [446, 238, 372, 114]$

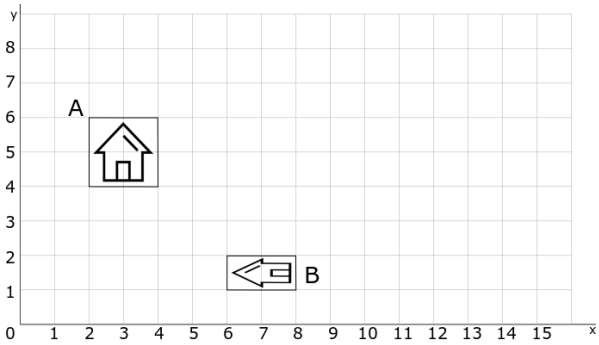
$P_4 = [52, 26, 39, 13]$

B] Consider the following object (house). What transformations and in which order you have to apply in order to transform the object from the configuration A into the configuration B? Write the **transformation matrices for every operation**.

Hint 1: For some transformations you first need to bring the object into origin and undo the previously done transformations. You can express this also by previously formulated matrices, their transposes or inverses.

Hint 2: You don't have multiply the matrices. The result showing what matrices and in which order is sufficient.

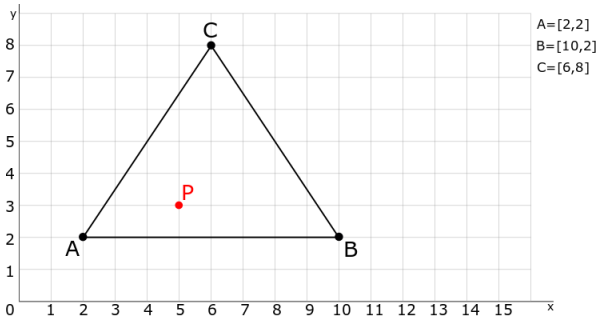
[Specification of matrices: 10 points; Correct order: 5 points]



02] Barycentric coordinates, colors:

a) You are given the following triangle ABC. Compute the barycentric coordinates of point P.

[Computation: 10 points]

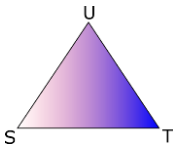


b) You are given three points P_1, P_2, P_3 specified by barycentric coordinates $P_x = [\alpha_x, \beta_x, \gamma_x]$ and an STU triangle with below specified colors in every vertex. Compute respective colors C_1, C_2, C_3 for the triangle STU in points P_1, P_2, P_3. Then, compute from C_1, C_2, C_3 resulting color $\boldsymbol{C_r = C_1 - C_2 + C_3}$.

[Computation: 8 points; Resulting color: 2 points]

$\boldsymbol{P_1 = [0.02, 0.33, 0.65]}$, $\boldsymbol{P_2 = [0.37, 0.41, 0.22]}$, $\boldsymbol{P_3 = [0.75, 0.15, 0.1]}$

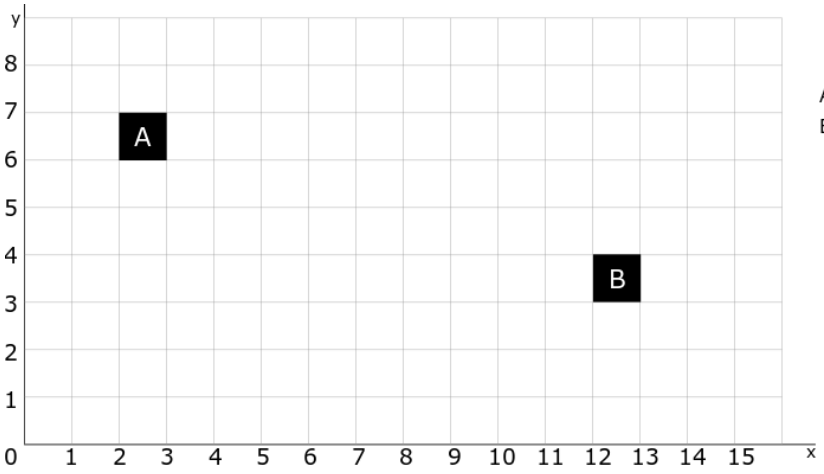
$\boldsymbol{S = (255, 255, 255)}$, $\boldsymbol{T = (0, 0, 191)}$, $\boldsymbol{U = (191, 140, 204)}$



03] Line Rasterization: Rasterize the line from center point of pixel A (A_c) to center point of pixel B (B_c). Describe the used algorithm and then draw pixels into the xy grid accordingly. Note that for each x value there should be just one drawn pixel.

Hint: you can design your own algorithm in case you do not remember the one from the course. It will count as long as it creates a *good-looking* line.

[Description of the algorithm: 5 points; Computation 15 points]



A_C=[2.5,6.5]
B_C=[12.5,3.5]

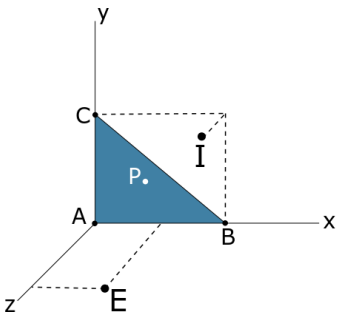
04] Illumination:

A] Describe and illustrate Blinn-Phong shading model. Write down illumination equation.

[Description of the algorithm: 3 points; Illustration: 3 points; Equation: 4 points]

B] You are given a triangle ABC visible from the point E=[0.5, 0, 1] and the light position I=[1 ,1 ,1]. What is the resulting light intensity L at point P=[0.4, 0.4, 0] that belongs to ABC? The color of I=(1.0,1.0,1.0), k_a=0.1, k_d=0.5, k_s=0.4. You can assume the specular exponent to be 1.0. For the computation consider per-face normal vector only.

[Computation: 10 points]



A=[0,0,0]
B=[1,0,0]
C=[0,1,0]

05] Implicit modeling:

You are given three skeletal points S_1, S_2, and S_3. Compute the value of $f(x, y)$ for points A and B where

$$f(x, y) = \sum_{i=1}^{i=n} g_i \circ d_i(x, y).$$

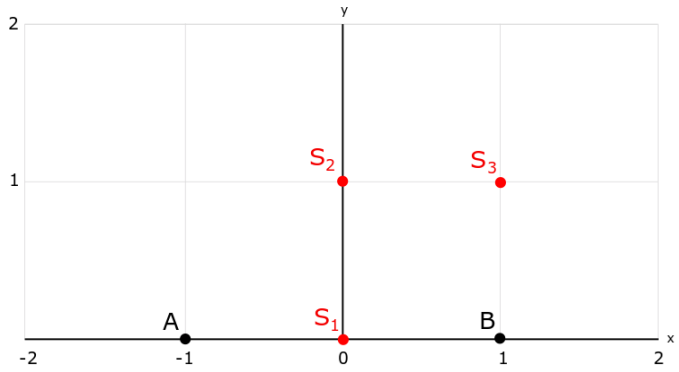
The fall-off filter function g is defined as follows:

$$g(d) = e^{-rd^2}.$$

Compute for $r = 1$.

[Computation: 20 points]

$S_1 = [0,0], S_2 = [0,1], S_3 = [1,1], A = [-1,0], B = [1,0]$



06] Spatial data structures: You are given the following 2D scene with 9 objects (numbered 1…9). Construct a bounding volume hierarchy that represents the scene. Illustrate individual steps and the resulting hierarchy.

Hint: You should differentiate whether to split the set of objects along the axis *x* or *y* in every other step.

[Description of the algorithm: 5 points; Computation: 10 points; drawing: 5 points]