A função Bolhas é a função responsável por gerar os pontos com seus raios e aplicar 2 processos de “thinning” sobre eles.
1° thinning: garantir que as bolhas não tem interseção entre si.
2° thining: garantir que as bolhas não ultrapassem o limite do cilindro em que se encontram.

Inputs:
n = número de bolhas desejado
raio = raio do cilindro
h = altura do cilindro

bolhar[[1]] = “time of arrival”, valores sorteados de forma uniforme entre 0 e 1 que indicam a ordem de eliminação das bolhas nos “thinning”s
bolhas[[2]] = números que indicam ordem de chegada de cada bolha gerada
bolhas[[3]] = coordenadas x, y e z de cada bolha
bolhas[[4]] = raios de cada bolha
bolhas[[5]] = os valores de Rzone de cada bolha (é importante para a aplicação do 2°finning)

In[ ]:=
```
Bolhas[n_, raio_, h_] :=
 (bubbles = {{}, {}, {}, {}, {}};

  numero = RandomVariate[PoissonDistribution[n]];
           variável aleatória   distribuição de Poisson
  For[j = 0, j <  numero, j++;
  para cada
   Rzone = raio * Sqrt[RandomReal[1]];
                  raiz···  real aleatório
   θ = RandomReal[2 π];
       real aleatório
   xvalue = Rzone Cos[θ];
                  cosseno
   yvalue = Rzone Sin[θ];
                  seno
   zvalue = RandomReal [{0, h}];
            real aleatório
   rvalue = RandomReal[{0.1, 2.1}];
            real aleatório
   u = RandomReal[{0, 1}];
       real aleatório
   t = j;

   AppendTo[bubbles[[3]], {xvalue, yvalue, zvalue}];
  adiciona a
   AppendTo[bubbles[[4]], rvalue]; AppendTo[bubbles[[1]], u];
                                   adiciona a
   AppendTo[bubbles[[2]], t]; AppendTo[bubbles[[5]], Rzone];];
                              adiciona a

  bubbles = SortBy[bubbles^T, First]^T;
            ordena por      primeiro
```

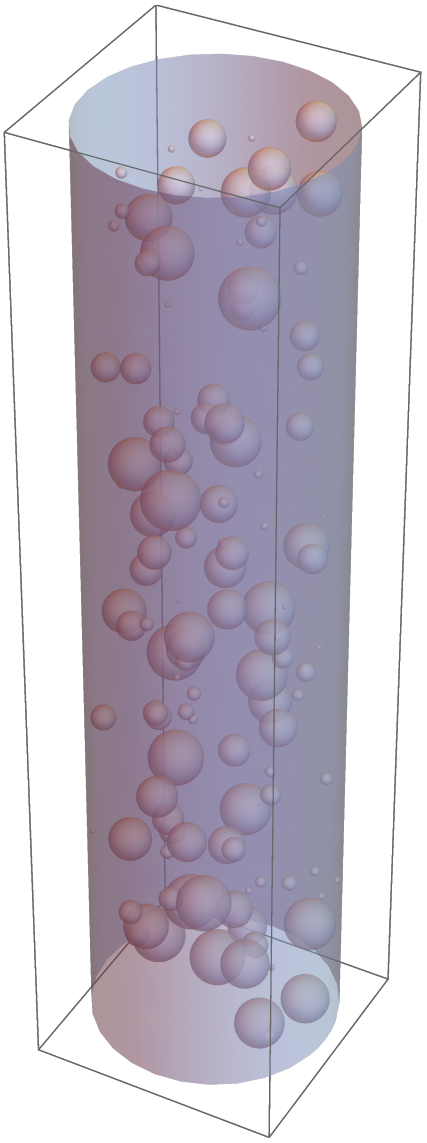
```
                ordena por          primeiro
For[k = 1, k < Length[bubbles[[1]]] - 1, k++,
                comprimento
 For[l = k + 1, l ≤ Length[bubbles[[1]]], l++,
                    comprimento
  Δx = bubbles[[3, k, 1]] - bubbles[[3, l, 1]];
  Δy = bubbles[[3, k, 2]] - bubbles[[3, l, 2]];
  Δz = bubbles[[3, k, 3]] - bubbles[[3, l, 3]];
  If[√(Δx^2 + Δy^2 + Δz^2) < (bubbles[[4, k]] + bubbles[[4, l]]),
  se
   bubbles = Delete[#, {l}] & /@ bubbles]]];
             deleta

For[i = 1, i ≤ Length[bubbles[[1]]], i++,
para cada       comprimento
 If[bubbles[[3, i, 3]] < bubbles[[4, i]] ||
 se
   bubbles[[3, i, 3]] + bubbles[[4, i]] > h || bubbles[[5, i]] + bubbles[[4, i]] > raio, i--;
  bubbles = Delete[#, {i + 1}] & /@ bubbles]];
            deleta
AppendTo[bubbles, Sum[4/3 π * (bubbles[[4, i]])^3, {i, Length[bubbles[[4]]]}]];
                  soma                                  comprimento

bubbles)
```

In[ ]:=
```
Cilindro2[r_, h_] := ParametricPlot3D[{r Cos[θ], r Sin[θ], z},
                     gráfico paramétrico 3D   cosseno   seno
  {θ, 0, 2 π}, {z, 0, h}, Mesh → None, PlotStyle → {Opacity[0.5], LightGray}]
                          malha  nen···  estilo do gráfico  opacidade  cinza claro
```

In[ ]:=
```
VistaBolhas3D[n_, r_, h_] := (bolhas = Bolhas[n, r, h];
  Show[Graphics3D[{Opacity[0.5], Sphere[bolhas[[3]], bolhas[[4]]]}],
       representação···  opacidade   esfera
   Cilindro2[r, h]])
```

In[ ]:=
```
VistaBolhas3D[200, 9.5, 76]
```

Out[ ]=



```
Bolhas[100, 9.5, 76]
```

```
{{0.0684682, 0.0832334, 0.106884, 0.123177, 0.12866, 0.129611, 0.132997,
  0.133755, 0.152645, 0.166399, 0.168842, 0.169037, 0.183564, 0.196903, 0.203101,
  0.221306, 0.234638, 0.238597, 0.284068, 0.29766, 0.35352, 0.355456, 0.366886,
  0.376628, 0.422882, 0.44312, 0.462948, 0.48577, 0.51732, 0.542945, 0.555247,
  0.557658, 0.581092, 0.586528, 0.59833, 0.624513, 0.628676, 0.646907, 0.653414,
  0.657729, 0.658994, 0.686739, 0.705056, 0.71032, 0.730222, 0.763607, 0.782126,
  0.816965, 0.834769, 0.841236, 0.869899, 0.870018, 0.87652, 0.887783, 0.889586,
  0.907177, 0.943571, 0.951286, 0.971923, 0.972739, 0.98332, 0.987944, 0.988},
 {23, 41, 32, 29, 53, 15, 97, 72, 3, 64, 71, 83, 85, 57, 8, 55, 47, 66, 56, 54, 88,
  75, 17, 58, 42, 35, 87, 11, 16, 20, 28, 10, 24, 34, 65, 74, 49, 95, 82, 33, 36, 78,
  45, 31, 90, 94, 63, 14, 84, 39, 76, 40, 9, 69, 2, 37, 61, 96, 22, 68, 100, 77, 43},
 {{3.65376, 7.48824, 56.731}, {3.83945, 0.467673, 61.2904},
  {8.05094, -0.500464, 50.4404}, {0.610159, -5.96388, 47.4951},
  {4.36353, 3.62346, 26.3062}, {-2.90348, 7.53593, 69.5591},
  {7.31577, -0.164071, 72.1472}, {-0.270748, -8.16729, 1.41398},
  {0.615552, -0.257709, 73.6998}, {-3.87065, -2.50708, 37.3175},
  {-5.04916, -0.444912, 10.8982}, {3.24991, -2.68166, 22.1502},
  {3.5873, -5.46143, 47.7752}, {5.97291, -4.79611, 13.0865},
  {-1.53213, 0.657608, 17.2954}, {-5.88466, -6.68228, 50.8733},
```

```
  {-2.16153, -1.5402, 5.02668}, {-2.47786, -7.61468, 36.2376},
  {4.46443, 4.64998, 72.2206}, {-8.73386, -0.987563, 18.3283},
  {5.3974, 1.61502, 26.3873}, {3.20352, 1.41552, 15.7148},
  {-2.29923, 4.26273, 9.12673}, {4.17405, -4.95152, 22.1849},
  {-4.8358, 0.431681, 26.4752}, {5.70907, -4.61123, 42.8489},
  {-3.72641, 3.79393, 13.7346}, {-8.30072, 0.567549, 15.4513},
  {0.554366, -0.600635, 48.319}, {3.77745, 7.0972, 30.2788},
  {-3.17143, 4.03886, 31.9906}, {-3.04605, 1.82487, 55.0784},
  {-4.5709, -0.76495, 38.9922}, {-2.65239, -6.22495, 30.4461},
  {0.943252, -6.43629, 56.0473}, {-1.20873, 3.53992, 46.0149},
  {-1.60089, 5.00573, 39.5164}, {-3.08668, -5.24716, 45.2662},
  {1.89728, 0.0829957, 43.1003}, {1.14905, -6.49007, 58.6996},
  {1.99851, -5.05655, 65.6509}, {7.77164, 2.60971, 20.3275},
  {5.4217, -0.304226, 20.9274}, {-5.12575, 4.12553, 64.3448},
  {-7.17506, -1.78039, 8.1859}, {-2.58966, -1.64807, 26.6794}, {1.26152, 1.6959, 73.7},
  {-0.622886, -6.11509, 70.1265}, {4.92883, -2.79802, 68.5391},
  {2.12497, 6.77663, 61.0602}, {2.21446, 2.28733, 51.1734},
  {-4.52912, 2.77068, 59.4848}, {4.39697, 6.17408, 42.7121},
  {0.251087, -3.84488, 52.4578}, {-3.68813, 2.41761, 22.2737},
  {6.28572, 3.84412, 33.242}, {-3.13445, 0.141728, 71.0198},
  {1.07193, 1.88565, 10.5336}, {2.25529, -3.40891, 44.9366},
  {3.45237, -3.04431, 8.76039}, {4.89085, 4.6173, 3.99832},
  {-4.33942, 4.51311, 57.1573}, {6.71547, -4.34469, 58.6092}},
 {0.815082, 0.937865, 0.78047, 1.62076, 0.428176, 1.37997, 0.601496, 1.18344,
  0.577015, 0.799891, 0.939936, 0.521088, 0.622469, 0.718243, 0.517556,
  0.352918, 1.66994, 0.465611, 1.34211, 0.122566, 0.220356, 1.6142, 1.18772,
  1.90961, 2.00383, 1.83367, 0.405645, 0.846467, 1.18919, 0.939375, 0.215813,
  1.69828, 0.540568, 1.9112, 0.177768, 0.955923, 0.623416, 0.688739, 1.96018,
  1.5545, 0.940881, 1.00963, 0.481399, 1.22537, 0.454011, 0.375004, 0.706719,
  2.00514, 0.261291, 0.227308, 1.89656, 1.63726, 0.456866, 2.01537, 1.66551,
  0.213149, 1.24648, 1.66393, 1.83629, 0.478514, 1.10264, 0.423903, 1.30608},
 {8.33209, 3.86783, 8.06648, 5.99501, 5.67185, 8.07591, 7.31761, 8.17178, 0.667321,
  4.61166, 5.06873, 4.21345, 6.53421, 7.66018, 1.66729, 8.90405, 2.65413, 8.00769,
  6.4462, 8.78951, 5.63385, 3.50232, 4.84328, 6.47613, 4.85503, 7.33873, 5.3179,
  8.3201, 0.817364, 8.03986, 5.13521, 3.55085, 4.63447, 6.76647, 6.50504, 3.7406,
  5.25549, 6.08771, 1.8991, 6.591, 5.43717, 8.19811, 5.43023, 6.57977, 7.39265, 3.0696,
  2.11365, 6.14673, 5.66765, 7.10198, 3.18366, 5.30939, 7.57975, 3.85307, 4.40989,
  7.368, 3.13765, 2.16903, 4.08742, 4.6029, 6.72606, 6.26089, 7.99836}, 537.75}
```

```
list = {{1, 2, 3}, {{4, 5, 6}, {7, 8, 9}, {10, 11, 12}}, {0, 1, 2}, {3, 4, 5}};
Delete[#, {{2}, {3}}] & /@ list
```

deleta

```
{{1}, {{4, 5, 6}}, {0}, {3}}
```

```
list
```

```
{{1, 2, 3}, {{4, 5, 6}, {7, 8, 9}, {10, 11, 12}}, {0, 1, 2}, {3, 4, 5}}
```

```
{{1, 2, 3}, {a, b, c}, {{1, 2, 3}, {5, 6, 7}}}
```

```
{{1, 2, 3}, {a, b, c}, {{1, 2, 3}, {5, 6, 7}}}
```