Dilatation thermique

Ex 1

```
dn = {l0 → 3000, alpha -> 1.2 * 10^-5, deltat → 70};
l0 (1 - alpha * deltat) /. dn
```

```
2997.48
```

Ex 2

```
dn = {l0 → 1000, t → 20, deltal → 0.1, alpha -> 1.66 * 10^-5};
t + deltal / (alpha * l0) /. dn
```

```
26.0241
```

Ex 3

```
dn = {alpha1 → 1.66 * 10^-5, alpha2 → 1.2 * 10^-5, alpha3 → 2.9 * 10^-5, l1 → 1};
sol = Solve[{alpha1 * l1 == alpha2 * l2 + alpha3 * l3, l1 == l2 + l3}, {l2, l3}]
sol /. dn
```

$$\left\{\left\{l2 \to -\frac{-alpha1\ l1 + alpha3\ l1}{alpha2 - alpha3},\ l3 \to -\frac{alpha1\ l1 - alpha2\ l1}{alpha2 - alpha3}\right\}\right\}$$

```
{{l2 → 0.729412, l3 → 0.270588}}
```

Ex 4

```
dn = {alpha1 → 1.66 * 10^-5, alpha2 → 1.2 * 10^-5, deltal → 0.2};
sol = Solve[{alpha1 * l1 == alpha2 * l2, l2 - l1 == deltal}, {l1, l2}]
sol /. dn
```

$$\left\{\left\{l1 \to \frac{alpha2\ deltal}{alpha1 - alpha2},\ l2 \to \frac{alpha1\ deltal}{alpha1 - alpha2}\right\}\right\}$$

```
{{l1 → 0.521739, l2 → 0.721739}}
```

Ex 5

```
dn = {deltav → 1., alpha → 7 * 10^-4, deltat → 80};
deltav / (alpha * deltat) /. dn
```

```
17.8571
```

Ex 6

```
dn = {v → 60., s → .01, alpha → 9 * 10^-6, gamma → 1.8 * 10^-4, deltat → 80};
gamma * v * deltat / s /. dn
(gamma - 3 alpha) v * deltat / (s (1 + 2 alpha * deltat)) /. dn
```

```
86.4
```

```
73.3344
```

Ex 7

```
dn = {v → 500, s → .02, alpha → 9 * 10^-6, gamma → 1.1 * 10^-3, h → 120};
s * h / (gamma * v) /. dn
sol = Solve[s (1 + 2 alpha * deltat) h == (gamma - 3 alpha) v * deltat, deltat] /. dn
```

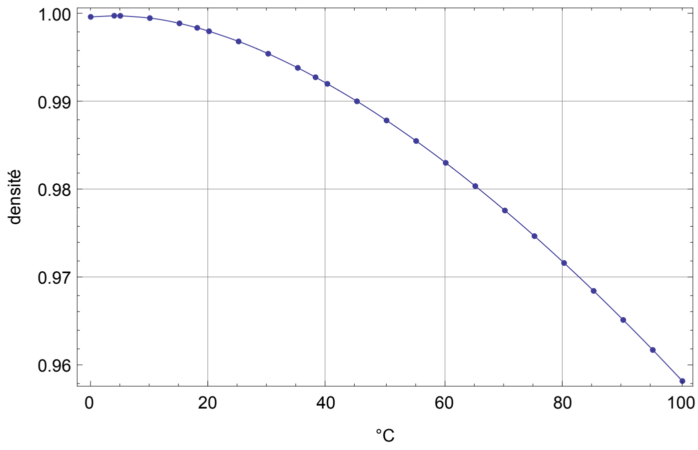
```
4.36364
```

```
{{deltat → 4.4738}}
```

Densité de l' eau en fonction de la température

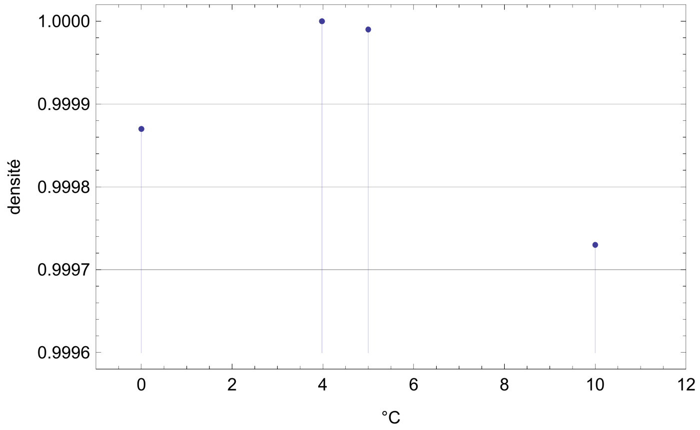
Handbook of Chemistry and Physics, 55 th Edition, 1975-1975.

```
ListPlot[dn = {{0, .99987}, {3.98, 1.00000}, {5, .99999}, {10, .99973},
    {15, .99913}, {18, .99862}, {20, .99823}, {25, .99707}, {30, .99567},
    {35, .99406}, {38, .99299}, {40, .99224}, {45, .99025}, {50, .98807},
    {55, .98573}, {60, .98324}, {65, .98059}, {70, .97781}, {75, .97489},
    {80, .97183}, {85, .96865}, {90, .96534}, {95, .96192}, {100, .95838}},
  FrameLabel → {"°C", "densité"}, Frame → True, Joined → True,
  InterpolationOrder → 3, Mesh → Full, GridLines → Automatic]
```



Mettons en évidence le comportement singulier de l' eau entre 0 et 4 °C:

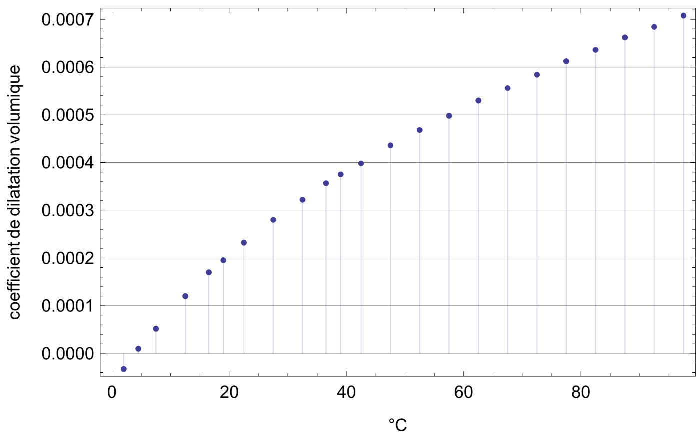
```
ListPlot[dn, AxesLabel → {"°C", "densité"},
 PlotRange → {{-1, 12}, {.99958, 1.00002}}, Frame → True,
 FrameLabel → {"°C", "densité"}, Filling → Axis, GridLines → {None, Automatic}]
```



Coefficient de dilatation volumique γ de l'eau en fonction de la température

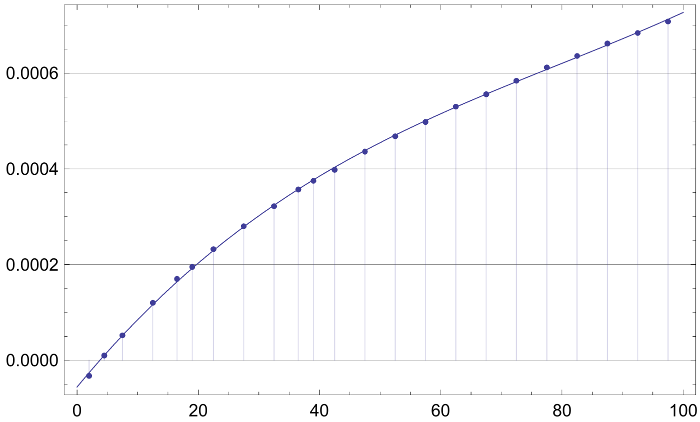
Nous obtenons les valeurs du coefficient γ en calculant la pente entre deux températures consécutives du premier graphique ci-dessus et en reportant l'opposé de cette pente pour la moyenne des deux températures à partir de laquelle elle a été obtenue:

```
val = ListPlot[Table[{Plus @@ Take[Transpose[dn][[1]], {m, m + 1}] / 2,
     -Coefficient[Fit[Take[dn, {m, m + 1}], {1, x}, x], x]},
   {m, Length[Transpose[dn][[1]]] - 1}],
  FrameLabel → {"°C", "coefficient de dilatation volumique"},
  Frame → True, Filling → Axis, GridLines → {None, Automatic}]
```



Ajustons une fonction sur les valeurs obtenues pour pouvoir calculer des valeurs intermédiaires:

```
Show[Plot[Evaluate[Fit[Table[{Plus @@ Take[Transpose[dn][[1]], {m, m + 1}] / 2,
        -Coefficient[Fit[Take[dn, {m, m + 1}], {1, x}, x], x]},
      {m, Length[Transpose[dn][[1]]] - 1}], {1, x, x^2, x^3}, x]],
   {x, 0, 100}, Frame → True, GridLines → {None, Automatic}], val]
```



En choisissant le pas deltat, cette fonction permet d'obtenir le coefficient de dilatation volumique de l'eau pour n'importe quelle température comprise entre 0 et 100 °C:

```
tmin = 0;
tmax = 100;
deltat = 10;
TableForm[Table[Evaluate[{x, Fit[Table[{Plus @@ Take[Transpose[dn][[1]], {m, m + 1}] / 2,
         -Coefficient[Fit[Take[dn, {m, m + 1}], {1, x}, x], x]},
       {m, Length[Transpose[dn][[1]]] - 1}], {1, x, x^2, x^3}, x]}],
   {x, tmin, tmax, deltat}], TableHeadings → {None, {"°C", "γ"}}]
```

°C	γ
0	-0.0000560657
10	0.0000847679
20	0.000202986
30	0.000301857
40	0.000384649
50	0.000454631
60	0.000515071
70	0.000569237
80	0.000620398
90	0.000671822
100	0.000726777