Calculate the initial conditions for the first stage Derivative[1][m][x] == $-u_*$

In[1]:=
```
Clear[all];
```
очистить

```
uu = List[-u*, +u*, -u*];
```
список

In[3]:=
```
sol1 =
 Flatten[Simplify[DSolve[{θ'[x] == ω[x], ω'[x] == m[x] + θ[x], m'[x] == uu[[1]], θ[0] == 1,
```
уплотнить упростить решить дифференциальные уравнения

```
    ω[0] == Ω0, m[0] == 0}, {θ[x], ω[x], m[x]}, x], Element[x, Reals]]]
```
принадлежи… множество действительных чи

Out[3]=
$$\left\{m[x] \to -x\, u_*,\ \theta[x] \to \frac{1}{2} e^{-x}\left(1 + e^{2x} + \left(-1 + e^{2x}\right)\Omega_0 + \left(1 - e^{2x} + 2\, e^{x}\, x\right) u_*\right),\right.$$
$$\left.\omega[x] \to \frac{1}{2} e^{-x}\left(\left(1 + e^{2x}\right)\Omega_0 - \left(-1 + e^{x}\right)\left(-1 - e^{x} + \left(-1 + e^{x}\right) u_*\right)\right)\right\}$$

In[4]:=
```
initForStage2 =
 {m[x] /. sol1[[1]] /. x → τ1, θ[x] /. sol1[[2]] /. x → τ1, ω[x] /. sol1[[3]] /. x → τ1}
```

Out[4]=
$$\left\{-\tau_1\, u_*,\ \frac{1}{2} e^{-\tau_1}\left(1 + e^{2\tau_1} + \left(-1 + e^{2\tau_1}\right)\Omega_0 + \left(1 - e^{2\tau_1} + 2\, e^{\tau_1}\, \tau_1\right) u_*\right),\right.$$
$$\left.\frac{1}{2} e^{-\tau_1}\left(\left(1 + e^{2\tau_1}\right)\Omega_0 - \left(-1 + e^{\tau_1}\right)\left(-1 - e^{\tau_1} + \left(-1 + e^{\tau_1}\right) u_*\right)\right)\right\}$$

Calculate the initial conditions for the second stage m′[x] == u

In[5]:=
```
sol2 =
 Flatten[Simplify[DSolve[{θ'[x] == ω[x], ω'[x] == m[x] + θ[x], m'[x] == uu[[2]], θ[τ1] ==
```
уплотнить упростить решить дифференциальные уравнения

```
     initForStage2[[2]], ω[τ1] == initForStage2[[3]], m[τ1] == initForStage2[[1]]},
   {θ[x], ω[x], m[x]}, x], Element[{τ1, τ2, τf, x}, Reals]]]
```
принадлежит множеству множество действительных чисел

Out[5]=
$$\left\{m[x] \to (x - 2\,\tau_1)\, u_*,\right.$$
$$\theta[x] \to \frac{1}{2}\left(e^{-x} + e^{x} + \left(-e^{-x} + e^{x}\right)\Omega_0 + \left(e^{-x} - e^{x} + 2\, e^{x-\tau_1} - 2\, e^{-x+\tau_1} - 2\, x + 4\,\tau_1\right) u_*\right),$$
$$\left.\omega[x] \to \frac{1}{2} e^{-x-\tau_1}\left(e^{\tau_1}\left(-1 + e^{2x}\right) + e^{\tau_1}\left(1 + e^{2x}\right)\Omega_0 - \left(-2\, e^{2x} + e^{\tau_1} - 2\, e^{2\tau_1} + 2\, e^{x+\tau_1} + e^{2x+\tau_1}\right) u_*\right)\right\}$$

Calculate the initial conditions for the third stage m′[x] == −u

In[6]:=
```
sol3 = Simplify[DSolve[
```
упростить решить дифференциальные уравнения

```
   {θ'[x] == ω[x], ω'[x] == m[x] + θ[x], m'[x] == uu[[3]], θ[τf] == 0, ω[τf] == 0, m[τf] == 0},
   {θ[x], ω[x], m[x]}, x], Element[{τ1, τ2, τf, x}, Reals]] // Flatten
```
принадлежит множеству множество … уплотнить

Out[6]=
$$\left\{m[x] \to (-x + \tau_f)\, u_*,\ \theta[x] \to \frac{1}{2}\left(-e^{x-\tau_f} + e^{-x+\tau_f} + 2\, x - 2\,\tau_f\right) u_*,\ \omega[x] \to -\frac{1}{2} e^{-x-\tau_f}\left(e^{x} - e^{\tau_f}\right)^2 u_*\right\}$$

In[7]:=
```
linkingStage2 = {m[x] /. sol2[[1]] /. x → τ2,
  θ[x] /. sol2[[2]] /. x → τ2 // Simplify, ω[x] /. sol2[[3]] /. x → τ2 // Simplify}
```
упростить упростить

Out[7]=
$$\left\{(-2\,\tau_1+\tau_2)\,u_*,\ \frac{1}{2}\,(e^{-\tau_2}+e^{\tau_2}+(-e^{-\tau_2}+e^{\tau_2})\,\Omega_0+(-2\,e^{\tau_1-\tau_2}+e^{-\tau_2}-e^{\tau_2}+2\,e^{-\tau_1+\tau_2}+4\,\tau_1-2\,\tau_2)\,u_*),\ \frac{1}{2}\,e^{-\tau_1-\tau_2}\left(e^{\tau_1}\left(-1+e^{2\,\tau_2}\right)+e^{\tau_1}\left(1+e^{2\,\tau_2}\right)\Omega_0-\left(e^{\tau_1}-2\,e^{2\,\tau_1}-2\,e^{2\,\tau_2}+2\,e^{\tau_1+\tau_2}+e^{\tau_1+2\,\tau_2}\right)u_*\right)\right\}$$

In[8]:=
```
linkingStage3 = {m[x] /. sol3[[1]] /. x → τ2,
  θ[x] /. sol3[[2]] /. x → τ2 // Simplify, ω[x] /. sol3[[3]] /. x → τ2 // Simplify}
```
упростить упростить

Out[8]=
$$\left\{(-\tau_2+\tau_f)\,u_*,\ \frac{1}{2}\,(-e^{\tau_2-\tau_f}+e^{-\tau_2+\tau_f}+2\,\tau_2-2\,\tau_f)\,u_*,\ -\frac{1}{2}\,e^{-\tau_2-\tau_f}\,(e^{\tau_2}-e^{\tau_f})^2\,u_*\right\}$$

In[9]:=
```
first = (linkingStage2[[1]] - linkingStage3[[1]] == 0 // Simplify)
```
упростить

Out[9]=
$$(2\,\tau_1-2\,\tau_2+\tau_f)\,u_*==0$$

Replace vars $e^{\tau 1} == x$, $e^{\tau 2} == y$, $e^{\frac{\tau f}{2}} == z$.

In[10]:=
```
first1 = z == y/x // FullSimplify
```
упростить в полно

```
first1eq = first1
```

Out[10]=
$$z==\frac{y}{x}$$

Out[11]=
$$z==\frac{y}{x}$$

In[12]:=
```
second = (linkingStage2[[2]] - linkingStage3[[2]] == 0 // Expand)
```
раскрыть (

Out[12]=
$$\frac{e^{-\tau_2}}{2}+\frac{e^{\tau_2}}{2}-\frac{1}{2}\,e^{-\tau_2}\,\Omega_0+\frac{1}{2}\,e^{\tau_2}\,\Omega_0-e^{\tau_1-\tau_2}\,u_*+\frac{1}{2}\,e^{-\tau_2}\,u_*-\frac{1}{2}\,e^{\tau_2}\,u_*+e^{-\tau_1+\tau_2}\,u_*+\frac{1}{2}\,e^{\tau_2-\tau_f}\,u_*-\frac{1}{2}\,e^{-\tau_2+\tau_f}\,u_*+2\,\tau_1\,u_*-2\,\tau_2\,u_*+\tau_f\,u_*==0$$

In[13]:=
```
Collect[second /. {e^(2 τ2) → y^2, e^τ2 → y, e^τ1 → x, e^-τ2 → 1/y, e^τf → z^2,
  τf → -2 τ1 + 2 τ2, e^(-τ1+τ2) → y/x, e^(τ1-τ2) → x/y} // Simplify, {e^τ2, e^τ1}, Simplify]
```
сгруппировать упростить упростить

Out[13]=
$$-e^{2\,\tau_1-\tau_2}\,u_*+e^{-2\,\tau_1+\tau_2}\,u_*+\frac{\left(x-x\,y^2\right)\Omega_0+\left(2\,x^2-2\,y^2+x\left(-1+y^2\right)\right)u_*}{x\,y}==\frac{1}{y}+y$$

Made handle substitutie for $-e^{2\,\tau_1-\tau_2}\,u_*+e^{-2\,\tau_1+\tau_2}\,u_*$

In[14]:=
```
second1 =
 (-x^2)/y u* + y/x^2 u* + ((x - x y^2) Ω0 + (2 x^2 - 2 y^2 + x (-1 + y^2)) u*)/(x y) == 1/y + y // FullSimplify;
```
упростить в полном

```
Expand[second1 // FullSimplify]
```
раскрыть скобки упростить в полном объёме

```
Together[second1]
```
собрать вместе

```
second1 = (x^2 + x^2 y^2 - x^2 Ω0 + x^2 y^2 Ω0 + x^2 u* - 2 x^3 u* + x^4 u* - y^2 u* + 2 x y^2 u* - x^2 y^2 u*)
second1eq = (second1 == 0);
```

Out[15]=
$$\frac{1}{y} + y - \frac{\Omega_0}{y} + y\,\Omega_0 + \frac{u_*}{y} - \frac{2\,x\,u_*}{y} + \frac{x^2\,u_*}{y} - y\,u_* - \frac{y\,u_*}{x^2} + \frac{2\,y\,u_*}{x} == 0$$

Out[16]=
$$\frac{x^2 + x^2\,y^2 - x^2\,\Omega_0 + x^2\,y^2\,\Omega_0 + x^2\,u_* - 2\,x^3\,u_* + x^4\,u_* - y^2\,u_* + 2\,x\,y^2\,u_* - x^2\,y^2\,u_*}{x^2\,y} == 0$$

Out[17]=
$$x^2 + x^2\,y^2 - x^2\,\Omega_0 + x^2\,y^2\,\Omega_0 + x^2\,u_* - 2\,x^3\,u_* + x^4\,u_* - y^2\,u_* + 2\,x\,y^2\,u_* - x^2\,y^2\,u_*$$

In[19]:=
```
third = (linkingStage2[[3]] - linkingStage3[[3]] == 0 // Expand);
```
раскрыть скобки

```
Collect[third /. {ℯ^(2 τ2) → y^2, ℯ^τ2 → y, ℯ^τ1 → x, ℯ^(-τ2) → 1/y, ℯ^τf → z^2,
```
сгруппировать

```
 τf → -2 τ1 + 2 τ2, ℯ^(-τ1+τ2) → y/x, ℯ^(τ1-τ2) → x/y} // Simplify, {ℯ^τ2, ℯ^τ1}, Simplify]
```
упростить упростить

Out[20]=
$$e^{2\,\tau_1 - \tau_2}\,u_* + e^{-2\,\tau_1 + \tau_2}\,u_* + \frac{y^2 + \left(1 + y^2\right)\,\Omega_0 + \left(-1 + 2\,x - 4\,y - y^2 + \frac{2\,y^2}{x}\right)\,u_*}{y} == \frac{1}{y}$$

handle transform $e^{2\,\tau_1 - \tau_2}\,u_* + e^{-2\,\tau_1 + \tau_2}\,u_*$

In[21]:=
```
third1 = x^2/y u* + y/x^2 u* + (y^2 + (1 + y^2) Ω0 + (-1 + 2 x - 4 y - y^2 + 2 y^2/x) u*)/y == 1/y // FullSimplify;
```
упростить в полном

```
Expand[third1 // FullSimplify]
```
раскрыть скобки упростить в полном объёме

Out[22]=
$$-\frac{x}{y} + x\,y + \frac{x\,\Omega_0}{y} + x\,y\,\Omega_0 - 4\,x\,u_* - \frac{x\,u_*}{y} + \frac{2\,x^2\,u_*}{y} + \frac{x^3\,u_*}{y} + 2\,y\,u_* + \frac{y\,u_*}{x} - x\,y\,u_* == 0$$

In[23]:=
```
Together[third1];
```
собрать вместе

```
third1 =
  (-x^2 + x^2 y^2 + x^2 Ω0 + x^2 y^2 Ω0 - x^2 u* + 2 x^3 u* + x^4 u* - 4 x^2 y u* + y^2 u* + 2 x y^2 u* - x^2 y^2 u*);
third1eq = (third1 == 0)
Expand[third1 /. {y → z * x} // FullSimplify]
```
раскрыть скобки упростить в полном объёме

```
third1 = third1 /. {y → z * x} // FullSimplify;
```
упростить в полном объёме

```
Expand[second1 /. {y → z * x} // FullSimplify]
```
раскрыть скобки упростить в полном объёме

```
second1 = second1 /. {y → z * x} // FullSimplify;
```
упростить в полном объёме

```
lasEq = second1 + third1 == 0 // FullSimplify
```
упростить в полном объёме

```
second1 - third1 == 0 // FullSimplify
```
упростить в полном объёме

```
xSol = Solve[(1 - Ω0 + (-1 + 2 x - z) (-1 + z) u*) == 0, {x}] // Flatten
```
решить уравнения уплостить

```
Collect[lasEq /. {x → xSol[[1]][[2]]} // Simplify, {z}, Simplify]
```
сгруппировать упростить упростить

```
z1final = Collect[(-1 + Ω0 + (-1 + z^2) u*) == 0, z];
```
сгруппировать

```
z2final = Collect[(z^2 - z^2 Ω0^2 - (-1 + z^4) u* - (-1 + z^2)^2 Ω0 u* + (-1 + z)^4 u*^2) == 0, z];
```
сгруппировать

Out[25]= $-x^2 + x^2 y^2 + x^2 \Omega_0 + x^2 y^2 \Omega_0 - x^2 u_* + 2 x^3 u_* + x^4 u_* - 4 x^2 y u_* + y^2 u_* + 2 x y^2 u_* - x^2 y^2 u_* == 0$

Out[26]= $-x^2 + x^4 z^2 + x^2 \Omega_0 + x^4 z^2 \Omega_0 - x^2 u_* + 2 x^3 u_* + x^4 u_* - 4 x^3 z u_* + x^2 z^2 u_* + 2 x^3 z^2 u_* - x^4 z^2 u_*$

Out[28]= $x^2 + x^4 z^2 - x^2 \Omega_0 + x^4 z^2 \Omega_0 + x^2 u_* - 2 x^3 u_* + x^4 u_* - x^2 z^2 u_* + 2 x^3 z^2 u_* - x^4 z^2 u_*$

Out[30]= $x \left(x z^2 (1 + \Omega_0) - (-1 + z) (x + (-2 + x) z) u_*\right) == 0$

Out[31]= $x (1 - \Omega_0 + (-1 + 2 x - z) (-1 + z) u_*) == 0$

Out[32]= $\left\{x \to \frac{-1 + \Omega_0 - u_* + z^2 u_*}{2 (-1 + z) u_*}\right\}$

Out[33]= $\frac{\left(-1 + \Omega_0 + \left(-1 + z^2\right) u_*\right) \left(z^2 - z^2 \Omega_0^2 - \left(-1 + z^4\right) u_* - \left(-1 + z^2\right)^2 \Omega_0 u_* + (-1 + z)^4 u_*^2\right)}{(-1 + z) u_*} == 0$

Make Numeric solution

In[36]:=
```
t* = 0.174; ω0 = 0.149;
ϕ0 = 0.021;
u* = -0.63;
Ω0 = t*/ϕ0 ω0;
Ω0 base = Ω0;
Print["Ω0=", Ω0];
```
печатать

```
Ω0=1.23457
```

In[38]:=
```
Ω0 = Ω0 base;
roots = NSolve[third1eq && second1eq && first1eq, {x, y, z}, Reals]
```
численное решение уравнений множести

NSolve : NSolve was unable to solve the system with inexact coefficients. The answer was obtained by solving a corresponding exact system and numericizing the result.

Out[39]=
$$\{\{x \to 1.73191 \times 10^{-17},\ y \to -2.02888 \times 10^{-17},\ z \to -1.17147\},$$
$$\{x \to 2.1933 \times 10^{-16},\ y \to 2.56938 \times 10^{-16},\ z \to 1.17147\},$$
$$\{x \to 0.0811281,\ y \to 0.0960679,\ z \to 1.18415\},$$
$$\{x \to 0.952909,\ y \to 0.324848,\ z \to 0.340902\}\}$$

In[40]:=
Make Algebraic solution

Out[40]=
```
Algebraic Make solution
```

In[41]:=
```
Solve[z1final, z, Reals] ~Join~ Solve[z2final, z, Reals] // Flatten
```
решить уравнения множес… сое… решить уравнения множеств… уплостить

```
2 * Log[1.17]
```
натуральный логарифм

Out[41]=
$$\{z \to -1.17147,\ z \to 1.17147,\ z \to 0.340902,\ z \to 1.18415\}$$

Out[42]=
```
0.314007
```

In[43]:=
```
τ1 = Log[roots[[1]][[1]][[2]];
```
натуральный логарифм

```
τ2 = Log[roots[[1]][[2]][[2]];
```
натуральный логарифм

```
τf = 2 * Log[roots[[1]][[3]][[2]];
```
натуральный логарифм

```
Print["τ1=", τ1, "; τ2=", τ2, "; τf=", τf]
```
печатать

```
τ1=-38.5947; τ2=-38.4365 + 3.14159 i; τf=0.316514 + 6.28319 i
```

In[45]:=
```
τ1 = Log[roots[[1]][[1]][[2]]];
     натуральный логарифм
τ2 = Log[roots[[1]][[2]][[2]]]; τf = 2 * Log[roots[[1]][[3]][[2]]];
     натуральный логарифм                  натуральный логарифм
pw1m = Piecewise[{{sol1[[1]][[2]], x > 0 && x ≤ τ1},
       кусочно-заданная функция
    {sol2[[1]][[2]], x > τ1 && x ≤ τ2}, {sol3[[1]][[2]], x > τ2 && x ≤ τf}}];
pw1θ = Piecewise[{{sol1[[2]][[2]], x > 0 && x ≤ τ1},
       кусочно-заданная функция
   {sol2[[2]][[2]], x > τ1 && x ≤ τ2}, {sol3[[2]][[2]], x > τ2 && x ≤ τf}}]
pw1ω = Piecewise[{{sol1[[3]][[2]], x > 0 && x ≤ τ1},
       кусочно-заданная функция
   {sol2[[3]][[2]], x > τ1 && x ≤ τ2}, {sol3[[3]][[2]], x > τ2 && x ≤ τf}}]
```

LessEqual : Invalid comparison with −38.4365 + 3.14159 i attempted.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

LessEqual : Invalid comparison with 0.316514 + 6.28319 i attempted.

LessEqual : Invalid comparison with −38.4365 + 3.14159 i attempted.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

LessEqual : Invalid comparison with 0.316514 + 6.28319 i attempted.

Out[47]=

$\frac{1}{2} e^{-x} \left(1 + e^{2x} + 1.23457 \left(-1 + e^{2x}\right) - 0.63 \left(1 - e^{2x} + 2 e^{x} x\right)\right)$	$x > 0 \&\& x \le -38.5947$
$\frac{1}{2} \left(e^{-x} + e^{x} + 1.23457 \left(-e^{-x} + e^{x}\right) - 0.63 \left(-154.379 - 2 e^{-38.5947-x} + e^{-x} - e^{x} + 2 e^{38.5947+x} - 2x\right)\right)$	$x > -38.5947 \&\& x \le -38.4365 + 3.14159\, i$
$-0.315 \left((-0.633028 - 12.5664\, i) + e^{(0.316514+6.28319\, i)-x} - e^{(-0.316514-6.28319\, i)+x} + 2x\right)$	$x > -38.4365 + 3.14159\, i \&\& x \le 0.316514 + 6.28319\, i$
0	True

LessEqual : Invalid comparison with −38.4365 + 3.14159 i attempted.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

LessEqual : Invalid comparison with 0.316514 + 6.28319 i attempted.

Out[48]=

$\frac{1}{2} e^{-x} \left(1.23457 \left(1 + e^{2x}\right) - \left(-1 + e^{x}\right) \left(-1 - e^{x} - 0.63 \left(-1 + e^{x}\right)\right)\right)$	$x > 0 \&\& x \le -38.5947$
$\frac{1}{2} e^{38.5947-x} \left(1.73191 \times 10^{-17} \left(-1 + e^{2x}\right) + 2.13817 \times 10^{-17} \left(1 + e^{2x}\right) + 0.63 \left(1.73191 \times 10^{-17} + 2 e^{-38.5947+x} - 2 e^{2x} + e^{-38.5947+2x}\right)\right)$	$x > -38.5947 \&\& x \le -38.4365 + 3.14159\, i$
$0.315 e^{(-0.316514-6.28319\, i)-x} \left(\left(-1.37234 + 3.36125 \times 10^{-16}\, i\right) + e^{x}\right)^2$	$x > -38.4365 + 3.14159\, i \&\& x \le 0.316514 + 6.28319\, i$
0	True

In[49]:=
```
Ω0 = 1.3 Ω0 base; roots = NSolve[third1 && second1 && first1, {x, y, z}, Reals]
                          численное решение уравнений                  множест

τ1 = Log[roots⟦1⟧⟦1⟧⟦2⟧];
     натуральный логарифм

τ2 = Log[roots⟦1⟧⟦2⟧⟦2⟧]; τf = 2 * Log[roots⟦1⟧⟦3⟧⟦2⟧];
     натуральный логарифм          натуральный логарифм

pw13m = Piecewise[{{sol1⟦1⟧⟦2⟧, x > 0 && x ≤ τ1},
                   кусочно-заданная функция

    {sol2⟦1⟧⟦2⟧, x > τ1 && x ≤ τ2}, {sol3⟦1⟧⟦2⟧, x > τ2 && x ≤ τf}}];
pw13θ = Piecewise[{{sol1⟦2⟧⟦2⟧, x > 0 && x ≤ τ1},
                   кусочно-заданная функция

   {sol2⟦2⟧⟦2⟧, x > τ1 && x ≤ τ2}, {sol3⟦2⟧⟦2⟧, x > τ2 && x ≤ τf}}]
pw13ω = Piecewise[{{sol1⟦3⟧⟦2⟧, x > 0 && x ≤ τ1},
                   кусочно-заданная функция

   {sol2⟦3⟧⟦2⟧, x > τ1 && x ≤ τ2}, {sol3⟦3⟧⟦2⟧, x > τ2 && x ≤ τf}}]
```

NSolve :

$x^2 \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z)(-1 - z + x (2 + x + \text{Times}[\ll 2 \gg])\right)) \&\& x^2 \left(1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.60494 \left(-1 + x^2 z^2\right)\right) \&\& z == \frac{y}{x}$ is not a quantified system of equations and inequalities.

Out[49]=
$$\text{NSolve}\left[x^2 \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) \&\& x^2 \left(1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.60494 \left(-1 + x^2 z^2\right)\right) \&\& z == \frac{y}{x}, \{x, y, z\}, \mathbb{R}\right]$$

Out[52]=

$\frac{1}{2} e^{-x} \left(1 + e^{2x} + 1.60494 \left(-1 + e^{2x}\right) - 0.63 \left(1 - e^{2x} + 2 e^x x\right)\right)$	$x > 0 \&\& x \le \text{Log}\left[-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right]$
$\frac{1}{2} \left(e^{-x} + e^x + 1.60494 \left(-e^{-x} + e^x\right) - 0.63 \left(e^{-x} - e^x - 2x + \left(2 e^x\right) / \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) - 2 e^{-x} \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) + 4 \text{Log}\left[-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right]\right)\right)$	$x > \text{Log}\left[-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right] \&\& x \le \text{Log}\left[1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.60494 \left(-1 + x^2 z^2\right)\right]$
$-0.315 \left(2x - \frac{e^x x^2}{y^2} + \frac{e^{-x} y^2}{x^2} - 4 \text{Log}\left[\frac{y}{x}\right]\right)$	$x > \text{Log}\left[1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.60494 \left(-1 + x^2 z^2\right)\right] \&\& x \le 2 \text{Log}\left[\frac{y}{x}\right]$
0	True

Out[53]=

$$\frac{1}{2}\, e^{-x} \left(1.60494 \left(1 + e^{2x}\right) - \left(-1 + e^{x}\right) \left(-1 - e^{x} - 0.63 \left(-1 + e^{x}\right)\right)\right)$$

$$\left(e^{-x} \left(\left(-1 + e^{2x}\right) \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) + 1.60494 \left(1 + e^{2x}\right) \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) + 0.63 \left(-1 - 2 e^{2x} + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z)) + 2 e^{x} \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) + e^{2x} \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) - 2 \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))^2\right)\right)\right) \Big/ \left(2 \left(-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right)\right)$$

$$\frac{0.315\, e^{-x} x^2 \left(e^{x} - \frac{y^2}{x^2}\right)^2}{y^2}$$

$$0$$

$$x > 0 \;\&\&\; x \le \text{Log}\left[-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right]$$

$$x > \text{Log}\left[-1 + x^2 z^2 + 1.60494 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right] \;\&\&\; x \le \text{Log}\left[1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.60494 \left(-1 + x^2 z^2\right)\right]$$

$$x > \text{Log}\left[1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.60494 \left(-1 + x^2 z^2\right)\right] \;\&\&\; x \le 2\, \text{Log}\left[\frac{y}{x}\right]$$

$$\text{True}$$

In[54]:=
```
Ω0 = 0.7 Ω0 base; roots = NSolve[third1 && second1 && first1, {x, y, z}, Reals]
                          численное решение уравнений                  множест

τ1 = Log[roots⟦1⟧⟦1⟧⟦2⟧];
     натуральный логарифм

τ2 = Log[roots⟦1⟧⟦2⟧⟦2⟧]; τf = 2 * Log[roots⟦1⟧⟦3⟧⟦2⟧];
     натуральный логарифм          натуральный логарифм

pw07m = Piecewise[{{sol1⟦1⟧⟦2⟧, x > 0 && x ≤ τ1},
         кусочно-заданная функция

    {sol2⟦1⟧⟦2⟧, x > τ1 && x ≤ τ2}, {sol3⟦1⟧⟦2⟧, x > τ2 && x ≤ τf}}];
pw07θ = Piecewise[{{sol1⟦2⟧⟦2⟧, x > 0 && x ≤ τ1},
         кусочно-заданная функция

   {sol2⟦2⟧⟦2⟧, x > τ1 && x ≤ τ2}, {sol3⟦2⟧⟦2⟧, x > τ2 && x ≤ τf}}]
pw07ω = Piecewise[{{sol1⟦3⟧⟦2⟧, x > 0 && x ≤ τ1},
         кусочно-заданная функция

   {sol2⟦3⟧⟦2⟧, x > τ1 && x ≤ τ2}, {sol3⟦3⟧⟦2⟧, x > τ2 && x ≤ τf}}]
```

••• NSolve : $x^2 \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z)(-1 - z + x (2 + x + \text{Times}[\ll 2 \gg])\right)\right) \&\& x^2 \left(1 + x^2 z^2 + 0.6$

equations and inequalities.

Out[54]=
$$\text{NSolve}\left[x^2 \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) \&\& x^2 \left(1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.12346 \left(-1 + x^2 z^2\right)\right) \&\& z == \frac{y}{x}, \{x, y, z\}, \mathbb{R}\right]$$

Out[57]=

$\frac{1}{2} e^{-x} \left(1 + e^{2x} + 1.12346 \left(-1 + e^{2x}\right) - 0.63 \left(1 - e^{2x} + 2 e^x x\right)\right)$	$x > 0 \&\& x \le \text{Log}\left[-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right]$
$\frac{1}{2} \left(e^{-x} + e^x + 1.12346 \left(-e^{-x} + e^x\right) - 0.63 \left(e^{-x} - e^x - 2x + \left(2 e^x\right) \Big/ \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) - 2 e^{-x} \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) + 4 \text{Log}\left[-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right]\right)\right)$	$x > \text{Log}\left[-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right] \&\& x \le \text{Log}\left[1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.12346 \left(-1 + x^2 z^2\right)\right]$
$-0.315 \left(2x - \frac{e^x x^2}{y^2} + \frac{e^{-x} y^2}{x^2} - 4 \text{Log}\left[\frac{y}{x}\right]\right)$	$x > \text{Log}\left[1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.12346 \left(-1 + x^2 z^2\right)\right] \&\& x \le 2 \text{Log}\left[\frac{y}{x}\right]$
0	True

Out[58]=

$$\frac{1}{2}\, e^{-x} \left(1.12346 \left(1 + e^{2x}\right) - \left(-1 + e^{x}\right) \left(-1 - e^{x} - 0.63 \left(-1 + e^{x}\right)\right)\right)$$

$$\left(e^{-x} \left(\left(-1 + e^{2x}\right) \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) + 1.12346 \left(1 + e^{2x}\right) \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) + 0.63 \left(-1 - 2 e^{2x} + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z)) + 2 e^{x} \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) + e^{2x} \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right) - 2 \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right)^2\right)\right) \Big/ \left(2 \left(-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right)\right)$$

$$\frac{0.315\, e^{-x} x^2 \left(e^{x} - \frac{y^2}{x^2}\right)^2}{y^2}$$

$$0$$

$$x > 0 \;\&\&\; x \le \text{Log}\left[-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right]$$

$$x > \text{Log}\left[-1 + x^2 z^2 + 1.12346 \left(1 + x^2 z^2\right) + 0.63 (-1 + z) (-1 - z + x (2 + x + (-2 + x) z))\right] \;\&\&\; x \le \text{Log}\left[1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.12346 \left(-1 + x^2 z^2\right)\right]$$

$$x > \text{Log}\left[1 + x^2 z^2 + 0.63 (-1 + x)^2 \left(-1 + z^2\right) + 1.12346 \left(-1 + x^2 z^2\right)\right] \;\&\&\; x \le 2\, \text{Log}\left[\frac{y}{x}\right]$$

$$\text{True}$$

In[59]:=
```
Plot[{pw1m, pw13m, pw07m}, {x, 0, 7},
 AxesLabel → {Style["τ", 17, Black], Style["m[τ]", 17, Black]},
 PlotLegends → {"Ω₀", "1.3Ω₀", "0.7Ω₀"}]
```
график функции · обозначения н··· · стиль · чёрный · стиль · чёрный · легенды графика

LessEqual : Invalid comparison with −38.4365 + 3.14159 i attempted.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

LessEqual : Invalid comparison with 0.316514 + 6.28319 i attempted.

LessEqual : Invalid comparison with −38.4365 + 3.14159 i attempted.

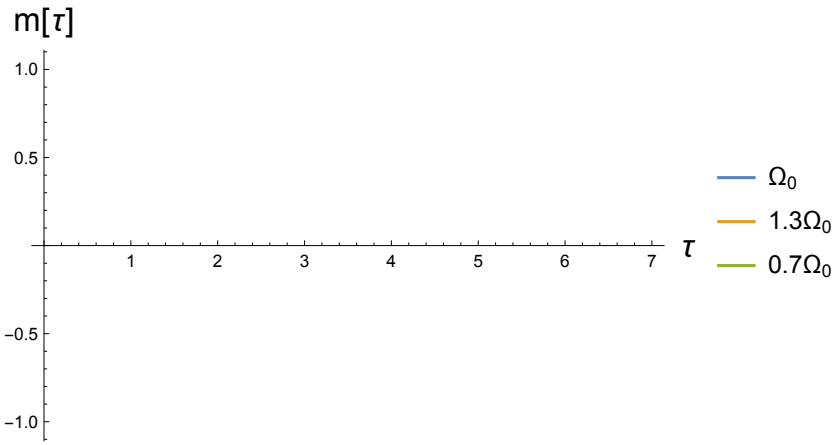
General : Further output of LessEqual::nord will be suppressed during this calculation.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

General : Further output of Greater::nord will be suppressed during this calculation.

Out[59]=



In[60]:=
```
Plot[{pw1θ, pw13θ, pw07θ}, {x, 0, 7},
 AxesLabel → {Style["τ", 17, Black], Style["Θ[τ]", 17, Black]},
 PlotLegends → {"Ω₀", "1.3Ω₀", "0.7Ω₀"}]
```
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LessEqual : Invalid comparison with −38.4365 + 3.14159 i attempted.

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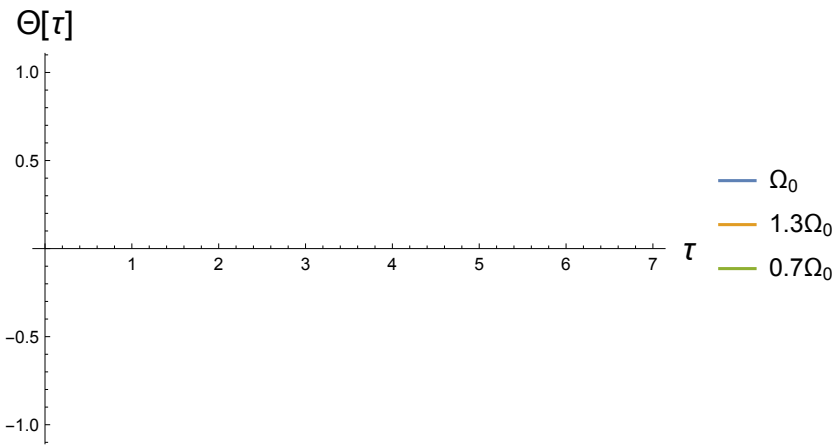
General : Further output of LessEqual::nord will be suppressed during this calculation.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

General : Further output of Greater::nord will be suppressed during this calculation.

Out[60]=



In[61]:=
```
Plot[{pw1ω, pw13ω, pw07ω}, {x, 0, 7},
 AxesLabel → {Style["τ", 17, Black], Style["ω[τ]", 17, Black]},
 PlotLegends → {"Ω₀", "1.3Ω₀", "0.7Ω₀"}]
```
график функции; обозначения н··· стиль чёрный стиль чёрный; легенды графика

LessEqual : Invalid comparison with −38.4365 + 3.14159 i attempted.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

LessEqual : Invalid comparison with 0.316514 + 6.28319 i attempted.

LessEqual : Invalid comparison with −38.4365 + 3.14159 i attempted.

General : Further output of LessEqual::nord will be suppressed during this calculation.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

Greater : Invalid comparison with −38.4365 + 3.14159 i attempted.

General : Further output of Greater::nord will be suppressed during this calculation.

Out[61]=