In[1]:=

```
(* Escenario 1: Estado puramente leucémico,
evolución al cabo de un año. Lento
 decrecimiento de los compartimientos sanos pero rápido
 crecimiento de los compartimientos leucémicos  *)

b = ParametricNDSolve [{x'[t] ==
    ((2 * a1c) / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t]) - 1) *
      p1c * x[t] - d1c * x[t],
   y'[t] == 2 * (1 - a1c / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t])) *
      p1c * x[t] - d2c * y[t],
   l'[t] == ((2 * a1l) / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t]) -
        1) * p1l * l[t] - d1l * l[t],
   m'[t] == 2 * (1 - a1l / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t])) *
      p1l * l[t] - d2l * m[t], x[0] == 6.25 * 10^7,
   y[0] == 6.25 * 10^9, l[0] == 10, m[0] == 0}, {x, y, l, m},
  {t, 365}, {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l}]
```

resolvedor diferencial numérico paramétrico

Out[1]=

```
{x → ParametricFunction[ Expression: x
    Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
 y → ParametricFunction[ Expression: y
    Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
 l → ParametricFunction[ Expression: l
    Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
 m → ParametricFunction[ Expression: m
    Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ]}
```

In[2]:=

```
x1 = x[0.55, 1, 0, 0.01, 0.57, 0.5, 0, 0.1] /.  b
y1 = y[0.55, 1, 0, 0.01, 0.57, 0.5, 0, 0.1] /.  b
l1 = l[0.55, 1, 0, 0.01, 0.57, 0.5, 0, 0.1] /.  b
m1 = m[0.55, 1, 0, 0.01, 0.57, 0.5, 0, 0.1] /.  b
```

Out[2]=

```
InterpolatingFunction[ Domain: {{0., 365.}}
    Output: scalar ]
```

Out[3]=

```
InterpolatingFunction[ Domain: {{0., 365.}}
    Output: scalar ]
```

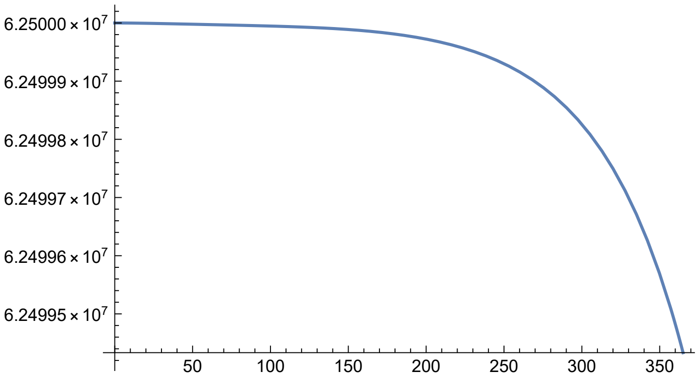
Out[4]=

```
InterpolatingFunction[ Domain: {{0., 365.}}
    Output: scalar ]
```

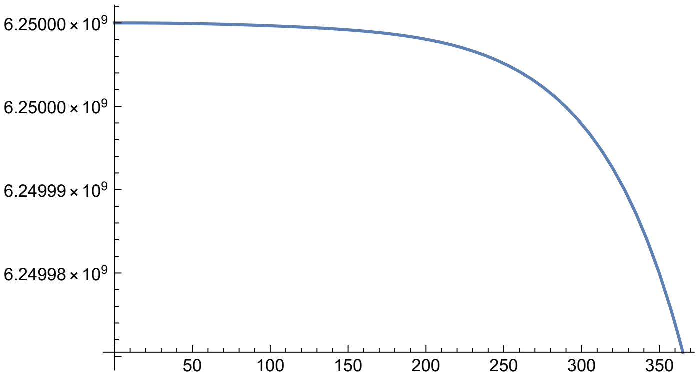
Out[5]=

```
InterpolatingFunction[ Domain: {{0., 365.}}
    Output: scalar ]
```

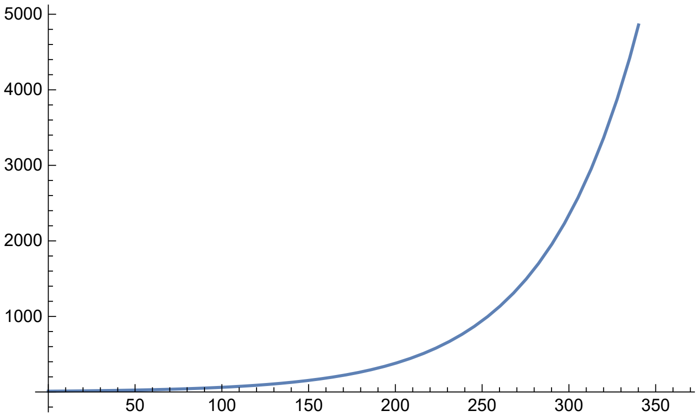
In[6]:=
```
Plot[x1[t], {t, 0., 365}]
```
representación gráfica

Out[6]=


In[7]:=
```
Plot[y1[t], {t, 0., 365}]
```
representación gráfica

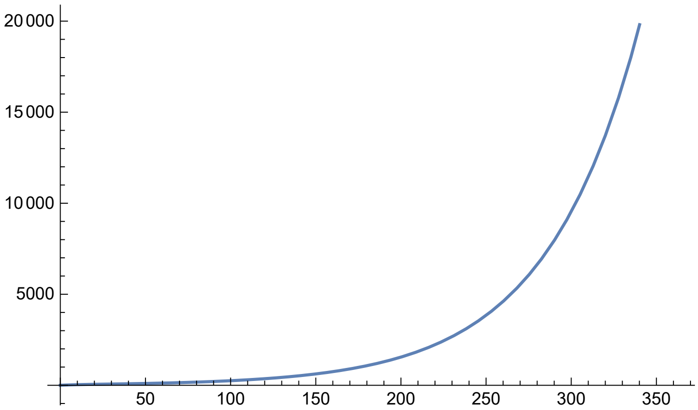
Out[7]=


In[8]:=
```
Plot[l1[t], {t, 0., 365}]
```
representación gráfica

Out[8]=


In[9]:=
```
Plot[m1[t], {t, 0., 365}]
```
representación gráfica

Out[9]=



In[10]:=
```
(* Escenario 2: Extinción de la población de células
  leucémicas y restablecimiento del equilibrio saludable:
 Estabilidad del estado de equilibrio saludable.*)

bb = ParametricNDSolve[
     resolvedor diferencial numérico paramétrico
  {x'[t] == (2 * a1c / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t]) - 1) *
      p1c * x[t] - d1c * x[t],
   y'[t] == 2 * (1 - a1c / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t])) *
      p1c * x[t] - d2c * y[t],
   l'[t] == (2 * a1l / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t]) - 1) *
      p1l * l[t] - d1l * l[t],
   m'[t] == 2 * (1 - a1l / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t])) *
      p1l * l[t] - d2l * m[t], x[0] == 6.25 * 10^7,
   y[0] == 6.25 * 10^9, l[0] == 10, m[0] == 0}, {x, y, l, m},
  {t, 730}, {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l}]
```

Out[10]=
```
{x → ParametricFunction[ Expression: x
                         Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
 y → ParametricFunction[ Expression: y
                         Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
 l → ParametricFunction[ Expression: l
                         Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
 m → ParametricFunction[ Expression: m
                         Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ]}
```

In[11]:=
```
x1 = x[0.55, 1, 0, 0.01, 0.53, 1.5, 0, 0.1] /. bb
y1 = y[0.55, 1, 0, 0.01, 0.53, 1.5, 0, 0.1] /. bb
l1 = l[0.55, 1, 0, 0.01, 0.53, 1.5, 0, 0.1] /. bb
m1 = m[0.55, 1, 0, 0.01, 0.53, 1.5, 0, 0.1] /. bb
```

Out[11]= InterpolatingFunction[Domain: {{0., 730.}} Output: scalar]

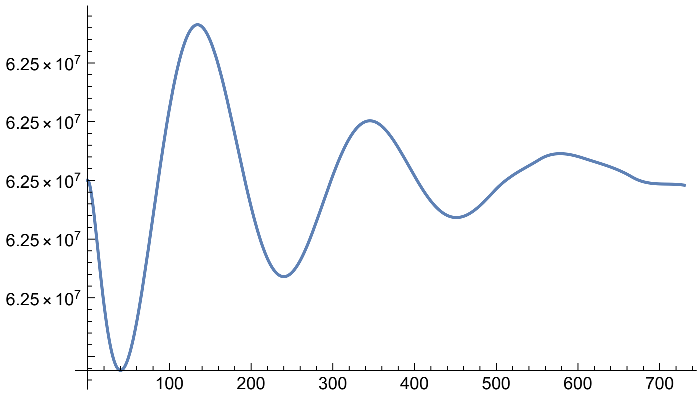
Out[12]= InterpolatingFunction[Domain: {{0., 730.}} Output: scalar]

Out[13]= InterpolatingFunction[Domain: {{0., 730.}} Output: scalar]

Out[14]= InterpolatingFunction[Domain: {{0., 730.}} Output: scalar]

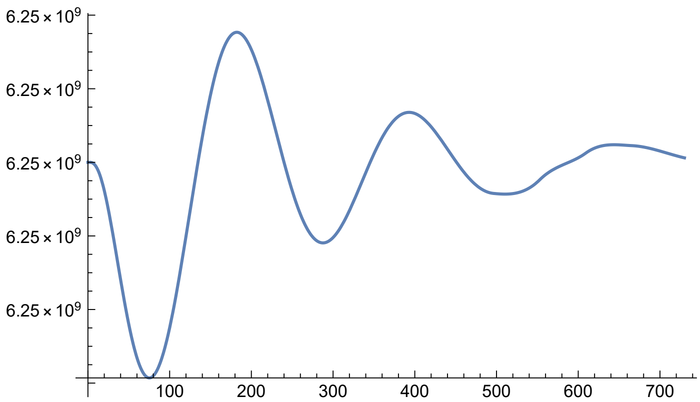
In[15]:=
```
Plot[x1[t], {t, 0., 730.}]
```
representación gráfica

Out[15]=

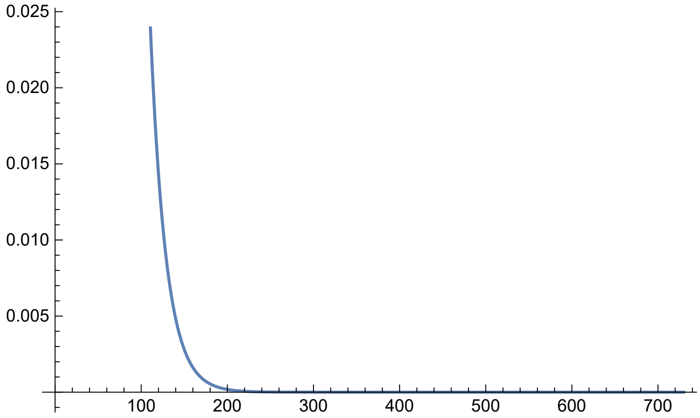


In[16]:=
```
Plot[y1[t], {t, 0., 730.}]
```
representación gráfica

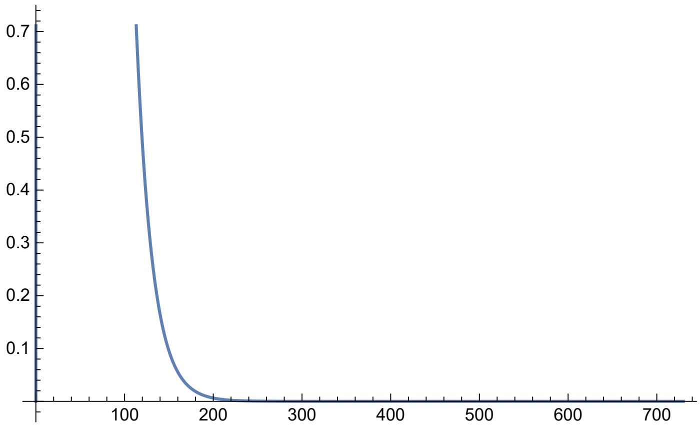
Out[16]=



In[17]:=
```
Plot[l1[t], {t, 0., 730.}]
```
representación gráfica

Out[17]=


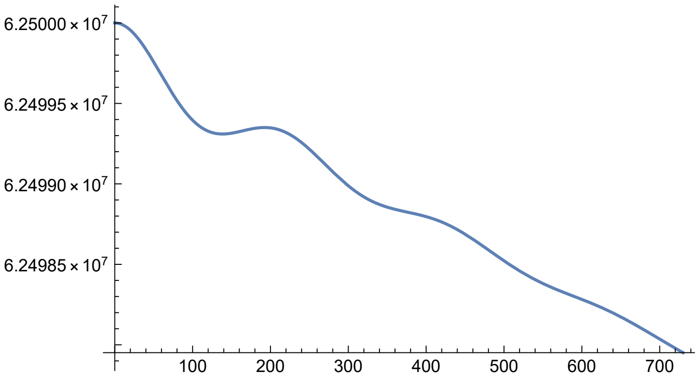
In[18]:=
```
Plot[m1[t], {t, 0., 730.}]
```
representación gráfica

Out[18]=


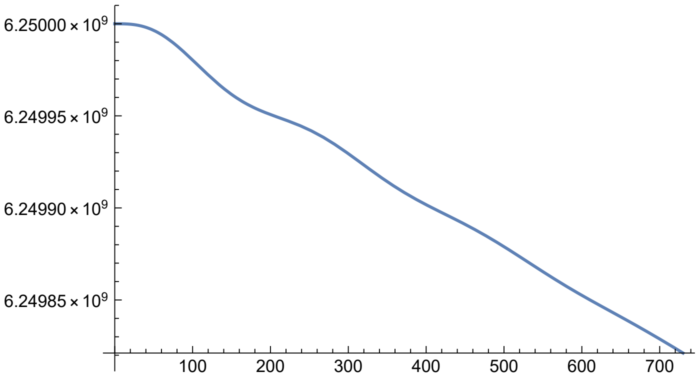

```
(*Escenario 3:
 Equilibrio con la coexistencia de células sanas y leucémicas:
 el recuento de células leucémicas está en el orden
  de magnitud del recuento de células maduras sanas. *)
```

```
In[19]:= bbb = ParametricNDSolve[{x'[t] ==
              resolvedor diferencial numérico paramétrico
           ((2 * a1c) / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t]) - 1) *
             p1c * x[t] - d1c * x[t],
          y'[t] == 2 * (1 - a1c / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t])) *
             p1c * x[t] - d2c * y[t],
          l'[t] == ((2 * a1l) / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t]) -
               1) * p1l * l[t] - d1l * l[t],
          m'[t] == 2 * (1 - a1l / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t])) *
             p1l * l[t] - d2l * m[t], x[0] == 6.25 * 10^7,
          y[0] == 6.25 * 10^9, l[0] == 100, m[0] == 0}, {x, y, l, m},
         {t, 730}, {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l}]

Out[19]= {x → ParametricFunction[ Expression: x
                                   Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
         y → ParametricFunction[ Expression: y
                                   Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
         l → ParametricFunction[ Expression: l
                                   Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
         m → ParametricFunction[ Expression: m
                                   Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ]}

In[20]:= x1 = x[0.55, 1, 0, 0.01, 0.55, 2.5, 0, 0.00001] /.  bbb
         y1 = y[0.55, 1, 0, 0.01, 0.55, 2.5, 0, 0.00001] /.  bbb
         l1 = l[0.55, 1, 0, 0.01, 0.55, 2.5, 0, 0.00001] /.  bbb
         m1 = m[0.55, 1, 0, 0.01, 0.55, 2.5, 0, 0.00001] /.  bbb

Out[20]= InterpolatingFunction[ Domain: {{0., 730.}}
                                Output: scalar ]

Out[21]= InterpolatingFunction[ Domain: {{0., 730.}}
                                Output: scalar ]

Out[22]= InterpolatingFunction[ Domain: {{0., 730.}}
                                Output: scalar ]

Out[23]= InterpolatingFunction[ Domain: {{0., 730.}}
                                Output: scalar ]
```

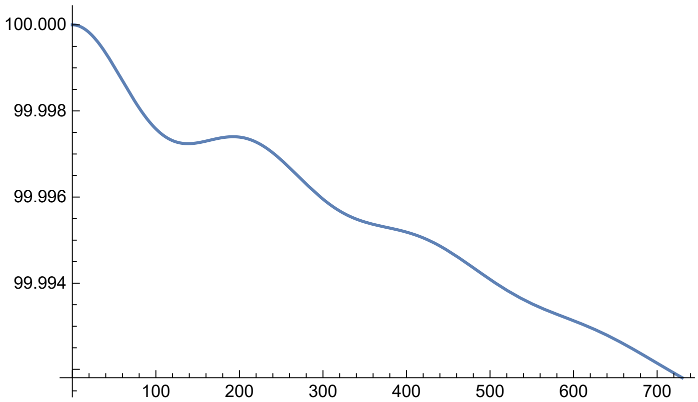
In[24]:=
```
Plot[x1[t], {t, 0.`, 730.}]
```
representación gráfica

Out[24]=


In[25]:=
```
Plot[y1[t], {t, 0.`, 730.}]
```
representación gráfica

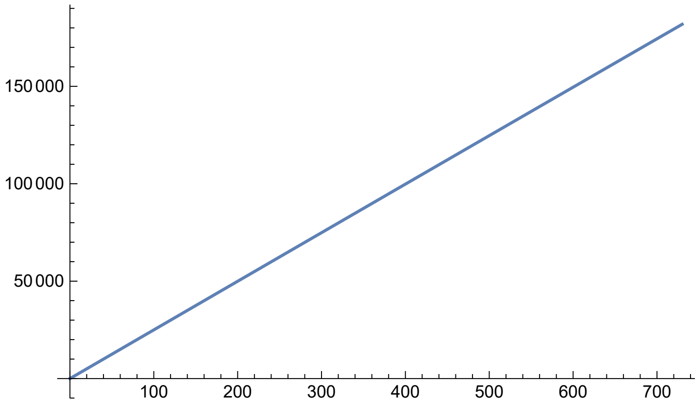
Out[25]=


In[26]:=
```
Plot[l1[t], {t, 0.`, 730.}]
```
representación gráfica

Out[26]=


In[27]:=
```
Plot[m1[t], {t, 0.`, 730.}]
```
representación gráfica

Out[27]=




```
(* Escenario 4:
 Equilibrio con la coexistencia de células sanas y leucémicas:
 el recuento de células leucémicas es pequeño
  y el cambio de recuentos de células sanas es
  invisible en una escala clínicamente relevante.*)
```

In[28]:=
```
bbbb = ParametricNDSolve [{x'[t] ==
    ((2 * a1c) / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t]) - 1) *
      p1c * x[t] - d1c * x[t],
   y'[t] == 2 * (1 - a1c / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t])) *
      p1c * x[t] - d2c * y[t],
   l'[t] == ((2 * a1l) / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t]) -
        1) * p1l * l[t] - d1l * l[t],
   m'[t] == 2 * (1 - a1l / (1 + 1.6 * (10^-11) * y[t] + 1.6 * (10^-11) * m[t])) *
      p1l * l[t] - d2l * m[t], x[0] == 6.25 * 10^7,
   y[0] == 6.25 * 10^9, l[0] == 10, m[0] == 0}, {x, y, l, m},
  {t, 730}, {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l}]
```
resolvedor diferencial numérico paramétrico

Out[28]=
```
{x → ParametricFunction[ Expression: x
    Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
 y → ParametricFunction[ Expression: y
    Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
 l → ParametricFunction[ Expression: l
    Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ],
 m → ParametricFunction[ Expression: m
    Parameters: {a1c, p1c, d1c, d2c, a1l, p1l, d1l, d2l} ]}
```

In[29]:=
```
x1 = x[0.55, 1, 0, 0.01, 0.55, 0.5, 0, 0.1] /. bbbb
y1 = y[0.55, 1, 0, 0.01, 0.55, 0.5, 0, 0.1] /. bbbb
l1 = l[0.55, 1, 0, 0.01, 0.55, 0.5, 0, 0.1] /. bbbb
m1 = m[0.55, 1, 0, 0.01, 0.55, 0.5, 0, 0.1] /. bbbb
```

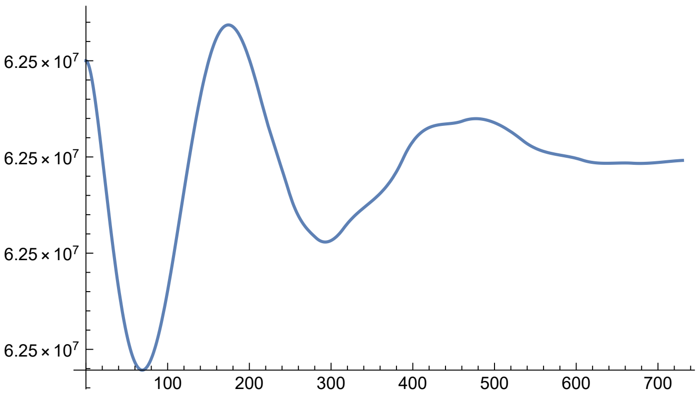
Out[29]= InterpolatingFunction[ Domain: {{0., 730.}} Output: scalar]

Out[30]= InterpolatingFunction[ Domain: {{0., 730.}} Output: scalar]

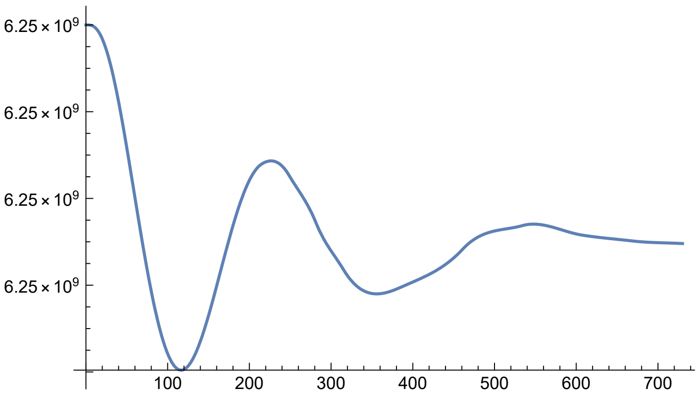
Out[31]= InterpolatingFunction[ Domain: {{0., 730.}} Output: scalar]

Out[32]= InterpolatingFunction[ Domain: {{0., 730.}} Output: scalar]

In[33]:=
```
Plot[x1[t], {t, 0., 730.}]
```
representación gráfica

Out[33]=


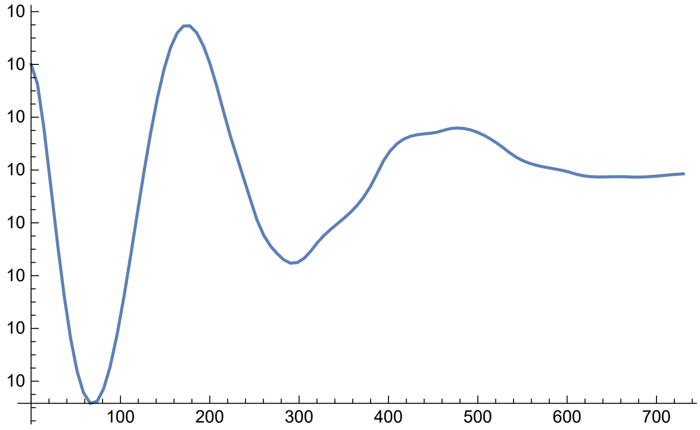
In[34]:=
```
Plot[y1[t], {t, 0., 730.}]
```
representación gráfica

Out[34]=


In[35]:= `Plot[l1[t], {t, 0., 730.}]`

representación gráfica

Out[35]=



In[36]:= `Plot[m1[t], {t, 0., 730.}]`

representación gráfica

Out[36]=