Mecánica de medios continuos
Parcial 1-Punto 1

- Definimos las constantes y los espacios con los cuales se va a trabajar

In[1]:=
```
a = 8.5*^-3;
k = 5.66*^-6;
cr = 3700;
xx = Range[0, 25000, 1];
yy = Range[0, 5000, 1];
tt = Range[0, 50, 0.05];
la = 40*^9;
g = 40*^9;
```

- Definimos los desplazamientos

In[9]:=
```
u = Function[{x, y, t},
    a * (Exp[-0.8475 * k * y] - 0.5773 * Exp[-0.3933 * k * y]) * Sin[k * (cr * t - x)]];
v = Function[{x, y, t}, a * (0.8475 * Exp[-0.8475 * k * y] + 1.4679 * Exp[-0.3933 * k * y]) *
     Cos[k * (cr * t - x)]];
w = Function[{x, y, t}, 0];
```

- Evaluamos si se puede utilizar el tensor infinitesimal

In[679]:=
```
gradU = Grad[{u[x, y, t], v[x, y, t], w[x, y, t]}, {x, y, z}];
Maximize[Norm[gradU], {x, y, t}]
```

Out[680]=
$$\left\{1.11372 \times 10^{-7},\ \{x \to 7.5764,\ y \to 39.5354,\ t \to 74.3147\}\right\}$$

- Dado que la máxima norma es mucho menor que 1, podemos utilizar la aproximación infinitesimal para el tensor de Green y de Almansi (son lo mismo)

1. Escriba el tensor de Green y Almansi, dado que para desplazamientos infinitesimales son lo mismo

In[1215]:=
```
ge = (gradU + Transpose[gradU]) / 2
```

Out[1215]=
$$\left\{\left\{-4.811 \times 10^{-8}\ \left(e^{-4.79685\times10^{-6}\,y} - 0.5773\ e^{-2.22608\times10^{-6}\,y}\right)\ \text{Cos}\left[5.66 \times 10^{-6}\ (3700\,t - x)\right],\right.\right.$$
$$\frac{1}{2}\left(0.0085\ \left(-4.79685 \times 10^{-6}\ e^{-4.79685\times10^{-6}\,y} + 1.28511 \times 10^{-6}\ e^{-2.22608\times10^{-6}\,y}\right)\right.$$
$$\text{Sin}\left[5.66 \times 10^{-6}\ (3700\,t - x)\right] + 4.811 \times 10^{-8}$$
$$\left.\left(0.8475\ e^{-4.79685\times10^{-6}\,y} + 1.4679\ e^{-2.22608\times10^{-6}\,y}\right)\ \text{Sin}\left[5.66 \times 10^{-6}\ (3700\,t - x)\right]\right), 0\},$$
$$\left\{\frac{1}{2}\left(0.0085\ \left(-4.79685 \times 10^{-6}\ e^{-4.79685\times10^{-6}\,y} + 1.28511 \times 10^{-6}\ e^{-2.22608\times10^{-6}\,y}\right)\right.\right.$$
$$\text{Sin}\left[5.66 \times 10^{-6}\ (3700\,t - x)\right] +$$
$$\left.4.811 \times 10^{-8}\ \left(0.8475\ e^{-4.79685\times10^{-6}\,y} + 1.4679\ e^{-2.22608\times10^{-6}\,y}\right)\ \text{Sin}\left[5.66 \times 10^{-6}\ (3700\,t - x)\right]\right),$$
$$0.0085\ \left(-4.06533 \times 10^{-6}\ e^{-4.79685\times10^{-6}\,y} - 3.26766 \times 10^{-6}\ e^{-2.22608\times10^{-6}\,y}\right)$$
$$\left.\left.\text{Cos}\left[5.66 \times 10^{-6}\ (3700\,t - x)\right], 0\right\}, \{0, 0, 0\}\right\}$$

- Encontramos el tensor de esfuerzos

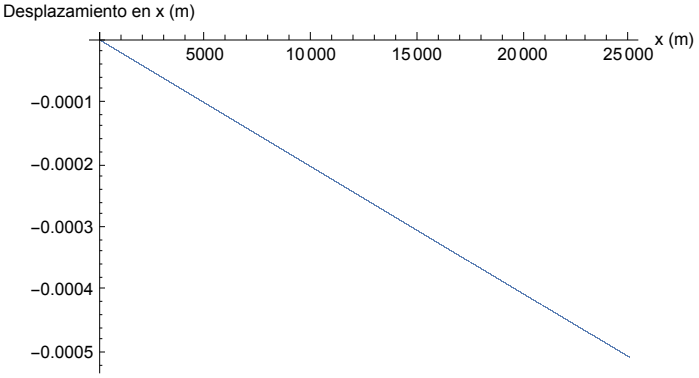
In[825]:=
```
sij = 2 * g * ge + Tr[ge] * la * IdentityMatrix[3];
Dimensions[sij]
```

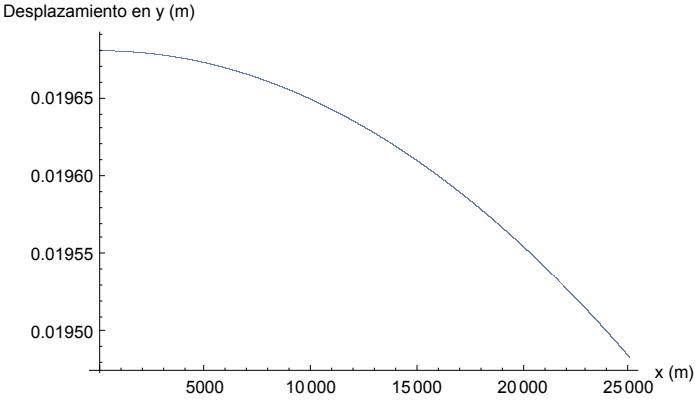
Out[826]=
```
{3, 3}
```

2. Diagrame la forma de la onda en la superficie libre (y=0)

- Para t=0

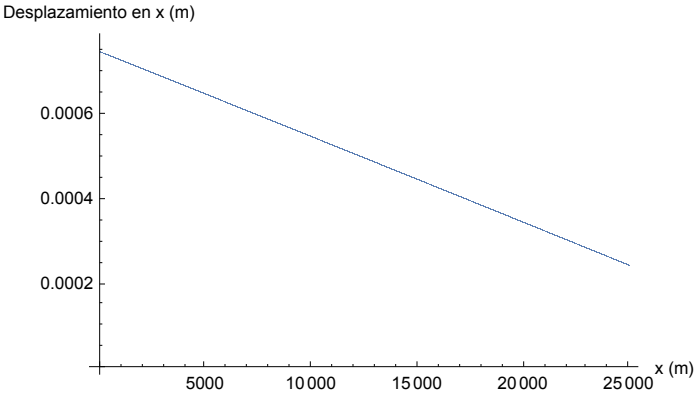
```
uy0t0 = Evaluate[u[x, 0, 0]] /. {x -> xx};
vy0t0 = Evaluate[v[x, 0, 0]] /. {x → xx};
data1u = Thread[{xx, uy0t0}];
data1v = Thread[{xx, vy0t0}];
ListPlot[data1u, AxesLabel → {"x (m)", "Desplazamiento en x (m)"}]
ListPlot[data1v, AxesLabel → {"x (m)", "Desplazamiento en y (m)"}]
```

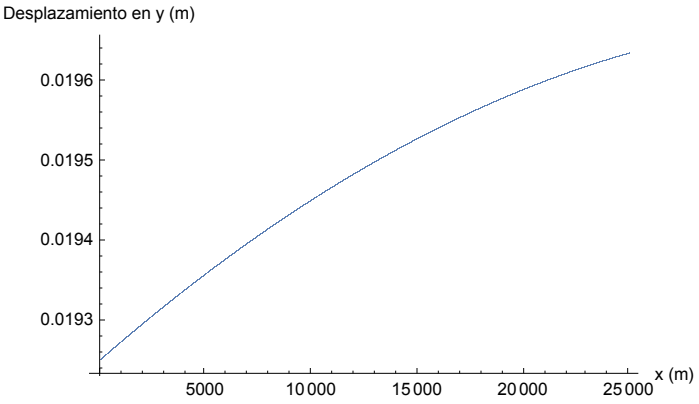




- Para t=10 s

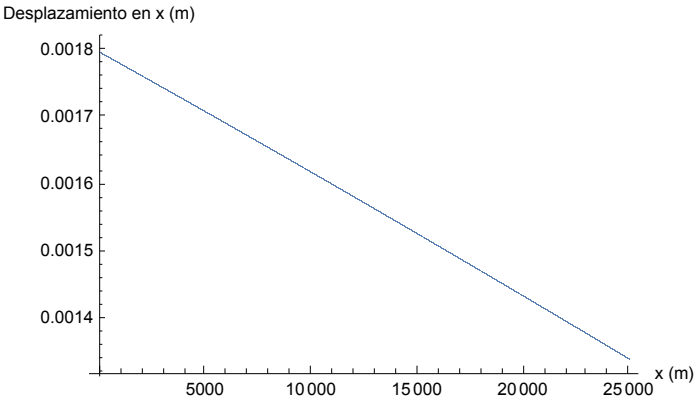
```
uy0t10 = Evaluate[u[x, 0, 10]] /. {x -> xx};
vy0t10 = Evaluate[v[x, 0, 10]] /. {x -> xx};
data2u = Thread[{xx, uy0t10}];
data2v = Thread[{xx, vy0t10}];
ListPlot[data2u, AxesLabel → {"x (m)", "Desplazamiento en x (m)"}]
ListPlot[data2v, AxesLabel → {"x (m)", "Desplazamiento en y (m)"}]
```

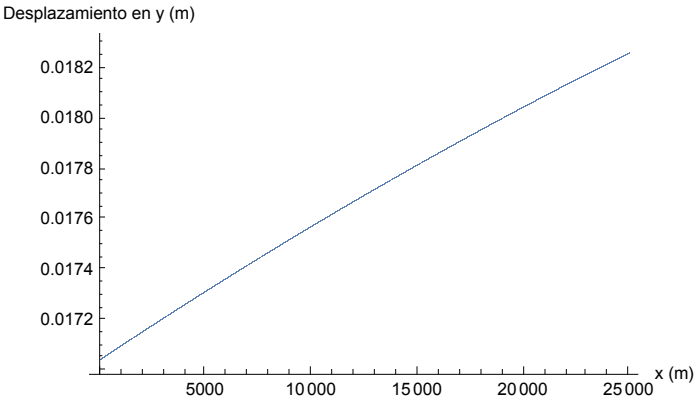




- Para t=25 s

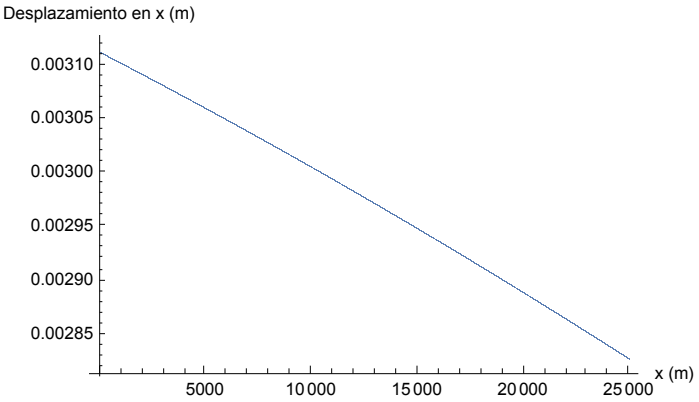
```
uy0t25 = Evaluate[u[x, 0, 25]] /. {x -> xx};
vy0t25 = Evaluate[v[x, 0, 25]] /. {x -> xx};
data3u = Thread[{xx, uy0t25}];
data3v = Thread[{xx, vy0t25}];
ListPlot[data3u, AxesLabel → {"x (m)", "Desplazamiento en x (m)"}]
ListPlot[data3v, AxesLabel → {"x (m)", "Desplazamiento en y (m)"}]
```

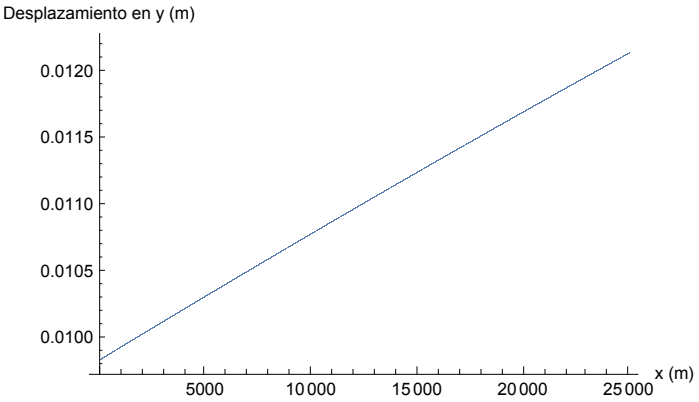




- Para t=50

```
uy0t50 = Evaluate[u[x, 0, 50]] /. {x → xx};
vy0t50 = Evaluate[v[x, 0, 50]] /. {x → xx};
data4u = Thread[{xx, uy0t50}];
data4v = Thread[{xx, vy0t50}];
ListPlot[data4u, AxesLabel → {"x (m)", "Desplazamiento en x (m)"}]
ListPlot[data4v, AxesLabel → {"x (m)", "Desplazamiento en y (m)"}]
```

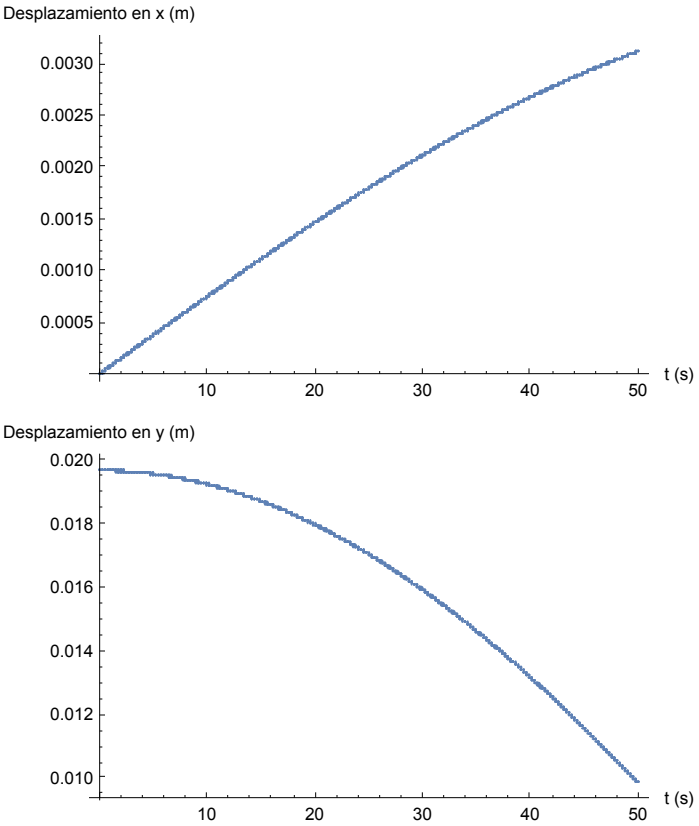




3. Diagrame la trayectoria de movimiento de las particulas en y=0 para varios valores de x. Haga lo mismo para varios y>0.

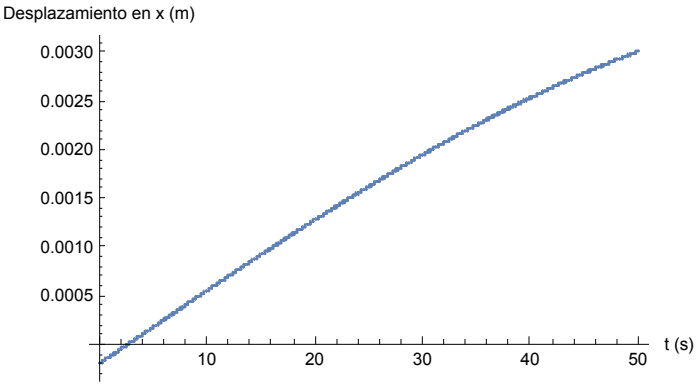
- Para y=0 & x=0

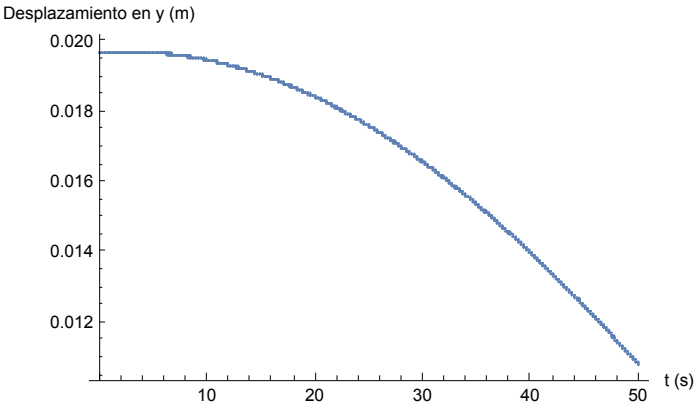
```
uy0x0 = Evaluate[u[0, 0, t]] /. {t → tt};
vy0x0 = Evaluate[v[0, 0, t]] /. {t → tt};
data5u = Thread[{tt, uy0x0}];
data5v = Thread[{tt, vy0x0}];
ListPlot[data5u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data5v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```



- Para y=0 & x=10000

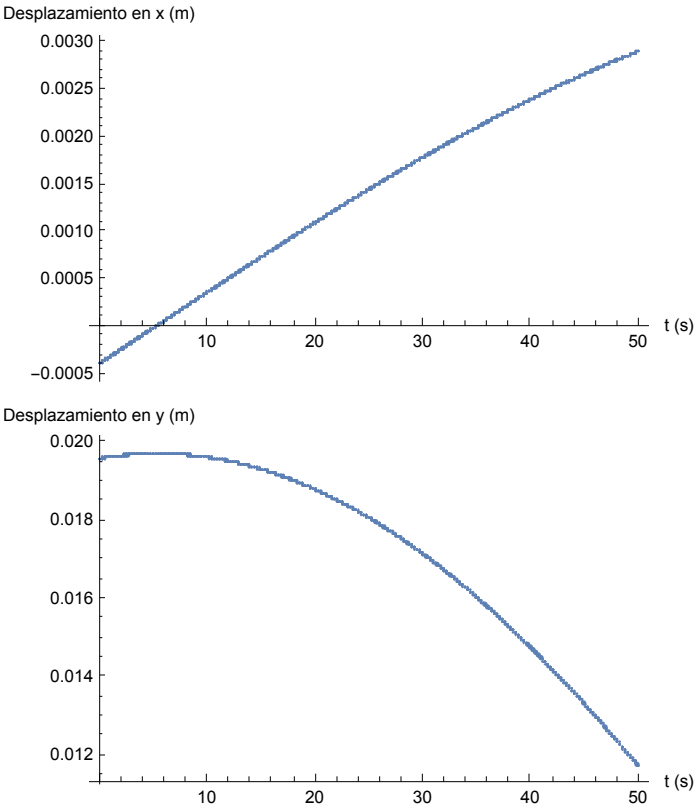
```
uy0x10 = Evaluate[u[10 000, 0, t]] /. {t → tt};
vy0x10 = Evaluate[v[10 000, 0, t]] /. {t → tt};
data6u = Thread[{tt, uy0x10}];
data6v = Thread[{tt, vy0x10}];
ListPlot[data6u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data6v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```





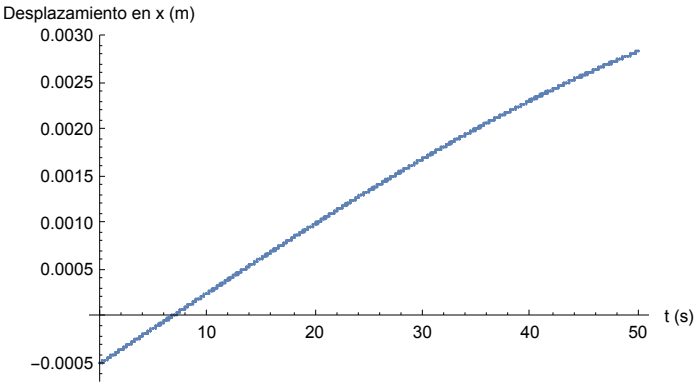
- Para y=0 & x=20000

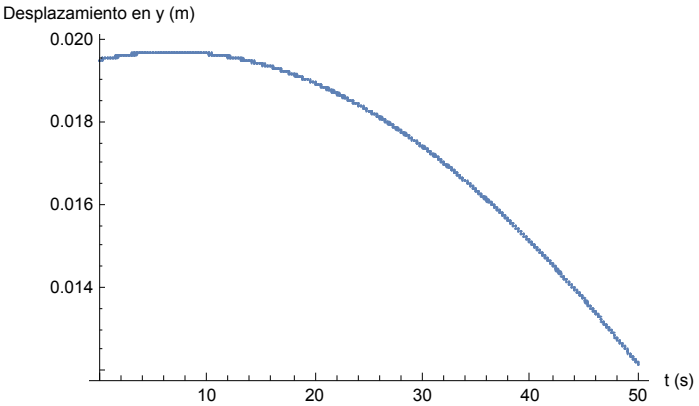
```
uy0x20 = Evaluate[u[20 000, 0, t]] /. {t → tt};
vy0x20 = Evaluate[v[20 000, 0, t]] /. {t → tt};
data7u = Thread[{tt, uy0x20}];
data7v = Thread[{tt, vy0x20}];
ListPlot[data7u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data7v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```



- Para y=0 & x=25000

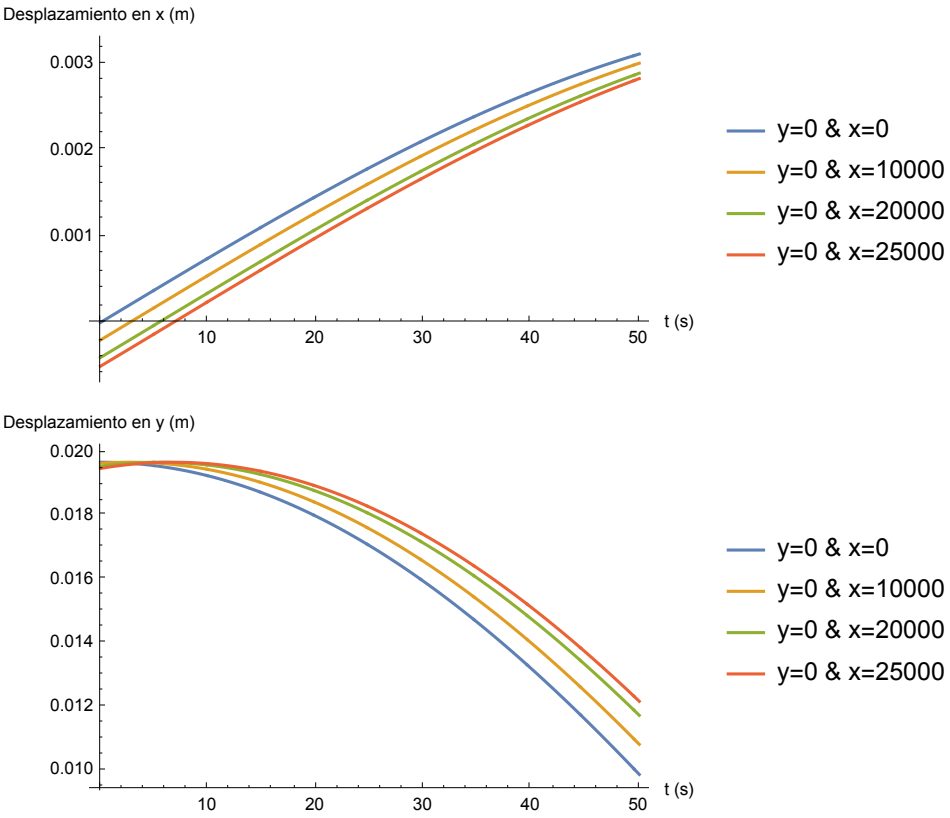
```
uy0x25 = Evaluate[u[25 000, 0, t]] /. {t → tt};
vy0x25 = Evaluate[v[25 000, 0, t]] /. {t → tt};
data8u = Thread[{tt, uy0x25}];
data8v = Thread[{tt, vy0x25}];
ListPlot[data8u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data8v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```





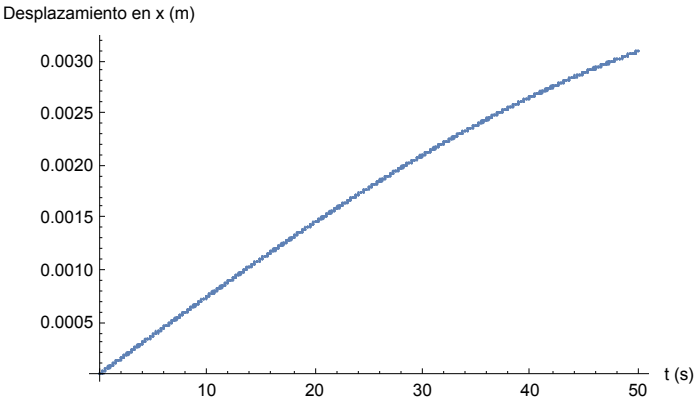
- Para y=0

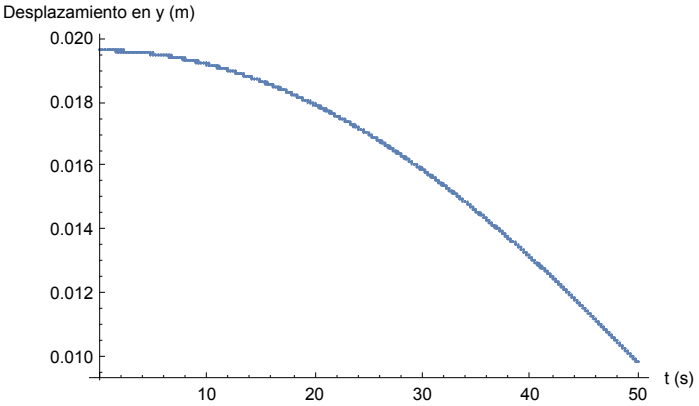
```
ListPlot[{data5u, data6u, data7u, data8u},
 PlotLegends → {"y=0 & x=0", "y=0 & x=10000", "y=0 & x=20000", "y=0 & x=25000"},
 AxesLabel → {"t (s)", "Desplazamiento en x (m)"}, Joined -> True]
ListPlot[{data5v, data6v, data7v, data8v},
 PlotLegends → {"y=0 & x=0", "y=0 & x=10000", "y=0 & x=20000", "y=0 & x=25000"},
 AxesLabel → {"t (s)", "Desplazamiento en y (m)"}, Joined -> True]
```



- Para y=1000 & x=0

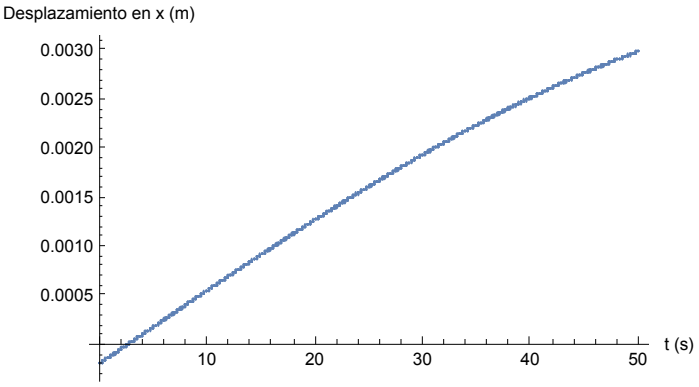
```
uy1x0 = Evaluate[u[0, 1000, t]] /. {t → tt};
vy1x0 = Evaluate[v[0, 1000, t]] /. {t → tt};
data9u = Thread[{tt, uy1x0}];
data9v = Thread[{tt, vy1x0}];
ListPlot[data9u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data9v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```

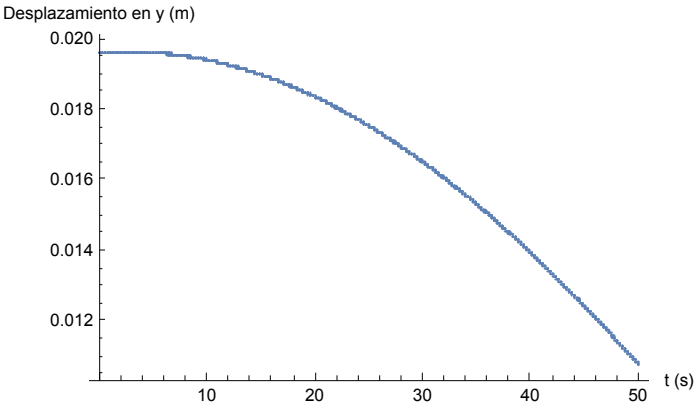




- Para y=1000 & x=10000

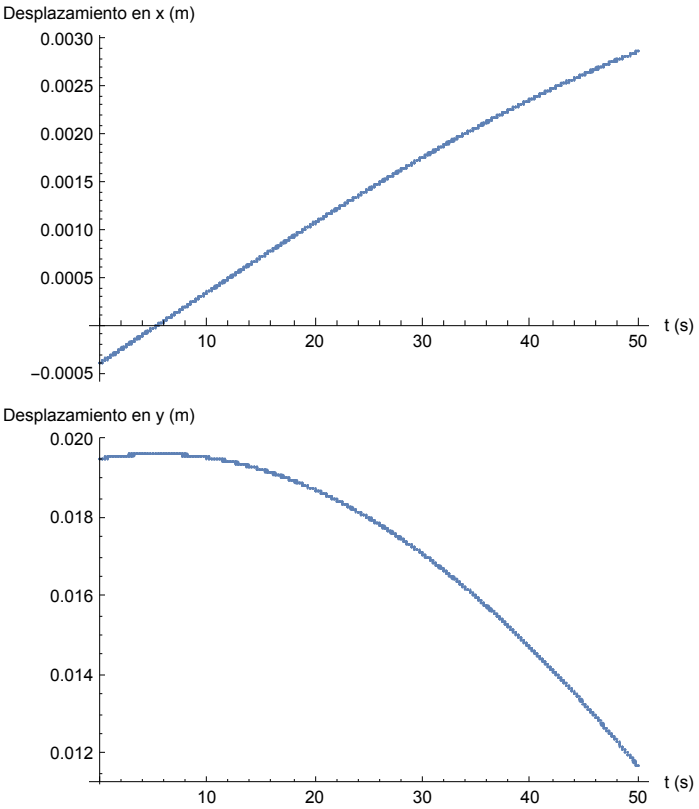
```
uy1x10 = Evaluate[u[10 000, 1000, t]] /. {t → tt};
vy1x10 = Evaluate[v[10 000, 1000, t]] /. {t → tt};
data10u = Thread[{tt, uy1x10}];
data10v = Thread[{tt, vy1x10}];
ListPlot[data10u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data10v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```





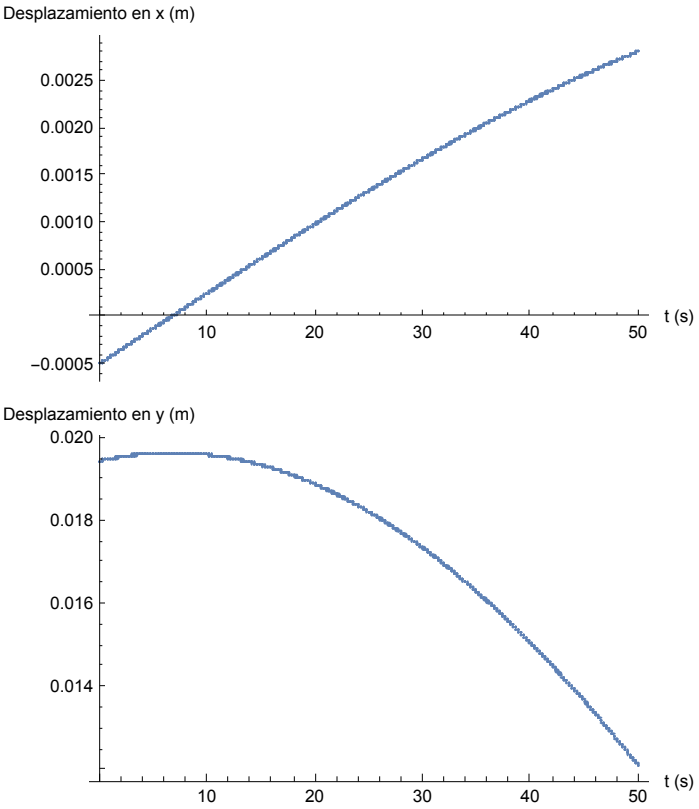
- Para y=1000 & x=20000

```
uy1x20 = Evaluate[u[20 000, 1000, t]] /. {t → tt};
vy1x20 = Evaluate[v[20 000, 1000, t]] /. {t → tt};
data11u = Thread[{tt, uy1x20}];
data11v = Thread[{tt, vy1x20}];
ListPlot[data11u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data11v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```

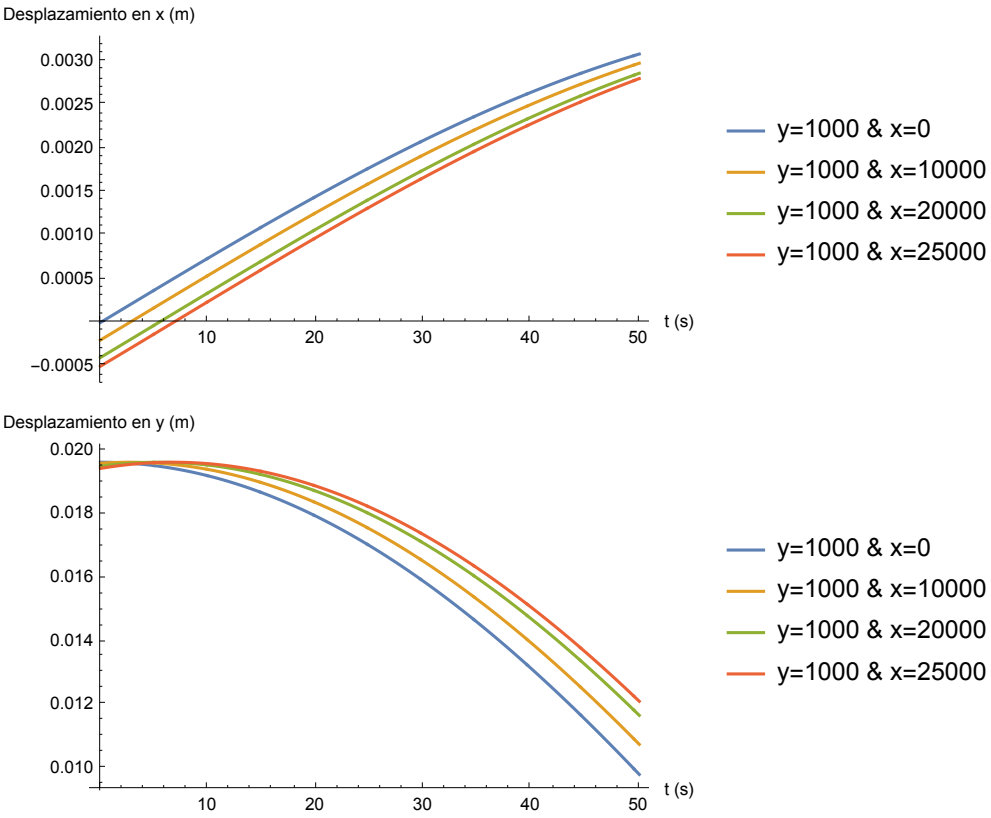


- Para y=1000 & x=25000

```
uy1x25 = Evaluate[u[25 000, 1000, t]] /. {t → tt};
vy1x25 = Evaluate[v[25 000, 1000, t]] /. {t → tt};
data12u = Thread[{tt, uy1x25}];
data12v = Thread[{tt, vy1x25}];
ListPlot[data12u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data12v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```

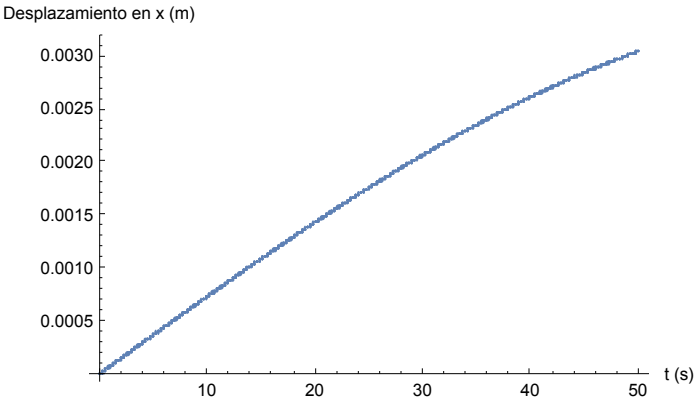


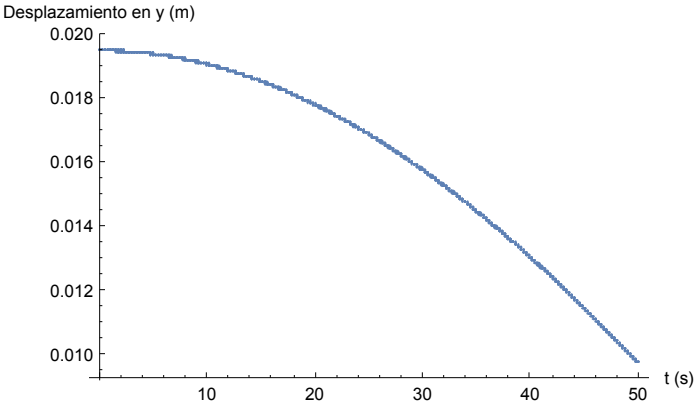
```
ListPlot[{data9u, data10u, data11u, data12u}, PlotLegends →
  {"y=1000 & x=0", "y=1000 & x=10000", "y=1000 & x=20000", "y=1000 & x=25000"},
 AxesLabel → {"t (s)", "Desplazamiento en x (m)"}, Joined -> True]
ListPlot[{data9v, data10v, data11v, data12v}, PlotLegends →
  {"y=1000 & x=0", "y=1000 & x=10000", "y=1000 & x=20000", "y=1000 & x=25000"},
 AxesLabel → {"t (s)", "Desplazamiento en y (m)"}, Joined -> True]
```



- Para y=3000 & x=0

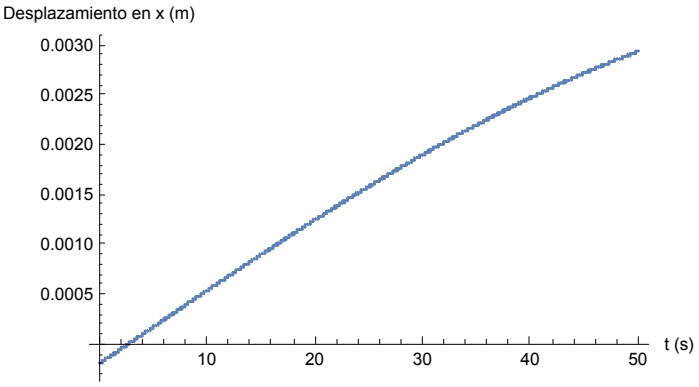
```
uy3x0 = Evaluate[u[0, 3000, t]] /. {t → tt};
vy3x0 = Evaluate[v[0, 3000, t]] /. {t → tt};
data13u = Thread[{tt, uy3x0}];
data13v = Thread[{tt, vy3x0}];
ListPlot[data13u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data13v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```

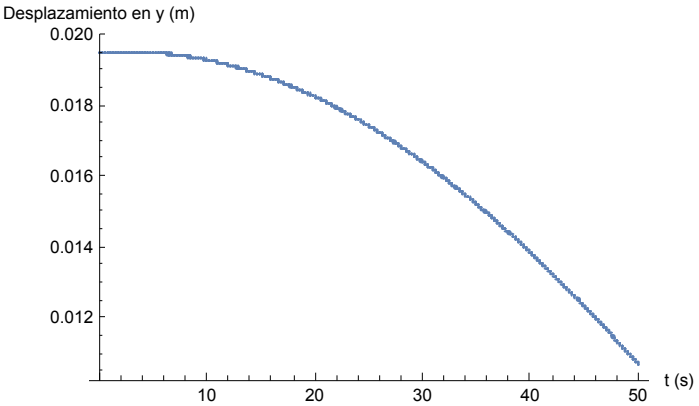




- Para y=3000 & x=10000

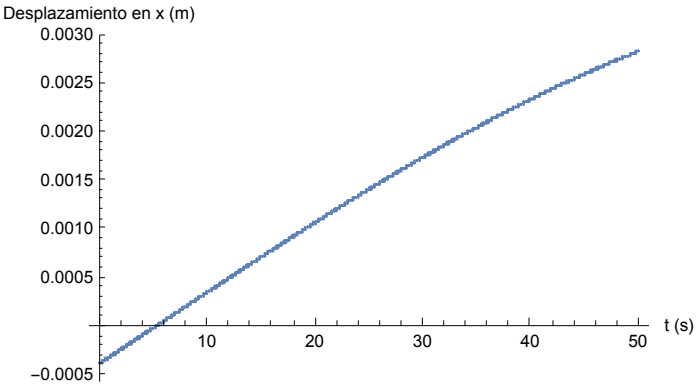
```
uy3x10 = Evaluate[u[10 000, 3000, t]] /. {t → tt};
vy3x10 = Evaluate[v[10 000, 3000, t]] /. {t → tt};
data14u = Thread[{tt, uy3x10}];
data14v = Thread[{tt, vy3x10}];
ListPlot[data14u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data14v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```

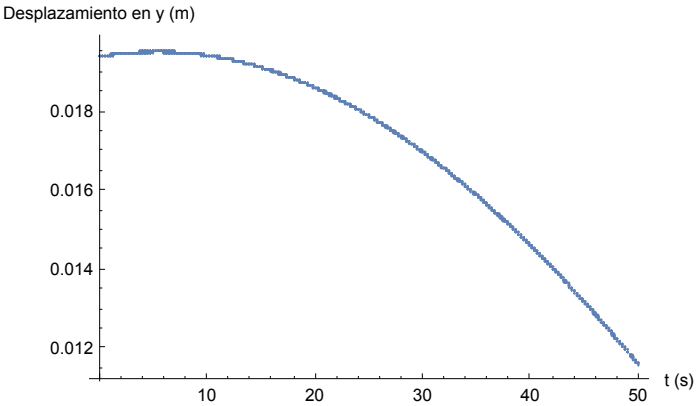




- Para y=3000 & x=20000

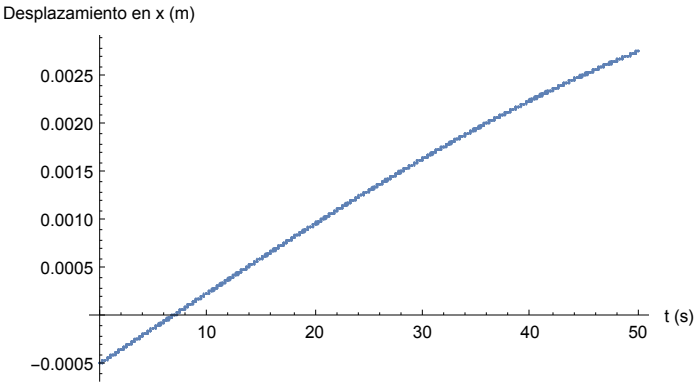
```
uy3x20 = Evaluate[u[20 000, 3000, t]] /. {t → tt};
vy3x20 = Evaluate[v[20 000, 3000, t]] /. {t → tt};
data15u = Thread[{tt, uy3x20}];
data15v = Thread[{tt, vy3x20}];
ListPlot[data15u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data15v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```

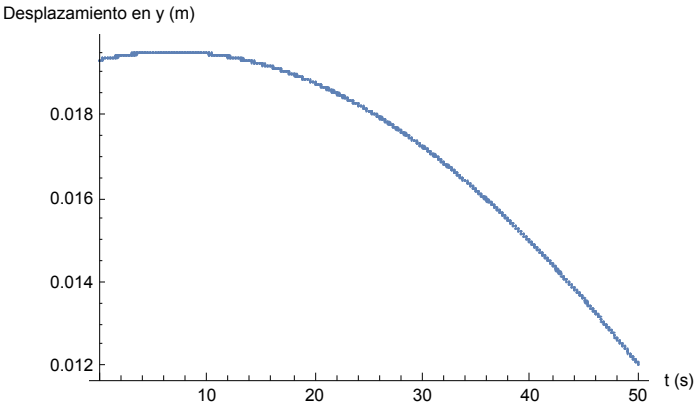




- Para y=3000 & x=25000

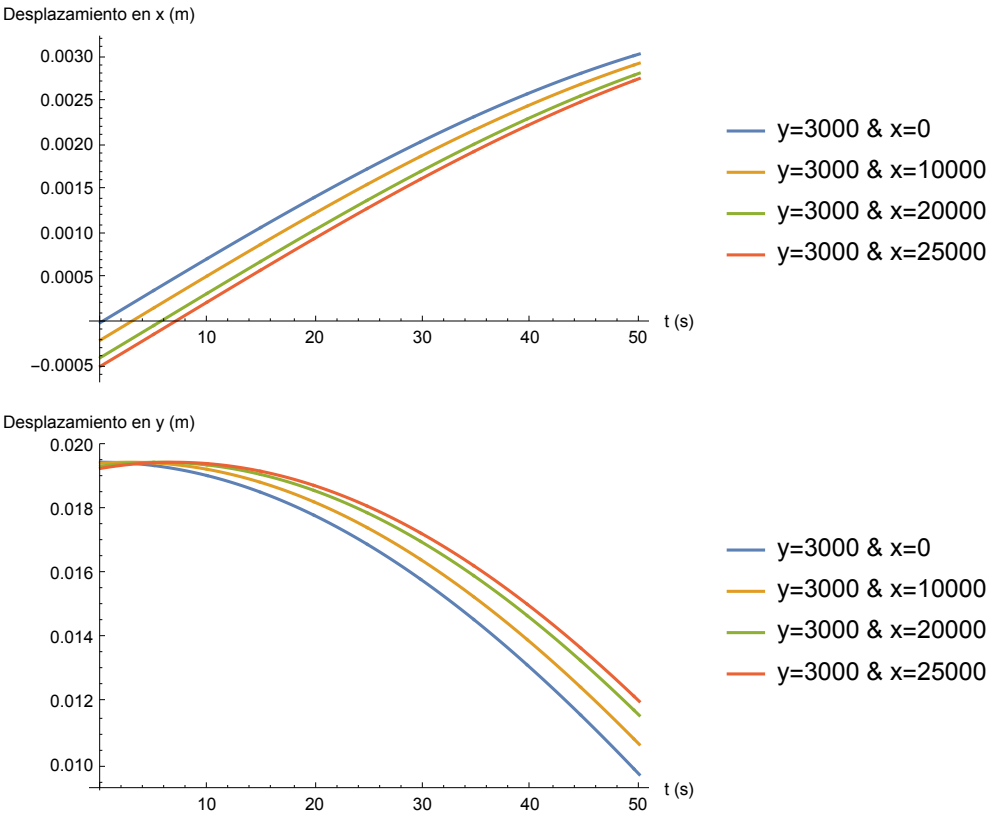
```
uy3x25 = Evaluate[u[25 000, 3000, t]] /. {t → tt};
vy3x25 = Evaluate[v[25 000, 3000, t]] /. {t → tt};
data16u = Thread[{tt, uy3x25}];
data16v = Thread[{tt, vy3x25}];
ListPlot[data16u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data16v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```





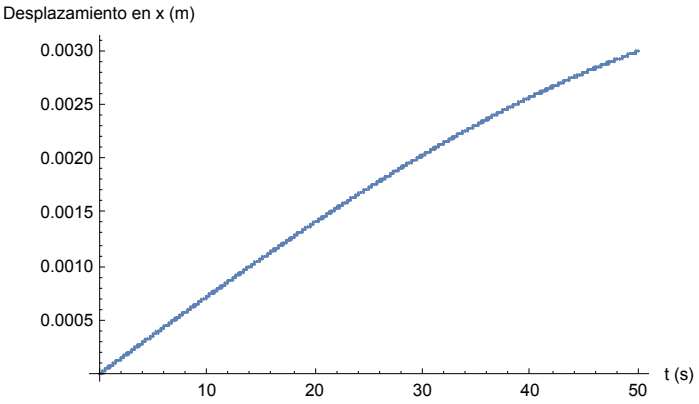
- Para y=3000

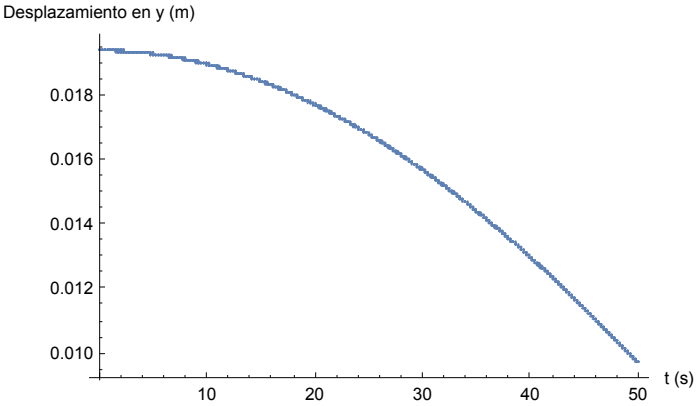
```
ListPlot[{data13u, data14u, data15u, data16u}, PlotLegends →
  {"y=3000 & x=0", "y=3000 & x=10000", "y=3000 & x=20000", "y=3000 & x=25000"},
 AxesLabel → {"t (s)", "Desplazamiento en x (m)"}, Joined -> True]
ListPlot[{data13v, data14v, data15v, data16v}, PlotLegends →
  {"y=3000 & x=0", "y=3000 & x=10000", "y=3000 & x=20000", "y=3000 & x=25000"},
 AxesLabel → {"t (s)", "Desplazamiento en y (m)"}, Joined -> True]
```



- Para y=5000 & x=0

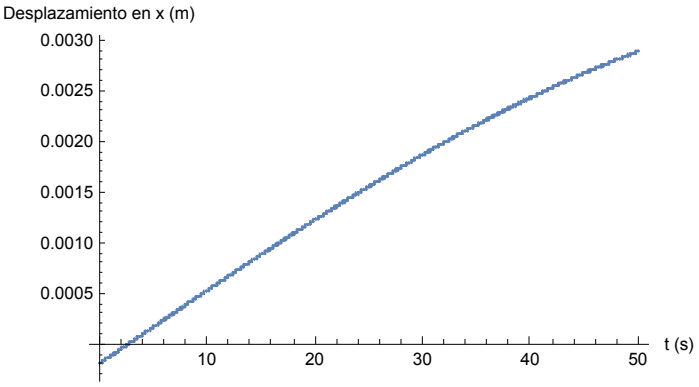
```
uy5x0 = Evaluate[u[0, 5000, t]] /. {t → tt};
vy5x0 = Evaluate[v[0, 5000, t]] /. {t → tt};
data17u = Thread[{tt, uy5x0}];
data17v = Thread[{tt, vy5x0}];
ListPlot[data17u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data17v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```

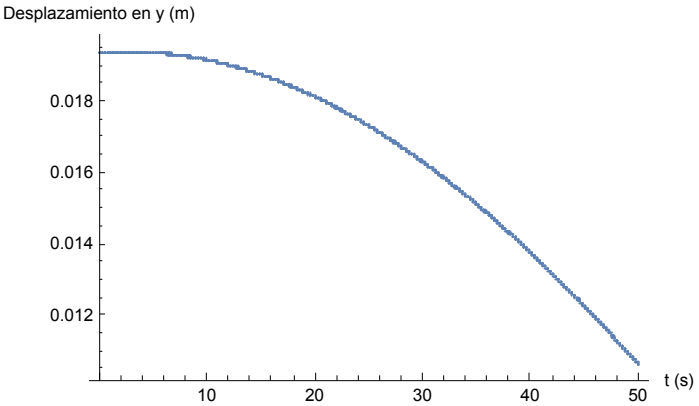




- Para y=5000 & x=10000

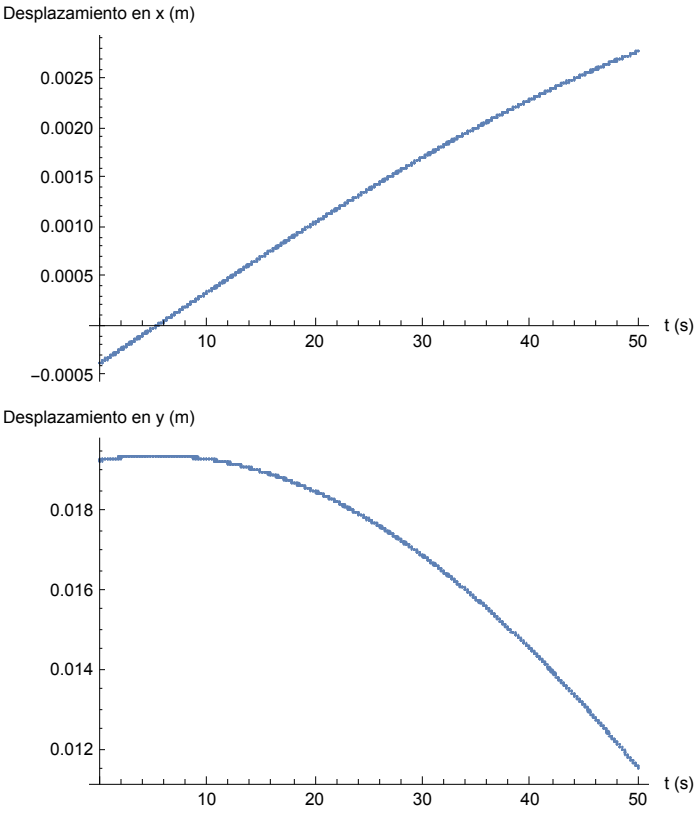
```
uy5x10 = Evaluate[u[10 000, 5000, t]] /. {t → tt};
vy5x10 = Evaluate[v[10 000, 5000, t]] /. {t → tt};
data18u = Thread[{tt, uy5x10}];
data18v = Thread[{tt, vy5x10}];
ListPlot[data18u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data18v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```





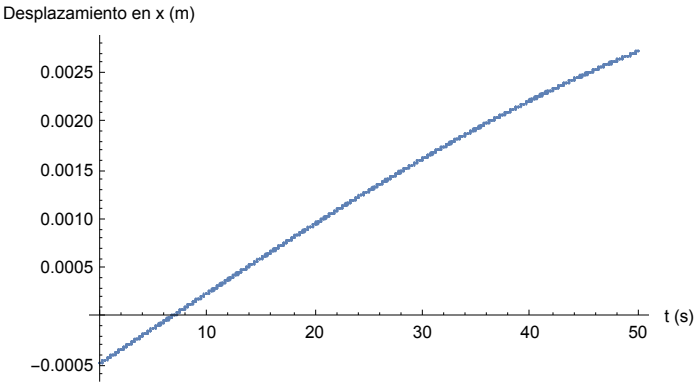
- Para y=5000 & x=20000

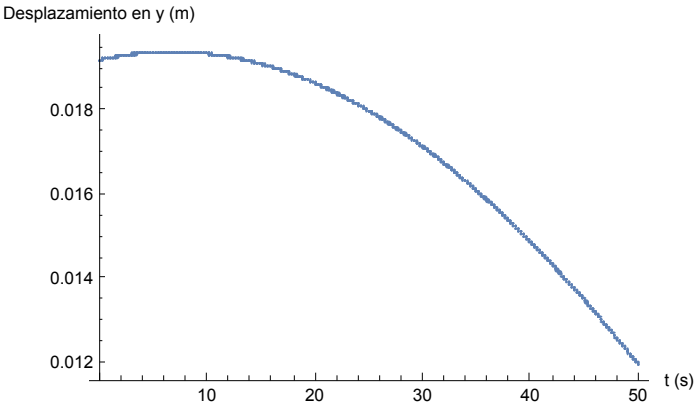
```
uy5x20 = Evaluate[u[20 000, 5000, t]] /. {t → tt};
vy5x20 = Evaluate[v[20 000, 5000, t]] /. {t → tt};
data19u = Thread[{tt, uy5x20}];
data19v = Thread[{tt, vy5x20}];
ListPlot[data19u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data19v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```



- Para y=5000 & x=25000

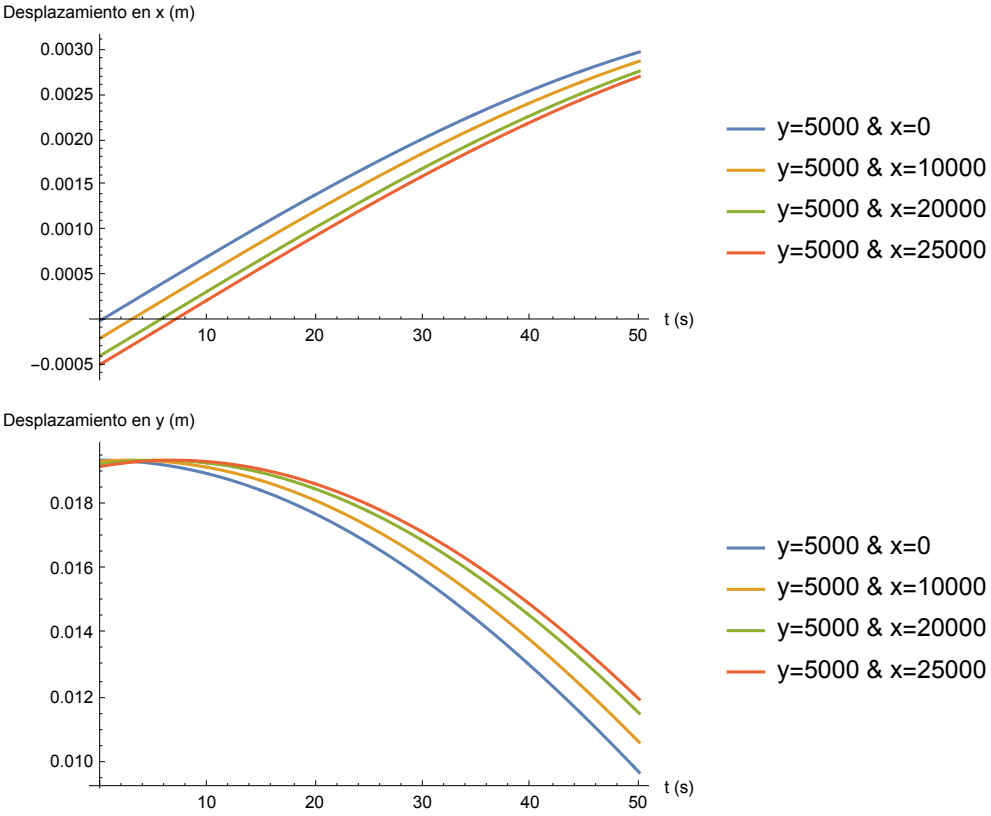
```
uy5x25 = Evaluate[u[25 000, 5000, t]] /. {t → tt};
vy5x25 = Evaluate[v[25 000, 5000, t]] /. {t → tt};
data20u = Thread[{tt, uy5x25}];
data20v = Thread[{tt, vy5x25}];
ListPlot[data20u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data20v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```





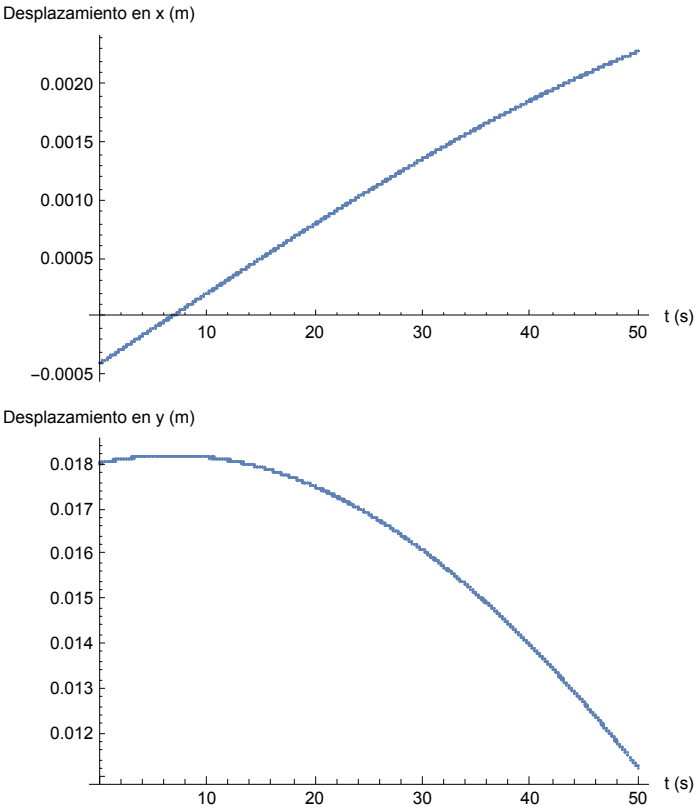
- Para y=5000

```
ListPlot[{data17u, data18u, data19u, data20u}, PlotLegends →
  {"y=5000 & x=0", "y=5000 & x=10000", "y=5000 & x=20000", "y=5000 & x=25000"},
 AxesLabel → {"t (s)", "Desplazamiento en x (m)"}, Joined -> True]
ListPlot[{data17v, data18v, data19v, data20v}, PlotLegends →
  {"y=5000 & x=0", "y=5000 & x=10000", "y=5000 & x=20000", "y=5000 & x=25000"},
 AxesLabel → {"t (s)", "Desplazamiento en y (m)"}, Joined -> True]
```



- Para y=25000 & x=0

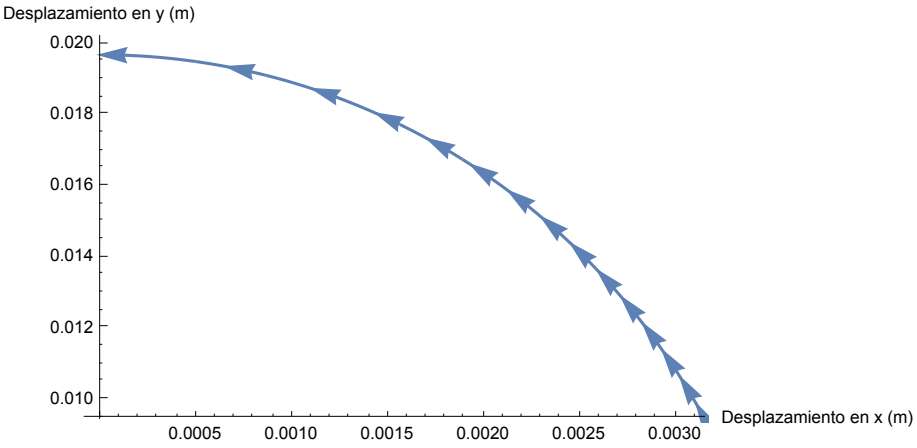
```
uy25x25 = Evaluate[u[25 000, 25 000, t]] /. {t → tt};
vy25x25 = Evaluate[v[25 000, 25 000, t]] /. {t → tt};
data21u = Thread[{tt, uy25x25}];
data21v = Thread[{tt, vy25x25}];
ListPlot[data21u, AxesLabel → {"t (s)", "Desplazamiento en x (m)"}]
ListPlot[data21v, AxesLabel → {"t (s)", "Desplazamiento en y (m)"}]
```



4. Muestre que el movimiento de las partículas es retrógrado a bajas profundidades, ¿qué sucede a grandes profundidades?

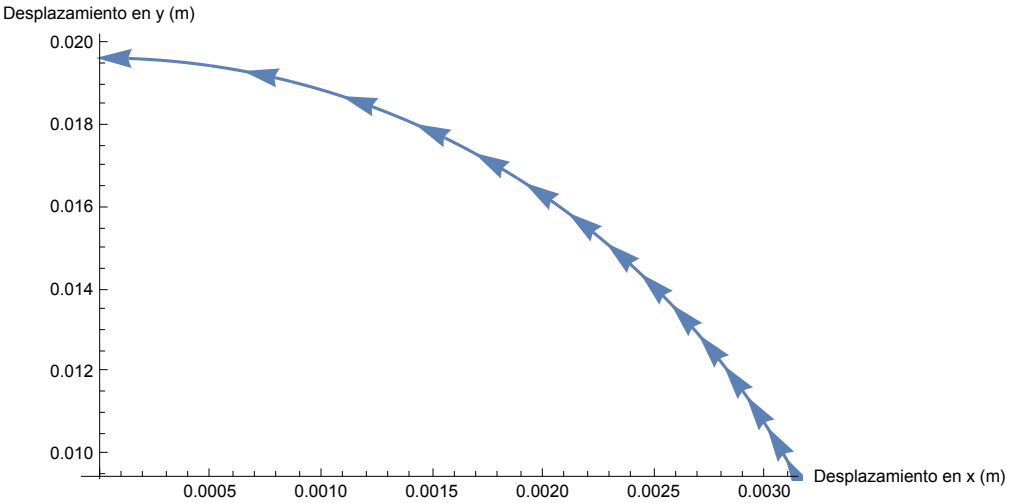
- Para este punto parametrizamos la curva de desplazamiento y mostramos explícitamente la dirección del flujo
- Para una profundidad de y=100

```
uu = Evaluate[u[1000, 100, t]] /. {t → tt};
vv = Evaluate[v[1000, 100, t]] /. {t → tt};
data22 = Thread[{uu, vv}];
p0 = ListPlot[data22, Joined → True,
    AxesLabel → {"Desplazamiento en x (m)", "Desplazamiento en y (m)"}];
p0 /. Line[x_] :→ {Arrowheads[Table[-0.05, {15}]], Arrow[x]}
```



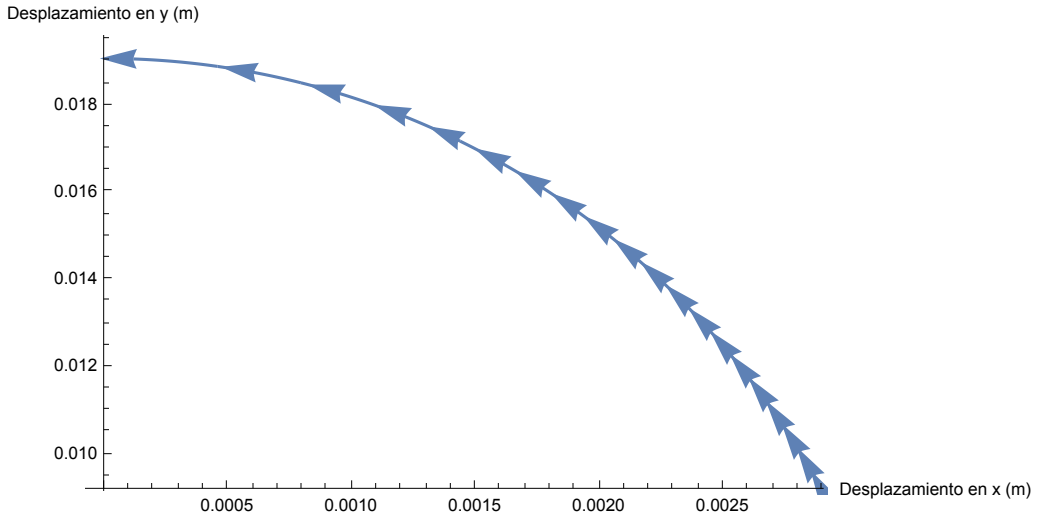
- Para una profundidad de y=500

```
uu = Evaluate[u[1000, 500, t]] /. {t → tt};
vv = Evaluate[v[1000, 500, t]] /. {t → tt};
data22 = Thread[{uu, vv}];
p0 = ListPlot[data22, Joined → True,
    AxesLabel → {"Desplazamiento en x (m)", "Desplazamiento en y (m)"}];
p0 /. Line[x_] :→ {Arrowheads[Table[-.05, {15}]], Arrow[x]}
```



- Para una profundidad de y=10000

```
uu = Evaluate[u[1000, 10 000, t]] /. {t → tt};
vv = Evaluate[v[1000, 10 000, t]] /. {t → tt};
data22 = Thread[{uu, vv}];
p0 = ListPlot[data22, Joined → True,
    AxesLabel → {"Desplazamiento en x (m)", "Desplazamiento en y (m)"}];
p0 /. Line[x_] :→ {Arrowheads[Table[-.05, {20}]], Arrow[x]}
```



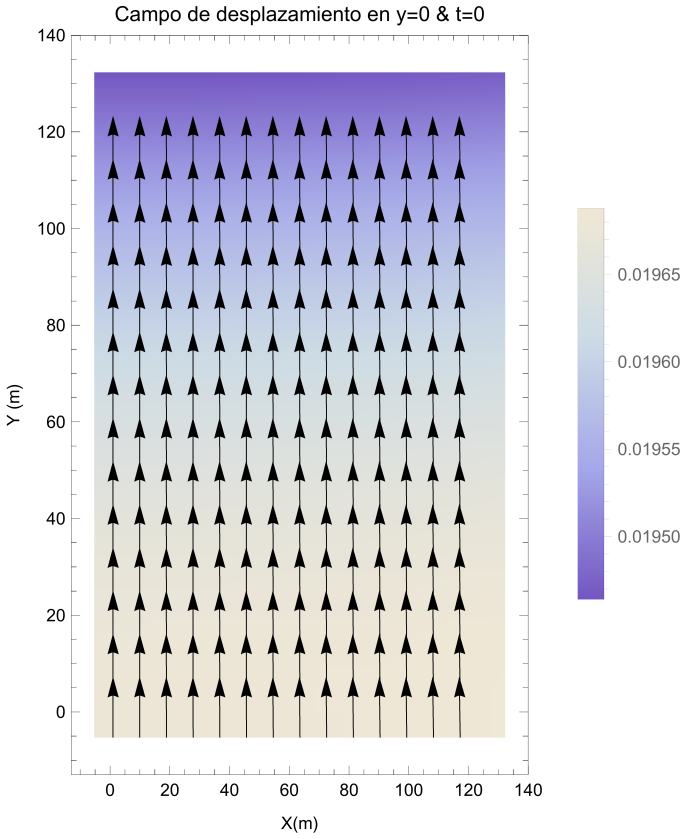
5. Diagrame los campos de desplazamiento, velocidad y aceleración en la superficie libre (y=0) para varios valores de t. Haga lo mismo para varios valores y>0.

- Para y=0 & t=0

In[1216]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 0, 0]] /. {x → xx};
vvv = Evaluate[v[x, 0, 0]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23, AspectRatio → GoldenRatio,
 FrameLabel → {"X(m)", "Y (m)"}, PlotLabel → "Campo de desplazamiento en y=0 & t=0",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 0, t]], t] /. {t → 0, x → xx};
dv = D[Evaluate[v[x, 0, t]], t] /. {t → 0, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24, AspectRatio → GoldenRatio,
 FrameLabel → {"X(m)", "Y (m)"}, PlotLabel → "Campo de velocidades en y=0 & t=0",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 0, t]], t], t] /. {t → 0, x → xx};
d2v = D[D[Evaluate[u[x, 0, t]], t], t] /. {t → 0, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25, AspectRatio → GoldenRatio,
 FrameLabel → {"X(m)", "Y (m)"}, PlotLabel → "Campo de aceleraciones en y=0 & t=0",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

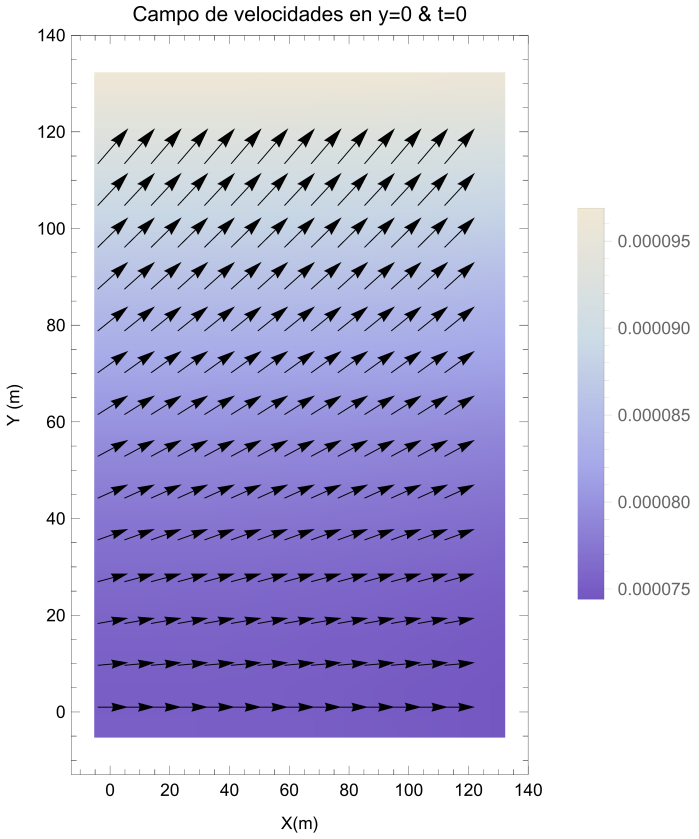
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[1220]=



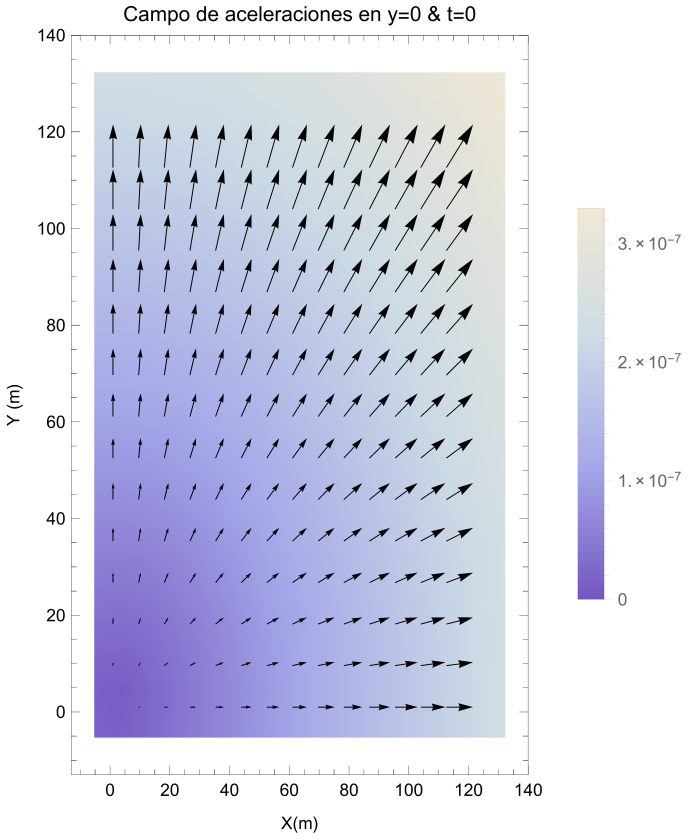
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[1224]=



ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[1228]=

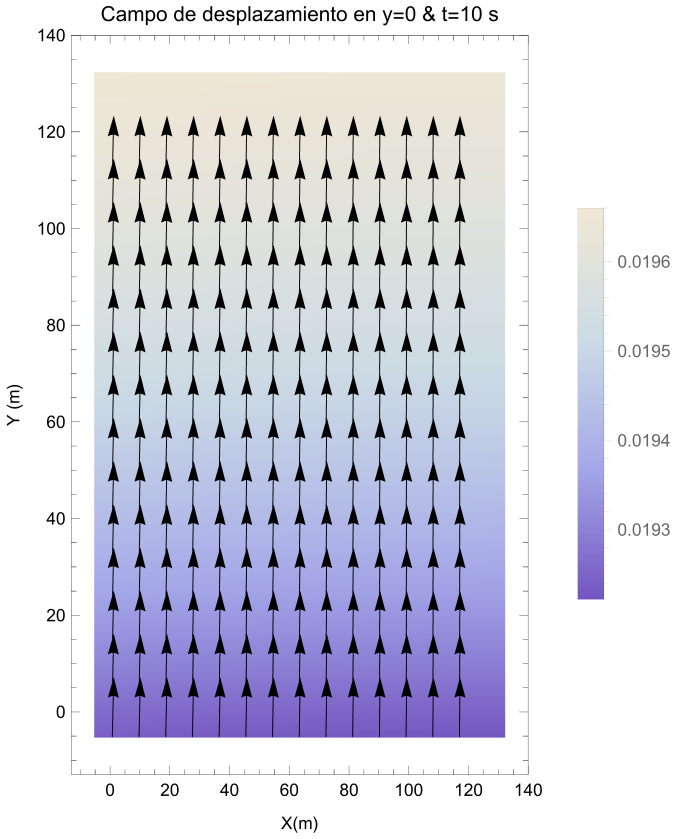


- Para y=0 & t=10

In[1242]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 0, 10]] /. {x → xx};
vvv = Evaluate[v[x, 0, 10]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de desplazamiento en y=0 & t=10 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 0, t]], t] /. {t → 10, x → xx};
dv = D[Evaluate[v[x, 0, t]], t] /. {t → 10, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de velocidades en y=0 & t=10 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 0, t]], t], t] /. {t → 10, x → xx};
d2v = D[D[Evaluate[u[x, 0, t]], t], t] /. {t → 10, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de aceleraciones en y=0 & t=10 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

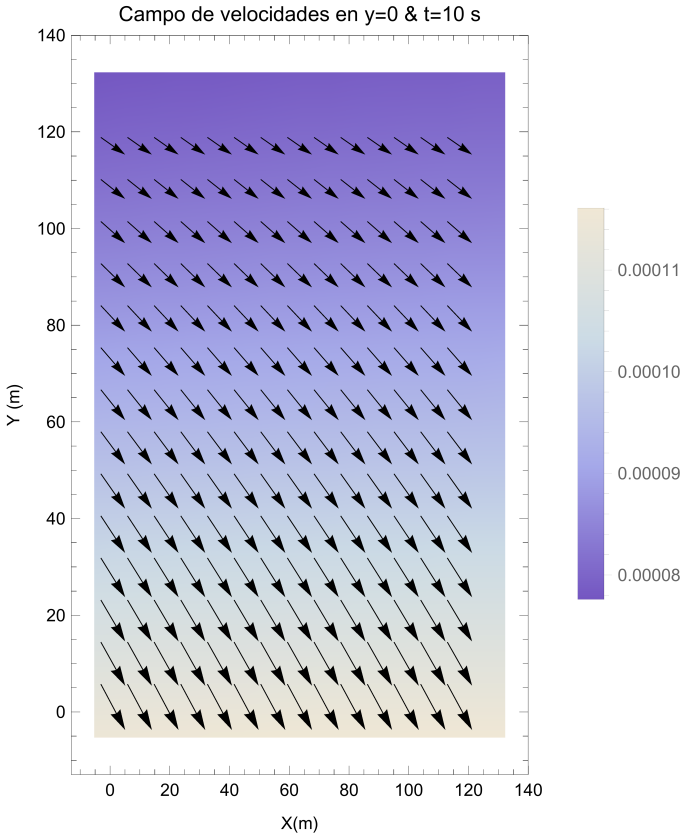
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradientColorData entity. >>

Out[1246]=



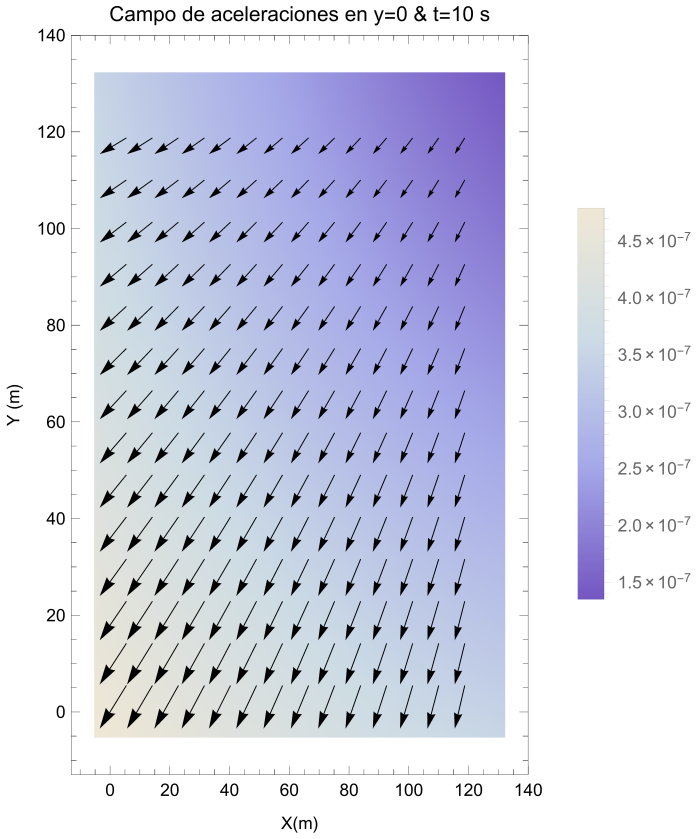
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[1250]=



ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

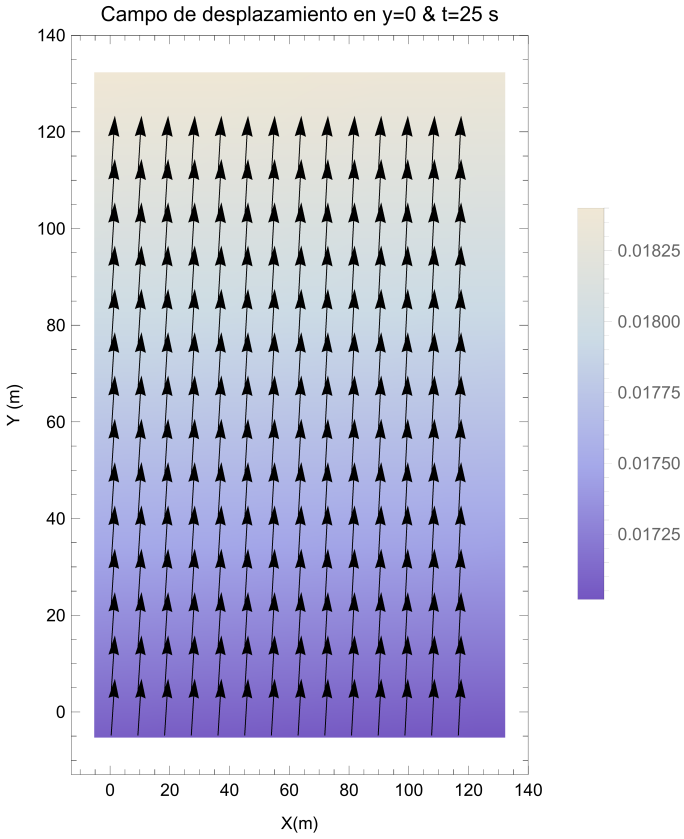
Out[1254]=



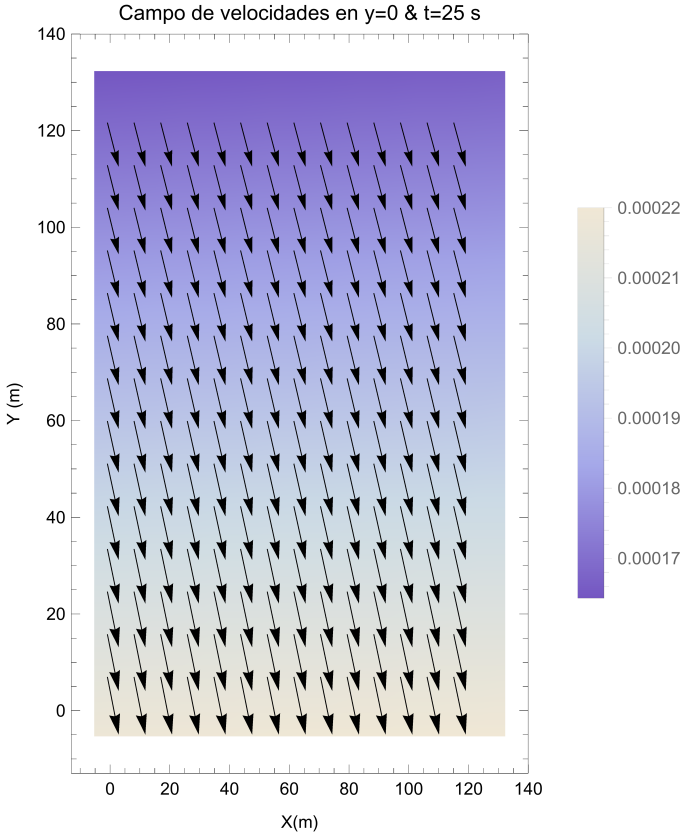
- Para y=0 & t=25

In[1268]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 0, 25]] /. {x → xx};
vvv = Evaluate[v[x, 0, 25]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de desplazamiento en y=0 & t=25 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 0, t]], t] /. {t → 25, x → xx};
dv = D[Evaluate[v[x, 0, t]], t] /. {t → 25, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de velocidades en y=0 & t=25 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 0, t]], t], t] /. {t → 25, x → xx};
d2v = D[D[Evaluate[u[x, 0, t]], t], t] /. {t → 25, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de aceleraciones en y=0 & t=25 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

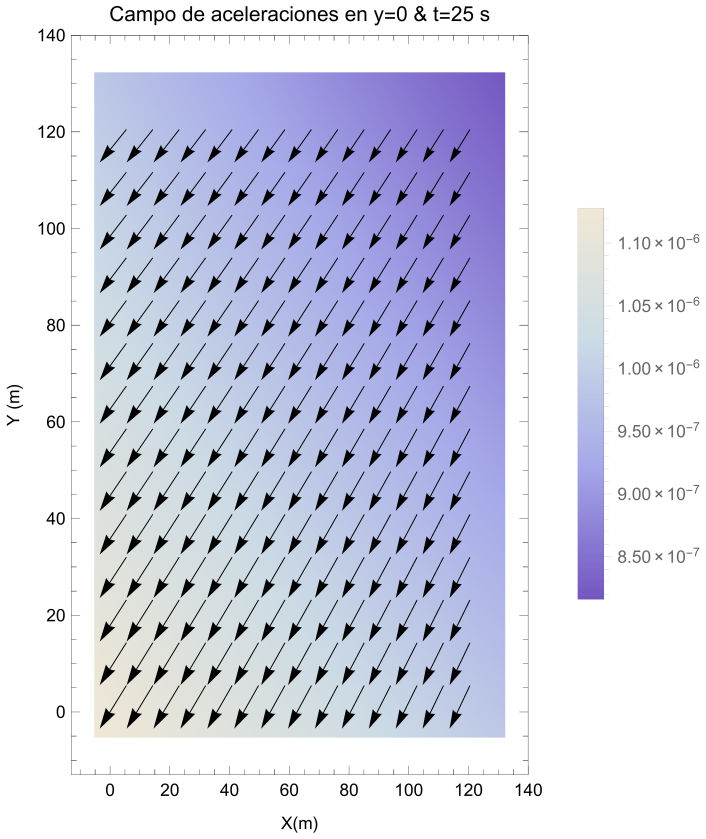
Out[1272]=



Out[1276]=



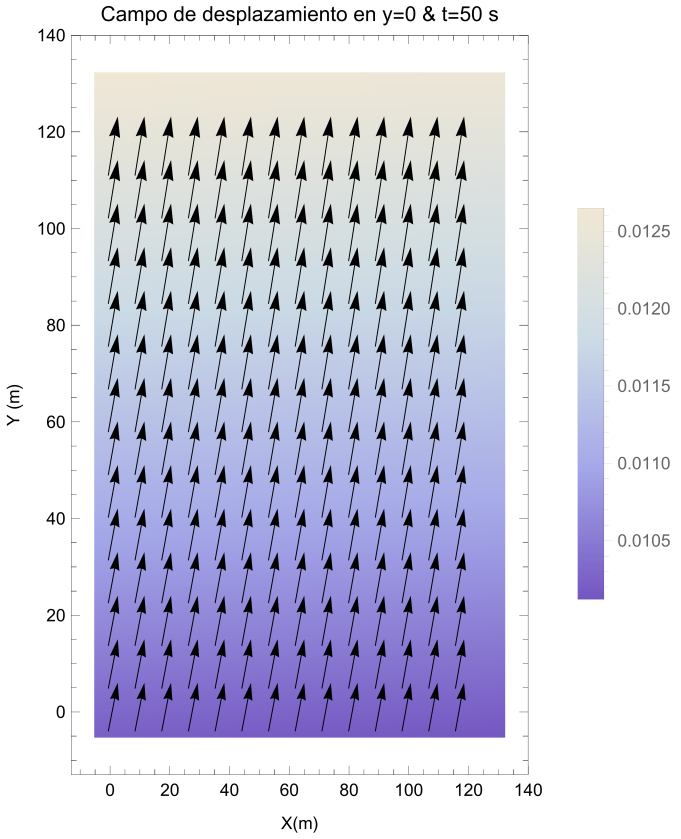
Out[1280]=



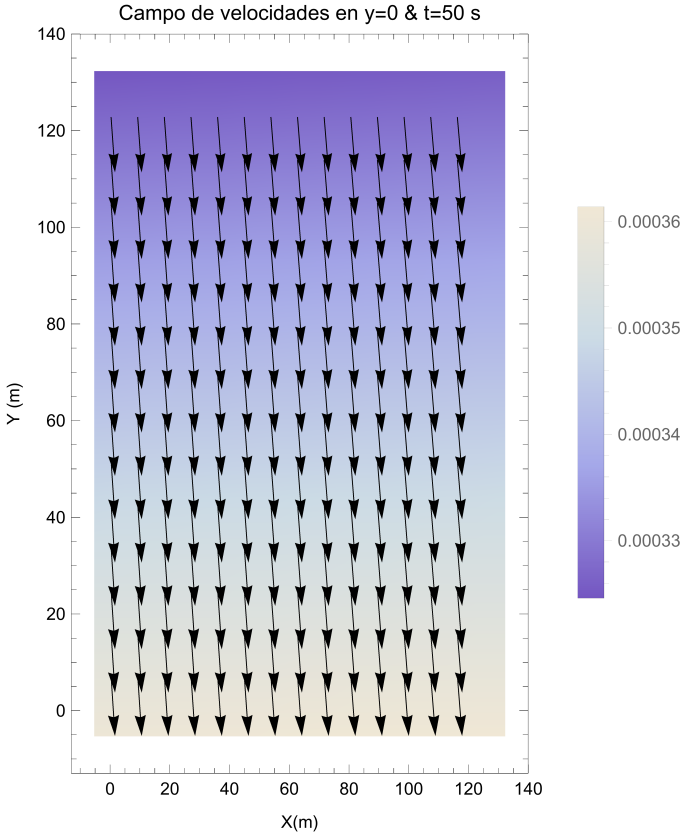
- Para y=0 & t=50

In[1255]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 0, 50]] /. {x → xx};
vvv = Evaluate[v[x, 0, 50]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de desplazamiento en y=0 & t=50 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 0, t]], t] /. {t → 50, x → xx};
dv = D[Evaluate[v[x, 0, t]], t] /. {t → 50, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de velocidades en y=0 & t=50 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 0, t]], t], t] /. {t → 50, x → xx};
d2v = D[D[Evaluate[u[x, 0, t]], t], t] /. {t → 50, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de aceleraciones en y=0 & t=50 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

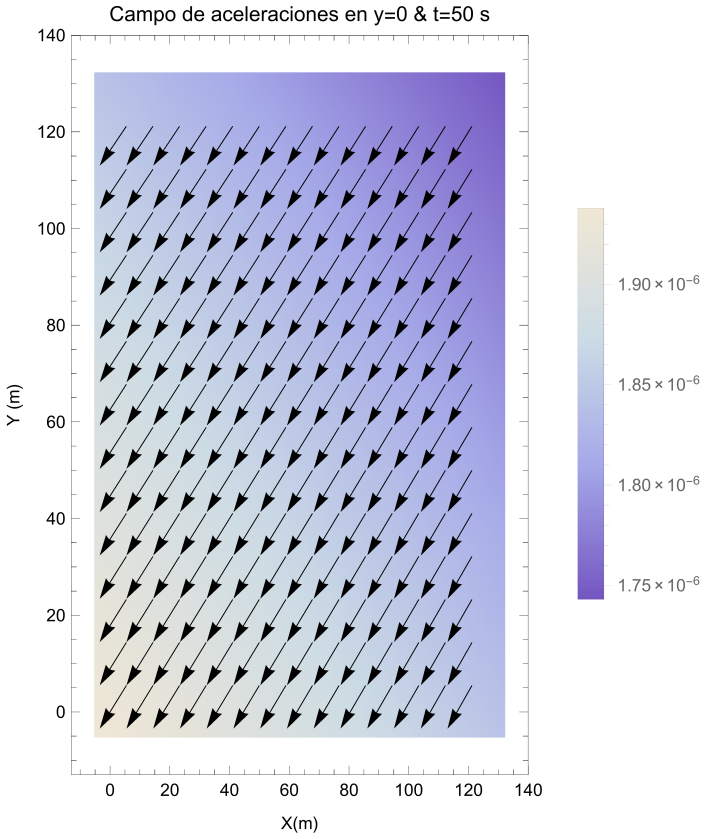
Out[1259]=



Out[1263]=



Out[1267]=

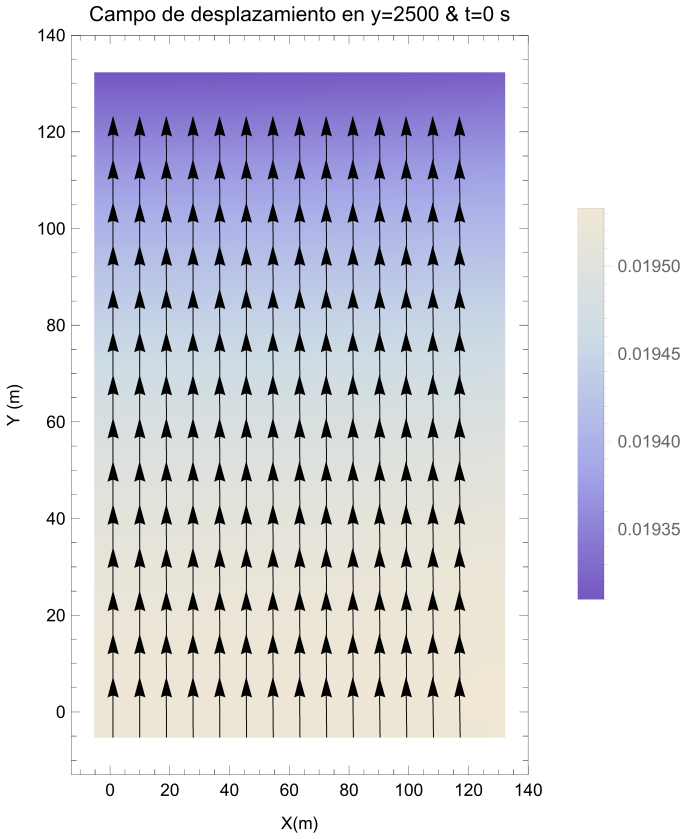


- Para y =2500 & t=0

In[1281]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 2500, 0]] /. {x → xx};
vvv = Evaluate[v[x, 2500, 0]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de desplazamiento en y=2500 & t=0 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 2500, t]], t] /. {t → 0, x → xx};
dv = D[Evaluate[v[x, 2500, t]], t] /. {t → 0, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de velocidades en y=2500 & t=0 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 2500, t]], t], t] /. {t → 0, x → xx};
d2v = D[D[Evaluate[u[x, 2500, t]], t], t] /. {t → 0, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de aceleraciones en y=2500 & t=0 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

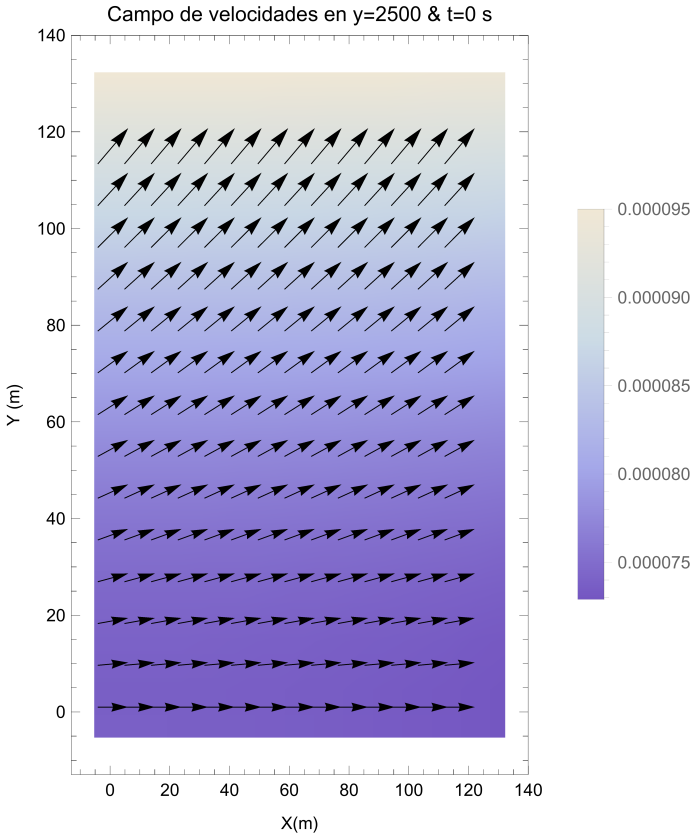
ListStreamDensityPlot::cfun:
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradientColorData entity. >>

Out[1285]=



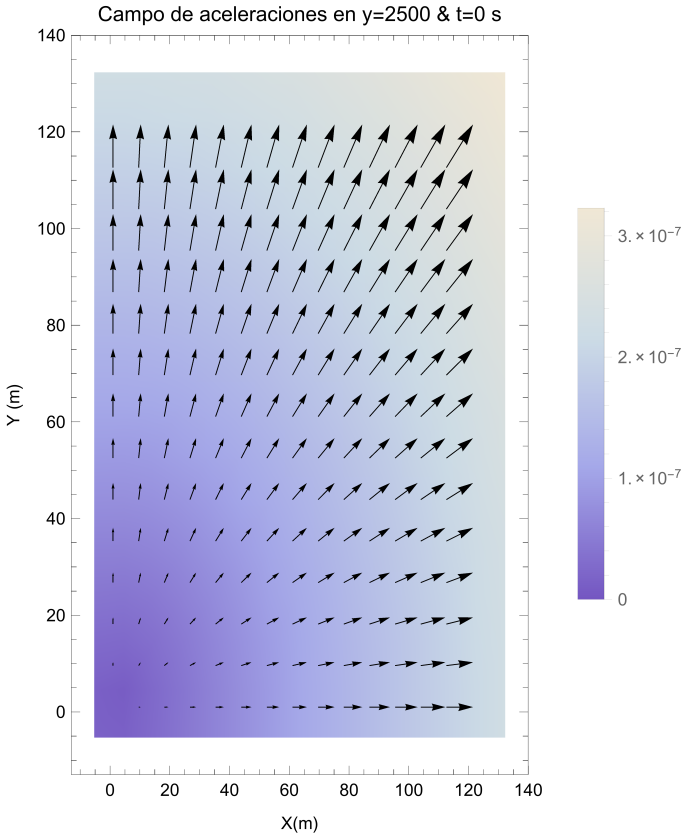
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[1289]=



ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[1293]=

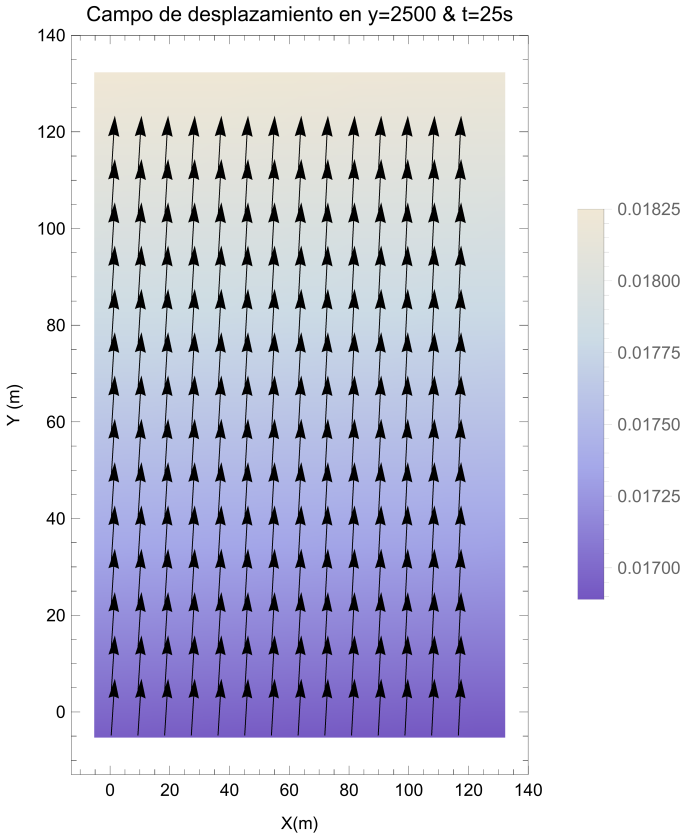


- Para y=2500 & t=25

In[1294]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 2500, 25]] /. {x → xx};
vvv = Evaluate[v[x, 2500, 25]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de desplazamiento en y=2500 & t=25s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 2500, t]], t] /. {t → 25, x → xx};
dv = D[Evaluate[v[x, 2500, t]], t] /. {t → 25, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de velocidades en y=2500 & t=25 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 2500, t]], t], t] /. {t → 25, x → xx};
d2v = D[D[Evaluate[u[x, 2500, t]], t], t] /. {t → 25, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de aceleraciones en y=2500 & t=25 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

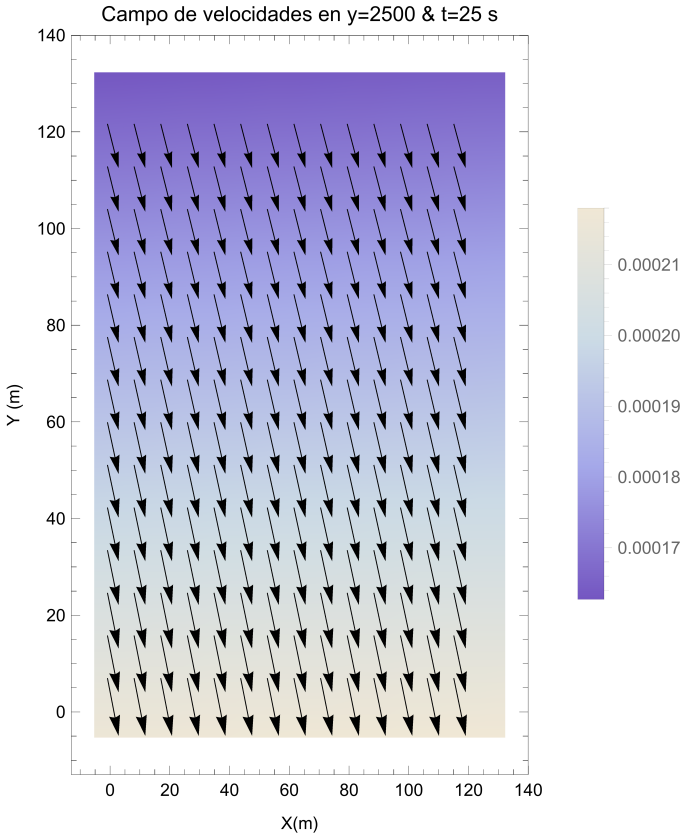
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradientColorData entity. >>

Out[1298]=



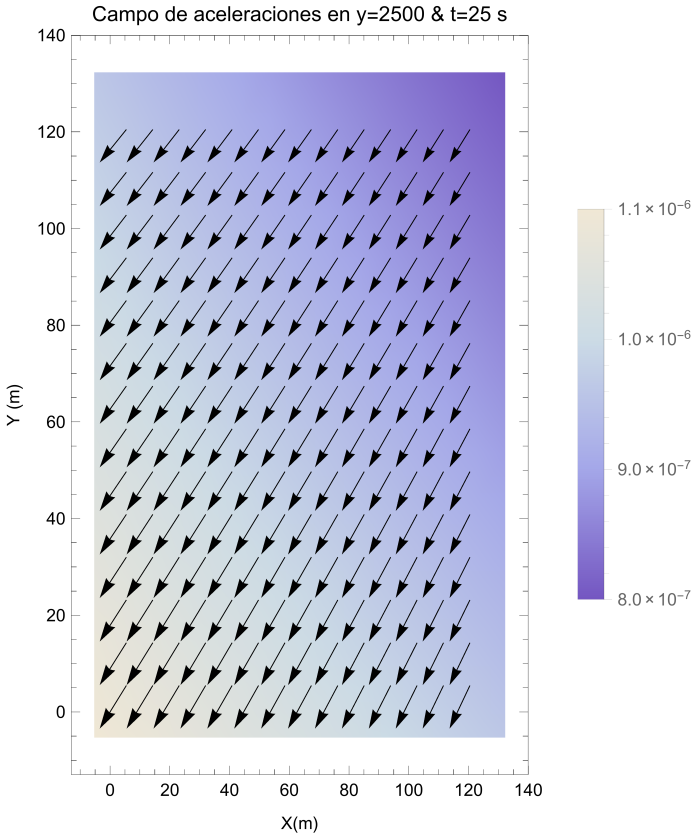
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[1302]=



ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[1306]=

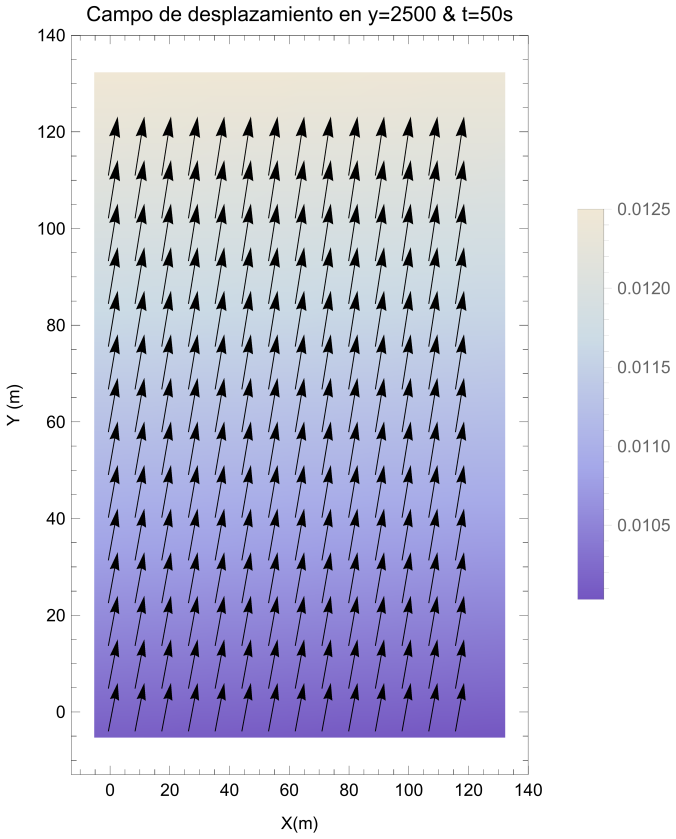


- Para y=2500 & t=50

In[1307]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 2500, 50]] /. {x → xx};
vvv = Evaluate[v[x, 2500, 50]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de desplazamiento en y=2500 & t=50s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 2500, t]], t] /. {t → 50, x → xx};
dv = D[Evaluate[v[x, 2500, t]], t] /. {t → 50, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de velocidades en y=2500 & t=50 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 2500, t]], t], t] /. {t → 50, x → xx};
d2v = D[D[Evaluate[u[x, 2500, t]], t], t] /. {t → 50, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de aceleraciones en y=2500 & t=50 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

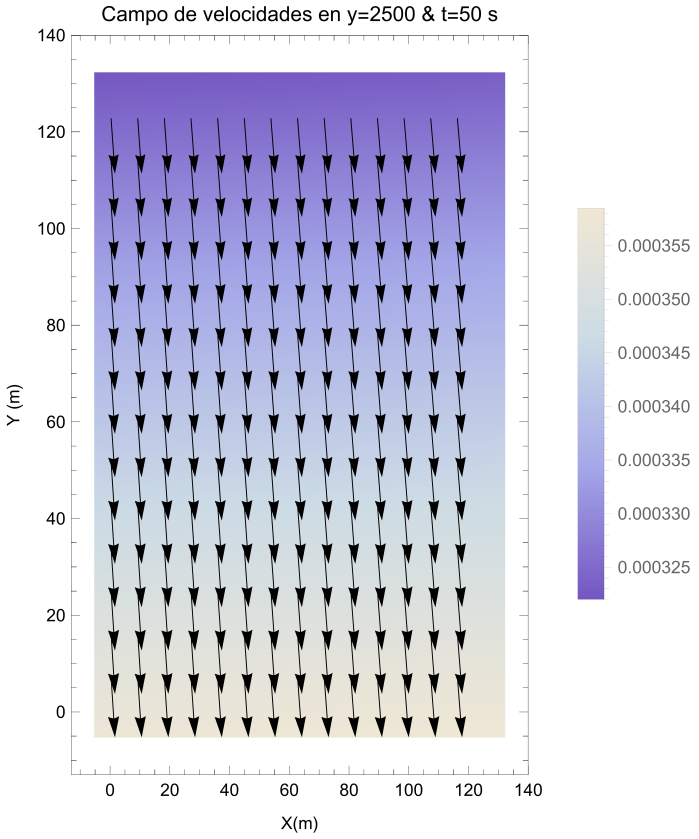
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradientColorData entity. >>

Out[1311]=



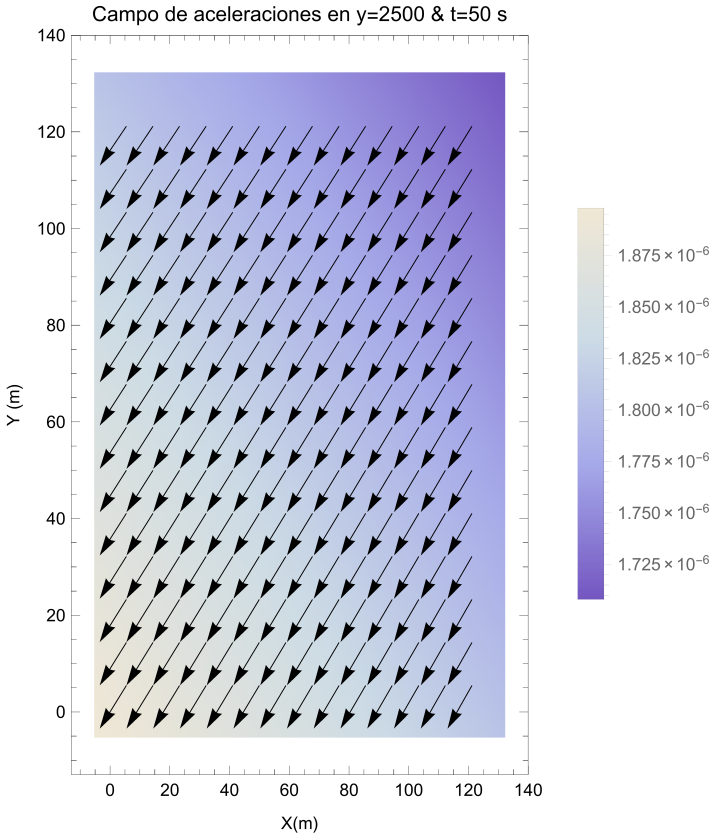
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> Rainbow Opacity is not a valid color function, or a gradient ColorData entity. >>

Out[1315]=



ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[1319]=

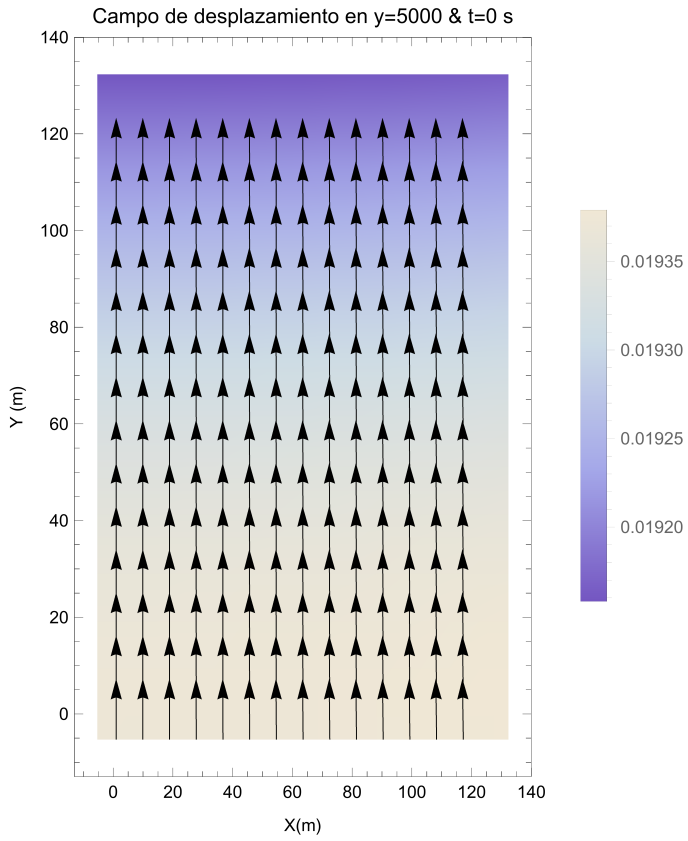


- Para y=5000 & t=0

In[639]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 5000, 0]] /. {x → xx};
vvv = Evaluate[v[x, 5000, 0]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de desplazamiento en y=5000 & t=0 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 5000, t]], t] /. {t → 0, x → xx};
dv = D[Evaluate[v[x, 5000, t]], t] /. {t → 0, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de velocidades en y=5000 & t=0 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 5000, t]], t], t] /. {t → 0, x → xx};
d2v = D[D[Evaluate[u[x, 5000, t]], t], t] /. {t → 0, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de aceleraciones en y=5000 & t=0 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

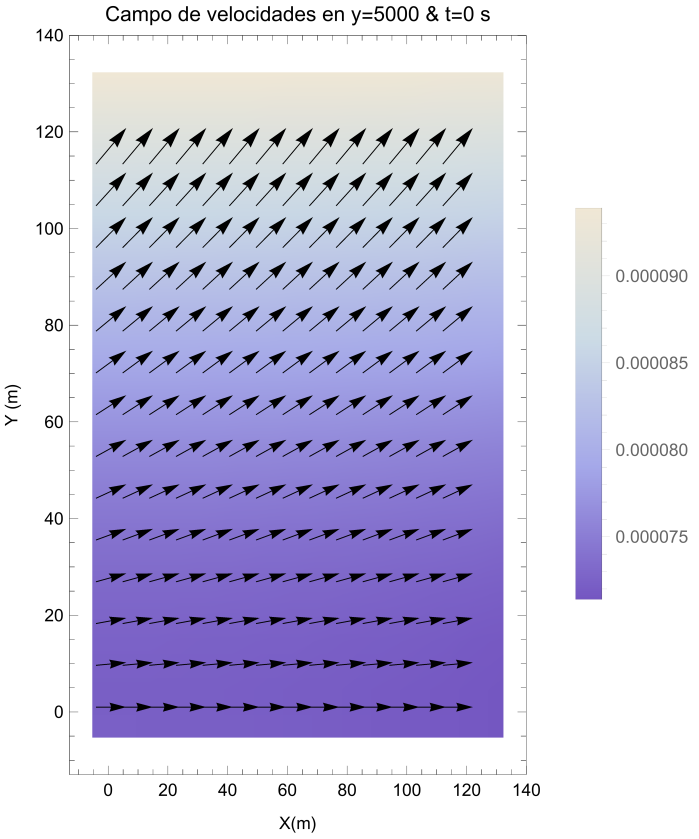
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradientColorData entity. >>

Out[643]=



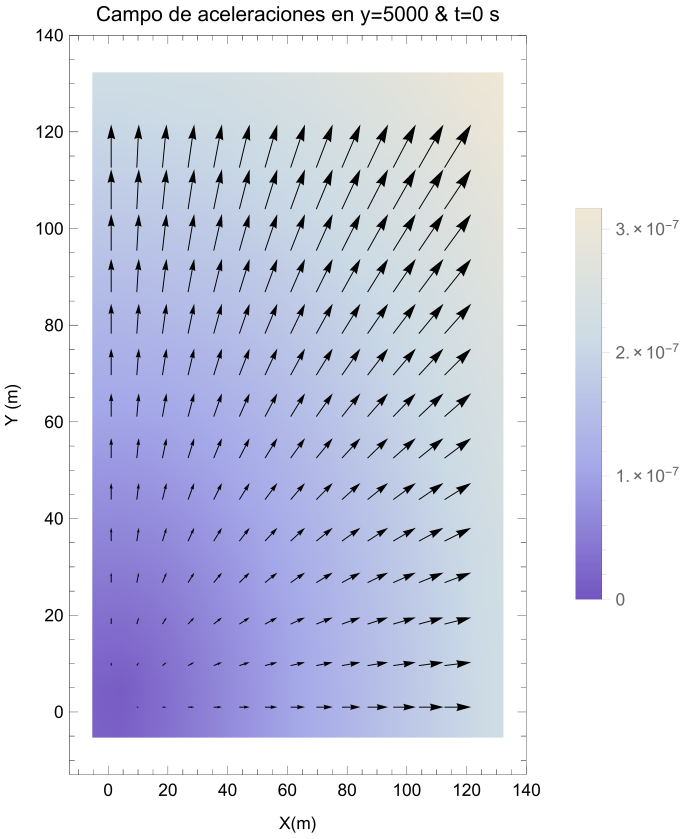
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[647]=



ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradientColorData entity. >>

Out[651]=

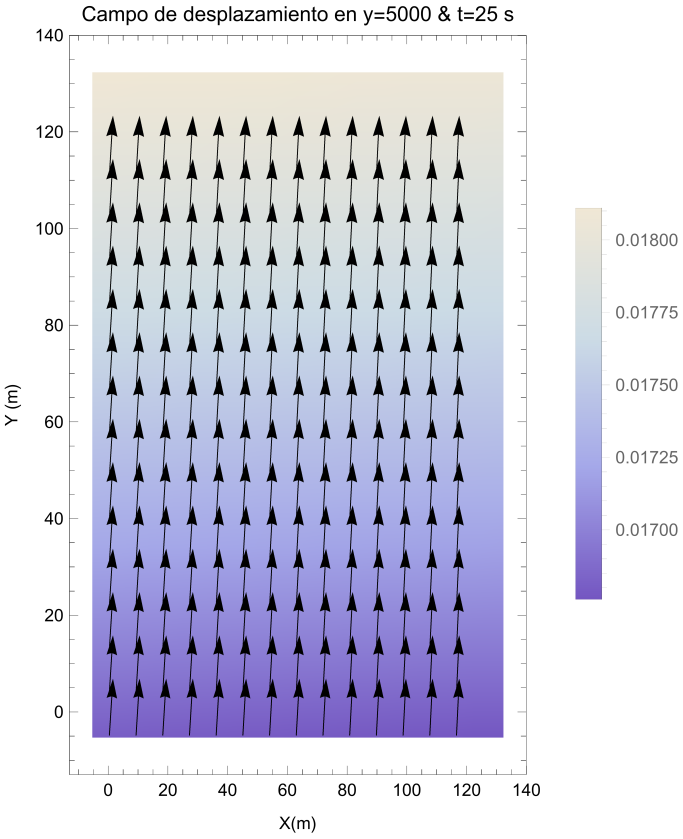


- Para y=5000 & t=25

In[652]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 5000, 25]] /. {x → xx};
vvv = Evaluate[v[x, 5000, 25]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de desplazamiento en y=5000 & t=25 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 5000, t]], t] /. {t → 25, x → xx};
dv = D[Evaluate[v[x, 5000, t]], t] /. {t → 25, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de velocidades en y=5000 & t=25 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 5000, t]], t], t] /. {t → 25, x → xx};
d2v = D[D[Evaluate[u[x, 5000, t]], t], t] /. {t → 25, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de aceleraciones en y=5000 & t=25 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

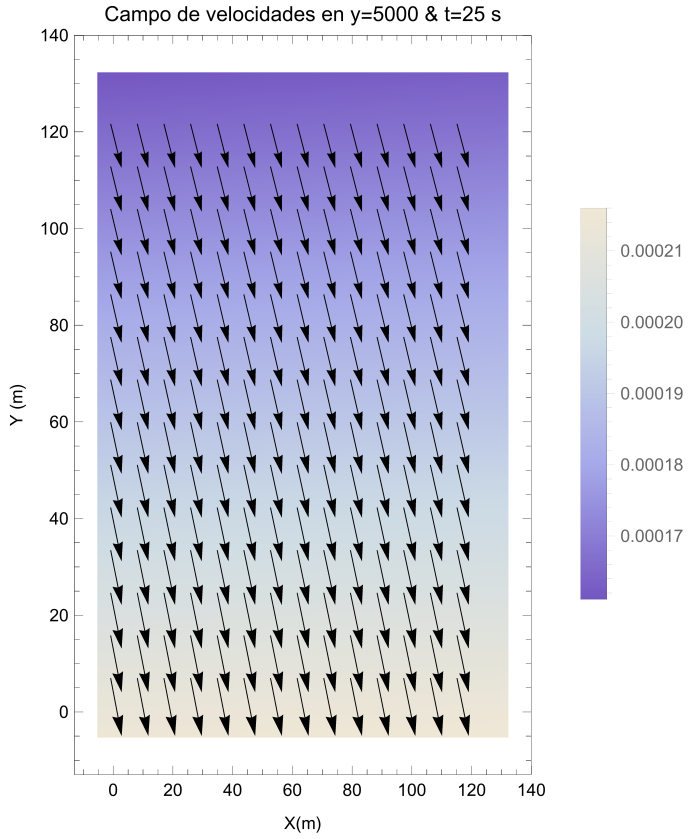
ListStreamDensityPlotcfun:
Value of optionColorFunction–> RainbowOpacityis not a valid colorfunction, or a gradientColorDataentity. >>

Out[656]=



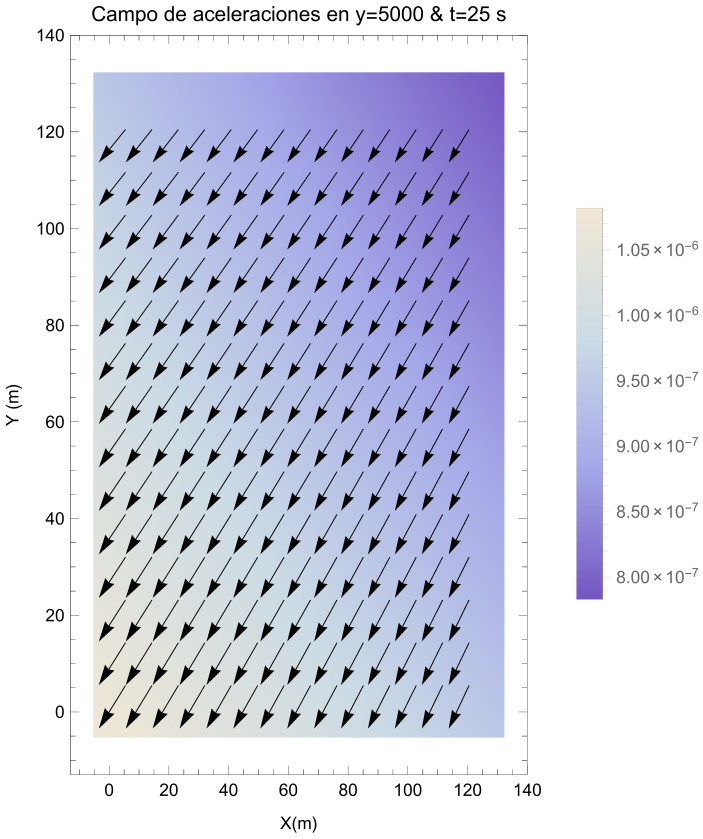
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[660]=



ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[664]=

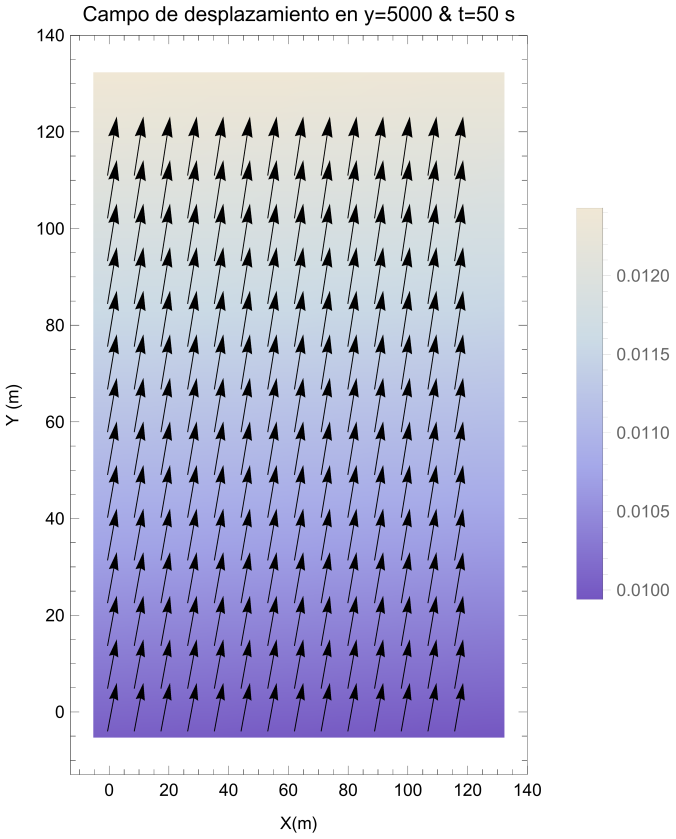


- Para y=5000 & t=50

In[665]:=
```
xx = Range[0, 25 000, 200];
uuu = Evaluate[u[x, 5000, 50]] /. {x → xx};
vvv = Evaluate[v[x, 5000, 50]] /. {x → xx};
data23 = Table[{uuu[[i]], vvv[[j]]}, {i, Length[uuu]}, {j, Length[vvv]}];
ListVectorDensityPlot[data23,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de desplazamiento en y=5000 & t=50 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
du = D[Evaluate[u[x, 5000, t]], t] /. {t → 50, x → xx};
dv = D[Evaluate[v[x, 5000, t]], t] /. {t → 50, x → xx};
data24 = Table[{du[[i]], dv[[j]]}, {i, Length[du]}, {j, Length[du]}];
ListVectorDensityPlot[data24,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de velocidades en y=5000 & t=50 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
d2u = D[D[Evaluate[u[x, 5000, t]], t], t] /. {t → 50, x → xx};
d2v = D[D[Evaluate[u[x, 5000, t]], t], t] /. {t → 50, x → xx};
data25 = Table[{d2u[[i]], d2v[[j]]}, {i, Length[d2u]}, {j, Length[d2u]}];
ListVectorDensityPlot[data25,
 AspectRatio → GoldenRatio, FrameLabel → {"X(m)", "Y (m)"},
 PlotLabel → "Campo de aceleraciones en y=5000 & t=50 s",
 ColorFunction → "RainbowOpacity", VectorStyle → {Black}, PlotLegends → Automatic]
```

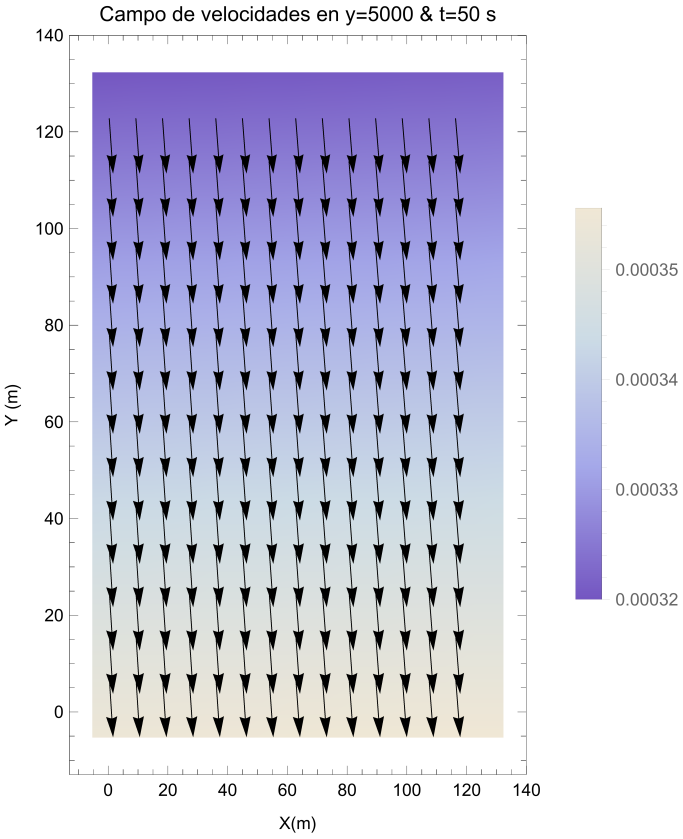
ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradientColorData entity. >>

Out[669]=



ListStreamDensityPlot::cfun :
Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

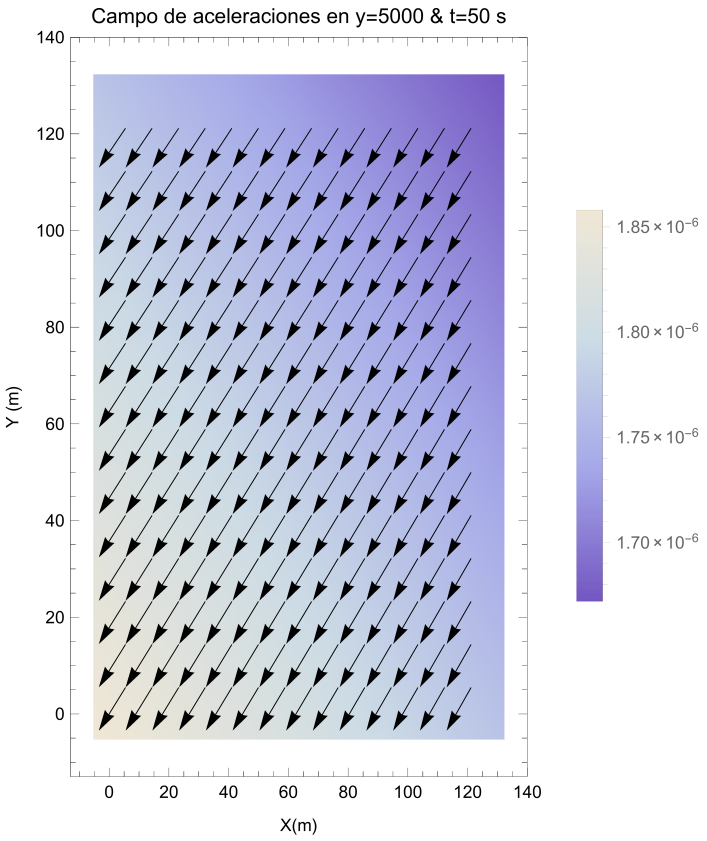
Out[673]=



ListStreamDensityPlotcfun :

Value of option ColorFunction -> RainbowOpacity is not a valid color function, or a gradient ColorData entity. >>

Out[677]=



6. Determine los lugares donde ocurre la máxima deformación unitaria principal, en un instante de tiempo dado, ¿cuál es el valor de esta deformación?

In[729]:=
```
Clear[x, y, z, t]
Maximize[{Eigenvalues[ge][[1]], x > 0, y > 0, t > 0}, {x, y, t}]
Maximize[{Eigenvalues[ge][[2]], x > 0, y > 0, t > 0}, {x, y, t}]
Maximize[{Eigenvalues[ge][[3]], x > 0, y > 0, t > 0}, {x, y, t}]
```

Out[730]= $\{0., \{x \to 84, y \to 67, t \to 5\}\}$

Out[731]= $\left\{2.03361 \times 10^{-8}, \{x \to 216\,364., y \to 1.21596 \times 10^{-22}, t \to 208.491\}\right\}$

Out[732]= $\left\{6.31462 \times 10^{-8}, \{x \to 3.64721, y \to 0., t \to 127.494\}\right\}$

7. Diagrame el cambio de volumen del suelo para varios valores de t, en y=0 & varios y>0.

- Para y=0 & t=0

In[764]:=
```
xx = Range[0, 25 000, 1];
epi = Eigenvalues[ge] /. {y → 0, t → 0};
dvol = Total[epi] /. {x → xx};
data26 = Thread[{xx, dvol}];
```

- Para y=0 & t=25

In[768]:=
```
xx = Range[0, 25 000, 1];
epi = Eigenvalues[ge] /. {y → 0, t → 25};
dvol = Total[epi] /. {x → xx};
data27 = Thread[{xx, dvol}];
```

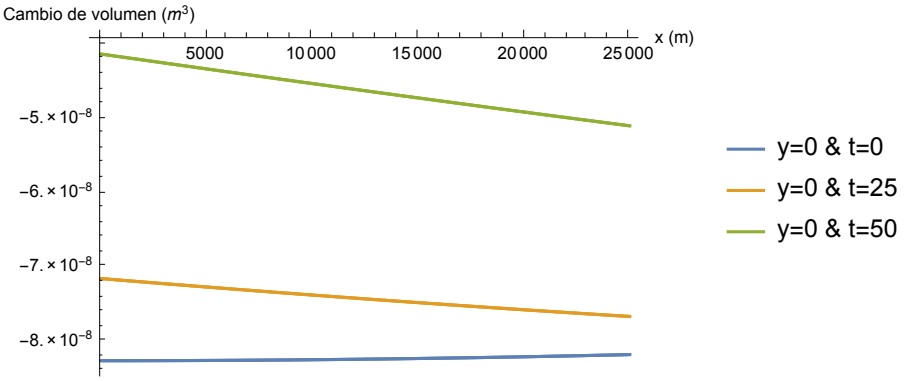
- Para y=0 & t=50

In[772]:=
```
xx = Range[0, 25 000, 1];
epi = Eigenvalues[ge] /. {y → 0, t → 50};
dvol = Total[epi] /. {x → xx};
data28 = Thread[{xx, dvol}];
```

- Para y=0

In[776]:=
```
ListPlot[{data26, data27, data28},
 PlotLegends → {"y=0 & t=0", "y=0 & t=25", "y=0 & t=50"},
 AxesLabel → {"x (m)", "Cambio de volumen (m^3)"}, Joined -> True]
```

Out[776]=



- Para y=1000 & t=0

In[781]:=
```
xx = Range[0, 25 000, 1];
epi = Eigenvalues[ge] /. {y → 1000, t → 0};
dvol = Total[epi] /. {x → xx};
data29 = Thread[{xx, dvol}];
```

- Para y=1000 & t=25

In[785]:=
```
xx = Range[0, 25 000, 1];
epi = Eigenvalues[ge] /. {y → 1000, t → 25};
dvol = Total[epi] /. {x → xx};
data30 = Thread[{xx, dvol}];
```

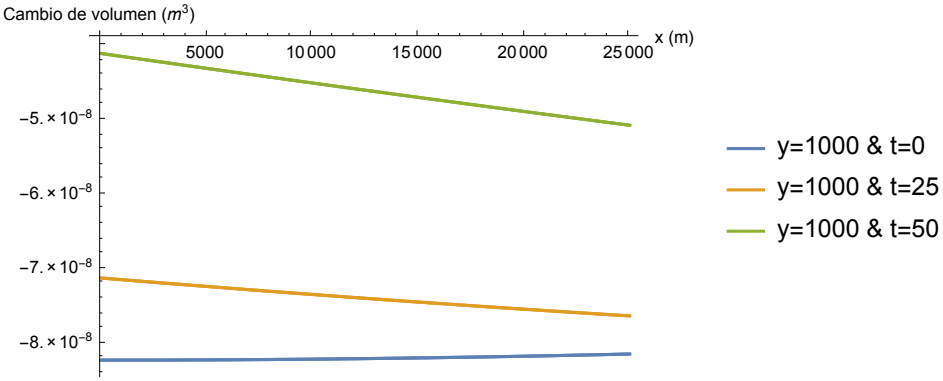
- Para y=1000 & t=50

In[789]:=
```
xx = Range[0, 25 000, 1];
epi = Eigenvalues[ge] /. {y → 1000, t → 50};
dvol = Total[epi] /. {x → xx};
data31 = Thread[{xx, dvol}];
```

- Para y=1000

In[793]:=
```
ListPlot[{data29, data30, data31},
 PlotLegends → {"y=1000 & t=0", "y=1000 & t=25", "y=1000 & t=50"},
 AxesLabel → {"x (m)", "Cambio de volumen (m³)"}, Joined -> True]
```

Out[793]=



- Para y=3000 & t=0

In[794]:=
```
xx = Range[0, 25000, 1];
epi = Eigenvalues[ge] /. {y → 3000, t → 0};
dvol = Total[epi] /. {x → xx};
data32 = Thread[{xx, dvol}];
```

- Para y=3000 & t=25

In[798]:=
```
xx = Range[0, 25000, 1];
epi = Eigenvalues[ge] /. {y → 3000, t → 25};
dvol = Total[epi] /. {x → xx};
data33 = Thread[{xx, dvol}];
```

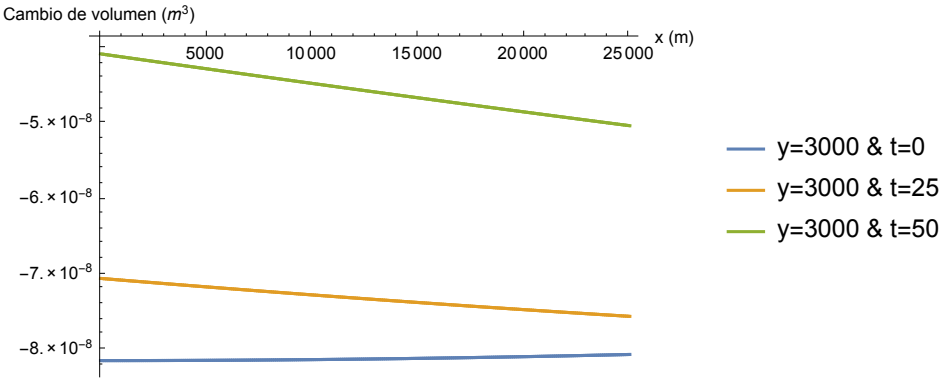
- Para y=3000 & t=50

In[802]:=
```
xx = Range[0, 25000, 1];
epi = Eigenvalues[ge] /. {y → 3000, t → 50};
dvol = Total[epi] /. {x → xx};
data34 = Thread[{xx, dvol}];
```

- Para y=3000

In[806]:=
```
ListPlot[{data32, data33, data34},
 PlotLegends → {"y=3000 & t=0", "y=3000 & t=25", "y=3000 & t=50"},
 AxesLabel → {"x (m)", "Cambio de volumen (m³)"}, Joined -> True]
```

Out[806]=



- Para y=5000 & t=0

In[807]:=
```
xx = Range[0, 25 000, 1];
epi = Eigenvalues[ge] /. {y → 5000, t → 0};
dvol = Total[epi] /. {x → xx};
data35 = Thread[{xx, dvol}];
```

- Para y=5000 & t=25

In[811]:=
```
xx = Range[0, 25 000, 1];
epi = Eigenvalues[ge] /. {y → 5000, t → 25};
dvol = Total[epi] /. {x → xx};
data36 = Thread[{xx, dvol}];
```

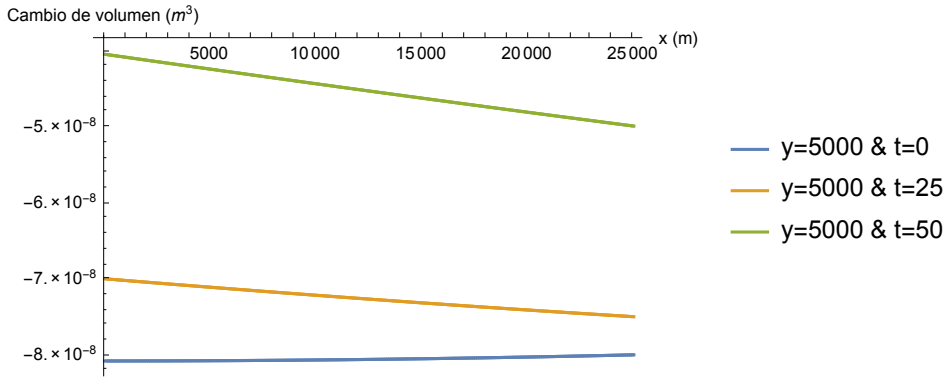
- Para y=5000 & t=50

In[815]:=
```
xx = Range[0, 25 000, 1];
epi = Eigenvalues[ge] /. {y → 5000, t → 50};
dvol = Total[epi] /. {x → xx};
data37 = Thread[{xx, dvol}];
```

- Para y=5000

In[819]:=
```
ListPlot[{data35, data36, data37},
 PlotLegends → {"y=5000 & t=0", "y=5000 & t=25", "y=5000 & t=50"},
 AxesLabel → {"x (m)", "Cambio de volumen (m^3)"}, Joined -> True]
```

Out[819]=

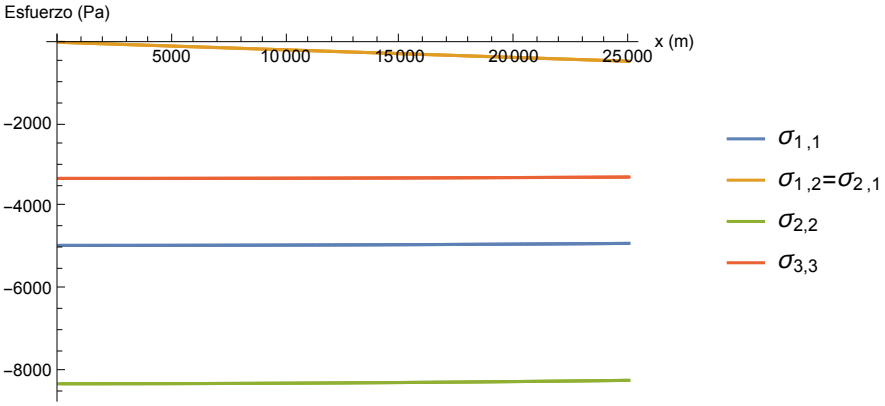


8. Diagrame las componentes del tensor de esfuerzos que son diferentes de 0 en y = 0, para varios valores de t. Haga lo mismo para varias particulas para varios y>0.

- Para y=0 & t=0

In[869]:=
```
sijx = sij /. {y → 0, t → 0};
s11 = Thread[{xx, sijx[[1, 1]] /. {x → xx}}];
s12 = Thread[{xx, sijx[[1, 2]] /. {x → xx}}];
s22 = Thread[{xx, sijx[[2, 2]] /. {x → xx}}];
s33 = Thread[{xx, sijx[[3, 3]] /. {x → xx}}];
ListPlot[{s11, s12, s22, s33}, PlotLegends → {"σ1 ,1", "σ1 ,2=σ2 ,1", "σ2,2", "σ3,3"},
 Joined → True, AxesLabel → {"x (m)", "Esfuerzo (Pa)"}]
```

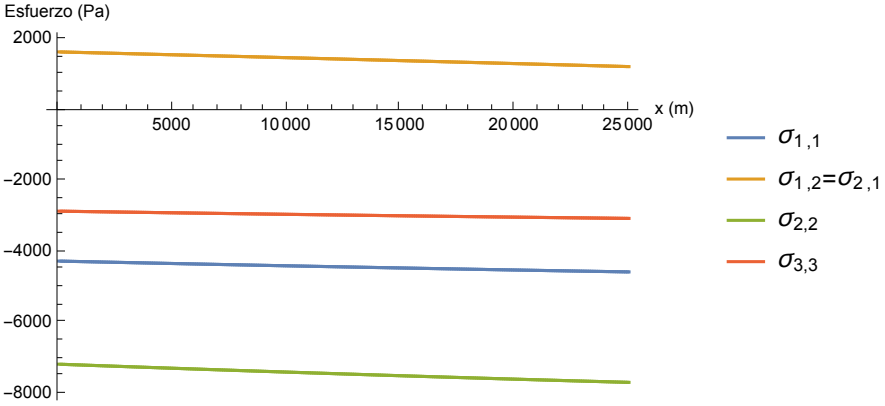
Out[874]=



- Para y=0 & t=25

In[875]:=
```
sijx = sij /. {y → 0, t → 25};
s11 = Thread[{xx, sijx[[1, 1]] /. {x → xx}}];
s12 = Thread[{xx, sijx[[1, 2]] /. {x → xx}}];
s22 = Thread[{xx, sijx[[2, 2]] /. {x → xx}}];
s33 = Thread[{xx, sijx[[3, 3]] /. {x → xx}}];
ListPlot[{s11, s12, s22, s33}, PlotLegends → {"σ1 ,1", "σ1 ,2=σ2 ,1", "σ2,2", "σ3,3"},
 Joined → True, AxesLabel → {"x (m)", "Esfuerzo (Pa)"}]
```

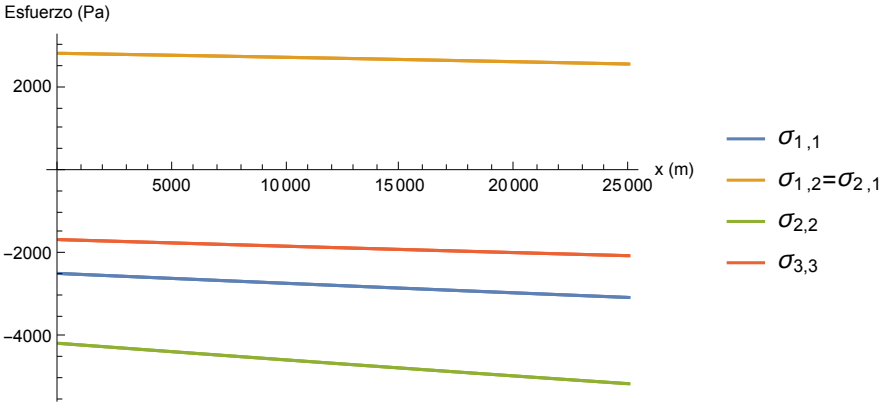
Out[880]=



- Para y=0 & t=50

In[881]:=
```
sijx = sij /. {y → 0, t → 50};
s11 = Thread[{xx, sijx[[1, 1]] /. {x → xx}}];
s12 = Thread[{xx, sijx[[1, 2]] /. {x → xx}}];
s22 = Thread[{xx, sijx[[2, 2]] /. {x → xx}}];
s33 = Thread[{xx, sijx[[3, 3]] /. {x → xx}}];
ListPlot[{s11, s12, s22, s33}, PlotLegends → {"σ1,1", "σ1,2=σ2,1", "σ2,2", "σ3,3"},
 Joined → True, AxesLabel → {"x (m)", "Esfuerzo (Pa)"}]
```

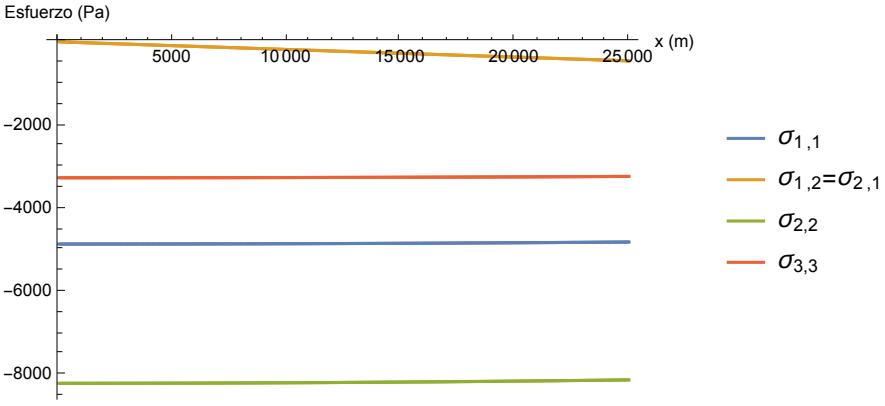
Out[886]=



- Para y=2500 & t=0

In[887]:=
```
sijx = sij /. {y → 2500, t → 0};
s11 = Thread[{xx, sijx[[1, 1]] /. {x → xx}}];
s12 = Thread[{xx, sijx[[1, 2]] /. {x → xx}}];
s22 = Thread[{xx, sijx[[2, 2]] /. {x → xx}}];
s33 = Thread[{xx, sijx[[3, 3]] /. {x → xx}}];
ListPlot[{s11, s12, s22, s33}, PlotLegends → {"σ1,1", "σ1,2=σ2,1", "σ2,2", "σ3,3"},
 Joined → True, AxesLabel → {"x (m)", "Esfuerzo (Pa)"}]
```

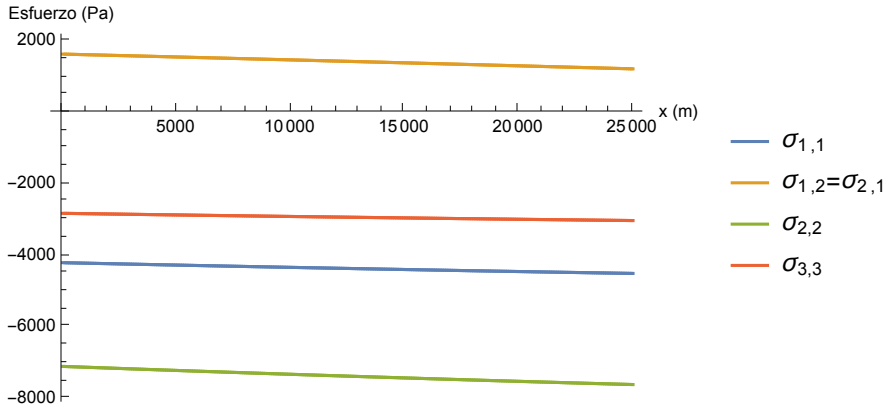
Out[892]=



- Para y=2500 & t=25

In[893]:=
```
sijx = sij /. {y → 2500, t → 25};
s11 = Thread[{xx, sijx[[1, 1]] /. {x → xx}}];
s12 = Thread[{xx, sijx[[1, 2]] /. {x → xx}}];
s22 = Thread[{xx, sijx[[2, 2]] /. {x → xx}}];
s33 = Thread[{xx, sijx[[3, 3]] /. {x → xx}}];
ListPlot[{s11, s12, s22, s33}, PlotLegends → {"σ1,1", "σ1,2=σ2,1", "σ2,2", "σ3,3"},
 Joined → True, AxesLabel → {"x (m)", "Esfuerzo (Pa)"}]
```

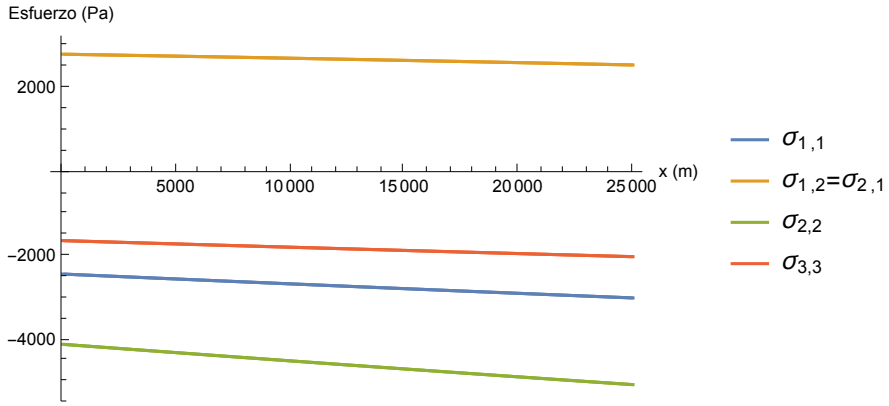
Out[898]=



- Para y=2500 & t=50

In[899]:=
```
sijx = sij /. {y → 2500, t → 50};
s11 = Thread[{xx, sijx[[1, 1]] /. {x → xx}}];
s12 = Thread[{xx, sijx[[1, 2]] /. {x → xx}}];
s22 = Thread[{xx, sijx[[2, 2]] /. {x → xx}}];
s33 = Thread[{xx, sijx[[3, 3]] /. {x → xx}}];
ListPlot[{s11, s12, s22, s33}, PlotLegends → {"σ1,1", "σ1,2=σ2,1", "σ2,2", "σ3,3"},
 Joined → True, AxesLabel → {"x (m)", "Esfuerzo (Pa)"}]
```

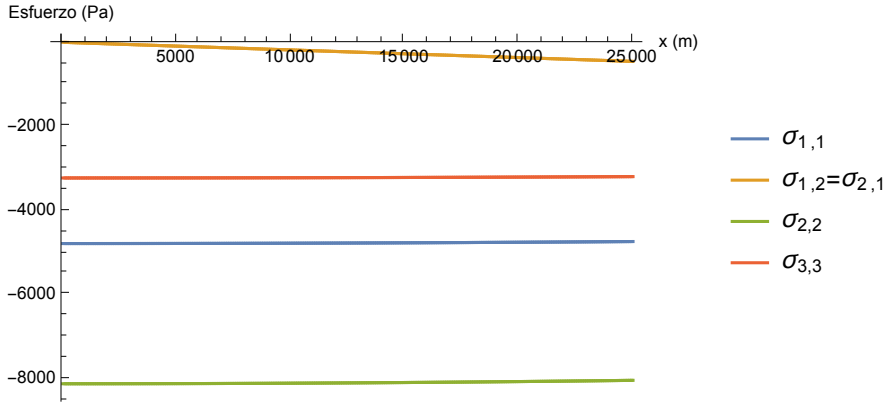
Out[904]=



- Para y=5000 & t=0

In[905]:=
```
sijx = sij /. {y → 5000, t → 0};
s11 = Thread[{xx, sijx[[1, 1]] /. {x → xx}}];
s12 = Thread[{xx, sijx[[1, 2]] /. {x → xx}}];
s22 = Thread[{xx, sijx[[2, 2]] /. {x → xx}}];
s33 = Thread[{xx, sijx[[3, 3]] /. {x → xx}}];
ListPlot[{s11, s12, s22, s33}, PlotLegends → {"σ1 ,1", "σ1 ,2=σ2 ,1", "σ2,2", "σ3,3"},
 Joined → True, AxesLabel → {"x (m)", "Esfuerzo (Pa)"}]
```

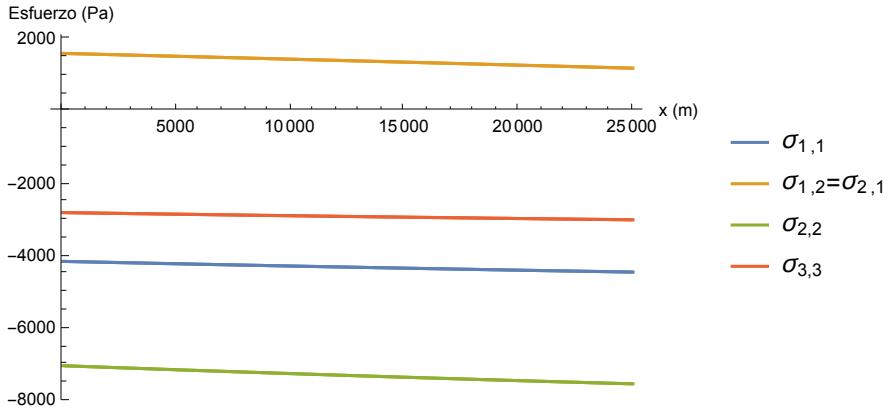
Out[910]=



- Para y=5000 & t=25

In[911]:=
```
sijx = sij /. {y → 5000, t → 25};
s11 = Thread[{xx, sijx[[1, 1]] /. {x → xx}}];
s12 = Thread[{xx, sijx[[1, 2]] /. {x → xx}}];
s22 = Thread[{xx, sijx[[2, 2]] /. {x → xx}}];
s33 = Thread[{xx, sijx[[3, 3]] /. {x → xx}}];
ListPlot[{s11, s12, s22, s33}, PlotLegends → {"σ1 ,1", "σ1 ,2=σ2 ,1", "σ2,2", "σ3,3"},
 Joined → True, AxesLabel → {"x (m)", "Esfuerzo (Pa)"}]
```

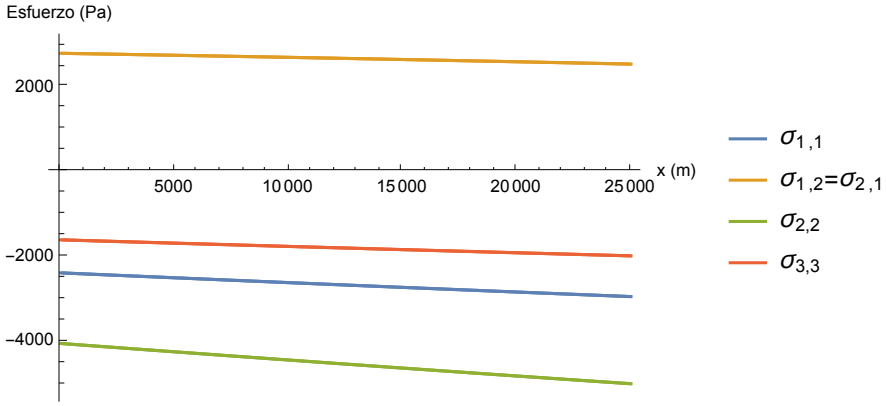
Out[916]=



- Para y=5000 & t=50

In[929]:=
```
sijx = sij /. {y → 5000, t → 50};
s11 = Thread[{xx, sijx[[1, 1]] /. {x → xx}}];
s12 = Thread[{xx, sijx[[1, 2]] /. {x → xx}}];
s22 = Thread[{xx, sijx[[2, 2]] /. {x → xx}}];
s33 = Thread[{xx, sijx[[3, 3]] /. {x → xx}}];
ListPlot[{s11, s12, s22, s33}, PlotLegends → {"σ1 ,1", "σ1 ,2=σ2 ,1", "σ2,2", "σ3,3"},
 Joined → True, AxesLabel → {"x (m)", "Esfuerzo (Pa)"}]
```

Out[934]=

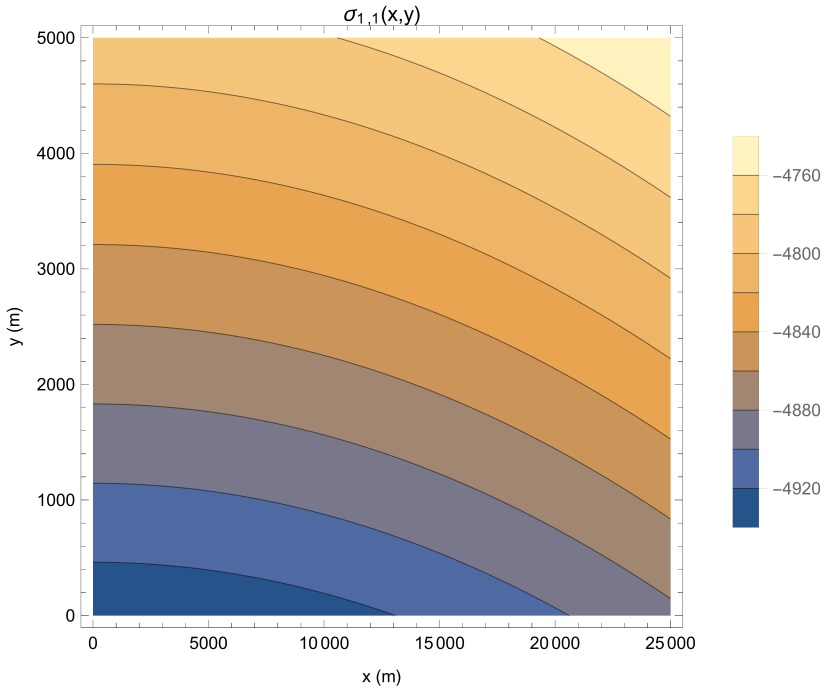


9. Para un tiempo dado, diagrame las componentes del tensor de esfuerzos que son diferentes de 0, como una función de x & y. Haga lo mismo para varios tiempos.

- Para t=0

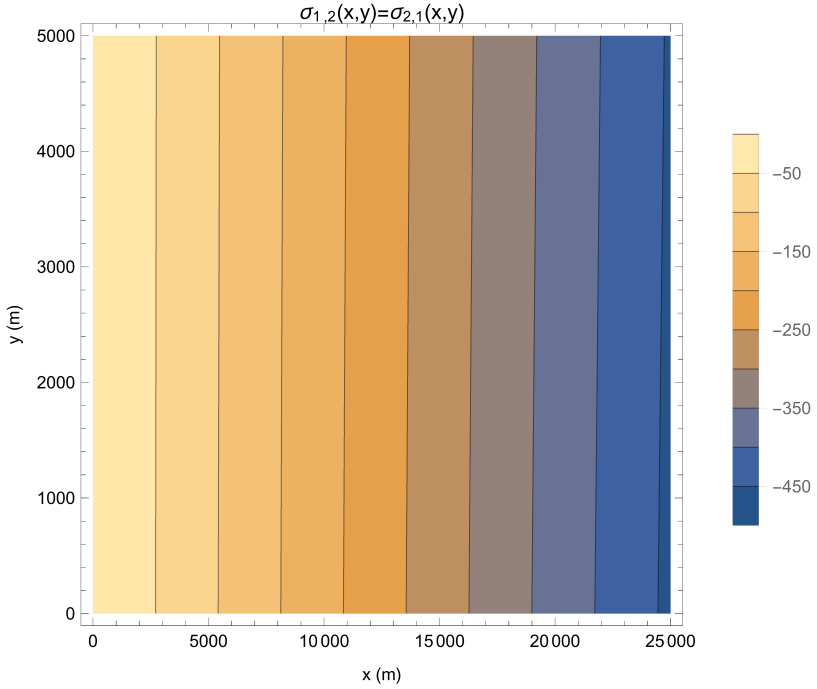
In[1151]:=
```
sijxy = sij /. {t → 0};
sijxy11 = sijxy[[1, 1]];
f[x_, y_] := Evaluate[sijxy11];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ1 ,1(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1154]=



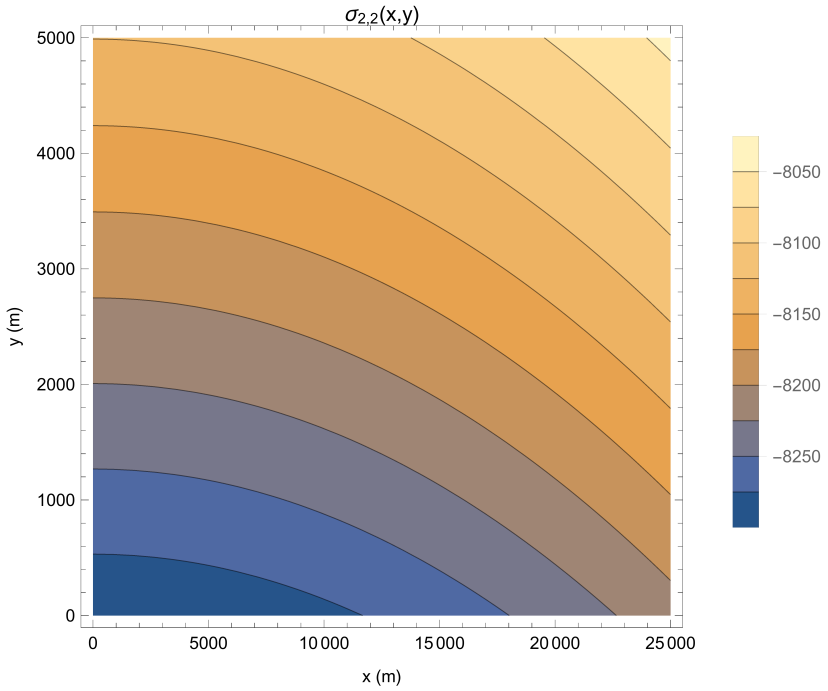
In[1147]:=
```
sijxy = sij /. {t → 0};
sijxy12 = sijxy[[1, 2]];
f[x_, y_] := Evaluate[sijxy12];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ1 ,2 (x,y) =σ2 ,1 (x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1150]=



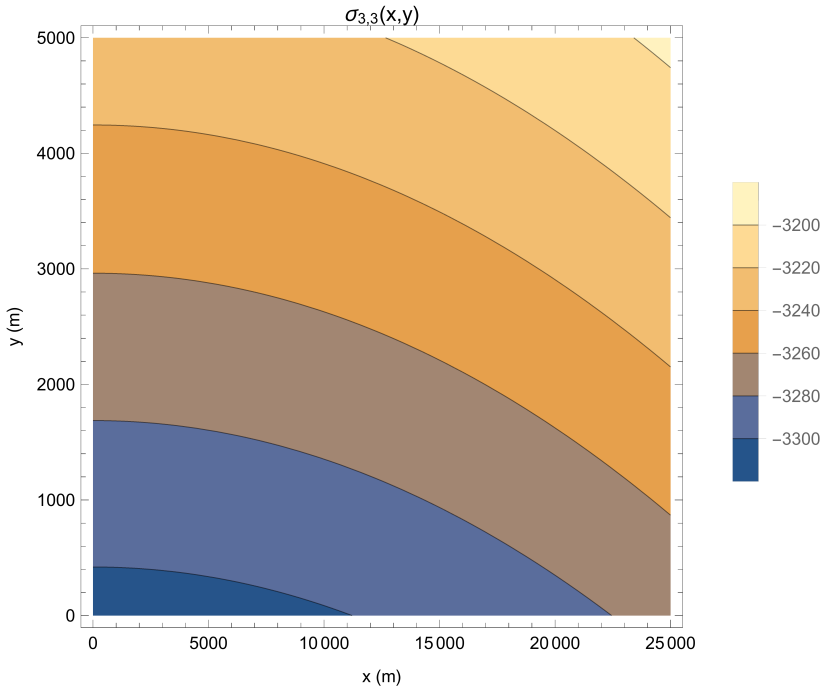
In[1155]:=
```
sijxy = sij /. {t → 0};
sijxy22 = sijxy[[2, 2]];
f[x_, y_] := Evaluate[sijxy22];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ2,2(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1158]=



In[1159]:=
```
sijxy = sij /. {t → 0};
sijxy33 = sijxy[[3, 3]];
f[x_, y_] := Evaluate[sijxy33];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ3,3(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

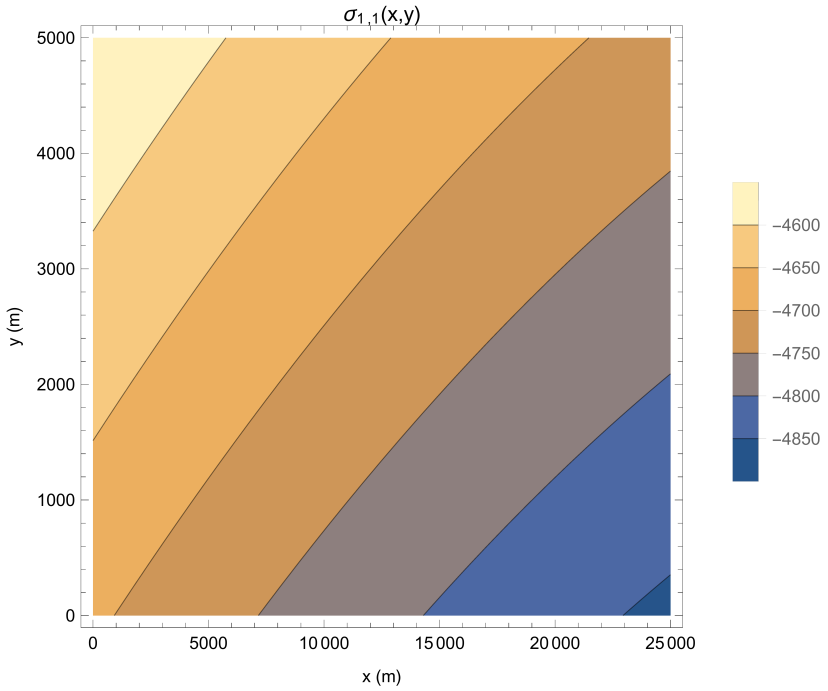
Out[1162]=



- Para t=15

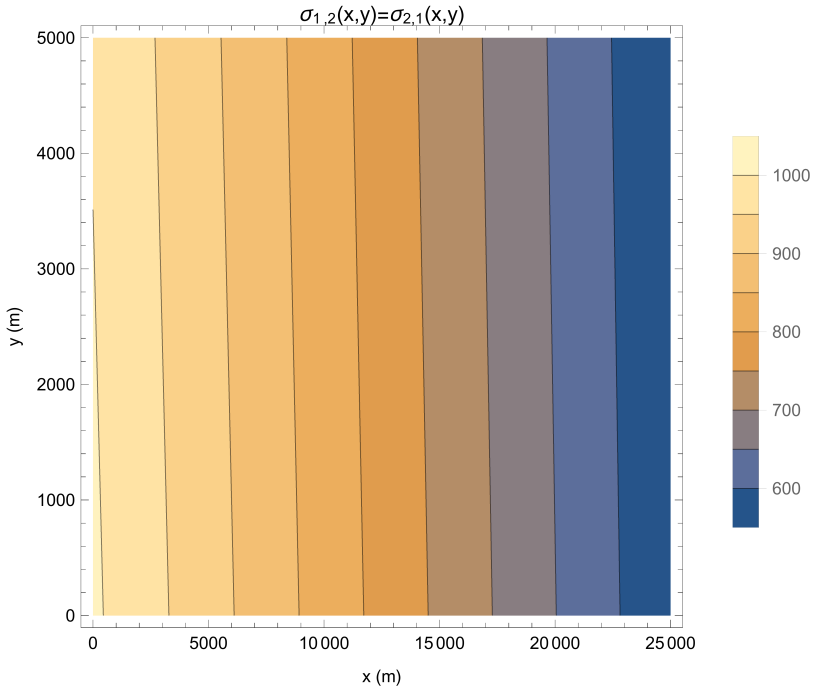
In[1163]:=
```
sijxy = sij /. {t → 15};
sijxy11 = sijxy[[1, 1]];
f[x_, y_] := Evaluate[sijxy11];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ1 ,1(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1166]=



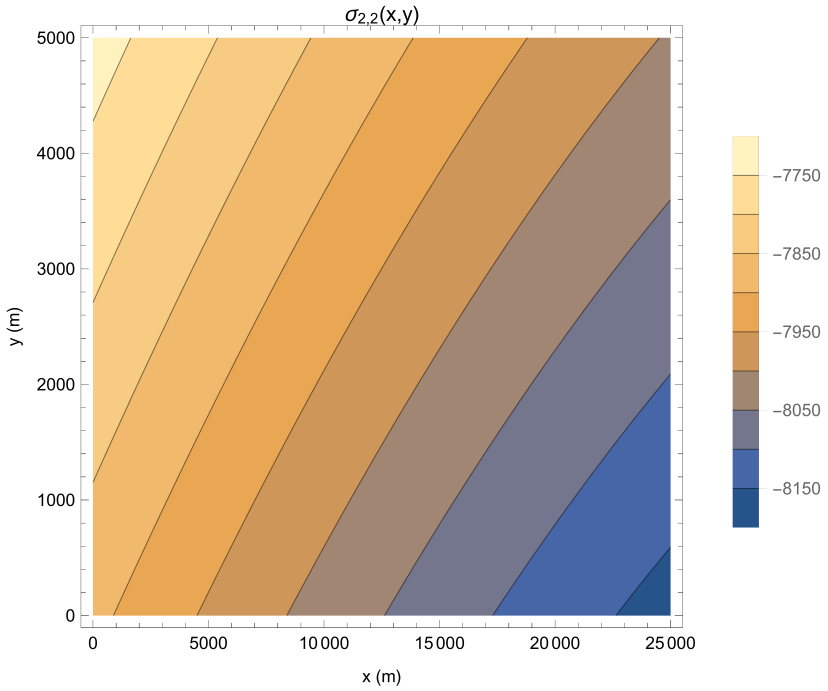
In[1167]:=
```
sijxy = sij /. {t → 15};
sijxy12 = sijxy[[1, 2]];
f[x_, y_] := Evaluate[sijxy12];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ1 ,2(x,y)=σ2 ,1(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1170]=



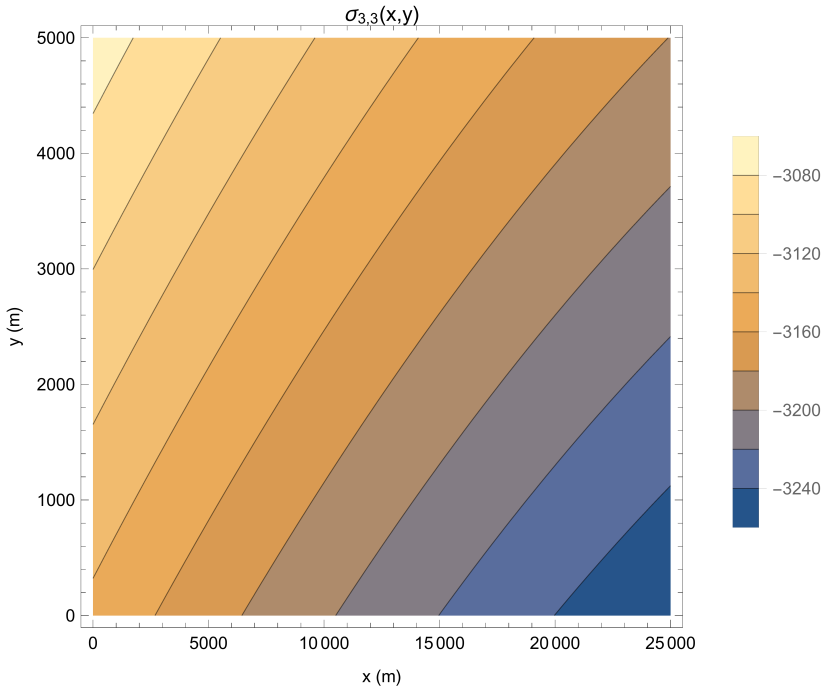
In[1171]:=
```
sijxy = sij /. {t → 15};
sijxy22 = sijxy[[2, 2]];
f[x_, y_] := Evaluate[sijxy22];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ2,2(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1174]=



In[1179]:=
```
sijxy = sij /. {t → 15};
sijxy33 = sijxy[[3, 3]];
f[x_, y_] := Evaluate[sijxy33];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ3,3(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

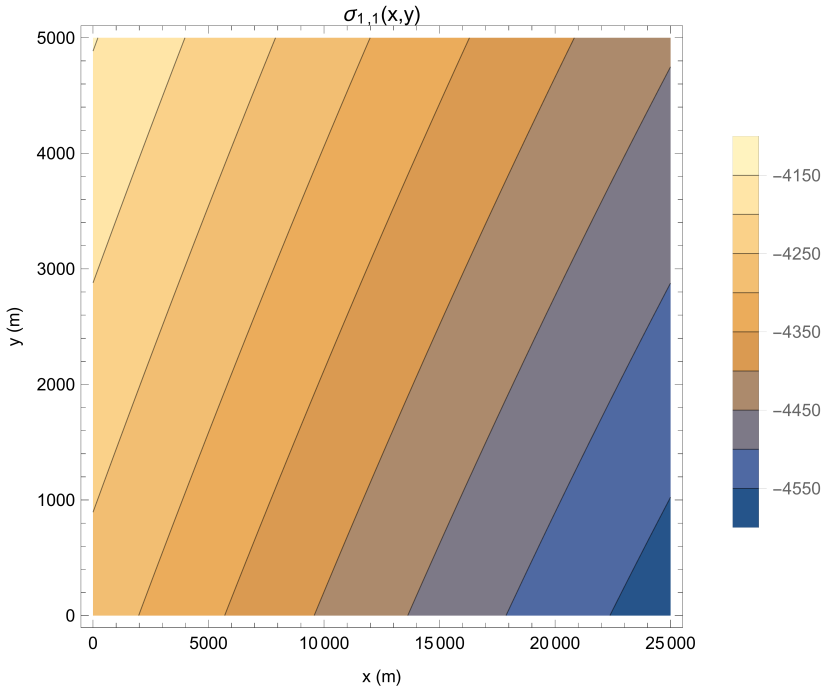
Out[1182]=



- Para t=25

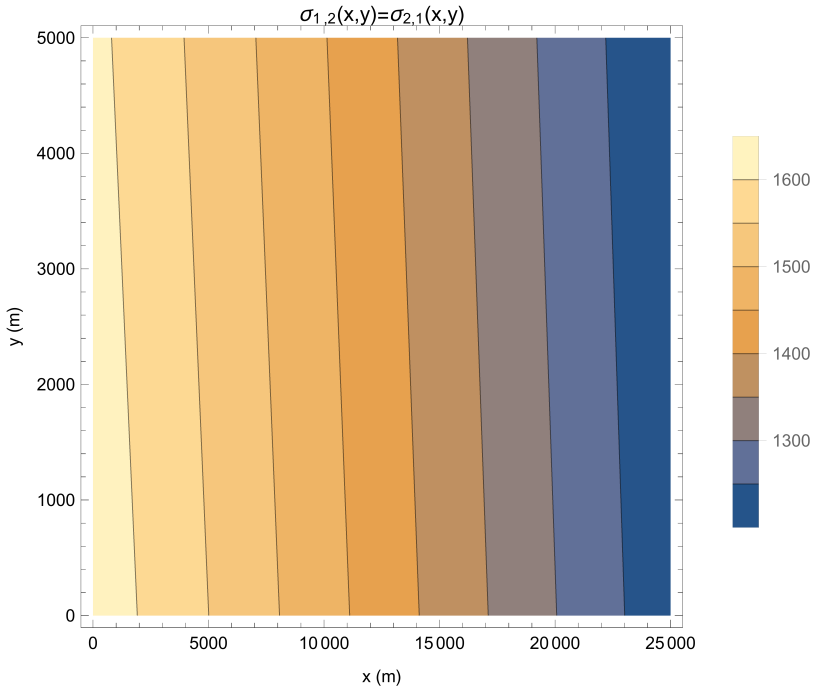
In[1183]:=
```
sijxy = sij /. {t → 25};
sijxy11 = sijxy[[1, 1]];
f[x_, y_] := Evaluate[sijxy11];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ1 ,1(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1186]=



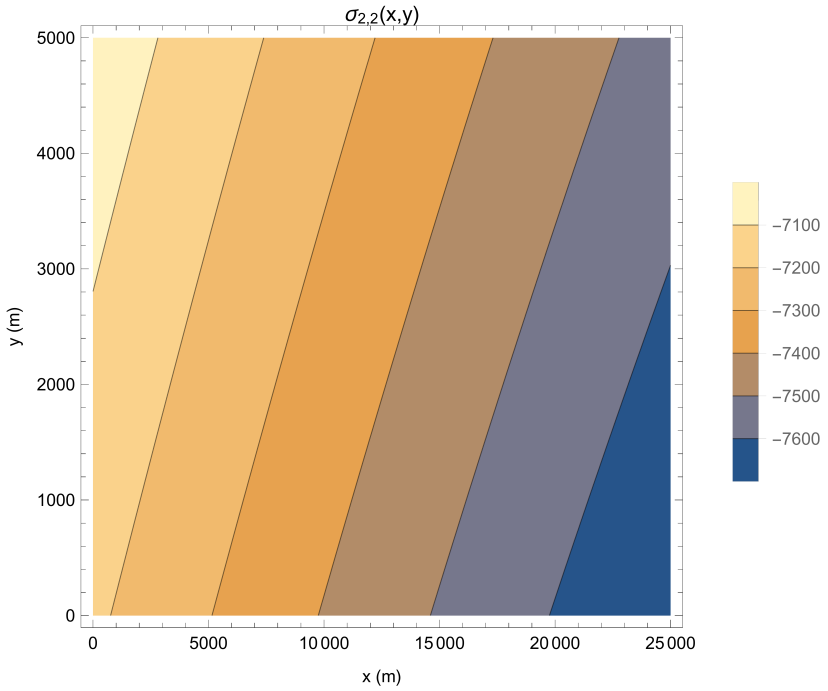
In[1187]:=
```
sijxy = sij /. {t → 25};
sijxy12 = sijxy[[1, 2]];
f[x_, y_] := Evaluate[sijxy12];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ1 ,2(x,y)=σ2 ,1(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1190]=



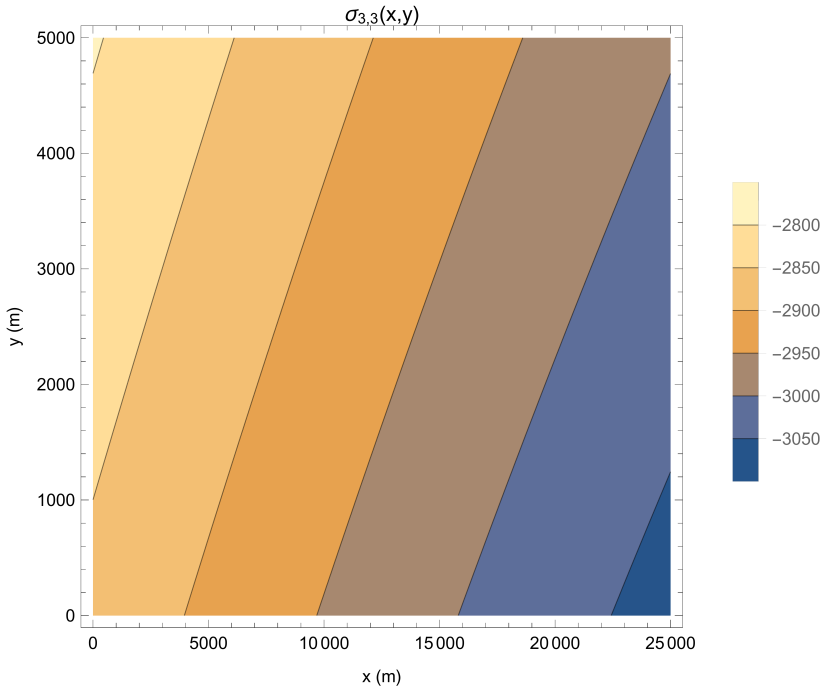
In[1191]:=
```
sijxy = sij /. {t → 25};
sijxy22 = sijxy[[2, 2]];
f[x_, y_] := Evaluate[sijxy22];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ2,2(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1194]=



In[1195]:=
```
sijxy = sij /. {t → 25};
sijxy33 = sijxy[[3, 3]];
f[x_, y_] := Evaluate[sijxy33];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ3,3(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

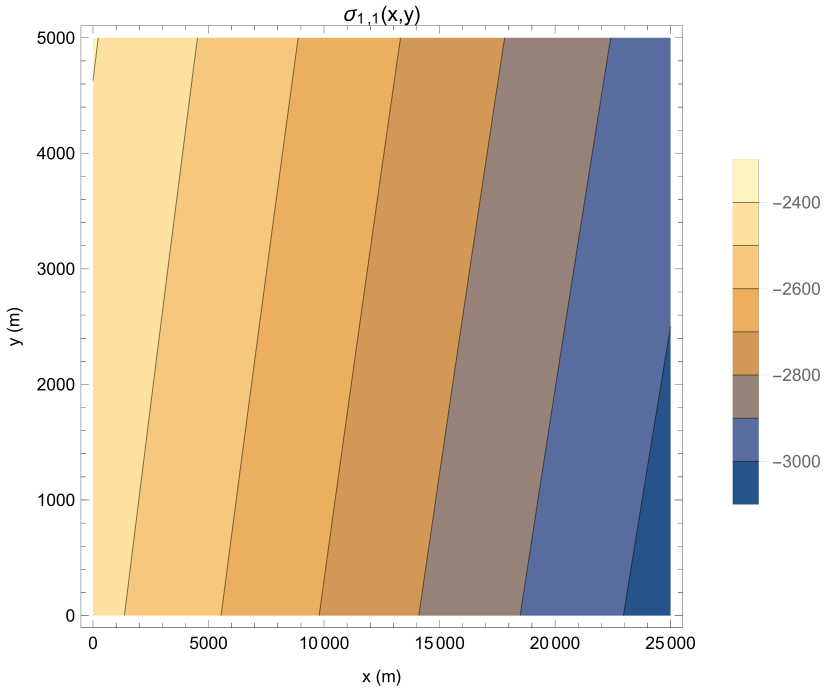
Out[1198]=



- t=50

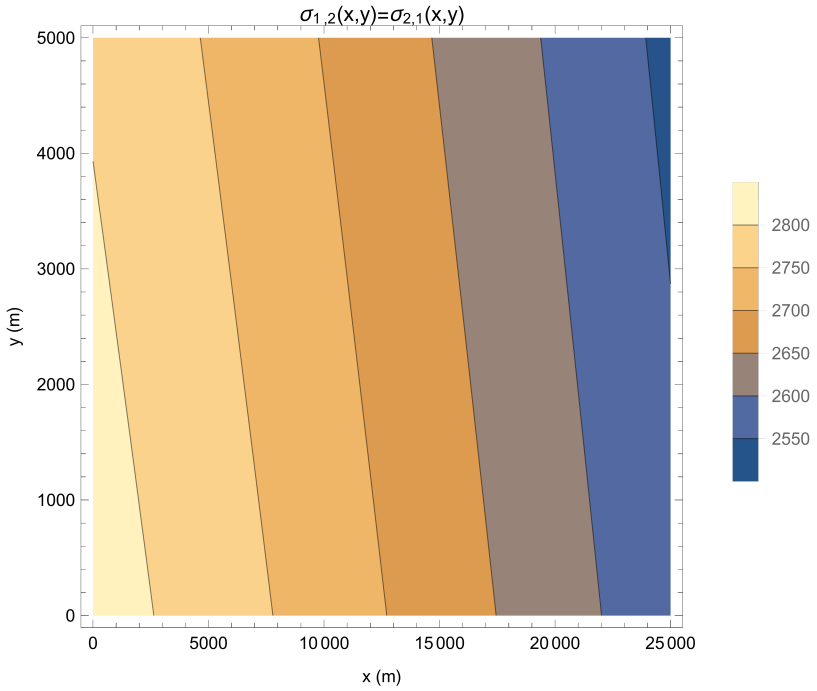
In[1199]:=
```
sijxy = sij /. {t → 50};
sijxy11 = sijxy[[1, 1]];
f[x_, y_] := Evaluate[sijxy11];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ1 ,1(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1202]=



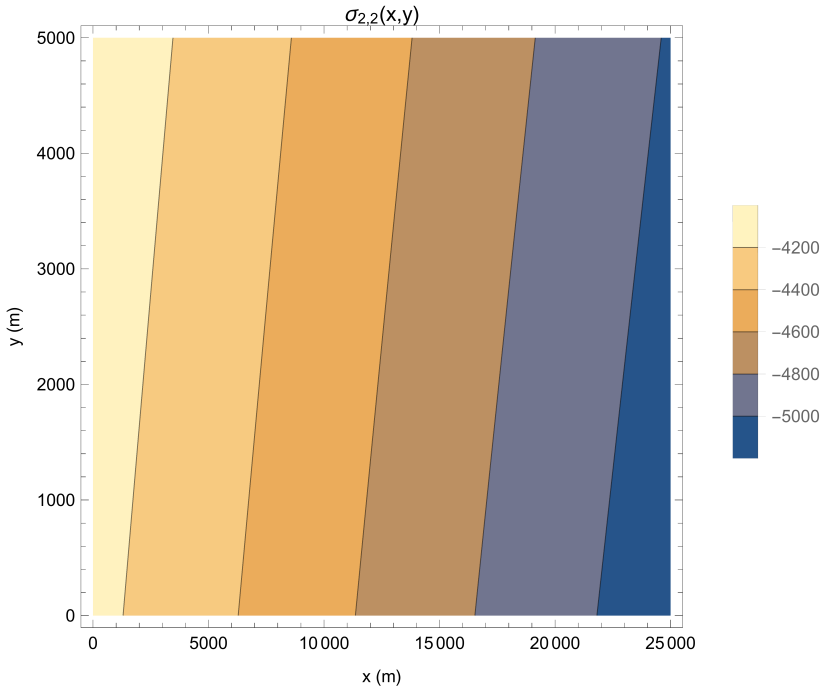
In[1203]:=
```
sijxy = sij /. {t → 50};
sijxy12 = sijxy[[1, 2]];
f[x_, y_] := Evaluate[sijxy12];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ1 ,2(x,y)=σ2 ,1(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1206]=



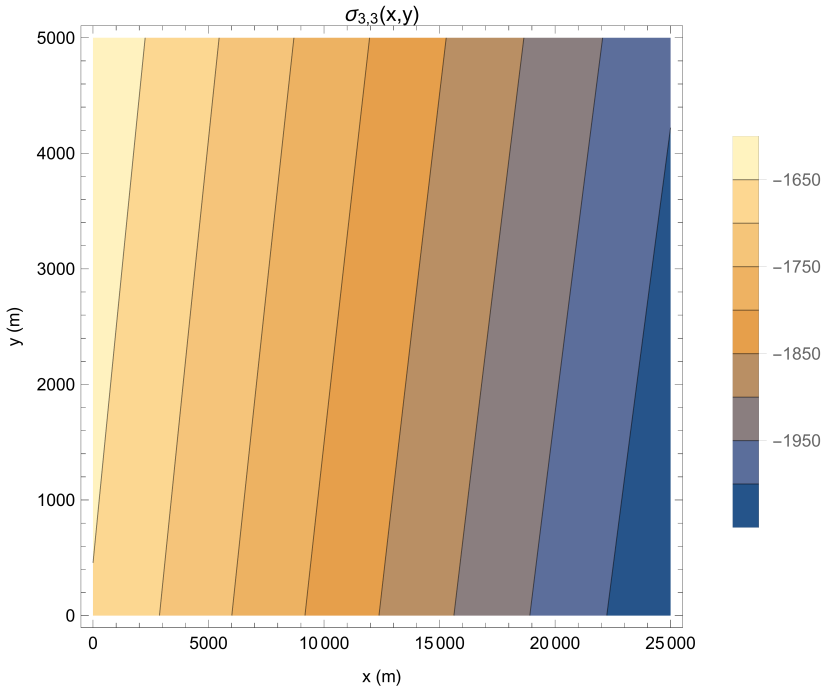
In[1207]:=
```
sijxy = sij /. {t → 50};
sijxy22 = sijxy[[2, 2]];
f[x_, y_] := Evaluate[sijxy22];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ2,2(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1210]=



In[1211]:=
```
sijxy = sij /. {t → 50};
sijxy33 = sijxy[[3, 3]];
f[x_, y_] := Evaluate[sijxy33];
ContourPlot[f[x, y], {x, 0, 25 000}, {y, 0, 5000}, PlotLegends → Automatic,
 PlotLabel → "σ3,3(x,y)", FrameLabel → {"x (m)", "y (m)"}]
```

Out[1214]=



10. Diagrame el esfuerzo cortante máximo del suelo en y = 0, para varios valores de t. Haga lo mismo para varias partículas en y > 0, ¿dónde ocurre este esfuerzo?

11. Lo mismo que 9.