

```
In [53]: from IPython.display import display, Math, Latex
import numpy as np
from sympy import *
```

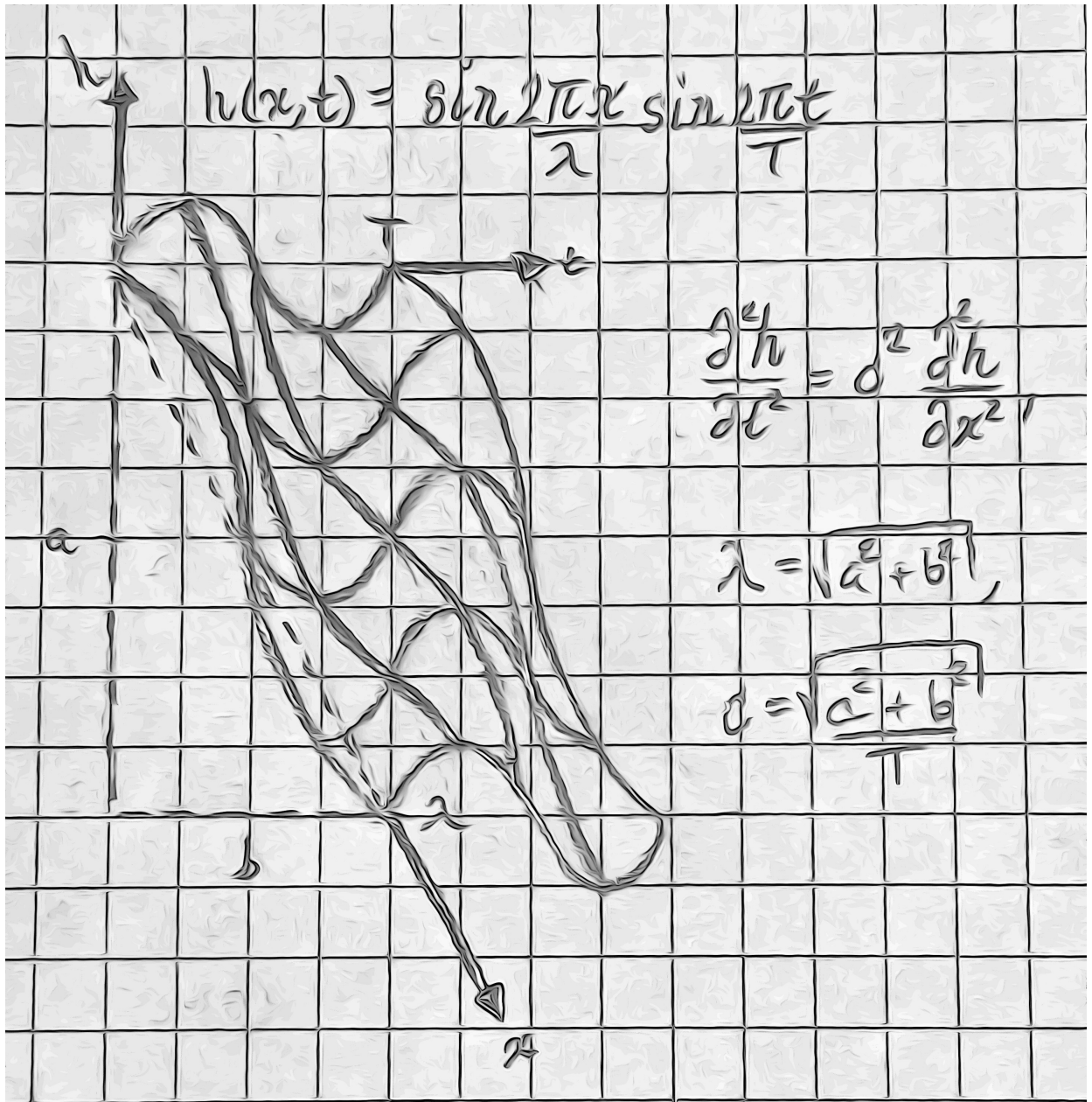
```
init_printing()
display(Math(r'\text{1D Wave Equation },'))
```

1D Wave Equation ,

$$\frac{\delta^2 h}{\delta t^2} = c^2 \frac{\delta^2 h}{\delta x^2}$$

```
In [54]: from IPython.display import Image
Image(filename='sketch.jpg')
```

Out[54]:



```

In [55]: a, b, x, t, T = symbols('a b x t T')
px, py, pt = symbols('k_x k_y p_t') # 1, 2, np.sqrt(5)
h, u, v = symbols('h u v', cls=Function)

L = Function("\lambda")(a,b)
c = Function("c")(a,b,T)
h = Function("h")(x, t) # f is a function of x and y

L = sqrt(a**2 + b**2)
c = sqrt(a**2 + b**2)/T
h = sin(2*pi/L*x)*sin(2*pi/T*t)

```

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In [56]: # display h
display(h)
```

$$\sin\left(\frac{2\pi t}{T}\right) \sin\left(\frac{2\pi x}{\sqrt{a^2 + b^2}}\right)$$

```
In [59]: # check solution -- should be 0
import sympy

hxx = sympy.diff(sympy.diff(h, x), x)
htt = sympy.diff(sympy.diff(h, t), t)

# wave equation 1d
htt - c**2*hxx
```

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Out[59]: 0
```

```
In [60]: import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits import mplot3d

%matplotlib inline
```

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In [82]: figure_a, figure_b = 8, 4
wave_length = np.sqrt(figure_a**2 + figure_b**2)
period = 4
wave_speed = wave_length**2/period
N = 20
x = np.linspace(0, wave_length, N)
t = np.linspace(0, period + 1, N)
#x = np.linspace(0, wave_length, N)
#t = np.linspace(0, wave_length, N)

def height(x, t):
    return np.sin(2*np.pi/wave_length*x)*np.sin(2*np.pi/period*t)

X, T = np.meshgrid(x, t)

H = height(X, T)
```

```
In [98]: %matplotlib notebook

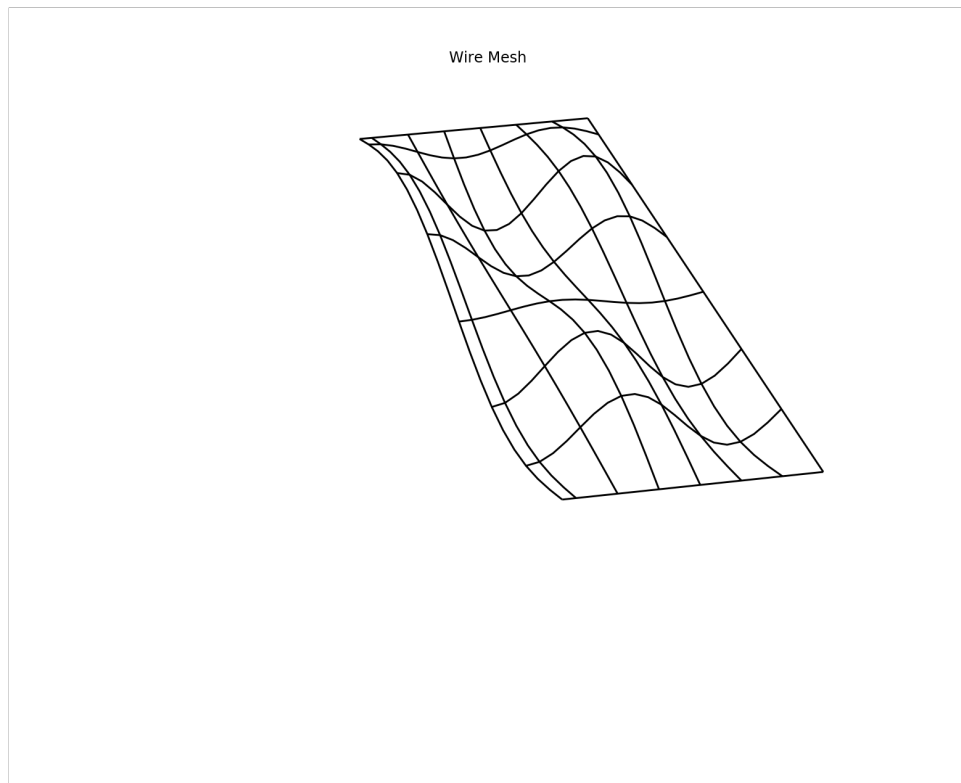
fig = plt.figure()

ax = plt.axes(projection='3d')
ax.plot_wireframe(T, X, H, color='black', rcount=7, ccount = 7)

ax.set_title('Wire Mesh')

ax.set_autoscaley_on(False)
ax.set_xlabel('t')
ax.set_ylabel('x')
ax.set_zlabel('h');
ax.set_xlim3d(0, wave_length+1 )
ax.set_ylim3d(0,period+1)
ax.set_zlim3d(-5,5)

plt.axis('off')
ax.grid(False);
```



```
In [68]: ax = plt.axes(projection='3d')
ax.plot_surface(T, X, H, rstride=1, cstride=1,
               cmap='bone', edgecolor='none')
ax.set_title('1D Wave');

ax.set_xlabel('time')
ax.set_ylabel('x')
ax.set_zlabel('height(x, time)');
```