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MATH 151-557

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In [1]:
```
from sympy import *
from sympy.plotting import (plot, plot_parametric)
```

1a Equation of tangent line when t=pi/4

In [2]:
```
t = symbols('t')
x = cos(t)
y = sin(t) + 3
t0 = pi/4
dydx = y.diff(t) / x.diff(t)
line = dydx.subs(t, t0) * (symbols('x') - x.subs(t, t0)) + y.subs(t, t0)
print(line)
print(line.evalf())
```

```
-x + sqrt(2) + 3
4.41421356237309 - x
```

1b points where tangent line is vertical

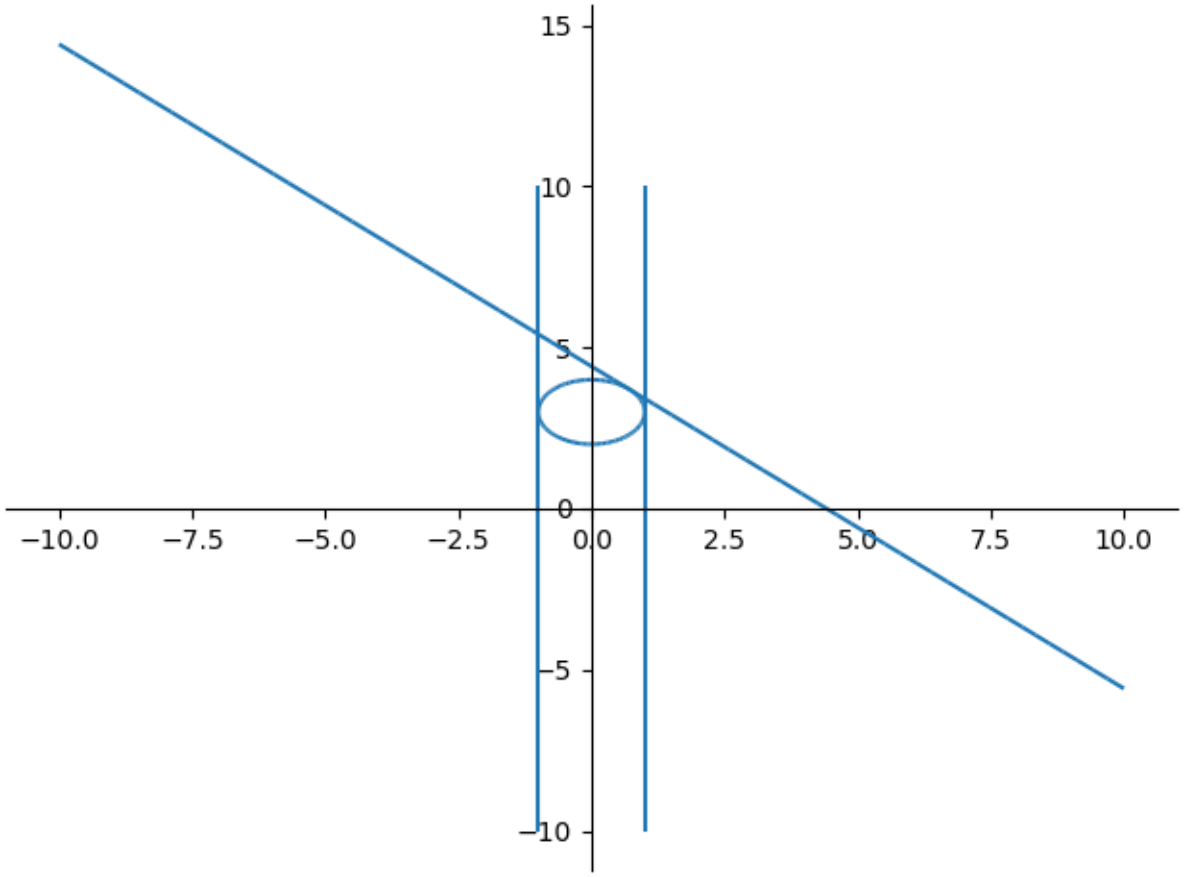
In [3]:
```
[(x.subs(t, t0), y.subs(t, t0)) for t0 in solve(x.diff(t), t)]
```

Out[3]: [(1, 3), (-1, 3)]

1c Plot parametrized curve and all tangent lines

In [4]:
```
matplotlib notebook
```

In [5]:
```
plt = plot_parametric((x, y, (t, 0, 2 * pi)), show = False)
p_vert = plot_parametric((-1, t), (1, t), show = False)
plt.extend(plot(line, show = False))
plt.extend(p_vert)
plt.show()
```



2 Tangent lines at (3,0)

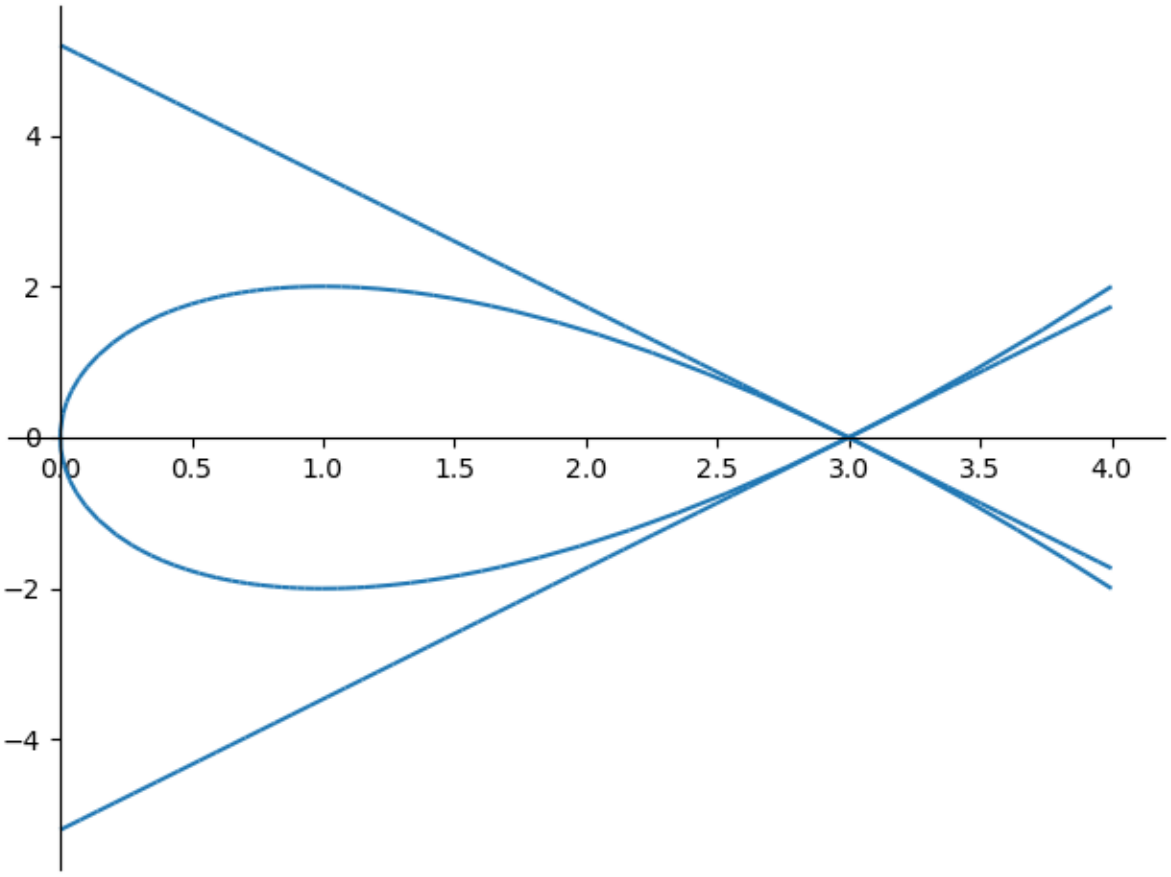
In [6]:
```
t = symbols('t')

x = t ** 2
y = t ** 3 - 3 * t
dydx = y.diff(t) / x.diff(t)
t_vals = list(set(solve(x - 3, t)) & set(solve(y - 0, t)))
slopes = [dydx.subs(t, t0) for t0 in t_vals]
lines = [slopes[t0] * (symbols('x') - x.subs(t, t_vals[t0])) + y.subs(t, t_vals[t0]) fo
print(lines)
```

```
[sqrt(3)*(x - 3), -sqrt(3)*(x - 3)]
```

2b Plot of parametrized curve and tangent lines

In [7]:
```
matplotlib notebook
```

In [8]:
```
plt = plot(lines[0], lines[1], (symbols('x'), 0, 4), show = False)
plt_par = plot_parametric((x, y, (t, -2, 2)), show = False)
plt_par.extend(plt)
plt_par.show()
```



3a find k and y0

In [9]:
```
k = symbols('k', real=True)
t = symbols('t')
y0 = symbols('y0', real=True)
y = y0 * exp(k * t)
eq1 = y.subs(t, 1) - 200
eq2 = y.subs(t, Rational(3,2))- 360
answers = solve((eq1, eq2), (y0, k))
print('y0 =', answers[0][0],', k =', answers[0][1])
```

```
y0 = 5000/81 , k = log(81/25)
```

3b When population = 2000

In [10]:
```
q = answers[0][0] * exp(answers[0][1] * t)
print(simplify(solve(q - 2000, t)[0]))
print(solve(q - 2000, t)[0].evalf())
```

```
log((162/5)**(1/log(81/25)))
2.95869116338109
```

3c find k and population 1 hour before "initial"

In [11]:
```
k = symbols('k', real=True)
t = symbols('t')
y0 = symbols('y0', real=True)
y = y0 * exp(k * t)
eq1 = y.subs(t, 0) - 200
eq2 = y.subs(t, Rational(1,2))- 360
answers = solve((eq1, eq2), (y0, k))
print('y0 =', answers[0][0],', k =', answers[0][1])
q = answers[0][0] * exp(answers[0][1] * t)
print(q.subs(t, -1))
print('The value of t = -1 when the equation if offset by one is equal to the y0 value
```

```
y0 = 200 , k = log(81/25)
5000/81
The value of t = -1 when the equation if offset by one is equal to the y0 value when the
equation was not offset
```

4a rate of change in f with respect to each variable

In [12]:
```
L = symbols('L')
T = symbols('T')
p = symbols('p')
f = (1 / (2 * L)) * sqrt(T / p)
dfdL = f.diff(L)
dfdT = f.diff(T)
dfdp = f.diff(p)
print('dfdL =', dfdL,'dfdT =', dfdT,'dfdp =', dfdp)
```

```
dfdL = -sqrt(T/p)/(2*L**2) dfdT = sqrt(T/p)/(4*L*T) dfdp = -sqrt(T/p)/(4*L*p)
```

4b interpret what happens to the pitch

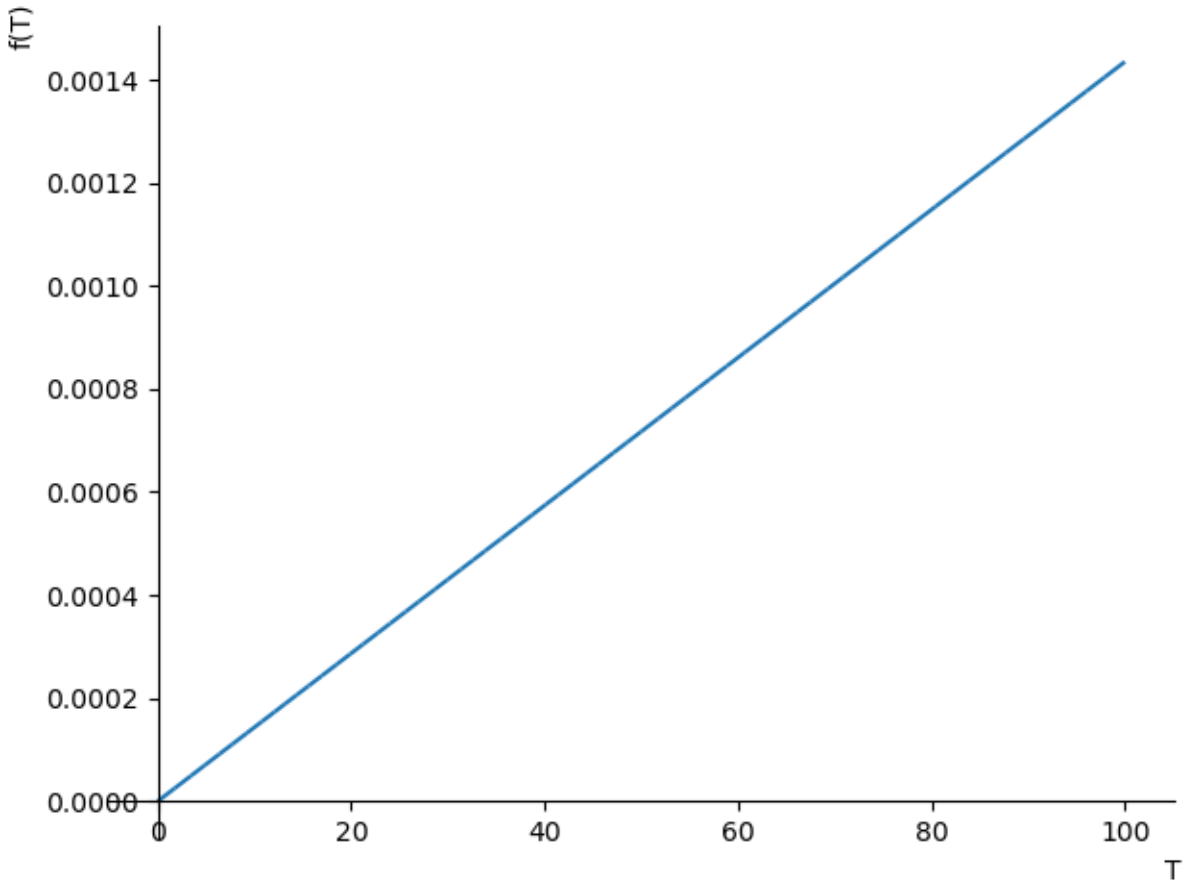
In [13]:
```
print('when the length decreases the frequency increases')
print('when the tension increases the frequency increases')
print('when the linear density increases the frequency decreases')
```

```
when the length decreases the frequency increases
when the tension increases the frequency increases
when the linear density increases the frequency decreases
```

4c Plot rho vs T

In [14]:
```
matplotlib notebook
```

In [15]:
```
L = symbols('L')
T = symbols('T')
p = symbols('p')
f = (1 / (2 * .3)) * sqrt(T / p)
f.subs(L, .3)
equ = solve(f - 440, p)
plt = plot(equ[0], (T, 0, 100))
```



4d tuning tension when rho=.00078

In [16]:
```
equa = equ[0] - .00078
answers = solve(equa, T)
print(answers[0])
```

```
54.3628800000000
```