Kernel: Python 3 (system-wide)

In [1]:
```
import numpy as np
from matplotlib import pyplot as plt
```

In [2]:
```
# sigularities
def sing(x,a,n):
    if not isinstance(x, np.ndarray):
        x = np.array([x])
    ni = np.zeros(x.size)
    for i in range(x.size):
        if x[i] >=a and n>=0:
            ni[i] = (x[i]-a)**n
    return ni/np.math.factorial(n)

def lx(ord_f,pc, tire_l, case):
    p1,p2 = pp(tire_l,case)
    react_f = GVWR*((1-pc)*sing(dx,0,ord_f)+pc/2*
(sing(dx,lw1,ord_f)+sing(dx, lw2, ord_f)))
    other_f =
p1*sing(dx,a2,ord_f)+p2*sing(dx,lc,ord_f)+W_tip*sing(dx,G_base, ord_f)
    if case == 1:
        return react_f - other_f - Rc*sing(dx, tire_l, ord_f)
    else:
        return react_f - other_f

def pp(tire_l,load_fac):
    react_f = Rc*((tire_l-a2)*load_fac+wheel_base)+W_tip*(G_tip-a2)
    p2 = react_f/(lc-a2)
    p1 = load_fac * Rc + W_tip - p2
    return p1,p2

def trail(ord_f,pc,tire_len, case=2):
    p1,p2 = pp(tire_len,case)
    react_f = p1*sing(dx,a2,ord_f)+p2*sing(dx,lc,ord_f)-W_tip*sing(dx,G_tip,
ord_f)#todo sigularity(a), mom = @sig(a,1,2)
    if case == 1:
        rc_f = Rc*sing(dx,tire_len,ord_f)
    else:
        rc_f = Rc*
(sing(dx,tire_len+wheel_base,ord_f)+sing(dx,tire_len,ord_f))
    return react_f - rc_f
```

note case on full front, case on half front,

case on back

In [3]:
```
len_full = 300

# predefined arrays
dx = np.linspace(-1,len_full, 200)
cat_tire_l_arr = np.arange(60,len_full-50,10)
```

In [0]:

In [4]:

```
def run_f(perc=None):
    max_p = [[0,0]]
    react_mat = []

    max_ptip = [[0,0]]
    react_mattip = []
    # loop through locations
    #const
    const_v = Rc*wheel_base+W_tip*(G_tip+G_base)
    const_react = GVWR*(lw1+lw2)/2
    if perc:
        f_arr = [perc]
    else:
        f_arr = cat_tire_l_arr
    for par_v in f_arr:
        if perc:
            p = par_v
            cat_tire_l = (cons_react*p-const_v)/(2*Rc)
        else:
            cat_tire_l = par_v
            p = (2*Rc*cat_tire_l+const_v)/const_react
        if cat_tire_l < a1:
            case = 1
        else:
            case = 2

        # initialize constants for each


        #singularity

        load = lx(0,p,cat_tire_l,case)
        mom = lx(1,p,cat_tire_l,case)

        tip_l = trail(0,p,cat_tire_l,case)
        tip_m = trail(1,p, cat_tire_l,case)
        #, v: {}, m:{}')
        sig = mom/(2*shear_mod)  # stress
        sigtip = tip_m/(2*shear_mod)

        react_mat.append([load, mom, sig])
        max_sig = np.max(np.abs(sig))

        max_p.append([p*1, max_sig*1])  # max stress for this loading
condition and this location

        react_mattip.append([tip_l, tip_m, sigtip])
        max_sigtip = np.max(np.abs(sigtip))

        max_ptip.append([p*1, max_sigtip*1])  # max stress for this loading
condition and this location

    # tabulation of this location, and max of location
    max_p = np.array(max_p)
    m_n = np.argmax(max_p,0)
    m_a = max_p[m_n[1],:]

    # adding to list of all locs
```

```
    # tabulation of this location, and max of location
    max_ptip = np.array(max_ptip)
    m_ntip = np.argmax(max_ptip,0)
    m_atip = max_ptip[m_ntip[1],:]


    # max for each percent, len
    for i in range(max_p.shape[0]-1):
        fis = max_p[i+1,1]
        fs2 = '||||||||||' if fis>= yield_s else ''
        print(f'Dis load loc {round(f_arr[i],1)}(in) at rear load:
{int(max_p[i+1,0]*100)}% = Max \u03C3: {round(fis,2)}(psi):::
{round(fis/1000,1)}(ksi){fs2}')


    print(f'\n--------------------\noverall max at len(in):
{round(f_arr[m_n[1]-1], 2)}, rear load: {int(m_a[0]*100)}%,  \u03C3 =
{round(m_a[1], 2)}(psi)')
    # max for each percent, len
    print(f'\n\n--------------------\ntrailer\n--------------------\n')

    for i in range(max_ptip.shape[0]-1):
        fis = max_ptip[i+1,1]
        fs2 = '||||||||||' if fis>= yield_s else ''
        print(f'Dis load loc {round(f_arr[i],1)}(in) at rear load:
{int(max_ptip[i+1,0]*100)}% = Max \u03C3: {round(fis,2)}(psi):::
{round(fis/1000,1)}(ksi){fs2}')


    print(f'\n--------------------\noverall max at len(in):
{round(f_arr[m_ntip[1]-1], 2)}, rear load: {int(m_atip[0]*100)}%,  \u03C3 =
{round(m_atip[1], 2)}(psi)')
    return react_mat,react_mattip,max_p, f_arr

def plot_x(react_mat,react_mattip,max_p, f_arr):
    # SFD BMD, \u03C3 vs distance for each condition of len,percent
    lft = [react_mat,react_mattip]
    plt_n = ['main', 'tip']
    for ii in range(len(react_mat)):
        fig, ax = plt.subplots(1,2)
        for i in range(2):
            ax[i].grid(True)
            m_half = lft[i][ii]

            ax[i].plot(dx,m_half[0])
            ax[i].plot(dx,m_half[1]*1e-2)
            ax[i].plot(dx,m_half[2]*1e-1)

            ax[i].legend(['Shear (lb)', 'Moment(100*lb*in)', 'Sigma
(10*psi)'])
            ax[i].set_title(f'SFD BMD, \u03C3 allong trailer(in) for current
loading on {plt_n[i]}')
        fig.suptitle(f'Plots for len of load: {round(f_arr[ii],2)}(in) rear
Load:{int(max_p[ii,0]*100)}%')
```

In [5]:

```
#test 1
#constants
yield_s = 50000
shear_mod = 5.61
shear_mod_tip=5.49

GVWR = 16000
```

```
W_tip = 1500 # tare/2
Rc = GVWR/2 - W_tip

lc = 200
a1 = 104


tip_len = 194
base_len = 200

G_base = base_len / 2
G_tip = tip_len / 2 + a1

a2 = a1 + 16
lw1 = lc -21
lw2 = lc +15

wheel_base = 48

react_mat1,react_mattip1,mp,fa = run_f()
plot_x(react_mat1,react_mattip1,mp,fa)
```

Out[5]:
```
Dis load loc 60(in) at rear load: 48% = Max σ: 49889.51(psi)::: 49.9(ksi)
Dis load loc 70(in) at rear load: 53% = Max σ: 49495.41(psi)::: 49.5(ksi)
Dis load loc 80(in) at rear load: 57% = Max σ: 49387.09(psi)::: 49.4(ksi)
Dis load loc 90(in) at rear load: 61% = Max σ: 49579.02(psi)::: 49.6(ksi)
Dis load loc 100(in) at rear load: 65% = Max σ: 49170.45(psi)::: 49.2(ksi)
Dis load loc 110(in) at rear load: 69% = Max σ: 49360.16(psi)::: 49.4(ksi)
Dis load loc 120(in) at rear load: 73% = Max σ: 42302.85(psi)::: 42.3(ksi)
Dis load loc 130(in) at rear load: 77% = Max σ: 35245.55(psi)::: 35.2(ksi)
Dis load loc 140(in) at rear load: 81% = Max σ: 28188.24(psi)::: 28.2(ksi)
Dis load loc 150(in) at rear load: 86% = Max σ: 21130.94(psi)::: 21.1(ksi)
Dis load loc 160(in) at rear load: 90% = Max σ: 14073.63(psi)::: 14.1(ksi)
Dis load loc 170(in) at rear load: 94% = Max σ: 9974.59(psi)::: 10.0(ksi)
Dis load loc 180(in) at rear load: 98% = Max σ: 10410.67(psi)::: 10.4(ksi)
Dis load loc 190(in) at rear load: 102% = Max σ: 10846.76(psi)::: 10.8(ksi)
Dis load loc 200(in) at rear load: 106% = Max σ: 14155.59(psi)::: 14.2(ksi)
Dis load loc 210(in) at rear load: 110% = Max σ: 21212.9(psi)::: 21.2(ksi)
Dis load loc 220(in) at rear load: 114% = Max σ: 28270.2(psi)::: 28.3(ksi)
Dis load loc 230(in) at rear load: 119% = Max σ: 35327.51(psi)::: 35.3(ksi)
Dis load loc 240(in) at rear load: 123% = Max σ: 42384.81(psi)::: 42.4(ksi)

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overall max at len(in): 60, rear load: 48%,  σ = 49889.51(psi)


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trailer
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Dis load loc 60(in) at rear load: 48% = Max σ: 34758.93(psi)::: 34.8(ksi)
Dis load loc 70(in) at rear load: 53% = Max σ: 28966.07(psi)::: 29.0(ksi)
Dis load loc 80(in) at rear load: 57% = Max σ: 27918.33(psi)::: 27.9(ksi)
Dis load loc 90(in) at rear load: 61% = Max σ: 27918.33(psi)::: 27.9(ksi)
Dis load loc 100(in) at rear load: 65% = Max σ: 27918.33(psi)::: 27.9(ksi)
Dis load loc 110(in) at rear load: 69% = Max σ: 8384.72(psi)::: 8.4(ksi)
Dis load loc 120(in) at rear load: 73% = Max σ: 10900.62(psi)::: 10.9(ksi)
Dis load loc 130(in) at rear load: 77% = Max σ: 10692.3(psi)::: 10.7(ksi)
Dis load loc 140(in) at rear load: 81% = Max σ: 10324.0(psi)::: 10.3(ksi)
Dis load loc 150(in) at rear load: 86% = Max σ: 11194.27(psi)::: 11.2(ksi)
Dis load loc 160(in) at rear load: 90% = Max σ: 9048.56(psi)::: 9.0(ksi)
Dis load loc 170(in) at rear load: 94% = Max σ: 10439.68(psi)::: 10.4(ksi)
```

```
Dis load loc 180(in) at rear load: 98% = Max σ: 16232.9(psi)::: 16.2(ksi)
Dis load loc 190(in) at rear load: 102% = Max σ: 22026.13(psi)::: 22.0(ksi)
Dis load loc 200(in) at rear load: 106% = Max σ: 27819.36(psi)::: 27.8(ksi)
Dis load loc 210(in) at rear load: 110% = Max σ: 39306.83(psi)::: 39.3(ksi)
Dis load loc 220(in) at rear load: 114% = Max σ: 50893.28(psi):::
50.9(ksi)||||||||||
Dis load loc 230(in) at rear load: 119% = Max σ: 62479.73(psi):::
62.5(ksi)||||||||||
Dis load loc 240(in) at rear load: 123% = Max σ: 74066.19(psi):::
74.1(ksi)||||||||||

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overall max at len(in): 240, rear load: 123%,  σ = 74066.19(psi)
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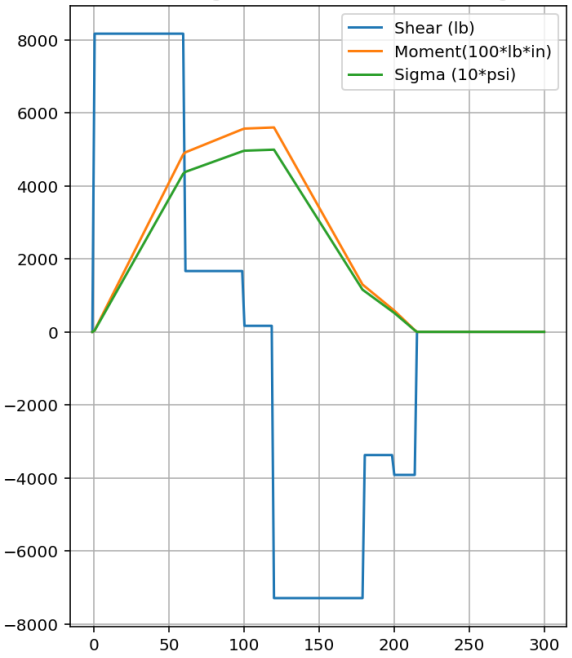
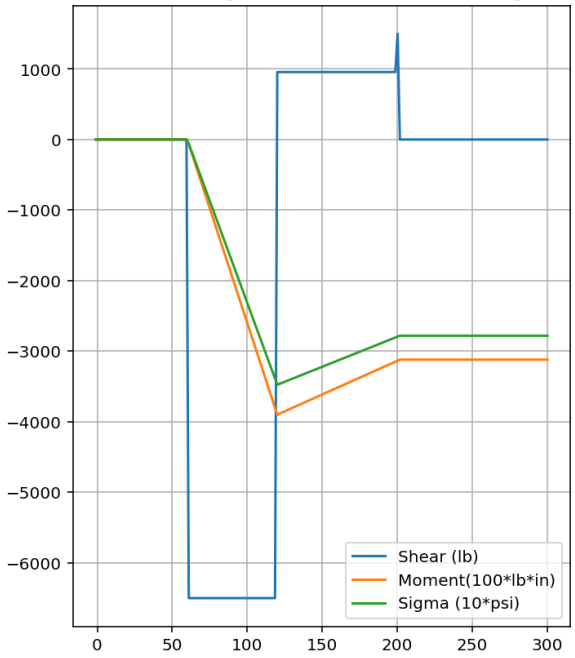
Plots for len of load: 60(in) rear Load:0%

SFD BMD, σ allong trailer(in) for current loading on main

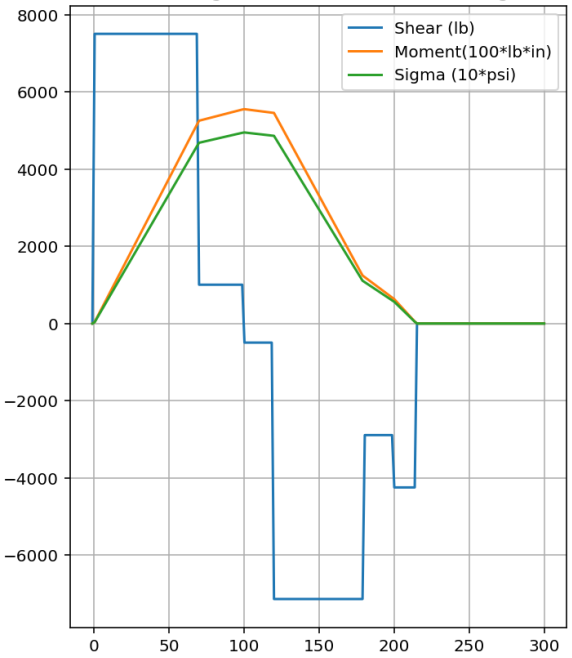


SFD BMD, σ allong trailer(in) for current loading on tip

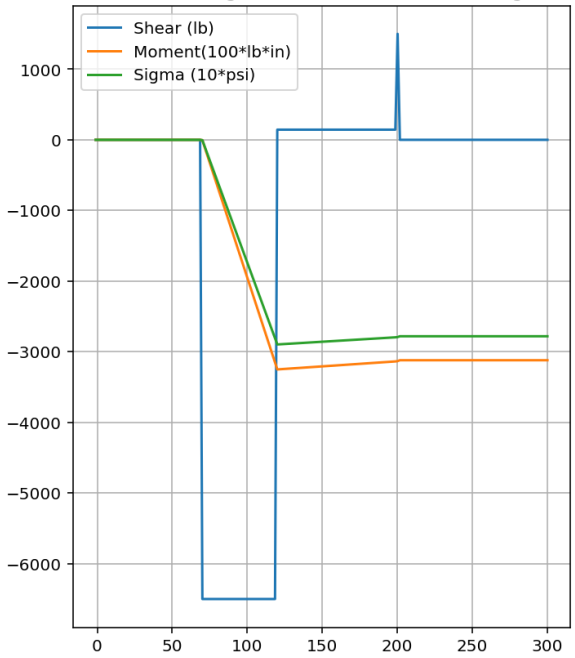


Plots for len of load: 70(in) rear Load:48%

SFD BMD, σ allong trailer(in) for current loading on main

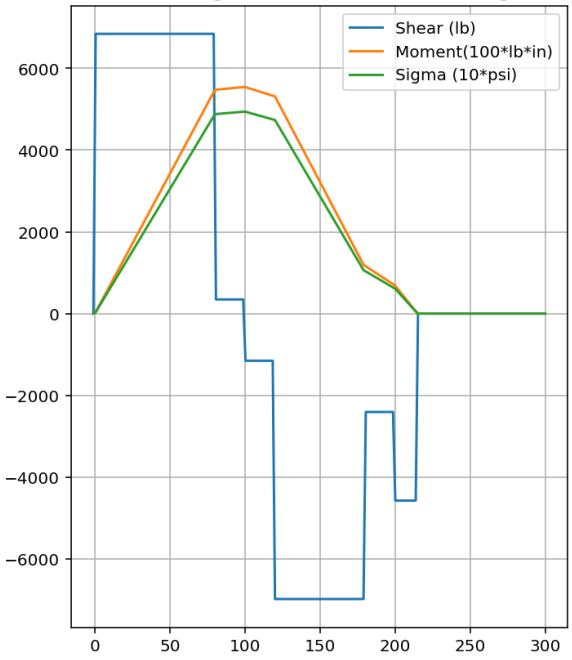


SFD BMD, σ allong trailer(in) for current loading on tip

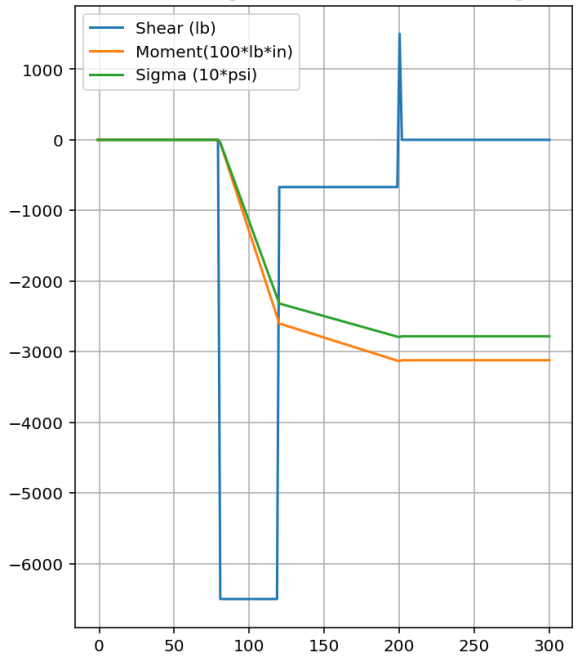


Plots for len of load: 80(in) rear Load:53%

SFD BMD, σ allong trailer(in) for current loading on main

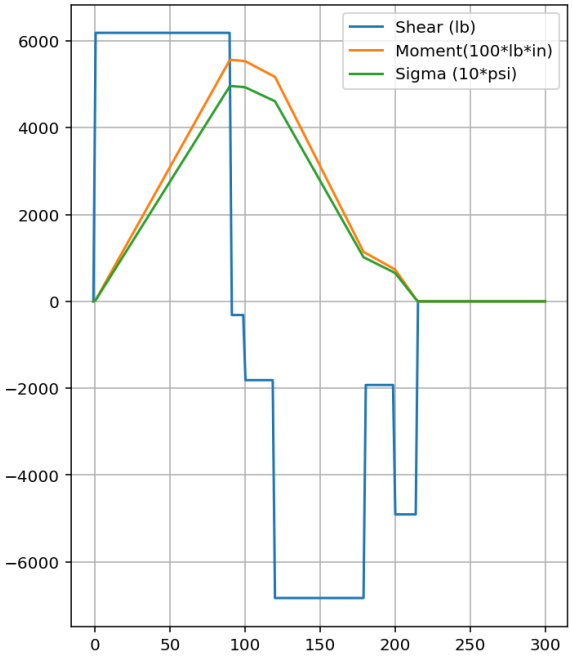


SFD BMD, σ allong trailer(in) for current loading on tip

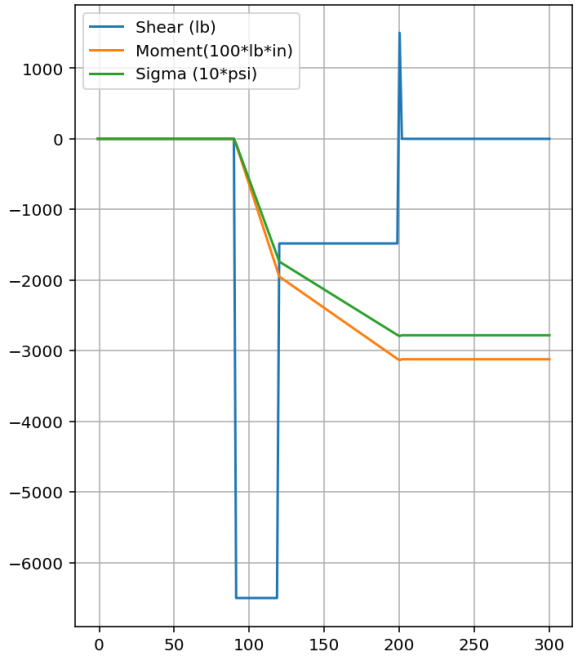


Plots for len of load: 90(in) rear Load:57%

SFD BMD, σ allong trailer(in) for current loading on main

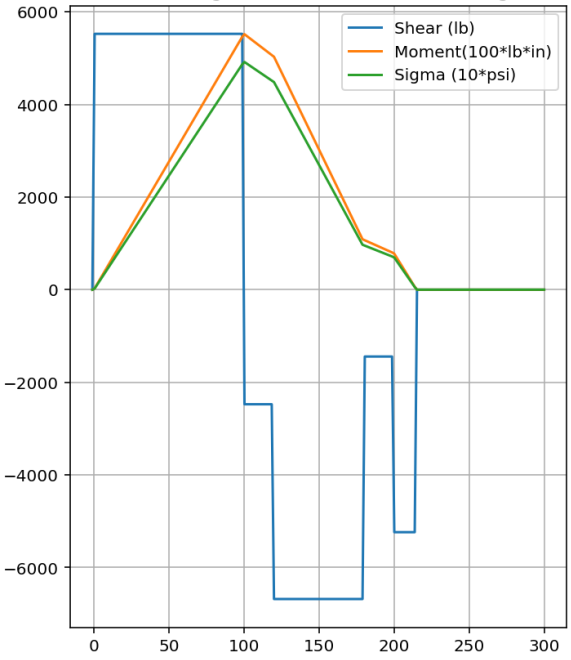


SFD BMD, σ allong trailer(in) for current loading on tip

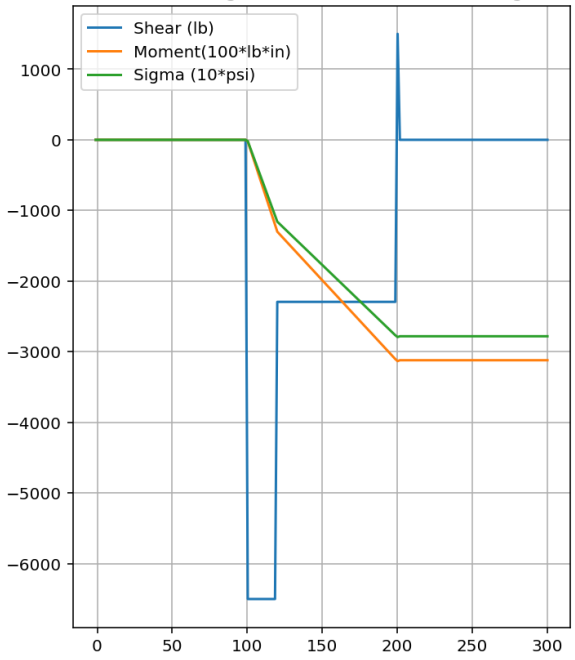


Plots for len of load: 100(in) rear Load:61%

SFD BMD, σ allong trailer(in) for current loading on main

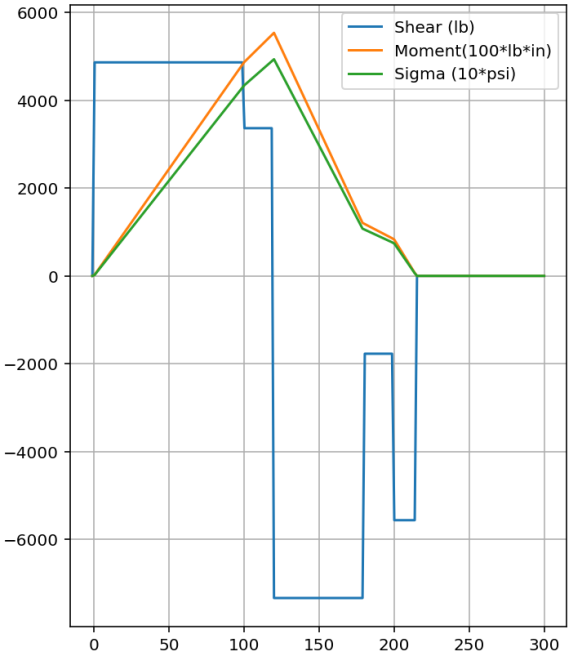


SFD BMD, σ allong trailer(in) for current loading on tip

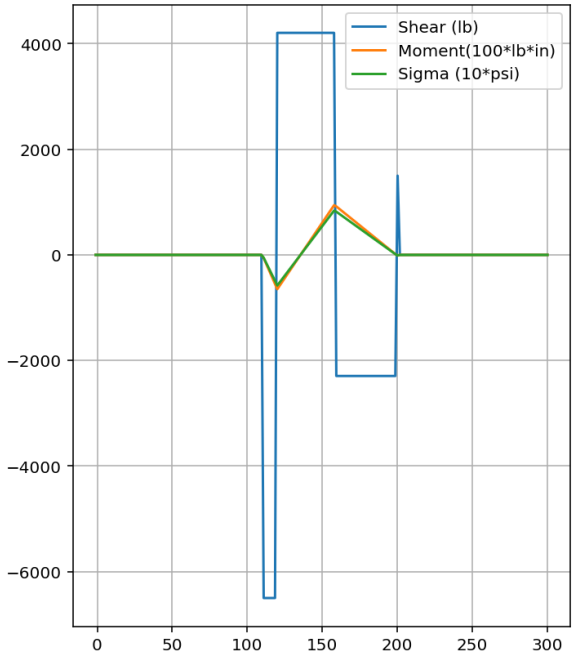


Plots for len of load: 110(in) rear Load:65%

SFD BMD, σ allong trailer(in) for current loading on main

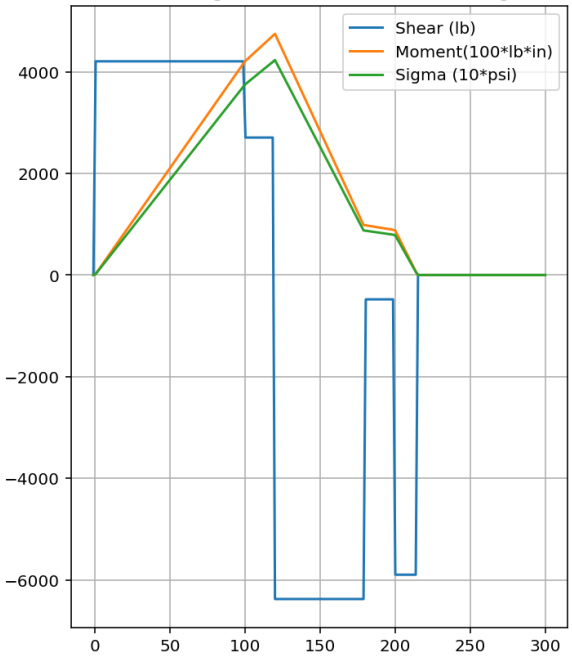


SFD BMD, σ allong trailer(in) for current loading on tip

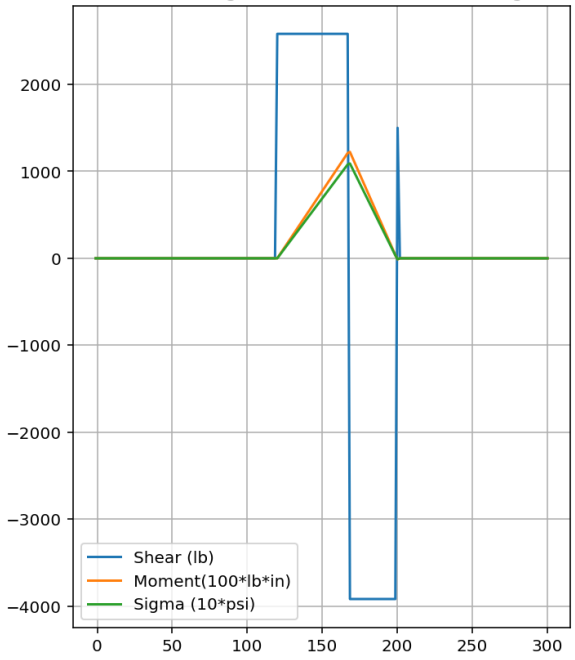


Plots for len of load: 120(in) rear Load:69%

SFD BMD, σ allong trailer(in) for current loading on main

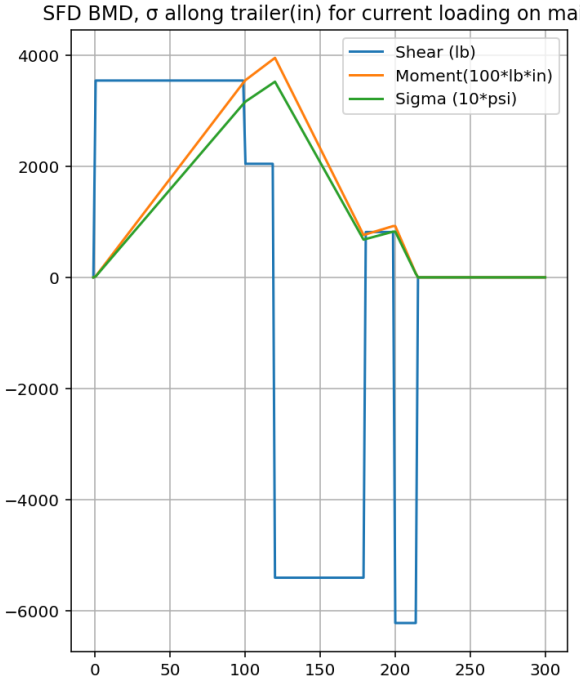


SFD BMD, σ allong trailer(in) for current loading on tip

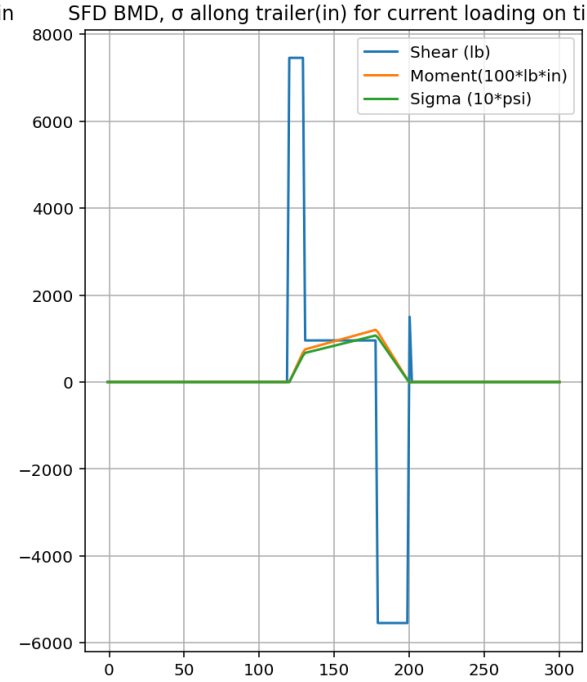


Plots for len of load: 130(in) rear Load:73%

SFD BMD, σ allong trailer(in) for current loading on main

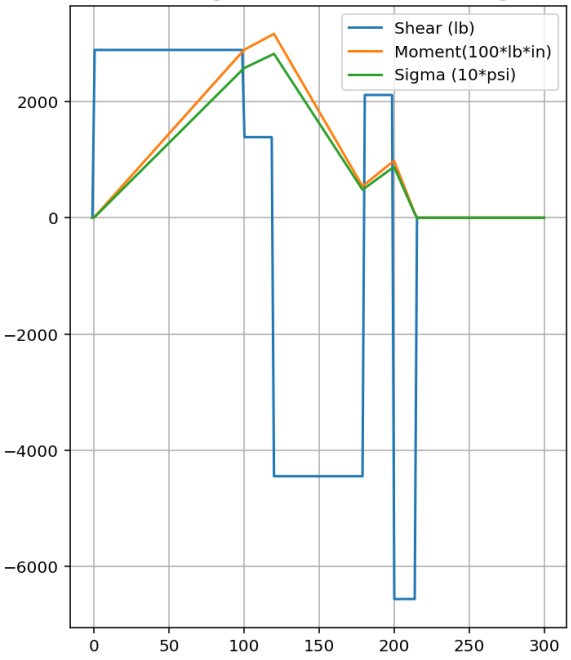


SFD BMD, σ allong trailer(in) for current loading on tip

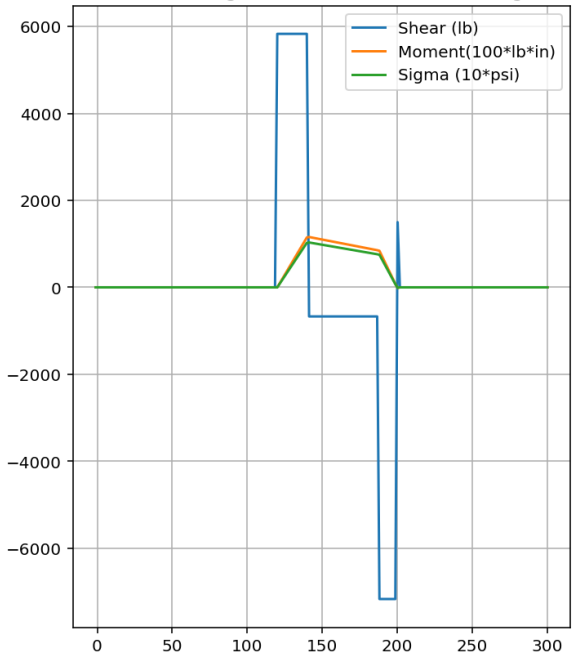


Plots for len of load: 140(in) rear Load:77%

SFD BMD, σ allong trailer(in) for current loading on main

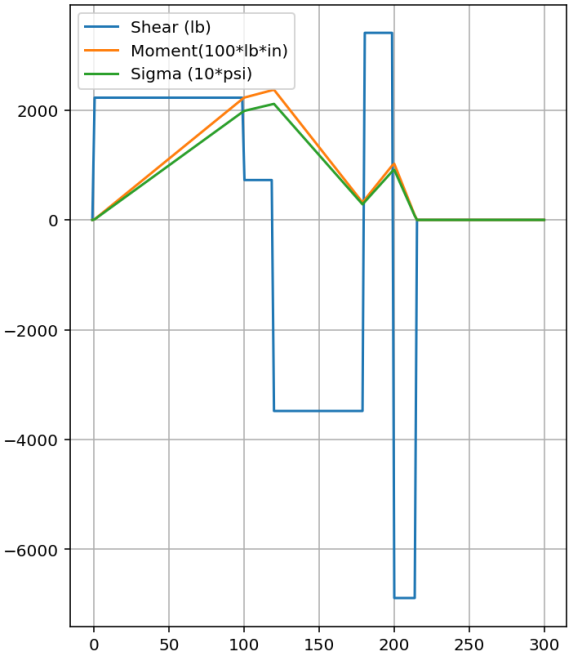


SFD BMD, σ allong trailer(in) for current loading on tip

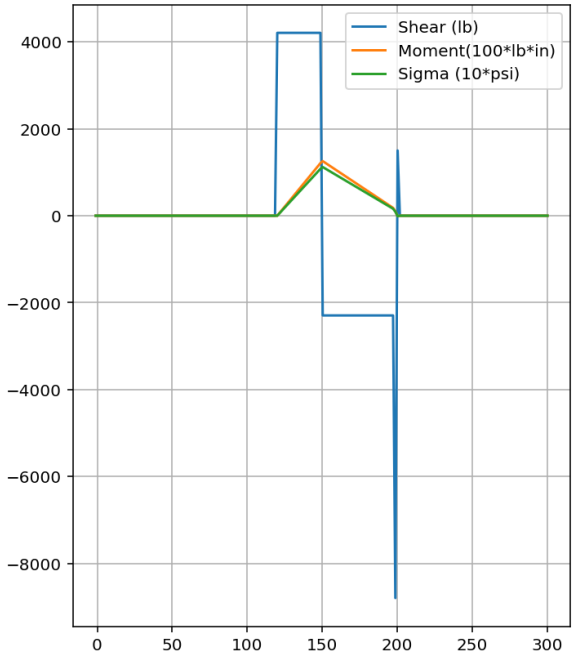


Plots for len of load: 150(in) rear Load:81%

SFD BMD, σ allong trailer(in) for current loading on main

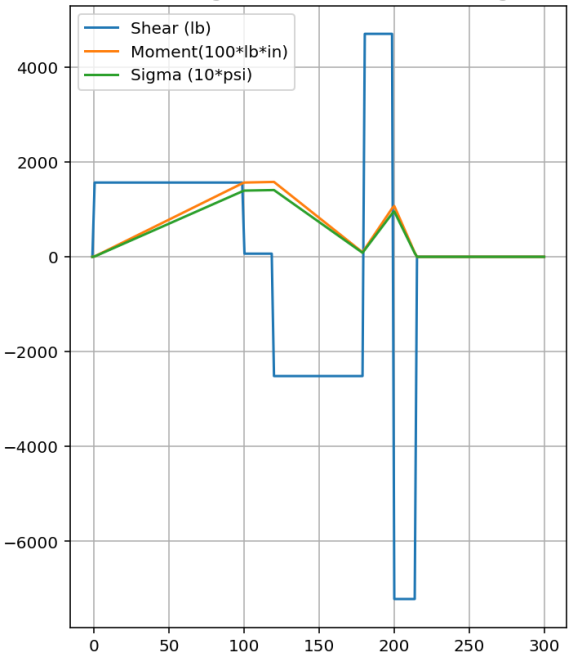


SFD BMD, σ allong trailer(in) for current loading on tip

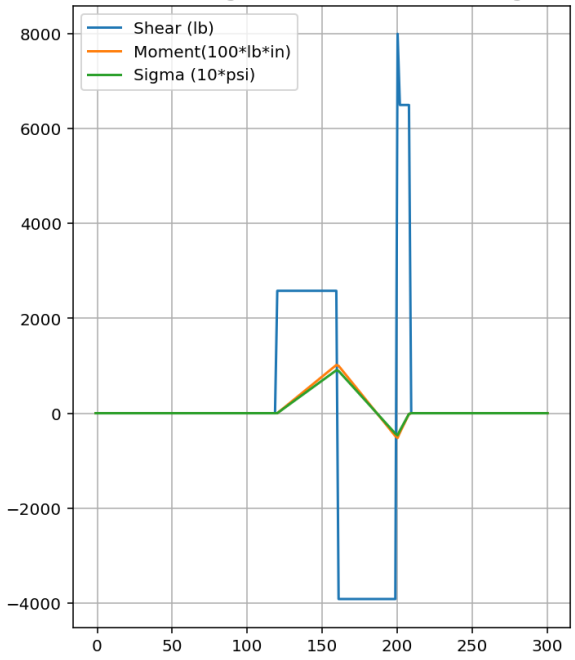


Plots for len of load: 160(in) rear Load:86%

SFD BMD, σ allong trailer(in) for current loading on main

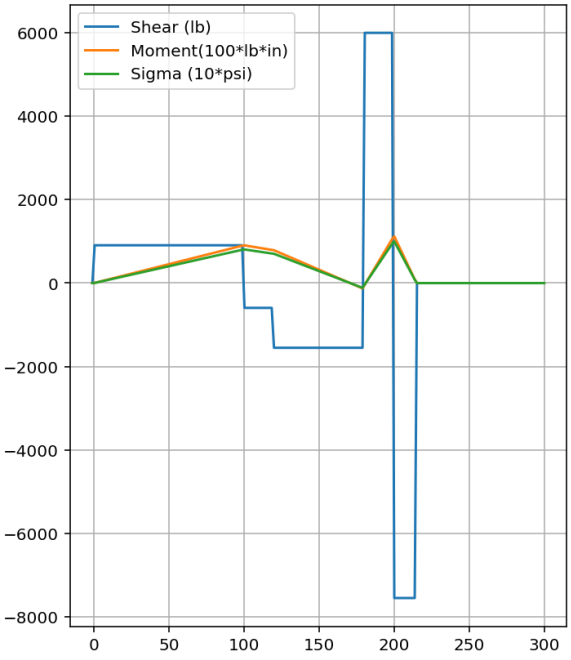


SFD BMD, σ allong trailer(in) for current loading on tip

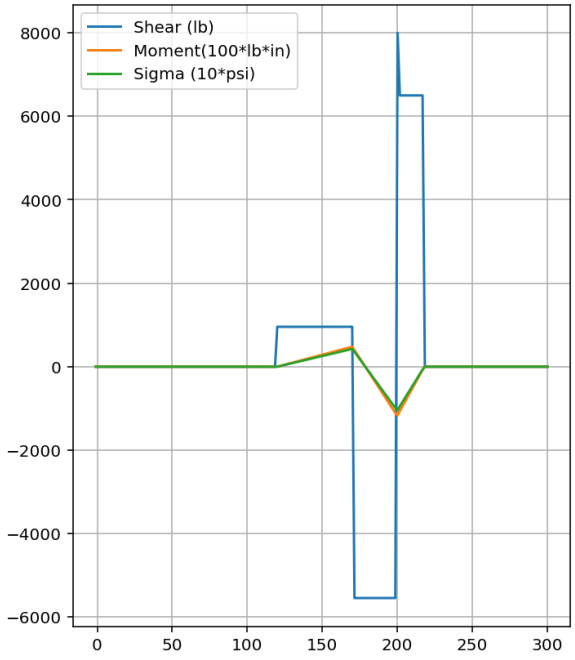


Plots for len of load: 170(in) rear Load:90%

SFD BMD, σ allong trailer(in) for current loading on main

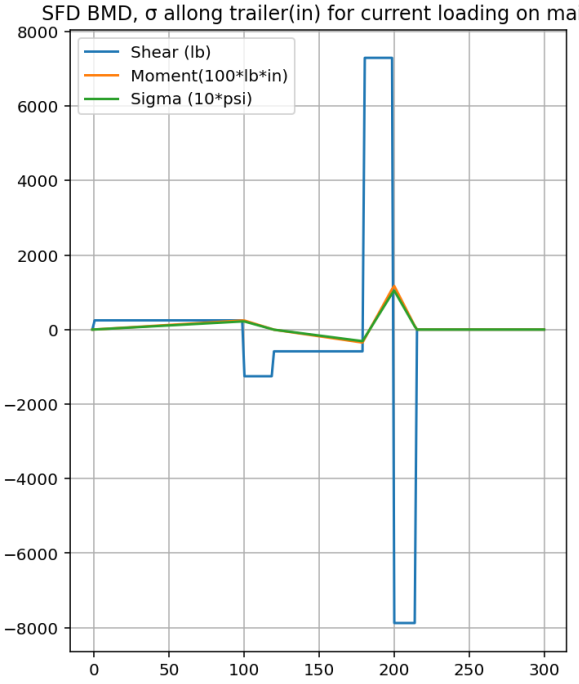


SFD BMD, σ allong trailer(in) for current loading on tip

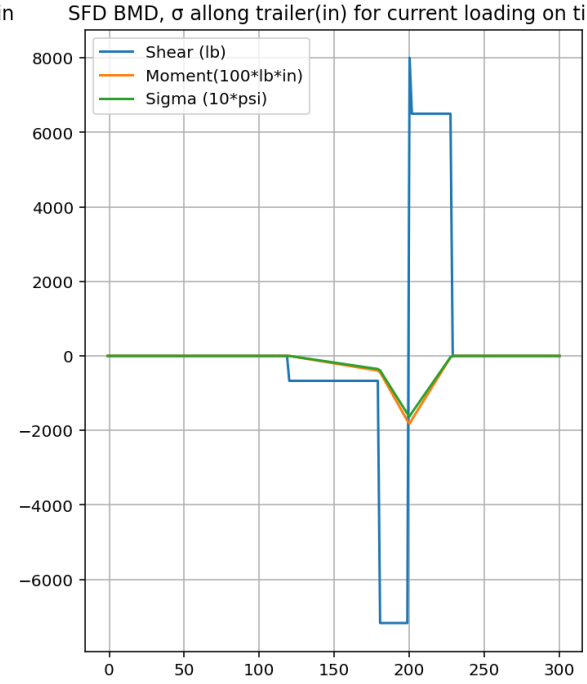


Plots for len of load: 180(in) rear Load:94%

SFD BMD, σ allong trailer(in) for current loading on main

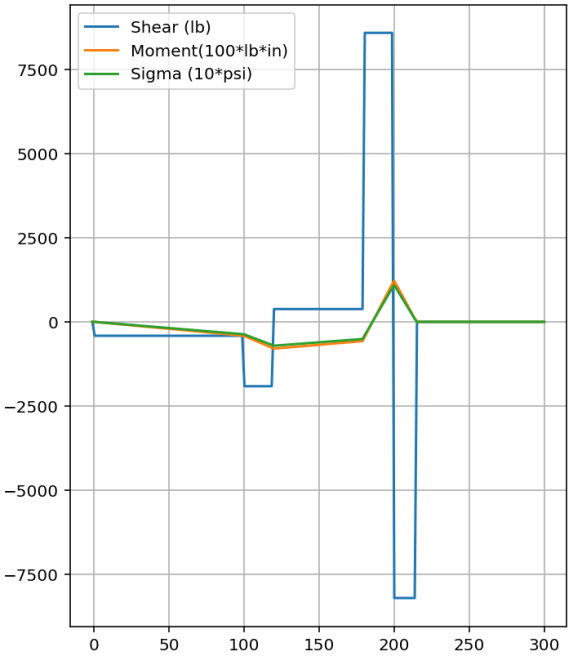


SFD BMD, σ allong trailer(in) for current loading on tip

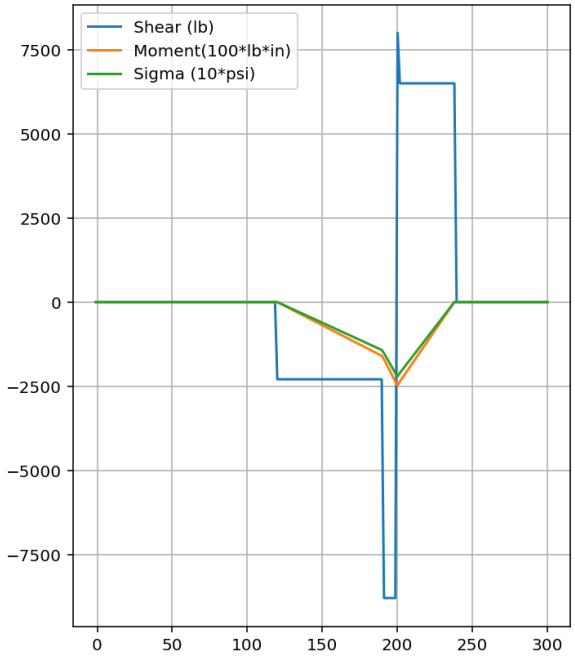


Plots for len of load: 190(in) rear Load:98%

SFD BMD, σ allong trailer(in) for current loading on main

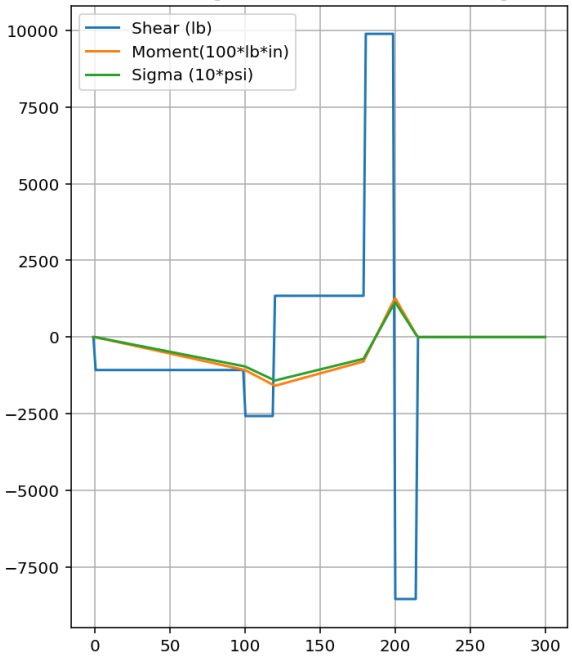


SFD BMD, σ allong trailer(in) for current loading on tip

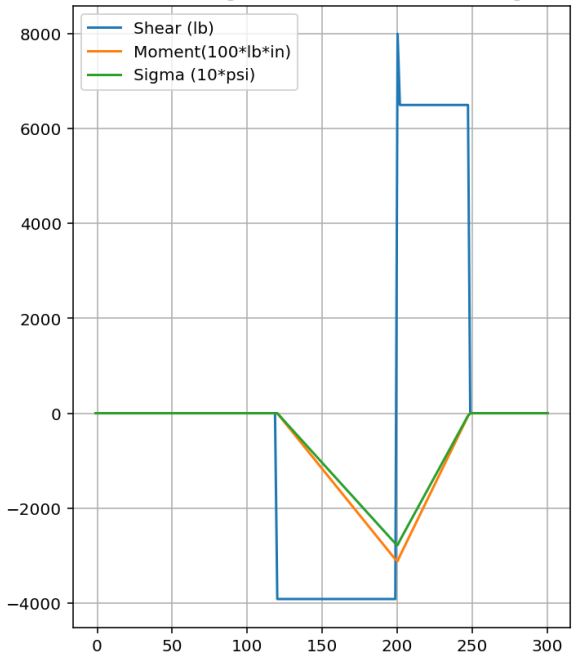


Plots for len of load: 200(in) rear Load:102%

SFD BMD, σ allong trailer(in) for current loading on main

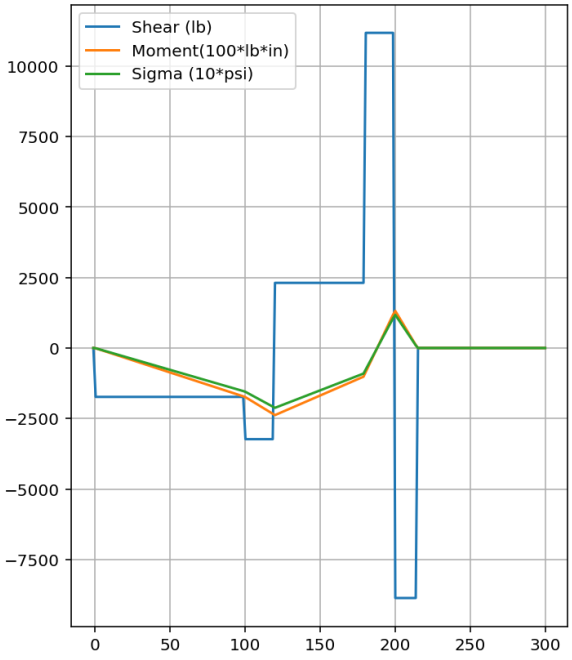


SFD BMD, σ allong trailer(in) for current loading on tip

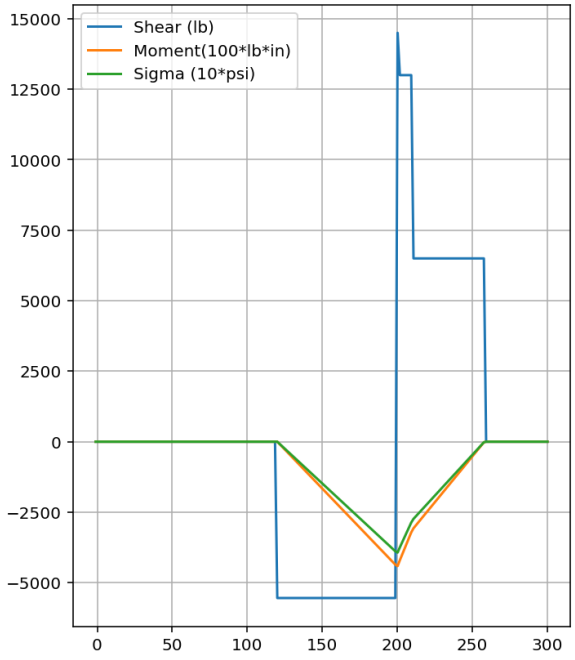


Plots for len of load: 210(in) rear Load:106%

SFD BMD, σ allong trailer(in) for current loading on main

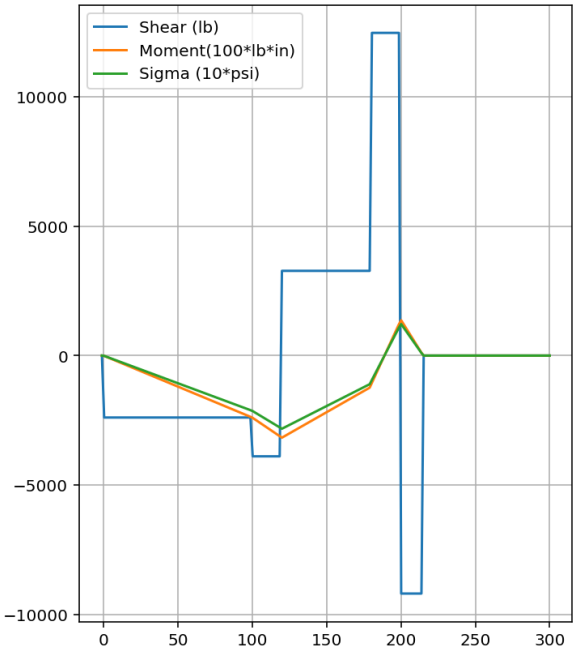


SFD BMD, σ allong trailer(in) for current loading on tip

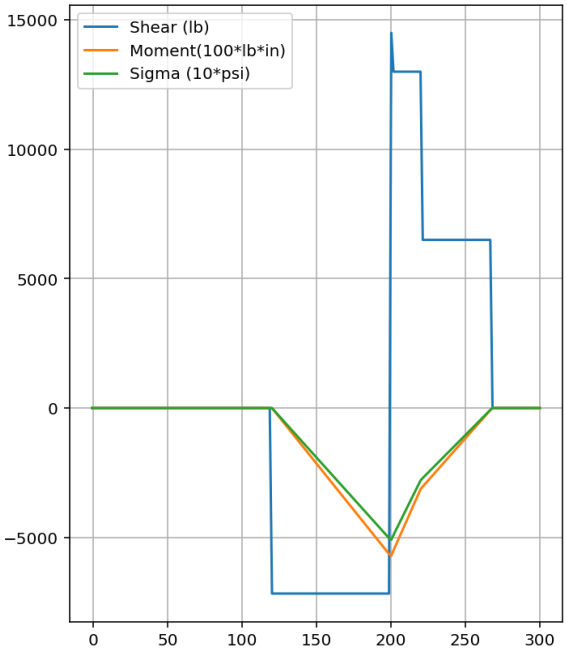


Plots for len of load: 220(in) rear Load:110%

SFD BMD, σ allong trailer(in) for current loading on main

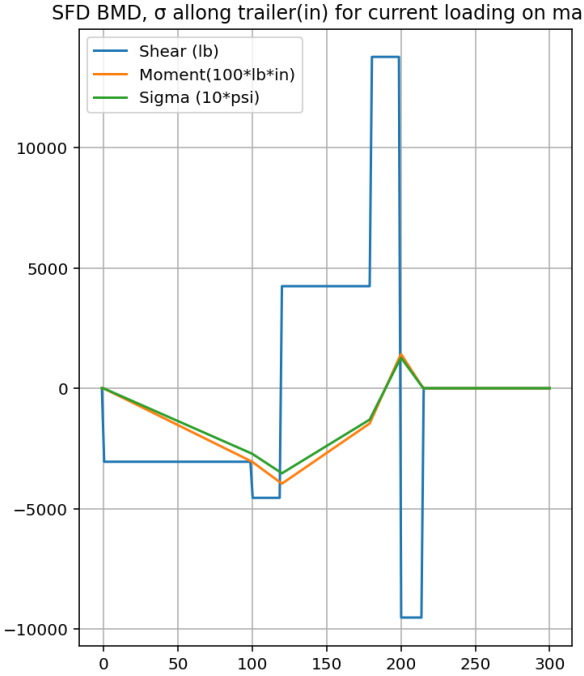


SFD BMD, σ allong trailer(in) for current loading on tip

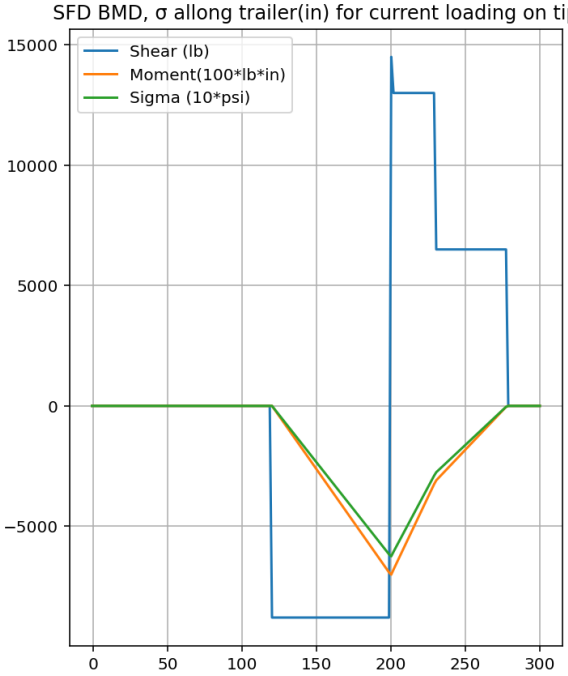


Plots for len of load: 230(in) rear Load:114%

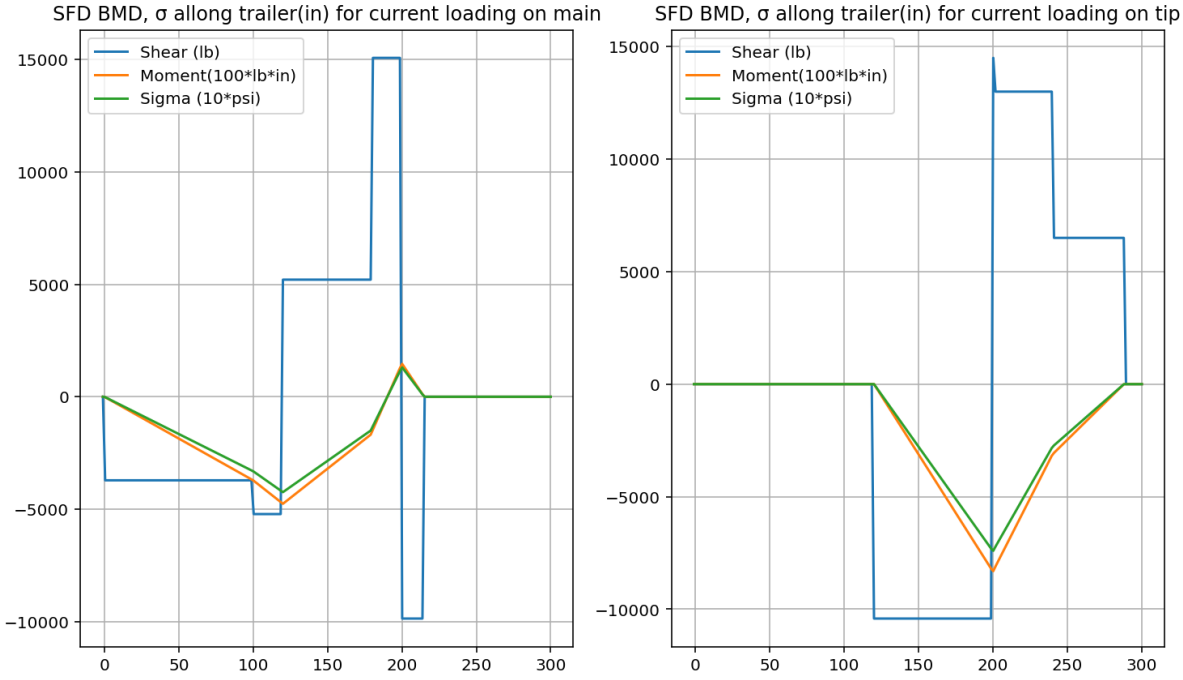
SFD BMD, σ allong trailer(in) for current loading on main



SFD BMD, σ allong trailer(in) for current loading on tip



Plots for len of load: 240(in) rear Load:119%



In [0]: