deformsbook

Jake Grohs

2023-05-30

Table of contents

Preface **3**

1 Strength of Materials Problem Workout **4**

2 Workout Example Solution **37**
2.1 Worked Out Solution 37

3 Summary **39**

References **40**

Preface

This is a Quarto book.

To learn more about Quarto books visit https://quarto.org/docs/books.

```
1 + 1
```

```
[1] 2
```

1 Strength of Materials Problem Workout

To scaffold your learning in this example, we have provided a free body diagram for you and a repeat of the problem statement.

A city planner is installing a new traffic light. Light A weighs 65 lb, while lights B and C weigh 50 lb each. The post at O has a hollow circular cross-section with an outer diameter of 5 inches and a wall thickness of 0.2 inches. Please calculate the magnitude of the maximum combined stress in the post. You may ignore the weight of the post.

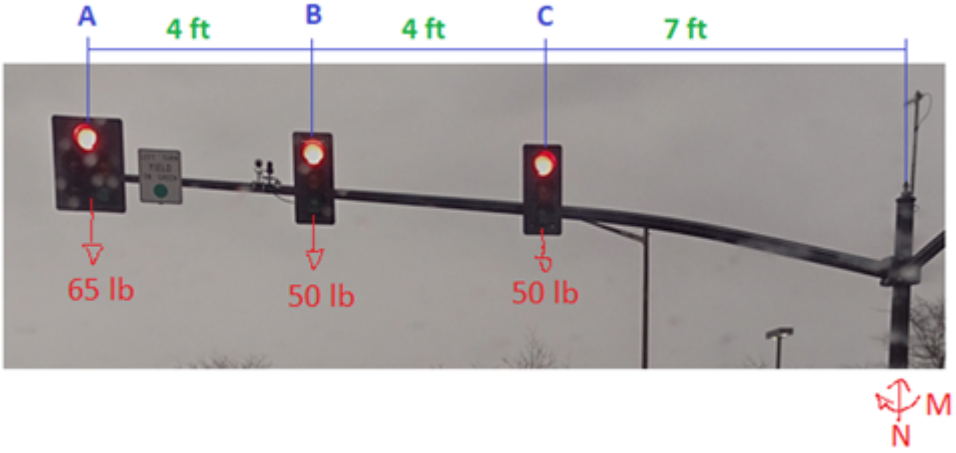

Figure 1.1: Figure 1: Three traffic light installation with loads

Please work through the problem step by step showing your math in the interactive interface here.

```
#| standalone: true
#| viewerHeight: 600
#| components: [viewer]



from shiny import App, render, ui, reactive, req
from sympy import solve, Eq, Symbol
```

```
from sympy.parsing.sympy_parser import parse_expr
from shiny.ui import h4

# load equations lists


class eqn:
    def __init__(self, name, inline_math, newline_math, working_sym, working_eqn_latex,wor
        self.name = name
        self.inline_math = inline_math
        self.newline_math = newline_math
        self.working_sym = working_sym
        self.working_eqn_latex = working_eqn_latex
        self.working_eqn_solver = working_eqn_solver

StaticsSumFx = eqn(
    "Equilibrium Forces in X",
    "\(\Sigma F_x=0\)",
    "$$\Sigma F_x=0$$",
    "SigmaFx",
    "$$F_x1+F_x2+F_x3+F_x4+F_x5=0$$",
    "F_x1+F_x2+F_x3+F_x4+F_x5=0"
)

StaticsSumFy = eqn(
    "Equilibrium Forces in Y",
    "\(\Sigma F_y=0\)",
    "$$\Sigma F_y=0$$",
    "SigmaFy",
    "$$F_y1+F_y2+F_y3+F_y4+F_y5=0$$",
    "F_y1+F_y2+F_y3+F_y4+F_y5=0"
)

StaticsSumM = eqn(
    "Equilibrium Moments about O",
    "\(\Sigma M_O=0\)",
    "$$\Sigma M_O=0$$",
    "SigmaM",
    "$$M_1+M_2+M_3+M_4+M_5=0$$",
    "M_1+M_2+M_3+M_4+M_5=0"
)
```

```
StressEqn = eqn(
    "Stress Equation",
    "\(\sigma=\\frac{F}{A}\)",
    "$$\sigma=\\frac{F}{A}$$",
    "sigma,F,A",
    "$$\sigma=\\frac{(F)}{(A)}$$",
    "Eq(sigma,(F)/(A))"
)

AxialDeform = eqn(
    "Axial Deformation by Force",
    "\(\delta_l=\\frac{P L}{AE}\)",
    "$$\delta_l=\\frac{P\cdot L}{A \cdot E}$$",
    "delta_l,P,L,A,E",
    "$$\delta_l=\\frac{(P)(L)}{(A)(E)}$$",
    "Eq(delta_l,(P)*(L)/(A)/(E))"
)

ThermalDeform = eqn(
    "Axial Deformation by Thermal",
    "\(\delta_t= \\alpha \Delta T L\)",
    "$$\delta_t= \\alpha \cdot \Delta T \cdot L$$",
    "delta_t,alpha,DeltaT,L",
    "$$\delta_t= \\alpha \Delta T L$$",
    "delta_t= alpha*(Delta_T)*L"
)

AreaTube = eqn(
    "Area of a Tube",
    "\(A_{tube}=\pi(r_o^2-r_i^2)\)",
    "$$A_{tube}=\pi(r_o^2-r_i^2)$$",
    "A_tube,r_o,r_i",
    "$$A_{tube}=\pi(r_o^2-r_i^2)$$",
    "Eq(A_tube,pi*((r_o)**2-(r_i)**2))"
)

ITube = eqn(
    "Moment of Inertia of a Tube",
    "\(I_{tube}=\\frac{\pi}{4}(r_o^4-r_i^4)\)",
    "$$I_{tube}=\\frac{\pi}{4}(r_o^4-r_i^4)$$",
    "I_tube,r_o,r_i",
```

```
    "$$I_{tube}=\\frac{\pi}{4}(r_o^4-r_i^4)$$",
    "Eq(I_tube,pi/4*((r_o)**4-(r_i)**4))"
)

BendingStress = eqn(
    "Bending Stress from a Moment",
    "\(\sigma_b=\\frac{M*y}{I}\)",
    "$$\sigma_b=\\frac{M*y}{I}$$",
    "sigma_b,M,y,I,",
    "$$\sigma_b=\\frac{M*y}{I}$$",
    "Eq(sigma_b,M*y/I))"
)

Compatability1 = eqn(
    "Compatability Equation 1",
    "\(a_1+\ldots=b_1+b_2+\ldots\)",
    "$$a_1+\ldots=b_1+b_2+\ldots$$",
    "",
    "$$a_1+a_n=b_1+b_n$$",
    "Eq(a_1+a_n=b_1+b_n)"
)

Compatability2 = eqn(
    "Compatability Equation 2",
    "\(c_1+\ldots=d_1+d_2+\ldots\)",
    "$$c_1+\ldots=d_1+d_2+\ldots$$",
    "",
    "$$c_1+c_n=d_1+d_n$$",
    "Eq(c_1+c_n=d_1+d_n)"
)


statics_eqnbank_inline = {
    StaticsSumFx.name: StaticsSumFx.inline_math,
    StaticsSumFy.name: StaticsSumFy.inline_math,
    StaticsSumM.name: StaticsSumM.inline_math,
}
deforms_eqnbank_inline = {
    StressEqn.name: StressEqn.inline_math,
    AxialDeform.name: AxialDeform.inline_math,
    ThermalDeform.name: ThermalDeform.inline_math,
```

```
}

geom_eqnbank_inline = {
    AreaTube.name: AreaTube.inline_math,
    ITube.name: ITube.inline_math,
}

eqnbank_inline = {
    StaticsSumFx.name: StaticsSumFx.inline_math,
    StaticsSumFy.name: StaticsSumFy.inline_math,
    StaticsSumM.name: StaticsSumM.inline_math,
    StressEqn.name: StressEqn.inline_math,
    BendingStress.name: BendingStress.inline_math,
    AxialDeform.name: AxialDeform.inline_math,
    ThermalDeform.name: ThermalDeform.inline_math,
    AreaTube.name: AreaTube.inline_math,
    ITube.name: ITube.inline_math,
    Compatability1.name: Compatability1.inline_math,
    Compatability2.name: Compatability2.inline_math,
}

eqnbank_newline = {
    StaticsSumFx.name: StaticsSumFx.newline_math,
    StaticsSumFy.name: StaticsSumFy.newline_math,
    StaticsSumM.name: StaticsSumM.newline_math,
    StressEqn.name: StressEqn.newline_math,
    BendingStress.name: BendingStress.newline_math,
    AxialDeform.name: AxialDeform.newline_math,
    ThermalDeform.name: ThermalDeform.newline_math,
    AreaTube.name: AreaTube.newline_math,
    ITube.name: ITube.newline_math,
    Compatability1.name: Compatability1.newline_math,
    Compatability2.name: Compatability2.newline_math,
}



working_equations_solver=reactive.Value([])
working_equations_latex_render=reactive.Value([])
working_symbols=reactive.Value([])
```

```
feedback_equations=reactive.Value([])
feedback_solns=reactive.Value([])
feedback_syms=reactive.Value([])

working_SumFx_render=reactive.Value("")
working_SumFy_render=reactive.Value("")
working_SumM_render=reactive.Value("")
working_StressEqn_render=reactive.Value("")
working_BendingStress_render=reactive.Value("")
working_AxialDeform_render=reactive.Value("")
working_ThermalDeform_render=reactive.Value("")
working_AreaTube_render=reactive.Value("")
working_Itube_render=reactive.Value("")
working_Compatability1_render=reactive.Value("")
working_Compatability2_render=reactive.Value("")

working_SumFx_string=reactive.Value("")
working_SumFy_string=reactive.Value("")
working_SumM_string=reactive.Value("")
working_StressEqn_string=reactive.Value("")
working_BendingStress_string=reactive.Value("")
working_AxialDeform_string=reactive.Value("")
working_ThermalDeform_string=reactive.Value("")
working_AreaTube_string=reactive.Value("")
working_Itube_string=reactive.Value("")
working_Compatability1_string=reactive.Value("")
working_Compatability2_string=reactive.Value("")

NumForcesY=reactive.Value(2)
F1y=reactive.Value("")
F2y=reactive.Value("")
F3y=reactive.Value("")
F4y=reactive.Value("")
F5y=reactive.Value("")
Equil_latex=reactive.Value("")

NumForcesX=reactive.Value(2)
F1x=reactive.Value("")
F2x=reactive.Value("")
F3x=reactive.Value("")
F4x=reactive.Value("")
```

```
F5x=reactive.Value("")

NumMoments=reactive.Value(2)
M1=reactive.Value("")
M2=reactive.Value("")
M3=reactive.Value("")
M4=reactive.Value("")
M5=reactive.Value("")

axial_stress_sigma=reactive.Value("")
axial_stress_force=reactive.Value("")
axial_stress_area=reactive.Value("")

bending_stress_sigma=reactive.Value("")
bending_stress_M=reactive.Value("")
bending_stress_y=reactive.Value("")
bending_stress_I=reactive.Value("")

axial_delta_l=reactive.Value("")
axial_P=reactive.Value("")
axial_L=reactive.Value("")
axial_A=reactive.Value("")
axial_E=reactive.Value("")

thermal_delta_t=reactive.Value("")
thermal_alpha=reactive.Value("")
thermal_Delta_T=reactive.Value("")
thermal_L=reactive.Value("")

area_tube_A_tube=reactive.Value("")
area_tube_Ar_o=reactive.Value("")
area_tube_Ar_i=reactive.Value("")

I_tube_I_tube=reactive.Value("")
I_tube_Ir_o=reactive.Value("")
i_tube_Ir_i=reactive.Value("")

Compatability1_NumLHS=reactive.Value(1)
Compatability1_NumRHS=reactive.Value(2)
Compatability1_a_1=reactive.Value("")
Compatability1_a_2=reactive.Value("")
```

```
Compatability1_a_3=reactive.Value("")
Compatability1_a_4=reactive.Value("")
Compatability1_a_5=reactive.Value("")
Compatability1_b_1=reactive.Value("")
Compatability1_b_2=reactive.Value("")
Compatability1_b_3=reactive.Value("")
Compatability1_b_4=reactive.Value("")
Compatability1_b_5=reactive.Value("")

Compatability2_NumLHS=reactive.Value(1)
Compatability2_NumRHS=reactive.Value(2)
Compatability2_c_1=reactive.Value("")
Compatability2_c_2=reactive.Value("")
Compatability2_c_3=reactive.Value("")
Compatability2_c_4=reactive.Value("")
Compatability2_c_5=reactive.Value("")
Compatability2_d_1=reactive.Value("")
Compatability2_d_2=reactive.Value("")
Compatability2_d_3=reactive.Value("")
Compatability2_d_4=reactive.Value("")
Compatability2_d_5=reactive.Value("")

active_eqn_tab=reactive.Value("Instructions")

app_ui = ui.page_fluid(
    ui.head_content(
        ui.tags.script(
            src="https://mathjax.rstudio.com/latest/MathJax.js?config=TeX-AMS-MML_HTMLorMM
        ),
        ui.tags.script(
            "if (window.MathJax) MathJax.Hub.Queue(['Typeset', MathJax.Hub]);"
        ),
    ),
    ui.panel_title("Interactive Problem Solving Environment"),
        ui.row(
            ui.markdown("Your Equation Workspace"),
            ui.column(3,ui.output_ui("dyn_eqns"),style='margin-bottom:30 px;border-right:1
            ui.column(9,ui.output_ui("dyn_working_eqns"),ui.output_text("txt")),
        ),
        ui.row(ui.output_ui("ui_equation_bookkeeping")),
        #ui.row(ui.input_action_button(
```

```
        #            "solveEquations", "Solve Equations", class_="btn-success", width="240
        #      ),
        ui.output_ui("ui_solutions"),
        ui.row(
            ui.column(8,ui.output_ui("dyn_ui_nav")),
            ui.column(4,
                ui.navset_tab_card(
                    ui.nav("Equation Bank",
                        ui.input_checkbox_group("selected_eqns","Choose your equations:",e
                        ),
                    ),
                ),
            ),
        ),
)


def server(input, output, session):

    @output
    @render.ui
    def dyn_eqns():
        eqns_keys = input.selected_eqns()
        req(eqns_keys)
        lookup_eqns = [eqnbank_newline[key] for key in eqns_keys]
        mystring_eqns = "".join(lookup_eqns)
        feedback_equations.set(lookup_eqns)

        return [
            ui.markdown(mystring_eqns),
            ui.tags.script(
                "if (window.MathJax) MathJax.Hub.Queue(['Typeset', MathJax.Hub]);"
            ),
        ]

    @output
    @render.ui
    def dyn_working_eqns():
        eqns_keys = input.selected_eqns()
        req(eqns_keys)
        lookup_eqns = [eqnbank_newline[key] for key in eqns_keys]
```

```
# Dynamic Filling of Force equations
if StaticsSumFy.newline_math in lookup_eqns:
    StaticsSumFy_list = ["F_y1","F_y2","F_y3","F_y4","F_y5"]
    StaticsSumFy_list = StaticsSumFy_list[:input.NumForcesY()]
    StaticsSumFy.working_sym = ",".join(StaticsSumFy_list)
    StaticsSumFy.working_eqn_latex = "$$" + "+".join(StaticsSumFy_list) + "=0$$"
    StaticsSumFy.working_eqn_solver = "+".join(StaticsSumFy_list)

    if str(input.F1y()) != "" :
        StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F
        StaticsSumFy.working_sym = StaticsSumFy.working_sym.replace("F_y1",str(inp
        StaticsSumFy.working_eqn_solver = StaticsSumFy.working_eqn_solver.replace(
    else:
        StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F

    if str(input.F2y()) != "" :
        StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F
        StaticsSumFy.working_sym = StaticsSumFy.working_sym.replace("F_y2",str(inp
        StaticsSumFy.working_eqn_solver = StaticsSumFy.working_eqn_solver.replace(
    else:
        StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F

    if str(input.F3y()) != "" :
        StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F
        StaticsSumFy.working_sym = StaticsSumFy.working_sym.replace("F_y3",str(inp
        StaticsSumFy.working_eqn_solver = StaticsSumFy.working_eqn_solver.replace(
    else:
        StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F

    if str(input.F4y()) != "" :
        StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F
        StaticsSumFy.working_sym = StaticsSumFy.working_sym.replace("F_y4",str(inp
        StaticsSumFy.working_eqn_solver = StaticsSumFy.working_eqn_solver.replace(
    else:
        StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F

    if str(input.F5y()) != "" :
        StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F
        StaticsSumFy.working_sym = StaticsSumFy.working_sym.replace("F_y5",str(inp
        StaticsSumFy.working_eqn_solver = StaticsSumFy.working_eqn_solver.replace(
```

```
            else:
                StaticsSumFy.working_eqn_latex = StaticsSumFy.working_eqn_latex.replace("F

    # Dynamic Filling of Force equations
          if StaticsSumFx.newline_math in lookup_eqns:
                StaticsSumFx_list = ["F_x1","F_x2","F_x3","F_x4","F_x5"]
                StaticsSumFx_list = StaticsSumFx_list[:input.NumForcesX()]
                StaticsSumFx.working_sym = ",".join(StaticsSumFx_list)
                StaticsSumFx.working_eqn_latex = "$$" + "+".join(StaticsSumFx_list) + "=0$$"
                StaticsSumFx.working_eqn_solver = "+".join(StaticsSumFx_list)

                if str(input.F1x()) != "" :
                    StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F
                    StaticsSumFx.working_sym = StaticsSumFx.working_sym.replace("F_x1",str(inp
                    StaticsSumFx.working_eqn_solver = StaticsSumFx.working_eqn_solver.replace(
                else:
                    StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F

                if str(input.F2x()) != "" :
                    StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F
                    StaticsSumFx.working_sym = StaticsSumFx.working_sym.replace("F_x2",str(inp
                    StaticsSumFx.working_eqn_solver = StaticsSumFx.working_eqn_solver.replace(
                else:
                    StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F

                if str(input.F3x()) != "" :
                    StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F
                    StaticsSumFx.working_sym = StaticsSumFx.working_sym.replace("F_x3",str(inp
                    StaticsSumFx.working_eqn_solver = StaticsSumFx.working_eqn_solver.replace(
                else:
                    StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F

                if str(input.F4x()) != "" :
                    StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F
                    StaticsSumFx.working_sym = StaticsSumFx.working_sym.replace("F_x4",str(inp
                    StaticsSumFx.working_eqn_solver = StaticsSumFx.working_eqn_solver.replace(
                else:
                    StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F

                if str(input.F5x()) != "" :
                    StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F
```

```
        StaticsSumFx.working_sym = StaticsSumFx.working_sym.replace("F_x5",str(inp
        StaticsSumFx.working_eqn_solver = StaticsSumFx.working_eqn_solver.replace(
    else:
        StaticsSumFx.working_eqn_latex = StaticsSumFx.working_eqn_latex.replace("F


# Dynamic Filling of Moment equations
if StaticsSumM.newline_math in lookup_eqns:
    StaticsSumM_list = ["M_1","M_2","M_3","M_4","M_5"]
    StaticsSumM_list = StaticsSumM_list[:input.NumMoments()]
    StaticsSumM.working_sym = ",".join(StaticsSumM_list)
    StaticsSumM.working_eqn_latex = "$$" + "+".join(StaticsSumM_list) + "=0$$"
    StaticsSumM.working_eqn_solver = "+".join(StaticsSumM_list)

    if str(input.M1()) != "" :
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_1
        StaticsSumM.working_sym = StaticsSumM.working_sym.replace("M_1",str(input.
        StaticsSumM.working_eqn_solver = StaticsSumM.working_eqn_solver.replace("M
    else:
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_1

    if str(input.M2()) != "" :
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_2
        StaticsSumM.working_sym = StaticsSumM.working_sym.replace("M_2",str(input.
        StaticsSumM.working_eqn_solver = StaticsSumM.working_eqn_solver.replace("M
    else:
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_2

    if str(input.M3()) != "" :
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_3
        StaticsSumM.working_sym = StaticsSumM.working_sym.replace("M_3",str(input.
        StaticsSumM.working_eqn_solver = StaticsSumM.working_eqn_solver.replace("M
    else:
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_3

    if str(input.M4()) != "" :
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_4
        StaticsSumM.working_sym = StaticsSumM.working_sym.replace("M_4",str(input.
        StaticsSumM.working_eqn_solver = StaticsSumM.working_eqn_solver.replace("M
    else:
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_4
```

```
    if str(input.M5()) != "" :
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_5
        StaticsSumM.working_sym = StaticsSumM.working_sym.replace("M_5",str(input.
        StaticsSumM.working_eqn_solver = StaticsSumM.working_eqn_solver.replace("M
    else:
        StaticsSumM.working_eqn_latex = StaticsSumM.working_eqn_latex.replace("M_5


# Dynamic Filling of A equations
if AreaTube.newline_math in lookup_eqns:
    AreaTube.working_eqn_latex = AreaTube.newline_math
    AreaTube.working_eqn_solver = "Eq(A_tube,pi*((r_o)**2-(r_i)**2))"
    AreaTube.working_sym = "A_tube,r_o,r_i"

    if str(input.A_tube()) != "" :
        AreaTube.working_eqn_latex = AreaTube.working_eqn_latex.replace("A_{tube}"
        AreaTube.working_sym = AreaTube.working_sym.replace("A_tube",str(input.A_t
        AreaTube.working_eqn_solver = AreaTube.working_eqn_solver.replace("A_tube"
    else:
        AreaTube.working_eqn_latex = AreaTube.working_eqn_latex.replace("A_{tube}"
    if str(input.Ar_o()) != "" :
        AreaTube.working_eqn_latex = AreaTube.working_eqn_latex.replace("r_o",str(
        AreaTube.working_sym = AreaTube.working_sym.replace("r_o",str(input.Ar_o()
        AreaTube.working_eqn_solver = AreaTube.working_eqn_solver.replace("r_o",st
    else:
        AreaTube.working_eqn_latex = AreaTube.working_eqn_latex.replace("r_o","\\b
    if str(input.Ar_i()) != "" :
        AreaTube.working_eqn_latex = AreaTube.working_eqn_latex.replace("r_i",str(
        AreaTube.working_sym = AreaTube.working_sym.replace("r_i",str(input.Ar_i()
        AreaTube.working_eqn_solver = AreaTube.working_eqn_solver.replace("r_i",st
    else:
        AreaTube.working_eqn_latex = AreaTube.working_eqn_latex.replace("r_i","\\b

# Dynamic Filling of I equations
if ITube.newline_math in lookup_eqns:
    ITube.working_eqn_latex = ITube.newline_math
    ITube.working_eqn_solver = "Eq(I_tube,pi/4*((r_o)**4-(r_i)**4))"
    ITube.working_sym = "I_tube,r_o,r_i"
    if str(input.I_tube()) != "" :
        ITube.working_eqn_latex = ITube.working_eqn_latex.replace("I_{tube}",str(i
        ITube.working_sym = ITube.working_sym.replace("I_tube",str(input.I_tube())
```

```
            ITube.working_eqn_solver = ITube.working_eqn_solver.replace("I_tube",str(i
        else:
            ITube.working_eqn_latex = ITube.working_eqn_latex.replace("I_{tube}","\\bo
        if str(input.Ir_o()) != "" :
            ITube.working_eqn_latex = ITube.working_eqn_latex.replace("r_o",str(input.
            ITube.working_sym = ITube.working_sym.replace("r_o",str(input.Ir_o()))
            ITube.working_eqn_solver = ITube.working_eqn_solver.replace("r_o",str(inpu
        else:
            ITube.working_eqn_latex = ITube.working_eqn_latex.replace("r_o","\\boxed{r
        if str(input.Ir_i()) != "" :
            ITube.working_eqn_latex = ITube.working_eqn_latex.replace("r_i",str(input.
            ITube.working_sym = ITube.working_sym.replace("r_i",str(input.Ir_i()))
            ITube.working_eqn_solver = ITube.working_eqn_solver.replace("r_i",str(inpu
        else:
            ITube.working_eqn_latex = ITube.working_eqn_latex.replace("r_i","\\boxed{r

    # Dynamic Filling of Stress equation
    if StressEqn.newline_math in lookup_eqns:
        StressEqn.working_eqn_latex = StressEqn.newline_math
        StressEqn.working_eqn_solver = "Eq(sigma,(F)/(A))"
        StressEqn.working_sym = "sigma,F,A"
        if str(input.sigma()) != "" :
            StressEqn.working_eqn_latex = StressEqn.working_eqn_latex.replace("\sigma"
            StressEqn.working_eqn_solver = StressEqn.working_eqn_solver.replace("sigma
            StressEqn.working_sym = StressEqn.working_sym.replace("sigma",str(input.si
        else:
            StressEqn.working_eqn_latex = StressEqn.working_eqn_latex.replace("\sigma"
        if str(input.force()) != "" :
            StressEqn.working_eqn_latex = StressEqn.working_eqn_latex.replace("F",str(
            StressEqn.working_eqn_solver = StressEqn.working_eqn_solver.replace("F",st
            StressEqn.working_sym = StressEqn.working_sym.replace("F",str(input.force(
        else:
            StressEqn.working_eqn_latex = StressEqn.working_eqn_latex.replace("F","\\b
        if str(input.area()) != "" :
            StressEqn.working_eqn_latex = StressEqn.working_eqn_latex.replace("A",str(
            StressEqn.working_eqn_solver = StressEqn.working_eqn_solver.replace("A",st
            StressEqn.working_sym = StressEqn.working_sym.replace("A",str(input.area()
        else:
            StressEqn.working_eqn_latex = StressEqn.working_eqn_latex.replace("A","\\b
```

```
# Dynamic Filling of Bending Stress equation
if BendingStress.newline_math in lookup_eqns:
    BendingStress.working_eqn_latex = BendingStress.newline_math
    BendingStress.working_eqn_solver = "Eq(sigma_b,M*y/I)"
    BendingStress.working_sym = "sigma_b,M,y,I"
    if str(input.bendingstress_sigma_b()) != "" :
        BendingStress.working_eqn_latex = BendingStress.working_eqn_latex.replace(
        BendingStress.working_eqn_solver = BendingStress.working_eqn_solver.replac
        BendingStress.working_sym = BendingStress.working_sym.replace("sigma_b",st
    else:
        BendingStress.working_eqn_latex = BendingStress.working_eqn_latex.replace(
    if str(input.bendingstress_M()) != "" :
        BendingStress.working_eqn_latex = BendingStress.working_eqn_latex.replace(
        BendingStress.working_eqn_solver = BendingStress.working_eqn_solver.replac
        BendingStress.working_sym = BendingStress.working_sym.replace("M",str(inpu
    else:
        BendingStress.working_eqn_latex = BendingStress.working_eqn_latex.replace(
    if str(input.bendingstress_y()) != "" :
        BendingStress.working_eqn_latex = BendingStress.working_eqn_latex.replace(
        BendingStress.working_eqn_solver = BendingStress.working_eqn_solver.replac
        BendingStress.working_sym = BendingStress.working_sym.replace("y",str(inpu
    else:
        BendingStress.working_eqn_latex = BendingStress.working_eqn_latex.replace(
    if str(input.bendingstress_I()) != "" :
        BendingStress.working_eqn_latex = BendingStress.working_eqn_latex.replace(
        BendingStress.working_eqn_solver = BendingStress.working_eqn_solver.replac
        BendingStress.working_sym = BendingStress.working_sym.replace("I",str(inpu
    else:
        BendingStress.working_eqn_latex = BendingStress.working_eqn_latex.replace(


# Dynamic Filling of Axial Deform equation
if AxialDeform.newline_math in lookup_eqns:
    AxialDeform.working_eqn_latex = AxialDeform.newline_math
    AxialDeform.working_eqn_solver = "Eq(delta_l,P*L/A/E)"
    AxialDeform.working_sym = "delta_l,P,L,A,E"
    if str(input.axial_delta_l()) != "" :
        AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("\de
        AxialDeform.working_eqn_solver = AxialDeform.working_eqn_solver.replace("d
        AxialDeform.working_sym = AxialDeform.working_sym.replace("delta_l",str(in
    else:
```

```
            AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("\de
        if str(input.axial_P()) != "" :
            AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("P",
            AxialDeform.working_eqn_solver = AxialDeform.working_eqn_solver.replace("P
            AxialDeform.working_sym = AxialDeform.working_sym.replace("P",str(input.ax
        else:
            AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("P",
        if str(input.axial_L()) != "" :
            AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("L",
            AxialDeform.working_eqn_solver = AxialDeform.working_eqn_solver.replace("L
            AxialDeform.working_sym = AxialDeform.working_sym.replace("L",str(input.ax
        else:
            AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("L",
        if str(input.axial_A()) != "" :
            AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("A",
            AxialDeform.working_eqn_solver = AxialDeform.working_eqn_solver.replace("A
            AxialDeform.working_sym = AxialDeform.working_sym.replace("A",str(input.ax
        else:
            AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("A",
        if str(input.axial_E()) != "" :
            AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("E",
            AxialDeform.working_eqn_solver = AxialDeform.working_eqn_solver.replace("E
            AxialDeform.working_sym = AxialDeform.working_sym.replace("E",str(input.ax
        else:
            AxialDeform.working_eqn_latex = AxialDeform.working_eqn_latex.replace("E",

    # Dynamic Filling of Thermal Deform equation
    if ThermalDeform.newline_math in lookup_eqns:
        ThermalDeform.working_eqn_latex = ThermalDeform.newline_math
        ThermalDeform.working_eqn_solver = "Eq(delta_t,alpha*Delta_T*L)"
        ThermalDeform.working_sym = "delta_t,Delta_T,alpha,L"
        if str(input.thermal_delta_t()) != "" :
            ThermalDeform.working_eqn_latex = ThermalDeform.working_eqn_latex.replace(
            ThermalDeform.working_eqn_solver = ThermalDeform.working_eqn_solver.replac
            ThermalDeform.working_sym = ThermalDeform.working_sym.replace("delta_t",st
        else:
            ThermalDeform.working_eqn_latex = ThermalDeform.working_eqn_latex.replace(
        if str(input.thermal_alpha()) != "" :
            ThermalDeform.working_eqn_latex = ThermalDeform.working_eqn_latex.replace(
            ThermalDeform.working_eqn_solver = ThermalDeform.working_eqn_solver.replac
            ThermalDeform.working_sym = ThermalDeform.working_sym.replace("alpha",str(
```

```
    else:
        ThermalDeform.working_eqn_latex = ThermalDeform.working_eqn_latex.replace(
    if str(input.thermal_Delta_T()) != "" :
        ThermalDeform.working_eqn_latex = ThermalDeform.working_eqn_latex.replace(
        ThermalDeform.working_eqn_solver = ThermalDeform.working_eqn_solver.replac
        ThermalDeform.working_sym = ThermalDeform.working_sym.replace("Delta_T",st
    else:
        ThermalDeform.working_eqn_latex = ThermalDeform.working_eqn_latex.replace(
    if str(input.thermal_L()) != "" :
        ThermalDeform.working_eqn_latex = ThermalDeform.working_eqn_latex.replace(
        ThermalDeform.working_eqn_solver = ThermalDeform.working_eqn_solver.replac
        ThermalDeform.working_sym = ThermalDeform.working_sym.replace("L",str(inpu
    else:
        ThermalDeform.working_eqn_latex = ThermalDeform.working_eqn_latex.replace(


# Dynamic Filling of Compatability equation 1
if Compatability1.newline_math in lookup_eqns:
    Compatability1_list__LHS = ["a_1","a_2","a_3","a_4","a_5"]
    Compatability1_list__RHS = ["b_1","b_2","b_3","b_4","b_5"]
    Compatability1_list_LHS = Compatability1_list__LHS[:input.Compatability1_NumLH
    Compatability1_list_RHS = Compatability1_list__RHS[:input.Compatability1_NumRH
    Compatability1_list = Compatability1_list_LHS + Compatability1_list_RHS
    Compatability1.working_sym = ",".join(Compatability1_list)
    Compatability1.working_eqn_latex = "$$" + "+".join(Compatability1_list_LHS) +
    Compatability1.working_eqn_solver = "Eq("+ "+".join(Compatability1_list_LHS) +

    if str(input.a_1()) != "" :
        Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
        Compatability1.working_sym = Compatability1.working_sym.replace("a_1",str(
        Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
    else:
        Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac

    if str(input.a_2()) != "" :
        Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
        Compatability1.working_sym = Compatability1.working_sym.replace("a_2",str(
        Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
    else:
        Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
```

```
if str(input.a_3()) != "" :
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
    Compatability1.working_sym = Compatability1.working_sym.replace("a_3",str(
    Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
else:
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac

if str(input.a_4()) != "" :
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
    Compatability1.working_sym = Compatability1.working_sym.replace("a_4",str(
    Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
else:
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac

if str(input.a_5()) != "" :
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
    Compatability1.working_sym = Compatability1.working_sym.replace("a_5",str(
    Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
else:
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac

if str(input.b_1()) != "" :
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
    Compatability1.working_sym = Compatability1.working_sym.replace("b_1",str(
    Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
else:
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac

if str(input.b_2()) != "" :
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
    Compatability1.working_sym = Compatability1.working_sym.replace("b_2",str(
    Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
else:
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac

if str(input.b_3()) != "" :
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
    Compatability1.working_sym = Compatability1.working_sym.replace("b_3",str(
    Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
else:
    Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
```

```
            if str(input.b_4()) != "" :
                Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
                Compatability1.working_sym = Compatability1.working_sym.replace("b_4",str(
                Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
            else:
                Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac

            if str(input.b_5()) != "" :
                Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac
                Compatability1.working_sym = Compatability1.working_sym.replace("b_5",str(
                Compatability1.working_eqn_solver = Compatability1.working_eqn_solver.repl
            else:
                Compatability1.working_eqn_latex = Compatability1.working_eqn_latex.replac

# Dynamic Filling of Compatability equation 2
        if Compatability2.newline_math in lookup_eqns:
            Compatability2_list__LHS = ["c_1","c_2","c_3","c_4","c_5"]
            Compatability2_list__RHS = ["d_1","d_2","d_3","d_4","d_5"]
            Compatability2_list_LHS = Compatability2_list__LHS[:input.Compatability2_NumLH
            Compatability2_list_RHS = Compatability2_list__RHS[:input.Compatability2_NumRH
            Compatability2_list = Compatability2_list_LHS + Compatability2_list_RHS
            Compatability2.working_sym = ",".join(Compatability2_list)
            Compatability2.working_eqn_latex = "$$" + "+".join(Compatability2_list_LHS) +
            Compatability2.working_eqn_solver = "Eq("+ "+".join(Compatability2_list_LHS) +

            if str(input.c_1()) != "" :
                Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
                Compatability2.working_sym = Compatability2.working_sym.replace("c_1",str(
                Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
            else:
                Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac

            if str(input.c_2()) != "" :
                Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
                Compatability2.working_sym = Compatability2.working_sym.replace("c_2",str(
                Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
            else:
                Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac

            if str(input.c_3()) != "" :
                Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
```

```
        Compatability2.working_sym = Compatability2.working_sym.replace("c_3",str(
        Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
    else:
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac

    if str(input.c_4()) != "" :
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
        Compatability2.working_sym = Compatability2.working_sym.replace("c_4",str(
        Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
    else:
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac

    if str(input.c_5()) != "" :
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
        Compatability2.working_sym = Compatability2.working_sym.replace("c_5",str(
        Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
    else:
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac

    if str(input.d_1()) != "" :
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
        Compatability2.working_sym = Compatability2.working_sym.replace("d_1",str(
        Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
    else:
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac

    if str(input.d_2()) != "" :
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
        Compatability2.working_sym = Compatability2.working_sym.replace("d_2",str(
        Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
    else:
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac

    if str(input.d_3()) != "" :
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
        Compatability2.working_sym = Compatability2.working_sym.replace("d_3",str(
        Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
    else:
        Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac

    if str(input.d_4()) != "" :
```

```
            Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
            Compatability2.working_sym = Compatability2.working_sym.replace("d_4",str(
            Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
        else:
            Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac

        if str(input.d_5()) != "" :
            Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac
            Compatability2.working_sym = Compatability2.working_sym.replace("d_5",str(
            Compatability2.working_eqn_solver = Compatability2.working_eqn_solver.repl
        else:
            Compatability2.working_eqn_latex = Compatability2.working_eqn_latex.replac


    eqnbank_working_latex = {
    StaticsSumFx.name: StaticsSumFx.working_eqn_latex,
    StaticsSumFy.name: StaticsSumFy.working_eqn_latex,
    StaticsSumM.name: StaticsSumM.working_eqn_latex,
    StressEqn.name: StressEqn.working_eqn_latex,
    BendingStress.name: BendingStress.working_eqn_latex,
    AxialDeform.name: AxialDeform.working_eqn_latex,
    ThermalDeform.name: ThermalDeform.working_eqn_latex,
    AreaTube.name: AreaTube.working_eqn_latex,
    ITube.name: ITube.working_eqn_latex,
    Compatability1.name: Compatability1.working_eqn_latex,
    Compatability2.name: Compatability2.working_eqn_latex
    }

    eqnbank_working_solver = {
    StaticsSumFx.name: StaticsSumFx.working_eqn_solver,
    StaticsSumFy.name: StaticsSumFy.working_eqn_solver,
    StaticsSumM.name: StaticsSumM.working_eqn_solver,
    StressEqn.name: StressEqn.working_eqn_solver,
    BendingStress.name: BendingStress.working_eqn_solver,
    AxialDeform.name: AxialDeform.working_eqn_solver,
    ThermalDeform.name: ThermalDeform.working_eqn_solver,
    AreaTube.name: AreaTube.working_eqn_solver,
    ITube.name: ITube.working_eqn_solver,
    Compatability1.name: Compatability1.working_eqn_solver,
    Compatability2.name: Compatability2.working_eqn_solver
    }
```

```
symbank_working = {
StaticsSumFx.name: StaticsSumFx.working_sym,
StaticsSumFy.name: StaticsSumFy.working_sym,
StaticsSumM.name: StaticsSumM.working_sym,
StressEqn.name: StressEqn.working_sym,
BendingStress.name: BendingStress.working_sym,
AxialDeform.name: AxialDeform.working_sym,
ThermalDeform.name: ThermalDeform.working_sym,
AreaTube.name: AreaTube.working_sym,
ITube.name: ITube.working_sym,
Compatability1.name: Compatability1.working_sym,
Compatability2.name: Compatability2.working_sym
}

working_eqns_latex = [eqnbank_working_latex[key] for key in eqns_keys]
working_SumFx_render.set(eqnbank_working_latex["Equilibrium Forces in X"])
working_SumFy_render.set(eqnbank_working_latex["Equilibrium Forces in Y"])
working_SumM_render.set(eqnbank_working_latex["Equilibrium Moments about O"])
working_StressEqn_render.set(eqnbank_working_latex["Stress Equation"])
working_BendingStress_render.set(eqnbank_working_latex["Bending Stress from a Mome
working_AxialDeform_render.set(eqnbank_working_latex["Axial Deformation by Force"]
working_ThermalDeform_render.set(eqnbank_working_latex["Axial Deformation by Therm
working_AreaTube_render.set(eqnbank_working_latex["Area of a Tube"])
working_Itube_render.set(eqnbank_working_latex["Moment of Inertia of a Tube"])
working_Compatability1_render.set(eqnbank_working_latex["Compatability Equation 1"
working_Compatability2_render.set(eqnbank_working_latex["Compatability Equation 2"
working_eqns_solver = [eqnbank_working_solver[key] for key in eqns_keys]

temp_working_equations_solver = "#".join(working_eqns_solver)
temp_working_equations_solver = temp_working_equations_solver.replace("Eq","Wrap_c
temp_working_equations_solver = temp_working_equations_solver.replace("E","E_clash
temp_working_equations_solver = temp_working_equations_solver.replace("I","I_clash
temp_working_equations_solver = temp_working_equations_solver.replace("N","N_clash
temp_working_equations_solver = temp_working_equations_solver.replace("Wrap_clash"
working_eqns_solver = temp_working_equations_solver.split("#")

#working_eqns_solver=[]
#for j in working_eqns_solver_pre:
#    temp=j.split(",")
#    temp2=temp.replace("I","I_clash")
#    temp3=temp2.replace("E","E_clash")
```

```
        #    working_eqns_solver.append(temp3)

        working_syms = [symbank_working[key] for key in eqns_keys]
        mystring_working_eqns = "".join(working_eqns_latex)
        mystring_working_eqns = mystring_working_eqns.replace("*","\\times")
        feedback_syms.set(working_syms)
        working_equations_solver.set(working_eqns_solver)

        working_syms_only=[]
        for j in working_syms:
            temp=j.split(",")
            for k in temp:
                try:
                    float(eval(k))
                except:
                    temp2=k.replace("I","I_clash")
                    temp3=temp2.replace("E","E_clash")
                    temp4=temp3.replace("N","N_clash")
                    working_syms_only.append(temp4)
        working_syms_only=list(dict.fromkeys(working_syms_only))
        working_symbols.set(working_syms_only)

        return [
            ui.markdown(mystring_working_eqns),
            ui.tags.script(
                "if (window.MathJax) MathJax.Hub.Queue(['Typeset', MathJax.Hub]);"
            )
        ]

    @output
    @render.ui
    def dyn_ui_nav():

        tab_Instructions = ui.nav(
            "Instructions",ui.markdown("Please choose the equations you would like to use
        )

        tab_StaticsSumFy = ui.nav(
                str(StaticsSumFy.inline_math),
                ui.markdown(working_SumFy_string()),
                ui.input_numeric("NumForcesY","How many terms do you want?",value=NumForce
```

```
            ui.input_text("F1y","\(F_{y_1}=\)", value=F1y(),placeholder="Please type i
            ui.input_text("F2y","\(F_{y_2}=\)", value=F2y(),placeholder="Please type i
            ui.panel_conditional("input.NumForcesY>=3", ui.input_text("F3y","\(F_{y_3}
            ui.panel_conditional("input.NumForcesY>=4", ui.input_text("F4y","\(F_{y_4}
            ui.panel_conditional("input.NumForcesY>=5", ui.input_text("F5y","\(F_{y_5}
            )

        tab_StaticsSumFx = ui.nav(
            str(StaticsSumFx.inline_math),
            ui.markdown(working_SumFx_string()),
            ui.input_numeric("NumForcesX","How many terms do you want?",value=NumForce
            ui.input_text("F1x","\(F_{x_1}=\)", value=F1x(),placeholder="Please type i
            ui.input_text("F2x","\(F_{x_2}=\)", value=F2x(),placeholder="Please type i
            ui.panel_conditional("input.NumForcesX>=3", ui.input_text("F3x","\(F_{x_3}
            ui.panel_conditional("input.NumForcesX>=4", ui.input_text("F4x","\(F_{x_4}
            ui.panel_conditional("input.NumForcesX>=5", ui.input_text("F5x","\(F_{x_5}
            )

        tab_StaticsSumM = ui.nav(
            str(StaticsSumM.inline_math),
            ui.markdown(working_SumM_string()),
            ui.input_numeric("NumMoments","How many terms do you want?",value=NumMomen
            ui.input_text("M1","\(M_1=\)", value=M1(),placeholder="Please type in vari
            ui.input_text("M2","\(M_2=\)", value=M2(),placeholder="Please type in vari
            ui.panel_conditional("input.NumMoments>=3", ui.input_text("M3","\(M_3=\)",
            ui.panel_conditional("input.NumMoments>=4", ui.input_text("M4","\(M_4=\)",
            ui.panel_conditional("input.NumMoments>=5", ui.input_text("M5","\(M_5=\)",
            )

        tab_StressEqn = ui.nav(
            str(StressEqn.inline_math),
            ui.markdown(working_StressEqn_string()),
            ui.input_text("sigma","\(\sigma\)", value=axial_stress_sigma(),placeholder
            ui.input_text("force","\(F\)", value=axial_stress_force(),placeholder="Ple
            ui.input_text("area","\(A\)", value=axial_stress_area(),placeholder="Pleas
            )

        tab_BendingStress = ui.nav(
            str(BendingStress.inline_math),
            ui.markdown(working_BendingStress_string()),
            ui.input_text("bendingstress_sigma_b","\(\sigma_b\)", value=bending_stress
```

```
        ui.input_text("bendingstress_M","\(M\)", value=bending_stress_M(), placeho
        ui.input_text("bendingstress_y","\(y\)", value=bending_stress_y(), placeho
        ui.input_text("bendingstress_I","\(I\)", value= bending_stress_I(), placeh
        )

tab_AxialDeform = ui.nav(
        str(AxialDeform.inline_math),
        ui.markdown(working_AxialDeform_string()),
        ui.input_text("axial_delta_l","\(\delta_l\)", value=axial_delta_l(), place
        ui.input_text("axial_P","\(P\)", value=axial_P(), placeholder="Please type
        ui.input_text("axial_L","\(L\)", value=axial_L(), placeholder="Please type
        ui.input_text("axial_A","\(A\)", value=axial_A(), placeholder="Please type
        ui.input_text("axial_E","\(E\)", value=axial_E(), placeholder="Please type
        )

tab_ThermalDeform = ui.nav(
        str(ThermalDeform.inline_math),
        ui.markdown(working_ThermalDeform_string()),
        ui.input_text("thermal_delta_t","\(\delta_t\)", value=thermal_delta_t(), p
        ui.input_text("thermal_alpha","\(\\alpha\)", value=thermal_alpha(), placeh
        ui.input_text("thermal_Delta_T","\(\Delta T\)", value=thermal_Delta_T(), p
        ui.input_text("thermal_L","\(L\)", value=thermal_L(), placeholder="Please
        )

tab_AreaTube = ui.nav(
        str(AreaTube.inline_math),
        ui.markdown(working_AreaTube_string()),
        ui.input_text("A_tube","\(A_{tube}=\)", value=area_tube_A_tube(), placehol
        ui.input_text("Ar_o","\(r_o=\)", value=area_tube_Ar_o(), placeholder="Plea
        ui.input_text("Ar_i","\(r_i\)", value=area_tube_Ar_i(), placeholder="Pleas
        )

tab_ITube = ui.nav(
        str(ITube.inline_math),
        ui.markdown(working_Itube_string()),
        ui.input_text("I_tube","\(I_{tube}=\)", value=I_tube_I_tube(), placeholder
        ui.input_text("Ir_o","\(r_o=\)", value=I_tube_Ir_o(), placeholder="Please
        ui.input_text("Ir_i","\(r_i\)", value=i_tube_Ir_i(), placeholder="Please t
        )

tab_Compatability1 = ui.nav(
```

```
            str(Compatability1.inline_math),
            ui.markdown(working_Compatability1_string()),
            ui.input_numeric("Compatability1_NumLHS","How many 'a' terms do you want?"
            ui.input_numeric("Compatability1_NumRHS","How many 'b' terms do you want?"
            ui.input_text("a_1","\(a_1=\)", value=Compatability1_a_1(),placeholder="Pl
            ui.panel_conditional("input.Compatability1_NumLHS>=2",ui.input_text("a_2",
            ui.panel_conditional("input.Compatability1_NumLHS>=3", ui.input_text("a_3"
            ui.panel_conditional("input.Compatability1_NumLHS>=4", ui.input_text("a_4"
            ui.panel_conditional("input.Compatability1_NumLHS>=5", ui.input_text("a_5"
            ui.input_text("b_1","\(b_1=\)", value=Compatability1_b_1(),placeholder="Pl
            ui.panel_conditional("input.Compatability1_NumRHS>=2",ui.input_text("b_2",
            ui.panel_conditional("input.Compatability1_NumRHS>=3",ui.input_text("b_3",
            ui.panel_conditional("input.Compatability1_NumRHS>=4",ui.input_text("b_4",
            ui.panel_conditional("input.Compatability1_NumRHS>=5",ui.input_text("b_5",
            )

    tab_Compatability2 = ui.nav(
            str(Compatability2.inline_math),
            ui.markdown(working_Compatability2_string()),
            ui.input_numeric("Compatability2_NumLHS","How many 'c' terms do you want?"
            ui.input_numeric("Compatability2_NumRHS","How many 'd' terms do you want?"
            ui.input_text("c_1","\(c_1=\)", value=Compatability2_c_1(),placeholder="Pl
            ui.panel_conditional("input.Compatability2_NumLHS>=2",ui.input_text("c_2",
            ui.panel_conditional("input.Compatability2_NumLHS>=3", ui.input_text("c_3"
            ui.panel_conditional("input.Compatability2_NumLHS>=4", ui.input_text("c_4"
            ui.panel_conditional("input.Compatability2_NumLHS>=5", ui.input_text("c_5"
            ui.input_text("d_1","\(d_1=\)", value=Compatability2_d_1(),placeholder="Pl
            ui.panel_conditional("input.Compatability2_NumRHS>=2",ui.input_text("d_2",
            ui.panel_conditional("input.Compatability2_NumRHS>=3",ui.input_text("d_3",
            ui.panel_conditional("input.Compatability2_NumRHS>=4",ui.input_text("d_4",
            ui.panel_conditional("input.Compatability2_NumRHS>=5",ui.input_text("d_5",
            )

    tab_bank = {
            StaticsSumFx.name: tab_StaticsSumFx,
            StaticsSumFy.name: tab_StaticsSumFy,
            StaticsSumM.name: tab_StaticsSumM,
            StressEqn.name: tab_StressEqn,
            BendingStress.name: tab_BendingStress,
            AxialDeform.name: tab_AxialDeform,
            ThermalDeform.name: tab_ThermalDeform,
```

```
            AreaTube.name: tab_AreaTube,
            ITube.name: tab_ITube,
            Compatability1.name: tab_Compatability1,
            Compatability2.name: tab_Compatability2,
            }
    eqns_keys = input.selected_eqns()
    tabs = [tab_bank[key] for key in eqns_keys]
    tabs.insert(0,tab_Instructions)
    equations = ui.navset_tab_card(*tabs,id="mytab",selected=active_eqn_tab())

    return [equations,
           ui.tags.script(
            "if (window.MathJax) MathJax.Hub.Queue(['Typeset', MathJax.Hub]);"
    ),]

@output
@render.ui
def ui_equation_bookkeeping():
    req(working_equations_solver())
    num_working_equations=len(working_equations_solver())
    num_working_symbols=len(working_symbols())
    string_working_symbols= "\\\\("+"\\\\),\\\\(".join(working_symbols())+"\\\\)"
    string_working_symbols=string_working_symbols.replace("N_clash","N")
    string_working_symbols=string_working_symbols.replace("I_clash","I")
    string_working_symbols=string_working_symbols.replace("E_clash","E")
    string_working_symbols=string_working_symbols.replace("delta","\delta")
    string_working_symbols=string_working_symbols.replace("Delta","\Delta")
    string_working_symbols=string_working_symbols.replace("sigma","\sigma")
    return [ui.markdown(f"Your equation-solver set up currently has **{num_working_equ
            ui.input_action_button(
                "solveEquations", "Solve Equations", class_="btn-success", width="240p
            ui.tags.script(
            "if (window.MathJax) MathJax.Hub.Queue(['Typeset', MathJax.Hub]);"
            )]

@output
@render.ui
@reactive.event(input.solveEquations)
def ui_solutions():
    for j in working_symbols():
        j=Symbol(j)
```

```
    print(working_equations_solver())
    print(working_symbols())
    my_solver_equations=[]
    for m in working_equations_solver():
        m=parse_expr(m)
    solve_eqns = solve(working_equations_solver(),working_symbols(),dict=True)
    answers=[]
    for k in working_symbols():
        try:
            temp=solve_eqns[0][parse_expr(k)]
            temp2="$$"+k+"="+f'{temp:.2f}'+"$$"
            answers.append(temp2)
        except:
            pass
    mystring_answers="".join(answers)
    mystring_answers=mystring_answers.replace("pi","\pi")
    mystring_answers=mystring_answers.replace("delta","\delta")
    mystring_answers=mystring_answers.replace("Delta","\Delta")
    mystring_answers=mystring_answers.replace("sigma","\sigma")
    mystring_answers=mystring_answers.replace("E_clash","E")
    mystring_answers=mystring_answers.replace("I_clash","I")
    mystring_answers=mystring_answers.replace("N_clash","N")
    #feedback_solns.set(mystring_answers)
    return [ui.markdown(f"Your solution is {mystring_answers}"),
            ui.input_text("answer","Answer:",placeholder="Please type in your answer"),
            ui.input_action_button("feedback", "Check answer and show feedback"),
            ui.download_button("download2", "Download PNG"),
            ui.tags.script(
            "if (window.MathJax) MathJax.Hub.Queue(['Typeset', MathJax.Hub]);"
            )]

#@reactive.Effect
#def _():

 #   active_eqn_tab.set(input.mytab())


@reactive.Effect
def _():

    input.selected_eqns()
```

```
    active_eqn_tab.set(input.mytab())

    working_SumFx_render()
    working_SumFy_render()
    working_SumM_render()
    working_StressEqn_render()
    working_BendingStress_render()
    working_AxialDeform_render()
    working_ThermalDeform_render()
    working_AreaTube_render()
    working_Itube_render()
    working_Compatability1_render()
    working_Compatability2_render()

    with reactive.isolate():
        if "Equilibrium Forces in Y" in input.selected_eqns():
            NumForcesY.set(input.NumForcesY())
            F1y.set(input.F1y())
            F2y.set(input.F2y())
            F3y.set(input.F3y())
            F4y.set(input.F4y())
            F5y.set(input.F5y())
            working_SumFy_string.set(str(working_SumFy_render()))
        else:
             pass

        if "Equilibrium Forces in X" in input.selected_eqns():
            NumForcesX.set(input.NumForcesX())
            F1x.set(input.F1x())
            F2x.set(input.F2x())
            F3x.set(input.F3x())
            F4x.set(input.F4x())
            F5x.set(input.F5x())
            working_SumFx_string.set(str(working_SumFx_render()))
        else:
             pass

        if "Equilibrium Moments about O" in input.selected_eqns():
            NumMoments.set(input.NumMoments())
            M1.set(input.M1())
            M2.set(input.M2())
```

```
            M3.set(input.M3())
            M4.set(input.M4())
            M5.set(input.M5())
            working_SumM_string.set(str(working_SumM_render()))
        else:
             pass

        if "Stress Equation" in input.selected_eqns():
            axial_stress_sigma.set(input.sigma())
            axial_stress_force.set(input.force())
            axial_stress_area.set(input.area())
            working_StressEqn_string.set(str(working_StressEqn_render()))
        else:
             pass

        if "Axial Deformation by Force" in input.selected_eqns():
            axial_delta_l.set(input.axial_delta_l())
            axial_P.set(input.axial_P())
            axial_L.set(input.axial_L())
            axial_A.set(input.axial_A())
            axial_E.set(input.axial_E())
            working_AxialDeform_string.set(str(working_AxialDeform_render()))
        else:
             pass

        if "Axial Deformation by Thermal" in input.selected_eqns():
            thermal_delta_t.set(input.thermal_delta_t())
            thermal_alpha.set(input.thermal_alpha())
            thermal_Delta_T.set(input.thermal_Delta_T())
            thermal_L.set(input.thermal_L())
            working_ThermalDeform_string.set(str(working_ThermalDeform_render()))
        else:
             pass

        if "Area of a Tube" in input.selected_eqns():
            area_tube_A_tube.set(input.A_tube())
            area_tube_Ar_o.set(input.Ar_o())
            area_tube_Ar_i.set(input.Ar_i())
            working_AreaTube_string.set(str(working_AreaTube_render()))
        else:
             pass
```

```
        if "Moment of Inertia of a Tube" in input.selected_eqns():
            I_tube_I_tube.set(input.I_tube())
            I_tube_Ir_o.set(input.Ir_o())
            i_tube_Ir_i.set(input.Ir_i())
            working_Itube_string.set(str(working_Itube_render()))
        else:
             pass

        if "Bending Stress from a Moment" in input.selected_eqns():
            bending_stress_sigma.set(input.bendingstress_sigma_b())
            bending_stress_M.set(input.bendingstress_M())
            bending_stress_y.set(input.bendingstress_y())
            bending_stress_I.set(input.bendingstress_I())
            working_BendingStress_string.set(str(working_BendingStress_render()))
        else:
             pass

        if "Compatability Equation 1" in input.selected_eqns():
            Compatability1_NumLHS.set(input.Compatability1_NumLHS())
            Compatability1_NumRHS.set(input.Compatability1_NumRHS())
            Compatability1_a_1.set(input.a_1())
            Compatability1_a_2.set(input.a_2())
            Compatability1_a_3.set(input.a_3())
            Compatability1_a_4.set(input.a_4())
            Compatability1_a_5.set(input.a_5())
            Compatability1_b_1.set(input.b_1())
            Compatability1_b_2.set(input.b_2())
            Compatability1_b_3.set(input.b_3())
            Compatability1_b_4.set(input.b_4())
            Compatability1_b_5.set(input.b_5())
            working_Compatability1_string.set(str(working_Compatability1_render()))
        else:
             pass

        if "Compatability Equation 2" in input.selected_eqns():
            Compatability2_NumLHS.set(input.Compatability2_NumLHS())
            Compatability2_NumRHS.set(input.Compatability2_NumRHS())
            Compatability2_c_1.set(input.c_1())
            Compatability2_c_2.set(input.c_2())
            Compatability2_c_3.set(input.c_3())
            Compatability2_c_4.set(input.c_4())
```

```
            Compatability2_c_5.set(input.c_5())
            Compatability2_d_1.set(input.d_1())
            Compatability2_d_2.set(input.d_2())
            Compatability2_d_3.set(input.d_3())
            Compatability2_d_4.set(input.d_4())
            Compatability2_d_5.set(input.d_5())
            working_Compatability2_string.set(str(working_Compatability2_render()))
        else:
             pass


@reactive.Effect
@reactive.event(input.feedback)
def _():
    inst_eqns=[eqnbank_newline[key] for key in ["Equilibrium Forces in Y", "Equilibriu
    inst_soln="6520"
    inst_unknowns=["N","M_o","\sigma_b", "\sigma_l","A_{tube}","I_{tube}","\sigma_{max
    attempt_equations=feedback_equations()
    attempt_soln=input.answer()
    attempt_unknowns=feedback_syms()
    missing_inst_eqns=set(inst_eqns).difference(attempt_equations)
    extra_student_eqns=set(attempt_equations).difference(inst_eqns)

    if inst_soln==attempt_soln:
      feedback_message=ui.markdown("Congratulations! You are correct, great work.")
    else:
      feedback_message=ui.markdown(f"This feedback is the list method -- checking your

    m = ui.modal(
        feedback_message, ui.tags.script(
            "if (window.MathJax) MathJax.Hub.Queue(['Typeset', MathJax.Hub]);"
            ),
        title="Feedback on your solution",
        easy_close=True,
        footer=None,
    )
    ui.modal_show(m)

@session.download(filename="image.png")
def download2():
    #fig, ax = plt.subplots()
```

```
        #ax.text(.2, .6, r'an equation: $E=mc^2$', fontsize=15)
        #ax = fig.add_subplot()
        #fig.subplots_adjust(top=0.85)


        # Set both x- and y-axis limits to [0, 10] instead of default [0, 1]
        #ax.axis([0, 10, 0, 10])

        #ax.text(2, 6, r'an equation:$E=mc^2$', fontsize=15)
        x = np.random.uniform(size=input.num_points())
        y = np.random.uniform(size=input.num_points())
        plt.figure()
        plt.scatter(x, y)
        plt.title(input.title())

        with io.BytesIO() as buf:
            plt.savefig(buf, format="png")
            yield buf.getvalue()

app = App(app_ui, server)
```

2 Workout Example Solution

2.1 Worked Out Solution

This demonstrates a worked out solution to the problem. The best way to begin is by drawing a free body diagram.

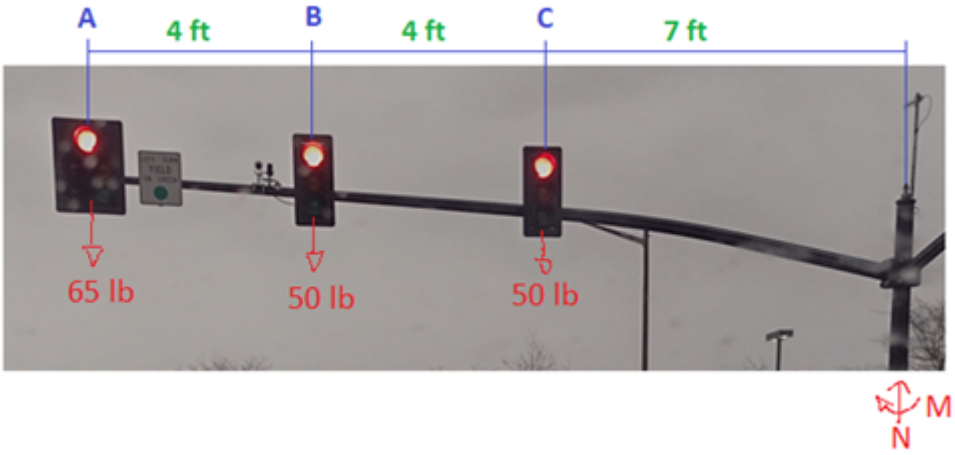

Figure 2.1: Figure 3: Three traffic light installation with loads

Use equilibrium equations to find the internal loads:

$$\Sigma F_y = 0 : N - 65 - 50 - 50 = 0$$
$$N = 165\ lbs$$

$$\Sigma M_O = 0 : -M + (50 \times 7) + (50 \times 11) + (65 \times 15) = 0$$
$$M = 1875\ lb \cdot ft = 22500\ lb \cdot in$$

Now, determine the cross-sectional properties:

$$A = \pi(r_0^2 - r_i^2) = \pi(2.5^2 - 2.3^2) = 3.02\ in^2 I = \frac{\pi}{4}(r_0^4 - r_i^4) = \frac{\pi}{4}(2.5^4 - 2.3^4) = 8.70\ in^4$$

Calculate stress due to normal force:

$$\sigma_n = \frac{F}{A} = \frac{-165\ lbs}{3.02\ in^2} = -54.7\ psi$$

Calculate maximum stress due to bending moment (will have same magnitude in both tension and compression):

$$\sigma_m = \pm\frac{M_c}{I} = \pm\frac{22500 \times 2.5}{8.70} = \pm 6460\ psi$$

Determine combined tensile stress: $\sigma_T = -54.7 + 6460 = 6410\ psi$

Determine combined compressive stress: $\sigma_T = -54.7 - 6460 = -6520\ psi$

3 Summary

In summary, this book has no content whatsoever.

```
1 + 1
```

```
[1] 2
```

References