ME35401
Spring Calculator
Sydney Free & Yağmur Önder

1. Code spreadsheet

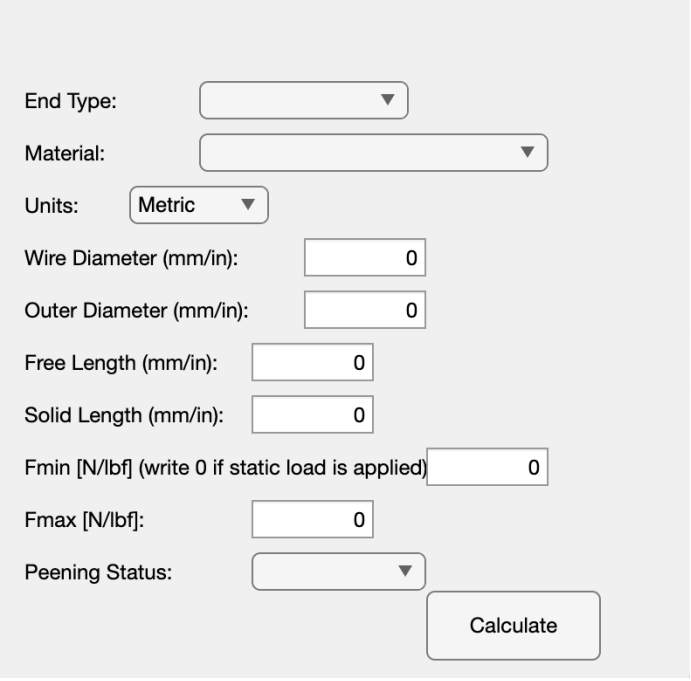
See the following pdf for all the code. For practical purposes, the code was organized with multiple files to be able to troubleshoot different functions with the unique calculations. For submission purposes, all the code and functions where copied into one script.

2. Calculator Demonstration

Demonstrated in class with TA Wenxi Chen on Dec 07th.

3. GUI extra credit

GUI is shown below where user can provide inputs as well as inform the calculator of either metric or english units.



```
function springCalculatorGUI
    % Create the main figure
    fig = uifigure('Name', 'Spring Calculator', 'Position', [400, 360, 400,
400]); % left, bottom, width, height

    % Create UI components

    % END TYPE
    endTypeLabel = uilabel(fig, 'Text', 'End Type:', 'Position', [20, 330,
80, 22]);
    endTypeDropDown = uidropdown(fig, 'Items', {'', 'Plain', 'Plain and
ground', 'Squared or closed', 'Squared and ground' }, 'Position', [120, 330,
120, 22]);

    % MATERIAL
    materialLabel = uilabel(fig, 'Text', 'Material:', 'Position', [20, 300,
80, 22]);
    materialDropDown = uidropdown(fig, 'Items', {'', 'Music wire A228', 'Hard-
drawn wire A227', 'Chrome-vanadium wire A232', 'Chrome-silicon wire A401',
'302 stainless wire A313', 'Phosphor-bronze wire B159'}, 'Position', [120,
300, 200, 22]);

    % Units Dropdown
    unitsLabel = uilabel(fig, 'Text', 'Units:', 'Position', [20, 270, 50,
22]);
    unitsDropDown = uidropdown(fig, 'Items', {'Metric', 'English'},
'Position', [80, 270, 80, 22]);

    % WIRE DIAMETER
    wireDiameterLabel = uilabel(fig, 'Text', 'Wire Diameter (mm/in):',
'Position', [20, 240, 120, 22]);
    wireDiameterEdit = uieditfield(fig, 'numeric', 'Position', [150, 240, 70,
22]);

    % OUTER DIAMETER
    outerDiameterLabel = uilabel(fig, 'Text', 'Outer Diameter (mm/in):',
'Position', [20, 210, 120, 22]);
    outerDiameterEdit = uieditfield(fig, 'numeric', 'Position', [150, 210,
70, 22]);

    % FREE LENGTH
    freeLengthLabel = uilabel(fig, 'Text', 'Free Length (mm/in):',
'Position', [20, 180, 120, 22]);
    freeLengthEdit = uieditfield(fig, 'numeric', 'Position', [150, 180, 70,
22]);

    % SOLID LENGTH
    solidLengthLabel = uilabel(fig, 'Text', 'Solid Length (mm/in):',
'Position', [20, 150, 120, 22]);
    solidLengthEdit = uieditfield(fig, 'numeric', 'Position', [150, 150, 70,
22]);
```

```
    % Input Fmin and Fmax
    fMinLabel = uilabel(fig, 'Text', 'Fmin [N/lbf] (write 0 if static load is
applied):', 'Position', [20, 120, 250, 22]);
    fMaxLabel = uilabel(fig, 'Text', 'Fmax [N/lbf]:', 'Position', [20, 90,
120, 22]);
    fMinEdit = uieditfield(fig, 'numeric', 'Position', [250, 120, 70, 22]);
    fMaxEdit = uieditfield(fig, 'numeric', 'Position', [150, 90, 70, 22]);

    % Peening Status
    peeningStatusLabel = uilabel(fig, 'Text', 'Peening Status:', 'Position',
[20, 60, 120, 22]);
    peeningStatusDropDown = uidropdown(fig, 'Items', {'', 'Peened',
'Unpeened'}, 'Position', [150, 60, 100, 22]);

    calculateButton = uibutton(fig, 'push', 'Text', 'Calculate', 'Position',
[250, 20, 100, 40], ...
    'ButtonPushedFcn', @(btn, event) calculateSpring(...
        endTypeDropDown.Value, materialDropDown.Value,
unitsDropDown.Value,wireDiameterEdit.Value, ...
        outerDiameterEdit.Value, freeLengthEdit.Value, solidLengthEdit.Value,
...
        fMinEdit.Value, fMaxEdit.Value, peeningStatusDropDown.Value));

end
```

calculate spring properties

Callback function to calculate spring properties

```
    function calculateSpring(endType, material, units, wireDiameter,
outerDiameter, freeLength, solidLength, fMin, fMax, peenedStatus)
```

Quality control

Check if end type and material are selected

```
        if isempty(endType) && isempty(material)
            errordlg('Please select End Type and Material', 'Error', 'modal');
            return;  % Exit the function if not selected
```

```
        elseif isempty(endType)
            errordlg('Please select End Type', 'Error', 'modal');
            return;  % Exit the function if not selected
        elseif isempty(material)
            errordlg('Please select Material', 'Error', 'modal');
            return;  % Exit the function if not selected
        end

         % Verification check for numeric values
    if ~isnumeric(wireDiameter) || ~isnumeric(outerDiameter) ||
~isnumeric(freeLength) || ~isnumeric(solidLength)
        errordlg('Please enter numeric values for diameters and lengths',
'Error', 'modal');
        return;
    end

    % Wire diameter verification
    if wireDiameter < 0
        errordlg('Invalid wire diameter. Please enter a positive value.',
'Error', 'modal');
        return;
    elseif wireDiameter == 0
        errordlg('Invalid wire diameter. Please enter a positive, non-zero
value.', 'Error', 'modal');
        return;
    end

    % Outer diameter verification
    if outerDiameter < 0
        errordlg('Invalid outer diameter. Please enter a positive value.',
'Error', 'modal');
        return;
    elseif outerDiameter == 0
        errordlg('Invalid outer diameter. Please enter a positive, non-zero
value.', 'Error', 'modal');
        return;
    end

    % Free length verification
    if freeLength <= solidLength || freeLength < 0
        errordlg('Invalid Free Length. Please enter a positive value greater
than Solid Length.', 'Error', 'modal');
        return;
    elseif freeLength == 0
        errordlg('Invalid Free Length. Please enter a non-zero, positive
value greater than Solid Length', 'Error', 'modal');
        return;
    end

    % Solid length verification
    if solidLength < 0
        errordlg('Invalid Solid Length. Please enter a positive value.',
'Error', 'modal');
        return;
```

```
    elseif solidLength == 0
        errordlg('Invalid Solid Length. Please enter a non-zero, positive
value.', 'Error', 'modal');
        return;
    end

    %peened or unpeened verification
    if fMin ~= 0 && isempty(peenedStatus)
        errordlg('If Fmin is not zero, peened or unpeened must be selected.',
'Error');
        return;
    elseif fMin == 0 && ~isempty(peenedStatus)
        errordlg('If Fmin is zero, neither peened nor unpeened should be
selected.', 'Error');
        return;
    end
```

Check if the units are in English or Metric

```
    if strcmp(units, 'English')
        % Convert to mm from inches and pounds based on Michael's test case
        convertToMetric_length = @(value) value * 25.4;  % from inches to mm
        convertToMetric_force = @(value) value * 4.44822; %from pound force
to newtons

        wireDiameter = convertToMetric_length(wireDiameter);
        solidLength = convertToMetric_length(solidLength);
        freeLength = convertToMetric_length(freeLength);
        outerDiameter = convertToMetric_length(outerDiameter);
        fMax = convertToMetric_force(fMax);
        fMin = convertToMetric_force(fMin);
        % Add any other conversions if needed
    end
 % Now user inputs are either in metric or remain unchanged
```

Call other functions to calculate and display results

```
        %use round to ensure the outcome is an integer
        totalCoils = round(calculateTotalCoils(endType, wireDiameter,
solidLength));
        activeCoils = round(calculateActiveCoils(endType, totalCoils));
        pitch = calculatePitch(activeCoils, freeLength, wireDiameter,
endType);
        springRate = calculateSpringRate(wireDiameter, outerDiameter,
activeCoils, material);
        force = calculateForce(freeLength, solidLength, springRate);
        force_FOS = calculateStaticFOS(material, wireDiameter, force,
outerDiameter);% fos calculated from force needed to compress the spring to
max length
```

```
        %calculate FOS - verify if static or inf life
        if fMin == 0
            fos = calculateStaticFOS(material, wireDiameter, fMax,
outerDiameter);
        else
            fos = calculateInfFOS(fMin, fMax, outerDiameter, wireDiameter,
peenedStatus, material);
        end

        % Display the results in a new figure
        displayResultsFigure(totalCoils, activeCoils, pitch, springRate,
force, fMin, fos, force_FOS, units);

    end
```

calculate total coils - Shigley Table 10-1

```
    function totalCoils = calculateTotalCoils(endType, d, Ls)
        % Default value, in case the end type is not recognized
        totalCoils = 0;

        % Use a switch statement to handle different end types
        switch endType
            case 'Plain'
                totalCoils = Ls / d - 1;

            case 'Squared or closed'
                totalCoils = Ls / d - 1;

            case 'Plain and ground'
                totalCoils = Ls / d;

            case 'Squared and ground'
                totalCoils = Ls / d;
        end
    end
```

calculate active coils - Shigley Table 10-1

```
    function activeCoils = calculateActiveCoils(endType, Nt)
            % Default value, in case the end type is not recognized
            activeCoils = 0;

            % Use a switch statement to handle different end types
            switch endType
                case 'Plain'
                    activeCoils = Nt;

                case 'Plain and ground'
                    activeCoils = Nt - 1;

                case 'Squared or closed'
                    activeCoils = Nt - 2;
```

```
            case 'Squared and ground'
                activeCoils = Nt - 2;
        end
    end
```

calculate pitch - Shigley Table 10-1

```
function pitch = calculatePitch(Na, L0, d, endType)
    % Default value, in case the end type is not recognized
    pitch = 0;

    % Use a switch statement to handle different end types
    switch endType
        case 'Plain'
            pitch = (L0-d)/Na;

        case 'Plain and ground'
            pitch = L0/(Na+1);

        case 'Squared or closed'
            pitch = (L0 - 3*d)/Na;

        case 'Squared and ground'
            pitch = (L0 - 2*d)/Na;
    end
end
```

calculate spring rate k

```
function springRate = calculateSpringRate(d, Do, Na, material)
    %springRate = 0;

    %Do = outer diameter
    D = Do - d; %mean diameter of the spring

    % Use a switch statement to handle different materials
    switch material
        case 'Music wire A228'
            %Table 10-5 Shigley
            if d < 0.8128 % converted to mm
                G = 82.7; %Gpa
            elseif d < 1.6256
                G = 81.7; %GPa
            elseif d <= 3.175
                G = 81.0; %GPa
            elseif d > 3.175
                G = 80.0; %GPa
            end

        case 'Hard-drawn wire A227'
            %Table 10-5 Shigley
            if d < 0.8128
```

```
                G = 80.7; %Gpa
            elseif d < 1.6256
                G = 80.0; %GPa
            elseif d <= 3.175
                G = 79.3; %GPa
            elseif d > 3.175
                G = 78.6; %GPa
            end

        case 'Chrome-vanadium wire A232'
            %Table 10-5 Shigley
            G = 77.2; %GPa

        case 'Chrome-silicon wire A401'
            %Table 10-5 Shigley
            G = 77.2; %GPa

        case '302 stainless wire A313'
            %Table 10-5 Shigley
            G = 69.0; %GPa

        case 'Phosphor-bronze wire B159'
            %Table 10-5 Shigley
            G = 41.4; %GPa
    end

    springRate = (d/1000)^4 * (G*10^9) / (8 * (D/1000)^3 * Na); %k, N/m

end
```

calculate force - The force needed to compress the spring to its solid length

```
function force = calculateForce(L0, Ls, k)
    force = k * ((L0 - Ls)/1000); %F=kx, newtons
end
```

calculate factor of safety - STATIC

```
function fos_static = calculateStaticFOS(material, d, F, D)
    % Use a switch statement to handle different materials
    switch material
        case 'Music wire A228'
            %Table 10-4 Shigley
            A = 2211; %MPa * mm^m
            m = 0.145; %exponent
            elasticpercent = .45;

        case 'Hard-drawn wire A227'
            %Table 10-4 Shigley
            A = 1783; %MPa * mm^m
```

```
            m = 0.190; %exponent
            elasticpercent = .45;

        case 'Chrome-vanadium wire A232'
            %Table 10-4 Shigley
            A = 2005; %MPa * mm^m
            m = 0.168; %exponent
            elasticpercent = .65;

        case 'Chrome-silicon wire A401'
            %Table 10-4 Shigley
            A = 1974; %MPa * mm^m
            m = 0.108; %exponent
            elasticpercent = .65;

        case '302 stainless wire A313'
            %Table 10-4 Shigley
            if d < 2.5
                A = 1867;
                m = 0.146;
            elseif d < 5
                A = 2065;
                m = 0.263;
            elseif d <= 10
                A = 2911;
                m = 0.478;
            end
            elasticpercent = .45;

        case 'Phosphor-bronze wire B159'
            %Table 10-4 Shigley
            if d < 0.6
                A = 1000;
                m = 0;
            elseif d < 2
                A = 913;
                m = 0.028;
            elseif d <= 7.5
                A = 932;
                m = 0.064;
            end
            elasticpercent = .45;
    end

    S_ut = A / (d^m);
    S_sy = elasticpercent*S_ut;
    tao = 8*F*D/(pi*d^3) + 4*F/(pi*d^2);
    fos_static = S_sy / tao;
end
```

FOS inf life

```
    function fos_inf = calculateInfFOS(Fmin, Fmax, D, d, peenedStatus,
material)
        Fa = (Fmax-Fmin)/2;
        Fm = (Fmax+Fmin)/2;

        switch material
            case 'Music wire A228'
                %Table 10-4 Shigley
                A = 2211; %MPa * mm^m
                m = 0.145; %exponent

            case 'Hard-drawn wire A227'
                %Table 10-4 Shigley
                A = 1783; %MPa * mm^m
                m = 0.190; %exponent

            case 'Chrome-vanadium wire A232'
                %Table 10-4 Shigley
                A = 2005; %MPa * mm^m
                m = 0.168; %exponent

            case 'Chrome-silicon wire A401'
                %Table 10-4 Shigley
                A = 1974; %MPa * mm^m
                m = 0.108; %exponent

            case '302 stainless wire A313'
                %Table 10-4 Shigley
                if d < 2.5
                    A = 1867;
                    m = 0.146;
                elseif d < 5
                    A = 2065;
                    m = 0.263;
                elseif d <= 10
                    A = 2911;
                    m = 0.478;
                end

            case 'Phosphor-bronze wire B159'
                %Table 10-4 Shigley
                if d < 0.6
                    A = 1000;
                    m = 0;
                elseif d < 2
                    A = 913;
                    m = 0.028;
                elseif d <= 7.5
                    A = 932;
                    m = 0.064;
                end
```

```
        end
        C = D / d;
        Kb = (4*C + 2)/(4*C - 3);
        tao_a = Kb * (8*Fa*D)/(pi*d^3);
        tao_m = Kb * (8*Fm*D)/(pi*d^3);
        S_ut = A / (d^m);
        S_su = 0.67*S_ut;
        %add S_se based on peened or unpeened
        switch peenedStatus
            case 'Peened'
                S_sa = 398; %MPa
                S_sm = 534; % MPa

            case 'Unpeened'
                S_sa = 241; %MPa
                S_sm = 379; % MPa

        end

        S_se = S_sa / (1 - S_sm/S_su);

        middleStep = (tao_a / S_se + tao_m / S_su);
        fos_inf = 1/middleStep;

        %fos_inf = (tao_a / S_se + tao_m / S_su)^(-1);


    end
```

Display the results in a new figure

```
 function displayResultsFigure(totalCoils, activeCoils, pitch, springRate,
force, fMin, fos, force_FOS, units)
    % Create a new figure
    resultsFig = uifigure('Name', 'Spring Results', 'Position', [600, 300,
800, 150]);

    % Create uicontrols to display the results
    uicontrol(resultsFig, 'Style', 'text', 'Position', [20, 120, 300, 20],
'String', ['Total Coils, Nt: ' num2str(totalCoils)]);
    uicontrol(resultsFig, 'Style', 'text', 'Position', [20, 90, 300, 20],
'String', ['Active Coils, Na: ' num2str(activeCoils)]);

        % Check if the units are in English and perform conversions if needed
    if strcmp(units, 'English')
        convertToEnglish_length = @(value) value / 25.4;  % from m to inches
        convertToEnglish_springRate = @(value) value * 0.00571; % from N/m to
lbf/in
        convertToEnglish_force = @(value) value * 0.224809; %from newtons to
pound force

        % Convert results to English units (replace with your conversion
logic)
```

```
        pitch = convertToEnglish_length(pitch);
        springRate = convertToEnglish_springRate(springRate);
        force = convertToEnglish_force(force);

        uicontrol(resultsFig, 'Style', 'text', 'Position', [20, 60, 300, 20],
'String', ['Pitch, p [in]: ' sprintf('%.4f', pitch)]);
        uicontrol(resultsFig, 'Style', 'text', 'Position', [20, 30, 300, 20],
'String', ['Spring Rate, k [lbf/in]: ' sprintf('%.3f', springRate)]);
        uicontrol(resultsFig, 'Style', 'text', 'Position', [400, 120, 400,
20], 'String', ['Force needed to compress spring, F [lbf]: ' sprintf('%.3f',
force)]);
    else
        uicontrol(resultsFig, 'Style', 'text', 'Position', [20, 60, 300, 20],
'String', ['Pitch, p [mm]: ' sprintf('%.4f', pitch)]);
        uicontrol(resultsFig, 'Style', 'text', 'Position', [20, 30, 300, 20],
'String', ['Spring Rate, k [N/m]: ' sprintf('%.3f', springRate)]);
        uicontrol(resultsFig, 'Style', 'text', 'Position', [400, 120, 400,
20], 'String', ['Force needed to compress spring, F [N]: ' sprintf('%.3f',
force)]);
    end


    uicontrol(resultsFig, 'Style', 'text', 'Position', [400, 90, 400,
20], 'String', ['Associated FOS with Force needed to compress spring: '
sprintf('%.1f', force_FOS)]);

    % Display Factor of Safety with one decimal place
    if fMin == 0
        uicontrol(resultsFig, 'Style', 'text', 'Position', [400, 60, 400,
20], 'String', ['Factor of Safety (static): ' sprintf('%.1f', fos)]);
    else
        uicontrol(resultsFig, 'Style', 'text', 'Position', [400, 60, 400,
20], 'String', ['Factor of Safety (inf life): ' sprintf('%.1f', fos)]);
    end


end
```

Published with MATLAB® R2023b