Centroid Calculator

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ME 1311

(Programming for Engineers or MATLAB for Engineers)

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Centroid Calculator Introduction and Equations

By finding an object's centroid (which is synonymous with its center of mass, assuming common density throughout the object), one can calculate subsequent properties, such as moments of inertia, terminal velocity, and air resistance. The equations to find an object's centroid are outlined here.

$$(\text{x component of centroid}) = \bar{x} = \frac{\sum \tilde{x}\, A}{\sum A} \qquad (\text{y component of centroid}) = \bar{y} = \frac{\sum \tilde{y}\, A}{\sum A}$$

Throughout this program, $\tilde{x} = x \quad \tilde{y} = y \quad A = area$

For the area between two polynomials, the below also applies.

$$(\text{x component of centroid}) = \bar{x} = \frac{\sum \tilde{x}\, A}{\sum A} = \frac{\int_a^b \left(\tilde{x}\big(f(x) - g(x)\big)\right) \mathrm{d}x}{\int_a^b \big(f(x) - g(x)\big) \mathrm{d}x}$$

$$(\text{y component of centroid}) = \bar{y} = \frac{\sum \tilde{y}\, A}{\sum A} = \frac{\int_a^b \left(\tilde{y}\big(f(x) - g(x)\big)\right) \mathrm{d}x}{\int_a^b \big(f(x) - g(x)\big) \mathrm{d}x}$$

Where $f(x)$ is the upper function, $g(x)$ is the lower function, a is the leftmost intersection point, and b is the rightmost intersection point.

Centroid Calculator Code

```
% This program offers choices to the user, allowing them to find the
% centroid of 1. An I-Beam, 2. A C-Beam, and 3. The area between two
polynomials.
% By Micah Holston, Nicholas Marr, and Jesus Arellano
clc
close all
close all
help Group_Project
% PER PROFESSOR'S FEEDBACK, added help function, corrected typos throughout,
removed conditions on the "else" line in else functions, and added a 2 second
pause after an invalid input before the program loops back to the spot of the
improper input.
toploop=0;

while ~toploop
    Selection=input('Select which object to find the centroid of: 1. An I-
Beam, 2. A C-Beam, or 3. The area between two polynomials \n');



    if Selection==1
        toploop=1;
        % Option to find the centroid of an I-beam by Micah Holston

        % Displays I-beam instruction image
        imshow I-Beam_Dimension_Guide.jpg
        loopIBeam=0;
        % Asks User for height, widths, flange thickness, and unit inputs
        while ~loopIBeam
            DimsI=input('Input the dimensions of your I-beam as a vector in
the following order: Height, width of top, width of bottom, and flange
thickness. \n');
            unit=input('Select units (mm, in, ft, etc.): \n', 's');
            h=DimsI(1);
            wt=DimsI(2);
            wb=DimsI(3);
            ft=DimsI(4);
            L=length(DimsI);

            % Since the flange thickness cannot possibly be greater than the
I-beam's width or half its height, these statements notify the user of
invalid input and return the user back to the original I-Beam input request.
            if ft>=wb
                fprintf('Invalid dimensions (flange thickness cannot possibly
be greater than the I-beams width), double check and reenter numbers. \n')
                pause(2)
                loopIBeam=0;
            elseif ft>=0.5*h
```

```
                fprintf('Invalid dimensions (flange thickness cannot possibly
be greater than half the I-beams height), double check and reenter numbers.
\n')
                pause(2)
                loopIBeam=0;
            % Since the vector should only have a length of 4 and the top
must be wider than the bottom, these statements notify the user of invalid
input and return the user back to the original I-Beam input request.
            elseif L~=4
                fprintf ('Invalid length of vector, please reenter the
required 4 numbers. \n')
                pause(2)
                loopIBeam=0;
            elseif wt<wb
                fprintf ('The width of the top must be greater than the
bottom. If necessary, flip the I-beam upside-down and input it accordingly.
\n')
                pause(2)
                loopIBeam=0;

            % If the user input is valid, the program proceeds.
            else
                loopIBeam=1;

                % Calculates centroid and breaks loop of "invalid input"
                x=0.5*wt;
                y=((0.5*wb*ft^2)+(ft*(h-(2*ft))*(ft+0.5*(h-(2*ft))))+((h-
(0.5*ft))*ft*wt))/((wt*ft)+(wb*ft)+(ft*(h-(2*ft))));

                % Graphs centroid on I-beam, consisting of three rectangles
                plot (x,y, 'r*')
                grid on
                grid minor
                xlabel('Width of I-Beam')
                ylabel('Height of I-Beam')
                title('Centroid of the I-Beam')
                legend({'Centroid'})
                top = rectangle('Position',[(0) (h-ft) (wt)
(ft)],'EdgeColor','b', 'LineWidth',4);
                middle = rectangle('Position',[(0.5*wt-(0.5*ft)) ft ft (h-
(2*ft))],'EdgeColor','b', 'LineWidth',4);
                bottom = rectangle('Position',[((0.5*wt)-(0.5*wb)) 0 wb
ft],'EdgeColor','b', 'LineWidth',4);

                % Output centroid's values to user
                fprintf('This I-beams centroid is located at (%g, %g) %s,
measured from the origin (the bottom left corner of its cross-section). \n',
x, y, unit)
                pause(1.5)

                % Write data into Excel sheet
                Titles={'Height','Width of Top', 'Width of Bottom','Flange
Thickness', 'X-Component of Centroid', 'Y-Component of Centroid'};
                xlswrite('Centroid_of_I-Beam.xlsx',Titles,1,'A1')
                xlswrite('Centroid_of_I-Beam.xlsx',h,1,'A2')
                xlswrite('Centroid_of_I-Beam.xlsx',wt,1,'B2')
```

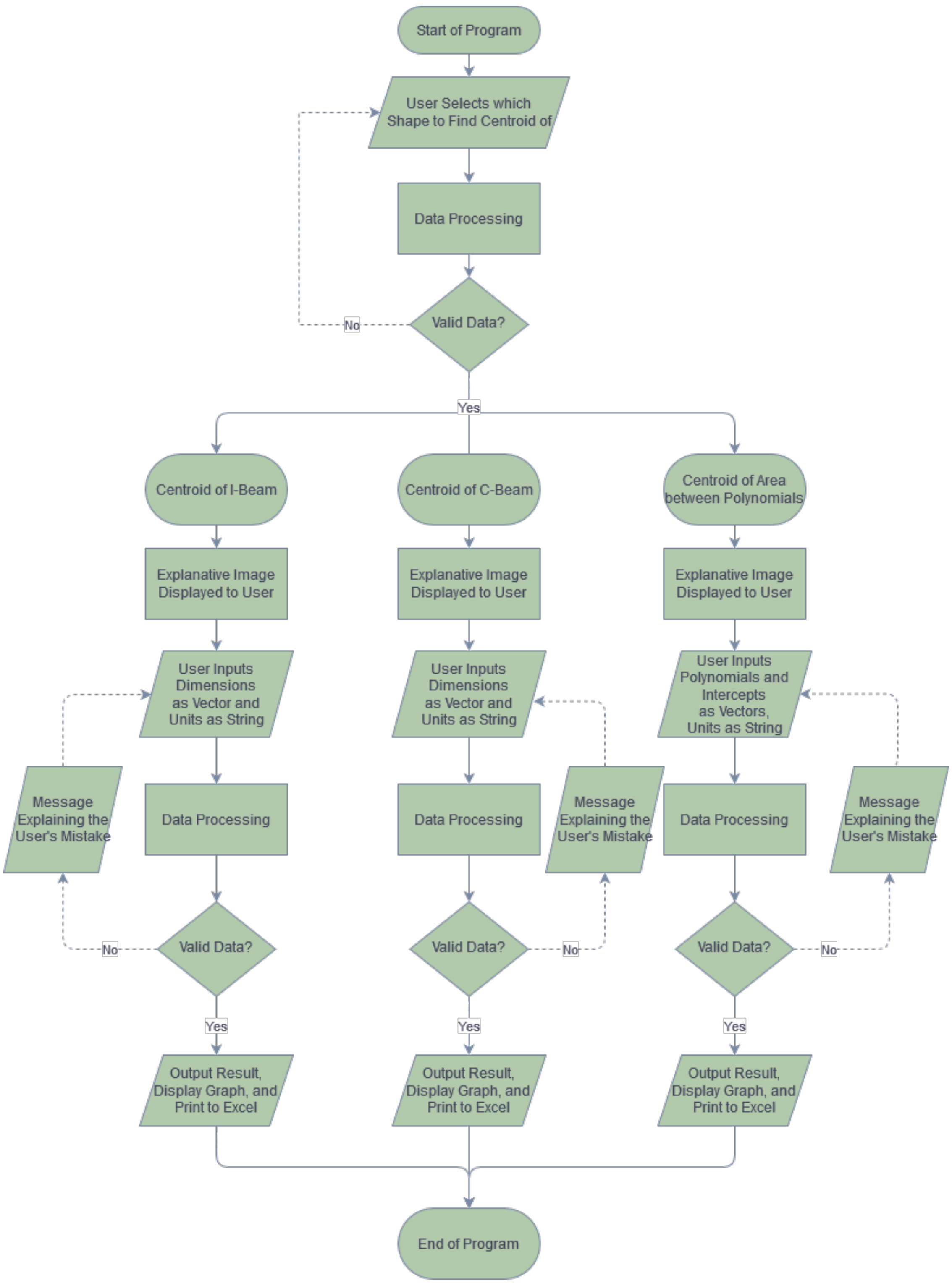
```
                xlswrite('Centroid_of_I-Beam.xlsx',wb,1,'C2')
                xlswrite('Centroid_of_I-Beam.xlsx',ft,1,'D2')
                xlswrite('Centroid_of_I-Beam.xlsx',x,1,'E2')
                xlswrite('Centroid_of_I-Beam.xlsx',y,1,'F2')
            end
        end





    elseif Selection==2
        toploop=1;
        % Option to find the centroid of a C-beam by Micah Holston and Jesus
Arellano

        % Displays C-beam instruction image
        imshow C_Beam_Dimension_Guide.jpg

        loopCBeam=0;
        while ~loopCBeam
            % Asks User for height, widths, flange thickness, and unit inputs
            DimsC=input('Input the dimensions of your C-beam as a vector in
the following order: Height, width of top, width of bottom, and flange
thickness. \n');
            unit=input('Select units (mm, in, ft, etc.): \n', 's');
            h=DimsC(1);
            wt=DimsC(2);
            wb=DimsC(3);
            ft=DimsC(4);
            L=length(DimsC);

            % Since the flange thickness cannot possibly be greater than the
C-beam's width or half its height, these statements notify the user of
invalid input and return the user back to the original C-Beam input request.
            if ft>=wb
                fprintf('Invalid dimensions (flange thickness cannot possibly
be greater than the C-beams width), double check and reenter numbers. \n')
                pause(2)
                loopCBeam=0;
            elseif ft>=0.5*h
                fprintf('Invalid dimensions (flange thickness cannot possibly
be greater than half the C-beams height), double check and reenter numbers.
\n')
                pause(2)
                loopCBeam=0;
            % Since the vector should only have a length of 4 and the top
must be wider than the bottom, these statements notify the user of invalid
input and return the user back to the original C-Beam input request.
            elseif L~=4
                fprintf ('Invalid length of vector, please reenter the
required 4 numbers. \n')
                pause(2)
                loopCBeam=0;
            elseif wt>wb
```

```
                fprintf ('The width of the bottom must be greater than the
top. If necessary, flip the C-beam upside-down and input it accordingly. \n')
                pause(2)
                loopCBeam=0;

            % If the user input is valid, the program proceeds.
            else
                loopCBeam=1;

                % Calculates centroid and breaks loop of "invalid input"
                x=((0.5*ft*wb^2)+(0.5*ft*(ft*(h-
(2*ft))))+(0.5*ft*wt^2))/((wb*ft)+(ft*(h-(2*ft)))+(wt*ft));
                y=((0.5*wb*ft^2)+(0.5*h*(ft*(h-(2*ft))))+(wt*ft*(h-
(0.5*ft))))/((wb*ft)+(ft*(h-(2*ft)))+(wt*ft));
                % Graphs centroid on I-beam, consisting of three rectangles
                plot (x,y, 'b*')
                axis ([-10 (wb+10) -10 (h+10)])
                grid on
                grid minor
                xlabel('Width of C-Beam')
                ylabel('Height of C-Beam')
                title('Centroid of the C-Beam')
                legend({'Centroid'})
                top = rectangle('Position',[0 (h-ft) wt ft],'EdgeColor','r',
'LineWidth',4);
                middle = rectangle('Position',[0 ft ft (h-
(2*ft))],'EdgeColor','r', 'LineWidth',4);
                bottom = rectangle('Position',[0 0 wb ft],'EdgeColor','r',
'LineWidth',4);
                % Output centroid's values to user
                fprintf('This C-beams centroid is located at (%g, %g) %s,
measured from the origin (the bottom left corner of its cross-section). \n',
x, y, unit)

                pause(1.5)

                % Write data into Excel sheet
                Titles={'Height','Width of Top', 'Width of Bottom','Flange
Thickness', 'X-Component of Centroid', 'Y-Component of Centroid'};
                xlswrite('Centroid_of_C-Beam.xlsx',Titles,1,'A1')
                xlswrite('Centroid_of_C-Beam.xlsx',h,1,'A2')
                xlswrite('Centroid_of_C-Beam.xlsx',wt,1,'B2')
                xlswrite('Centroid_of_C-Beam.xlsx',wb,1,'C2')
                xlswrite('Centroid_of_C-Beam.xlsx',ft,1,'D2')
                xlswrite('Centroid_of_C-Beam.xlsx',x,1,'E2')
                xlswrite('Centroid_of_C-Beam.xlsx',y,1,'F2')
            end
        end
```

```
    elseif Selection==3

        toploop=1;
        % Option to find the centroid of the area between two polynomials by
Nicholas Marr and Micah Holston
        clc
        close all
        imshow('Polynomial_Instructions.jpg');

            unit=input('Select units (mm, in, ft, etc.):\n', 's');
            loopPolynomial=0;
            fprintf('NOTE: Inputted vectors of each polynomial must be the
same length.\n When necessary, add zeroes before a lower-degree polynomials
vector to ensure both vectors possess the same length. \n For example, find
the centroid between [0,1,0,0] and [1,0,0,0] \n')
            while ~loopPolynomial
                upper=input('Enter the coefficients of the shape`s upper
function in the form of a matrix:\n');
                lower=input('Enter the coefficients of the shape`s lower
function in the form of a matrix:\n');
                x1=input('Enter the x value of the first (left-most)
intersection of the two functions:\n');
                x2=input('Enter the x value of the second (right-most)
intersection of the two functions:\n');
                xtest=abs((abs(x2)-abs(x1))*0.5)+x1;
                Utest=polyval(upper,xtest);
                Ltest=polyval(lower,xtest);
                L1=length(upper);
                L2=length(lower);
                if x1>x2
                    fprintf('Invalid input! The first intersection of the two
functions must possess a smaller x-value than the second intersection. \n')
                    loopPolynomial=0;
                    pause(2)
                elseif Utest<=Ltest
                    fprintf('Invalid input! The lower function must be below
the upper function across the selected range. n\ Recheck the order of
functions inputted and the points of intersection. \n')
                    loopPolynomial=0;
                    pause(2)
                elseif L1~=L2
                    fprintf('Invalid input! The vectors of both polynomials
must be the same length. If necessary, \n add zeros (i.e. preface a quadratic
function with one zero when comparing it to a cubic function).\n ')
                    loopPolynomial=0;
                    pause(2)
                else
                    loopPolynomial=1;

                  dA= upper - lower;
                  A=polyint(dA);
                  Area=diff(polyval(A,[x1 x2]));

                  x=[1 0];
                  xdA=conv(x,dA);
                  B=polyint(xdA);
```

```
                    xbar=(1/Area).*diff(polyval(B,[x1 x2]));

                    C=polyint(conv(upper,upper)-conv(lower,lower));
                    ybar=0.5*(1/Area).*diff(polyval(C,[x1 x2]));

                    fprintf('The centroid, (xbar,ybar) is located at: \n')
                    fprintf('(%.2f,%.2f)\n',[xbar,ybar])
                    range=x1-.1:0.1:x2+.1;


                    plot(range,polyval(upper,range))
                    hold on
                    plot(range,polyval(lower,range))
                    hold on
                    plot(xbar,ybar,'gd')
                    xlabel('x-axis')
                    ylabel('y-axis')
                    title('Centroid of the Shape between the Polynomials')
                    legend({'Upper Function','Lower Function','Centroid'})
                    pause(1.5)
                    grid on


                    Titles={'Leading Coefficient of Upper Function','Leading
Coefficient of Lower Function','X-Component of Centroid', 'Y-Component of
Centroid'};

xlswrite('Area_Between_Polynomials_Centroid.xlsx',Titles,1,'A1')

xlswrite('Area_Between_Polynomials_Centroid.xlsx',upper,1,'A2')

xlswrite('Area_Between_Polynomials_Centroid.xlsx',lower,1,'B2')

xlswrite('Area_Between_Polynomials_Centroid.xlsx',xbar,1,'C2')

xlswrite('Area_Between_Polynomials_Centroid.xlsx',ybar,1,'D2')

                end
            end

    else
        % If the user fails to select "1", "2", or "3" at the program's first
request for input, it returns this error message.
        fprintf('Invalid input, please input either "1", "2", or "3" to
select your choice. \n')
        pause(2.5)
        toploop=0;
    end
end
```

Operations Flowchart



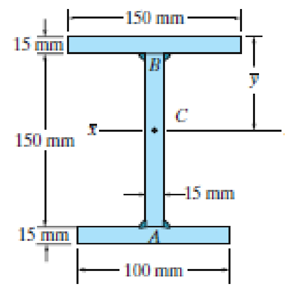
Centroid of an I-Beam

Below is the type of physics problem that this portion of the program solves.

$$(\text{x component of centroid}) = \bar{x} = \frac{\sum \tilde{x}\,A}{\sum A} \qquad (\text{y component of centroid}) = \bar{y} = \frac{\sum \tilde{y}\,A}{\sum A} \qquad A = area$$

9–61.

Determine the location $\bar{y}$ of the centroid C of the beam having the cross-sectional area shown.



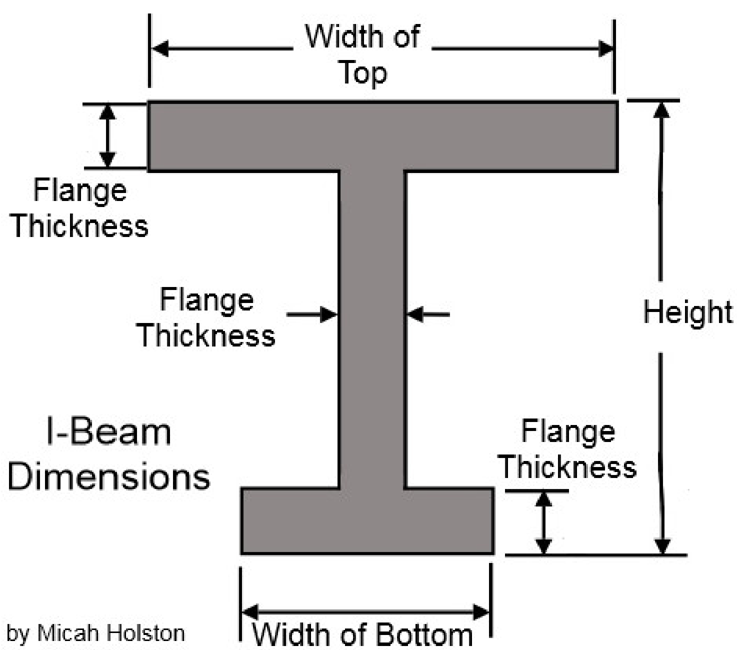
SOLUTION

Centroid. The locations of the centroids measuring from the x axis for segments ①, ② and ③ are indicated in Fig. *a*. Thus

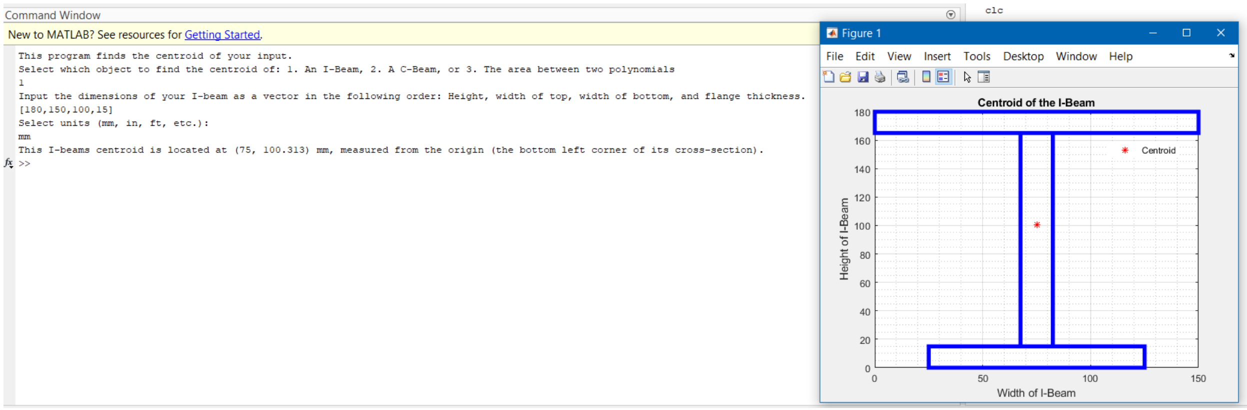
$$\bar{y} = \frac{\Sigma \tilde{y}\,A}{\Sigma A} = \frac{7.5(15)(150) + 90(150)(15) + 172.5(15)(100)}{15(150) + 150(15) + 15(100)}$$

$$= 79.6875 \text{ mm} = 79.7 \text{ mm} \qquad \textbf{Ans.}$$

When the user inputs “1”, this option first displays the below explanative image.



Then the program runs, reliant upon user inputs, as pictured and typed below.



This program finds the centroid of your input.

Select which object to find the centroid of: 1. An I-Beam, 2. A C-Beam, or 3. The area between two polynomials

1

Input the dimensions of your I-beam as a vector in the following order: Height, width of top, width of bottom, and flange thickness.

[180,150,100,15]

Select units (mm, in, ft, etc.):

mm

This I-beams centroid is located at (75, 100.313) mm, measured from the origin (the bottom left corner of its cross-section).

NOTE: The program also outputs a graph of the I-Beam (pictured) and an Excel sheet containing the data.

NOTE: My program calculates the centroid from the bottom left of the cross-section. The original problem calculates y-bar from the top of the I-Beam, thus my program's output of 100.313 is still correct (180 - 79.7 = 100.313).

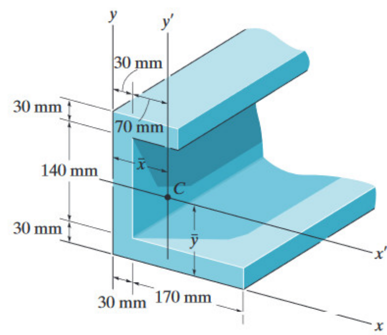
Centroid of a C-Beam

Below is the type of physics problem that this portion of the program solves.

$$(\text{x component of centroid}) = \bar{x} = \frac{\sum \tilde{x} A}{\sum A} \qquad (\text{y component of centroid}) = \bar{y} = \frac{\sum \tilde{y} A}{\sum A} \qquad A = area$$

***10–44.**

Determine the distance $\bar{y}$ to the centroid C of the beam's cross-sectional area



SOLUTION

$$\bar{y} = \frac{170(30)(15) + 170(30)(85) + 100(30)(185)}{170(30) + 170(30) + 100(30)}$$

$= 80.68 = 80.7$ mm **Ans.**

10–45.

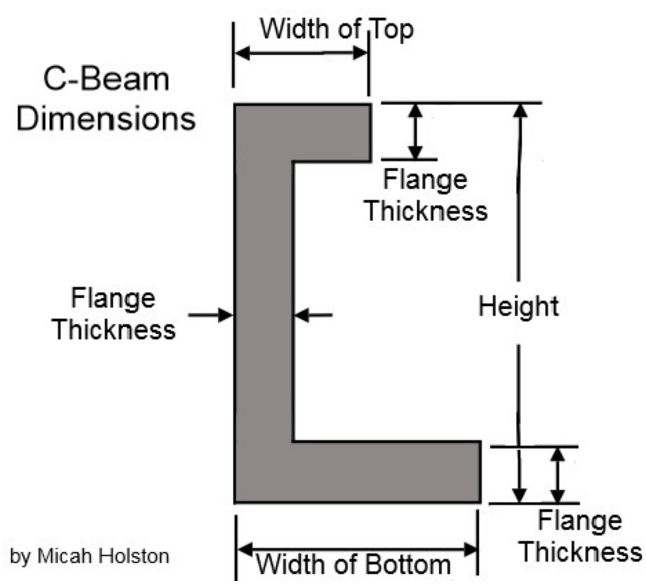
Determine the distance $\bar{x}$ to the centroid C of the beam's cross-sectional area

SOLUTION

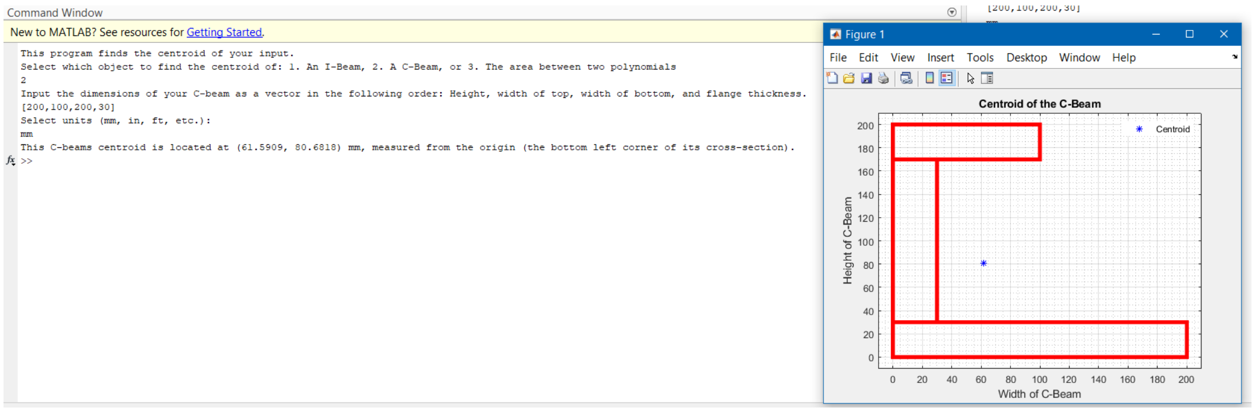
$$\bar{x} = \frac{170(30)(115) + 170(30)(15) + 100(30)(50)}{170(30) + 170(30) + 100(30)}$$

$= 61.59 = 61.6$ mm **Ans.**

When the user inputs "2", this option first displays the below explanative image.



Then the program runs, reliant upon user inputs, as pictured and typed below.



This program finds the centroid of your input.

Select which object to find the centroid of: 1. An I-Beam, 2. A C-Beam, or 3. The area between two polynomials

2

Input the dimensions of your C-beam as a vector in the following order: Height, width of top, width of bottom, and flange thickness.

[200,100,200,30]

Select units (mm, in, ft, etc.):

mm

This C-beams centroid is located at (61.5909, 80.6818) mm, measured from the origin (the bottom left corner of its cross-section).

NOTE: The program also outputs a graph of the C-Beam (pictured) and an Excel sheet containing the data.

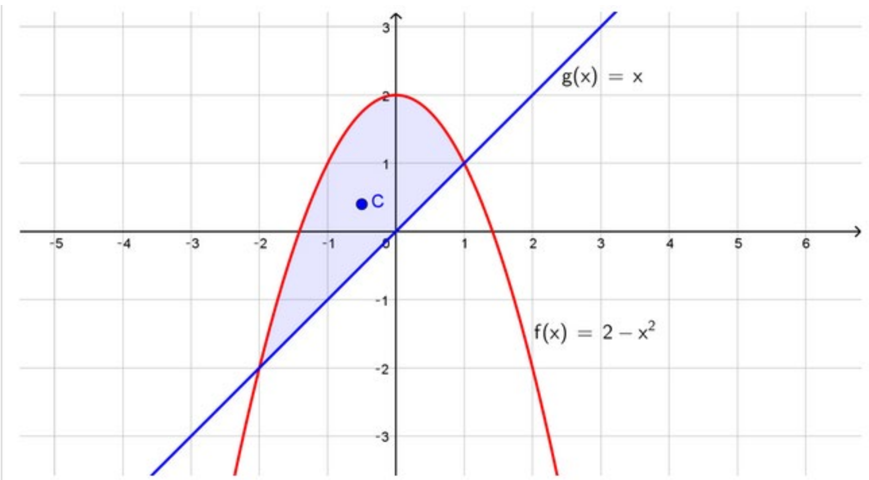
Centroid of the Area between Two Polynomials

Below is the type of physics problem that this portion of the program solves.

$$\text{(x component of centroid)} = \bar{x} = \frac{\sum \tilde{x} A}{\sum A} = \frac{\int_a^b \left(\tilde{x}\left(f(x) - g(x)\right)\right) \mathrm{d}x}{\int_a^b \left(f(x) - g(x)\right) \mathrm{d}x}$$

$$\text{(y component of centroid)} = \bar{y} = \frac{\sum \tilde{y} A}{\sum A} = \frac{\int_a^b \left(\tilde{y}\left(f(x) - g(x)\right)\right) \mathrm{d}x}{\int_a^b \left(f(x) - g(x)\right) \mathrm{d}x}$$

Where $f(x)$ is the upper function, $g(x)$ is the lower function, a is the leftmost intersection point, and b is the rightmost intersection point.



2

$f(x) = 2 - x^2 \qquad g(x) = x$

Find the intersections

$$x = 2 - x^2$$
$$x^2 + x - 2 = 0$$
$$(x+2)(x-1) = 0 \quad \rightarrow \quad x = -2,\ 1$$

3

Find the area of the bounded region.

$$A = \int_a^b (f(x) - g(x))\, dx = \int_{-2}^{1} (2 - x^2 - x)\, dx$$

$$= \left[2x - \frac{1}{3}x^3 - \frac{1}{2}x^2\right]_{-2}^{1}$$

$$= 2 - \frac{1}{3} - \frac{1}{2} - \left(2(-2) - \frac{1}{3}(-8) - \frac{1}{2}(4)\right)$$

$$= \frac{12}{6} - \frac{2}{6} - \frac{3}{6} - \left(-4 + \frac{8}{3} - 2\right)$$

$$= \frac{7}{6} - \left(-6 + \frac{16}{6}\right)$$

4

Find the x-coordinate of the centroid.

$$\overline{x} = \frac{1}{A}\int_a^b x[f(x) - g(x)]dx$$

$$= \frac{1}{\frac{27}{6}}\int_{-2}^{1} x\left(2 - x^2 - x\right)\ dx = \frac{6}{27}\int_{-2}^{1}\left(2x - x^3 - x^2\right) dx$$

$$= \frac{6}{27}\left[x^2 - \frac{1}{4}x^4 - \frac{1}{3}x^3\right]_{-2}^{1}$$

$$= \frac{6}{27}\left[1 - \frac{1}{4} - \frac{1}{3} - \left(4 - \frac{1}{4}(16) - \frac{1}{3}(-8)\right)\right]$$

$$= \frac{6}{27}\left[\frac{12}{12} - \frac{3}{12} - \frac{4}{12} - \left(4 - 4 + \frac{8}{3}\right)\right]$$

$$= \frac{6}{27}\left[\frac{5}{12} - \frac{8}{3}\right]$$

$$= \frac{6}{27}\left[\frac{5}{12} - \frac{32}{12}\right]$$

$$= \frac{6}{27}\left[-\frac{27}{12}\right]$$

$$= -\frac{1}{2}$$

5

Find the y-coordinate of the centroid.

$$\overline{y} = \frac{1}{A}\int_a^b \frac{1}{2}([f(x)]^2 - [g(x)]^2)dx$$

$$= \frac{6}{27}\cdot\frac{1}{2}\int_{-2}^{1}\left((2 - x^2)^2 - (x)^2\right) dx = \frac{1}{9}\int_{-2}^{1}(4 - 4x^2 + x^4 - x^2)\ dx$$

$$= \frac{1}{9}\int_{-2}^{1}(4 + x^4 - 5x^2)\ dx$$

$$= \frac{1}{9}\left[4x + \frac{1}{5}x^5 - \frac{5}{3}x^3\right]_{-2}^{1}$$

$$= \frac{1}{9}\left[4 + \frac{1}{5} - \frac{5}{3} - \left(4(-2) + \frac{1}{5}(-32) - \frac{5}{3}(-8)\right)\right]$$

$$= \frac{1}{9}\left[4 + \frac{1}{5} - \frac{5}{3} + 8 + \frac{32}{5} - \frac{40}{3}\right]$$

6

$$= \frac{1}{9}\left[12 + \frac{33}{5} - \frac{45}{3}\right]$$

$$= \frac{1}{9}\left[12 + \frac{33}{5} - 15\right]$$

$$= \frac{1}{9}\left[\frac{33}{5} - 3\right]$$

$$= \frac{1}{9}\left[\frac{33}{5} - \frac{15}{5}\right]$$

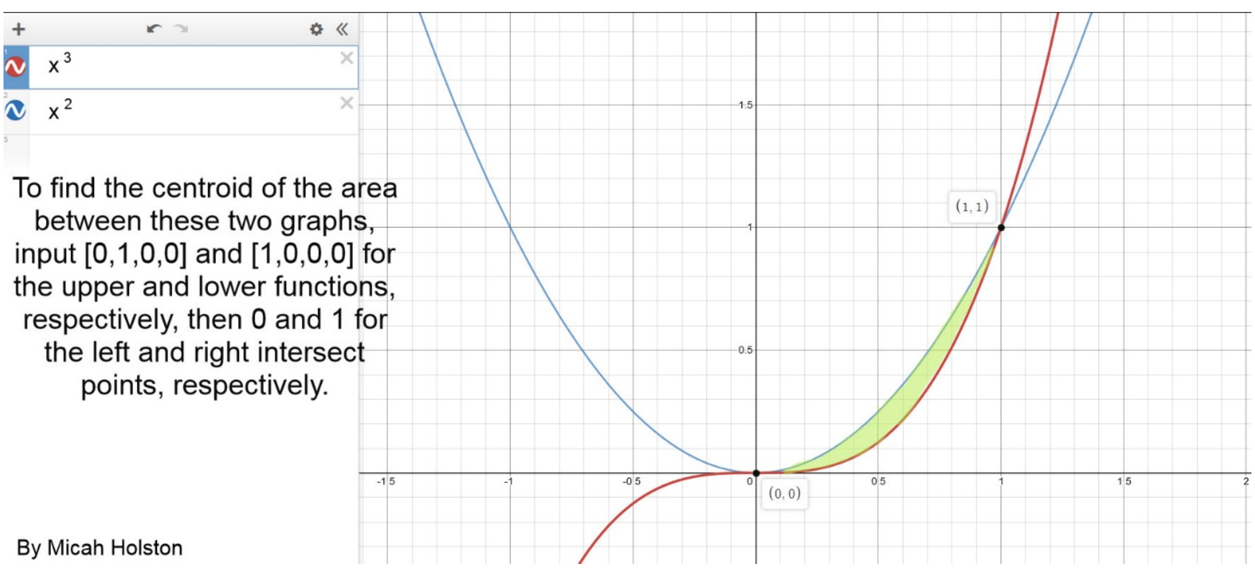
$$= \frac{1}{9}\left[\frac{18}{5}\right]$$

$$= \frac{2}{5}$$

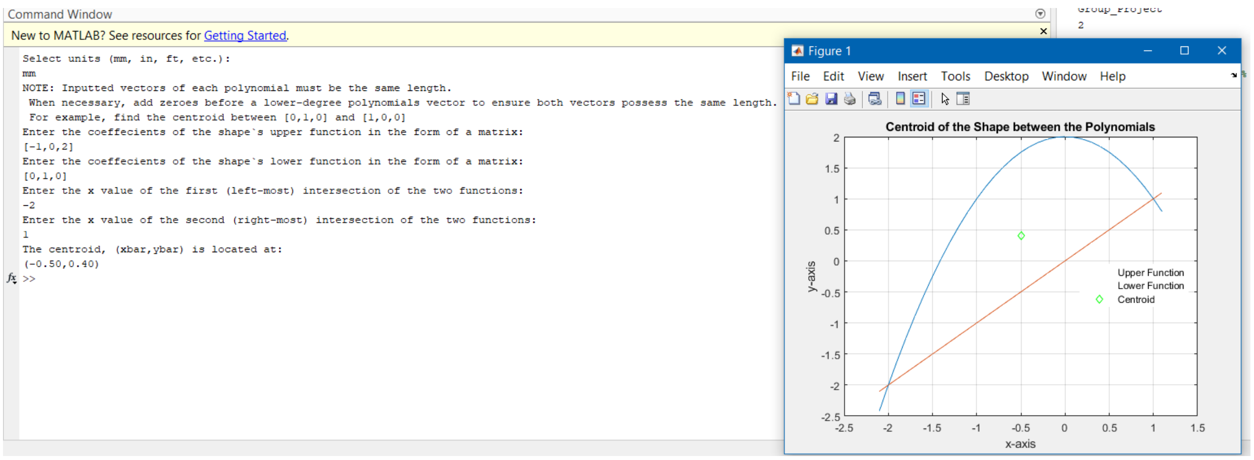
RESULT

$$(\overline{x}, \overline{y}) = \left(-\frac{1}{2}, \frac{2}{5}\right)$$

When the user inputs “3”, this option first displays the below explanative image.



Then the program runs, reliant upon user inputs, as pictured and typed below.



Select units (mm, in, ft, etc.):

mm

NOTE: Inputted vectors of each polynomial must be the same length.

When necessary, add zeroes before a lower-degree polynomials vector to ensure both vectors possess the same length.

For example, find the centroid between [0,1,0,0] and [1,0,0,0]

Enter the coeffecients of the shape`s upper function in the form of a matrix:

[-1,0,2]

Enter the coeffecients of the shape`s lower function in the form of a matrix:

[0,1,0]

Enter the x value of the first (left-most) intersection of the two functions:

-2

Enter the x value of the second (right-most) intersection of the two functions:

1

The centroid, (xbar,ybar) is located at:

(-0.50,0.40)

NOTE: The program also outputs a graph of the polynomials (pictured) and an Excel sheet containing the data.