RITIKA GOYAL (301401516)

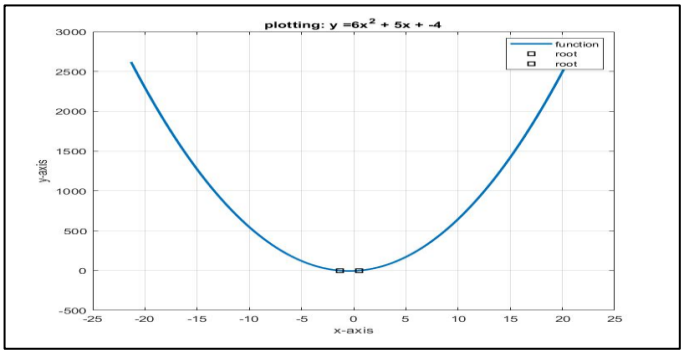
# MACM316, CA1

This MATLAB code, returns all real roots of the quadratic function ($a*x^2+b*x+c$). This code handles all the cases including where D>0, D<0, D=0, a =0, and b=0. In some cases, $b^2$ is much larger than 4*a*c which generates more relative error due to cancellation error, which is handled by avoiding subtraction while calculating roots. This is done by generating alternate quadratic formula by rationalizing the numerator. In some cases when $b^2$ exceeds realmax, roots reach +Inf or -Inf and division by infinity gives 0 as root. After finding the roots, the function is plotted on a graph with the suitable plotting interval, which include all the roots found using "usual" and "alternate" formula.

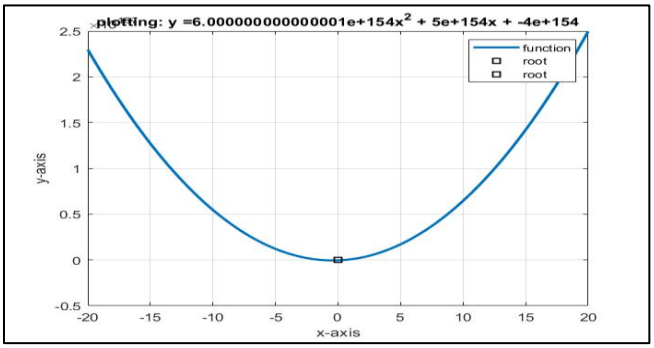
| CASE# | a | b | c | Root1 | Root2 | Explanation (roots) |
|---|---|---|---|---|---|---|
| 1 | 6 | 5 | -4 | -1.3333 | 0.5000 | Both the roots are real, D>0, doesn't involve cancellation error. |
| 2 | $6 \times 10^{154}$ | $5 X 10^{154}$ | $-4 X 10^{154}$ | -Inf | 0 | Roots are negative infinity (because $b^2$ exceeds realmax) and 0 (obtained by diving the result by infinity). By zooming in the plot, the point (0,0) is not actually on the function. |
| 3 | 0 | 1 | 1 | -1 | -- | Only one real root, since a=0(linear equation), roots is computed by -c/b. |
| 4 | 1 | $-10^5$ | 1 | 1.0000e -05 | 1.0000e+05 | Two real roots. |
| 5 | 1 | -4 | 3.999999 | 1.9990 | 2.0010 | Two real roots. Since these are very close to each other, they can be seen by zooming in the plot. |
| 6 | $10^{-155}$ | $-10^{155}$ | $10^{155}$ | 0 | Inf | Roots are 0(obtained by dividing the result by infinity) and infinity (because $b^2$ exceeds realmax). By zooming in the plot, the point (0,0) is not actually on the function. |

**Plots:**

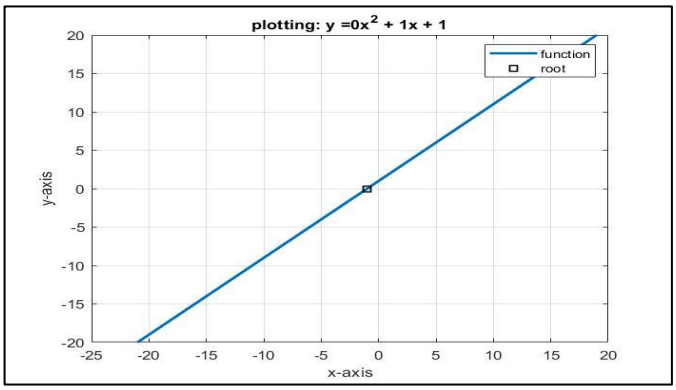
1.



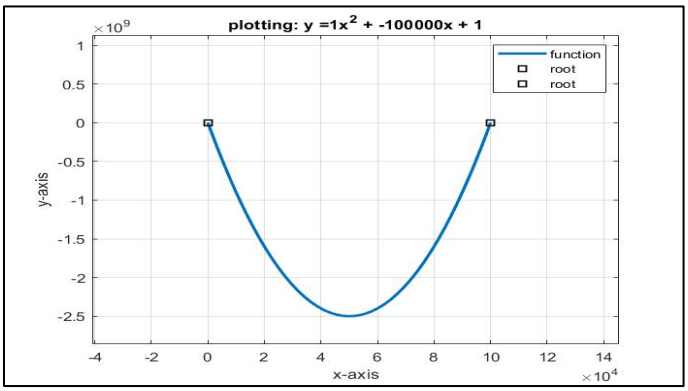

2.



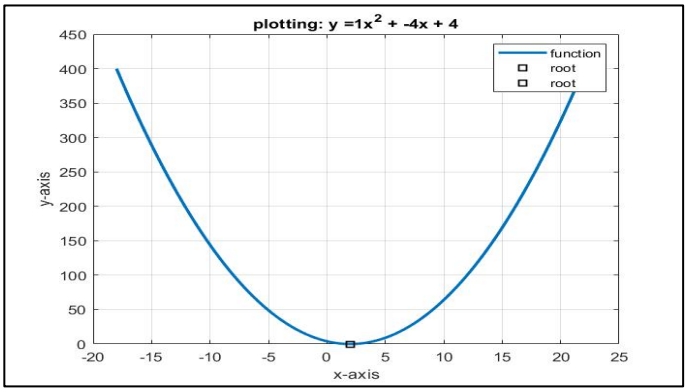

3.



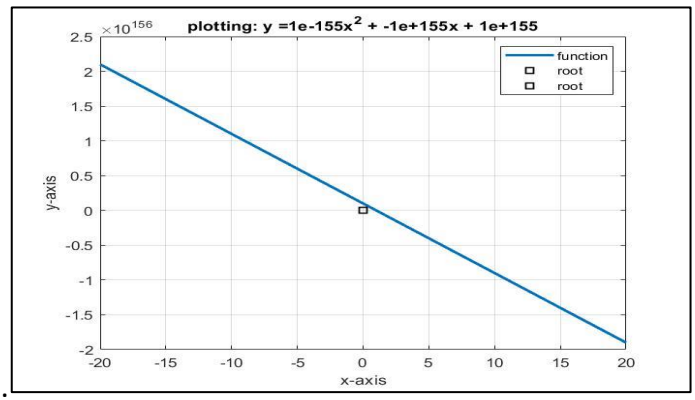

4.




5.




6.



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## MATLAB CODE

```
function roots = quadformula(a,b,c)
D = b^2 -4*a*c; %calculating discriminant
if a==0
    if b~=0
        roots =-c/b;
        disp("when a=0, there is only one real root: " + roots);
        count =1; %count is used to count number of roots
    else
        roots=[];
        disp("when a=0,b=0, there is no real root ");
        count = 0;
    end
elseif D > 0
    if b<0
        root1 = (-b +sqrt(D)) / (2*a);
        root2 = (-2*c)/(b-sqrt(D));  %using alternate formula to avoid cancellation error
    else
        root1 =(-2*c)/(b+sqrt(D));  %using alternate formula to avoid cancellation error
        root2 = (-b -sqrt(D)) / (2*a);
    end
    roots = [min(root1,root2), max(root1,root2)];%storing small root first
    disp("The equation has two real roots : " );
    disp(roots);
    count =2;
elseif D==0
    roots = -b/(2*a);
    disp("The equation has one real root : "+ roots);
    count =1;
elseif D<0
    roots=[];
    disp("The equation has no real roots, it has two complex roots: "+ roots);
    count =0;
end
if isempty(roots)
     x = linspace(-20,20); %choosing suitable interval depending on root values
elseif(count == 1)
    if roots(1)==-Inf
        x = linspace(-20,20);
    elseif roots(1)== Inf
        x = linspace(-20,20);
    else
        x = linspace(roots(1)-20,roots(1)+20);
    end
elseif (count == 2)
    if (roots(1)== -Inf) && (roots(2)== Inf)
        x = linspace(-20,20);
    elseif (roots(1)== -Inf) && (roots(2) ~= Inf)
         x = linspace(roots(2)-20,roots(2)+20);
    elseif (roots(1)~= -Inf) && (roots(2) == Inf)
         x = linspace(roots(1)-20,roots(1)+20);
    else
        x = linspace(min(roots)-20, max(roots)+20);
    end
end
plot(x, a*(x.^2) + b*x + c,'LineWidth',2);
legend('function');
hold on;
if ~isempty(roots) %check if there are no roots
    plot(roots,0,'sk','LineWidth',1,'DisplayName','root');
end
xlabel("x-axis");
ylabel("y-axis");
title("plotting: y =" + a+"x^2 + " +b+"x + "+c);
hold off;grid on;
end
```