## *Root Locus 1*
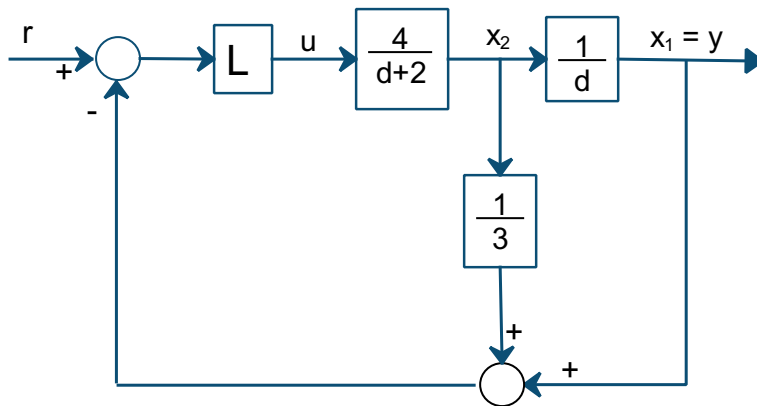
*Sketch the root locus for the system shown in figure below*



## Solution:

From the figure above we get the following equations.

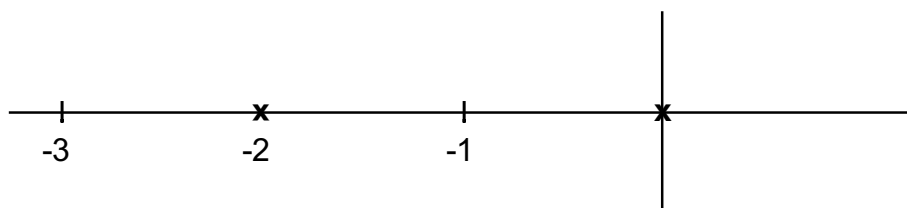$$G_p := \frac{4}{d\,(d+2)} \qquad\qquad H_{eq} := \frac{d+3}{3}$$

$$L_p := 4 \qquad\qquad L_n := \frac{1}{3}$$

and the loop transfer function is

$$L\ G_p\ H_{eq} = \frac{1.3333\ L\ d + 4\ L}{d^2 + 2\ d}$$
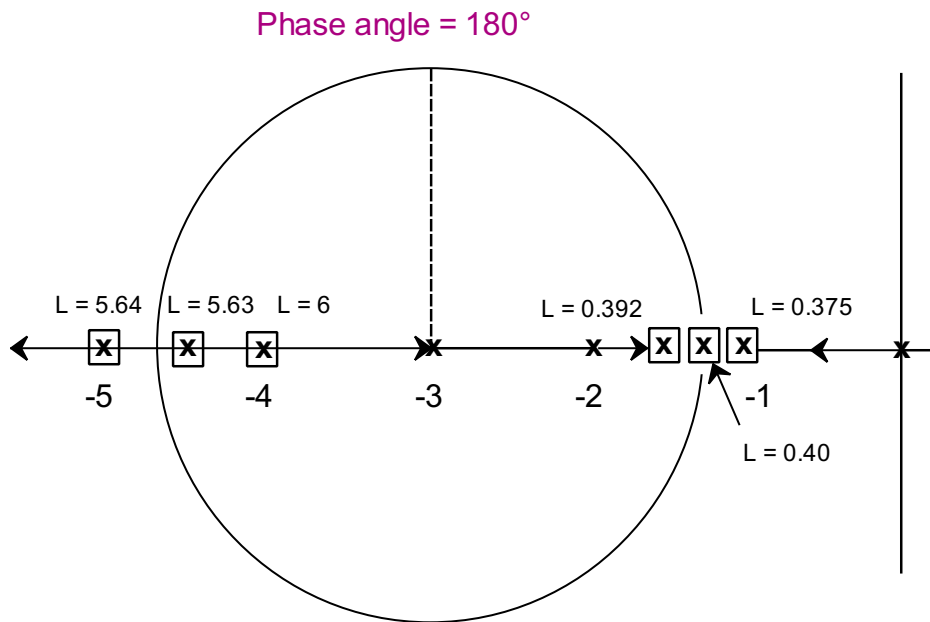
The pool-zero plot of the loop transfer function is



   The breakaway point is the point between d = -2 and d = 0 where the gain reaches its minimum. The re-entry point is located to the left of d = -3 at a point midway between two very close values of the gain. We shall examine some more points in the upper half plane. Since the root locus is symmetrical about the real axis we don't have to worry about the lower half of the plane. We shall find the point on the line d = -3  where the phase angle is 180°. The branches of the root locus must

be 90° apart at both the breakaway and re-entry points. Thus the angle between the root loci and the real axis must be ± 90°. Connecting the points found so far will make a smooth curve that passes through the point on the d = -3 line and is perpendicular to the real axis at the point of breakaway or re-entry we'll obtain a semicircle.

The complete root locus of the system is

Phase angle = 180°

L = 5.64   L = 5.63   L = 6                    L = 0.392              L = 0.375

-5            -4            -3            -2            -1

L = 0.40

# *Routh and Hurwitz Criteria*

*For the system shown below find the value of P for which the system is stable.*

R   +                          $\dfrac{P}{q^3 + 5\,q^2 + 8\,q + 5}$                          C

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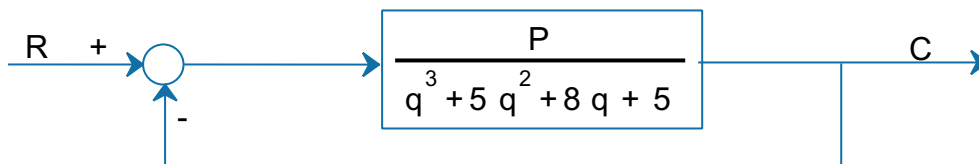
## Solution:

The characteristic equation is

$$D_q := q^3 + 5\,q^2 + 8\,q + 5 + P$$

The Hurwitz determinant value is

$$a := \begin{bmatrix} 5 & 5+P \\ 1 & 8 \end{bmatrix}$$

$$b := \text{mat determinant}(a)$$

$$b = 35 - P$$

$$b > 0 = \begin{bmatrix} P & (-\text{inf}, 35) \end{bmatrix}$$

For when **P < 35** the system is stable.