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# Hard Disk Design

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## Task 1

The differential equation of input voltage and head position is given, so it is pretty easy to get the open loop transfer function by taking the lapalce transform of both side and can easily get

$$\frac{Y(s)}{U(s)} = \frac{1}{Js^2 + bs}$$

## Task 2

open loop transfer function is given by multiplying both G1 and G2

$$G1(s)G2(s) = \frac{Km}{(Ls + R) * (Js^2 + bs)} = \frac{Km}{LJs^3 + Lbs^2 + RJs^2 + pbs}$$

```
s = tf('s');
J = 1;
b = 20;
R = 1;
L = 0.001;
Km = 5;
G1 = Km/(L*s+R)
G2 = 1/(J*s^2+b*s)
openTF = G1*G2
t=[0:0.005:0.5];
y = step(openTF,t);
plot(t,y);
```

G1 =

$$\frac{5}{0.001 s + 1}$$

*Continuous-time transfer function.*

$G2 =$

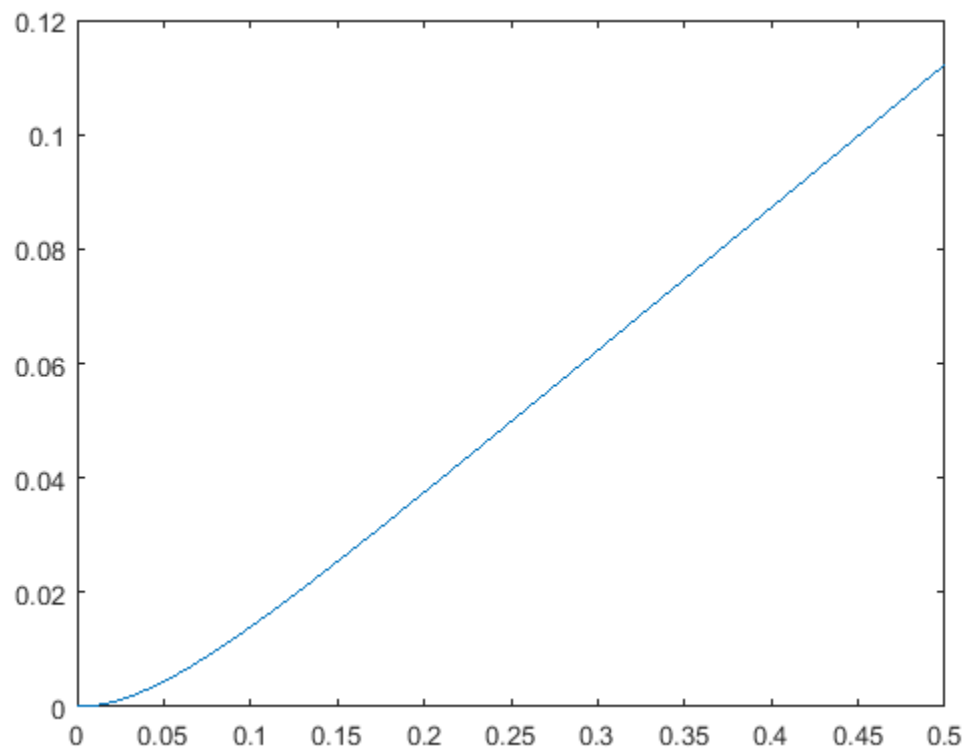
$$\frac{1}{s^2 + 20s}$$

Continuous-time transfer function.

$openTF =$

$$\frac{5}{0.001s^3 + 1.02s^2 + 20s}$$

Continuous-time transfer function.



You can see that if a constant voltage is applied, then the read head will move in a constant speed. And at the beginning when the voltage is applied, there is a curve, which indicates that the read head is accelerating under applied voltage.

## Task 3a

The proportional compensator is applied, so that the open loop transfer function is given by

$$K a * G1(s) * G2(s)$$

and closed loop transfer function is given by

$$\frac{K a * G1(s) * G2(s)}{1 + K a * G1(s) * G2(s)}$$

after plug in  $G1(s)G2(s)$  from previous computation, we have

$$\frac{K a * K m}{L J s^3 + (L b + R J) s^2 + p b s + K a K m}$$

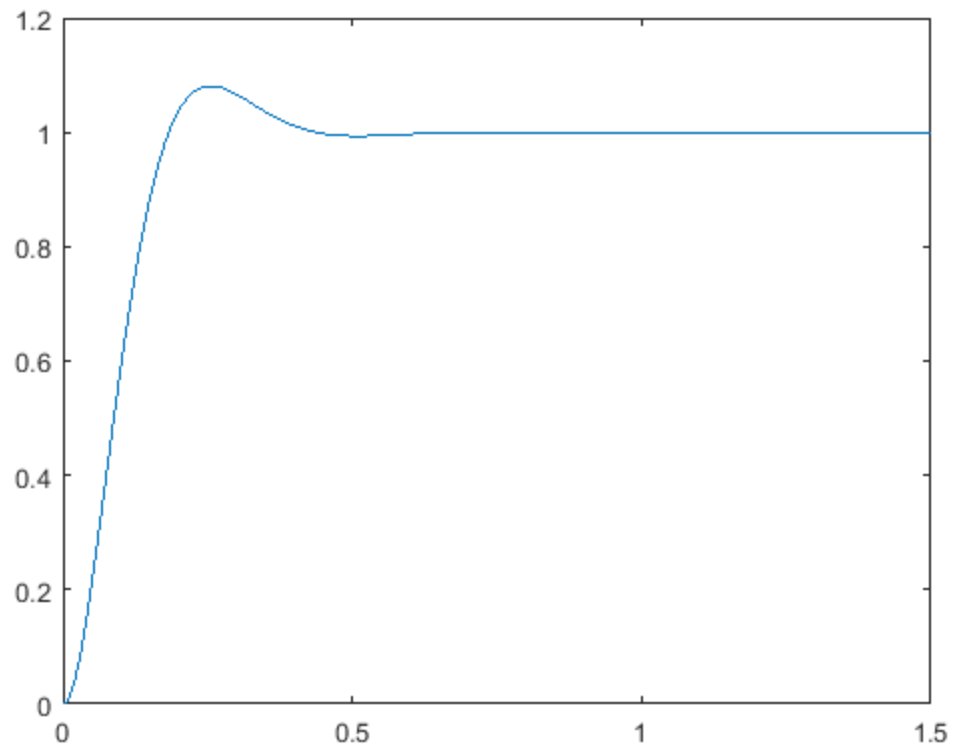
Try plugging in  $K a = 50$ , we can get the following plot

```
Ka = 50;
t=[0:0.005:1.5];
ProportionalTF = (Ka*G1*G2)/(1+Ka*G1*G2)
y = step(ProportionalTF, t);
plot(t,y);
```

*ProportionalTF =*

$$\frac{0.25 s^3 + 255 s^2 + 5000 s}{1e-06 s^6 + 0.00204 s^5 + 1.08 s^4 + 41.05 s^3 + 655 s^2 + 5000 s}$$

*Continuous-time transfer function.*



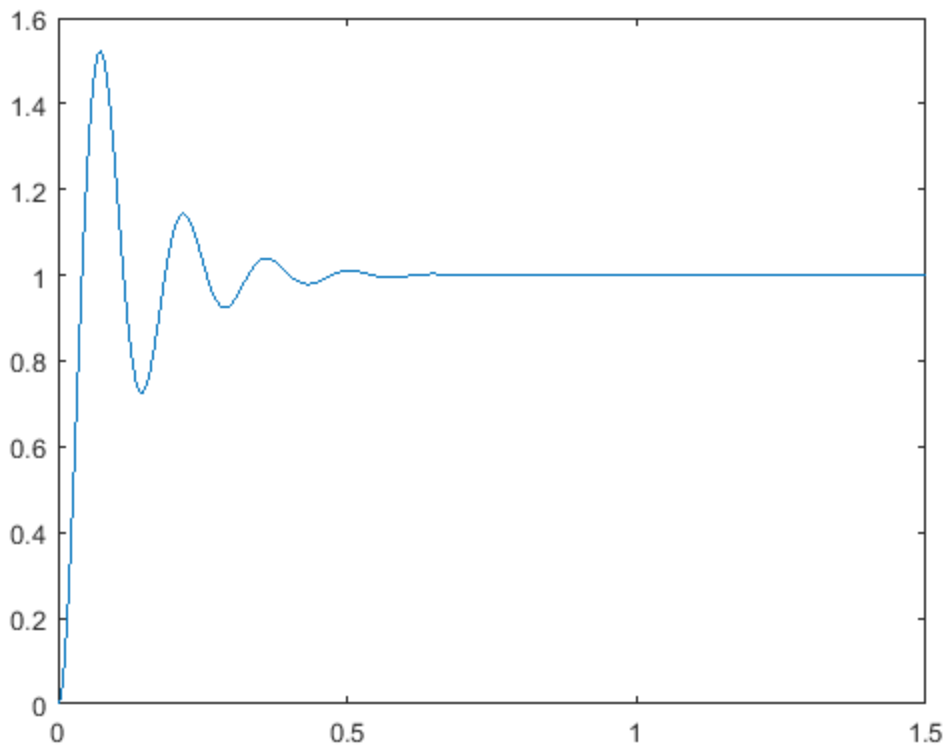
Then applied step when  $K_a = 400$

```
Ka = 400;
ProportionalTF = (Ka*openTF)/(1+Ka*openTF)
y = step(ProportionalTF, t);
plot(t,y);
```

*ProportionalTF =*

$$\frac{2 s^3 + 2040 s^2 + 40000 s}{1e-06 s^6 + 0.00204 s^5 + 1.08 s^4 + 42.8 s^3 + 2440 s^2 + 40000 s}$$

*Continuous-time transfer function.*



Clearly you can see that the  $K_a=50$  has less over shoot than  $K_a=400$  does. This is because for  $K_a=400$ , the feedback amplification is too big and make system too sensitive.

## Task 3b

So when disturbance is Introduced to the system, the disturbance input flows into system between  $G1$  and  $G2$ . So that we can derive the transfer function for disturbance:

$$Tw = \frac{G2(s)}{1 + Ka * G1(s)}$$

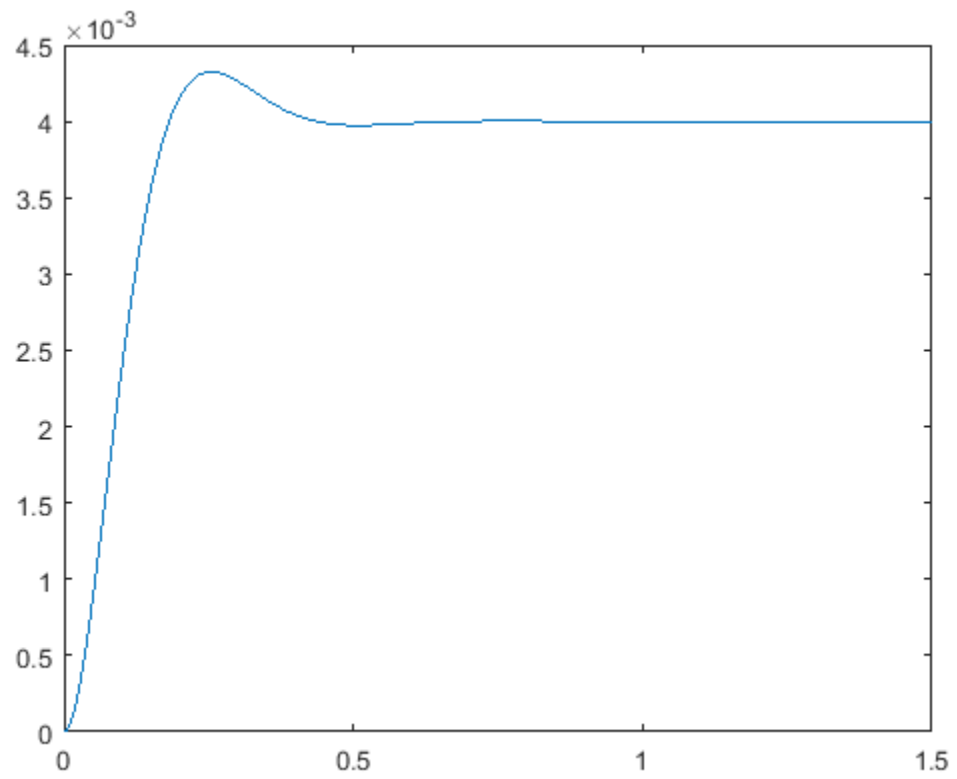
First plot the response of disturbance in case of  $ka = 50$

```
Ka = 50;
Tw = G2/(1+Ka*G1*G2)
y = step(Tw, t);
plot(t,y);
```

$Tw =$

$$\frac{0.001 s^3 + 1.02 s^2 + 20 s}{0.001 s^5 + 1.04 s^4 + 40.4 s^3 + 650 s^2 + 5000 s}$$

*Continuous-time transfer function.*



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