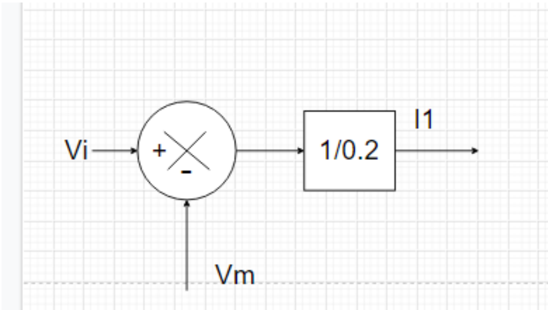
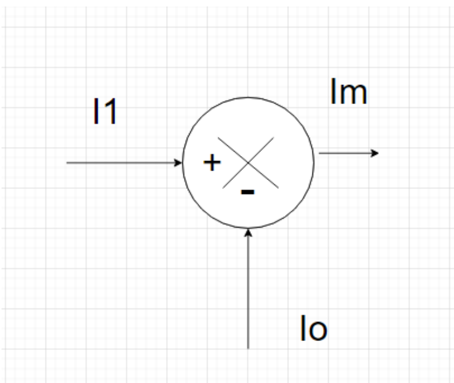
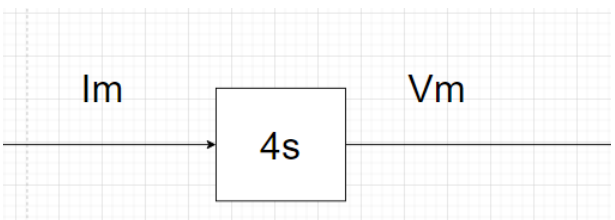
1. Vi - Vm = 0.2I1



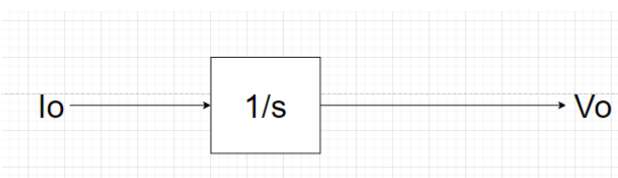
2. Im = I1 - Io



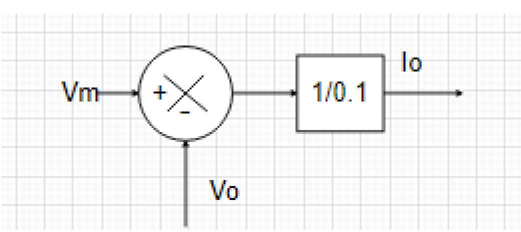
3. Vm = Im * 4s



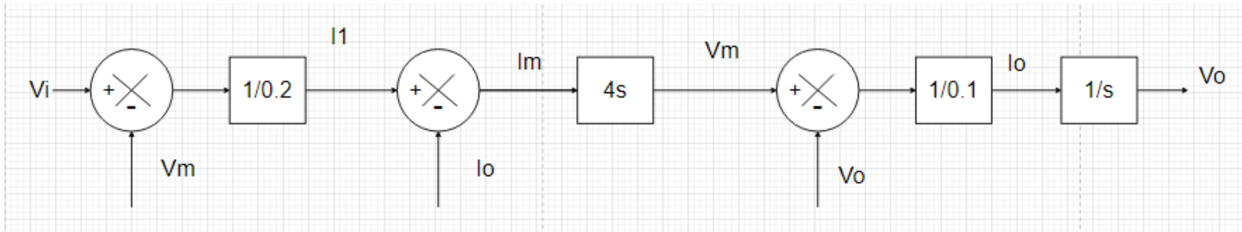
4. Vo = 1/s * Io



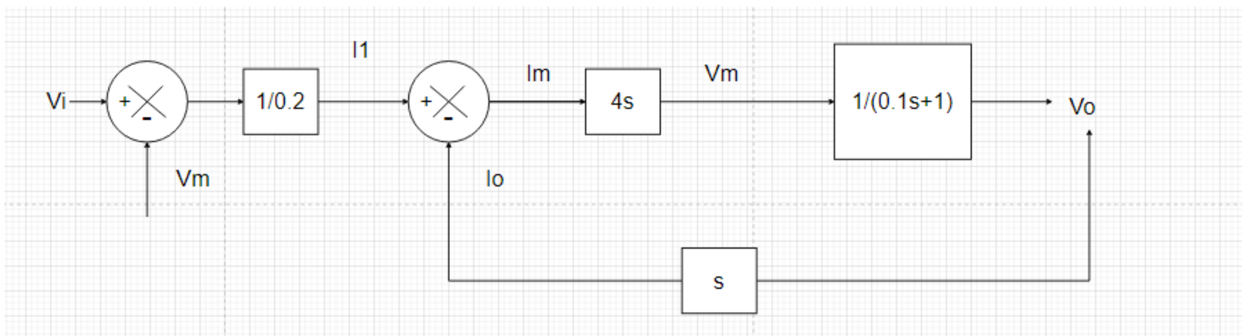
5. Vm - Vo = 0.1Io



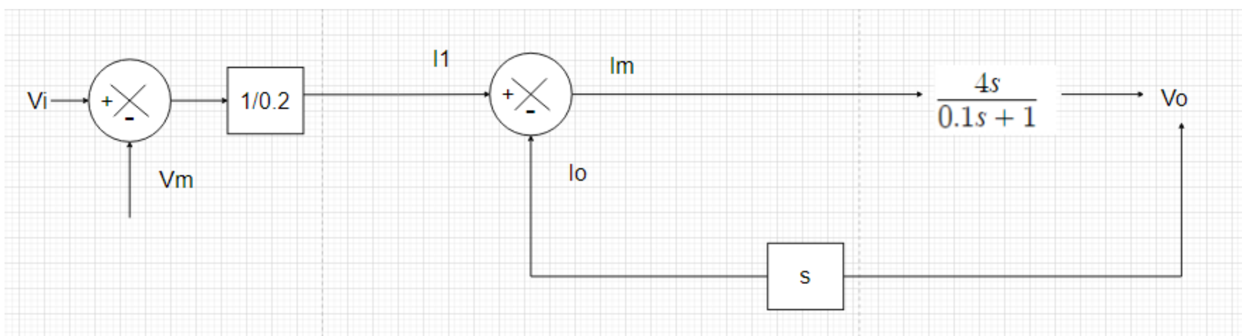
Rearranged into a line



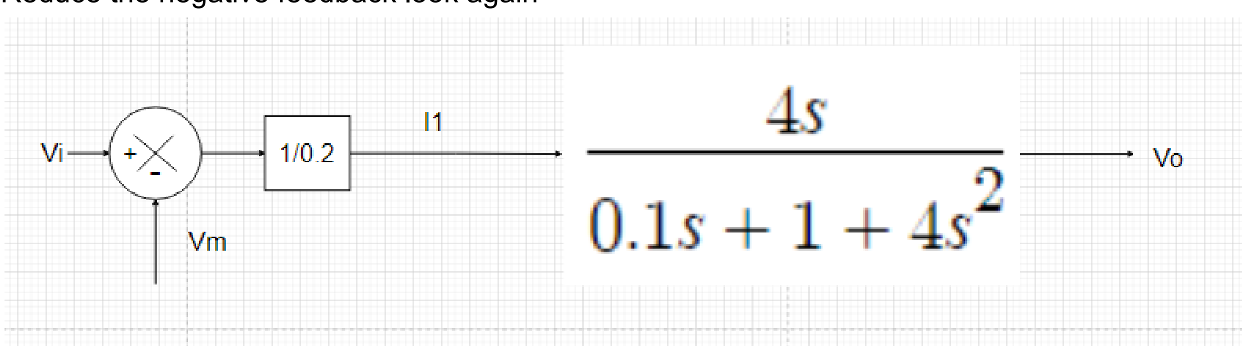
Reduce the 2nd half into a negative feedback and insert Vo = Io/s



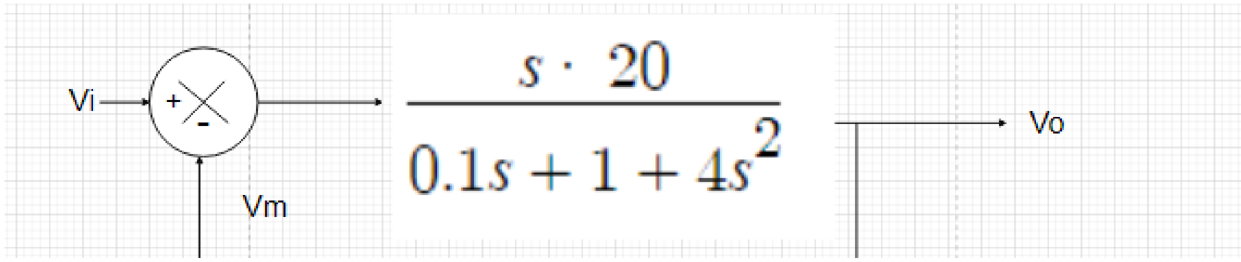
Reduce the first part *



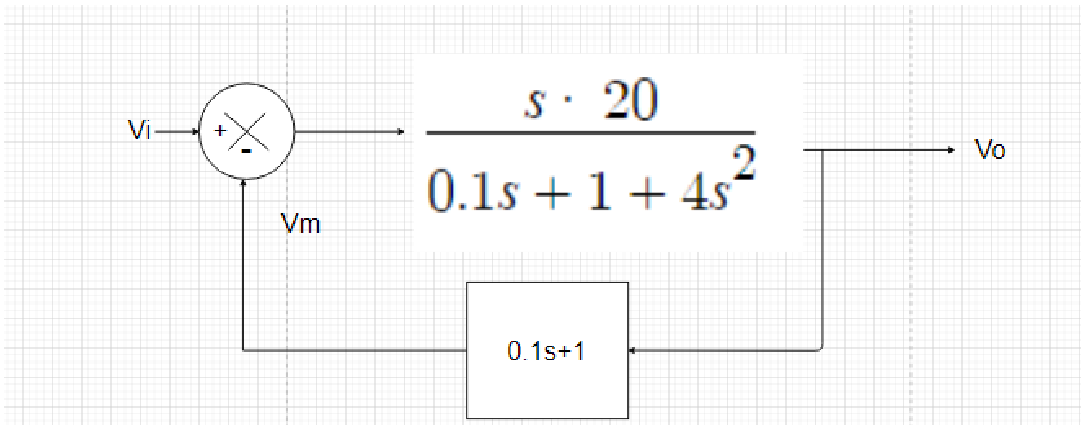
Reduce the negative feedback look again



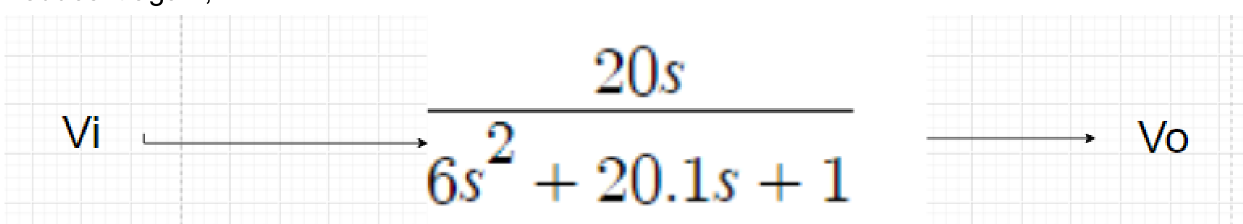
Merge 1/0.2 and the current transfer function and plug in the Vo to Vm as feedback



Inserting into the loop, and finally we got a negative feedback look again



Reduce it again,



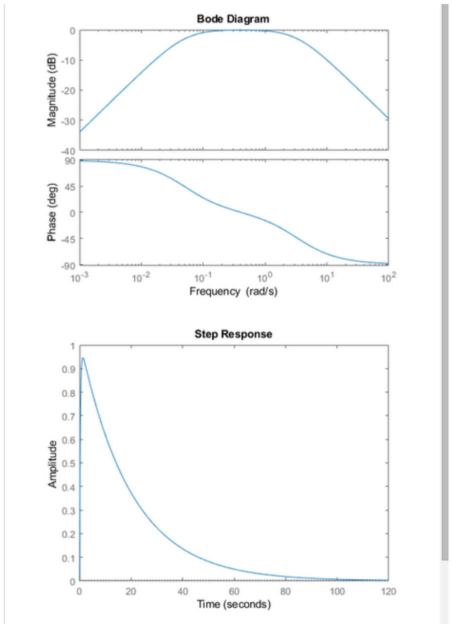
To get Vo we can just divide the fraction by s to add in the unit step function

$$Vo = \frac{20}{6s^2 + 20.1s + 1}$$

Then to inverse laplace we got

Plot the graph

```
clear all;
sys = tf([20 0],[6 20.1 1]);

bodeplot(sys)

step(sys)
```

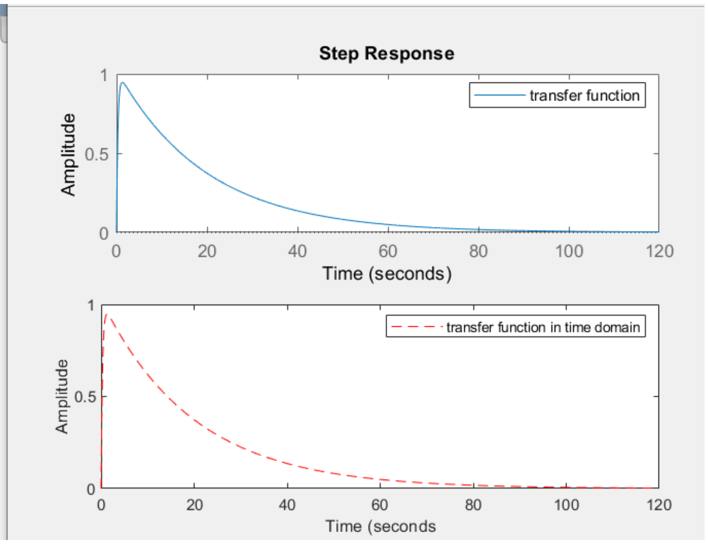


$$\frac{1.02596}{s + 0.0505129} - \frac{1.02596}{s + 3.29949}$$

Therefore our output

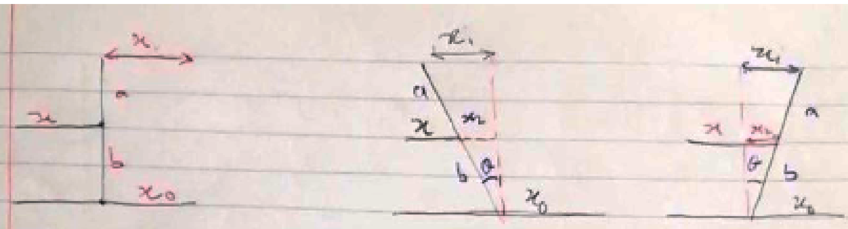
$$V(t) = 1.02596(e^{-0.0505129t} - e^{-3.29949t})$$

```
clear all
sys = tf([20 0],[6 20.1 1]);

subplot(2,1,1)
step(sys);
legend("transfer function")


syms t;
t = linspace(0,120,1000);
y = 1.02596*(exp(-0.0505129*t) - exp(-3.29949*t));
subplot(2,1,2)
plot(t,y, 'r--')
xlabel('Time (seconds)');
ylabel('Amplitude');
legend("transfer function in time domain");
```



as we can see they both match.

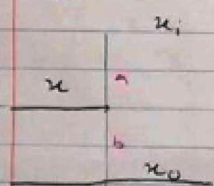
Part 2

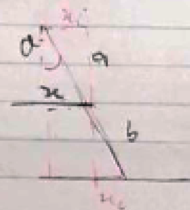


If system is fixed at x_0 Joint. This will cause x_2 to shift with the displacement of x_1

$x_i = \sin\theta \cdot (a+b)$

$x_2 = \sin\theta \cdot b$





$x_i \,\alpha\, x_0$ displacement

$x_i = \sin\theta \cdot a$

$x_0 = \sin\theta\,(a+b)$

Law of super position $x = x_0 - x_i$

$$\sin^{-1}\left(\frac{x_i}{a}\right) = \theta = \sin^{-1}\left(\frac{x_0}{a+b}\right) \Rightarrow \frac{x_i}{a} = \frac{x_0}{a+b}, \quad x_i = \frac{a}{a+b}\, x_0$$

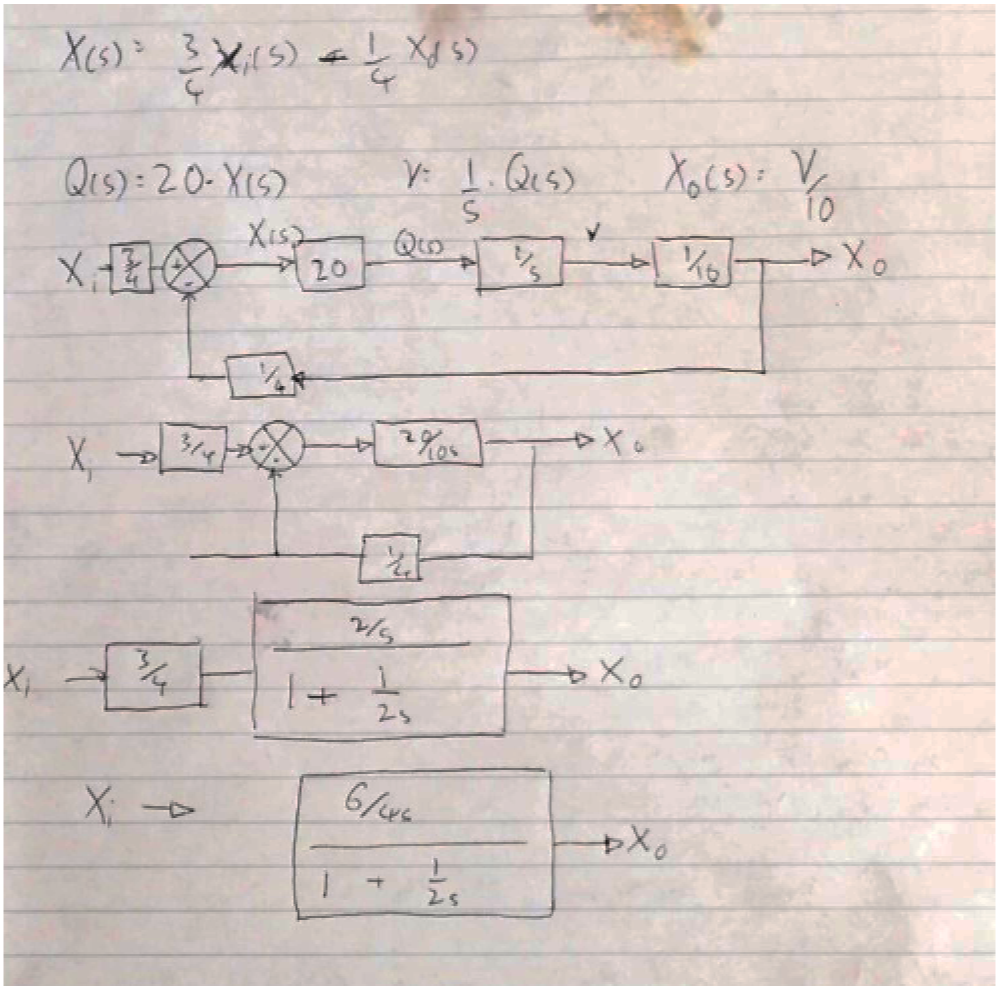
$$\sin^{-1}\left(\frac{x_0}{b}\right) = \theta = \sin^{-1}\left(\frac{x_i}{a+b}\right) \Rightarrow \frac{x_0}{b} = \frac{x_i}{a+b}, \quad x_0 = \left(\frac{b}{a+b}\right) x_i$$

sub

$$x = \left(\frac{b}{a+b}\right) x_i - \left(\frac{a}{a+b}\right) x_0$$

Q(s) = K*X(s), V = 1/s * Q(s), Xo = V/A

Sub in the values ⇒



A major environmental condition that this product will perform in is underwater. This is because it needs to be able to send and receive signals underwater.An optional task that was issued by the client was that the modem could interact with each other even though said modems may be in different mediums.