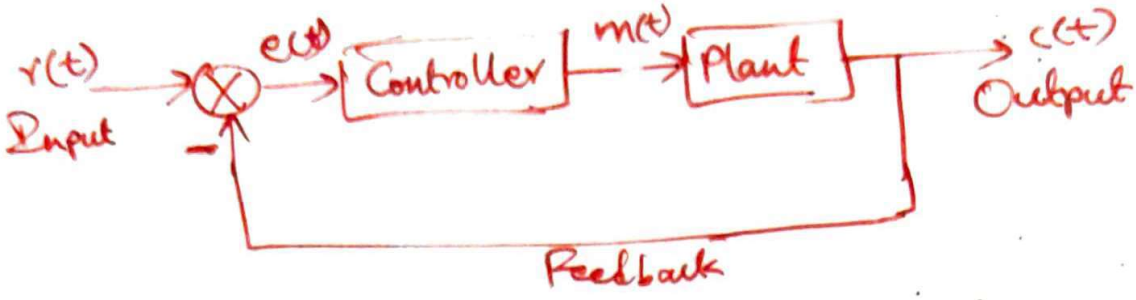
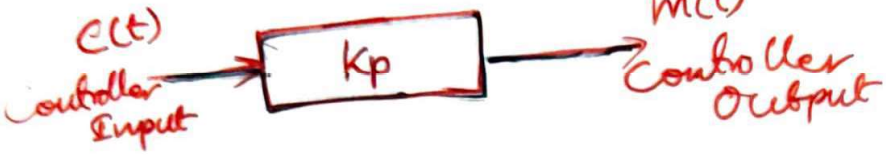
P, PI, PID Controllers using Op-Amp



Proportional Controller (P)



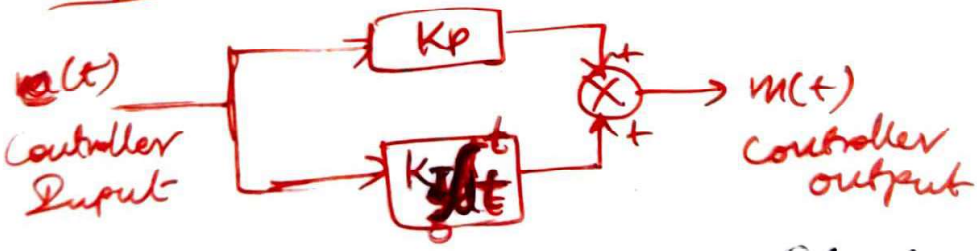
$$m(t) \propto e(t)$$

$$m(t) = K_p e(t)$$

$$M(s) = K_p E(s)$$

$$\frac{M(s)}{E(s)} = K_p$$

Proportional Integral Controller (PI)

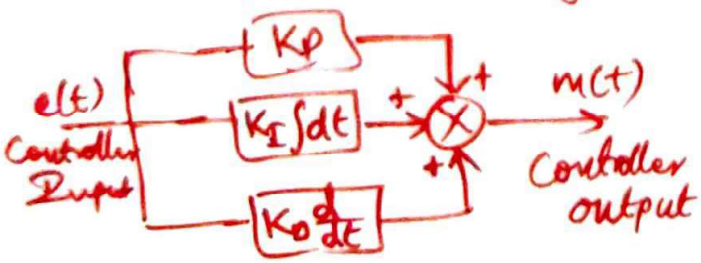


$$m(t) = K_p e(t) + K_I \int e(t)\,dt$$

$$M(s) = K_p E(s) + K_I \frac{E(s)}{s}$$

$$\frac{M(s)}{E(s)} = K_p + \frac{K_I}{s}$$

Proportional Integral Derivative Controller (PID)



$$m(t) = K_p e(t) + K_I \int e(t)\,dt + K_D \frac{de(t)}{dt}$$

$$\frac{M(s)}{E(s)} = K_p + \frac{K_I}{s} + K_D s$$

PID Controller using Op-Amp