Reglerteknik Ö7

Köp övningshäfte på kårbokhandeln

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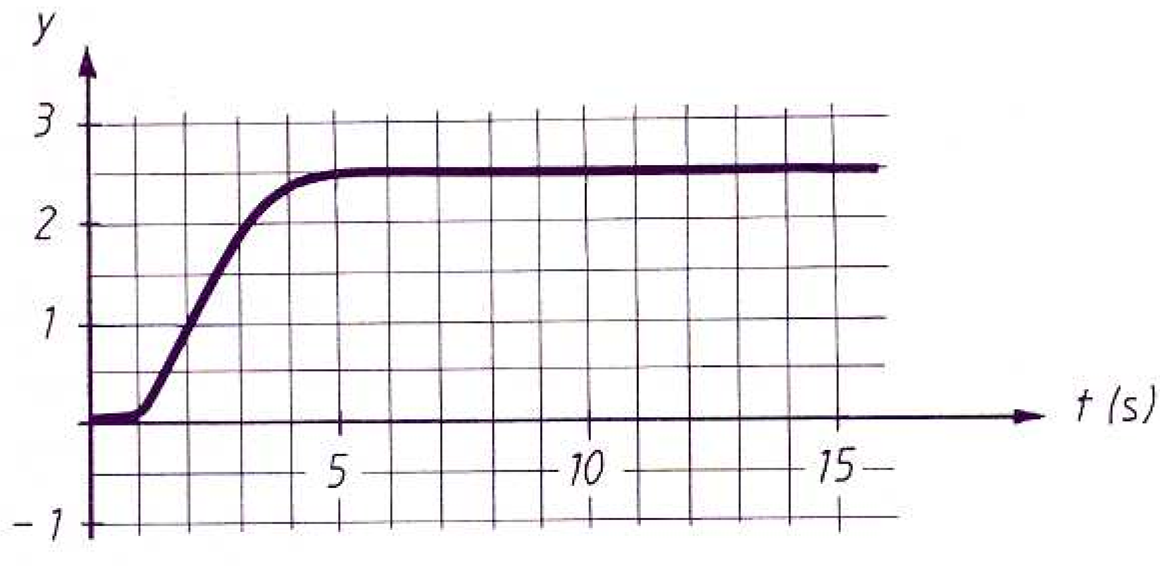
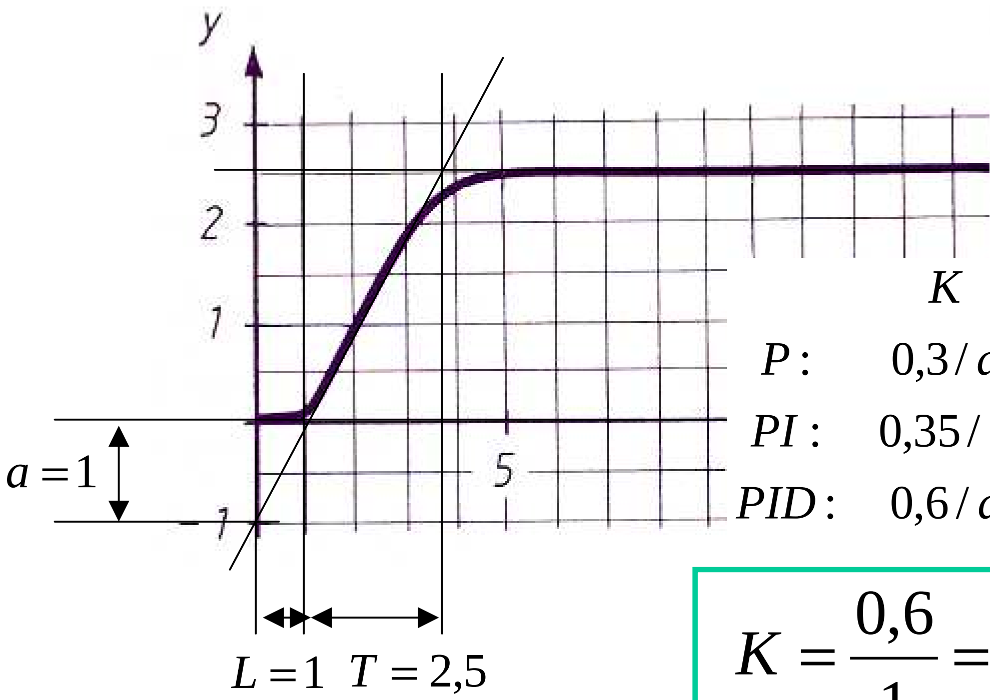
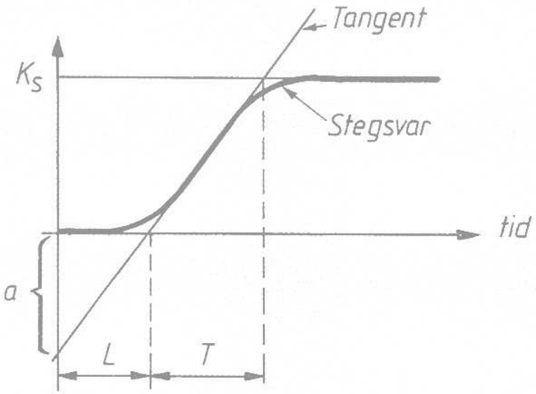
11.4 b PID-Stegsvarsmetod



11.4 b lösn. PID-Stegsvarsmetod



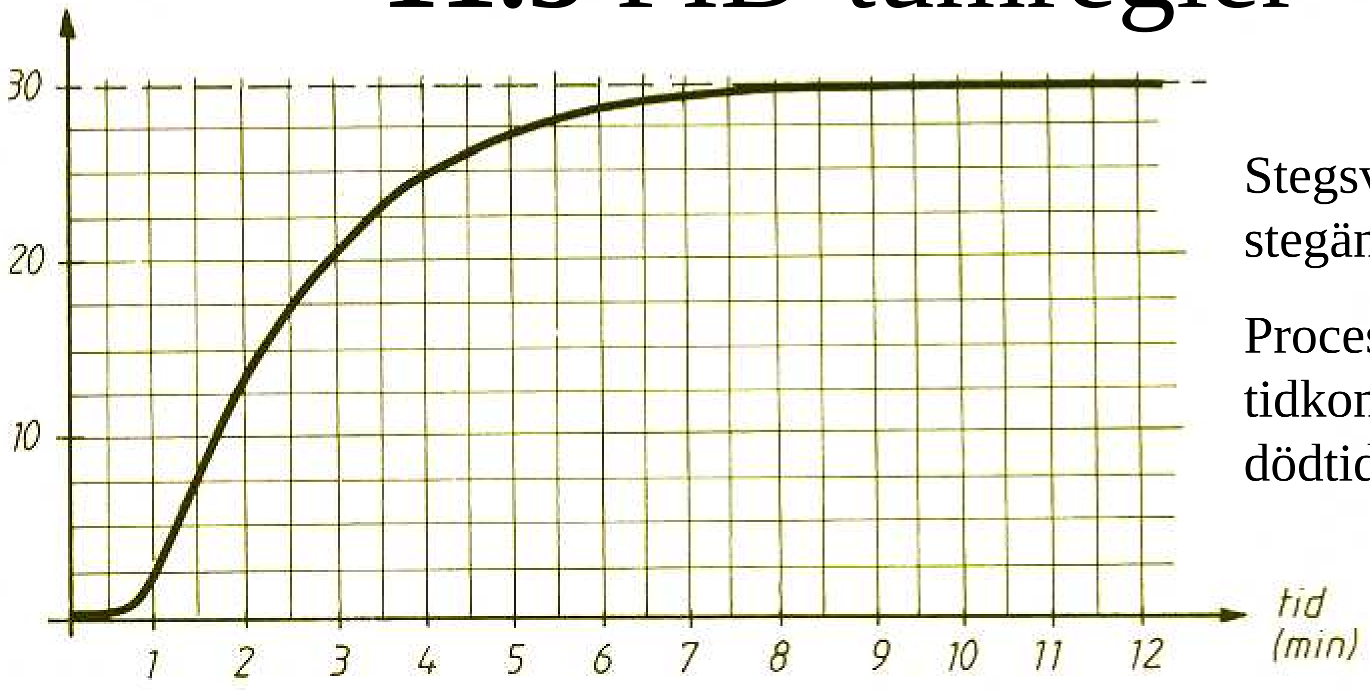


	K	T_I	T_D
$P:$	$0{,}3/a$	–	–
$PI:$	$0{,}35/a$	$1{,}2\cdot T$	–
$PID:$	$0{,}6/a$	T	$0{,}5\cdot L$

$$K=\frac{0{,}6}{1}=0{,}6 \quad T_I=2{,}5$$

$$T_D=0{,}5\cdot 1=0{,}5$$

11.5 PID-tumregler



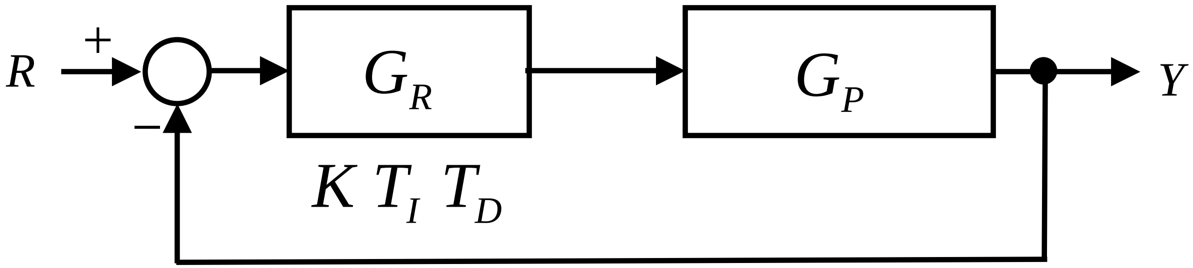
Stegsvar för ugn vid stegändring 1 kW.

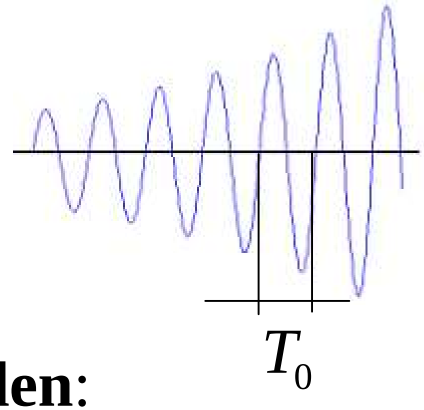
Processen har två tidkonstanter och dödtiden är 0,5 min.

Ugnen ska PID-regleras. **a**) ZN-parametrar. **b**) CHR-parametrar. **c**) Vilken metod ger bäst dämpning av lågfrekventa processtörningar (dvs. har lägst J_V)?

$$J_V = \frac{T_I}{K}$$

Ziegler-Nichols svängningsmetod



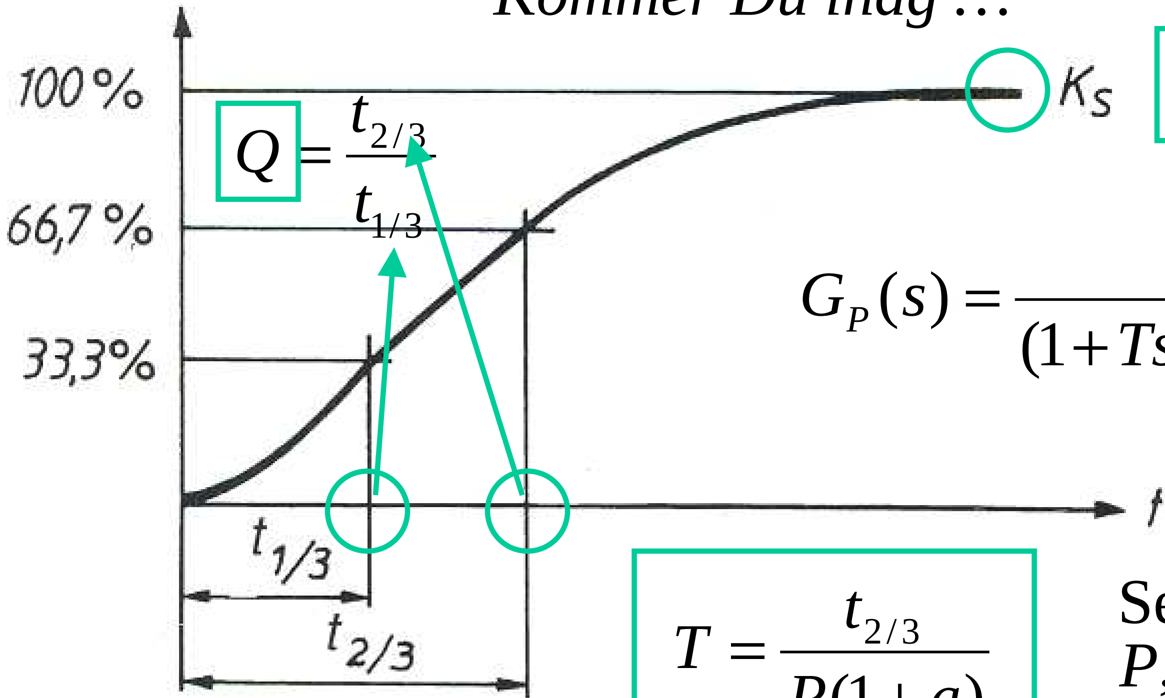


- Ställ in regulatorn med dessa **tumregelvärden**:

	K	T_I	T_D
$P:$	$0{,}5 \cdot K_0$	–	–
$PI:$	$0{,}45 \cdot K_0$	$0{,}85 \cdot T_0$	–
$PID:$	$0{,}6 \cdot K_0$	$0{,}5 \cdot T_0$	$0{,}125 \cdot T_0$

Processer med **två** tidkonstanter

Kommer Du ihåg …



$$\boxed{Q} = \frac{t_{2/3}}{t_{1/3}}$$

$$\boxed{K} = \frac{K_S}{h} \leftarrow \textit{steget}$$

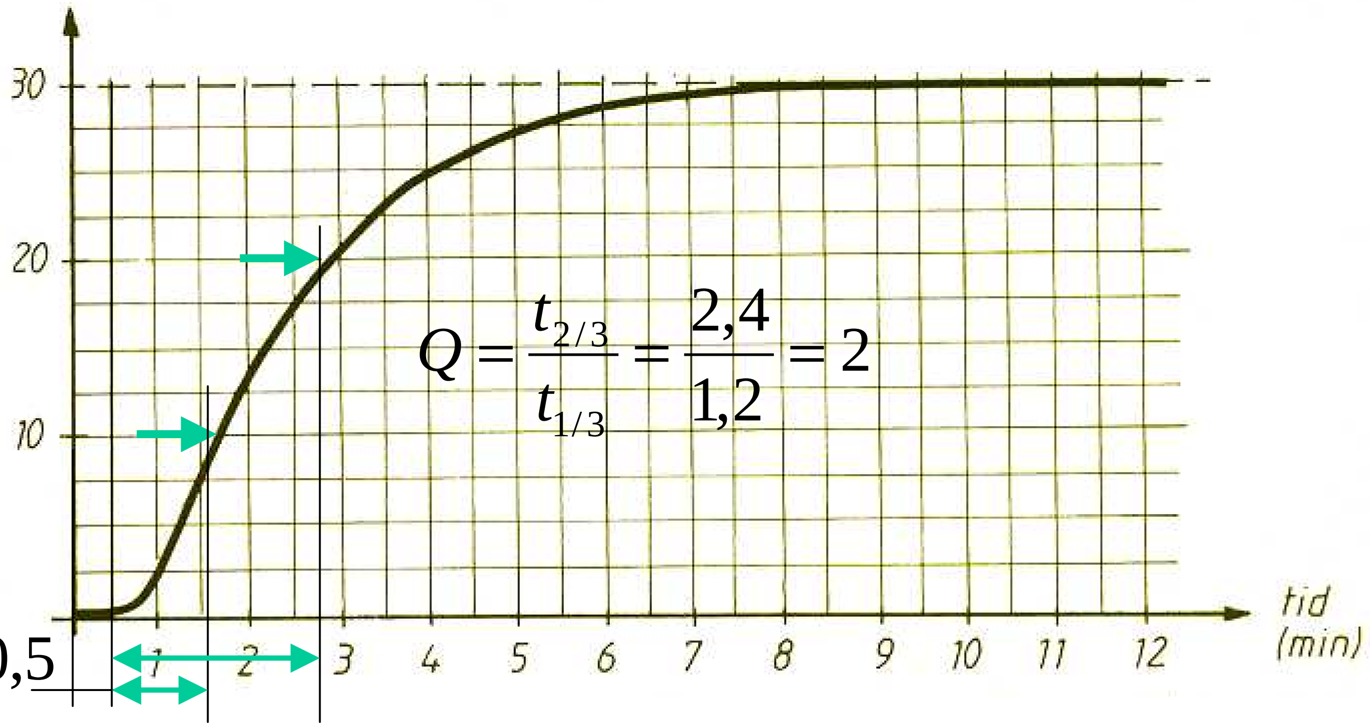
$$G_P(s) = \frac{K}{(1+Ts)(1+aTs)}$$

$$\boxed{T = \frac{t_{2/3}}{P(1+a)}}$$

Se
P,a-diagram, $n = 2$

$1{,}92 < Q < 2{,}71$ *Ok med två tidkonstanter*

11.5 a lösn. PID-tumregler

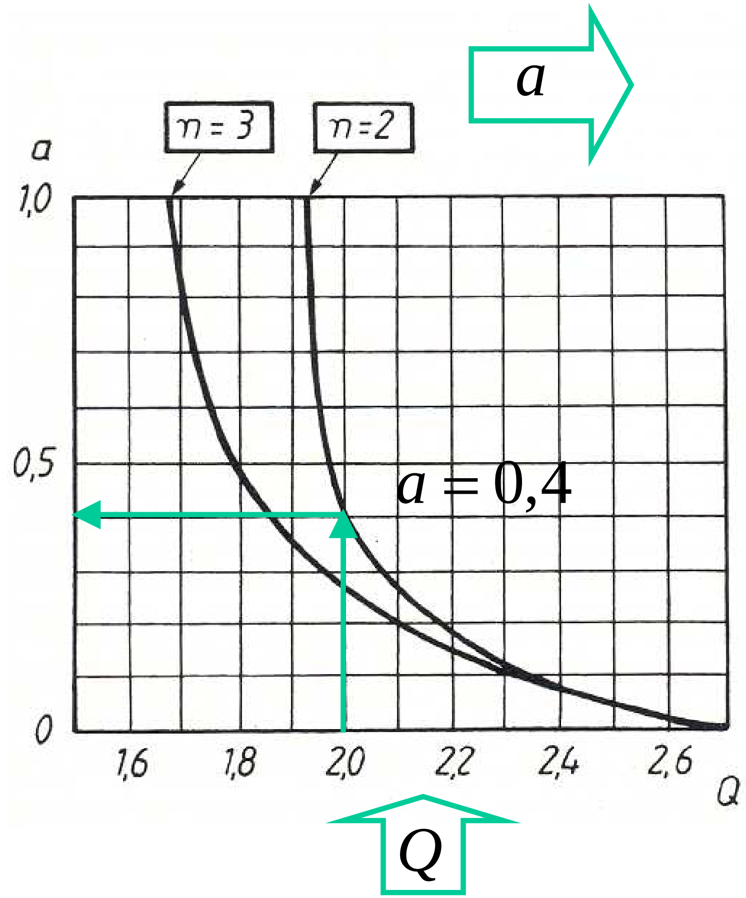


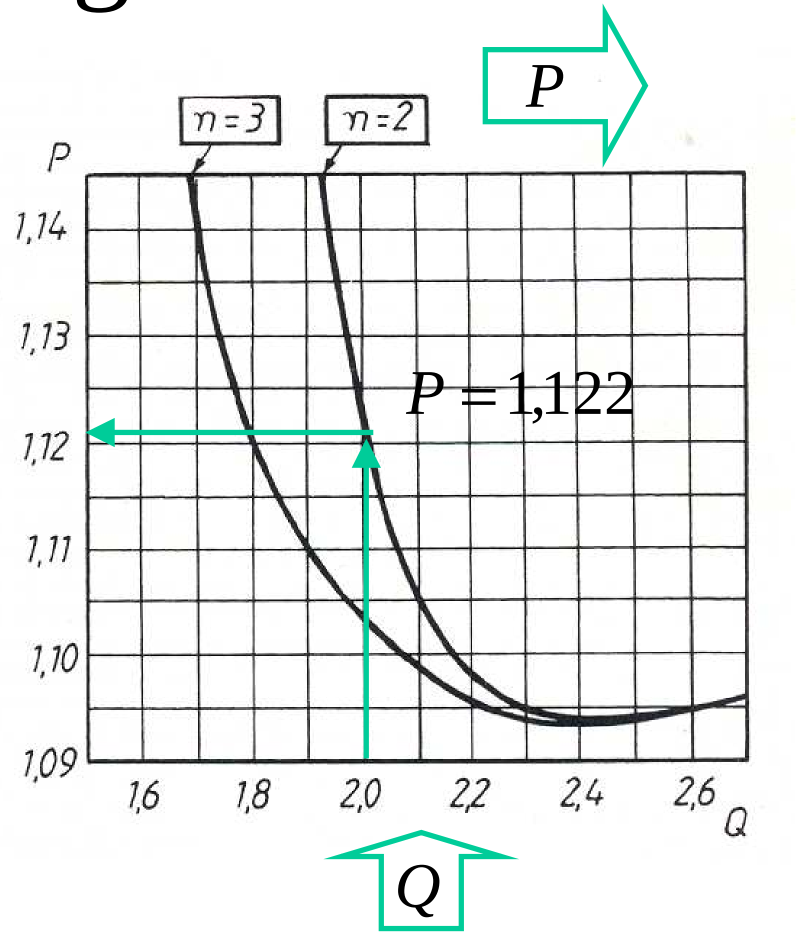
$$Q = \frac{t_{2/3}}{t_{1/3}} = \frac{2,4}{1,2} = 2$$

$$L = 0,5$$

P,a-diagram

$$Q = \frac{t_{2/3}}{t_{1/3}} = \frac{2,4}{1,2} = 2$$





11.5 a lösn. PID-tumregler

$$T = \frac{t_{2/3}}{P(1+a)} = \frac{2,4}{1,122 \cdot (1+0,4)} = 1,5$$

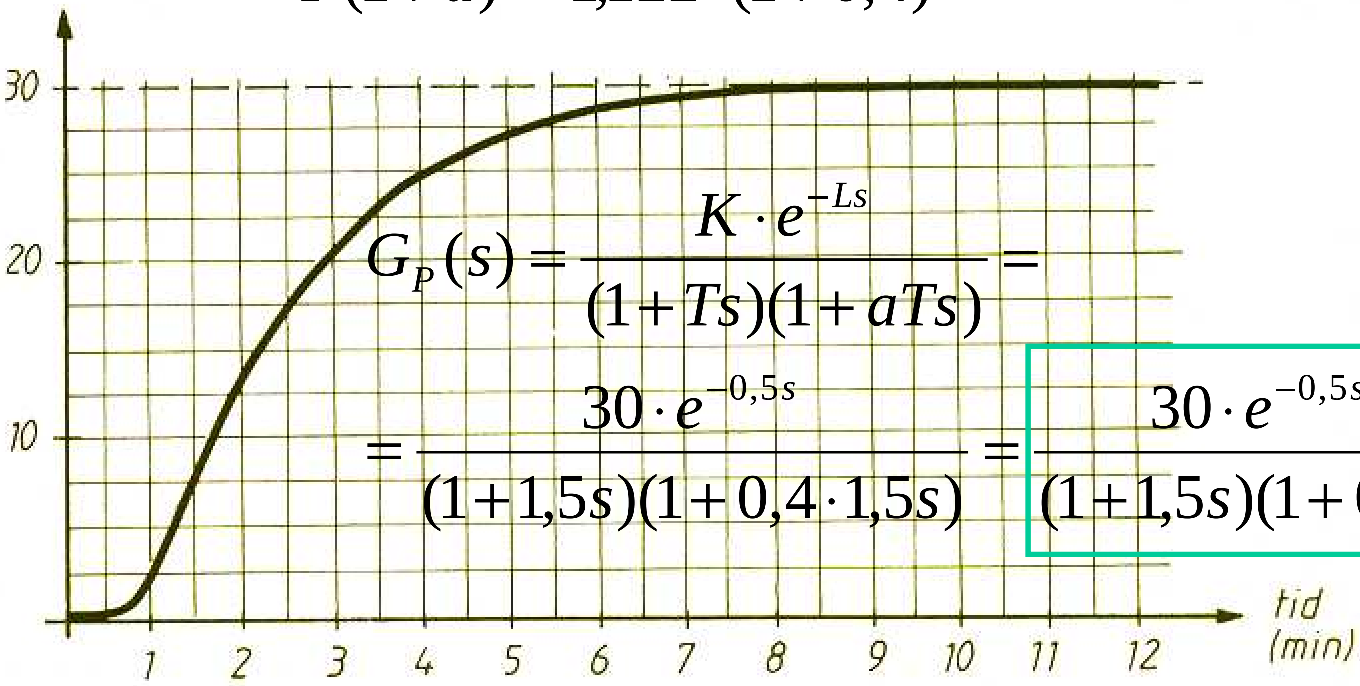
$$L = 0,5$$

$$t_{2/3} = 2,4$$

$$t_{1/3} = 1,2$$

$$a = 0,4$$

$$P = 1,122$$



$$G_P(s) = \frac{K \cdot e^{-Ls}}{(1+Ts)(1+aTs)} =$$

$$= \frac{30 \cdot e^{-0,5s}}{(1+1,5s)(1+0,4 \cdot 1,5s)} = \boxed{\frac{30 \cdot e^{-0,5s}}{(1+1,5s)(1+0,6s)}}$$

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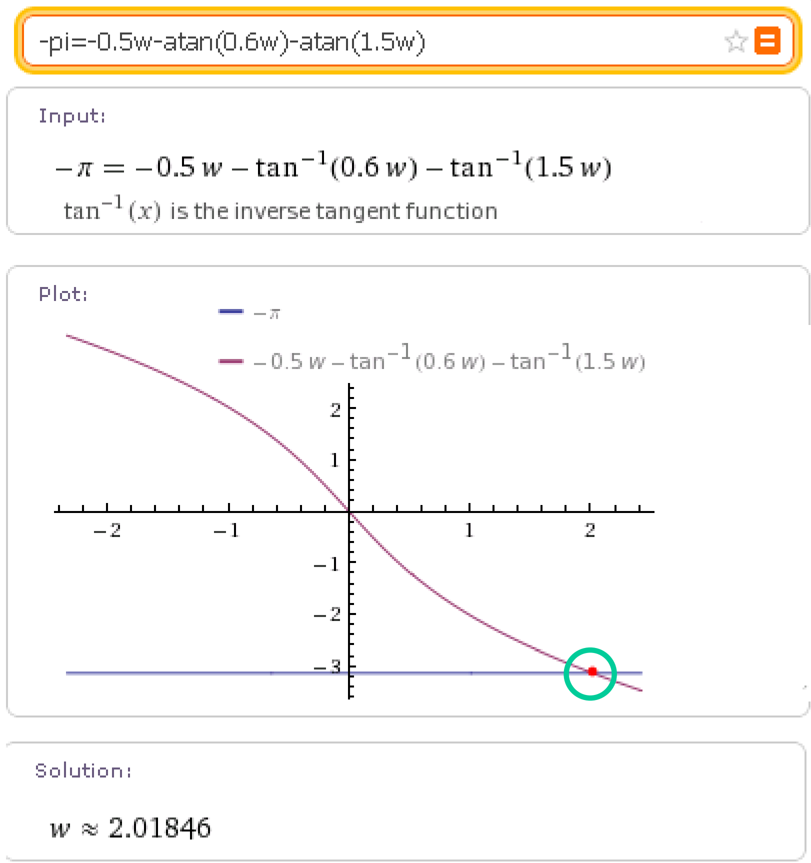
11.5 a lösn. PID-tumregler ω_π

$$G_P(s) = \frac{30 \cdot e^{-05s}}{(1+1{,}5s)(1+0{,}6s)}$$

$$\arg\left[\underline{G}_P(j\omega)\right] = -0{,}5 \cdot \omega$$
$$-\arctan(0{,}6\omega) - \arctan(1{,}5\omega)$$

$$\pi = +0{,}5 \cdot \omega_\pi +$$
$$\arctan(0{,}6\omega_\pi) + \arctan(1{,}5\omega_\pi)$$

WolframAlpha



$$\boxed{\omega_\pi = 2} \Rightarrow \boxed{T_0} = \frac{2\pi}{\omega_\pi} = \frac{2\pi}{2} = \boxed{\pi}$$

11.5 a lösn. PID-tumregler K_0

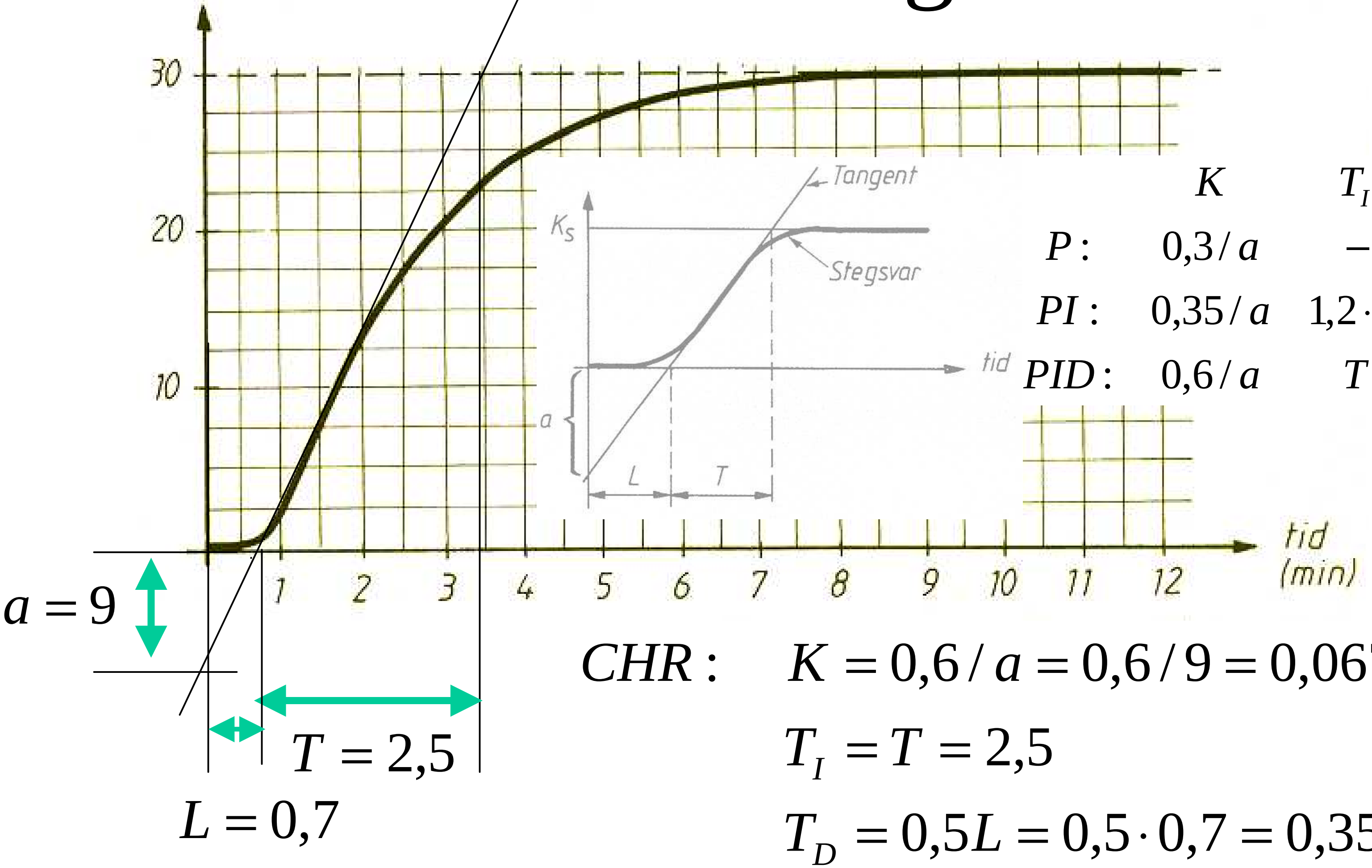
$$G_P(s) = \frac{30 \cdot e^{-0,5s}}{(1+1,5s)(1+0,6s)} \qquad T_0 = \pi$$

$$1 = K_0 \cdot G_P(\omega_\pi) \quad \Rightarrow \quad K_0 = \frac{1}{G_P(\omega_\pi = 2)} =$$

$$= \frac{\sqrt{1+1,2^2} \cdot \sqrt{1+3^2}}{30} = 0,16$$

$$\boxed{\begin{aligned} ZN: \quad & K = 0,6K_0 = 0,6 \cdot 0,16 = 0,1 \\ & T_I = 0,5T_0 = 0,5\pi = 1,6 \\ & T_D = 0,125T_0 = 0,125\pi = 0,4 \end{aligned}}$$

11.5 b lösn. PID stegsvarsmetod



	K	T_I	T_D
$P:$	$0{,}3/a$	$-$	$-$
$PI:$	$0{,}35/a$	$1{,}2 \cdot T$	$-$
$PID:$	$0{,}6/a$	T	$0{,}5 \cdot L$

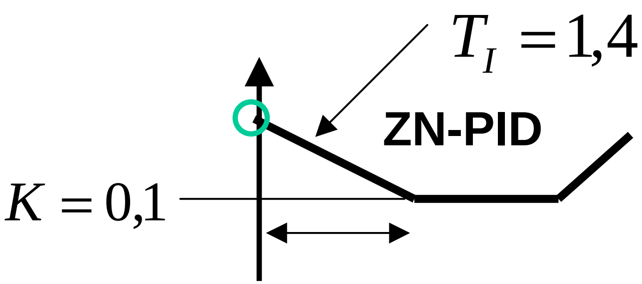
$$CHR: \quad K = 0{,}6/a = 0{,}6/9 = 0{,}067$$

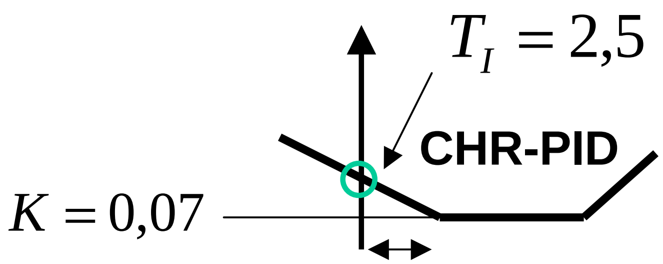
$$T_I = T = 2{,}5$$

$$T_D = 0{,}5L = 0{,}5 \cdot 0{,}7 = 0{,}35$$

11.5 c lösn. PID jämförelse

Störningsdämpningen bestäms av regulatorns **lågfrekvensegenskaper**.

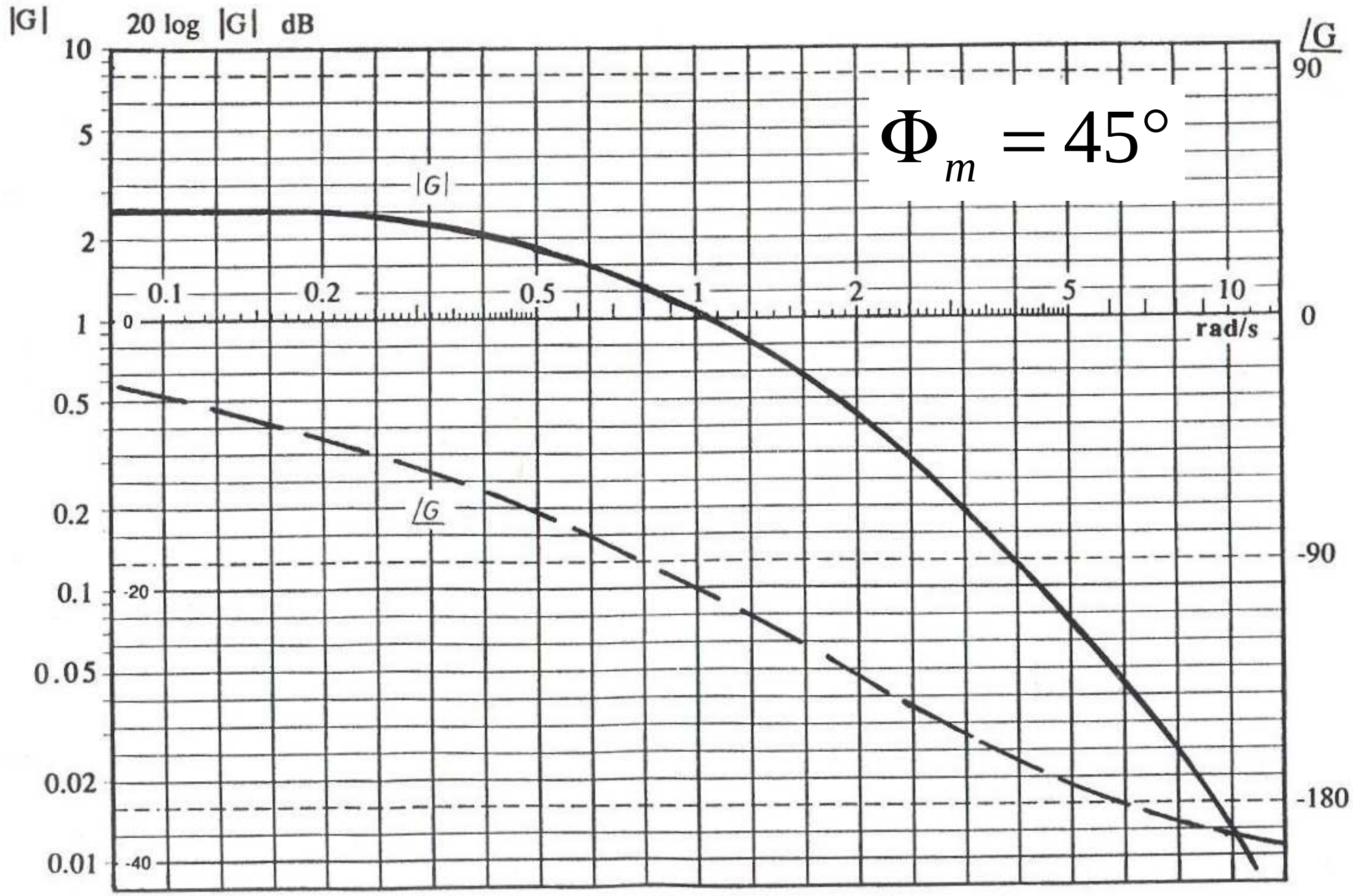




$$J_V = \frac{T_I}{K} = \frac{1{,}4}{0{,}1} = 14 \qquad J_V = \frac{T_I}{K} = \frac{2{,}5}{0{,}067} = 37$$

- Lägsta J_V-värdet har högsta lågfrekvensförstärkningen.

11.6 P-regulator Bodediagram



$\Phi_m = 45°$

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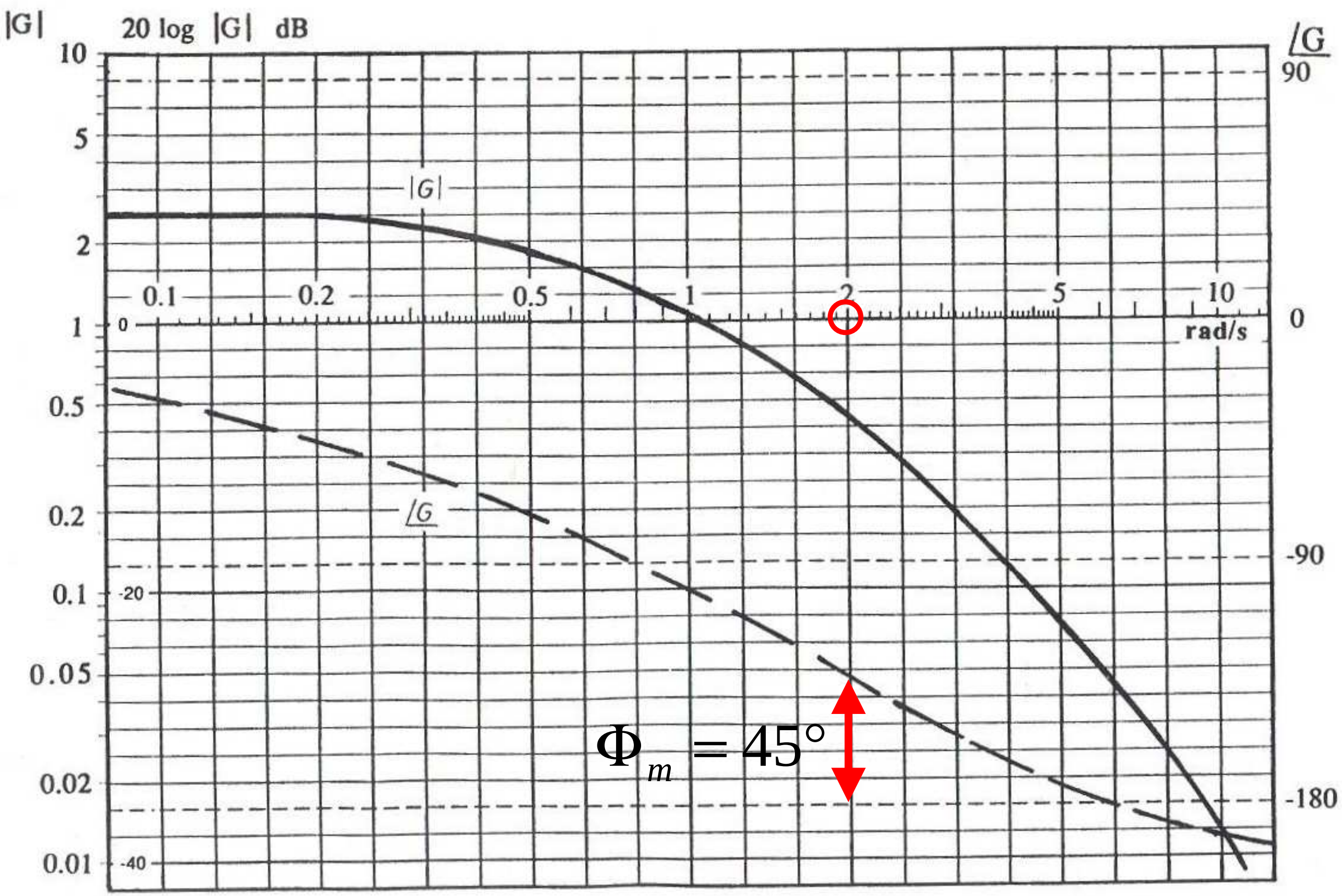
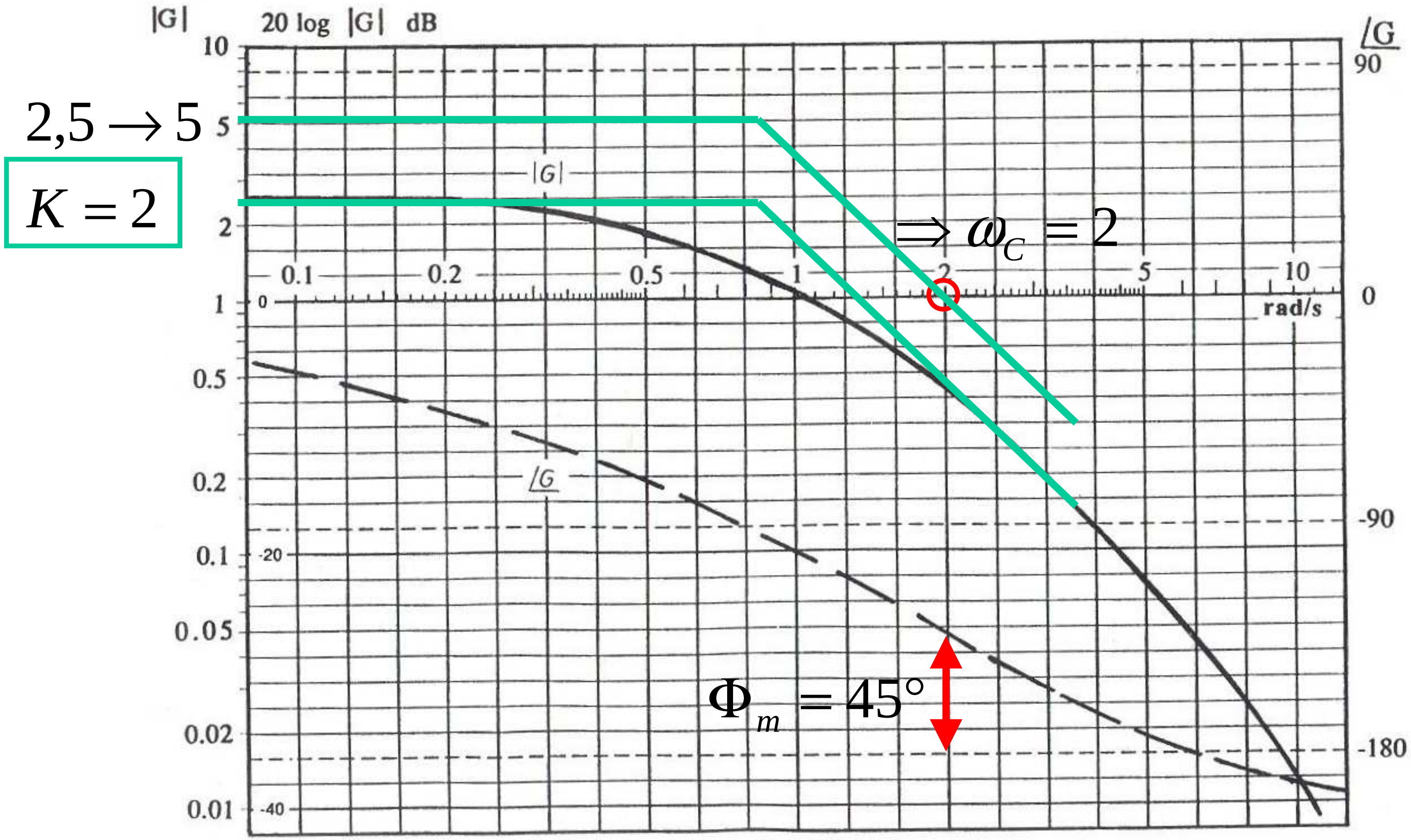
11.6 P-regulator lösning



11.6 P-regulator lösning



11.6 P-regulator lösning

Hur stort blir felet vid stegformad och rampformad börvärdesändring?

$$e_0 = \lim_{s \to 0} \frac{1}{1 + G_R \cdot G_P} = \frac{1}{1 + 2 \cdot 2{,}5} = 0{,}17$$

$e_1 = \infty$ Ingen integrering!

11.10 P-regulatorer

$$G_P = \frac{3}{(1+s)(1+5s)} \qquad G_{R(P)} = K$$

Bestäm K för $\Phi_m = 45°$.

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11.10 lösn. P-regulator

$$G_P \cdot G_{R(P)} = \frac{3K}{(1+s)(1+5s)} \qquad G(\omega) = \frac{3K}{\sqrt{1+\omega^2} \cdot \sqrt{1+25\omega^2}}$$

$$\varphi(\omega) = -\arctan(\omega) - \arctan(5\omega)$$

$$\Phi_m = 45^\circ : \quad (-180^\circ + 45^\circ)\frac{\pi}{180^\circ} = -\arctan(\omega_m) - \arctan(5\omega_m)$$

$$\Rightarrow \quad \omega_m = 1.35\,[rad/s]$$

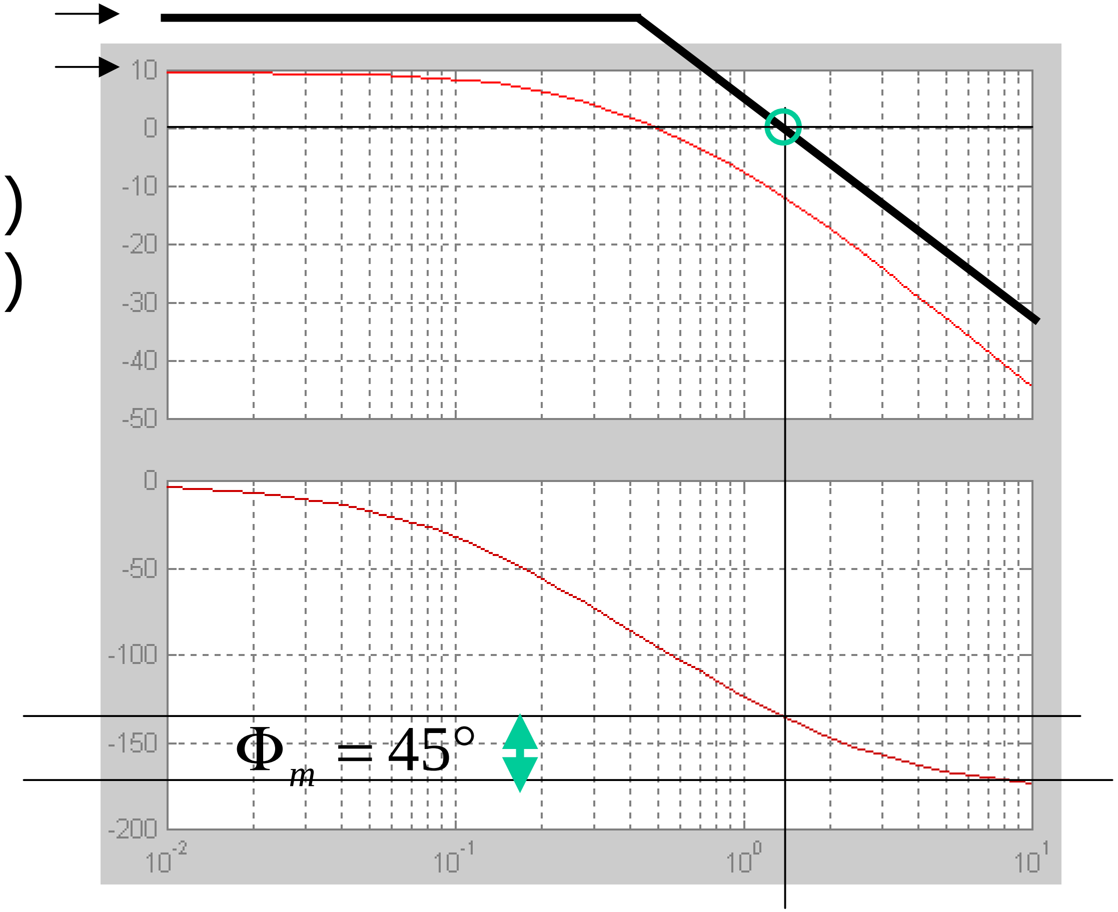
$$1 = \frac{3K}{\sqrt{1+\omega_m^2} \cdot \sqrt{1+25\omega_m^2}} \quad \Rightarrow \quad K = \frac{\sqrt{1+1{,}35^2} \cdot \sqrt{1+25 \cdot 1{,}35^2}}{3} = 3{,}8$$

Med K = 3,8 blir ω_C = 1,35 och Φ_m = 45°.

11.10 visualisering med Matlab

$$G_P = \frac{3}{(1+s)(1+5s)}$$

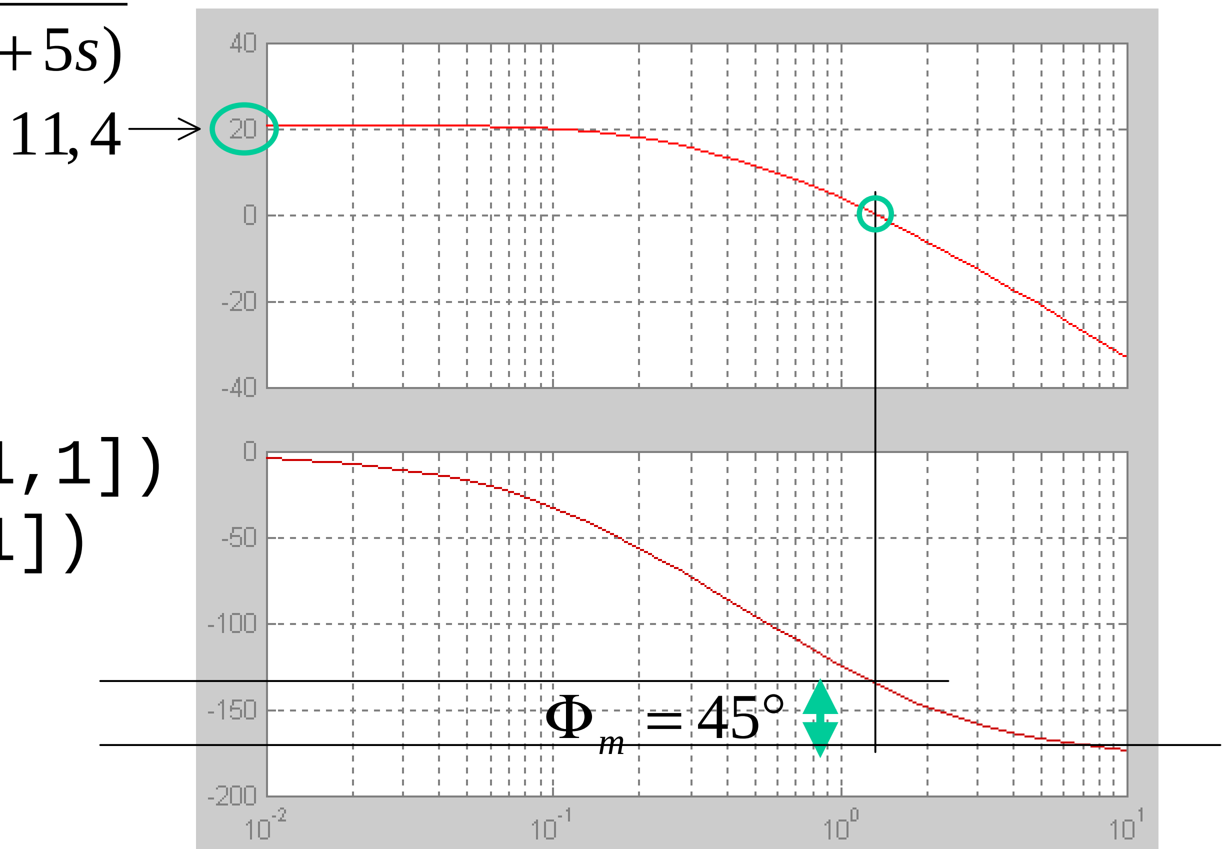
```
G1=tf([1],[1,1])
G2=tf([3],[5,1])
G=G1*G2
bode(G)
```



11.10 visualisering med Matlab

$$G_P \cdot G_{R(P)} = \frac{\boxed{3{,}8} \cdot 3}{(1+s)(1+5s)}$$

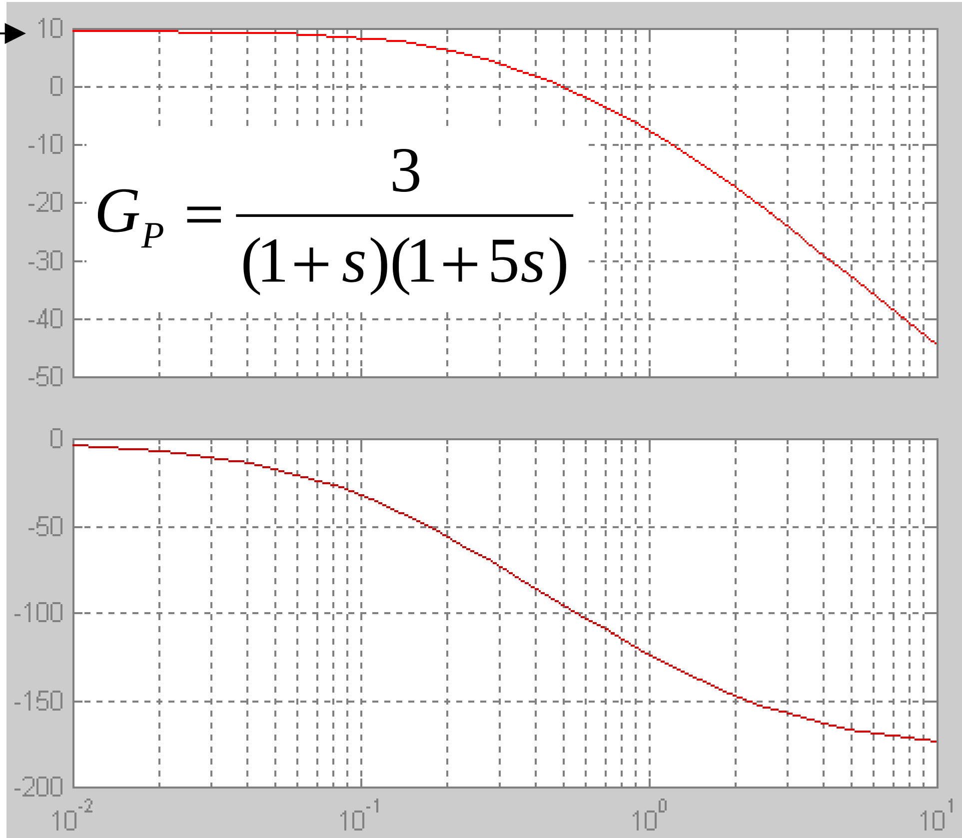
```
G1=tf([3.8],[1,1])
G2=tf([3],[5,1])
G=G1*G2
bode(G)
```



11.11 b PI-regulator

$$\Phi_m = 45°$$

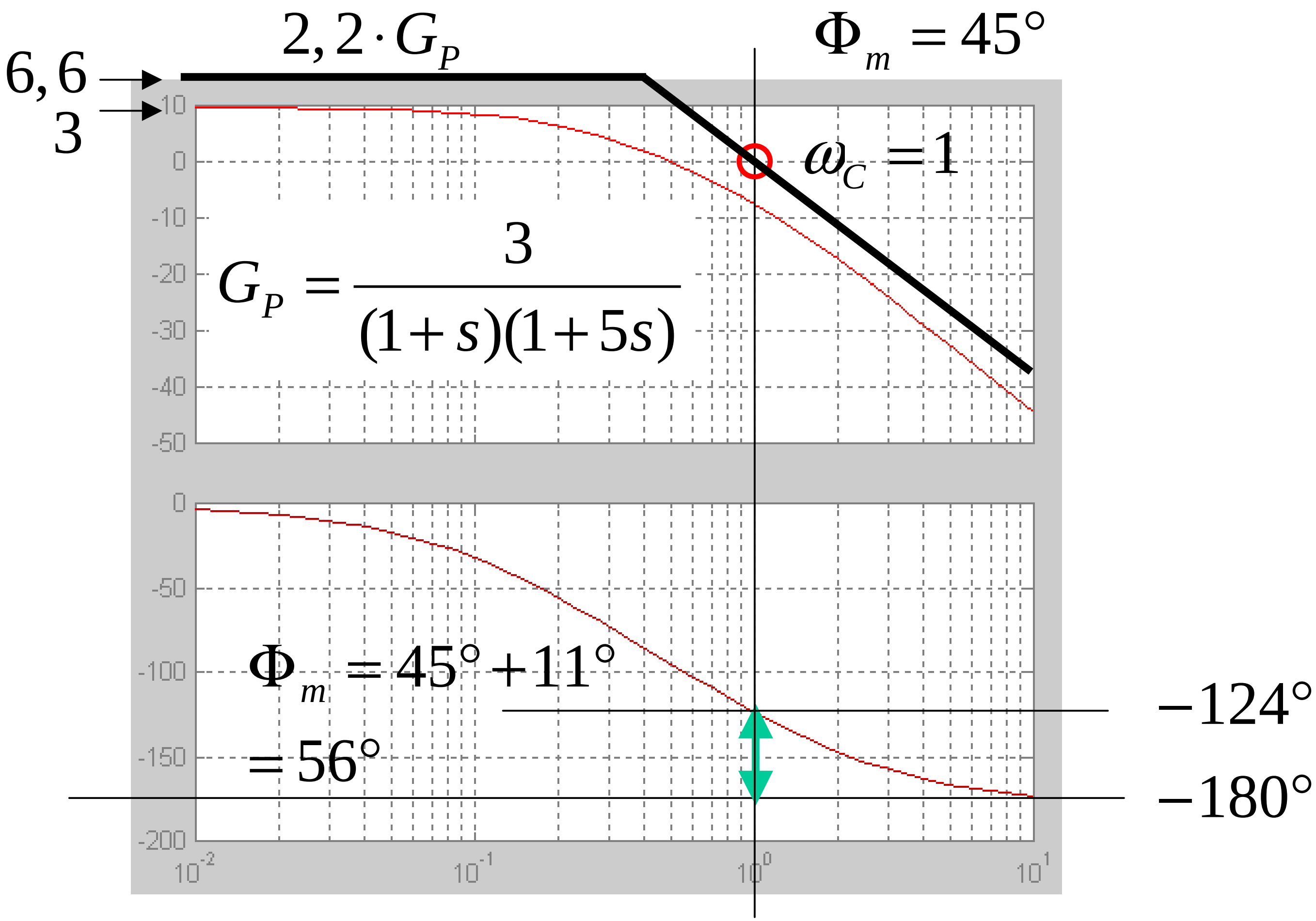
3



$$G_P = \frac{3}{(1+s)(1+5s)}$$

11.11 b lösn. PI-regulator

$\boxed{K = 2,2}$



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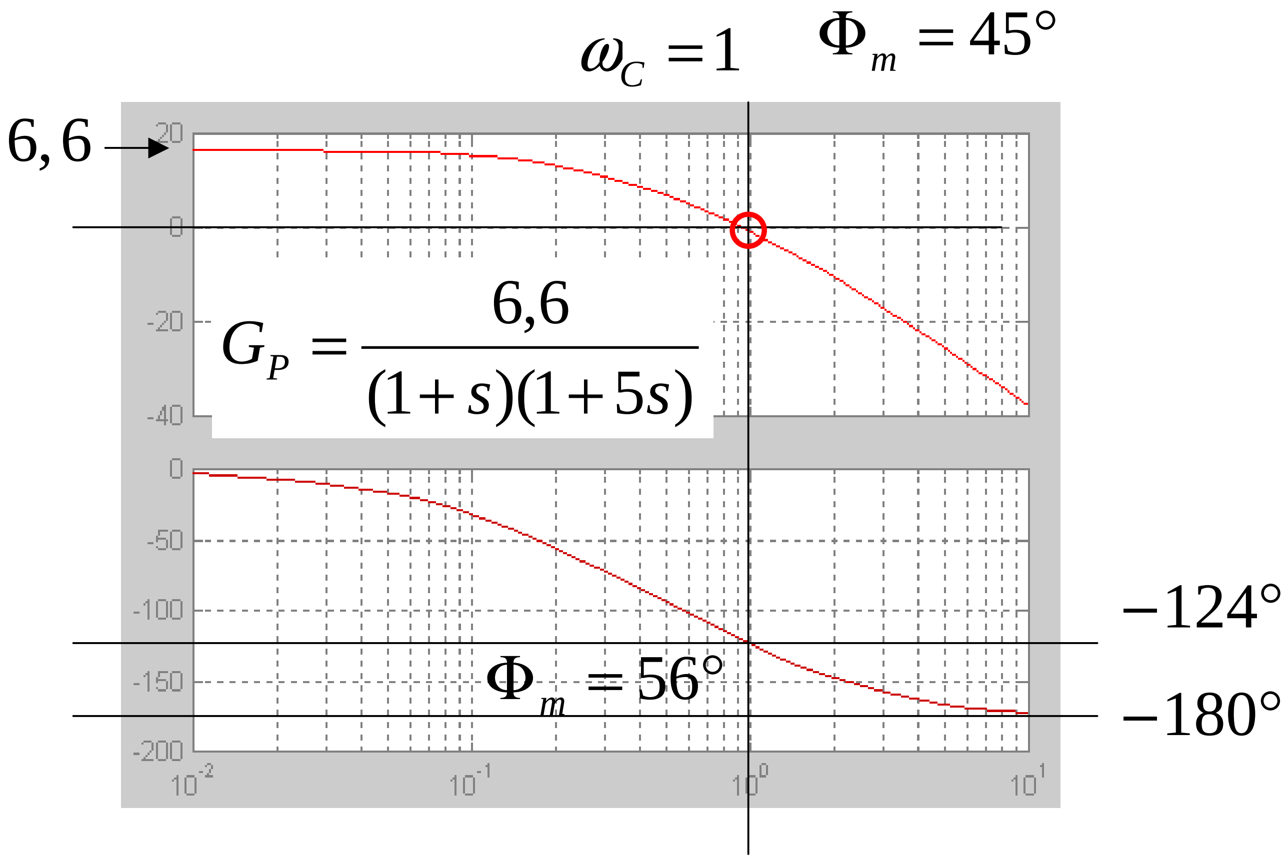
11.11 b lösn. PI-regulator



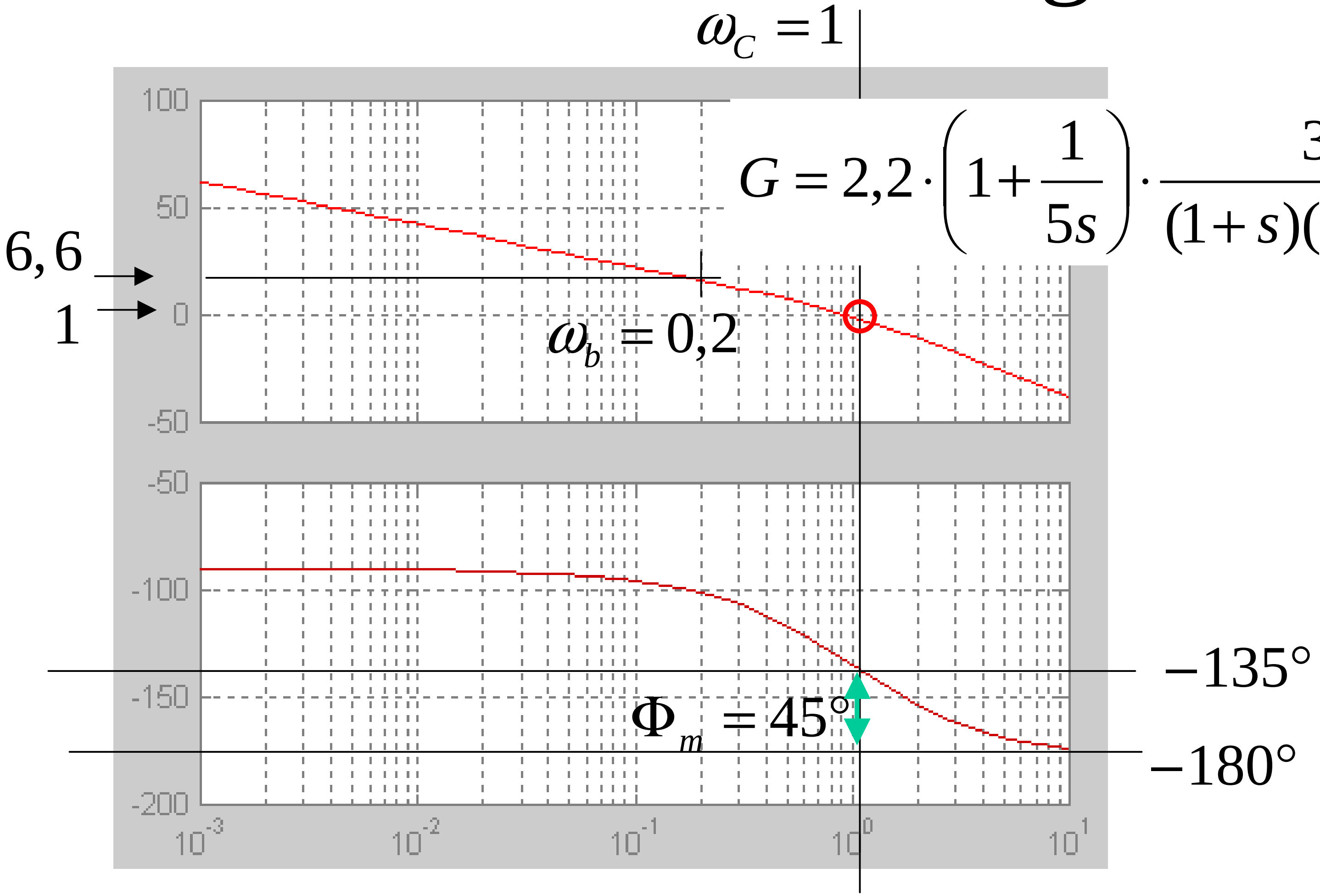
11.11 b lösn. PI-regulator

$$G_P = K \cdot \left(1 + \frac{1}{T_I s}\right)$$

Välj: $\boxed{\omega_b} = 0{,}2 \cdot \omega_C = \boxed{0{,}2}$ $\quad T_I = \frac{1}{\omega_b} = \frac{1}{0{,}2} = 5$

PI: $G = G_R G_P = 2{,}2 \cdot \left(1 + \frac{1}{5s}\right) \cdot \frac{3}{(1+s)(1+5s)}$

11.11 b lösn. PI-regulator



$$G = 2{,}2 \cdot \left(1 + \frac{1}{5s}\right) \cdot \frac{3}{(1+s)(1+5s)}$$