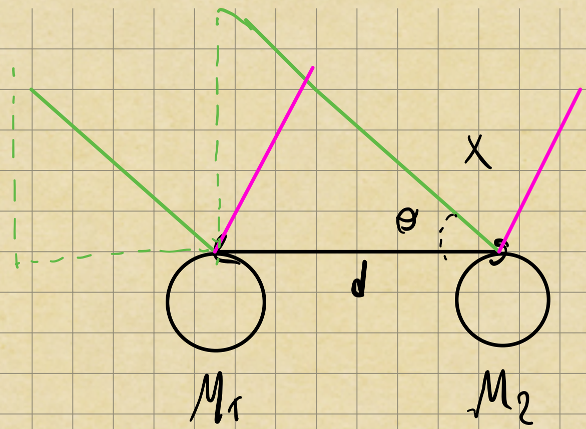


1) Hvis vi kjenner til $\tau$, $d$, $C$ Hva er $\cos(\theta)$

$\cos(\theta) = \frac{\text{hos}}{\text{hyp}}$ , Tidsforsinkelsen mellom de to signalene er gitt som $\tau = \frac{X}{C} = \frac{d\cos(\theta)}{C}$

$$\Rightarrow \frac{\tau C}{d} = \cos(\theta)$$

2)

a) $f = \frac{C\tau}{d}$ , ,

Relativ usikkerhet:

$$\left|\frac{\Delta\tau}{\tau}\right|_{maks} = 0{,}01 \quad , \quad \left|\frac{\Delta d}{d}\right|_{maks} = 0{,}02$$

$$\Delta f = \left|\frac{\partial f}{\partial J} \cdot \Delta J\right|_{maks} + \left|\frac{\partial f}{\partial d} \cdot \Delta d\right|_{maks}$$

$$= \left|\frac{C}{d} \cdot \Delta J\right|_{maks} + \left|\frac{-CJ}{d^2} \cdot \Delta d\right|_{maks}$$

$$= \left|\frac{CJ}{d} \frac{\Delta J}{J}\right|_{maks} + \left|-\frac{CJ}{d} \cdot \frac{\Delta d}{d}\right|_{maks}$$

$$\Delta f = \left| f \frac{\Delta J}{J}\right|_{maks} + \left| f \frac{\Delta d}{d}\right|_{maks}$$

$$= f\left(\left|\frac{\Delta J}{J}\right| + \left|\frac{\Delta d}{d}\right|\right)$$

$$\left|\frac{\Delta f}{f}\right|_{maks} = 0{,}01 + 0{,}02 = 0{,}03 = 3\%$$

b) Siden den relative usikkerheten beregnet i forrige oppgave er konstant så er den uavhengig av d, C, J osv.

c)

```
/usr/bin/python3 "/Users/Eier/Documents/NTNU/6
● Eier@dhcp-10-24-39-85 TTT4280 % /usr/bin/pytho
ppgave2.py"
The max value is:  0.030007698464872057
The min value is:  0.02802826274418313
The relative uncertainty is:  0.03
○ Eier@dhcp-10-24-39-85 TTT4280 %
```

Stemmer bra med beregnet teoretisk verdi, men stemmer ikke alltid.

## Oppgave 3)

$$\theta = \cos^{-1} t = \cos^{-1}\left(\frac{CJ}{d}\right)$$

a)

$$\Delta\theta = \left|\frac{\partial\theta}{\partial J}\cdot\Delta J\right| + \left|\frac{\partial\theta}{\partial d}\cdot\Delta d\right|$$

$$= \left|\frac{J\cdot C/d\cdot\Delta J}{\sqrt{1-\left(\frac{CJ}{d}\right)^2}\cdot J}\right| + \left|-\frac{1}{\sqrt{1-\left(\frac{CJ}{d}\right)^2}}\cdot\frac{-CJ}{d^2}\cdot\Delta d\right|$$

$$= \left| \frac{\frac{\sigma c}{d}}{-\sqrt{1-\left(\frac{c\sigma}{d}\right)^2}} \cdot \frac{\Delta\sigma}{\sigma} \right| + \left| \frac{\frac{c\sigma}{d}}{\sqrt{1-\left(\frac{c\sigma}{d}\right)^2}} \cdot \frac{\Delta d}{d} \right|$$

$$\cos(\theta) = \frac{c\sigma}{d}$$

$$= \left| \frac{\cos(\theta)}{-\sqrt{1-\cos^2(\theta)}} \cdot \frac{\Delta\sigma}{\sigma} \right| + \left| \frac{\cos(\theta)}{\sqrt{1-\cos^2(\theta)}} \cdot \frac{\Delta d}{d} \right|$$

$$= \left| \frac{\cos(\theta)}{\sqrt{\sin^2(\theta)}} \cdot 0{,}01 \right| + \left| \frac{\cos(\theta)}{\sqrt{\sin^2(\theta)}} \cdot 0{,}02 \right|$$

$$\Delta\theta = \left| \frac{\cos(\theta)}{\sin(\theta)} \right| \left( \left| 0{,}01 + 0{,}02 \right| \right)$$

$$\left|\frac{\Delta\theta}{\theta}\right|_{maks} = \frac{1}{\tan(\theta)\cdot\theta}\left(0{,}03\right) = \frac{0{,}03}{\tan(\theta)\theta}$$

b) Den er avhengig av $\theta = \cos^{-1}\left(\frac{C\eta}{d}\right)$. Den er altså avhengig av $J, d, \theta$.

Den relative feilen er $\infty$ når $\theta \to 0$.

c)

```
The max value is:  2.499740894933999
```

Task 4)

$$\frac{\sigma_\lambda}{\lambda} = 0{,}01 , \quad \frac{\sigma_d}{d} = 0{,}02 , \quad \sigma_\lambda = 0{,}01\lambda , \; \sigma_d = 0{,}02\, d$$

$$\sigma_\theta^2 = \sigma_\lambda^2 \cdot \left(\frac{\partial\theta}{\partial\lambda}\right)^2 + \sigma_d^2 \left(\frac{\partial\theta}{\partial d}\right)^2$$

$$= \sigma_\lambda^2 \left(\frac{C/d}{\sqrt{1-\left(\frac{C\lambda}{d}\right)^2}}\right)^2 + \sigma_d^2 \left(\frac{C\lambda/d^2}{\sqrt{1-\left(\frac{C\lambda}{d}\right)^2}}\right)^2 .$$

$$= (0{,}01\lambda)^2 \left(\frac{C^2/d^2}{1-\left(\frac{C\lambda}{d}\right)^2}\right) + (0{,}02d)^2 \left(\frac{C^2\lambda^2/d^4}{1-\left(\frac{C\lambda}{d}\right)^2}\right)$$

$$= \left(0{,}01^2 + 0{,}02^2\right) \left(\frac{C^2\lambda^2/d^2}{1-\left(C^2\lambda^2/d^2\right)}\right) , \quad \cos^2(\theta) = \frac{C^2\lambda^2}{d^2}$$

$$= \left(0{,}01^2 + 0{,}02^2\right) \frac{\cos^2(\theta)}{1-\cos^2(\theta)}$$

$$\sigma_\theta^2 = (0{,}0005) \frac{\cos^2(\theta)}{\sin^2(\theta)}$$

$$\sqrt{\sigma_\theta^2} = \sqrt{\frac{0{,}0005}{\tan^2(\theta)}}$$

$$\frac{\sigma_\theta}{\theta} = \sqrt{\frac{0{,}0005}{\tan^2(\theta)}} \cdot \frac{1}{\theta} = \underline{\underline{\frac{0{,}022}{\theta \cdot \tan(\theta)}}}$$