Ex 16.3

$t_p = \frac{d}{v_p}$; $t_s = \frac{d}{v_s}$

$$t_s = t_p + \Delta t \Rightarrow \frac{d}{v_s} = \frac{d}{v_p} + \Delta t \Rightarrow d = \frac{\Delta t}{\frac{1}{v_s} - \frac{1}{v_p}} = \frac{v_s v_p \Delta t}{\Delta v}$$

$$d = \frac{5\cdot10^3 \cdot 8\cdot10^3 \cdot 1.8\cdot60}{3\cdot10^3} = 1440\ km$$

Ex 16.9

$F_2 = 2F_1$ b) $\Rightarrow v_2 = \sqrt{2}\, v_1$ $\left(v = \sqrt{\frac{F}{\mu}}\right)$

a) $v = f\cdot\lambda \Rightarrow f_2 = \sqrt{2}\, f_1$

Ex 16.15

a) $\frac{\partial y}{\partial x} = kA\cdot\cos(kx - \omega t)$

b) $\left(\frac{\partial y}{\partial x}\right)_{max} = kA$; $v = \frac{\omega}{k}$; $\left(\frac{\partial y}{\partial t}\right)_{max} = \omega A$

$$\Rightarrow \left(\frac{\partial y}{\partial x}\right)_{max} = \frac{\omega}{v}\cdot\frac{\left(\frac{\partial y}{\partial t}\right)_{max}}{\omega} = \frac{\left(\frac{\partial y}{\partial t}\right)_{max}}{v}$$

Ex 16.19

a) $t - \frac{x}{v} = -\frac{1}{v}(x - vt)$ (konstant) ja

b) $(kx-\omega t)^2 = k^2(x-vt)^2$ ja c) $(kx)^2 - (\omega t)^2$ nej

d) $(x-vt)^2$ ja e) $(x+vt)^3$ ja

f) $kx - \omega t$ ser bra ut men ej $e^{-\alpha t}$ nej

Ex 16.21

$y(x,t) = 0.02 \sin(0.4x + 50t + 0.8)$

x och y i cm

a) $k = 0.4\ rad/cm$ $\lambda = \frac{2\pi}{k} = \frac{2\pi}{0.4}\ cm = 15.7\ cm$

b) $\phi = 0.8\ rad$

c) $\omega = 50\ rad/s$ $T = \frac{2\pi}{\omega} = \frac{2\pi}{50}\ s = 0.126\ s$

d) $A = 0.02\ cm$

e) $v = \frac{\omega}{k} = \frac{50}{0.4}\ cm/s = 1.25\ m/s$ (längs $-x$)

f) $\frac{\partial y}{\partial t} = 1\cdot\cos(0.4x + 50t + 0.8)$

OBS radianer

$\frac{\partial y}{\partial t}(x=1, t=0.5) = \cos(0.4 + 25 + 0.8) = \cos(26.2) = 0.483\ cm/s$

Ex 16.23

$y = y_0 \sin(kx + \omega t + \phi)$

$\lambda = 2.5\ cm$ $T = 0.01\ s$ $y_0 = 0.03\ m$

$y(0,0) = -0.02\ m$ $\frac{\partial y}{\partial t}(0,0) > 0$

$k = \frac{2\pi}{\lambda} = \frac{2\pi}{2.5}\ cm^{-1} = \frac{4\pi}{5}\ cm^{-1}$

$\omega = \frac{2\pi}{T} = 200\pi\ s^{-1}$

$\therefore\ y = 3\cdot\sin\left(\frac{4\pi}{5}x + 200\pi t + \phi\right)$ [cm]

$3\cdot\sin\phi = -2 \Rightarrow \sin\phi = -\frac{2}{3} \Rightarrow \phi_0 = -0.730$?

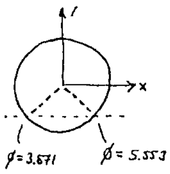
Möjliga lösningar $\phi = \phi_0 + 2\pi = 5.553\ rad$

eller $\phi = \pi - \phi_0 = 3.871\ rad$

$\frac{\partial y}{\partial t} = 600\pi\cdot\cos\left(\frac{4\pi}{5}x + 200\pi t + \phi\right)$

$\cos\phi > 0$ för $\phi = 5.553$ ⟸

$\cos\phi < 0$ för $\phi = 3.871$



$\therefore\ y = 3\cdot\sin\left(\frac{4\pi}{5}x + 200\pi t + 5.553\right)$

(x och y i cm)

Ex 16.27

a) $y = 2A\sin(kx)\cos(\omega t)$

$A = 2\ cm$ $\omega = 2\pi f = 16\pi\ s^{-1}$

$k = \frac{\omega}{v} = \frac{16\pi}{0.4} = 40\pi\ m^{-1}$

$\therefore\ y = 0.04\cdot\sin(40\pi x)\cos(16\pi t)$ [m]

b) $\frac{\lambda}{2} = \frac{\pi}{k} = \frac{1}{40}\ m = 2.5\ cm$

c) $(y)_{max} = 0.04\,|\sin(40\pi x)|$

$(y)_{max}(x = 0.5\ cm) = 0.04\cdot|\sin 0.2\pi| = 2.35\ cm$

Ex 16.29

$\frac{\lambda_n}{2} = 18\ cm$ $\frac{\lambda_{n+1}}{2} = 16\ cm$

a) $\lambda_n = \frac{2L}{n} \Rightarrow \frac{L}{n} = 18\ cm \Rightarrow L = n\cdot18\ cm$

$\lambda_{n+1} = \frac{2L}{n+1} \Rightarrow \frac{L}{n+1} = 16\ cm$

$18n = 16(n+1) \Rightarrow 2n = 16 \Rightarrow n = 8$ $\therefore\ L = 1.44\ m$

b) $f_1 = \frac{v}{2L} = \frac{\sqrt{\frac{F}{\mu}}}{2L} = \frac{\sqrt{10/0.004}}{2.88} = \frac{50}{2.88} = 17.4\ Hz$

Ex 16.33

$F_1 = F_2$ · $\rho_1 = 0.5\rho_2$ $L_1 = L_2$ $r_1 = 2r_2 \Rightarrow A_1 = 4A_2$

$\mu_1 = \rho_1 A_1 = 0.5\rho_2\cdot4A_2 = 2\rho_2 A_2 = 2\mu_2$

$v_1 = \sqrt{\frac{F_1}{\mu_1}} = \sqrt{\frac{F_2}{2\mu_2}} = \frac{1}{\sqrt{2}}v_2$

${}_1f_1 = \frac{v_1}{2L_1} = \frac{1}{\sqrt{2}}\cdot\frac{v_2}{2L_2} = \frac{1}{\sqrt{2}}\,{}_2f_1$

Ex 16.37

$$P = \frac{1}{2}\mu(\omega y_0)^2 v = \frac{1}{2}\mu\left(2\pi\frac{v}{\lambda}y_0\right)^2 v = 2\pi^2\mu\left(\frac{y_0}{\lambda}\right)^2 v^3$$

$y_0 = 1.5\ cm$
$\lambda = 40\ cm$
$v = 30\ m/s$
$\mu = 20\ g/m$

$P = 2\pi^2\cdot0.020\left(\frac{0.015}{0.40}\right)^2(30)^3 \approx 15\ W$

Ex 16.41

$y = A\sin(kx)\cos(\omega t)$

$\frac{\partial y}{\partial x} = kA\cos(kx)\cos(\omega t)$ $\frac{\partial^2 y}{\partial x^2} = -k^2A\sin(kx)\cos(\omega t)$

$\frac{\partial y}{\partial t} = -\omega A\sin(kx)\sin(\omega t)$ $\frac{\partial^2 y}{\partial t^2} = -\omega^2A\sin(kx)\cos(\omega t)$

$$\therefore\ \frac{\partial^2 y}{\partial x^2} = \frac{k^2}{\omega^2}\frac{\partial^2 y}{\partial t^2} \Rightarrow \frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

P 16.1

$F = 2\cdot 10^{8}\ N\cdot A$

$\mu = 7.8\cdot 10^{3}\ kg/m \cdot A$

$v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{2\cdot 10^{8}}{7.8\cdot 10^{3}}} = 160\ m/s$

P 16.3 tråden lämnar strängen om $\left(\frac{\partial^2 y}{\partial t^2}\right) > g$

$\Rightarrow \omega^2 y_0 > g \Rightarrow y_0 > \frac{g}{\omega^2} = \frac{g}{4\pi^2 f^2}$

P 16.7 $P = \mu (\omega A)^2 v \cos^2(kx-\omega t+\phi)$

$y = A \sin(kx-\omega t+\phi)$

$y=0 \Rightarrow \sin(kx-\omega t+\phi) = 0 \Rightarrow \cos(kx-\omega t+\phi) = \pm 1$

$\Rightarrow \cos^2(kx-\omega t+\phi) = 1$

$\Rightarrow$ P är maximal

$y = \pm A \Rightarrow \sin(\ldots) = \pm 1 \Rightarrow \cos(\ldots) = 0$

$\Rightarrow \cos^2(\ldots) = 0 \Rightarrow$ P är minimal

Ex 17.5 a) $v_{Hg} = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{2.8\cdot 10^{10}}{13.6\cdot 10^{3}}} = 1.43\ km/s$

b) $\lambda = \frac{v}{f} = 1.43\cdot 10^{3}/10^{3} = 1.43\ m$

Ex 17.7 $v = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{2\cdot 10^{11}}{7.8\cdot 10^{3}}} = 5.06\ km/s$

Ex 17.13 $f_n = \frac{nv}{4L}$ (n udda) f fixerat L varierar

$\Rightarrow L_n = \frac{nv}{4f}$ (n udda)

$L_1 = \frac{v}{4f} = \frac{340}{4\cdot 440} = 19.3\ cm$

$L_3 = \frac{3v}{4f} = 58.0\ cm$

Ex 17.15 $_p f_5 = \frac{5v}{4L} = \frac{5\cdot 340}{4\cdot 1} = 425\ Hz$

$_s f_2 = \frac{2v}{2L} = \frac{1}{L}\sqrt{\frac{F}{\mu}} \Rightarrow F = \mu (L_s f_2)^2 =$

$= 1.2\cdot 10^{-3}(0.60\cdot 425)^2 = 78\ N$

Ex 17.17 $f_n = \frac{nv}{2L}$; $f_1 = 8.5\ Hz$; $f_2 = 17\ Hz$; $f_3 = 25.5\ Hz$

Ex 17.21 $f_1 = \frac{v}{2L} \Rightarrow \Delta f_1 = \frac{\Delta v}{2L} = \frac{-9}{2\cdot 0.3} = -15\ Hz$

<u>Våglängd och dopplershift</u>

Våglängden påverkas inte av observatörens rörelse

(λ är ju avståndet mellan två vågtoppar)

$\because \lambda' = \frac{v_w}{f'}$ med $f' = \frac{v_w}{v_w - v_s} f$ oberoende av v_L

$\Rightarrow \boxed{\lambda' = \frac{v_w - v_s}{f}}$

Ex 17.23 a) $f' = \frac{v_w - v_L}{v_w - v_s} f = \frac{340}{340-25}\cdot 400 = 432\ Hz$

$\lambda' = \frac{v_w - v_s}{f} = 79\ cm$

b) $f' = \frac{340}{340+25}\cdot 400 = 373\ Hz$

$\lambda' = 91\ cm$

Ex 17.25 a) $f' = \frac{340}{340-40}\cdot 200 = 226.7\ Hz$ $\lambda' = 1.50\ m$

b) $f' = \frac{340+40}{340}\cdot 200 = 223.5\ Hz$ $\lambda' = 1.70\ m$

c) $f' = \frac{340+20}{340-20}\cdot 200 = 225.0\ Hz$ $\lambda' = 1.60\ m$

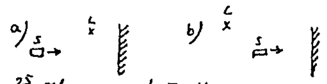
Ex 17.27 a) $\Delta f = \left(\frac{v_w - |v_L|}{v_w - |v_s|} - \frac{v_w + |v_L|}{v_w + |v_s|}\right) f =$

$= \left(\frac{325}{300} - \frac{355}{380}\right)\cdot 400 = 59.6\ Hz$

b) $\Delta f = \left(\frac{v_w + |v_L|}{v_w - |v_s|} - \frac{v_w - |v_L|}{v_w + |v_s|}\right) f = \left(\frac{355}{300} - \frac{325}{380}\right)\cdot 400$

$= 131.2\ Hz$

Ex 17.29



$v_s = 30\ km/h = \frac{25}{3}\ m/s$ $f = 500\ Hz$

a) $\Delta f = 0$ (Både spegelbild och bild rör sig mot lyssnaren)

b) $\Delta f = \left(\frac{v_w}{v_w - |v_s|} - \frac{v_w}{v_w + |v_s|}\right) f = 24.5\ Hz$

Ex 17.31 $f' = \frac{v_w}{v_w - |v_s|} f \Rightarrow |v_s| = \frac{v_w (f'-f)}{f'}$ (21.25 m/s)

$f'' = \frac{v_w}{v_w + |v_s|} f = \frac{f}{1 + \frac{f'-f}{f'}} = \frac{ff'}{2f'-f}$ $f = 600\ Hz$, $f' = 640\ Hz$

$f'' = 565\ Hz$

Ex 17.33 $P = A\cdot I = A\cdot I_0 \cdot 10^{\beta/10}$

a) $P = 0.4\cdot 10^{-4}\cdot 10^{-12}\cdot 10^{12} = 4\cdot 10^{-5}\ W$

b) $P = 0.4\cdot 10^{-4}\cdot 10^{-12}\cdot 1 = 4\cdot 10^{-17}\ W$

Ex 17.35 $I_1 = I_0\ 10^{80/10} = I_0\cdot 10^{8}$

$I_2 = I_0\cdot 10^{85/10} = I_0\cdot 10^{8.5} = 3.16\ I_0\cdot 10^{8}$

$\beta_T = 10\cdot \log \frac{4.16\ I_0\cdot 10^{8}}{I_0} = 10\cdot \log 4.16\cdot 10^{8} = 10\cdot \log 4.16 + 80$

$= 86.2\ dB$

Ex 17.37 a) $I = \frac{1}{2}\rho(\omega s_0)^2 v = \frac{1}{2}\,1.29\,(2\pi\,600\cdot 8\cdot 10^{-9})^2\cdot 340$

$= 1.99\cdot 10^{-7}\ W/m^2$

b) $I = \frac{P_0^2}{2\rho v} = \frac{3.5^2}{2\cdot 1.21\cdot 340} = 1.49\cdot 10^{-2}\ W/m^2$ (oberoende av f)

Ex 17.39 $\frac{S_{01}}{S_{02}} = \sqrt{\frac{I_1}{I_2}}$; $\frac{I_1}{I_2} = \frac{10^{\beta_1/10}}{10^{\beta_2/10}} = 10^{(\beta_1-\beta_2)/10}$

$\Rightarrow \frac{S_{01}}{S_{02}} = 10^{\Delta\beta/20} = 10^{3/20} = 1.41$

Ex 17.41 $P = 0.005\cdot 40 = 0.20\ W$; $I = \frac{P}{4\pi r^2} \Rightarrow$

$r = \sqrt{\frac{P}{4\pi I}} = \sqrt{\frac{P}{4\pi\, 10^{\beta/10}\cdot I_0}} = \sqrt{\frac{P}{4\pi I_0}}\cdot 10^{-\beta/20}$

a) $\beta = 120\ dB \Rightarrow r = \sqrt{\frac{0.20\cdot 10^{12}}{4\pi}}\cdot 10^{-6} \Rightarrow r = 12.6\ cm$ b) $\beta = 60\ dB \Rightarrow r = 126\ m$

Ex 17.43 $p_0 = 12$ Pa $\quad \rho = 1.29$ kg/m³ $\quad \omega = 2700$ rad/s

$v = \frac{\omega}{k} \qquad k = 8.18$ rad/m

a) $S_0 = \frac{p_0}{\rho\omega v} = \frac{p_0 k}{\rho\omega^2} = \frac{12 \cdot 8.18}{1.29 \cdot (2700)^2} = 1.04 \cdot 10^{-5}$ m $= 10.4\ \mu m$

b) $I = \frac{p_0^2}{2\rho v} = \frac{k p_0^2}{2\rho\omega} = \frac{12^2 \cdot 8.18}{2 \cdot 1.29 \cdot 2700} = 0.169$ W/m²

Ex 17.45 $S_0 = \frac{p_0}{\rho\omega v} \Rightarrow \omega = \frac{p_0}{S_0 \rho v} \Rightarrow f = \frac{p_0}{2\pi S_0 \rho v} =$

$= \frac{4.2 \cdot 10^{-2}}{2\pi \cdot 2.4 \cdot 10^{-9} \cdot 1.29 \cdot 340} = 6.35$ kHz

——— O ———

P 17.1 a) $I = \frac{P}{4\pi r^2} = \frac{10^{-3}}{4\pi \cdot 4^2} = 4.97 \cdot 10^{-6}$ W/m²

b) $\beta = 10 \cdot \log \frac{I}{I_0} = 10 \cdot \log 4.97 \cdot 10^6 = 10(6 + \log 4.97) = 67.0$ dB

c) $p_0 = \sqrt{2\rho v I} = \sqrt{2 \cdot 1.29 \cdot 340 \cdot 4.97 \cdot 10^{-6}} = 6.6 \cdot 10^{-2}$ Pa

d) $S_0 = \sqrt{\frac{2I}{\rho v \omega^2}} = \sqrt{\frac{I}{2\rho v \pi^2 f^2}} = \sqrt{\frac{4.97 \cdot 10^{-6}}{2 \cdot 1.29 \cdot 340\pi^2 \cdot 240^2}} = 9.98 \cdot 10^{-8}$ m

P 17.3 a) $v \approx 20\sqrt{T}$; $\frac{dv}{dT} = 10 \cdot \frac{1}{\sqrt{T}} \Rightarrow$

$\Rightarrow \frac{\Delta v}{v} \approx 10 \cdot \frac{\Delta T}{\sqrt{T}} \cdot \frac{1}{20\sqrt{T}} \Rightarrow \frac{\Delta v}{v} = 0.5 \frac{\Delta T}{T}$

b) $f = v/\lambda \quad \lambda =$ konstant (beror bara av pipans längd)

$\lambda = 2L$ för öppen pipa 

$\lambda = 4L$ för sluten pipa 

$\therefore \frac{\Delta f}{f} = \frac{\Delta v}{v} = \frac{1}{2}\frac{\Delta T}{T} = \frac{1}{2}\frac{20}{285} = \frac{10}{285}$

$f + \Delta f = f\left(1 + \frac{10}{285}\right) = 400 \cdot \frac{295}{285} = 414$ Hz

c) $\frac{10}{285} \approx 3.5\%$ (6% för helton)

P 17.9 $L_s = 52$ cm $\quad \mu_s = 2$ g/m $\quad f_s = 400$ Hz $\quad f_{beat} = 4$ Hz pipan öppen

a) $f_{beat} = \Delta f \Rightarrow f_p = 396$ Hz eller $f_p = 404$ Hz

eftersom $v = \sqrt{\frac{F}{\mu}}$ ökar hastigheten då strängen spännes (strängens längdändring kan försummas), d.v.s då λ är konstant måste $f = v/\lambda$ också öka.

Δf minskar då spännen sträckes $\therefore f_p = 404$ Hz

b) $f = \frac{v}{2L} = \sqrt{\frac{F}{\mu}} \cdot \frac{1}{2L} \Rightarrow F = \mu(2Lf)^2 = 2 \cdot 10^{-3}(2 \cdot 0.52 \cdot 400)^2 = 346$ N

c) $f = \frac{v}{2L} \Rightarrow L = \frac{v}{2f} = \frac{340}{2 \cdot 404} = 42.1$ cm

Ex 34.11 $B_y = 2 \cdot 10^{-7} \sin(0.5 \cdot 10^3 x + 1.5 \cdot 10^{11} t)$ [T]

a) $\lambda = \frac{2\pi}{k} = \frac{2\pi}{0.5 \cdot 10^3} = 1.26$ cm

$f = \frac{\omega}{2\pi} = \frac{1.5 \cdot 10^{11}}{2\pi} = 23.9$ GHz $\qquad (\lambda \cdot f = 3.0 \cdot 10^8$ m/s $= c)$

b) $\vec{B} = B \cdot \vec{j} \quad \vec{S} = -S\vec{i}$

$(+\vec{k}) \times (+\vec{j}) = (-\vec{i}) \Rightarrow$

$E_z = 60 \cdot \sin(0.5 \cdot 10^3 x + 1.5 \cdot 10^{11} t)$ [V/m]

Ex 34.13 $u_{av} = 10^{-7}$ J/m³ $\quad \left(u_{av} = \frac{S_{av}}{c}\right) \quad (\varepsilon_0 = 8.854 \cdot 10^{-12}$ F/m$)$

a) $u_{av} = \frac{E_0^2 \varepsilon_0}{2} \Rightarrow E_0 = \sqrt{\frac{2u_{av}}{\varepsilon_0}} = \sqrt{\frac{2 \cdot 10^{-7}}{8.854 \cdot 10^{-12}}} = 150$ V/m

b) $B_0 = \frac{E_0}{c} = \frac{150}{3 \cdot 10^8} = 5.0 \cdot 10^{-7}$ T

Ex 34.17 $r = 6$ m $\quad E_0 = 10$ V/m

a) $B_0 = \frac{E_0}{c} = 3.3 \cdot 10^{-8}$ T

b) $P_{av} = S_{av} \cdot 4\pi r^2 = \frac{E_0 B_0}{2\mu_0} \cdot 4\pi r^2 = \frac{E_0^2}{2c\mu_0} \cdot 4\pi r^2 =$

$= \frac{10^2 \cdot 4\pi \cdot 6^2}{2 \cdot 3 \cdot 10^8 \cdot 4\pi \cdot 10^{-7}} = 60$ W

Ex 37.1 $d \cdot \sin\theta = m\lambda \Rightarrow d \cdot \frac{y_m}{L} \approx m\lambda$

$\lambda = 490$ nm
$m = 6$
$y_m = 38$ mm
$L = 2.2$ m

$d = \frac{m\lambda L}{y_m} = \frac{6 \cdot 490 \cdot 10^{-9} \cdot 2.2}{38 \cdot 10^{-3}} = 0.17$ mm

Ex 37.3
$\lambda = 450$ nm
$L = 2$ m
$y = 3.2$ mm

a) $d = \frac{(m+\frac{1}{2})\lambda L}{y_m} \underset{m=0}{=} \frac{\frac{1}{2} \cdot 450 \cdot 10^{-9} \cdot 2}{3.2 \cdot 10^{-3}} = 0.141$ mm

b) $d = \frac{m\lambda L}{y_m} \underset{m=1}{=} \frac{1 \cdot 450 \cdot 10^{-9} \cdot 2}{3.2 \cdot 10^{-3}} = 0.281$ mm

Ex 37.7
$d = 0.2$ mm
4:de mörka
$\theta = 0.7°$

$d \cdot \sin\theta = (m + \frac{1}{2})\lambda \Rightarrow \lambda = \frac{d \cdot \sin\theta}{m + \frac{1}{2}} = \frac{0.2 \cdot 10^{-3} \cdot \sin 0.7°}{4.5}$

$= 543$ nm

*) Vilken är fjärde ordningens mörka frans?

Ex 37.27
$d = 0.6$ mm
$\lambda = 480$ nm
$L = 1.25$ m
$y = 0.45$ mm

$\delta = d \cdot \sin\theta \approx d \cdot \frac{y}{L} \Rightarrow \phi = 2\pi\frac{\delta}{\lambda} = \frac{2\pi d y}{\lambda L}$

$I = 4I_0 \cos^2 \phi/2 = 4I_0 \cos^2\left(\frac{\pi d y}{\lambda L}\right) =$ (obs radianer)

$= 4I_0 \cos^2(0.450\pi) = 9.8\%$ av I_0

P 37.1

$n = 1.6$ $\lambda_{01} = 504\,nm$ $\lambda_{02} = 672\,nm$ saknas

a) Minima för $2t = m\lambda_F$ $\quad t = m\dfrac{\lambda_0}{2n}$

$$\Rightarrow m_0 \frac{\lambda_{01}}{2n} = (m_0 - 1)\frac{\lambda_{02}}{2n}$$

$$\Rightarrow m_0 = \frac{\lambda_{02}}{\lambda_{02} - \lambda_{01}} = \frac{672}{168} = 4 \quad \text{(heltal!)}$$

$$t = 4\frac{\lambda_{01}}{2n} = 4 \cdot \frac{504 \cdot 10^{-9}}{2 \cdot 1.6} = \underline{630\,nm}$$

check $t = 3 \cdot \dfrac{\lambda_{02}}{2n} = 3 \cdot \dfrac{672 \cdot 10^{-9}}{2 \cdot 1.6} = 630\,nm$

($m = 2 \Rightarrow \lambda_0 = 1008\,nm$; $m = 5 \Rightarrow \lambda_0 = 403\,nm$ — Synligt ljus 400 - 700 nm)

b) Maxima för $2t = (m + \frac{1}{2})\lambda_F = (m + \frac{1}{2}) \cdot \dfrac{\lambda_0}{n}$

$\Rightarrow m = \dfrac{2nt}{\lambda_0} - \dfrac{1}{2}$ men $400\,nm \le \lambda_0 \le 700\,nm$

$$\therefore \frac{2 \cdot 1.6 \cdot 630}{700} - \frac{1}{2} \le m \le \frac{2 \cdot 1.6 \cdot 630}{400} - \frac{1}{2}$$

$\Rightarrow 2.38 \le m \le 4.54 \Rightarrow m = 3$ eller 4

$m = 3 \Rightarrow \lambda_0 = \dfrac{2nt}{m + \frac{1}{2}} = \dfrac{2 \cdot 1.6 \cdot 630 \cdot 10^{-9}}{3.5} = \underline{576\,nm}$

$m = 4 \Rightarrow \lambda_0 = \dfrac{2 \cdot 1.6 \cdot 630 \cdot 10^{-9}}{4.5} = \underline{448\,nm}$

P 37.5

$t = 900\,nm$, $n = 1.5$, $400\,nm \le \lambda_0 \le 700\,nm$

a) $2t = m\dfrac{\lambda_0}{n} \Rightarrow m = \dfrac{2tn}{\lambda_0}$

$$\frac{2 \cdot 900 \cdot 1.5}{700} \le m \le \frac{2 \cdot 900 \cdot 1.5}{400}$$

$3.86 \le m \le 6.75 \Rightarrow m = 4, 5$ eller 6

$\lambda_0 = \dfrac{2tn}{m}$

$m = 4 \Rightarrow \lambda_0 = 675\,nm$; $m = 5 \Rightarrow \lambda_0 = 540\,nm$; $m = 6 \Rightarrow \lambda_0 = 450\,nm$

b) $2t = (m + \frac{1}{2})\dfrac{\lambda_0}{n} \Rightarrow m = \dfrac{2tn}{\lambda_0} - \dfrac{1}{2} \Rightarrow 3.36 \le m \le 6.25$

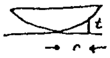
$\Rightarrow m = 4, 5$ eller 6

$\lambda_0 = \dfrac{2tn}{m + \frac{1}{2}}$ $\quad m = 4 \Rightarrow \lambda_0 = 600\,nm$; $m = 5 \Rightarrow \lambda_0 = 491\,nm$

$m = 6 \Rightarrow \lambda_0 = 415\,nm$

P 37.7

$R = 3\,m$, $r = 0.8\,cm$, $\lambda_0 = 600\,nm$



$r^2 \approx 2Rt$ (från Ex 37.5 sid 770)

$t = \frac{1}{2}(m + \frac{1}{2})\lambda$ (ljusa fransar)

$$m = \frac{2t}{\lambda} - \frac{1}{2} = \frac{r^2}{R\lambda} - \frac{1}{2} = \frac{(0.8 \cdot 10^{-3})^2}{3 \cdot 600 \cdot 10^{-9}} - \frac{1}{2}$$

$\Rightarrow m = 35.05$

$\therefore$ Ringen med den största radien har $m = 35$, men den första ringen har $m = 0$

$\therefore$ 36 ringar observeras

P 37.11 $\delta = 12\lambda$; $t \cdot n = t + 12\lambda \Rightarrow t = \dfrac{12\lambda}{n - 1} =$

$$= \frac{12 \cdot 650 \cdot 10^{-9}}{0.6} = 13\,\mu m$$

P 37.13

$2L(n-1) = m\lambda \Rightarrow n = \dfrac{m\lambda}{2L} + 1$

$$= \frac{40 \cdot 600 \cdot 10^{-9}}{2 \cdot 4.0 \cdot 10^{-2}} + 1 = \underline{1.00030}$$

$\dfrac{2L}{\lambda_0} = \dfrac{2L}{\lambda_g} - m \Rightarrow$

$\Rightarrow m = \dfrac{2L}{\lambda_0}(n_g - 1)$

Ex 38.1 $\lambda = 680\,nm$ $a = 0.06\,mm$ $L = 1.8\,m$

a) 1'a minimat: $a \cdot \sin\theta = \lambda$

$$y_w = 2 \cdot \tan\theta \cdot L \approx 2\frac{\lambda}{a} \cdot L = 2 \cdot \frac{680 \cdot 10^{-9}}{0.06 \cdot 10^{-3}} \cdot 1.8 = 4.08\,cm$$

b) 2'a minimat: $a \cdot \sin\theta_2 = 2\lambda$

1'a minimat: $a \cdot \sin\theta_1 = \lambda$

$$y_{12} = \tan\theta_2 L - \tan\theta_1 L \approx \left(\frac{2\lambda}{a} - \frac{\lambda}{a}\right)L = \frac{\lambda}{a}L = \frac{680 \cdot 10^{-9}}{0.06 \cdot 10^{-3}} \cdot 1.8$$

$= 2.04\,cm$

Ex 38.3

$y_{w_1} = 3\,cm$ $\lambda_1 = 589\,nm$ $\lambda_2 = 436\,nm$

$y_w = 2\dfrac{\lambda}{a} \cdot L \Rightarrow \dfrac{y_{w_1}}{\lambda_1} = \dfrac{y_{w_2}}{\lambda_2} \Rightarrow y_{w_2} = \dfrac{\lambda_2}{\lambda_1} y_{w_1}$

$= \dfrac{436}{589} \cdot 0.03 = 2.22\,cm$

Ex 38.5 $\lambda = 480\,nm$ $L = 2.80\,m$ $y_{12} = 3\,cm$

$$y_{12} = \frac{\lambda}{a}L \Rightarrow a = \frac{\lambda L}{y_{12}} = \frac{480 \cdot 10^{-9} \cdot 2.80}{0.03} = 44.8\,\mu m$$

Ex 38.7 1'a diff.-min: $a \cdot \sin\theta = \lambda$

Int.-max: $d \cdot \sin\theta = m\lambda$

$m = \dfrac{d}{a} = \dfrac{0.6\,mm}{0.15\,mm} = 4$ dvs 4:de maximat hamnar i diff.-min

Med definitionen att hela 4:de maximat ligger innanför diff-min fås 7 ljusa fransar och allmänt 2·m fransar (7 enligt facit)

Ex 38.9 $a = 0.8\,mm$ ($f = 20\,cm$) $L = 16\,m$ $\lambda = 600\,nm$

$\theta_c = \dfrac{1.22 \cdot \lambda}{a}$; $\dfrac{d}{L} \approx \theta_c$

$$\Rightarrow d = \frac{1.22 \cdot \lambda \cdot L}{a} = \frac{1.22 \cdot 600 \cdot 10^{-9} \cdot 16}{0.8 \cdot 10^{-3}} = 1.46\,cm$$

Ex 38.11 $\lambda = 550\,nm$ $L_Q = 3.84 \cdot 10^8\,m$

a) $a = 5\,mm$ $\quad d = \dfrac{1.22 \cdot \lambda \cdot L_Q}{a} = \dfrac{1.22 \cdot 550 \cdot 10^{-9} \cdot 3.84 \cdot 10^8}{0.005} = 51.5\,km$

b) $a = 4.5\,m$ $\quad d = \dfrac{1.22 \cdot 550 \cdot 10^{-9} \cdot 3.84 \cdot 10^8}{4.5} = 57.3\,m$

Ex 38.13 $\lambda = 500\,nm$ $L = 25\,cm$ $a = 3\,mm$

$$d = \frac{1.22 \cdot \lambda \cdot L}{a} = \frac{1.22 \cdot 500 \cdot 10^{-9} \cdot 0.25}{0.003} = 51\,\mu m$$

Ex 38.15 $L = 10^{16}\,m$

a) $\lambda = 500\,nm$ $a = 5.08\,m$ $\quad d = \dfrac{1.22 \cdot 500 \cdot 10^{-9} \cdot 10^{16}}{5.08} = 1.2 \cdot 10^9\,m$

b) $\lambda = 0.21\,m$ $a = 305\,m$ $\quad d = \dfrac{1.22 \cdot 0.21 \cdot 10^{16}}{305} = 8.4 \cdot 10^{12}\,m$

Ex 38.17 $\lambda_1 = 410.1\,nm$ $\lambda_2 = 656.3\,nm$ $d = \dfrac{10^{-3}}{300}\,m$

a) $m = 1$ $\quad \sin\theta = \dfrac{\lambda}{d} \Rightarrow \theta_1 = 7.07°$, $\theta_2 = 11.36°$ $\Rightarrow \Delta\theta = 4.29°$

b) $m = 2$ $\quad \sin\theta = \dfrac{2\lambda}{d} \Rightarrow \theta_1 = 14.24°$, $\theta_2 = 23.19°$ $\Rightarrow \Delta\theta = 8.95°$

c) $2\lambda_2 = 1312.6\,nm$; $3\lambda_1 = 1230.3\,nm$

$3\lambda_1 < 2\lambda_2 \Rightarrow$ överlapp

Ja

Ex 38.19 $\sin\theta = \frac{m\lambda}{d}$ De största vinklarna fås för de största våglängderna

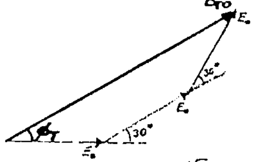
$$\frac{\lambda}{d} m_{max} \leq 1 \Rightarrow m_{max} \leq \frac{d}{\lambda} = \frac{0.01/6000}{700\cdot 10^{-9}} = 2.38$$

$\therefore$ 2 fulla ordningar på varje sida om central-max.

Ex 38.21

$$\left.\begin{aligned} d\cdot\sin 11^\circ &= 1\cdot 640\cdot 10^{-9} \\ d\cdot\sin\theta &= 2\cdot 490\cdot 10^{-9} \end{aligned}\right\} \Rightarrow \sin\theta = \frac{2\cdot 490}{640}\cdot\sin 11^\circ \Rightarrow \theta = 17.0^\circ$$

Ex 38.23 a) $\phi = 30^\circ$



$$E_{TO_x} = E_o + E_o\cos 30^\circ + E_o\cos 60^\circ = E_o + \frac{\sqrt{3}}{2}E_o + \frac{1}{2}E_o = \frac{3+\sqrt{3}}{2}E_o$$

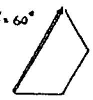
$$E_{TO_y} = 0 + E_o\sin 30^\circ + E_o\sin 60^\circ = \frac{1}{2}E_o + \frac{\sqrt{3}}{2}E_o = \frac{1+\sqrt{3}}{2}E_o$$

$$\tan\phi_T = \frac{E_{OT_y}}{E_{OT_x}} = \frac{1+\sqrt{3}}{3+\sqrt{3}} \Rightarrow \phi_T = 30^\circ$$

$$E_{TO} = \sqrt{E_{TO_x}^2 + E_{TO_y}^2} = \frac{E_o}{2}\sqrt{(3+\sqrt{3})^2 + (1+\sqrt{3})^2} =$$

$$= \frac{E_o}{2}\sqrt{12+6\sqrt{3}+4+2\sqrt{3}} = \frac{E_o}{2}\sqrt{16+8\sqrt{3}} = (1+\sqrt{3})E_o = 2.73\,E_o$$

b) $\phi = 60^\circ$



$$E_{TO_x} = E_o + E_o\cdot\cos 60^\circ + E_o\cdot\cos 120^\circ = E_o\left(1+\tfrac{1}{2}-\tfrac{1}{2}\right) = E_o$$

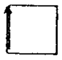
$$E_{TO_y} = 0 + E_o\cdot\sin 60^\circ + E_o\sin 120^\circ = E_o\cdot\sqrt{3}$$

$$\tan\phi_T = \sqrt{3} \Rightarrow \phi_T = 60^\circ$$

$$E_{TO} = E_o\sqrt{1^2+\sqrt{3}^2} = 2E_o$$

c) $\phi = 90^\circ$

$E_{OT_x} = E_o + 0 - E_o = 0$ $\quad E_{OT_y} = 0 + E_o + 0 = E_o$



$\phi_T = 90^\circ$ $\quad E_{TO} = E_o$

d)

$$E_{TO_x} = E_o + E_o\cdot\cos 120^\circ + E_o\cdot\cos 240^\circ = E_o\left(1-\tfrac{1}{2}-\tfrac{1}{2}\right) = 0$$

$$E_{TO_y} = 0 + E_o\cdot\sin 120^\circ + E_o\cdot\sin 240^\circ = E_o\left(\tfrac{\sqrt{3}}{2}-\tfrac{\sqrt{3}}{2}\right) = 0$$

$$E_{TO} = 0$$

Ex 38.25 $N = 5$ $\quad d = 25\,m$ $\quad f = 100\,MHz$

Eq 38.6 $\Rightarrow$ första minimat då $\phi = \frac{2p\pi}{N}$ för $p = 1$

$\Rightarrow \phi = \frac{2\pi}{5}$ (72°) oberoende av d och f

Ex 38.27 $\lambda = 656.2\,nm$ $\quad a = 0.08\,mm$

a) 1'a minimat $a\cdot\sin\theta = \lambda \Rightarrow \theta = 0.47^\circ$

b) $\alpha = \frac{2\pi a\sin\theta/2}{\lambda}$ och $I = I_o\cdot\frac{\sin^2(\alpha/2)}{(\alpha/2)^2}$

$\alpha = 3.1416\ (=\pi)$ radianer $\Rightarrow I = I_o\cdot 0.405$ (40.5%)

Ex 38.31 $d = \frac{10^{-2}}{4200}$ $\quad w = 2.8\,cm$ $\quad \lambda = 550\,nm$ $\quad m = 2$

$$R \equiv \frac{\lambda}{\Delta\lambda} = m\cdot N \Rightarrow \Delta\lambda = \frac{\lambda}{m\cdot w/d} = \frac{550\cdot 10^{-9}}{2\cdot 4200\cdot 10^{2}\cdot 0.028} = 0.023\,nm$$

P 38.3 $N = 4$ $\quad \lambda = 450\,nm$ $\quad d = 0.08\,mm$ $\quad L = 3.6\,m$

a) max: $d\cdot\sin\theta = m\lambda$; $m = 1 \Rightarrow \frac{y}{L} \approx \frac{\lambda}{d} \Rightarrow y = \frac{\lambda L}{d} = 20.25\,mm$

b) min: $d\cdot\sin\theta = \frac{p\lambda}{N}$; $p = 1 \Rightarrow \frac{y}{L} \approx \frac{\lambda}{Nd} \Rightarrow y = \frac{\lambda L}{4d} = 5.06\,mm$

$p = 2 \Rightarrow y = \frac{2\lambda L}{4d} = 10.12\,mm$.