$\boxed{1a}$

$\zeta_a = 2{,}5 \qquad \lambda = 100$

$\zeta_1 = \zeta_a \cos(kx - \omega t)$

a) Total energy in wave $= E_k + E_p$

$dE_k = \frac{1}{2}\rho\, dx\, dz\, V^2 = \frac{1}{2}\rho\, dx\, dz\, [u^2 + w^2]$

$u = \frac{kg\,\zeta_a}{\omega} e^{kz} \cos(kx - \omega t)$

$w = \text{———}\ \text{''} \text{—}\ \sin(\quad)$

$E_k = \frac{1}{2}\rho \int_0^{\lambda} \int_{-\infty}^{\zeta} (u^2 + w^2)\, dz\, dx$

$\approx \frac{1}{2}\rho \int_0^{\lambda} dx \int_{-\infty}^{0} e^{2kz}\, dz \cdot \left(\frac{kg\,\zeta_a}{\omega}\right)^2$

Neglect $0 \to \zeta$ in linear wave theory

$E_k = \underline{\frac{1}{4}\rho g \zeta_a^2 \lambda}$

$(kg = \omega^2)$
dypt vann

1a) forts.

$$dE_p = \rho g (dx\, \zeta)\, \frac{1}{2} \zeta$$

over bølgelengden ↑ Væske element ved overflaten

$$E_p = \int_0^\lambda \frac{1}{2} \rho g \zeta^2 dx = \frac{1}{4} \rho g \zeta_a^2 \lambda$$

$$E = E_k + E_p = \frac{1}{2} \rho g \zeta_a^2$$

1b) ~~Potensiell~~ Potensiell energi i bølger:

Vannpartiklene har blitt tatt ut av Equilibrium posisjon når de er over eller under Null Nivået.

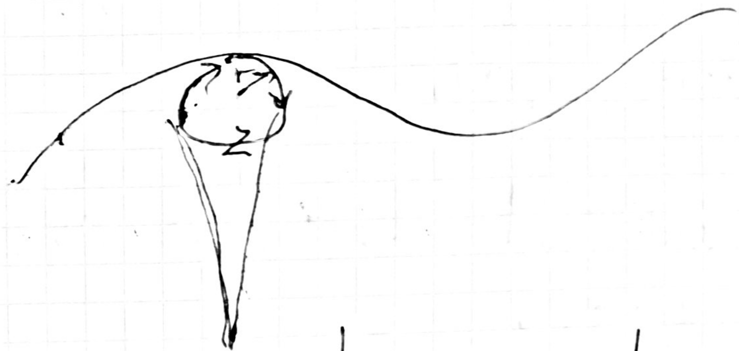
Akkurat som for en streng, har ~~er~~ bølgene potensell energi når de ikke er i ekvilibriums posisjon.

$\boxed{2}$

Tank 150 x 5

$\zeta_a = 0.2$ m $\qquad T = 2$ s

$\boxed{2a}$ For dypt vann får vi sirkel bevegelse med $\underline{r = \zeta_A e^{kz}}$



Som vi ser minsker r nedover i dypet

$$u = \frac{kg\,\zeta_A}{\omega}\cos(kx - \omega t)\cdot e^{kz}$$

$$w = \frac{k\,\zeta_A}{\omega}\sin(kx - \omega t)\, e^{kz},$$

Ved Overflaten $r = \zeta_A$.

$\underline{z = -0,5}$

$$r = 0.2\, e^{-0,5 \cdot 1,006} = \underline{0,121\text{ m}}.$$

$\underline{1\,\%}$: $\zeta_a e^{kz} = 0,01\,\zeta_a$

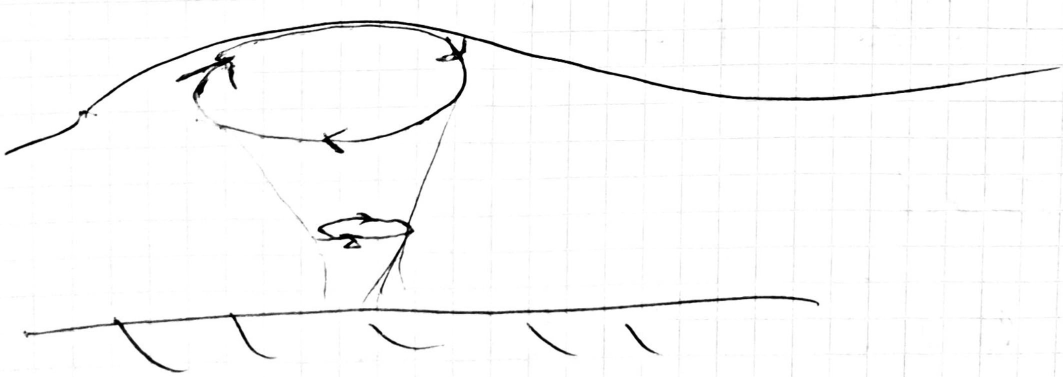
$$\underline{z = -4,6\text{ m}}.$$

$\boxed{2b}$ ~~Har~~ Av praktiske hensyn ønsker ~~[illegible]~~ man å bruke dypt-vann modellen så lenge den ikke gir for stor feil..

Vanndypde H bør være minst halve bølge lengden.

For ~~vårt~~ vårt eksempel bør H være minst 3,123m.

Ved endelig Vanndyp ~~[illegible]~~ vil vannpartiklene gå i elliptiske baner.



~~Bølgen~~ Ellipsen blir flatere og flatere ~~[illegible]~~ ~~[illegible]~~ Nedover i vannet.

$\boxed{3}$ $\boxed{a)}$ $P_d = -\rho \frac{d\phi}{dt} = \rho g \zeta_a e^{kz} \cos(kx - \omega t)$

Froude-Krilloff force: $F_k = -\int_S p \cdot n_k \, dS$

$k = \underline{0.0628}$

$\lambda = 100 \quad \zeta_a = 2m \quad \rho = 1025 \, kg/m^3$

Horizontal: $n_1 = 0$ på toppen og bunnen

$$F_1 = \rho g \zeta_a \cos(k(-\tfrac{b}{2}) - \omega t) \int_{-2b}^{-b} e^{kz} dz$$

$$-\rho g \zeta_a \cos(k\tfrac{b}{2} - \omega t) \int_{-2b}^{-b} e^{kz} dz$$

$$= -\rho g \zeta_a \, 2 \sin\left(\frac{kb}{2}\right) \sin(\omega t) \frac{1}{k} \underbrace{\left[e^{kz}\right]_{-2b}^{-b}}_{= e^{-bk} - e^{-2bk}}$$

$$= \underline{-49230 \sin(\omega t) \; N}$$

3 $\boxed{a2}$ Vertical

$$F_3 = -\rho g \zeta_a e^{-bk} \int_{-\frac{b}{2}}^{\frac{b}{2}} \cos(kx - \omega t)\, dx + \rho g \zeta_a e^{-2bk}$$

$$\int_{-\frac{b}{2}}^{b/2} \cos(kx - \omega t)\, dx$$

$$= -\rho g \zeta_a \left(e^{-bk} - e^{-2bk}\right) \frac{1}{k}\left[\sin\left(\frac{kb}{2}\right) - \sin\left(\frac{-kb}{2}\right)\right] \cos(\omega t$$

$$= -\underline{49230 \ N \cdot \cos(\omega t)}.$$

$\boxed{4a}$ $\quad r = 2m \qquad \lambda = 100 \qquad k = \frac{\pi}{50}$

$\zeta_a = 2m \qquad \underline{H = 200}\ m.$

$C_m = 2$

$C_D = 0.7.$

$$Re = \frac{UL}{\nu} \qquad \omega = \sqrt{kg}$$

$$\omega \approx \underline{0,785}$$

$$u_{max} = \frac{kg\zeta_a}{\omega} = \underline{1,57\ m/s}$$

$$Re = \frac{1,57\ m/s \cdot 4\ m}{1 \cdot 10^{-6}\ m^2/s} = \underline{6,28 \cdot 10^6}$$

Fra kompendiet.

$$\dot{u} = \frac{kg}{\omega} \zeta_a e^{kz} \sin(kx - \omega t)$$

$$dF = \underbrace{\rho \frac{\pi D^2}{4} C_m \dot{u}\, dz}_{F_m} + \underbrace{\frac{1}{2} \rho C_D D\, u|u|\, dz}_{F_D}.$$

Velger z-aksen gjennom sylinder slik at $x = 0$.

$$F_m = \rho \frac{\pi D^2}{4} 2 \int_{-H}^{0} e^{kz}\, dz \cdot kg\zeta_a \sin(\omega t)$$

$$= -\rho \frac{\pi D^2}{2} g \zeta_a (1 - e^{-kH}) \sin(\omega t)$$

$$= \underline{-505\ kN \sin(\omega t)}$$

$\boxed{4a}$ $F_D = \frac{0.7}{2} \rho D \int_{-H}^{0} u|u| \, dz$

$= 0.35 \rho D \left(\frac{kg \zeta_a}{\omega}\right)^2 \int_{-H}^{0} e^{2kz} dz \, |\cos(\omega t)| \cos(\omega t)$

$= \frac{0.35}{2} \rho D k \left(\frac{g \zeta_a}{\omega}\right)^2 (1 - e^{-2kH}) \, |\cos(\omega t)| \cos(\omega t)$

$= \underline{28 \text{ kN} \cdot |\cos(\omega t)|}$

$\boxed{4b}$ phase angle between cos( ) and sin( )

is $\underline{90°}$. / $\frac{\pi}{2}$ radians.

4c)

$\underline{F_{max} = 505 \text{ kN}}$

at $\underline{\omega = \frac{3\pi}{2}}$