9-3 (1) $\lambda = \frac{u}{f} = \frac{80\,cm/s}{10\,Hz} = 8\,cm$

(2) $y = A\cos(\omega t+\varphi)$ 有 $t=0$ 时 $y=0$，$\dot{y}>0$，不妨 $\varphi=0$

$y = 2\cos\left(20\pi t - \frac{\pi}{2}\right)\,cm$ （t单位为s）

(3) 波方程：$y = A\sin\left(\omega t - kx + \varphi\right)$ 其中 $k = \frac{2\pi}{\lambda}$

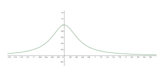
$y = 2\sin\left[2\pi\left(10t - \frac{x}{8}\right) - \frac{\pi}{2}\right]\,cm$ （t, x 单位 s, cm）

(4) $x_1 = 4\,cm$ 处 $\Delta\varphi = -kx_1 = -\frac{2\pi}{\lambda}x_1 = -\pi$ $\varphi' = \varphi + \Delta\varphi = -\frac{3}{2}\pi$

9-5 (1) $x_1 < x_2$，x_1 处相位落后于 x_2 $(x_2 - x_1 < \lambda)$ 故向 x 负正向传播

(2) $\Delta\varphi = k(x_2 - x_1)$ 其中 $k = \frac{2\pi}{\lambda}$，故 $\lambda = \frac{2\pi}{\Delta\varphi}(x_2 - x_1) = 24\,cm = 0.24\,m$

$v = \lambda\cdot f = 48\,cm/s = 0.48\,m/s$

9-8 (1) $b=1$，$u=1$ 

(2) $y(x,t) = f\left(x - \frac{u}{2}t\right)$，速率为 $\frac{u}{2}$，沿 x 正向传播

(3) $v(x) = \left.\frac{\partial y(x,t)}{\partial t}\right|_{t=0} = \left.\frac{2b^3u(2x-ut)}{[b^2+(2x-ut)^2]^2}\right|_{t=0} = \frac{4b^3xu}{(b^2+4x^2)^2}$ （y 正向）

9-11 (1) $v_{p_1} = \frac{\omega_1}{k_1} = 1.2\,m/s$ $v_{p_2} = \frac{\omega_2}{k_2} = 1.25\,m/s$

(2) $y = y_1 + y_2 = A\cos(6t - 5x) + A\cos(5t - 4x) = 2A\cos\left(\frac{1}{2}t - \frac{1}{2}x\right)\cos\left(\frac{11}{2}t - \frac{9}{2}x\right)$

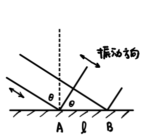
相邻振幅为0的距离 $\Delta x = \frac{\lambda_g}{2} = \frac{\pi}{\frac{1}{2}(m^{-1})} = 2\pi\ m$

(3) $v_g = \frac{\frac{1}{2}s^{-1}}{\frac{1}{2}m^{-1}} = 1\,m/s$

9-12 (1) $\frac{B}{A} = \left|\frac{u_1 - u_2}{u_1 + u_2}\right| = \frac{1}{3}$，其中 $u_1 = \sqrt{\frac{T}{\rho_{l_1}}}$，$u_2 = \sqrt{\frac{T}{\rho_{l_2}}}$

得 $\frac{\rho_{l_1}}{\rho_{l_2}} = 4$ 或 $\frac{1}{4}$

(2) $\frac{C}{A} = \frac{2\cdot u_1}{u_1 + u_2} = \frac{2}{1+\sqrt{\frac{\rho_{l_1}}{\rho_{l_2}}}} = \frac{2}{3}$ 或 $\frac{3}{4}$

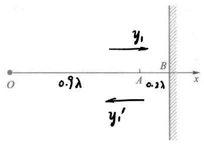
9-14 

入射纵波与反射横波振动方向相同，如图，界面上 A, B 为两次波源，距离 l

纵波 B 落后 A：$\frac{l\sin\theta}{u_p}$ 横波 B 超前 A：$\frac{l\cos\theta}{u_s}$

有 $\frac{l\sin\theta}{u_p} = \frac{l\cos\theta}{u_s}$ 从而 $\theta = \arctan\frac{u_p}{u_s} = \frac{\pi}{3}$

9-19



题 9-19 图

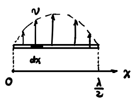
(1) 入射波 $y_1 = A\cos\left[\omega t + 0.2\pi - k(x - 0.9\lambda)\right] = A\cos\left(\omega t - \frac{2\pi}{\lambda}x\right)$

(2) 反射波 $y_1' = A\cos\left[\omega t - k(2.2\lambda - x) + \pi\right] = A\cos\left(\omega t + \frac{2\pi}{\lambda}x + 0.6\pi\right)$

(3) 合成驻波 $y = y_1 + y_1' = A\cos\left(\omega t - \frac{2\pi}{\lambda}x\right) + A\cos\left(\omega t + \frac{2\pi}{\lambda}x + 0.6\pi\right)$

$$= 2A\cos\left(\frac{2\pi}{\lambda}x + 0.3\pi\right)\cos\left(\omega t + 0.3\pi\right)$$

9-20



取位移为0时刻，相邻波节总能量 $E = E_k$，x处 dx长绳元动能为 dE_k

$dE_k = \frac{1}{2}\rho v^2 dx$ 其中 $v = 2\omega A\sin\frac{2\pi}{\lambda}x$

故相邻波节总能量 $E = E_k = \int_0^{\frac{\lambda}{2}} \frac{1}{2}\rho\left(2\omega A\sin\frac{2\pi}{\lambda}x\right)^2 dx = \frac{1}{2}\rho\omega^2\lambda A^2 = 6.3165\times10^{-2}J$

9-21 弦线上的横波波动方程： $\frac{\partial^2 y}{\partial t^2} - \sqrt{\frac{T}{\rho}}\frac{\partial^2 y}{\partial x^2} = 0$ 故波速： $u = \sqrt{\frac{T}{\rho}}$ 波长， $\lambda = \frac{u}{f}$

形成k个波腹的驻波， $l = k\cdot\frac{\lambda}{2}$

由上述各式得： $T = \rho\left(\frac{2fl}{k}\right)^2$ ，重物质量， $m = \frac{T}{g} = \frac{\rho}{g}\left(\frac{2fl}{k}\right)^2$

代入k=1,2,3得：

$k=1$	$k=2$	$k=3$
$T=15.3kg$	$T=3.83kg$	$T=1.70kg$

9-27 潜艇接收频率 $f = \frac{u+v}{u}f_0$ 其中 u, v分别为声速和艇速，f_0为声呐发射频率

声呐接收频率 $f' = \frac{u}{u-v}f$。 结合二式知 $f' = \frac{u+v}{u-v}f$

$y = \cos(\omega t + \varphi_1) + \cos(\omega' t + \varphi_2) = 2\cos\left(\frac{\omega'-\omega}{2}t + \varphi_2 - \varphi_1\right)\cos\left(\frac{\omega+\omega'}{2}t + \varphi_1 + \varphi_2\right) = A(t)\cos\left(\frac{\omega+\omega'}{2}t + \varphi_1 + \varphi_2\right)$

强度正比于 $A^2(t) = 2\left[1 - \cos\left((\omega'-\omega)t + \varphi_2 - \varphi_1\right)\right]$ 为 $|\omega' - \omega|$ 的拍

故拍频 $f_b = f' - f_0 = \frac{2u}{u-v}f_0$ 得 $v = \frac{f_b}{2f_0 + f_b}u \approx 6\,m/s$

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9-3

(1) $\lambda=\frac{u}{f}=8\text{cm}$

(2) $y=2\sin(\omega t)$ (cm)

$\omega=2\pi f=20\pi$ rad/s

$\therefore y=2\sin(20\pi t)$ (cm)

(3) $y=2\sin(\omega t-kx)$ (cm)

$k=\frac{\omega}{u}=\frac{\pi}{4}$ cm^{-1}

$y=2\sin(20\pi t-\frac{\pi}{4}x)$ (cm)

(4). $y=2\cos(20\pi t-\frac{\pi}{4}x-\frac{\pi}{2})$ (cm)

初相位 $\varphi_0=-\frac{3}{2}\pi$

9-5

(1) 沿x轴负方向传播

(2) $k\cdot(x_2-x_1)=\frac{\pi}{4}$

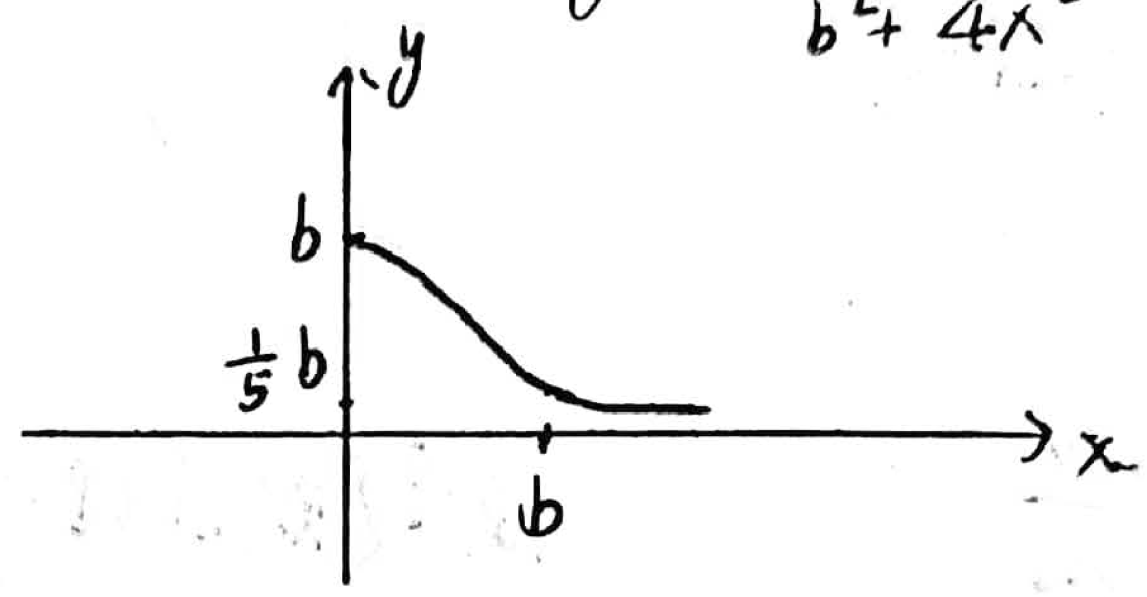
$k=\frac{\pi}{12}$ cm^{-1} $=\frac{2\pi}{\lambda}$

$\therefore \lambda=24$ cm

$v=\lambda f=48$ cm/s

9-8.

(1). $t=0$ 时 $y(x)=\frac{b^3}{b^2+4x^2}$



(2) $\frac{d(2x-ut)}{dt}=0$　　$2\cdot\frac{dx}{dt}-u=0$

$\frac{dx}{dt}=\frac{1}{2}u$, $\therefore$ 脉冲速率 $v=\frac{1}{2}u$, 方向沿x正方向

(3). $\frac{\partial y}{\partial t}=-\frac{2b^3(2x-ut)\cdot(-u)}{[b^2+(2x-ut)^2]^2}=\frac{2b^3(2x-ut)u}{[b^2+(2x-ut)^2]^2}$

$\left.\frac{\partial y}{\partial t}\right|_{t=0}=\frac{4ub^3x}{(b^2+4x^2)^2}$

9-11.

(1) $v_{p_1}=\frac{\omega_1}{k_1}=1.2$ m/s

$v_{p_2}=\frac{\omega_2}{k_2}=1.25$ m/s

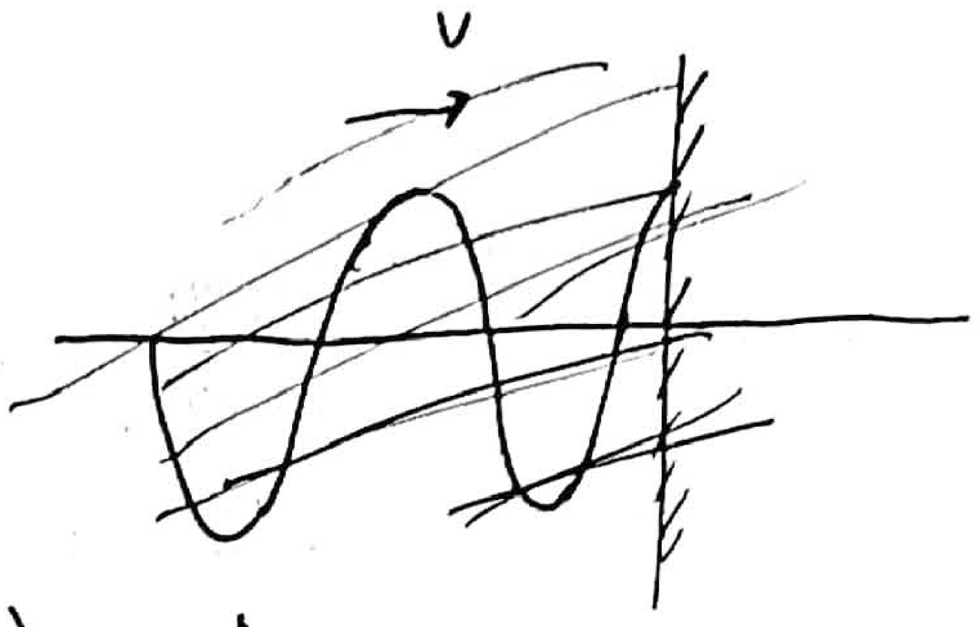
(2). $y_1+y_2=2A\cos(\frac{11t-9x}{2})\cos(\frac{t-x}{2})$

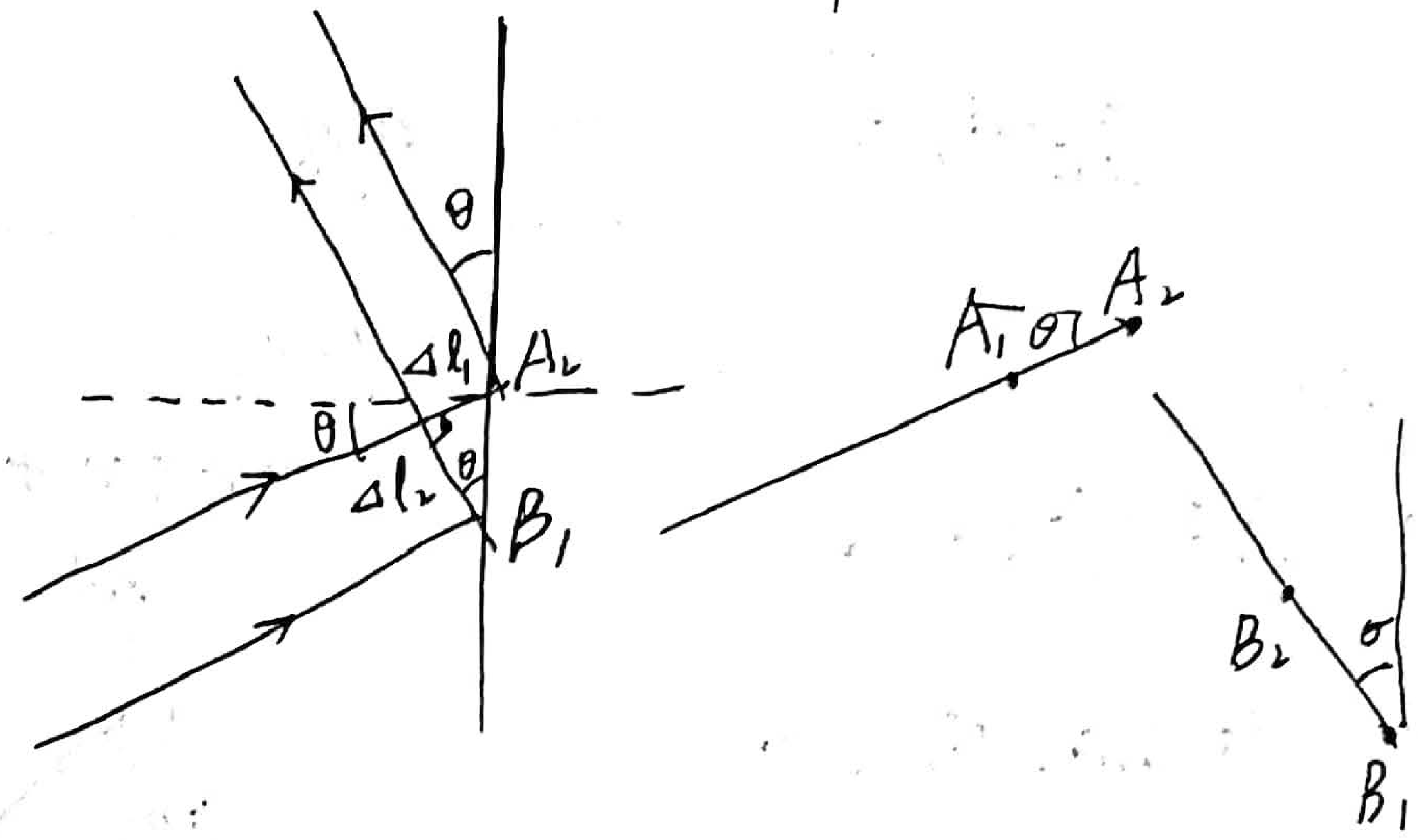
将 $2A\cos(\frac{t-x}{2})$ 一项看成振幅

相邻两点距离 $\Delta x=2\pi$ m

(3) 群速度 $V_g=\frac{\Delta w}{\Delta k}=1\,m/s$

9-14.





由惠更斯原理可找到等相位的波阵面

考虑相位差 $\varphi_{A_1A_2}$, $\varphi_{B_1B_2}$

$\varphi_{A_1A_2}=\frac{w}{u_1}\cdot\Delta l_1$

$\varphi_{B_1B_2}=\frac{w}{u_2}\Delta l_2$ 有 $\frac{u_1}{u_2}=\sqrt{3}$

又 $\varphi_{A_1A_2}=\varphi_{B_1B_2}$

得 $\frac{\Delta l_1}{\Delta l_2}=\tan\theta=\frac{u_1}{u_2}=\sqrt{3}$

$\therefore\theta=60^\circ$

9-12.

(1).

设入射波 $y_1=A\cos(wt-k_1x)$

反射波 $y_2=B\cos(wt+k_1x+\varphi_2)$

出射波: $y_3=C\cos(wt-k_2x+\varphi_3)$

满足: $y_1+y_2=y_3\Big|_{x=0}$

其中 $k_1=\frac{w}{u_1}$, $k_2=\frac{w}{u_2}$

$u_1=\sqrt{\frac{F_T}{\rho_{l1}}}$ $u_2=\sqrt{\frac{F_T}{\rho_{l2}}}$

且满足:

$$-\frac{\partial(y_1+y_2)}{\partial x}F_T\Big|_{x=0}+\frac{\partial y_3}{\partial x}\cdot F_T\Big|_{x=0}=0$$

$$\begin{cases}A+B\cos\varphi_2=C\cos\varphi_3\\ B\sin\varphi_2=C\sin\varphi_3\end{cases}$$

$k_1A-k_1B\cos\varphi_2=k_2C\cos\varphi_3$

$-k_1B\sin\varphi_2=k_2C\sin\varphi_3$

且有: $\frac{B}{A}=\frac{1}{3}$

得 $k_1=2k_2$ 即 $\frac{\rho_{l1}}{\rho_{l2}}=4$

或 $k_1=\frac{1}{2}k_2$ 即 $\frac{\rho_{l1}}{\rho_{l2}}=\frac{1}{4}$

(2).

若 $k_1=2k_2$, 有: $A+B=C \Rightarrow C=\frac{4}{3}A$

若 $k_1=\frac{1}{2}k_2$, 有: $A-B=C \Rightarrow C=\frac{2}{3}A$

（科目 基础物理学 ）

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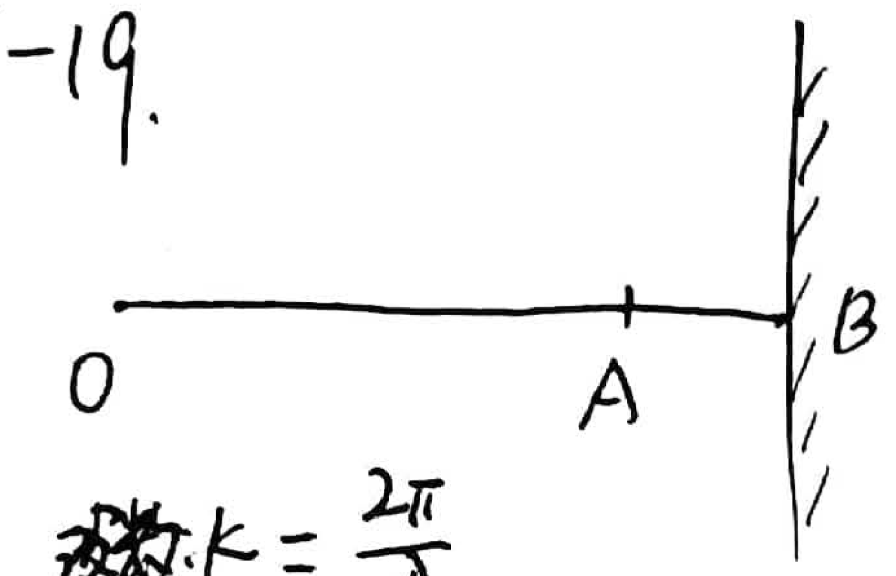
9-19.



波数 $k = \frac{2\pi}{\lambda}$

(1) 入射波 $y_{in} = A\cos(\omega t \mp k(x-0.9\lambda)+0.2\pi)$

$y_{in} = A\cos(\omega t - kx)$

(2).

反射波 $y_{re} = A\cos(\omega t + kx + \varphi_1)$

满足 $(y_{in}+y_{re})\Big|_{x=1.1\lambda} = 0$

$y_{in}+y_{re} = 2A\cos(\omega t+\frac{1}{2}\varphi_1)\cos(kx+\frac{1}{2}\varphi_1)$

$\cos(1.1\lambda k+\frac{1}{2}\varphi_1)=0$

得 $\varphi_1 = 0.6\pi$

$\therefore y_{re} = A\cos(\omega t + kx + 0.6\pi)$

(3). 驻波方程:

$y = y_{in}+y_{re} = 2A\cos(\omega t+\frac{3}{10}\pi)\cos(kx+\frac{3}{10}\pi)$

9-20.

取 x处长度 dx 为微元

其动能

$dE_k = \frac{1}{2}(\rho_l \cdot dx)\left(\frac{\partial y}{\partial t}\right)^2$

其势能

$dE_p = \frac{1}{2}\cdot E dV\cdot\left(\frac{\partial y}{\partial x}\right)^2$

有体密度 $\rho_V S = \rho_l$

波速 $u = \frac{\omega}{k} = \sqrt{\frac{E}{\rho_V}}$

可以化简得到

$dE_k+dE_p = 2\rho_l\cdot\omega^2A^2\cdot\Big[\cos^2(\omega t+\frac{3}{10}\pi)\sin^2(kx+\frac{3}{10}\pi) + \sin^2(\omega t+\frac{3}{10}\pi)\cos^2(kx+\frac{3}{10}\pi)\Big]$

令 $dE = dE_k + dE_p$

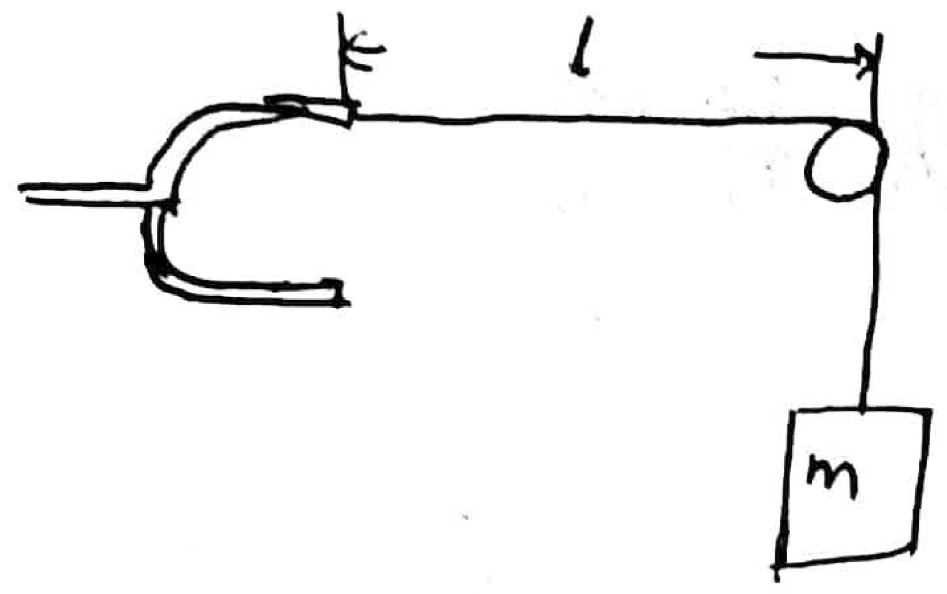
$E_0 = \int_0^{E_0} dE = 2\rho_l\omega^2A^2\Big(\int_0^{\frac{\lambda}{2}}\cos^2(\omega t+\frac{3}{10}\pi)\sin^2(kx+\frac{3}{10}\pi)\,dx + \int_0^{\frac{\lambda}{2}}\sin^2(\omega t+\frac{3}{10}\pi)\cdot\cos^2(kx+\frac{3}{10}\pi)\,dx\Big)$

$= \frac{1}{2}\rho_l\omega^2A^2\lambda$

代入数据得

$E_0 = 0.0632\ J = 6.32\times10^{-2} J$

9-21.



有波传播速度：

$$u=\sqrt{\frac{F_T}{\rho_l}}=\sqrt{\frac{mg}{\rho_l}}$$

波长：$\lambda=\frac{u}{f}=\frac{1}{f}\sqrt{\frac{mg}{\rho_l}}$

设形成 n 个波腹

有：$\frac{n}{2}\lambda=l$

$$m=\frac{4\rho_l f^2 l^2}{n^2 g}$$

$n=1$ 时，$m=15.3\ kg$

$n=2$ 时 $m=3.83\ kg$

$n=3$ 时 $m=1.70\ kg$

9-27.

入射波频率记为 f_0

设潜艇接收到的频率 f_1，潜艇速度 v

$$f_1=\frac{u+v}{u}f_0$$，其中 u 为波速.

接收器接收频率 f_2

$$f_2=\frac{u}{u-v}f_1=\frac{u+v}{u-v}f_0$$

有：$f_2-f_0=\Delta f$

Δf 为拍频频率

$$v=\frac{\Delta f\cdot u}{2f_0+\Delta f}=6.00\ m/s$$

第九章作业

9-3

解：(1) $u=80\,cm/s$ $\quad \nu=10Hz$ $\quad \therefore T=\frac{1}{\nu}=0.1s$ $\quad \therefore \lambda=u\cdot\nu=8cm$.

(2) $\omega=2\pi\nu=20\pi\ rad/s$

$\therefore y(0,t)=2\cos(20\pi t-\frac{\pi}{2})\ cm$

(3) $\therefore y(x,t)=2\cos[20\pi\ t-\frac{2\pi}{\lambda}\cdot x-\frac{\pi}{2}]=2\cos[20\pi t-\frac{\pi}{4}x-\frac{\pi}{2}]\ cm$

(4) $y(4,0)=2\cos(-\pi-\frac{\pi}{2})=2\cos(-\frac{3}{2}\pi)$ $\quad \therefore \varphi'=-\frac{3}{2}\pi$

9-5

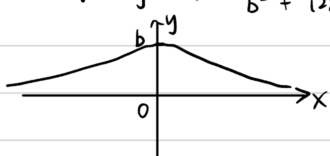
解：(1) $\nu=2.0Hz$ $\quad$ 又 $\because \Delta\varphi=-\frac{2\pi}{\lambda}\Delta x$ $\quad \therefore \lambda=-2\pi\frac{\Delta x}{\Delta\varphi}=-24cm$

$\therefore$ 沿 x 轴负方向

(2) 由(1)知：$\lambda=24cm$. $\quad u=\lambda\cdot\nu=48\,cm/s$

9-8

解：(1) $t=0$ 时：$y(x,0)=\frac{b^3}{b^2+(2x)^2}=\frac{b^3}{b^2+4x^2}$



(2) 方向：沿 $+x$ 方向 $\quad$ 设经过 Δt 时间，波峰位置：$2x-u\Delta t=0$ $\quad \therefore x=\frac{u}{2}\Delta t$

$\therefore$ 波速：$\frac{u}{2}$

(3) $\therefore \frac{\partial y}{\partial t}=\frac{-b^3\cdot 2(2x-ut)(-u)}{[b^2+(2x-ut)^2]^2}=\frac{2b^3u(2x-ut)}{[b^2+(2x-ut)^2]^2}$

当 $t=0$ 时 $\left.\frac{\partial y}{\partial t}\right|_{t=0}=\frac{2b^3u\cdot 2x}{(b^2+4x^2]^2}=\frac{4xub^3}{(b^2+4x^2)^2}$

9-11

解：(1) $\because V_P=V_{波}$ $\quad$ 又 $\because \omega_1=6\,rad/s$ $\quad \therefore T_1=\frac{2\pi}{\omega_1}=\frac{\pi}{3}s$.

又 $\because -\frac{2\pi}{\lambda_1}=-5$ $\quad \therefore \lambda_1=\frac{2\pi}{5}m$ $\quad \therefore V_{波1}=\frac{\lambda_1}{T_1}=\frac{6}{5}m/s$

$\omega_2 = 5\,rad/s$ $\quad T_2 = \frac{2\pi}{\omega_2} = \frac{2\pi}{5}\,rad/s.$ $\quad -\frac{2\pi}{\lambda_2} = -4$ $\quad \therefore \lambda_2 = \frac{\pi}{2}\,m$

$\therefore V_{波2} = \frac{\lambda_2}{T_2} = \frac{5}{4}\,m/s$ $\quad \therefore V_{p2} = \frac{5}{4}\,m/s$

(2) $\therefore y = y_1 + y_2 = A\cos(6t-5x) + A\cos(5t-4x)$

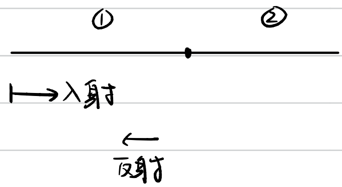
$$= A\left(2\cos\frac{11t-9x}{2}\cos\frac{t-x}{2}\right)$$

$$= 2A\cos\frac{t-x}{2}\cos\frac{11t-9x}{2}$$

$\therefore$ 令 $2A\cos\frac{t-x}{2} = 0$ $\quad \therefore \Delta x = 2\pi\ (m)$

(3) $V_g' = \frac{\Delta\omega}{\Delta k} = \frac{1}{1} = 1\,m/s$

9-12



解: (1) ① 波密→波疏:

$$Z = \rho u = \rho\sqrt{\frac{T}{\rho}} = \sqrt{T\rho}$$

$$\therefore A_1' = \frac{\sqrt{T\rho_1} - \sqrt{T\rho_2}}{\sqrt{T\rho_1} + \sqrt{T\rho_2}} A_1 = \frac{\sqrt{\rho_1} - \sqrt{\rho_2}}{\sqrt{\rho_1} + \sqrt{\rho_2}} A_1$$

$\therefore \frac{B}{A} = \frac{1}{3} = \frac{\sqrt{\rho_1} - \sqrt{\rho_2}}{\sqrt{\rho_1} + \sqrt{\rho_2}}$ $\quad \therefore \rho_1 = 4\rho_2$ $\quad \therefore \frac{\rho_{l1}}{\rho_{l2}} = 4$

② 波疏→波密

$\frac{B}{A} = -\frac{1}{3} = \frac{\sqrt{\rho_1} - \sqrt{\rho_2}}{\sqrt{\rho_1} + \sqrt{\rho_2}}$ $\quad \therefore \rho_2 = 4\rho_1$ $\quad \therefore \frac{\rho_{l1}}{\rho_{l2}} = \frac{1}{4}$

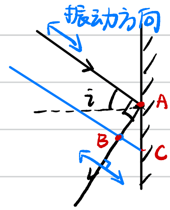
(2) ① $\rho_1 = 4\rho_2$ 时: $z_1 = 2z_2$:

$A_2 = \frac{2z_1}{z_1+z_2} A_1 = \frac{4z_2}{2z_2+z_2} A_1 = \frac{4}{3} A_1$ $\quad \therefore \frac{C}{A} = \frac{4}{3}$

② $\rho_2 = 4\rho_1$ 时: $z_2 = 2z_1$:

$A_2 = \frac{2z_1}{z_1+z_2} A_1 = \frac{2z_1}{z_1+2z_1} A_1 = \frac{2}{3} A_1$ $\quad \therefore \frac{C}{A} = \frac{2}{3}$

9-14



解: ∵ $u_{纵}=\sqrt{3}\,u_{横}$ ∴ $z_1=\sqrt{3}\,z_2$

∴ $l_{BC}=u_{纵}\Delta t$ $l_{AB}=u_{横}\Delta t$

∴ $\tan i=\dfrac{l_{BC}}{l_{AB}}=\dfrac{u_{纵}}{u_{横}}=\sqrt{3}$ ∴ $i=60^\circ$

9-19

解: (1) $y_A=A\cos(\omega t+0.2\pi)$

$y_1=A\cos[\omega t+0.2\pi-\frac{2\pi}{\lambda}(x-0.9\lambda)]$

∴ $y_1=A\cos(\omega t-\frac{2\pi}{\lambda}x)$

(2) ∴ $y_1(1.1\lambda,t)=A\cos(\omega t-\frac{2\pi}{\lambda}1.1\lambda)=A\cos(\omega t-0.2\pi)$

设反射波: $y_2(x,t)=A\cos(\omega t+\frac{2\pi}{\lambda}x+\varphi)$.

∴ $y_2(1.1\lambda,t)=A\cos(\omega t+0.2\pi+\varphi')$

∴根据固定端 ∴ $y_1(1.1\lambda,t)+y_2(1.1\lambda,t)=0$

∴ $2A\cos\dfrac{2\omega t+\varphi'}{2}\cos\dfrac{0.4\pi+\varphi'}{2}=0$

∴ $0.4\pi+\varphi'=\pi$ ∴ $\varphi'=0.6\pi$

∴ $y_2(x,t)=A\cos(\omega t+\frac{2\pi}{\lambda}x+0.6\pi)$.

(3) 驻波: $y=y_1+y_2=A\cos(\omega t-\frac{2\pi}{\lambda}x)+A\cos(\omega t+\frac{2\pi}{\lambda}x+0.6\pi)$

$=2A\cos(\omega t+0.3\pi)\cos(\frac{2\pi}{\lambda}x+0.3\pi)$

$=2A\cos(\frac{2\pi}{\lambda}x+0.3\pi)\cos(\omega t+0.3\pi)$

9-20

解: $\begin{cases}\frac{2\pi}{\lambda}x+0.3\pi=\frac{\pi}{2}\\ \frac{2\pi}{\lambda}x+0.3\pi=-\frac{\pi}{2}\end{cases}$ ∴ $\begin{cases}x=0.1\lambda\\ x=-0.4\lambda\end{cases}$

又∵ $W=\int_{-0.4\lambda}^{0.1\lambda}\frac{1}{2}\rho\,dx\,4A^2\omega^2\cos^2(\frac{2\pi}{\lambda}x+0.3\pi)=\int_{-0.4\lambda}^{0.1\lambda}\rho A^2\omega^2[\cos(\frac{4\pi}{\lambda}x+0.6\pi)+1]dx$

$=\rho A^2\omega^2[\frac{\lambda}{4\pi}\cdot 0+0.5\lambda]=\frac{1}{2}\rho A^2\omega^2\lambda=6.3\times10^{-2}\,J$

9-21

解: $T=mg$ $\quad T=u^2\cdot\rho_l$. $\quad u=\lambda\cdot\nu$

① $\frac{1}{2}\lambda=l$ 时 $\quad u=2\times50=100\,m/s \quad \therefore T=150N \quad \therefore m=\frac{T}{g}=15.3kg$

② $\lambda=l$ 时 $\quad u=1\times50=50m/s \quad \therefore T=37.5N \quad m=3.8kg$

③ $\frac{3}{2}\lambda=l$ 时 $\quad u=\frac{100}{3}m/s \quad T=\frac{50}{3}N \quad m=1.7kg$

9-27

解: 舰艇接收到的频率: $\nu'=\frac{u-v_R}{u}\nu$

探测器接收到的反射波频率: $\nu_R'=\frac{u}{u+v_R}\nu'=\frac{u-v_R}{u+v_R}\nu$

$\therefore$ 拍频 $241Hz=|\nu-\nu_R'|=\frac{2v_R}{u+v_R}\cdot\nu$ $\quad$ 解得: $v_R=6m/s$