第六章习题、参考解答

6-1 [解] 设振动方程为 $x = A\cos(\omega t + \varphi_0)$

① 由题给出 $\omega = 2\pi\nu = 2\times\pi\times 0.25 = 0.5\pi = 1.57$ (弧度/秒)

而 $t=0$ 时 $x = 0.37 = A\cos\varphi_0$ ，$\dot{x} = 0 = -\omega A\sin\varphi_0$

可得 $A = 0.37$ cm ，$\varphi_0 = 0$ ，$T = \frac{1}{\nu} = 4(\text{sec})$

今 $x = 0.37\cos(0.5\pi t)$

② 位移 $x = 0.37\cos(\frac{\pi}{2}t)$ ，速度 $\dot{x} = -\frac{\pi}{2}\times 0.37\sin(\frac{\pi}{2}t)$

③ 最大速度 $|\dot{x}|_{max} = \frac{\pi}{2}\times 0.37$ (cm/sec) $= 0.58$ cm/sec

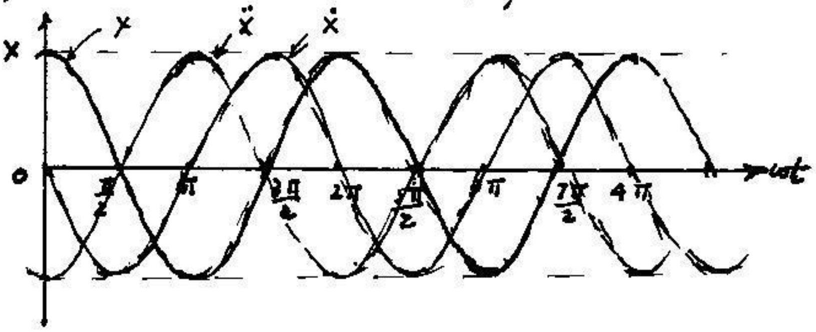
最大加速度 $\ddot{x}_{max} = (\frac{\pi}{2})^2\times 0.37 = 0.91$ cm/sec^2

6-2 [解] $x = A\cos(\omega t + \alpha) = A\cos(\omega t)$ $(\alpha = 0)$

$\dot{x} = -A\omega\sin(\omega t+\alpha) = -A\omega\sin\omega t = A\omega\cos(\omega t + \frac{\pi}{2})$

$\ddot{x} = -A\omega^2\cos(\omega t + \alpha) = -A\omega^2\cos(\omega t) = A\omega^2\cos(\omega t + \pi)$

今：$\dot{x}$ 超前 x 的相位是 $\frac{\pi}{2}$ ，$\ddot{x}$ 超前 x 的相位是 π 。



6-3 [解] 物体的运动方程为：$x = A\cos(\omega t + \varphi_0) = A\cos(4\pi t + \varphi_0)$

今有 $\dot{x} = -4\pi A\sin(4\pi t + \varphi_0)$ ，$\ddot{x} = -16\pi^2 A\cos(4\pi t + \varphi_0)$

而 物体受力(水平方向)为摩擦力，$f = \mu mg$

应有 $f = \mu mg \geq m\ddot{x} = -m16\pi^2 A\cos(4\pi t + \varphi_0)$

今要求：$A \leq \frac{\mu g}{16\pi^2} = \frac{0.5\times 9.8}{16\times\pi^2} = 0.031\,m = 3.1$ cm

6-4 [解]，单摆周期 $T=\sqrt{\frac{l}{g}}$

在校准之处：$T=T_1$，$g=g_1=9.8$ 即 $T_1=\sqrt{\frac{l}{g_1}}$

减慢处：$T=T_2$，$g=g_2$ ∴ $T_2=\sqrt{\frac{l}{g_2}}$

设摆钟一天摆动 N 次，应有 $T_1\times N=3600\times 24$

$T_2\times N=3600\times 24+10$

∴有 $\frac{T_2}{T_1}=1+\frac{10}{3600\times 24}$

即 $\frac{\sqrt{l/g_2}}{\sqrt{l/g_1}}=\sqrt{\frac{g_1}{g_2}}=1+\frac{10}{3600\times 24}=1+\frac{1}{360\times 24}=\frac{360\times 24+1}{360\times 24}$

∴ $g_2=g_1\times\left(\frac{360\times 24}{360\times 24+1}\right)^2=9.798$ 米/秒^2

6-5 [解] 由 $Y=\frac{F/S}{\Delta l/l}$ 则有 $F=SY\frac{\Delta l}{l}=\frac{SY}{l}\Delta l=k\Delta l$

令 $k=\frac{SY}{l}$

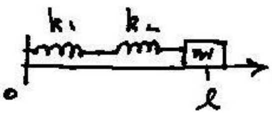
现在 $l_1+l_2=l$，且 $l_1=nl_2$，则有 $l_2(n+1)=l$

∴ $l_1=\frac{l}{n+1}$，$l_1=nl_2=\frac{n}{n+1}l$

∴ $K_1=\frac{SY}{l_1}=\frac{n+1}{n}\frac{SY}{l}=(1+\frac{1}{n})k$

$k_2=\frac{SY}{l_2}=(n+1)\frac{SY}{l}=(n+1)k$

6-6 [解] (1) $\frac{1}{\omega_1}=\sqrt{\frac{m}{k_1+k_2}}$；(2) $\frac{1}{\omega_2}=\sqrt{\frac{m}{k_1+k_2}}$；(3)



∵ 总伸长 Δl，弹簧1伸长 Δl_1，弹簧2伸长

应有 $\Delta l=\Delta l_1+\Delta l_2$，而每个弹簧的恢复力分别为

$F_1=-k_1\Delta l_1$，$F_2=-k_2\Delta l_2$，而 $F_1=F_2$

即 $k_1\Delta l_1=k_2\Delta l_2$ 即 $\Delta l_1=\frac{k_2}{k_1}\Delta l_2$

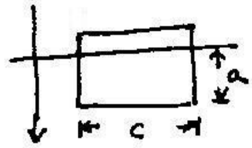
∴ $\Delta l=(\frac{k_2}{k_1}+1)\Delta l_2=\frac{k_1+k_2}{k_1}\Delta l_2$ 或 $\Delta l_2=\frac{k_1}{k_1+k_2}\Delta l$

作用于物体上的力 $F_2=-k_2\Delta l_2=-\frac{k_1\cdot k_2}{k_1+k_2}\Delta l=m\Delta\ddot{l}=-k\Delta l=m\Delta\ddot{l}$

∴ $k=\frac{k_1k_2}{k_1+k_2}$ ∴ $\frac{1}{\omega_3}=\sqrt{\frac{m}{k}}=\sqrt{\frac{(k_1+k_2)m}{k_1\cdot k_2}}$

或 $\omega_3=\sqrt{\frac{k_1k_2}{(k_1+k_2)}\cdot\frac{1}{m}}$

6-7 [解] 设立方体边长为 C



应有 $\rho_{水} a C^2 = \rho_{木} C^3$

或 $\rho_{水} a = \rho_{木} C$ （$\rho_{水}$、$\rho_{木}$分别是水和木块的质量密度）①

设木块浸入水中的增量部分为 x，则应有

$$[\rho_{木} C^3 g - \rho_{水}(a+x) C^2 g] = \rho_{木} C^3 \ddot{x} \qquad ②$$

代入①得 $-\rho_{水} x C^2 g = \rho_{木} C^3 \ddot{x}$，即：$\rho_{木} C \ddot{x} + \rho_{水} x g = 0$

由①又得 $\rho_{水} a \ddot{x} + \rho_{水} x g = 0$ 即 $\ddot{x} + \frac{x}{a} g = 0$ ③

解得： $x = A\cos(\omega t + \varphi_0)$，其中，$\omega = \sqrt{\frac{g}{a}}$，$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{a}{g}}$（秒）

又：$\dot{x} = -A\omega\sin(\omega t + \varphi_0)$ 由 $t=0$ 时 $x = b-a$，$\dot{x} = 0$

可得：$\varphi_0 = 0$ $A = b-a$ ∴ $x = (b-a)\cos\omega t$

6-8 [解] 摆在右侧时，相当于摆长为 $l_1 = 1.05\,m$ 的单摆，周期 $T_1 = 2\pi\sqrt{\frac{l_1}{g}} = 2\pi/\omega_1$

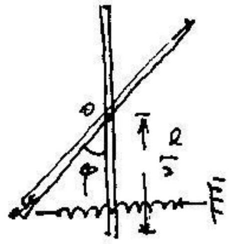
摆在左侧时，… $l_2 = 1.5\,m$ …，∴ $T_2 = 2\pi\sqrt{\frac{l_2}{g}} = 2\pi/\omega_2$

∴ 合系统的周期 $T = \frac{1}{2}(T_1 + T_2) = \pi\left[\sqrt{\frac{l_1}{g}} + \sqrt{\frac{l_2}{g}}\right] \simeq 2.26\,(sec)$

∵ 系统的机械能守恒，因此有 $\frac{1}{2} m\omega_1^2 A_1^2 = \frac{1}{2} m\omega_2^2 A_1^2$

∴ 振幅比为 $\frac{A_2}{A_1} = \frac{\omega_1}{\omega_2} = \sqrt{\frac{l_2}{l_1}} \simeq 1.2$

6-10 [解]



杆偏转φ角，所受的弹性力矩为：

$$-k\frac{l}{2}\varphi\cdot\frac{l}{2}=I\ddot{\varphi}$$

$\because\quad I=\frac{1}{12}ml^2\qquad\therefore -k\frac{l^2}{4}\varphi=\frac{1}{12}ml^2\ddot{\varphi}$

即 $\qquad \ddot{\varphi}+\frac{3k}{m}\varphi=0\qquad\therefore$ 振动周期 $T=2\pi\sqrt{\frac{m}{3k}}$

6-11 [解] 时间平均： $\bar{E}_p=\frac{1}{T}\int_0^T\frac{1}{2}kA^2\cos^2(\omega t+\alpha)\,dt$

$$=\frac{1}{T}\int_0^T\frac{1}{2}kA^2\left[\frac{1}{2}(1+\cos 2(\omega t+\alpha))\right]dt$$

$$=\frac{1}{4}kA^2$$

$$\bar{E}_k=\frac{1}{T}\int_0^T\frac{1}{2}m\omega^2A^2\sin^2(\omega t+\varphi)\,dt$$

即 $\bar{E}_k=\frac{1}{T}\int_0^T\frac{1}{2}m\omega^2A^2\left[\frac{1}{2}(1-\cos 2(\omega t+\alpha))\right]dt=\frac{1}{4}m\omega^2A^2\frac{T}{T}=\frac{1}{4}m\omega^2A^2$

$\because\quad \omega^2=\frac{k}{m}$ or $\quad m\omega^2=k\qquad\therefore\ \bar{E}_k=\frac{1}{4}kA^2=\bar{E}_p$

同理 对空间平均 $\bar{E}_p=\frac{1}{2A}\int_{-A}^{A}\frac{1}{2}kA^2\cos^2(\omega t+\alpha)\,dx$

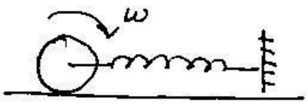
而 $\qquad x=A\cos(\omega t+\alpha)\qquad\therefore\ \bar{E}_p=\frac{2}{2A}\int_{-A}^{A}\frac{1}{2}kx^2\,dx=\frac{k}{4A}\cdot\frac{4}{3}A^3=\frac{k}{3}A^2$

$$\bar{E}_k=\frac{2}{2A}\int_{-A}^{A}\frac{1}{2}m\omega^2A^2\sin^2(\omega t+\varphi)\,dx=\frac{1}{A}\int_{-A}^{A}\frac{1}{2}m\omega^2A^2\left[1-\cos^2(\omega t+\varphi)\right]$$

$$=\frac{1}{A}\int_{-A}^{A}\frac{1}{2}m\omega^2A^2\,dx-\frac{1}{A}\int_{-A}^{A}\frac{1}{2}m\omega^2x^2\,dx$$

$$=\frac{1}{A}\left\{m\omega^2A^3-\frac{1}{2}m\omega^2\frac{2}{3}A^3\right\}=\frac{2}{3}m\omega^2A^2=\frac{2}{3}kA^2$$

6-12 [解]



∵ 机械能守恒

有 $\frac{1}{2}MV_c^2+\frac{1}{2}I_c\omega^2+\frac{1}{2}kx^2=\frac{1}{2}kA^2$

即 $\frac{1}{2}M\dot{x}_c^2+\frac{1}{4}MR^2\frac{\dot{x}^2}{R^2}+\frac{1}{2}kx^2=\frac{1}{2}kA^2$

即 $\frac{3}{2}M\dot{x}^2+kx^2=\frac{1}{2}kA^2$

两边求导得 $3M\dot{x}\ddot{x}+2kx\dot{x}=0$ 或 $\ddot{x}+\frac{2k}{3M}x=0$

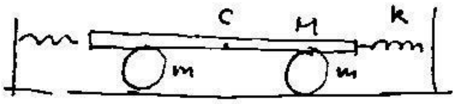
∴ $\omega=\sqrt{\frac{2k}{3M}}$，$T=2\pi\sqrt{\frac{3M}{2k}}$

在平衡位置 $x=0$ $\frac{1}{2}M\dot{x}^2+\frac{1}{4}M\dot{x}^2=\frac{1}{2}kA^2$

即 $E_{平}=2E_{转}$ $E_{平}=\frac{2}{3}(\frac{1}{2}kA^2)=\frac{1}{3}kA^2=0.0625$ N.米

$E_{转}=\frac{1}{3}(\frac{1}{2}kA^2)=\frac{1}{6}kA^2=0.0312$ N·米

6-13 [解] 以系统的平衡位置为坐标原点，x 为偏离平衡位置的坐标.



∵ 摩擦力与支承力都不做功，∴ 系统机械能守恒

即 $2\times\frac{1}{2}kx^2+\frac{1}{2}M\dot{x}^2+2(\frac{1}{2}mV_m^2+\frac{1}{2}I\omega^2)=C$

又∵ $\omega=\frac{V_m}{r}$，$\dot{x}=2r\omega=2V_m$ or $V_m=\frac{1}{2}\dot{x}$

即有 $kx^2+\frac{1}{2}M\dot{x}^2+mV_m^2+I\omega^2=C$

代入 $I=mr^2$ 得到 $kx^2+\frac{1}{2}M\dot{x}^2+m(\frac{\dot{x}}{2})^2+mr^2\frac{V_m^2}{r^2}=C$

亦即 $kx^2+\dot{x}^2[\frac{1}{2}(M+m)]=C$

两边求导得 $2kx\dot{x}+(M+m)\dot{x}\ddot{x}=0$

即 $\ddot{x}+\frac{2k}{M+m}x=0$ ∴ $\omega=\sqrt{\frac{2k}{M+m}}$，$T=2\pi\sqrt{\frac{M+m}{2k}}$

6-15 [解] ① 证：$E=E_k+E_p=\frac{1}{2}kx^2+\frac{1}{2}m\dot{x}^2$

$\therefore\quad \frac{dE}{dt}=m\dot{x}\ddot{x}+kx\dot{x}=\dot{x}(m\ddot{x}+kx)$

而在欠阻尼振动中：$f=-\gamma\dot{x}=m\ddot{x}+kx$

因此，$\frac{dE}{dt}=\dot{x}(-\gamma\dot{x})=\dot{x}f=vf$

② $\because\quad x=A_0e^{-\beta t}\cos(\omega t+\alpha)$

任意时刻，系统的能量为 $E=\frac{1}{2}m\dot{x}^2+\frac{1}{2}m\omega_0^2x^2$

($\because\quad E=\frac{1}{2}m\dot{x}^2+\frac{1}{2}kx^2$ 而 $\omega_0^2=\frac{k}{m}$ 即 $k=m\omega_0^2$

$\therefore\quad E=\frac{1}{2}m\dot{x}^2+\frac{1}{2}m\omega_0^2x^2$)

即 $E=\frac{1}{2}mA_0^2e^{-2\beta t}\{[\beta\cos(\omega t+\alpha)+\omega\sin(\omega t+\alpha)]^2+\omega_0^2\cos^2(\omega t+\alpha)\}$

$=\frac{1}{2}mA_0^2\,e^{-2\beta t}\,f(t)=E(t)$

其中：$f(t)=[\beta\cos(\omega t+\alpha)+\omega\sin(\omega t+\alpha)]^2+\omega_0^2\cos^2(\omega t+\alpha)$

显然有：$T=\frac{2\pi}{\omega}=\frac{2\pi}{\sqrt{\omega_0^2-\beta^2}}$，$f(t+T)=f(t)$

$\therefore$ 有 $E(t+T)=\frac{1}{2}mA_0^2e^{-2\beta(t+T)}f(t+T)$

$=\frac{1}{2}mA_0^2e^{-2\beta t}f(t)\,e^{-2\beta T}=E(t)e^{-2\beta T}$

即 $E(t+T)=E(t)e^{-2\beta T}$ 得证，

6-16 [解] 阻尼振动的周期为 $T=\frac{2\pi}{\omega}=\frac{2\pi}{\sqrt{\omega_0^2-\beta^2}}$

而 $\omega_0^2=\frac{k}{m}=\frac{8}{1.5}$ ； $\beta=\frac{\gamma}{2m}=\frac{0.23}{3}$

代入上式可得 $T=2.73\ (s)$

又 $\because\quad A=A_0e^{-\beta t}$ or $\frac{A_0}{A}=e^{\beta t}=3$ 解得 $t=14.3\ (s)$

$\therefore$ 振动次数 $N=\frac{t}{T}\doteq 5$ 次

6-17 解：一个周期内，策动力做的功 $dA_{策} = F_{策}\dot{x}\,dt$

$$A_{策} = \int_0^T -HAp\cos pt\sin(pt+\phi)\,dt = \gamma p A^2 \pi$$

阻尼力做的功

$$A_{阻} = \int_0^T -\gamma A^2 p^2 \sin^2(pt+\phi)\,dt = -\gamma p A^2 \pi$$

$\therefore \quad A_{策} + A_{阻} = 0 \qquad$ 即 $A_{阻} = -A_{策}$

$(dA_{阻} = f\dot{x}\,dt = -\gamma\dot{x}^2\,dt)$

6-18 解：受迫振动稳定时 $A = \dfrac{h}{\sqrt{(\omega_0^2-p^2)^2+4\beta^2p^2}}$

当 $p \gg \omega_0$ 时 $A = \dfrac{h}{\sqrt{p^4+4\beta^2p^2}} = \dfrac{h}{p\sqrt{p^2+4\beta^2}}$

当 $\omega_0 \gg p$ 时 $A \doteq \dfrac{h}{\sqrt{\omega_0^4+4\beta^2p^2}} \approx \dfrac{h}{\omega_0^2}$

第七章习题参考解答

7-1 解： $x=6.0\cos(4\pi t+0.02\pi y)=A\cos(\omega t-ky+\varphi)$

① 振幅： $A=6.0\ \text{cm}$ ， $\omega=2\pi\nu=4\pi$

② 频率： $\nu=\frac{\omega}{2\pi}=\frac{4\pi}{2\pi}=2\ \text{Hz}$

③ 波长： $k=\frac{2\pi}{\lambda}=0.02\pi$ ； $\lambda=\frac{2\pi}{k}=\frac{2\pi}{0.02\pi}=100\ \text{cm}$

④ 波速： $\lambda=T\upsilon=\frac{\upsilon}{\nu}$ ， $\upsilon=\lambda\nu=100\times2=200\ \text{cm/s}$

⑤ 传播方向： $-y$

⑥ 弦上质点的最大振动速度. $\dot{x}=-A\omega\sin(\omega t-ky+\varphi)$

$$\dot{x}_{max}=A\omega=6.0\times4\pi=75.4\ \text{cm/s}$$

7-2 解： $\nu=500\ \text{Hz}$ ， $\upsilon=350\ \text{m/s}$

① $\Delta\varphi=k\Delta y=\frac{2\pi}{\lambda}\Delta y=\frac{2\pi}{T\upsilon}\Delta y=2\pi\frac{\nu}{\upsilon}\Delta y=\frac{\pi}{3}$

$\therefore\quad \Delta y=\frac{\upsilon}{\nu}\frac{\Delta\varphi}{2\pi}=\frac{\frac{\pi}{3}\times350}{500\times2\pi}=\frac{7}{60}=0.117$ (米)

② $\Delta\varphi=\omega t_2-ky_0-\omega t_1+ky_0=\omega(t_2-t_1)=2\pi\nu\Delta t$

$=2\pi\times500\times0.001=\pi$ (弧度)

7-3 $\quad x=A\cos(\omega t-ky+\varphi)$

斜率： $\frac{\partial x}{\partial y}=kA\sin(\omega t-ky+\varphi)$

振动速度： $\left|\frac{\partial x}{\partial t}\right|=A\omega\sin(\omega t-ky+\varphi)$

$\therefore\quad \frac{\partial x}{\partial y}=kA\sin(\omega t-ky+\varphi)=\frac{k}{\omega}A\omega\sin(\omega t-ky+\varphi)$

$$=\frac{k}{\omega}\left|\frac{\partial x}{\partial t}\right|=\frac{2\pi}{\lambda\omega}\left|\frac{\partial x}{\partial t}\right|=\frac{1}{\upsilon}\left|\frac{\partial x}{\partial t}\right|$$

7-5 解： $\because\ x=0.021\cos30(t+\frac{y}{30})=A\cos(\omega t-ky)=A\cos\omega(t-\frac{y}{\upsilon})$

$\therefore\quad \omega=30$ ； $\upsilon=30\ \text{m/s}$

又 $\because\quad \upsilon=\sqrt{\frac{\tau}{\rho}}$ $\qquad\therefore\quad \tau=\upsilon^2\rho=30^2\times1.3\times10^{-4}$ 千克/米 $=0.117\text{N}$

7-6 解： $I=\frac{1.0(\text{W})}{4\pi r^2(\text{m}^2)}=\frac{1}{4\pi}\ (\text{W/m}^2)$

7-7 解：设两列波为 $x_A = A\cos(\omega t - ky_A)$

$x_B = A\cos(\omega t - ky_B)$

① 位相差：$\Delta\phi = k(y_A - y_B) = \frac{2\pi}{\lambda}(50 - 45.5) = 9\pi \Rightarrow \pi$

② 要得到最大的合振幅，则两列波在该点的位相差为 0 或 $2\pi N$

则 $\Delta\phi = \frac{2\pi}{\lambda}(50 - y_B) = 2N\pi \quad (N = 0, \pm 1, \pm 2)$

$50 - y_B = N$ 或 $y_B = 50 - N$

本题要求在 $y_D = 45.5$ 附近，所以取 $N_1 = 5$ 或 $N_2 = 4$

当 $N_1 = 5$ 时 $y_B = 45$ 此时 $\Delta\phi = 10\pi \Rightarrow 0$

当 $N_2 = 4$ 时 $y_B = 46$ 此 $\Delta\phi = 8\pi \Rightarrow 0$

7-8 解：由 $x_1 = 6.0\cos\frac{\pi}{2}(8.0t - 0.020y) = 6.0\cos(4\pi t - 0.01\pi y)$

$x_2 = 6.0\cos\frac{\pi}{2}(8.0t + 0.020y) = 6.0\cos(4\pi t + 0.01\pi y)$

∴ $\omega = 4\pi$，$k = 0.01\pi$，而 $k = \frac{2\pi}{\lambda}$ ∴ $\lambda = \frac{2\pi}{k} = \frac{2\pi}{0.01\pi} = 200$ cm

合成波：$x = x_1 + x_2 = 12\cos ky\cos\omega t = 12\cos 0.01\pi y\cos 4\pi t$

$= 12\cos\frac{2\pi}{200}y\cos 4\pi t$

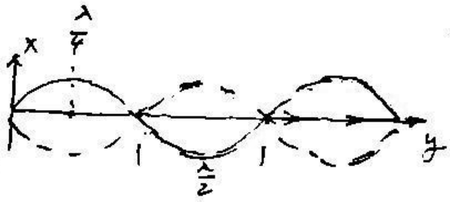
∵ 两端为波腹，端点为波腹

波腹：$y = 0, \frac{\lambda}{2}, \lambda; \frac{3}{2}\lambda, \ldots$

$= 0, 100, 200, 300, \ldots$

波节：$y = 50, 150, 250, 350, \ldots$

7-9 解：三个波腹，波腹到波节的距离 $\frac{\lambda}{4}$



所以有 $\frac{\lambda}{4}\times 6 = 3$ m，∴ $\lambda = 2\text{ m} = 200$ cm

$x_1 = A\cos(\omega t - ky)$，$x_2 = A\cos(\omega t + ky)$

$x = 2A\cos ky\cos\omega t$

而 $2A = 1$ cm 得 $A = 0.5$ cm ∵ $\lambda = 200\text{ cm} = Tv$

∴ $T = \frac{\lambda}{v} = \frac{200}{100\times 100} = 0.02$ 秒 ∵ $k = \frac{2\pi}{200} = \frac{\pi}{100} = \frac{2\pi}{200}$

∴ $\omega = \frac{2\pi}{T} = \frac{2\pi}{0.02} = 100\pi = 2\pi\times 50$

∴ $x_1 = 0.5\cos 2\pi(50t - \frac{y}{200}) = 0.5\cos 2\pi(50t - 0.005y)$

$x_2 = 0.5\cos 2\pi(50t + 0.005y)$

7-10 解：① $x = 0.5\sin\frac{\pi}{3}y\cos 40\pi t = 2\times 0.25\cos(\frac{\pi}{3}y - \frac{\pi}{2})\cos 40\pi t$

$$= 2A\cos(Ky - \frac{\varphi_1-\varphi_2}{2})\cos(\omega t + \frac{\varphi_1+\varphi_2}{2})$$

∴ $A = 0.25$(cm)，$K = \frac{\pi}{3}$，$\omega = 40\pi$

由 $k = \frac{2\pi}{\lambda} = \frac{\pi}{3}$，$\lambda = 6$ cm，$T = \frac{2\pi}{\omega} = \frac{2\pi}{40\pi} = 0.05$ sec

$v = \frac{\lambda}{T} = \frac{6}{0.05} = 120$ cm/s

② $s_{节-节} = \frac{\lambda}{2} = \frac{6}{2} = 3$ cm

③ 由 $x = 0.5\cos(Ky - \frac{\pi}{2})\cos 40\pi t = 0.5\cos(\frac{\pi}{3}y - \frac{\pi}{2})\cos 40\pi t$

得 $\dot{x} = -0.5\times 40\pi\cos(\frac{\pi}{3}y - \frac{\pi}{2})\sin 40\pi t$

代入 $y = 1.5$cm，$t = \frac{9}{8}$ 秒

得 $\dot{x} = -0.5\times 40\pi\cos(\frac{\pi}{3}\times 1.5 - \frac{\pi}{2})\sin 40\pi\times\frac{9}{8}$

$= -20\pi\cos 0\sin 45\pi = 0$

7-11 解：$\nu = 2$ Hz，$u_{车} = 60$ km/h

∴ $\nu' = (1 + \frac{v_s}{v})\nu = (1 + \frac{60\times 10^3/3600}{340})\times 2 = 2.1$ Hz

∴ $N = \nu'\times 5\times 60 = 2.1\times 300 = 630$(次)

7-12 解：(1) ~~墙反射波~~的频率为 ν'

$\nu' = \frac{v}{v - v_s}\nu$，而 $\Delta\nu = \nu' - \nu = 3$ (Hz)

即 $3 = (\frac{v}{v - v_s} - 1)\nu = \frac{v_s}{v - v_s}\nu$

整理得 $3v - 3v_s = v_s\nu$ 或 $v_s(\nu + 3) = 3v$

∴ $v_s = \frac{3v}{\nu + 3} = \frac{3\times 340}{2040 + 3} = \frac{3\times 340}{2043} = 0.498$ 米/秒

(2) 反射面反射的频率 ν'，$\nu' = \frac{v + v_s}{v}\nu$ （相当接收者运动）

人接收反射面反射波频率（相当波源运动）ν''

$$\nu'' = \frac{v}{v - v_s}\nu' = \frac{v + v_s}{v - v_s}\nu$$

而 $\Delta\nu = \nu'' - \nu = 4 = (\frac{v + v_s}{v - v_s} - 1)\nu = \frac{2v_s}{v - v_s}\nu$

∴ $\nu = \frac{\Delta\nu\times(v - v_s)}{2v_s} = \frac{4\times(340 - 0.20)}{2\times 0.20} = \frac{340 - 0.2}{0.4}\times 4$

$= 3398$ Hz