6.4

(1) $x = A\cos(\omega t + \varphi)$ $\quad x_m = A = 2\text{cm}$

$v = -\omega A \sin(\omega t + \varphi)$ $\quad v_m = A\omega = 3\text{cm/s}$

$\Rightarrow \omega = 1.5 \text{ rad/s}$

$T = \frac{2\pi}{\omega} = \frac{4\pi}{3}\text{ s}$

(2) $a = -\omega^2 A\cos(\omega t + \varphi)$

$\Rightarrow a_m = A\omega^2 = \frac{9}{2}\text{ cm/s}^2$

(3) $x = 2\cos(1.5t - \frac{\pi}{2})$ (cm)

6.8

(1) $E = E_{k0} + E_{p0} = 0.8\text{J} = \frac{1}{2}kA^2$

$\Rightarrow A = \frac{\sqrt{1.6}}{5}\text{ m} \approx 0.25\text{ m}$

(2) $E_p = \frac{1}{2}kx^2 = \frac{1}{2}E$

$x = \pm\frac{\sqrt{0.8}}{5}\text{ m} \approx \pm 0.18\text{m}$

(3) $E_p' = \frac{1}{2}k(\frac{A}{2})^2$

$= 0.6\text{J}$

6.11

$k = \frac{1}{\frac{1}{k_1} + \frac{1}{k_2}} = \frac{k_1 k_2}{k_1 + k_2}$

$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m(k_1+k_2)}{k_1 k_2}}$

6.14

(1) $F = \frac{GM_E m}{r^2} \times \frac{r^2}{R_E^2} = \frac{GM_E m}{R_E^3} r$

(2) $F_x = -ma_x = \frac{GM_E m}{R_E^2} r\sin\theta = \frac{GM_E m}{R_E^3} x$

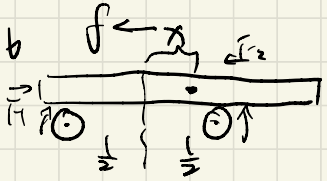
$\Rightarrow a_x = -\frac{GM_E}{R_E^3} x$

$\Rightarrow$ 简谐运动, $T = 2\pi\sqrt{\frac{R_E^3}{GM_E}}$

(3) $m' \frac{4\pi^2}{T^2} R_E = \frac{GM_E m'}{R_E^2}$

$\Rightarrow T = 2\pi\sqrt{\frac{R_E^3}{GM_E}}$

6.16



$f = F_L - F_1$

$= \mu mg \cdot \frac{(\frac{l}{2} - x) - (\frac{l}{2} + x)}{l}$

$= \mu mg \frac{-2x}{l}$

$= -2\mu mg \frac{1}{l} \cdot x = ma$

$a = \frac{-2\mu g}{l} \cdot x$

$T = 2\pi\sqrt{\frac{l}{2\mu g}} \approx 0.9\,s$

6.21

(1) $\frac{dE_p}{dr} = \frac{e^2}{4\pi\varepsilon_0}\cdot\frac{1}{r^2} - 9\frac{\beta}{r^{10}} \Rightarrow r=r_0$ 时, $\frac{dE_p}{dr}=0 \Rightarrow \beta = \frac{e^2 r_0^8}{36\pi\varepsilon_0}$

$k = \frac{d^2E_p}{dr^2} = \frac{-e^2}{2\pi\varepsilon_0}\cdot\frac{1}{r^3} + \frac{90\beta}{r^{11}} \Rightarrow r=r_0,\ k = \frac{2e^2}{\pi\varepsilon_0 r_0^3}$

$T = 2\pi\sqrt{\frac{m_p}{k}}$

$\nu = \frac{1}{T} = 2\pi\sqrt{\frac{k}{m_p}} = 2\pi\sqrt{\frac{2e^2}{\pi\varepsilon_0 r_0^3 m_p}} \approx 1.1\times10^{14}\ Hz$

(2)

$E = \frac{1}{2}kA^2 = \frac{3}{2}h\nu$

$\Rightarrow A = \sqrt{\frac{3h\nu}{k}} = \frac{1}{2\pi}\sqrt{\frac{3h}{m\nu}} \approx 1.7\times10^{-11}\ m$

6.22

$x = \underbrace{A_0 e^{-\beta t}}_{\text{振幅衰减}}\cos(\omega t+\varphi_0)$

$\Rightarrow e^{-\beta t}\big|_{t=100s} = \frac{4}{5}$

$\Rightarrow \beta = \frac{1}{100}\ln\frac{5}{4} \approx 2.2\times10^{-3}\ (s^{-1})$

$e^{-\beta t'} = \frac{2}{5} \Rightarrow t' = \frac{1}{\beta}\ln\frac{5}{2} \approx 4.1\times10^2\ s$

$\Rightarrow \Delta t = t' - t = 3.1\times10^2 s$

$Q = \frac{\omega}{2\beta} = \sqrt{\frac{g}{l}}\cdot\frac{1}{2\beta} \approx 712$

6.25

(1) $\omega = 314\ rad/s$

$A = (\frac{1}{5}+1+\frac{1}{2})A_0 = 0.16m$

$\varphi = \frac{\pi}{2}$

$x = 0.16\cos(314t+\frac{\pi}{2})$

(2) $\cos(314t+\frac{\pi}{2}) = \frac{\sqrt{2}}{2}$

$314t_{min} + \frac{\pi}{2} = \frac{7\pi}{4}$

$t_{min} = \frac{1}{314}\cdot\frac{5\pi}{4} \approx 1.3\times10^{-2}\ s$

6.26

$$\frac{x^2}{0.06^2}+\frac{y^2}{0.04^2}=\cos^2(20\pi t)+\cos^2(20\pi t+\frac{\pi}{2})$$

$$=\cos^2(20\pi t)+\sin^2(20\pi t+\frac{\pi}{2})=1$$

$\Rightarrow$ 长半轴 $=0.06m$

短半轴 $=0.04m$

$T=\frac{2\pi}{20\pi}=\frac{1}{10}s$

由于 y 相位超前 $x\ \frac{\pi}{2}$ $\Rightarrow$ $t=0$，x 极大且 y 极小

$\frac{dx}{dt}=0$ $\frac{dy}{dt}\to min<0$ $\Rightarrow$ 右旋

$|\frac{dy}{dt}|\to max$

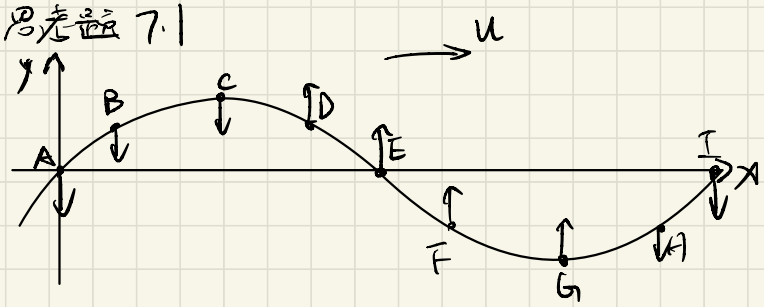
6.27

$$2T_\perp=3T_{//}$$

$$T_\perp=\frac{3}{2}T_{//}$$

$$\nu_\perp=\frac{2}{3}\nu_{//}=1.80\times10^4Hz$$

思考题 7.1



思考题 7.3

氦气 (ρ大)

思考题 7.4

x=0处 动能密度最大，弹性势能最大 总能量密度最大

↓

平衡位置

$x=\pm A$处 ——— 最小 ——— 小 ——— 小

7.2

$$y(t)=0.05\sin(1-4t)$$

$$y(t-\frac{x}{u})=0.05\sin\left(1-4\times(t-\frac{x}{0.8})\right)$$

$$=0.05\sin(1+5x-4t)$$

7.4

$$v=\sqrt{2gh}$$

$$A=\frac{v}{\omega}=\frac{v}{\frac{2\pi}{T}}=\frac{vT}{2\pi}=\frac{v}{2\pi\nu}=\frac{\sqrt{2gh}}{2\pi\nu}\approx 1.0\,m$$

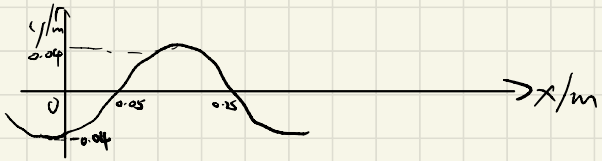
$$\lambda=\frac{u}{\nu}=3\,km=3\times10^{3}\,m$$

7.5

(1) $y(x,0)=0.04\cos(-5\pi x+\frac{\pi}{2})$

$$y(x,t)=0.04\cos\left(\frac{2\pi}{0.2\pi}\cdot t-10\pi x\right)=0.04\cos(0.4\pi t-5\pi x+\frac{\pi}{2})$$

(2) $y(x,\frac{1}{8}T)=y(x,\frac{5}{8})=0.04\cos(\frac{3\pi}{4}-5\pi x)$



7.6

(1) $\pi(4\times4.2+2x)=2k\pi$ $(k\in Z)$

$16.8+2x=2k$

$x=k-8.4$ (m)

$(k\in Z)$

最近：$x_0=-0.4m$ $(k=8)$

$u=\frac{4\pi}{2\pi}=2m/s$

$\Delta t=\frac{x_0}{u}=-0.2s$

$t'=t+\Delta t=4s$

(2)

7.8

$u=\sqrt{\frac{Y}{\rho}}$

$Y=u^2\rho=2.03\times10^{11}$ N/m^2