# 习题参考答案

**第1章 质点运动学**

1-1～1-9 （略）.

1-10 (1) $y=5$,（图略）；(2) $4x+3y-5=0$,（图略）.

1-11 (1) $y=19-\frac{1}{2}x^2\ (x>0)$；(2) $2i+17j$, $4i+11j$；$6.32$ m/s，与 $x$ 轴夹角为 $-71°34'$；(3) $4.47$ m/s，$-63°26'$；$8.25$ m/s，$-75°58'$，$a=a_y=-4$ m/s$^2$；(4) $t=0$，$x=0$，$y=19$ m，$v_x=2$ m/s，$v_y=0$；$t=3$ s，$x=6$ m，$y=1$ m，$v_x=2$ m/s，$v_y=-12$ m/s；(5) $t=3$ s，$6.08$ m.

1-12 (1) $\Delta x=-0.5$ m，$\bar{v}=-0.5$ m/s；(2) $v_1=3$ m/s，$v_2=-6$ m/s；(3) $2.25$ m；(4) $-9$ m/s$^2$，$3$ m/s$^2$，$-3$ m/s$^2$.

1-13 $v=(4t-\frac{1}{3}t^3-1)$ m/s，$x=(2t^2-\frac{1}{12}t^4-t+\frac{3}{4})$ m.

1-14 $\Delta x\approx3.82$ m.

1-15 (1) $t=1.5$ s；(2) $h=6.75$ m；(3) 下降.

1-16 (1) $2.3\times10^4$ m；(2) $151.45$ s；(3)（略）.

1-17 $v=\frac{(h^2+s^2)^{\frac{1}{2}}v_0}{s}$，$a=\frac{h^2v_0^2}{s^3}$.

1-18 (1) $76°$；(2) $\frac{n}{2}\sqrt{2gh}$.

1-19 $0$ m,10 次.

1-20 (1) $3.18\times10^4$ m；(2) $1.38\times10^4$ m；(3) $375.4$ m/s，$1.12\times10^4$ m；(4) $404.9$ m，$25.3$ s 和 $80.5$ s.

1-21 (1) $1\,084$ m/s；(2) $1\,533$ m/s；(3) $t_1=$

$t_2=110$ s.

1-22 (1) $225$ m/s；(2) $898$ m；(3) $v_x=180$ m/s，$v_y=184$ m/s.

1-23 $\theta=\frac{\pi}{4}+\frac{\alpha}{2}$.

1-24 先落地小石块的抛射角为 $26°34'$，后落地小石块的抛射角为 $63°26'$.

1-25 $6\,402$ km.

1-26 (1) $2$ m/s；(2) $a_n=1$ m/s$^2$；(3) $12.6$ s.

1-27 (1) $1.0$ s；(2) $1.5$ m.

1-28 (1) $600$ r/s；(2) $188$ m/s.

1-29 (1) $-2.1$ rad/s$^2$；(2) $70.8$ r；(3) $40$ s.

1-30 (1) $v=4.65\times10^2$ m/s，$a_n=3.37\times10^{-2}$ m/s$^2$；(2) $v=3.56\times10^2$ m/s，$a_n=2.58\times10^2$ m/s$^2$.

1-31 (1) $a_t=4.8$ m/s$^2$，$a_n=230.4$ m/s$^2$；(2) $\theta=3.15$ rad；(3) $t=0.55$ s.

1-32 (1) $14.1$ km/h；(2) $81.2$ km/h.

1-33 (1) $100$ km/h,北偏西 $53.1°$；(2) 无；(3) $100$ km/h,北偏东 $53.1°$；无.

1-34 (1) $l=200$ m；(2) $v=\frac{1}{3}$ m/s，与河岸夹角 $53°8'$（逆水）；(3) $u=0.2$ m/s,沿河岸方向.

1-35 $5.0$ km/h.

1-36 (1) $\alpha=\arcsin\left(\frac{v_1}{v_2}\sin\theta\right)$；(2) $t=\frac{L}{\sqrt{v_2^2-v_1^2\sin^2\theta}+v_1\cos\theta}$.

**第2章 质点动力学**

2-1～2-11 （略）.

2-12 $v=4.0$ m/s.

2-13 (1) $1.86\times10^{-1}$ m/s, $\theta=-27°$; (2) $\Delta \boldsymbol{p}_1$ $=(-4.9\times10^{-2}\boldsymbol{i}+2.6\times10^{-2}\boldsymbol{j})$ kg·m/s, $\Delta \boldsymbol{p}_2=-\Delta \boldsymbol{p}_1$.

2-14 (1) $\theta=36.8°$; (2) $a=1.95$ m/s²; (3) $t=2.5$ s.

2-15 2.9 m.

2-16 (1) $a=2.70$ m/s²; (2) $T_1=112.5$ N; (3) $T_2=87.5$ N.

2-17 (1) $a=1.5$ m/s², $v=2.7$ m/s; (2) $a=1.5$ m/s², $v=2.3$ m/s.

2-18 $f=0.15$ N.

2-19 $r_{max}=0.67$ m, $r_{min}=0.57$ m.

2-20～2-22 （略）.

2-23 (1)（略）; (2) 6 N/s, 15 N; (3) 3 m/s.

2-24 3 000 N.

2-25 1.5 N.

2-26 32 N.

2-27 (1) $I_\perp=(1+\sqrt{2})m\sqrt{gh}$; (2) $I_{//}=\frac{1}{2}mv$.

2-28 $v_{He}'=3.7\times10^5$ m/s, $\alpha=40°33'$.

2-29 $\frac{mu}{M+m}$.

2-30 （略）.

2-31 (1) 1 kg·m²/s; (2) 1 m/s.

2-32 $5.26\times10^{12}$ m.

2-33 (1) 2 275 kg·m²/s; (2) 均为 13 m/s.

### 第3章 机械能守恒

3-1～3-9 （略）.

3-10 (1) 530 J; (2) 12 W.

3-11 (1) $\frac{1}{2}m\frac{v_0^2}{t_0^2}t^2$; (2) $\frac{mv_0^2}{t_0^2}t$.

3-12 (1) 3 035 J; (2) 水平力做功 1 504 J, 斜面平行力做功 2 000 J, 摩擦力做功$-200$ J, 重力做功$-268$ J.

3-13 拉力做的功 $W_F=mgR\left[1-\frac{\sqrt{2}}{2}(1-\mu)\right]$, 重力做的功 $W_G=-mgR\left(1-\frac{\sqrt{2}}{2}\right)$, 摩擦力做的功 $W_f=-\frac{\sqrt{2}\mu mgR}{2}$.

3-14 (1) 4 800 N·s; $5.904\times10^5$ J.

3-15 7.84 kW.

3-16 (1) $-\frac{3}{8}mv_0^2$; (2) $\frac{3v_0^2}{16\pi rg}$; (3) $\frac{4}{3}$圈.

3-17 (1) $m_0v_0$; (2) $m_0v_0^2$; (3) $\frac{E_k}{E}=50\%$.

3-18 (1) $E_k=\frac{Gmm_E}{6R}$; (2) $E_p=-\frac{Gmm_E}{3R}$; (3) $E=-\frac{Gmm_E}{6R}$.

3-19 $1.6\times10^{24}$ J, $1.6\times10^6$ 倍.

3-20 2.8 m/s.

3-21 $\frac{\Delta x_1}{\Delta x_2}=\frac{k_2}{k_1}$, $\frac{E_{p1}}{E_{p2}}=\frac{k_2}{k_1}$; $\Delta x=\frac{2(k_1+k_2)}{k_1k_2}mg$, $F_{max}=2mg$.

3-22 (1) 31.8 m, 22.5 m/s; (2) 不会.

3-23 (1) 子弹可以穿过木块; (2) 子弹速度为 40 m/s, 木块速度为 15 m/s.

3-24 $\frac{M}{m\cos\alpha}\sqrt{2gl\sin\alpha}$.

3-25 (1) 4.1 m; (2) 4.5 m/s.

3-26 (1) $F\geqslant(m_1+m_2)g$; (2) 不变.

3-27 (1) $\Delta x=0.06$ m; (2) 非弹性碰撞, $e=0.65$; (3) $\Delta x=0.04$, $e=0$.

3-28 $mv_0\left[\frac{M}{k(m+M)(m+2M)}\right]^{\frac{1}{2}}$.

3-29 $v_1=\sqrt{v_0^2+2ghe^2}$, $\tan\theta=\frac{e\sqrt{2gh}}{v_0}$. （证明略）

3-30 $v=\frac{5}{13}v_0$.

### 第4章 刚体的定轴转动

4-1～4-7 （略）.

4-8 (1) $\frac{11}{16}mL^2$; (2) $\frac{11}{16}mL^2+\frac{7}{48}ML^2$.

4-9 $\frac{1}{3}mb^2$, $\frac{1}{3}ma^2$, $\frac{1}{12}m(a^2+b^2)$.

4-10 (1) $4\times10^{-2}$ kg·m²; (2) $2.5\times10^{-2}$ kg·m²; (3) $2\times10^{-2}$ kg·m².

4-11 (1) 8.7 rad/s²; (2) 4.4 m/s²; (3) 54.5 N; (4)（略）.

4-12 7.61 m/s², $T_1=380.5$ N, $T_2=438.0$ N.

4-13 (1) $3.5\times10^{-2}$ kg·m²; (2) 0.82 m/s², 1.64 m/s², 1.56 s; (3) 21.2 N, 16.3 N.

4-14 $\frac{11}{8}mg$.

4-15　(1) $\tau=\dfrac{3}{4}mgl$(顺时针)；(2) $I=\dfrac{37}{48}ml^2$；

　　　(3) $\beta=\dfrac{36g}{37l}$.

4-16　(1) $I=17.316$ kg·m²；(2) $M=1.818$
　　　N·m；(3) 91.7 r.

4-17　$I=191$ kg·m².

4-18　$\mu=0.20$.

4-19　(1) 6 r/min；(2) 6 r/min.

4-20　(1) $-0.05$ rad/s，与人相对地面角速度方
　　　向相反；(2) 32.7°；(3) 36.1°.

4-21　$\dfrac{2mv_1}{2m+M}$.

4-22　$\dfrac{3v}{4l}$.

4-23　(1) 43 kg·m²/s；(2) 8 rad/s；(3) 107.5
　　　J, 172.8 J(其他略).

4-24　(1) 12 rad/s；(2) 0.027 J.

4-25　(1) $4.02\times10^{-3}$ kg·m/s, $4.53\times10^{-3}$
　　　kg·m/s; $2.52\times10^{-2}$ J, $0.95\times10^{-2}$ J;
　　　(2) 6.11 rad/s, $2.61\times10^{-2}$ J；(3) 0.36
　　　rad/s, $0.93\times10^{-4}$ J.

4-26　(1) 8.89 rad/s；(2) 94°12′.

4-27　$\omega_B=\dfrac{I_0\omega_0}{I_0+mR^2}$, $v_B=\sqrt{2gR+\dfrac{I_0\omega_0^2R^2}{mR^2+I_0}}$；

　　　$\omega_C=\omega_0$, $v_C=\sqrt{4gR}$.

4-28　(1) $\dfrac{3}{4}g$；(2) $\dfrac{1}{4}mg$,向上.

4-29　$\omega=\sqrt{\dfrac{4g}{3R}}$.

4-30　(1) $\dfrac{R^2\omega^2}{2g}$；(2) $\omega$, $\left(\dfrac{1}{2}M-m\right)\omega R^2$,

　　　$\dfrac{1}{4}(M-2m)\omega^2R^2$.

4-31　(1) $a_C=\dfrac{4F_0}{3M}$；(2) $f_r=\dfrac{1}{3}F_0$.

4-32　(1) 向右运动；(2) $a=4.52$ m/s², $f_r=$
　　　$5.30\times10^3$ N；(3) $\mu=0.54$.

4-33　(1) $a=\dfrac{2}{3}g$；(2) $T=\dfrac{1}{6}Mg$.

4-34　54°.

4-35　$a=\dfrac{F-\mu(m_1+m_2)g}{m_1+\dfrac{1}{3}m_2}$.

**第5章　流体力学**

5-1～5-4　(略).

5-5　(1) 98 N；(2) 1.95 N；(3) $p$ 与容器形状
　　　无关.

5-6　(1) $1.32\times10^3$ kg/m³；(2) 54.8 N.

5-7　(1) $3.7\times10^5$ N；(2) $6.1\times10^5$ N·m；
　　　(3) $3.1\times10^5$ N·m；(4) $5.5\times10^5$ N·m.

5-8　46 cm.

5-9　(1) $2\sqrt{(H-h)h}$；(2) $H-h$；(3) $\dfrac{H}{2}$,$H$.

5-10　(1) 10 m/s, $2.375\times10^5$ N/m²；(2) 30
　　　m³/min 或 $3\times10^4$ kg/min.

5-11　(1) 0.10 m；(2) 11.2 s.

5-12　0.026 8 m³.

5-13　$5.35\times10^{-4}$ m².

5-14　(1) 0.75 m/s, 3 m/s；(2) $4.22\times10^3$
　　　Pa；(3) 3.42 cm.

5-15　8.04 Pa.

5-16　(略).

5-17　0.326 cm/s, 54.1 cm/s.

5-18　(1) 0.77 cm/s；(2) 1.88 cm/s.

**第6章　振　　动**

6-1～6-9　(略).

6-10　(1) 4 m, 20π s, $\dfrac{1}{20\pi}$ Hz, 0.5 rad；(2) $v=$
　　　$-0.4\sin(0.1t+0.5)$ m/s, $a=-0.04$
　　　$\cos(0.1t+0.5)$ m/s²；(3) 3.51 m, $-0.192$
　　　m/s, $-0.035$ m/s²；(4) 2.16 m, $-0.336$
　　　m/s, $-0.022$ m/s²；(5) (略).

6-11　(1) 3.77 m/s, 94.7 m/s²；(2) ±3.02 m/s,
　　　∓56.8 m/s²；(3) 0.036 9 s.

6-12　(1) 1.007 kHz；(2) 1.26 m/s, 1.01 m/s；
　　　(3) $F=-4\times10^4x$ N, $F=-8\cos(6\,324t)$
　　　N.

6-13　(1) $x=A\cos\left(\dfrac{2\pi}{T}t+\pi\right)$；(2) $x=A\cos\left(\dfrac{2\pi}{T}t-\right.$

　　　$\left.\dfrac{\pi}{2}\right)$；(3) $x=A\cos\left(\dfrac{2\pi}{T}t+\dfrac{\pi}{3}\right)$；(4) $x=$

　　　$A\cos\left(\dfrac{2\pi}{T}t+\dfrac{5}{4}\pi\right)$.

6-14　(1) 0, $\dfrac{\pi}{3}$, $\dfrac{\pi}{2}$, $\dfrac{2\pi}{3}$, $\dfrac{4\pi}{3}$；

　　　(2) $x=0.05\cos\left(\dfrac{5\pi}{6}t-\dfrac{\pi}{3}\right)$.

6-15　(1) 2.72 s；(2) ±10.8 cm.

6-16　(证明略)，$\omega=\dfrac{kR^2}{I+mR^2}$.

6-17 (1) $\dfrac{d^2x}{dt^2} + \omega^2 x = 0$, 其中 $\omega^2 = \dfrac{2S\rho g}{m}$;

(2) 1.09 s.

6-18 4.4 s.

6-19 (1) 1.64 s, $\dfrac{2}{3}$ m;(2) 1.64 s.

6-20 $T_0 = \infty$, $T_{R/4} = 1.043$ s, $T_{R/2} = 0.852$ s,

$T_{3R/4} = 0.828$ s, $T_R = 0.852$ s.

6-21 (1) 0.94,1.15; (2) 0 或 $\dfrac{2}{3}$.

6-22 (1) 5 N/m; (2) $1 \times 10^{-3}$; (3) $1 \times 10^{-3}$J.

6-23 31.8 Hz.

6-24 (1) 0.08 m; (2) $\pm 0.056\ 6$ m;

(3) $\pm 0.8$ m/s.

6-25 (1) $8\dfrac{2}{3}\pi$, $16\dfrac{2}{3}\pi$, $40\dfrac{2}{3}\pi$, $80\dfrac{2}{3}\pi$;

(2) (略); (3) $F_{max} = 0.63$ N, $E = 3.16 \times 10^{-2}$ J, $\overline{E}_k = 1.58 \times 10^{-2}$ J, $\overline{E}_p = 1.58 \times 10^{-2}$ J.

6-26 (1) $0.1\pi$ s;(2) $2 \times 10^{-3}$ J, $2 \times 10^{-3}$ J;

(3) $0.707 \times 10^{-2}$ m;(4) $\dfrac{3}{4}$, $\dfrac{1}{4}$.

6-27 $A = 1$, $\varphi = \dfrac{\pi}{6}$.

6-28 (图略), $x = 2 \times 10^{-2}\cos\left(4t + \dfrac{\pi}{3}\right)$ (SI).

6-29 $x = 0.05\cos(2\pi t + 2.21)$ (SI).

6-30 0.10 m, $\dfrac{\pi}{2}$.

**第 7 章 波 动**

7-1~7-6 (略).

7-7 (1) $A = 0.05$ m, $v = 2.5$ m/s, $\nu = 5$ Hz, $\lambda = 0.5$ m; (2) 1.57 m/s, 49.3 m/s²;

(3) $\dfrac{46\pi}{5}$, 0.92 s, 0.825 m, 1.45 m;

(4) (略).

7-8 (1) $y = 0.1\cos 2\pi(2t - 0.1x)$; (2) (略).

7-9 $y = 2\cos(0.25\pi t - \pi x)$.

7-10 (略).

7-11 $y = 0.001\cos\left[(3\ 300\pi t + 10\pi x) + \dfrac{\pi}{2}\right]$.

7-12 (1) $y = -10\sin\pi t$; (2) $y = -10\sin\pi\left(t - \dfrac{x}{100}\right)$; (3) $y = -10\sin\pi(t - 150)$; (4) 31.4 cm/s; (5) 7.07 cm, $-22.2$ cm/s.

7-13 (1) $y_0 = A\cos\left(\omega t + \omega\dfrac{l}{u} + \dfrac{\pi}{2}\right)$; (2) $y = A\cos\left[\omega\left(t - \dfrac{x}{u}\right) + \omega\dfrac{l}{u} + \dfrac{\pi}{2}\right]$.

7-14 (1) $y = A\cos\left[2\pi\left(250 t + \dfrac{x}{200}\right) + \dfrac{\pi}{4}\right]$;

(2) $y_{x=100\,m} = A\cos\left(500\pi t + \dfrac{5\pi}{4}\right)$,

$v_{x=100\,m} = -500\pi A\sin\left(500\pi t + \dfrac{5\pi}{4}\right)$.

7-15 (1) 200 m/s, 20 m; (2) 14.1 Hz.

7-16 (1) $6 \times 10^{-5}$ J/m³, $12 \times 10^{-5}$ J/m³;

(2) $9.24 \times 10^{-7}$ J.

7-17 (1) $2.70 \times 10^{-3}$ J/s; (2) $9.00 \times 10^{-2}$ J/s·m²; (3) $2.65 \times 10^{-4}$ J/m³.

7-18 $4.0 \times 10^{-5}$ W.

7-19 (1) 26.02 dB; (2) 100 m.

7-20 $6.41 \times 10^{-6}$ J/m³, $2.18 \times 10^{-3}$ J·m⁻²·s.

7-21 (1) 同相;(2) $0.4 \times 10^{-2}$ m;(3) $0.283 \times 10^{-2}$ m.

7-22 $2.00 \times 10^{-3}$ m.

7-23 $1.7 \times 10^3$ Hz.

7-24 $2\left[\sqrt{4(H+h)^2 + d^2} - \sqrt{4H^2 + d^2}\right]$.

7-25 (1) $3\pi$; (2) 0.

7-26 以 $A$ 为原点, $x = (2k + 15)$ m, $k = 0$, $\pm 1, \cdots \pm 7$;$AB$ 之外都是加强.

7-27 (1) $y = A\cos 2\pi\left(\dfrac{t}{T} - \dfrac{x}{\lambda}\right)$; (2) $y = 2A\cos\dfrac{2\pi x}{\lambda}\cos\dfrac{2\pi t}{T}$, 波腹 $x = k \cdot \dfrac{\lambda}{2}$, $k = 0, 1, 2, \cdots$; 波节 $x = (2k+1)\dfrac{\lambda}{4}$, $k = 0, 1, 2, \cdots$.

7-28 (1) 1.0 cm, $4.7 \times 10^3$ cm/s; (2) 19.6 cm;

7-29 $41.67 \times 10^{-2}$ m.

7-30 (1) $y = A\cos\left[2\pi\left(\nu t - \dfrac{x}{\lambda}\right) + \dfrac{\pi}{2}\right]$;

(2) $y = A\cos\left[2\pi\left(\nu t + \dfrac{x}{\lambda}\right) + \dfrac{\pi}{2}\right]$;

(3) $y = \sqrt{3}A\sin 2\pi\nu t$.

7-31 A 每秒 30 拍, B 每秒 29 拍.

7-32 约 204 Hz.

7-33 6 m/s.

**第 8 章 静电场**

8-1~8-6 (略).

8-7 (1) $9.1 \times 10^{22}$ m/s²;(2) $2.19 \times 10^6$ m/s;
(3) $4.15 \times 10^6$ rad/s.

8-8 (1) $Q = -2\sqrt{2}q$;(2) 不能.

8-9 $-\dfrac{4}{9}q$,位于离 $+q$ 所在点 $\dfrac{l}{3}$.(系统是不稳定平衡)

8-10 (1) $\dfrac{qq'r}{2\pi\varepsilon_0 (r^2+a^2)^{3/2}}$;(2) $r=\dfrac{\sqrt{2}}{2}a$;(3) $q'$ 与 $q$ 同号,$q'$ 沿中垂线做加速运动,走向无穷远;$q'$ 与 $q$ 异号时,$q'$ 以 $O$ 点为中心沿中垂线做周期性振动(注意不是简谐运动).

8-11 $Q' = -\dfrac{2\sqrt{2}+1}{4}Q$,与正方形边长无关,是不稳定平衡.

8-12 (略).

8-13 $E = 1.01 \times 10^3$ V/m.

8-14 $\dfrac{3ql^2}{2\pi\varepsilon_0 r^4}$.

8-15 $E = \dfrac{rq}{4\pi\varepsilon_0 (r^2+R^2)^{3/2}}$,$E$ 沿 $r$ 轴方向,$\dfrac{r}{R} = \pm\dfrac{\sqrt{2}}{2}$ 时,$E(r)$ 最大.

8-16 $\dfrac{q}{\pi\varepsilon_0} \left| \dfrac{1}{(4r^2-l^2)} \right|$.

8-17 $E = \dfrac{q}{2\varepsilon_0 (\pi R)^2}$,方向沿半圆的平分线.

8-18 $E = \dfrac{q\sin\dfrac{\theta_0}{2}}{2\pi\varepsilon_0 a^2 \theta_0}$.

8-19 $E = \dfrac{q}{\pi^2\varepsilon_0 a^2}$,方向竖直向下.

8-20 $E = \dfrac{q}{2\pi\varepsilon_0 a^2} \left( 1 - \dfrac{x}{\sqrt{x^2+a^2}} \right)$,方向沿 $x$ 轴方向.

8-21 $E = \dfrac{\sigma}{2\varepsilon_0} \cdot \dfrac{r}{(r^2+a^2)^{1/2}}$.

8-22 (1) $\Phi_I = 2.4 \times 10^3$ V·m,$\Phi_{II} = 0$;(2) $E = 100$ V/m,方向沿 $-x$ 轴.

8-23 (1) $\Phi = \dfrac{q}{6\varepsilon_0}$;(2) $\Phi_1 = \Phi_2 = \Phi_3 = 0$,$\Phi_4 = \Phi_5 = \Phi_6 = \dfrac{q}{24\varepsilon_0}$.

8-24 $\Phi = \dfrac{q}{2\varepsilon_0} \left( 1 - \dfrac{x}{\sqrt{R^2+x^2}} \right)$.

8-25 (1) $Q = -9.1 \times 10^5$ C;(2) $\rho = 1.14 \times 10^{-12}$ C/m³.

8-26 (略).

8-27 $\sigma = 5.0 \times 10^{-9}$ C/m².

8-28 $\dfrac{\lambda^2}{4\varepsilon_0 a}$.

8-29 (略).

8-30 (1) $E = 0$ $(r<R_1)$;(2) $E = \dfrac{(r^2-R_1^2)\rho}{2\varepsilon_0 r}$ $(R_1 < r < R_2)$;(3) $E = \dfrac{(R_2^2-R_1^2)\rho}{2\varepsilon_0 r}$ $(r>R_2)$.

8-31 $E = \dfrac{e}{8\pi\varepsilon_0 b^2 r^2} \left[ 2b^2 - (r^2 + 2br + 2b^2) e^{-r/b} \right]$,$1.2 \times 10^{-21}$ N/C.

8-32 (1) $3.0 \times 10^{10}$ J;(2) 833 户.

8-33 (1) $2.5 \times 10^4$ eV;(2) $9.4 \times 10^7$ m/s.

8-34 (1) $v(\infty) = \sqrt{\dfrac{1}{\pi\varepsilon_0} \cdot \dfrac{qq'}{ma}}$;(2) $v(x) = \sqrt{\dfrac{1}{\pi\varepsilon_0} \cdot \dfrac{qq'}{m} \cdot \left( \dfrac{1}{a} - \dfrac{1}{\sqrt{a^2+x^2}} \right)}$;(3) $x = \sqrt{15}a$.

8-35 (1) 电场力做功 $-3.6 \times 10^{-6}$ J,电势能增加 $+3.6 \times 10^{-6}$ J;(2) 电场力做功 $-3.6 \times 10^{-6}$ J,电势能增加 $+3.6 \times 10^{-6}$ J;(3) 电场力做功 $+3.6 \times 10^{-6}$ J,电势能增加 $-3.6 \times 10^{-6}$ J;(4) $W = -1.01 \times 10^{-4}$ J.

8-36 (1) $2.5 \times 10^3$ V;(2) $4.3 \times 10^3$ V.

8-37 (略).

8-38 (1) $v = 0.999\,999\,996c$;(2) $v = 4.8 \times 10^{10}$ m/s.

8-39 $r_{min} = 2.28 \times 10^{-14}$ m.

8-40 (1) (略);(2) $E = \dfrac{\sigma}{2\varepsilon_0} \left( 1 - \dfrac{|x|}{\sqrt{x^2+R^2}} \right)$.

## 第9章 静电场中的导体和电介质

9-1～9-9 (略).

9-10 (1) $E_1 = 0$,$E_2 = 1.50 \times 10^4$ V/m,$E_3 = 0$,$E_4 = -1.26 \times 10^4$ V/m;$U_1 = -1\,040$ V,$U_2 = -1\,220$ V,$U_3 = -1\,400$ V,$U_4 = -1\,260$ V;(2) $E_1 = E_2 = E_3 = 0$,$E_4 = -1.26 \times 10^4$ V/m;$U_1 = U_2 = U_3 = -1\,400$ V,$U_4 = -1\,260$ V.

9-11 $\sigma_1 = 5 \times 10^{-6}$ C/m²,$\sigma_2 = -2 \times 10^{-6}$ C/m²,$\sigma_3 = 2 \times 10^{-6}$ C/m²,$\sigma_4 = 5 \times 10^{-6}$

C/m².

9-12 $\sigma_1 = 0$, $\sigma_2 = 3 \times 10^{-6}$ C/m², $\sigma_3 = -3 \times 10^{-6}$ C/m², $\sigma_4 = 0$.

9-13 (1) $q_B = -1.0 \times 10^{-7}$ C, $q_M = -2.0 \times 10^{-7}$ C; (2) $U_A = 2.27 \times 10^3$ V; (3) $q_B = -2.14 \times 10^{-7}$ C, $q_M = -0.86 \times 10^{-7}$ C, $U_A = 970$ V.

9-14 (1) 9.15 cm; (2) 2.93 kW; (3) $2.00 \times 10^{-5}$ C/m², $1.13 \times 10^6$ V/m.

9-15 $C = \dfrac{\pi \varepsilon_0}{\ln \dfrac{b-a}{a}}$.

9-16 0.152 mm.

9-17 (a) $C = 3 \times \dfrac{\varepsilon_0 S}{d}$; (b) $C = 2 \times \dfrac{\varepsilon_0 S}{d}$.

9-18 (1) 25 μF; (2) $U_1 = U_2 = U_3 = 50$ V, $Q_1 = 2.5 \times 10^{-3}$ C, $Q_2 = 1.5 \times 10^{-3}$ C, $Q_3 = 1.0 \times 10^{-3}$ C.

9-19 (1) $C_{ab} = 1$ μF; (2) $Q = 9 \times 10^{-4}$ C; (3) $U_{cd} = 100$ V.

9-20 (1) $Q_1 = Q_2 = 8 \times 10^{-4}$ C, $U_1 = 800$ V, $U_2 = 400$ V; (2) $Q_1' = 5.33 \times 10^{-4}$ C, $Q_2' = 10.66 \times 10^{-4}$ C, $U_1' = U_2' = 533$ V.

9-21 (1) $Q_1 = 1.2 \times 10^{-3}$ C, $Q_2 = 2.4 \times 10^{-3}$ C, $U_1 = U_2 = 1\,200$ V; (2) $U_1' = U_2' = 400$ V, $Q_1' = 4 \times 10^{-4}$ C, $Q_2' = 8 \times 10^{-4}$ C.

9-22 (1) $U_{ab} = 66.7$ V; (2) $U_b' = +100$ V; (3) $3 \times 10^{-4}$ C.

9-23 $\dfrac{C}{C_0} = 2$, $\dfrac{C}{C_0} = \dfrac{2\varepsilon_r}{1+\varepsilon_r}$.

9-24 增加一倍.

9-25 $C = \dfrac{(\varepsilon_{r1} + \varepsilon_{r2})\varepsilon_0 S}{2d}$.

9-26 (1) $C = \dfrac{\varepsilon_0 S}{\dfrac{d_1}{\varepsilon_{r1}} + \dfrac{d_2}{\varepsilon_{r2}}}$; (2) $C = 93.2$ pF.

9-27 (1) $9.8 \times 10^6$ V/m; (2) 51 mV.

9-28 (1) $Q_1 = 1.6 \times 10^{-2}$ C, $Q_2 = 0.4 \times 10^{-2}$ C; (2) $\Delta W = 3.6$ J.

9-29 (1) 不会被击穿; (2) 玻璃片插入后, 电容器会被击穿.

9-30 (略).

9-31 带电孤立导体球电场能量的一半储存在 $R \to 2R$ 的球壳内.

9-32 $W = \dfrac{1}{4\pi\varepsilon_0} \dfrac{3q^2}{5a}$.

9-33 (1) $w = \dfrac{Q^2}{8\pi^2 \varepsilon_0 \varepsilon_r r^2 l^2}$; (2) $W = \dfrac{Q^2}{4\pi\varepsilon_0 \varepsilon_r l} \cdot \ln\left(\dfrac{b}{a}\right)$; (3) $C = \dfrac{2\pi\varepsilon_0 \varepsilon_r l}{\ln\left(\dfrac{b}{a}\right)}$.

9-34 (1) $E = 5 \times 10^3$ V/m, $W = 2.21 \times 10^{-7}$ J; (2) $E' = 5 \times 10^3$ V/m, $W' = 4.42 \times 10^{-7}$ J.

9-35 (1) $W = \dfrac{q^2 x}{2\varepsilon_0 S}$; (2) $W = \dfrac{q^2(x + dx)}{2\varepsilon_0 S}$; (3) (略).

9-36 (1) $\Delta W = -\dfrac{Q^2 b}{2\varepsilon_0 S}$; (2) $A = -\dfrac{Q^2 b}{2\varepsilon_0 S}$, 吸入; (3) $\Delta W = \dfrac{\varepsilon_0 S b U^2}{2d(d-b)}$, $A = -\dfrac{\varepsilon_0 S b U^2}{2d(d-b)}$, 吸入.

## 第 10 章 直流电路

10-1~10-6 (略).

10-7 (1) $I = 20$ mA; (2) $v = 2.75 \times 10^{-6}$ m/s.

10-8 (1) 每秒需将 $1 \times 10^{-4}$ C 电荷量喷射在传送带上; (2) $\sigma = 4 \times 10^{-6}$ C/m².

10-9 (1) $j = 10^7$ A/m²; (2) $E = 0.16$ V/m; (3) $t = 1.6 \times 10^5$ s.

10-10 (1) $Q = 603$ C; (2) $I = 120.7$ A.

10-11 (略).

10-12 $R = \dfrac{\rho}{2\pi a}$.

10-13 (1) $I = 9.09 \times 10^{-4}$ A; (2) $R = 1.1 \times 10^5$ Ω.

10-14 (1) (略); (2) $j = \dfrac{U_{ab} r_a r_b}{\rho r^2 (r_b - r_a)}$.

10-15 $\dfrac{1}{35}$.

10-16 $R_T = 223.76$ Ω.

10-17 (略).

10-18 $R = 10$ Ω.

10-19 (1) $R_{AB} = \dfrac{1}{2}R$; (2) $R_{AB}' = \dfrac{R_0 R}{R_0 + R}$.

10-20 $a = 1$ Ω, $b = 3$ Ω, $c = 4$ Ω, $d = 5$ Ω, $e = 2$ Ω, $f = 6$ Ω.

10-21 (a) 3 A; (b) $\dfrac{12}{7}$ A.

10-22 (1) $U_{ab} = -6$ V; (2) $U_b = 6$ V, 流经 S 的电荷量为 $5.4 \times 10^{-5}$ C.

10-23 (1) $U_{ab}=18$ V；(2) $U_b=6$ V，$\Delta q_3=$
$-3.6\times10^{-5}$ C，$\Delta q_6=-3.6\times10^{-5}$ C.

10-24 $\mathscr{E}_1=18$ V，$\mathscr{E}_2=7$ V，$U_{ab}=13$ V.

10-25 (1) $U_{ab}=0.22$ V；(2) 12 V 电池中流过的电流为 0.464 A.

10-26 (a) $I_{16}=1.18$ A，$I_2=2.56$ A，$I_{18}=$
1.38 A；(b) $I_{16}$，$I_2$，$I_{18}$ 同上题，$I_{24}=$
0.25 A，$I_{36}=0.167$ A.

10-27 $I_{10}=I_{14}=0.5$ A，$I_7=I_5=0.5$ A，$I_{ba}=$
1 A，$I_8=0.75$ A.

10-28 0.156 A，0.125 A，0.281 A.

10-29 $I_{3\ V}=0.6$ A，$I_{6\ V}=2.4$ A，2 Ω 中电流分别为 1.2 A，1.8 A，0.6 A.

**第 11 章 恒定磁场**

11-1~11-5 （略）.

11-6 $8.3\times10^{-3}$ m.

11-7 (1) $E_p=E_d=\frac{1}{2}E_a$；(2) $R_d=R_a=14$ cm.

11-8 $T=3.6\times10^{-10}$ s，$h=0.17$ mm，$r=$
1.5 mm.

11-9 中子在磁场中以 $v=1.49\times10^8$ m/s 做直线运动；质子在磁场中做圆周运动，$R=$
1.0 m.

11-10 （略）.

11-11 $\frac{e}{m}=\frac{8\pi^2n^2}{B^2l^2}U$.

11-12 (1) $v=8.45\times10^{-4}$ m/s；(2) $E=1.25\times$
$10^{-3}$ V/m；(3) $U=2.54\times10^{-5}$ V.

11-13 $q=3.8$ C.

11-14 $B=1.32$ T，$E_k=6.76\times10^{-13}$ J，$v=$
$2.01\times10^7$ m/s.

11-15 0.48 T.

11-16 $9.35\times10^{-3}$ T.

11-17 (1)（略）；(2) 338 A/cm².

11-18 (1) $1.8\times10^5$ 倍；(2) $2.9\times10^6$ A；
(3) 3.0 MkW.

11-19 (1) $M=8.3\times10^{-3}$ N·m；(2) $M=$
$4.8\times10^{-3}$ N·m；(3) 所需转矩相同.

11-20 (1) $M_{max}=0.18$ N·m；(2) 线圈的法线方向与 **B** 方向成 30°角.

11-21 $\alpha=1.2°$.

11-22、11-23 （略）.

11-24 (1) $I_2=2$ A，方向与 $I_1$ 反向；(2) $B_Q=$
$2.14\times10^{-6}$ T，方向垂直于 $QP$ 连线向右；(3) $B_S=1.62\times10^{-6}$ T，方向与 $SI_1$ 连线成 $\theta=66°$ 并指向 $PQ$ 连线.

11-25 $8\times10^4$ N 向左，$8\times10^{-15}$ N 向右，$9.2\times$
$10^{-5}$ N 向上，$9.2\times10^{-5}$ N 向下；合力 $F$
$=7.2\times10^{-4}$ N，方向向左.

11-26 $B=8.0\times10^{-5}$ T，方向向上.

11-27 $\frac{\mu_0i}{4R}$，$\frac{\mu_0i}{8R}$，0，0；$\frac{\mu_0i}{8R}$，方向垂直纸面向里.

11-28 (a) $\frac{\mu_0i}{2R}-\frac{\mu_0i}{2\pi R}$（方向略）；(b) $\frac{\mu_0i}{2R}+\frac{\mu_0i}{2\pi R}$
（方向略）.

11-29 $B=0$.

11-30 $B=\frac{\mu_0I}{2\pi b}\ln\frac{a+b}{a}$.

11-31 $B=6.37\times10^{-5}$ T，方向水平向左.

11-32 （略）.

11-33 (1) $B=6.1\times10^{-4}$ T；(2) $B=5.6\times$
$10^{-4}$ T.

11-34 $B=6.28\times10^{-3}$ T.

11-35 $\Phi_1=-0.0024$ Wb，$\Phi_2=+0.0024$ Wb，
$\Phi_3=\Phi_4=\Phi_5=0$.

11-36 $\Phi=\frac{\mu_0I}{4\pi}$.

11-37 $B_1=0$，$B_2=\frac{\mu_0}{2\pi}\cdot\frac{I}{b^2-a^2}\cdot\frac{r^2-a^2}{r}$，
$B_3=\frac{\mu_0I}{2\pi r}$.

11-38 (1) $B=\frac{\mu_0Ir}{2\pi R_1^2}$；(2) $B=\frac{\mu_0I}{2\pi r}$；(3) $B=$
$\frac{\mu_0I}{2\pi r}\left(1-\frac{r^2-R_2^2}{R_3^2-R_2^2}\right)$；(4) $B=0$.

11-39 $B_1=\frac{\mu_0I}{\pi}\cdot\frac{2r^2-a^2}{r(4r^2-a^2)}$，$B_2=\frac{\mu_0I}{\pi}\cdot$
$\frac{2r^2+a^2}{r(4r^2+a^2)}$.

11-40 (1) $\frac{\mu_0IR_2^2}{2\pi a(R_1^2-R_2^2)}$；(2)、(3) $\frac{\mu_0Ia}{2\pi(R_1^2-R_2^2)}$.

11-41 （略）.

**第 12 章 电磁感应**

12-1 $\mathscr{E}=8.7\times10^{-2}\cos(100\pi t)$ V.

12-2 $\mathscr{E}=3\times10^{-3}$ V.

12-3 $\mathscr{E}=3.1\times10^{-2}$ V.

12-4 (1) $\mathscr{E}_{ab} = -\dfrac{\mu_0 Iv}{2\pi}\ln\dfrac{d+L}{d}$，$\mathscr{E}_{ac} = -\dfrac{\mu_0 Iv}{2\pi}$ ·

$\ln\dfrac{d+L\cos\theta}{d}$；(2) $c$ 点的电势高于 $b$ 点.

12-5 $I_m = \dfrac{\pi^2 BR^2 f}{R_m}$，频率为 $f$.

12-6 （略）.

12-7 $\bar{\mathscr{E}} = 6\times10^{-3}$ V.

12-8 （略）.

12-9 (1)（略）；(2) $v_T = \dfrac{FR}{B^2 l^2}$；(3) $v = v_T\left(1-\right.$

$\left. e^{-\frac{B^2 l^2}{Rm}t}\right)$.

12-10 (1) $\Phi = \dfrac{\mu_0 \pi r^2 R^2 I}{2y^3}$；(2) $\mathscr{E} = \dfrac{3\mu_0 \pi r^2 R^2 I}{2y^4}v$；

(3) 逆时针方向，与大回路中电流方向
相同.

12-11 (1) 29.8 A；(2) 2.2 J；(3) 4 倍.

12-12 (1) $\mathscr{E}_{ab} = 8$ V，方向为 $a\to b$，$\mathscr{E}_{cd} = 4$ V，方向为 $c\to d$；(2) $U_{ab} = 6$ V，$U_{cd} = 6$ V；

(3) $U_{O1}-U_{O2} = 0$ V.

12-13 $M = \dfrac{(Bar)^2 \omega b}{\rho}$.

12-14 (1) $E = 5\times10^{-3}$ V/m，顺时针沿圆周
的切向；(2) $I = 1.57$ mA；(3) $U_{ab} = 0$；

(4) $U = 3.14$ mV.

12-15 (1) $\mathscr{E}_{ac} = 0$，$\mathscr{E}_{cd} = 1\times10^{-3}$ V，$\mathscr{E}_{de} = 2\times$

$10^{-3}$ V，$\mathscr{E}_{ea} = 1\times10^{-3}$ V；(2) $\mathscr{E} = 4\times$

$10^{-3}$ V；(3) $U_{ac} = 1\times10^{-3}$ V.

12-16 $\mathscr{E}_{ab} = -\dfrac{l}{2}\dfrac{dB}{dt}\sqrt{R^2-\left(\dfrac{l}{2}\right)^2}$，方向为

$a\to b$，即 $b$ 端电势高.

12-17 (1) $B = \dfrac{mv}{eR}$；(2) $U = \pi R^2\dfrac{dB}{dt}$.

12-18 (1) $\bar{E} = 430$ eV；(2) $n = 2.3\times10^5$；

(3) $s = 1.2\times10^6$ m.

12-19 (1) $\mathscr{E}_2 = 12\pi\cos(120\pi t)$ V；(2) $\mathscr{E}_1 = 12\pi\cos(120\pi t)$ V.

12-20 $M = 0.50$ mH.

12-21 (1) $M = 6.28\times10^{-6}$ H；(2) $\mathscr{E} = 3.14\times$

$10^{-4}$ V.

12-22 $L = \mu_0 N^2\dfrac{S}{l}$，$N = 400$ 匝.

12-23、12-24 （略）.

12-25 (1) $L = \dfrac{\mu_0 N^2 h}{2\pi}\ln\dfrac{b}{a}$；(2)（略）.

12-26 (1) $L = L_1 + L_2 + 2M$；(2) $L = L_1 + L_2 - 2M$.

12-27 $w_m = 0.63$ J/m³.

12-28 $w_m = 1.6\times10^5$ J/m³，$w_e = 4.4$ J/m³，磁
场更有利于储存能量.

12-29 9.0 m³，29 H.

12-30、12-31 （略）.

12-32 (1) $w_m = 0.987$ J/m³；(2) $w_e = 0.498\times$

$10^{-14}$ J/m³.

12-33 $E = 1.5\times10^8$ V/m.

12-34 (1) $\dfrac{di}{dt} = 4$ A/s；(2) $\dfrac{di}{dt} = 2$ A/s；(3) $i = 0.662$ A；(4) $I = 2$ A.

12-35 (1) $I = 0.05$ A；(2) $\dfrac{di}{dt} = 1$ A/s；

(3) $\dfrac{di}{dt} = 0.5$ A/s；(4) $t = 0.23$ s.

12-36 (1) $P = 6$ W；(2) $P_R = 1.5$ W；(3) $P_L = 4.5$ W；(4) $W = 6$ J.

12-37 (1) $\tau = 10$ μs；(2) $U = 2.55$ V.

12-38 (1) $W = C\mathscr{E}^2$；(2) $W_R = \dfrac{1}{2}C\mathscr{E}^2$.

12-39 (1) $\dfrac{dQ}{dt} = 9.6\times10^{-7}$ C/s；(2) $\dfrac{dW_C}{dt} = 1.1\times10^{-6}$ W；(3) $\dfrac{dW_R}{dt} = 2.7\times10^{-6}$

W；(4) $\dfrac{dW}{dt} = 3.8\times10^{-6}$ W.

### 第13章 物质的磁性

13-1 (1) $B = 0.226$ T；(2) $H = 300$ A/m；

(3) $B' = 0.225\,6$ T.

13-2 (1) $H = 2\,000$ A/m；(2) $M = 7.97\times10^5$

A/m；(3) $\chi_m = 399$；(4) $\mu_r = 400$.

13-3 $I = 8$ A.

13-4 (1) $H = 175$ A/m；(2) $B = 1.1$ T；

(3) $\mu_r = 5\,000$.

13-5 $I = 0.045$ A.

13-6 当 $r < R_1$ 时，$H = \dfrac{Ir}{2\pi R_1^2}$，$B = \dfrac{\mu_0 Ir}{2\pi R_1^2}$；

当 $R_1 < r < R_2$ 时，$H = \dfrac{I}{2\pi r}$，$B = \dfrac{\mu_r \mu_0 I}{2\pi r}$；

当 $r > R_2$ 时，$H = \dfrac{I}{2\pi r}$，$B = \dfrac{\mu_0 I}{2\pi r}$.

13-7 (1) $I_s = 6\times10^3$ A；(2) $B = 12.57\times$

$10^{-2}$ J；(3) $H = -1.4\times10^6$ A/m；

(4) $m = 17.0$ A·m².

**第 14 章　交变电流**

14-1　（略）.

14-2　$Z = 40$ Ω，$I = 5.5$ A.

14-3　$Z = 10$ Ω，$I = 22$ A.

14-4　$f = 16$ Hz.

14-5　(1) $U_C = 60$ V，$U_R = 80$ V；(2) 超前 36°52′.

14-6　$I_L = 1$ mA，$I_C = 2$ mA.

14-7　$U = 37$ V.

14-8　(1) $-\dfrac{3}{4}\pi$；(2) $\dfrac{\pi}{4}$（图略）.

14-9　$f = 484$ Hz～$1\,838 \times 10^3$ Hz，能满足.

14-10　(1) $f = 10^5$ Hz；(2) $U_L = 316$ V.

14-11　$I = 2.84$ A.

14-12　$P = 105$ W.

14-13　$P = 154$ W.

**第 15 章　麦克斯韦方程组和电磁波**

15-1　(1) $I_d = 7.0 \times 10^{-2}$ A；(2) $B = 2.8 \times 10^{-7}$ T.

15-2　$E = 7.3 \times 10^2$ V/m，$H = 1.9$ A/m.

15-3　(1) $v = 3 \times 10^6$ m/s；(2) $\lambda = 3 \times 10^{-2}$ m.

15-4　$B = 3.33 \times 10^{-12}$ T，$\dfrac{B}{B_0} = (1.5 \times 10^7)^{-1}$.

15-5　$E = 10.9 \times 10^{-2}$ V/m，$H = 2.9 \times 10^{-4}$ A/m.

15-6　(1) $f = 1 \times 10^{10}$ Hz；(2) $B = 1 \times 10^{-7}$ T；(3) $\bar{S} = 1.19$ W/m².

15-7　(1) $E = \rho \dfrac{I}{\pi a^2}$，方向与导线平行；(2) $H = \dfrac{Ir}{2\pi a^2}$，方向沿圆周的切向；(3) $S = \dfrac{I^2 \rho r}{2\pi^2 a^4}$，方向与导线垂直；(4) $\dfrac{S}{P} = \dfrac{1}{2\pi rl}$.