大学物理习题参考解答

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Tu We Th Fr Sa Su MEMO NO.

DATE / /

习题

习题 1-2. (2).

解: $v=\frac{dx}{dt}=8t-6t^2$. $a=\frac{dv}{dt}=8-12t$.

再次回原点$x=0$时. $t=2$. ∴ $v=-8\ m/s$. $a=-16\ m/s^2$.

(5). $\theta=10\pi t+\frac{1}{2}\pi t^2$. ∴ $\omega=\frac{d\theta}{dt}=10\pi+\pi t$.

$\alpha=\frac{d\omega}{dt}=\pi$.

$a_t=R\cdot\alpha=\pi R$.

$a_n=\omega^2 R=(10\pi+\pi t)^2 R$.

1-3. 知 $x=at^2$, $y=bt^2$, 求 r 和轨道方程, 并判断运动情况.

解: $\vec{r}=at^2\vec{i}+bt^2\vec{j}$. 轨道方程: $\begin{cases}\frac{x}{a}=t^2\\ \frac{y}{b}=t^2\end{cases}$ ∴ $\frac{x}{a}=\frac{y}{b}$ ∴ $y=\frac{b}{a}x$.

$\vec{v}=\frac{d\vec{r}}{dt}=2at\vec{i}+2bt\vec{j}$

$\vec{a}=\frac{d\vec{v}}{dt}=2a\vec{i}+2b\vec{j}$ 为常数. ∴ 做匀变速直线运动.

1-4. (1). $\vec{r}=(3t+5)\vec{i}+(\frac{1}{2}t^2+3t-4)\vec{j}$.

(2). $t=1s$ 时. $\vec{r}_1=8\vec{i}+(-\frac{1}{2})\vec{j}=8\vec{i}-\frac{1}{2}\vec{j}$.

$t=2s$ 时. $\vec{r}_2=11\vec{i}+4\vec{j}$

$\Delta\vec{r}=\vec{r}_2-\vec{r}_1=3\vec{i}+\frac{9}{2}\vec{j}$

(3) $\vec{v}=\frac{d\vec{r}}{dt}=3\vec{i}+(t+3)\vec{j}$ $t=4s$ 时. $\vec{v}=3\vec{i}+7\vec{j}$ $|\vec{v}|=\sqrt{58}\approx 7.6\ m/s$.

$\tan\alpha=\frac{v_y}{v_x}=\frac{7}{3}$ ∴ $\alpha=\arctan 7/3$.

(4). $\vec{a}=\frac{d\vec{v}}{dt}=\frac{d^2\vec{r}}{dt^2}=1\vec{j}$ 方向: 沿y轴正方向.

习题 ~~2-1(1)~~ 2-5.

$I=\int_0^3 F(t)dt=\int_0^3(4+2t^2)dt=(4t+\frac{2}{3}t^3)\Big|_0^3=30\ N\cdot S$.

$I=mv-mv_0$ ∴ $v=3\ m/s$.

$A=\frac{1}{2}mv^2=45\ J$.

另解: $F=m\frac{dv}{dt}\rightarrow v=\int_0^t\frac{F}{m}$

$=\frac{2}{5}t+\frac{1}{15}t^3$ v_3

$A=\int F dx=\int F\frac{dx}{dt}dt=\int_0^3 Fv$

$=45(J)$

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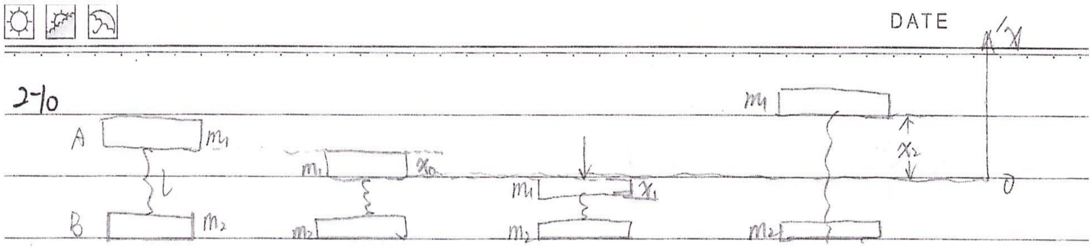
2-10



$mg = kx_0$

$E_p = \frac{1}{2}k(x-x_0)^2 - \frac{1}{2}kx_0^2 + mgx = \frac{1}{2}kx^2$

$m_2 g = k(x_2 - x_0)$

$F + mg = k(x_1 + x_0)$

$\therefore \frac{1}{2}kx_1^2 = \frac{1}{2}kx_2^2$

$F = (m_1+m_2)g$

2-3. $x = ct^3$ $\cancel{dt=}$ $v = \frac{dx}{dt} = 3ct^2$.

$\cancel{\int kv^2}$ $f = kv^2 = -9c^2t^4k$. 阻力做负功.

$x=l$ 时. $t = (\frac{l}{c})^{\frac{1}{3}}$

$W = \int_0^{(\frac{l}{c})^{\frac{1}{3}}} f\cdot v\,dt = \int_0^{(\frac{l}{c})^{\frac{1}{3}}} -9c^2t^4k\cdot 3ct^2\,dt = -\frac{27}{7}kc^{\frac{2}{3}}l^{\frac{7}{3}}$.

2-2 (1). $A = \vec{F}\cdot\Delta\vec{r} = \int \vec{F}_1 d\vec{r} + \int \vec{F}_2 d\vec{r}$

$\cancel{\vec{F} = \vec{F}_1 + \vec{F}_2 = (12+\vec{F}_{2x})\vec{i} + (\vec{F}_{2y}-3)\vec{j}}$.

$\cancel{\Delta\vec{r} = 3\vec{i} + 8\vec{j}}$.

$\int \vec{F}_1 d\vec{r} = \int (12\vec{i} - 3\vec{j})\cdot d(3\vec{i}+8\vec{j}) = 12J$.

$\therefore \int \vec{F}_2 d\vec{r} = 24 - 12 = 12J$

$A = (\vec{F}_1 + \vec{F}_2)\cdot\Delta\vec{r} = 24$

$\vec{F}_1\cdot\Delta\vec{r} + \vec{F}_2\cdot\Delta\vec{r} = 24$

$\vec{F}_2\cdot\Delta\vec{r} = 24 - \vec{F}_1\cdot\Delta\vec{r} = 12(J)$

We Th Fr Sa Su　　MEMO NO. ______

DATE　/　/

2-2.(3)　$F=400-\frac{4\times10^5}{3}t$　当 $F=0$ 时　$t=3\times10^{-3}$ s

冲量　$I=\int_{t_1}^{t_2}F\,dt=(400t-\frac{4\times10^5}{3}\times\frac{1}{2}t^2)\Big|_{t_1}^{t_2}=0.6$ N·S.

$I=mv$　∴ $m=2\times10^{-3}$ kg.

2-19. 角动量守恒　$L=mvr$.　∴ $v=\frac{L}{mr}$.　$E_k=\frac{1}{2}mv^2=\frac{L^2}{2mr^2}$

$\begin{cases}E_p=-mar\ \times\\ a=\frac{v^2}{r}\end{cases}$　∴ $E_p=-\frac{L^2}{mr^2}$　$E=E_k+E_p$,　$E=-\frac{L^2}{2mr^2}$.

$\frac{v^2}{r}=\frac{4\pi^2}{T^2}\cdot r$　∴ $T=\frac{2\pi r}{v}=\frac{2\pi mr^2}{L}$,　$E_p=\int_r^{\infty}\vec{F}\cdot d\vec{r}=\int_r^{\infty}\frac{GMm}{r^2}dr(-i$

$=\frac{GMm}{r}$

$\frac{GMm}{r^2}=m\frac{v^2}{r}\rightarrow\frac{GMm}{r}=mv^2=\frac{L^2}{mr^2}$

3-3.　$J=\int l^2dm+\int l^2dm=2ml^2$.

$J_0=3\times\int d^2dm=3md^2$　∵ $\sqrt{3}d=l$,　∴ $J_0=ml^2$.

4-1(3).　$x=A\cos(\omega t+\varphi)$　$t=0$ 时. $2\cos\varphi=-1$　∴ $\cos\varphi=-\frac{1}{2}$,

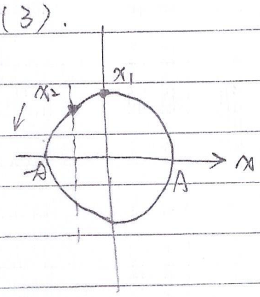
D　　$t=1$ 时. $2\cos(\omega+\varphi)=2$　∴ $\cos(\omega+\varphi)=1$.

$t=0$ 时 v 向负方向运动, 在 x 轴上方.　∴ $\varphi=\frac{2}{3}\pi$.

$\rightarrow\omega+\frac{2}{3}\pi=2\pi\rightarrow\omega=\frac{4}{3}\pi$

4-1(5).　$A=\sqrt{A_1^2+A_2^2+2A_1A_2\cos(\varphi_1-\varphi_2)}=\sqrt{0.03^2+0.04^2}=0.05$.

4-2(3).



$A\cdot\cos\varphi_2=-\frac{A}{2}$.　∴ $\varphi_2=\frac{2}{3}\pi$ 或 $\frac{4}{3}\pi$.

v_2 为正.　∴ $\varphi_2=\frac{2}{3}\pi$.

$\frac{2}{3}\pi-\frac{\pi}{2}=\frac{\pi}{6}$.

4-12 (1) $v_m=A\omega$, 知 $v_m=3$, $A=2\Rightarrow\omega=\frac{3}{2}$.　$\omega=\frac{2\pi}{T}$　∴ $T=\frac{4}{3}\pi$.

(2) $a_m=A\omega^2=10^{-2}\times2\times\frac{9}{4}=4.5\times10^{-2}$ m/s².

(3) $v=-A\omega\sin(\omega t+\varphi)=-3\sin(\frac{3}{2}t+\varphi)$. 将 $(0,1.5)$ 代入得 $\varphi=-\frac{5\pi}{6}$

∴ $x=2\cos(\frac{3}{2}t-\frac{5}{6}\pi)$

4-14.　$A=\sqrt{1^2+(\sqrt{3})^2+0}=2$ cm.

$\varphi=\arctan\frac{A_1\sin\varphi_1+A_2\sin\varphi_2}{A_1\cos\varphi_1+A_2\cos\varphi_2}=\arctan\sqrt{3}$　∴ $\varphi_合=\frac{\pi}{3}$.

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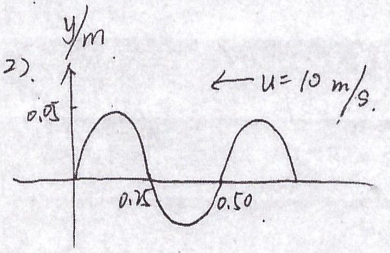
5-2 (1)

解：∵ $y=A\cos\left[2\pi\left(\frac{t}{T}-\frac{x}{\lambda}\right)+\varphi\right]$ ∴ $A=0.2$, $\varphi=0$, $T=0.02s$. $\lambda=0.05\,m$.

$u=\frac{\lambda}{T}=2.5\,m/s$. 又∵ $\begin{cases}\omega=2\pi\nu \\ u=\lambda\cdot\nu\end{cases}$ ∴ $\omega=100\pi$ rad/s. $\boxed{-\frac{x}{\lambda}}$ 为正

∴ 沿 x轴正向

5-2 (2).



当t=0时, y=0

解：$\lambda=0.50\,m/s$. $A=0.05\,m$. $\begin{cases}u=\frac{\lambda}{T} \\ \omega=2\pi\nu \\ \nu=\frac{1}{T}\end{cases}$ ∴ $\begin{cases}T=0.05\,s \\ \omega=40\pi\ \text{rad/s}\end{cases}$

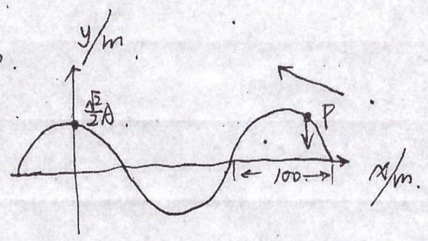
∴ $y_0=0.05\cos(40\pi t+\varphi)$.

∵ $y_0=0$ 且向正方向振动 ∴ $\varphi=-\frac{\pi}{2}$ ∴ $y_0=0.05\cos(40\pi t-\frac{\pi}{2})$.

当t=0时. y=0 ∴ $\varphi=-\frac{\pi}{2}$. 波动方程 $y=0.05\cos(40\pi t+4\pi x-\frac{\pi}{2})$.

5-6.

解：



∴ 质点沿 x轴负方向传播.

∴ 波动方程 $y=A\cos(500\pi t+\frac{\pi}{4}$

$\lambda=200\,m$. $T=\frac{1}{f}=0.04\,s$.

$v=\frac{\lambda}{T}=5\times10^4\,m/s$. $\omega=\frac{2\pi}{T}=500\pi$.

当t=0时. $y_0=A\cos\varphi=\frac{\sqrt{2}}{2}\varphi$ ∴ $\varphi=\pm\frac{\pi}{4}$.

$v_0=-500\pi A\sin(500\pi t+\varphi)$. 当t=0时. $v_0=-500\pi A\cdot\sin\varphi<0$ ∴ $\varphi=\frac{\pi}{4}$.

Mo Tu We Th Fr Sa Su

MEMO NO.

DATE / /

6-2 (1). $C=3.00\times10^{8}\ m/s$. $u=\frac{c}{n}$. $\lambda_n=\frac{u}{\nu}=\frac{c}{n\nu}=\frac{\lambda}{n}$.

6-2 (5). $\Delta x=\frac{D}{d}\lambda$, $\lambda=\frac{\Delta x\, d}{D}=\frac{2.27\times10^{-3}\times0.6\times10^{-3}}{2.5}=5.448\times10^{-7}m=544.8\times10^{-9}nm$.

$\Delta x'=\frac{D}{d}\lambda'$ $\therefore \Delta x'=\frac{2.5}{0.6\times10^{-3}}\times632.8\times10^{-9}=2.637\times10^{-3}m=2.637\ mm$.

6-6. 正面为反射. 光的波长范围 390nm ~ 760 nm.

$n=3$, $\Delta=2en+\frac{\lambda}{2}=k\lambda$, $\therefore \lambda=\frac{4en}{2k-1}$

$e=380nm$

$\therefore$ $k=4$时, $\lambda=651$ nm 红; $k=5$时. $\lambda=506.7$nm绿;

$k=6$时, $\lambda=414.5$nm 紫.

反面为透射

$\Delta=2en+\frac{\lambda}{2}=(2k+1)\frac{\lambda}{2}$. $\therefore \lambda=\frac{2en}{k}$,

$\therefore k=3$时. $\lambda=760$nm 红; $k=4$时. $\lambda=570$nm 绿;

$k=5$时, $\lambda=456$nm 青.

6-7. 相邻明纹对应的厚度差 $\Delta e=\frac{\lambda}{2n}$,

$\because$有20条明纹 $\therefore$有19个厚度差.

$\therefore$ $e=19\cdot\Delta e=19\cdot\frac{\lambda}{2n}=$ ~~4.01 um~~ $4007.7\ nm=4.01\ um$.

6-19. (1) $\Delta x=\frac{D}{d}\lambda=\frac{2\times10^{3}\times480\times10^{-6}}{0.4}=2.4\ mm$.

(2) 要求在单缝衍射中央明条纹范围内的双缝干涉明条纹数 必须先求出单缝衍射时中央明纹的宽度 $\Delta x_0=2\frac{\lambda f}{a}=\frac{2\times480\times10^{-9}\times2}{0.08\times10^{-3}}=24\ mm$.

又$\because$ 一条明纹间距 2.4 mm $\therefore \frac{24}{2.4}-1=9$ 有9条干涉明纹,

5-14.

已知 $a=10^{-4}m$. $\lambda=5.46\times10^{-7}m$. $f=0.5m$.

$\Delta x=2x_1=\frac{2\lambda f}{a}=5.46\times10^{-3}m$.

放入水中. $\lambda_n=\frac{\lambda}{n}=\frac{5.46\times10^{-7}}{1.33}$

$\Delta x=\frac{2\lambda_n f}{a}=4.1\times10^{-3}m$.

6-26. 设自然光为 I_0. ~~偏振~~光为 I_1.

$$\frac{\frac{I_0}{2}+I_1}{\frac{I_0}{2}+I_1\cos^2 60^\circ}=2.$$

$\Rightarrow I_0=I_1$ 各占50%.

9-2. (1).

1° 当 q_0 在左侧时. $\frac{kqq_0}{(-1-x)^2}+\frac{kq(-2q)}{(1-x)^2}=0\Rightarrow x^2+6x+1=0.$

$x=-3-2\sqrt{2}$, $x=-3+2\sqrt{2}$

2° 当 q_0 在右侧时. $\frac{kqq_0}{(x+1)^2}=\frac{kq_0 2q}{(x-1)^2}\Rightarrow x^2+6x+1=0.$

$x=-3\pm2\sqrt{2}$ (舍)

∴ q_0 在 $x=-3-2\sqrt{2}$ m 处时. 所受合力为零.

9-3.

$E_A=\frac{kq_A}{AC^2}=1.8\times10^4$ V/m.

$E_B=\frac{kq_B}{BC^2}=2.7\times10^4$ V/m.

$E_C=\sqrt{E_A^2+E_B^2}=3.24\times10^4$ V/m.

$\tan\theta=\frac{E_A}{E_B}=\frac{2}{3}$. $\theta=33.7^\circ$ ~~与BC夹角~~ 方向与BC成 33.7°.

9-5. $dq=\lambda dx$ $dE=\frac{1}{4\pi\varepsilon_0}\frac{\lambda dx}{r^2}=\frac{1}{4\pi\varepsilon_0}\frac{\lambda dx}{(l+a-x)^2}$

$E=\int dE=\frac{l\lambda}{4\pi\varepsilon_0 a(l+a)}$

Tu We Th Fr Sa Su

MEMO NO.

DATE / /

9-10. $\Phi_e = ES = 800 \times 0.2^{\frac{1}{2}} \times 0.1 \times 0.1 - 800 \times 0.1^{\frac{1}{2}} \times 0.1 \times 0.1 = 1.05\ N\cdot m^2/c$

$\Phi = \frac{q_0}{\varepsilon_0}$ 得 $\therefore q_0 = \Phi\varepsilon_0 = 1.05 \times 8.85 \times 10^{-12} = 9.29 \times 10^{-12}\ C.$

9-12. ~~1° 0<r<R₁~~ $\oint \vec{E}\cdot d\vec{s} = \oint E\,ds = 2\pi r l E = \frac{\Sigma q_0}{\varepsilon_0}.$

1° $0<r<R_1$. $\Sigma q_0 = 0$ $\therefore E=0.$

2° $R_1<r<R_2$ $\Sigma q_0 = \lambda_1 l.$ $E = \frac{\lambda_1}{2\pi\varepsilon_0 r}$

3° $r>R_2$. $\Sigma q_0 = (\lambda_1+\lambda_2)l.$ $E = \frac{\lambda_1+\lambda_2}{2\pi\varepsilon_0 r}.$

9-16. $V_0 = 2\int_R^{2R} \frac{\lambda}{4\pi\varepsilon_0 r}dr + \frac{1}{4\pi\varepsilon_0 R}\cdot\lambda\pi R.$

$= \frac{\lambda}{2\pi\varepsilon_0}\ln 2 + \frac{\lambda}{4\varepsilon_0}$

$= \frac{\lambda}{4\pi\varepsilon_0}(2\ln 2+\pi).$

9-18. ~~1° -a<x<a 时. $V=\int_x^0 \vec{E}d\vec{l} = -\frac{\sigma}{\varepsilon_0}$~~

1°. 当 $x<-a$ 时. $V = \int_x^{-a}\vec{E}d\vec{l} + \int_{-a}^{0}\vec{E}d\vec{l} = \frac{\sigma}{\varepsilon_0}a.$

2° $-a<x<a$ 时. $V = \int_x^0 \vec{E}d\vec{l} = -\frac{\sigma}{\varepsilon_0}x.$

3° $x>a$ 时. $V = \int_x^a \vec{E}d\vec{l} + \int_a^0 \vec{E}d\vec{l} = -\frac{\sigma}{\varepsilon_0}a.$

9-2.(5). $W_O = \int_O^\infty \frac{Q}{4\pi\varepsilon_0}\frac{q_0}{r^2}dr + \int_D^\infty \frac{1}{4\pi\varepsilon_0}\frac{-Q}{r^2}q_0\,dr = \int_R^\infty \frac{q_0 Q}{4\pi\varepsilon_0 r^2}dr + \int_{3R}^\infty \frac{-q_0 Q}{4\pi\varepsilon_0 r^2}dr$

$= \frac{q_0 Q}{6\pi\varepsilon_0 R}.$

$A_{O\infty} = \int_O^\infty \vec{F}d\vec{r} = W_O - W_\infty = 0.$

$A_{OD} = W_O - W_D = -\frac{q_0 Q}{6\pi\varepsilon_0 R}$

$A_{D\infty} = W_D - W_\infty = \frac{q_0 Q}{6\pi\varepsilon_0 R}.$

11-1 #. (1) $B_{AB}=0$, $B_{CD}=\frac{\mu_0 I}{4\pi R}$, $B_{BC}=\frac{\mu_0 I}{2R}\cdot\frac{\pi}{2\pi}=\frac{\mu_0 I}{4R}$.

$$B=B_{AB}+B_{CD}+B_{BC}=\frac{\mu_0 I}{4R}+\frac{\mu_0 I}{4\pi R}.$$ 方向：垂直纸面向里.

11-3. $B_{BC}=\frac{\mu_0 I}{2R}\cdot\frac{\frac{\pi}{2}}{2\pi}=\frac{\mu_0 I}{8R}$ 方向垂直纸面向里.

$$dB_{CD}=\frac{\mu_0 I\,dl\sin\theta}{4\pi r^2}$$

$$B_{CD}=\frac{\mu_0 I\cdot\sqrt{2}R\cdot\frac{\sqrt{2}}{2}}{4\pi\left(\frac{R}{\sqrt{2}}\right)^2}=\frac{\mu_0 I}{2\pi R}.$$

$$B=\frac{\mu_0 I}{8R}+\frac{\mu_0 I}{2\pi R}$$ 方向垂直纸面向里.

11-8. (1) $$B_1=\frac{\mu_0 I}{2\pi\times\frac{(r_1+r_2+r_3)}{2}}=2\times10^{-4}\,T.$$

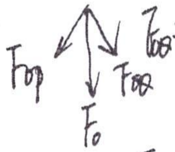
$B_2=B_1=2\times10^{-4}$ T.

$\vec{B}=\vec{B}_1+\vec{B}_2=4\times10^{-4}$ T. 垂直纸面向里.

$$\Phi=\iint_S dB\cdot dS=\int_{r_1}^{r_1+r_2}dB\cdot(l\,dx)=\int_{0.1}^{0.3}\left(\frac{\mu_0 I}{2\pi x}+\frac{\mu_0 I}{2\pi(r_1+r_2+r_3-x)}\right)\cdot(l\,dx)$$

$$=2.2\times10^{-5}\ Wb.$$

11-13.



$$F_{OQ}=F_{OP}=\frac{\mu_0}{2\pi}\times\frac{I_1 I_2}{r}=\frac{\mu_0 I^2}{2\pi a}.$$

$$F_0=F_{OP}\cdot\cos30^\circ+F_{OQ}\cos30^\circ=\frac{\mu_0 I^2}{\pi a}\cdot\frac{\sqrt{3}}{2}=3.46\times10^{-6}\ N/m.$$