2018年大学物理阶段二答案

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选择题

1. C

> 相对论情境下对于任何参考系都有动量守恒成立，但请注意牛顿第三定理可能会失效。

2. B

> 长度收缩只会发生在运动方向上，而不会发生在垂直于运动方向的方向上。
> 实际角度为：
>
> $$\arctan\sqrt{\frac{3}{1-\beta^2}} > \frac{\pi}{3}$$

3. C

> $$\begin{aligned}&\tau=\sqrt{1-\beta^2}t\\&t=5\quad year;\tau=3\quad year\\&\beta=0.8\end{aligned}$$

4. A

> $$M=\frac{2m_0}{\sqrt{1-\beta^2}}$$
>
> $$m_0=\frac{M}{2}\cdot\sqrt{1-\beta^2}$$
>
> $$=\frac{\mu}{2}\cdot\frac{3}{5}=0.3m_0$$

5. B

> $$\begin{aligned}5.W=\Delta E=\left[\frac{m_0}{\sqrt{1-\beta^2}}-m_0\right]c^2\\=0.25\mathrm{m}_0c^2\end{aligned}$$

6. C

7. D

> $$\begin{aligned}\varphi_M &= \int_M^P \frac{q\hat{r}}{4\pi\varepsilon_0 r^2} dr \\ &= \left.\frac{q}{4\pi\varepsilon_0 r}\right|_a^{2a} \\ &= -\frac{1}{4\pi\varepsilon_0 2a}\end{aligned}$$

8. A

> $$\begin{aligned}E = 0; \quad U &= \frac{q'_{感应+} + q'_{感应-}}{4\pi\varepsilon_0 R} + \frac{q}{4\pi\varepsilon_0 a} \\ &= \frac{q}{4\pi\varepsilon_0 a}\end{aligned}$$

9. B

> $$\begin{aligned}C &= C_1 + C_2 \\ C_1 &= \varepsilon_r C_2 \\ q_1 &= \varepsilon_r q_2 \\ q_2 &= \frac{1}{1+\varepsilon_r} Q < \frac{1}{2} Q \\ \sigma_{初} &< \sigma_{末} \\ E_{初} &< E_{末}\end{aligned}$$

10. D

填空题

1. c
2. $8.89 \times 10^{-8}\ \mathrm{s}$

> $$\Delta\tau = \sqrt{1-\beta^2 \Delta t} = \sqrt{1-\beta^2} \frac{20\ \mathrm{m}}{0.6c} = \frac{4}{5} \times \frac{20\ \mathrm{m}}{0.6c}$$
>
> $$= \frac{80\ \mathrm{m}}{3\mathrm{c}} \approx 8.89 \times 10^{-8}\ \mathrm{s}$$

1. $(n-1)M_0C^2$

> $$\frac{\tau}{t}=\sqrt{1-\beta^2}=\frac{1}{n}$$
>
> $$E_k=mc^2-M_0c^2$$
>
> $$=\frac{1-\sqrt{1-\beta^2}}{\sqrt{1-\beta^2}}\cdot\frac{1}{m_0c^2}=$$
>
> $$=(n-1)M_0C^2$$

4. $7.5\times10^{-9}\ \mathrm{s}$

> $$t=\frac{3m}{0.8c}\quad\beta=\frac{0.8c}{c}=0.8$$
>
> $$\begin{aligned}\tau&=\sqrt{1-\beta^2}\cdot\frac{3\mathrm{M}}{0.8\mathrm{C}}\\&=\frac{9\ \mathrm{m}}{4\mathrm{c}}=7.5\times10^{-9}\ \mathrm{s}\end{aligned}$$

5. $\frac{\sqrt{3}}{2}c$

> $$mV=2m_0V\quad\frac{m_0}{\sqrt{1-\beta^2}}=2m_0\quad\beta^2=\frac{3}{4}\quad\beta=\frac{\sqrt{3}}{2}\quad V=\frac{\sqrt{3}}{2}c$$

6. $4\ \mathrm{V}$

> $$U_{OA}=\int_0^A\vec{E}\cdot dx=\int_0^2 2xdx=4\ \mathrm{V}$$

7.

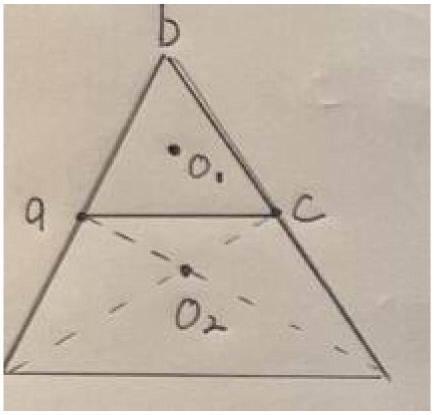
$$\frac{q}{4\pi\varepsilon_0r^2};\quad\varphi_A=\varphi_B=\frac{q}{4\pi\varepsilon_0r_C}$$

8.

$$\frac{2}{3}u_1;u_2-\frac{1}{3}u_1$$

> 考虑如图所示对称性：

$$
\begin{aligned}
&\varphi_1, \varphi_2; \varphi_1 = 2\varphi_2 \\
&u_1 = 3\varphi_1 \\
&u_2 = \varphi_1 + 2\varphi_2 \\
&u_1' = 2\varphi_1 = \tfrac{2}{3}u_1 \\
&u_2' = 2\varphi_2 = u_2 - \tfrac{1}{3}u_1
\end{aligned}
$$



9. $\varepsilon_r; \varepsilon_r$

(1).

$$
\begin{aligned}
&c' = \varepsilon_r c \\
&\tfrac{c'}{c} = \varepsilon_r
\end{aligned}
$$

(2.1)

$$
\frac{\varepsilon_0}{2} \int DE d\tau = \varepsilon_r \frac{\varepsilon_0}{2} \int E^2 d\tau
$$

(2.2) :

$$
\frac{1}{2} c' u^2 = \varepsilon_r \frac{1}{2} c u^2
$$

10. $\vec{D} = \varepsilon_0 \varepsilon_r \vec{E}$

解答题

1.

$$
(m - m_0)\, c^2 = qV
$$

$$m = m_0 + \frac{q\,\mathrm{V}}{c^2} =$$
$$\approx 2.69 \times 10^{-30}\ \mathrm{kg}$$

$$m = \frac{m_0}{\sqrt{1-\beta^2}}$$
$$1-\beta^2 = \left(\frac{m_0}{m}\right)^2$$
$$\beta = \sqrt{1-\left(\frac{m_0}{m}\right)^2}$$

$$V = 0.94\mathrm{c} = 2.82 \times 10^8\ \mathrm{m/s}$$

2. (1).

$$\tau = \frac{L_0\sqrt{1-\beta^2}}{V_0} = \frac{\frac{3}{5}\times 90\ \mathrm{m}}{0.8\mathrm{C}} = \frac{45\ \mathrm{m}}{2\mathrm{C}}\frac{135\ \mathrm{m}}{2\mathrm{c}} = 2.25 \times 10^{-7}\ \mathrm{S}$$

$$= 0.225\mu\mathrm{s}$$

(2).

$$t = \frac{\tau}{\sqrt{1-\beta^2}} = \frac{5}{3}\tau = 3.75 \times 10^{-7}\ \mathrm{S} = 0.375\mu\mathrm{S}$$

或

$$t = \frac{L_0}{V_0} = \frac{90\ \mathrm{m}}{0.80} \approx 3.75 \times 10^{-7}\ \mathrm{s}$$

3. (1)

$$D \cdot 2\pi r \cdot L = \lambda \cdot L$$

$$D = \frac{\lambda}{2\pi r}$$

$$E = \frac{D}{\varepsilon_0\varepsilon_r} = \frac{\lambda}{2\pi\varepsilon_0\varepsilon_r r}$$

(2).

$$C = \frac{Q}{U}$$

$$Q = \lambda L$$

$$U = \int_{R_1}^{R_2} E \cdot dr = \frac{\lambda}{2\pi\varepsilon_0\varepsilon r} \ln \frac{R_2}{R_1}$$

$$C = \frac{\lambda L_2\pi\varepsilon_0\varepsilon_r}{\lambda \ln \frac{R_2}{R_1}} = \frac{2\pi\varepsilon_0\varepsilon_r L}{\ln \frac{R_2}{R_1}}$$

4.(1).

$$E = \begin{cases} 0 & r < R \\ \frac{q\hat{r}}{4\pi\varepsilon_0 r^2} & r > R \end{cases}$$

(2).

$$F = \int_{r_0}^{r_0+L} \frac{q \cdot (\lambda dr)}{4\pi\varepsilon_0 r^{-2}} \hat{r} dr$$

$$= \frac{q\lambda}{4\pi\varepsilon_0} \left(\frac{1}{r_0} - \frac{1}{r_0 + L} \right) \hat{r}$$

$$U = \int_{r_0}^{r_0+L} \frac{q(\lambda dr)}{4\pi\varepsilon_0 r} dr$$

$$= \frac{q\lambda}{4\pi\varepsilon_0} \ln \frac{r_0 + L}{r_0}$$