一、

1. 无散无旋

2. 零

3. $\nabla \times \vec{H} = \vec{J} + \dfrac{\partial \vec{D}}{\partial t}$

4. $\vec{E} = -\nabla U - \dfrac{\partial \vec{A}}{\partial t}$

5. 等相位面上电场、磁场的大小、方向均相等；等相位面为平面

6. 连续；连续；不连续

7. 零

8. 无；有；有；

9. 反射系数的模值为 *1*；反射系数为零；$\theta_B = \arctan\sqrt{\dfrac{\mu_1\varepsilon_1}{\mu_2\varepsilon_2}}$；$\theta_c = \arcsin\sqrt{\dfrac{\mu_2\varepsilon_2}{\mu_1\varepsilon_1}}$

10. $a < \lambda < 2a$；$\lambda < a$

二、

1. 线极化

2. 右旋椭圆极化

3. 右旋椭圆极化

4. 左旋椭圆极化

5. 左旋圆极化

三、

将 $\rho_l dz'$ 看成为一个点电荷，则其镜像电荷位于 $\dfrac{a^2}{z'}$，电荷大小为 $-\dfrac{a}{z'}\rho_l dz'$。

则在导体球外的任意一点处电位为

$dU = \dfrac{\rho_l dz'}{4\pi\varepsilon_0 R_1} + \dfrac{-\dfrac{a}{z'}\rho_l dz'}{4\pi\varepsilon_0 R_2}$，其中 $R_1 = \sqrt{\rho^2 + (z-z')^2}$；

那么整个线段的总电位为

$$U = \int_b^{b+l} \dfrac{\rho_l dz'}{4\pi\varepsilon_0 R_1} + \dfrac{-\dfrac{a}{z'}\rho_l dz'}{4\pi\varepsilon_0 R_2} = \dfrac{\rho_l}{4\pi\varepsilon_0}\int_b^{b+l}\left(\dfrac{1}{R_1} + \dfrac{-\dfrac{a}{z'}}{R_2}\right)dz'；$$

$$\frac{\rho_l}{4\pi\varepsilon_0}\int_b^{b+l}\frac{1}{R_1}dz' = \frac{\rho_l}{4\pi\varepsilon_0}\int_b^{b+l}\frac{1}{\sqrt{\rho^2+(\mathrm{z}-\mathrm{z}')^2}}dz'$$

$$= \frac{\rho_l}{4\pi\varepsilon_0}\ln\left[(\mathrm{z}'-\mathrm{z})+\sqrt{\rho^2+(\mathrm{z}-\mathrm{z}')^2}\right]\Big|_b^{b+l}$$

$$= \frac{\rho_l}{4\pi\varepsilon_0}\ln\left[\frac{(b-l-\mathrm{z})+\sqrt{\rho^2+(b-l-z)^2}}{(b-\mathrm{z})+\sqrt{\rho^2+(b-z)^2}}\right]$$

第二部分积分计算：

$$U_m = \frac{\rho_l}{4\pi\varepsilon_0}\int_b^{b+l}\left(\frac{-\frac{a}{z'}}{R_2}\right)dz' = \frac{\rho_l}{4\pi\varepsilon_0}\int_b^{b+l}\frac{-\frac{a}{z'}}{\sqrt{\rho^2+(\mathrm{z}-\frac{a^2}{z'})^2}}dz' = \frac{\rho_l}{4\pi\varepsilon_0}\int_b^{b+l}\frac{-a}{\sqrt{(z'\rho)^2+(z'\mathrm{z}-a^2)^2}}dz'$$

$$= -\frac{a\rho_l}{4\pi\varepsilon_0}\int_b^{b+l}\frac{1}{\sqrt{(z')^2\left(\rho^2+\mathrm{z}^2\right)-2(\mathrm{z}\,a^2)z'+a^4}}dz' = -\frac{a\rho_l}{4\pi\varepsilon_0}\int_b^{b+l}\frac{1}{\sqrt{(z')^2R^2-2(\mathrm{z}\,a^2)z'+a^4}}dz'$$

$$= -\frac{a\rho_l}{4\pi\varepsilon_0 R}\int_b^{b+l}\frac{1}{\sqrt{(z')^2-\frac{2(\mathrm{z}\,a^2)}{R^2}z'+\frac{a^4}{R^2}}}dz' = -\frac{a\rho_l}{4\pi\varepsilon_0 R}\int_b^{b+l}\frac{1}{\sqrt{\left(z'-\frac{\mathrm{z}\,a^2}{R^2}\right)^2-\frac{\mathrm{z}^2a^4}{R^4}+\frac{a^4}{R^2}}}dz'$$

令 $Z=\frac{\mathrm{z}\,a^2}{R^2}$； $Q^2=-\frac{\mathrm{z}^2a^4}{R^4}+\frac{a^4}{R^2}$；

则上式变为

$$U_m = -\frac{a\rho_l}{4\pi\varepsilon_0 R}\int_b^{b+l}\frac{1}{\sqrt{(z'-Z)^2+Q^2}}dz' = -\frac{a\rho_l}{4\pi\varepsilon_0 R}\ln\left[\frac{(b-l-Z)+\sqrt{Q^2+(b-l-Z)^2}}{(b-Z)+\sqrt{Q^2+(b-Z)^2}}\right]$$

四、

解：求解空间电位满足拉普拉斯方程，$\nabla^2\varphi = 0$

边界条件：$\varphi(x,0) = 0$，$\varphi(x,d) = 0$，$0 < x < \infty$

$\varphi(0,y) = 0$，$\varphi(x\to\infty, y) = 0$，$0 < y < d$

通解为：

$$\varphi(\rho,\phi) = (A_0 + B_0x)(C_0 + D_0y) + \sum_{n=1}^{\infty}(A_n\sinh k_nx + B_n\cosh k_nx)(C_n\sin k_ny + D_n\cos k_ny)$$

进行待定系数求解，傅里叶级数展开

得到电位结果为

$$\varphi(x,y) = \sum_{n=1,3,5}^{\infty}\frac{4U_0}{n\pi}\sin\frac{n\pi}{d}ye^{-\frac{n\pi}{d}x}$$

五、

1) $k=\omega\sqrt{\varepsilon_r\varepsilon_0\mu_r\mu_0}=\omega\sqrt{\varepsilon_r\mu_r}\sqrt{\varepsilon_0\mu_0}=\frac{\omega\sqrt{\varepsilon_r\mu_r}}{c}=\frac{10^{10}\pi 9}{3\cdot 10^{8}}=300\pi$

$$\eta=\sqrt{\frac{\mu_r\mu_0}{\varepsilon_r\varepsilon_0}}=\sqrt{\frac{\mu_r}{\varepsilon_r}}\sqrt{\frac{\mu_0}{\varepsilon_0}}=\frac{1}{9}120\pi=\frac{40}{3}\pi$$

$$v_p=\frac{\omega}{k}=\frac{\omega}{\frac{\omega\sqrt{\varepsilon_r\mu_r}}{c}}=\frac{c}{\sqrt{\varepsilon_r\mu_r}}=0.33e10^{8}$$

2) $\vec{H}(y,t)=0.1\sin(10e10\pi t-\pi/3-ky)\hat{x}\quad A/m$

$$\vec{H}(y,t)=0.1\cos\left(10e10\pi t-\pi/3-ky-\frac{\pi}{2}\right)\hat{x}$$

$$\Rightarrow\vec{H}(y)=0.1\exp\left(j\left(10e10\pi t-ky-\frac{5\pi}{6}\right)\right)\hat{x}$$

$$\vec{E}(y)=-\eta\hat{k}\times\vec{H}(y)=\frac{4}{3}\pi\hat{z}\exp\left(j\left(10e10\pi t-ky-\frac{5\pi}{6}\right)\right)\quad V/m$$

3) $\vec{P}=\frac{1}{2}\mathrm{Re}\left[\vec{E}(y)\times\vec{H}^*(y)\right]=\frac{\pi}{15}\hat{y}\quad W$

六、

（1）左旋圆极化波

（2）$\boldsymbol{E}_r=-\boldsymbol{e}_x E_0\cos(\omega t+kz)-\boldsymbol{e}_y E_0\sin(\omega t+kz)$

（3）右旋圆极化波

七、

1) $TE_{10}: f_c=\frac{\sqrt{\left(\frac{1}{a}\right)^2}}{2\sqrt{\varepsilon_0\mu_0}}=\frac{c}{2a}$

$$\beta=k\sqrt{1-\frac{f_c^2}{f^2}}=\frac{2\pi f}{c}\sqrt{1-\frac{f_c^2}{f^2}}=80\pi\sqrt{1-\left(\frac{1}{80a}\right)^2}=102.65rad/m\Rightarrow \text{a= 0.0137m}$$

2)

$\lambda_g=\frac{2\pi}{\beta}=0.0612m$；$v_p=\frac{\omega}{\beta}=\frac{2\pi f}{\beta}=7.345e8$

$$\eta_{TE}=\frac{\omega\mu}{\beta}=\frac{\omega\mu}{k\sqrt{1-\frac{f_c^2}{f^2}}}=\eta\left(1-\frac{f_c^2}{f^2}\right)^{-\frac{1}{2}}=120\pi\sqrt{1-\left(\frac{1}{80a}\right)^2}=154.295\Omega$$

3) 已知 *TE10* 模的纵向磁场为：$H_z(x,y,z)=H_{\mathrm{m}}\cos(\dfrac{\pi}{a}x)\mathrm{e}^{-\mathrm{j}\gamma z}$

则横向磁场和电场为：

$$H_x(x,y,z)=-\frac{j\beta}{k_{\mathrm{c}}^2}\nabla_t H_z=\frac{ja\beta}{\pi}H_{\mathrm{m}}\sin(\frac{\pi}{a}x)\mathrm{e}^{-\mathrm{j}\gamma z}$$

$$E_y(x,y,z)=-Z_{TE}\,\frac{ja\beta}{\pi}H_{\mathrm{m}}\sin(\frac{\pi}{a}x)\mathrm{e}^{-\mathrm{j}\gamma z}$$

$$\vec{S}_{\mathrm{av}}=\frac{1}{2}\mathrm{Re}[\vec{E}\times\vec{H}^*]=\frac{1}{2}\mathrm{Re}[(\vec{e}_yE_y)\times(\vec{e}_xH_x+\vec{e}_zH_z)^*]$$

$$=-\hat{z}\frac{1}{2}\mathrm{Re}(E_yH_x^*)=\hat{z}\frac{1}{2}\frac{\left|E_y\right|^2}{Z_{TE_{10}}}=\hat{z}\frac{1}{2}Z_{TE_{10}}\left|H_x\right|^2=\hat{z}\frac{1}{2}Z_{TE_{10}}\left|\frac{a\beta}{\pi}H_{\mathrm{m}}\sin(\frac{\pi}{a}x)\right|^2$$