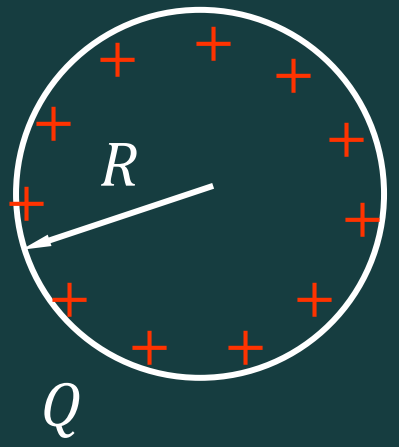
例2　均匀带电球壳的电势.

真空中，有一带电为$Q$，半径为$R$的带电球壳.

试求任意点的电势.



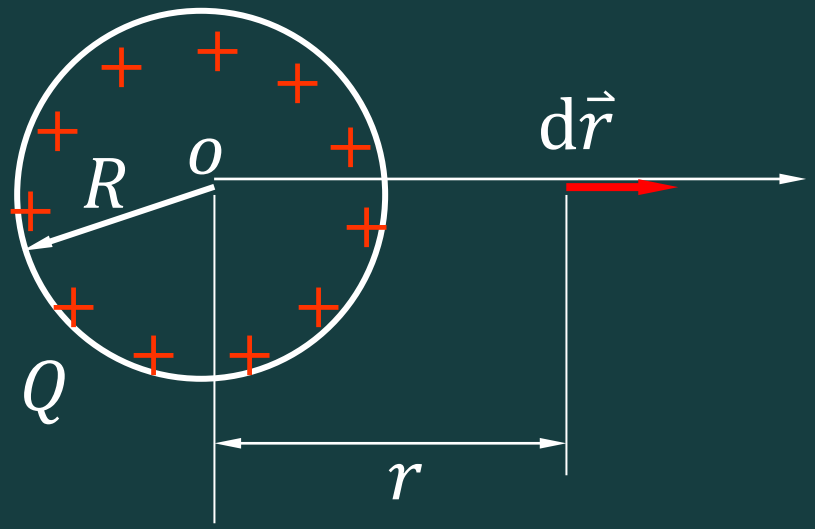
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解

$$\begin{cases} r < R, \ \vec{E}_1 = 0 \\ r > R, \ \vec{E}_2 = \dfrac{q}{4\pi\varepsilon_0 r^2}\vec{e}_r \end{cases}$$

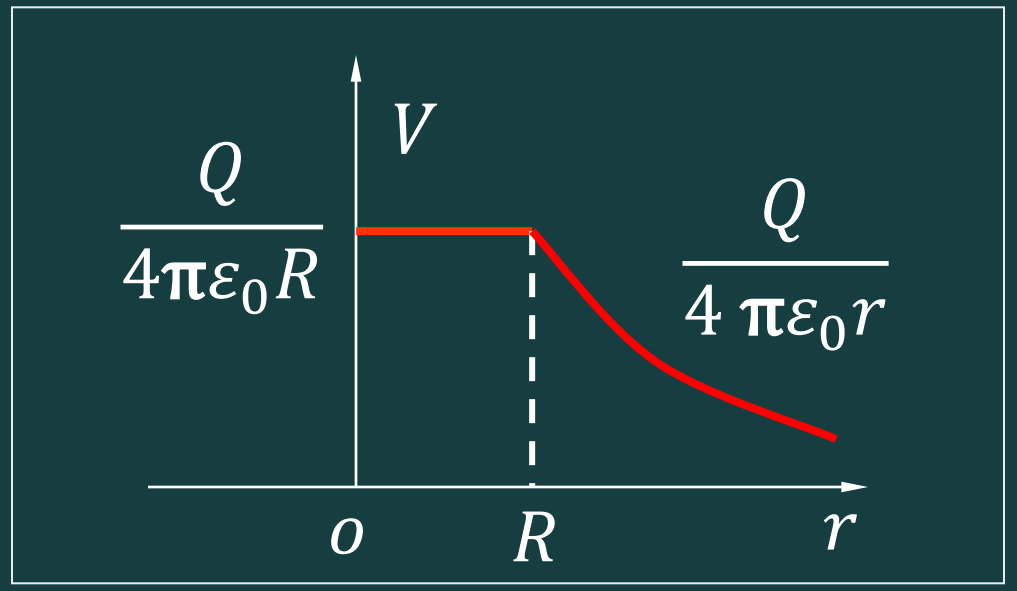



- $V_{外}(r) = \int_r^{\infty} \vec{E}_2 \cdot \mathrm{d}\vec{r} = \int_r^{\infty} \dfrac{Q}{4\pi\varepsilon_0 r^2}\mathrm{d}r = \dfrac{Q}{4\pi\varepsilon_0 r}$

- 由 $V_{外}(r)=\dfrac{Q}{4\pi\varepsilon_0 r}$ 可得 $V(R)=\dfrac{Q}{4\pi\varepsilon_0 R}$

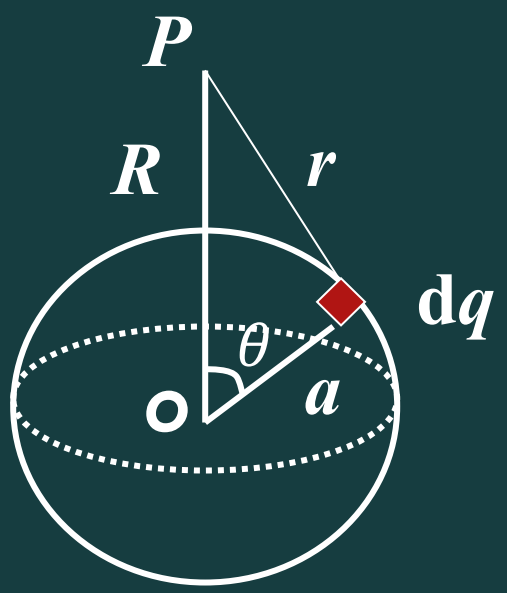
- 得 $V_{内}(r)=\int_r^R \vec{E}_1\cdot \mathrm{d}\vec{r}+\int_R^\infty \vec{E}_2\cdot \mathrm{d}\vec{r}=\dfrac{Q}{4\pi\varepsilon_0 R}$

$$\begin{cases} V_{外}(r)=\dfrac{Q}{4\pi\varepsilon_0 r} \\ V_{内}(r)=\dfrac{Q}{4\pi\varepsilon_0 R} \end{cases}$$



也可以根据电势叠加原理，

$$U(R)=\oint_S \frac{\sigma \mathrm{d}S'}{4\pi\varepsilon_0 r}$$

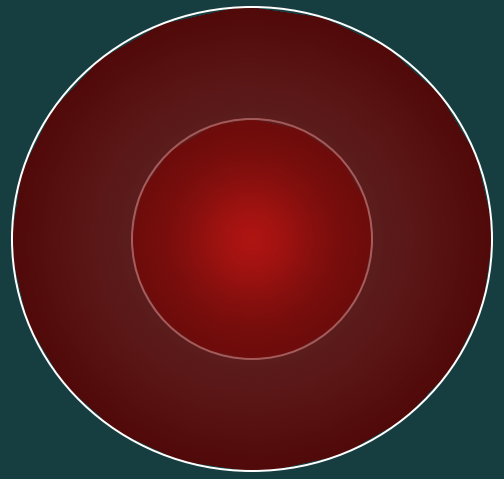



求出球壳内、外任一点的电势，其中

$$r=(R^2+a^2-2Ra\cos\theta)^{1/2}$$

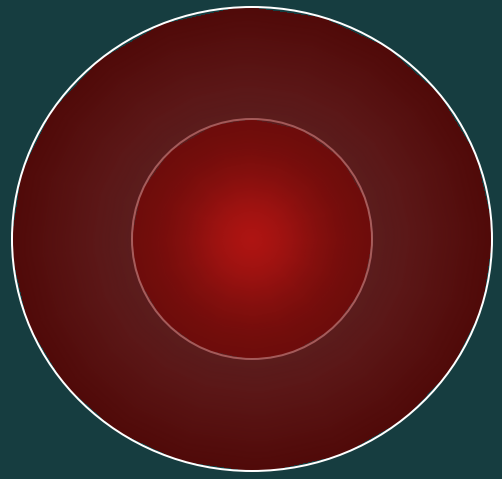
积分时需要考虑$R>a$（场点P在球外）和$R<a$（场点P在球内）两种情况。

- 两个半径分别为$R_1$及$R_2$的同心均匀带电球面，内球带电荷$q_1$，外球带电荷$q_2$。求内球电势。（参考点选在无限远。）



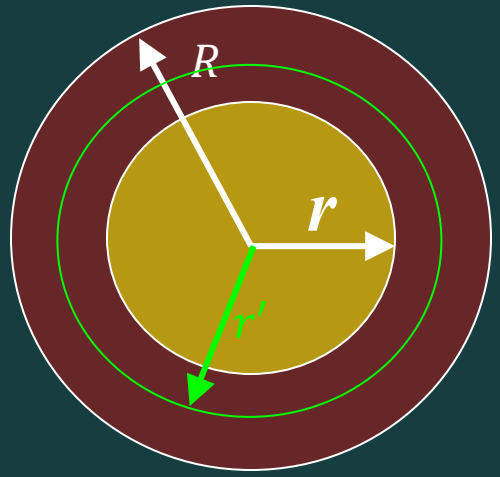
- 答：内球的电势为

$$V_1 = \frac{q_1}{4\pi\varepsilon_0 R_1} + \frac{q_2}{4\pi\varepsilon_0 R_2}$$



- 电荷$Q$均匀分布在半径为$R$的球体内，选电势参考点在无限远处，求离球心$r$处$(r < R)$的电势。

# 解法（一）

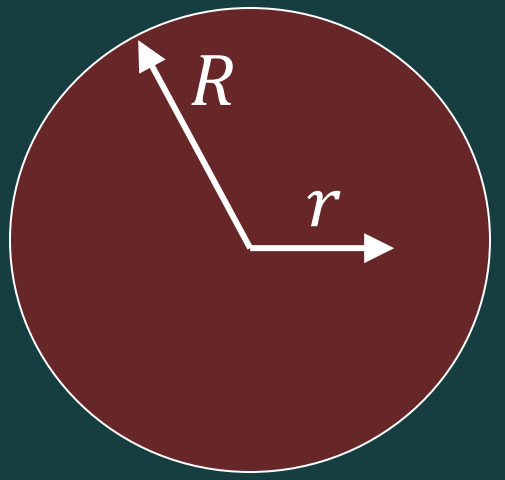



- 答：

$$U=\frac{\rho\frac{4}{3}\pi r^3}{4\pi\varepsilon_0 r}+\int_r^R\frac{\rho 4\pi r'^2\mathrm{d}r'}{4\pi\varepsilon_0 r'}=\frac{\rho r^2}{3\varepsilon_0}+\int_r^R\frac{\rho r'\mathrm{d}r'}{\varepsilon_0}$$

$$=\frac{\rho r^2}{3\varepsilon_0}+\frac{\rho(R^2-r^2)}{2\varepsilon_0}=\frac{Q}{\frac{4}{3}\pi R^3}\frac{(3R^2-r^2)}{6\varepsilon_0}=\frac{Q(3R^2-r^2)}{8\pi R^3\varepsilon_0}$$

# 解法（二）




$$U = \frac{Q}{4\pi\varepsilon_0 R} + \int_r^R E\,\mathrm{d}r'$$

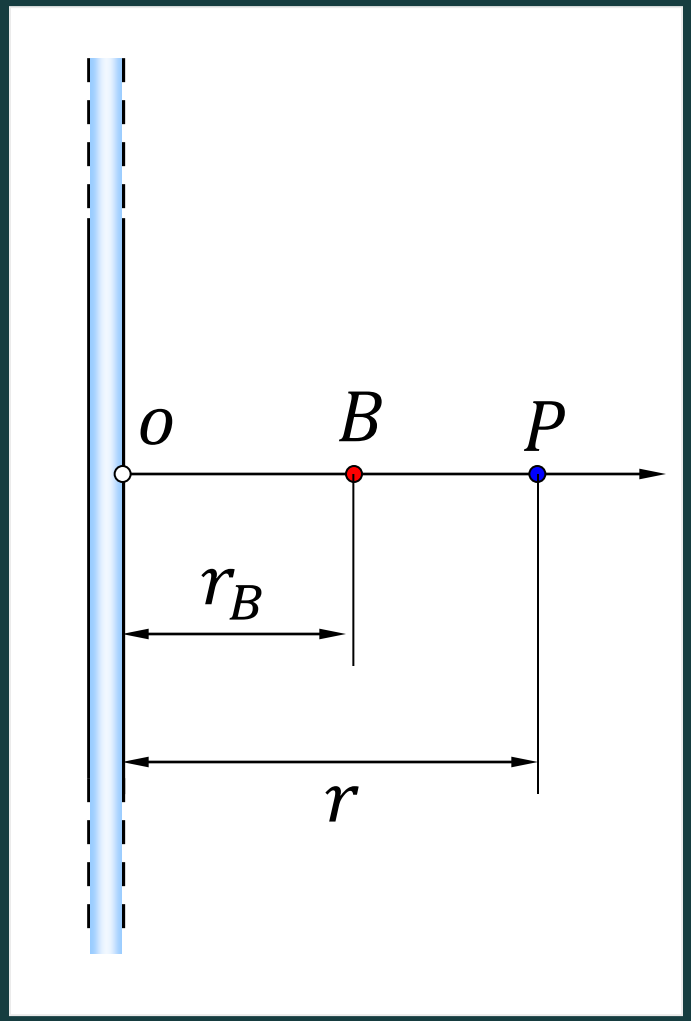
$$= \frac{Q}{4\pi\varepsilon_0 R} + \int_r^R \frac{\rho r'\,\mathrm{d}r'}{3\varepsilon_0} = \frac{Q}{4\pi\varepsilon_0 R} + \frac{\rho(R^2 - r^2)}{6\varepsilon_0}$$

$$= \frac{Q}{4\pi\varepsilon_0 R} + \frac{Q}{\frac{4}{3}\pi R^3}\frac{(R^2 - r^2)}{6\varepsilon_0} = \frac{Q}{4\pi\varepsilon_0 R} + \frac{Q(R^2 - r^2)}{8\pi R^3\varepsilon_0}$$

$$= \frac{Q(3R^2 - r^2)}{8\pi R^3\varepsilon_0}$$

# 例3　“无限长”均匀带电直线的电势

令　$V_B = 0$



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