Information

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Office hour: Tuesday 14:00-16:00

Teaching outline and Grading policy

Chapter	Sections
21	1,2,3
22	1,2,3,4,5,6,7
23	1,2,3,4,5,6
24	1,2,3,4,5,6,7,8
25	1,2,3,4,5,6
26	1,2,3,4,5
27	1,2,3,4
28	1,2,3,4,5,6,7,8
29	1,2,3,4,5
30	1,2,3,4,5,6,7,8,9
31	1,2,3,4,5,6
32	1,2,3,4,5,6,7,8
33	1,2,3,4,5,6,7
34	1,2,3,4,5,6
35	1,2,3,4,5
36	1,2,3,4,5,6,7
37	1,2,3,4,5,6
38	1,2,3,4,5,6,7,8,9

Mid-term Exam (chapters 21–29)

Final Exam (chapters 21–38)

Grading Policy:

❖Selected Homework: 10%,

❖In class test:10%

❖Midterm exam: 40%,

❖Final Exam: 40% .

Exam arrangement:

❖Midterm, chapters 21-29

Nov. 20th 9:00~11:00

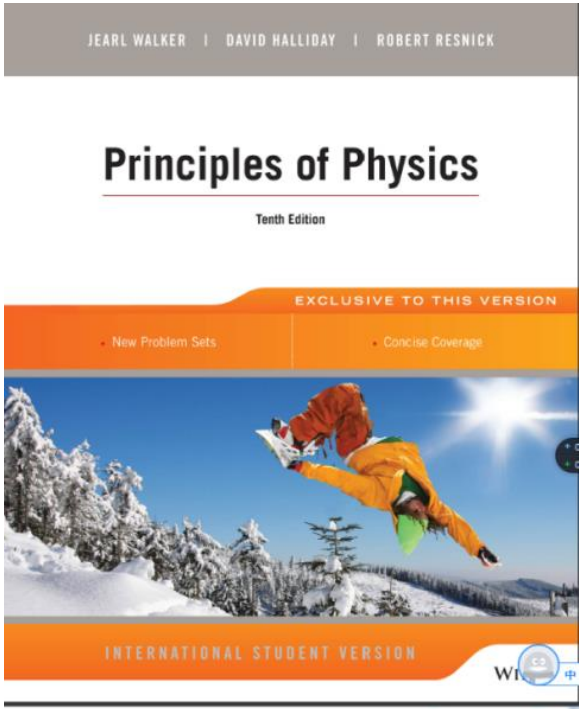
Make-up Nov. 26th 19:00~21:00

❖Final exam, chapters 21-33&35-38

The sections marked in red are not included in examinations.

The schedule may be adjusted according to the real pace of the course:

Attentions:



1. Use blackboard system to submit, grade and return homework.

2. Text book: 《Principles of Physics》 Tenth Edition
download its soft copy from QQ group or from blackboard

3. Write answers in order on the paper, take photos , save them as a single pdf file and uploaded it to the blackboard

4. Write your NAME, student number and chapter-number(Example: Ch21-10) on the top of the paper.

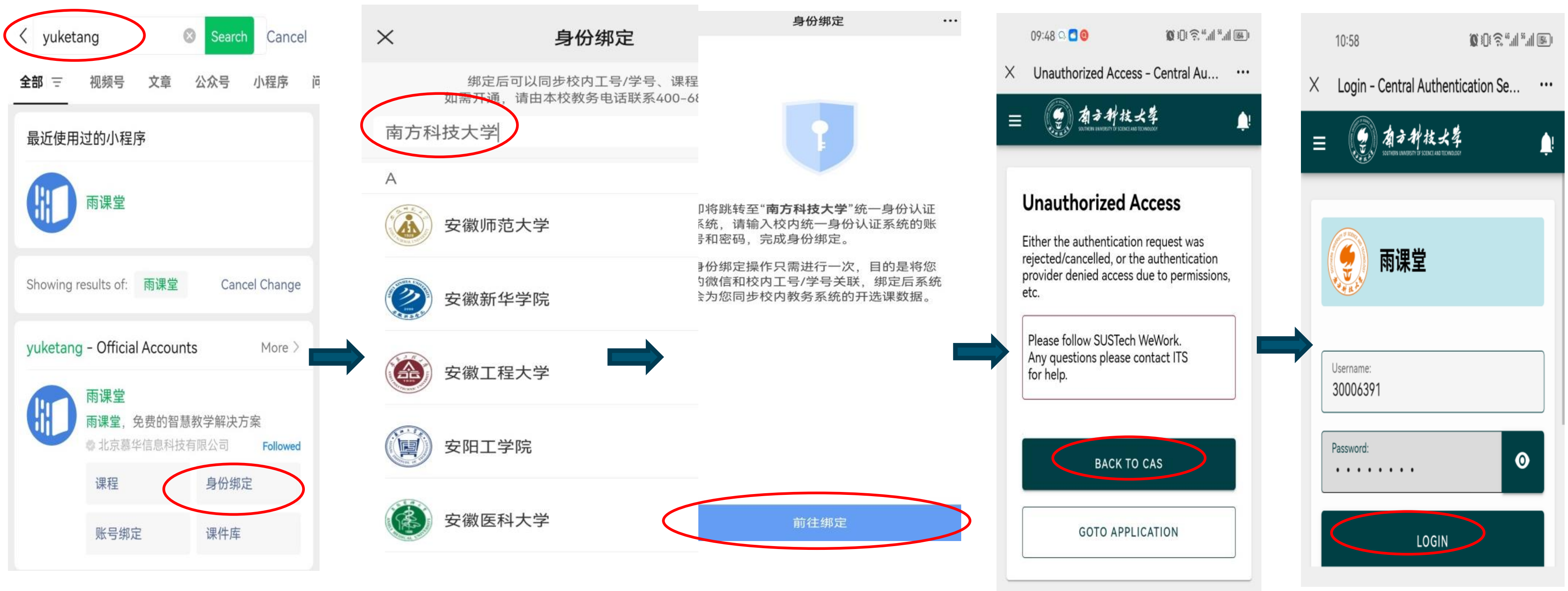
5. **Homework submitted within 48 hours after the deadline will be graded, but with a maximum score of 50%; homework submitted 48 hours after the deadline will not be graded!**

6. Check your homework from blackboard and QQ group weekly.

7. Prepare a calculate. Homework, exams need it!

Prepare for In-class Test

1. We use Yuketang to do the in-class test
2. First we need to binding Yuketang by following the steps :



1) Search Yuketang in wechat 3) Search “南方科技大学” 4) Click the icon “前往绑定” 5) BACK TO CAS 6) LOGIN

2) Chose “身份绑定” in Official Accounts

Key words for chapter 21~22

Electric Charge

Point charge

Conductor

Insulator

Semiconductor

Superconductor

Coulomb

Coulomb’s law

Permittivity constant

Superposition

Proton

Neutron

Neutralize

Electron

Electric filed

Shell theorem

Electrostatic

Polarization

Elementary charge

Quantized

Electrostatic force

Repulsion

Attraction

Rod， Sheet， Disk， Ring

Spherical

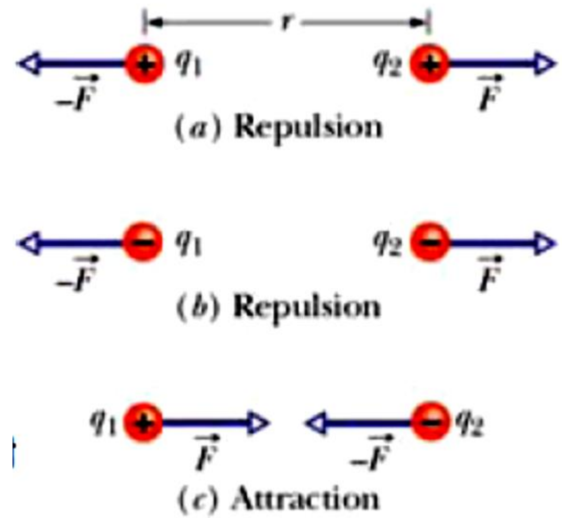
Electric dipole

Electric dipole moment

Coulomb's law (库伦定律)

The **electrostatic force** between two charges q_1 and q_2 separated by a distance r has the magnitude

$$\boxed{F = k\frac{|q_1 q_2|}{r^2}}$$



$$\boxed{k = \frac{1}{4\pi\varepsilon_0} = 8.99\times10^9\ \mathrm{N{\cdot}m^2/C^2}}$$

k is the electromagnetic constant

ε_0 is the permittivity constant (介电常数，电容率)

$$\boxed{\varepsilon_0 = 8.85\times10^{-12}\ \mathrm{C^2/N\cdot m^2}}$$

The electric field due to a point charge

The magnitude of the electric field from a point charge is:

$$\boxed{E = k\frac{|q|}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{|q|}{r^2}}$$

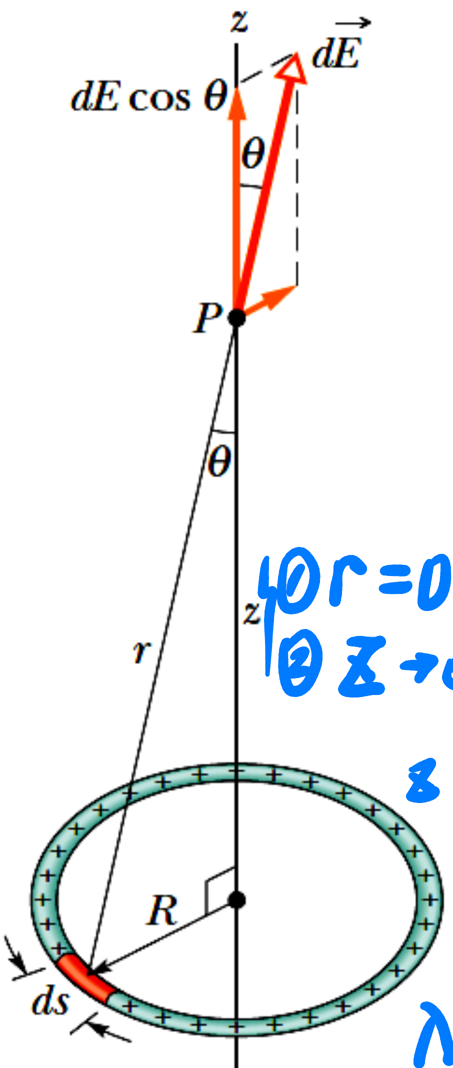
连线方向上

单位向量

Vector form :

$$\boxed{\vec{E} = k\frac{q}{r^3}\vec{r} = \frac{q}{4\pi\varepsilon_0 r^3}\vec{r} = \frac{q}{4\pi\varepsilon_0 r^2}\hat{r}}$$

Electric field due to a uniform charged ring



$$dq = \lambda\, ds$$ **λ is the charge per unit (arc) length**

$$dE = \frac{1}{4\pi\varepsilon_0}\frac{dq}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{\lambda\, ds}{r^2}$$

$$dE = \frac{1}{4\pi\varepsilon_0}\frac{\lambda\, ds}{(z^2 + R^2)}$$

$$\cos\theta = \frac{z}{r} = \frac{z}{(z^2 + R^2)^{1/2}}$$

① $r=0$
② $z\to\infty$ 可视为点电荷

$$dE\cos\theta = \frac{z\lambda}{4\pi\varepsilon_0(z^2 + R^2)^{3/2}}\, ds$$

z与r可比时应积分

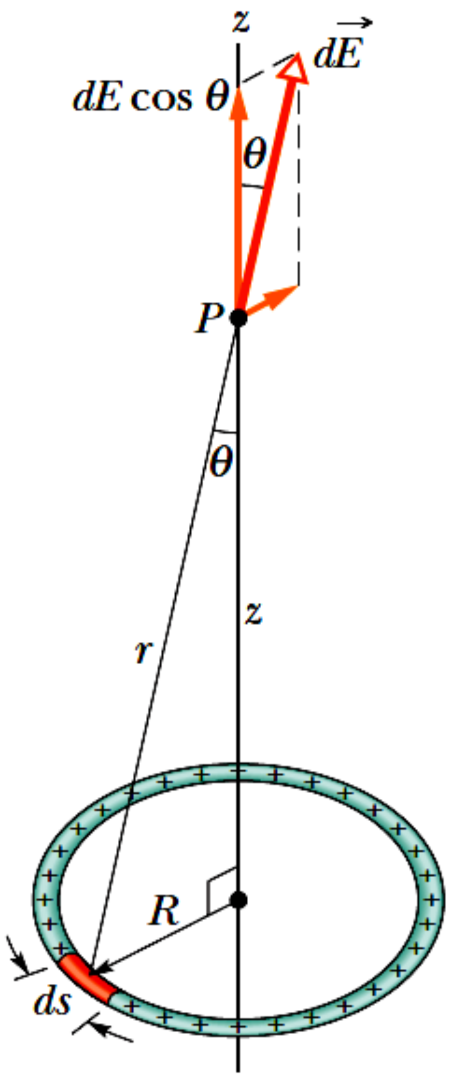
$$E = \int dE\cos\theta = \frac{z\lambda}{4\pi\varepsilon_0(z^2 + R^2)^{3/2}}\int_0^{2\pi R} ds$$

$\lambda = \frac{dq}{dl}$ ↓ 电荷密度(线)

λ不均匀时写成函数

二维 $\sigma = \frac{dq}{dA}$

Electric field due to a uniform charged ring



$$E = \int dE\cos\theta = \frac{z\lambda}{4\pi\varepsilon_0(z^2+R^2)^{3/2}}\int_0^{2\pi R} ds$$

$$= \frac{z\lambda(2\pi R)}{4\pi\varepsilon_0(z^2+R^2)^{3/2}}$$

$$\boxed{E = \frac{qz}{4\pi\varepsilon_0(z^2+R^2)^{3/2}} \quad \text{(charged ring)}}$$

if z >> R

$$\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{q}{z^2} \quad \text{(charged ring at large distance)}}$$

(Point charge)

E field due to a continuous charge distribution

Apply integral to calculate the *E* field at a point *P* set up by a continuous charge distribution:

1, divide the charge into proper charge elements

2, Write the ***E*** field at point *P* due to an arbitrary charge element

3, Sometimes the symmetry of the charge distribution can simplify our calculation

4, Write *dq* in terms of the charge density and geometry element:

$$dq = \lambda dl = \cdots\cdots$$

$$dq = \sigma dA = \cdots\cdots$$

$$dq = \rho dV = \cdots\cdots$$

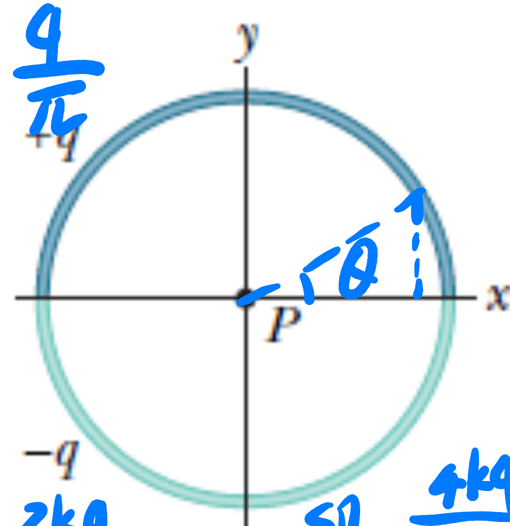
rewrite the components of the ***E*** filed, the "*r*", the interval etc. to get the integral expression.

5, Solve the integral.

Problem 1

Two curved plastic rods, one of charge $+q$ and the other of charge $-q$, form a circle of radius R = 8.50cm in an xy plane. The x axis passes through both of the connecting points, and the charge is distributed uniformly on both rods. If q =15.0pC, what are the (a)magnitude and (b) direction of the electric field at P, the center of the circle?

$$dE = \frac{k\,dq}{r^2} \qquad \frac{dq}{d\theta} = \frac{q}{\pi}$$



$$dE_y = \frac{kq}{\pi r^2} d\theta \sin\theta$$

$$E_y = \frac{kq}{\pi r^2}\int_0^{\pi} d\theta \sin\theta$$

$$= \frac{kq}{\pi r^2}(-\cos\theta)\Big]_0^{\pi} = \frac{2kq}{\pi r^2}$$

so $\frac{4kq}{\pi r^2}$

若单位向量表示

$+ \; -\hat{y}$

(方向)

Problem 1

From symmetry, we see that the net field at P is twice the field caused by the upper semicircular charge $+q = \lambda(\pi R)$ (and it points downward)

Consider a differential element having arc length ds, $dq = \lambda ds$

Our element produces a differential electric field at point P $\quad dE = \dfrac{1}{4\pi\varepsilon_0}\dfrac{\lambda ds}{r^2}$

we need sum (via integration) only the y components of the differential electric fields set up by all the differential elements of the rod.

$$dE_y = dE\cos\theta = \frac{1}{4\pi\varepsilon_0}\frac{\lambda}{r^2}\cos\theta ds = \frac{1}{4\pi\varepsilon_0}\frac{\lambda}{r^2}\cos\theta r d\theta$$

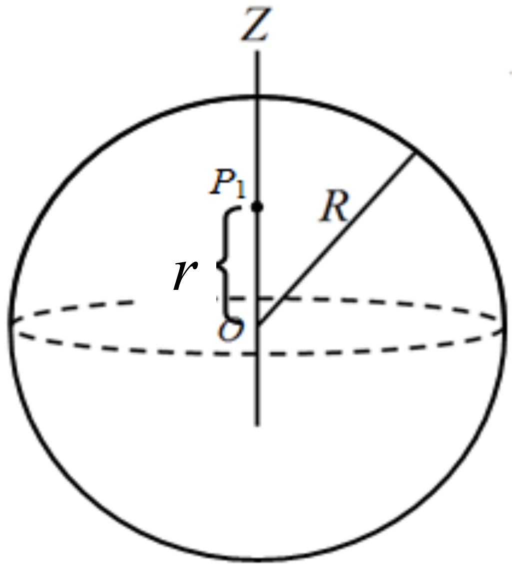
$$So,\ \vec{E}_{\text{net}} = 2\left(-\hat{\text{j}}\right)\int dE_y = 2\left(-\hat{\text{j}}\right)\int_{-90^\circ}^{90^\circ}\frac{1}{4\pi\varepsilon_0}\frac{\lambda}{r^2}\cos\theta r d\theta$$

$$\vec{E}_{\text{net}} = 2\left(-\hat{\text{j}}\right)\frac{\lambda}{4\pi\varepsilon_0 R}\sin\theta\Big|_{-90^\circ}^{90^\circ} = -\left(\frac{q}{\varepsilon_0\pi^2 R^2}\right)\hat{\text{j}}$$

(a) $|\vec{E}_{\text{net}}| = 23.8\ \text{N/C}.$

(b) The net electric field $\vec{E}_{\text{net}}$ points in the $-\hat{\text{j}}$ direction, or $-90°$ counterclockwise from the $+x$ axis.

Problem 2



A spherical shell has radius R and uniform surface charge density σ as shown in figure. Start from the ***E*** field due to a uniform thin ring on its central axis to derive the ***E*** field inside and outside of the spherical shell?

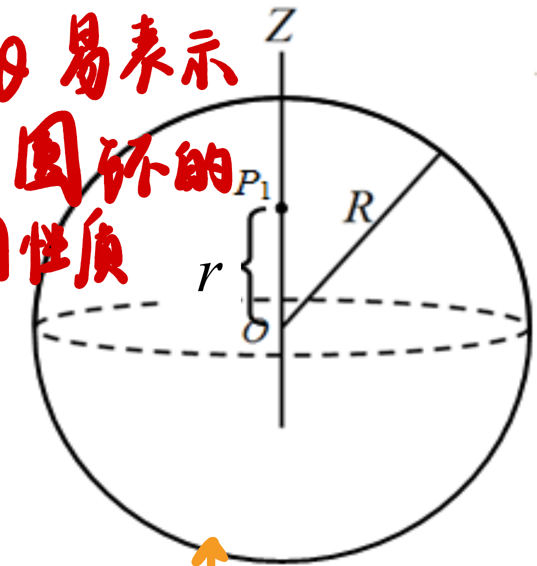
$$\boxed{E = \frac{qz}{4\pi\varepsilon_0(z^2 + R^2)^{3/2}} \qquad \text{(charged ring)}}$$

Problem 2

*从一个面积的模型出发 化二重积分为两次积分

a) Find $\boldsymbol{E}$ field inside of shell (at point P_1) ?

设θ易表示整个圆环的共同性质



We can divide the spherical shell into many tiny rings. For each ring, we have calculated the E field created by it at a point P_1 setting on its central axis, if we choose an arbitrary ring as show in figure, the tiny charge of this ring is dq and the magnitude of E field at point P_1 is:

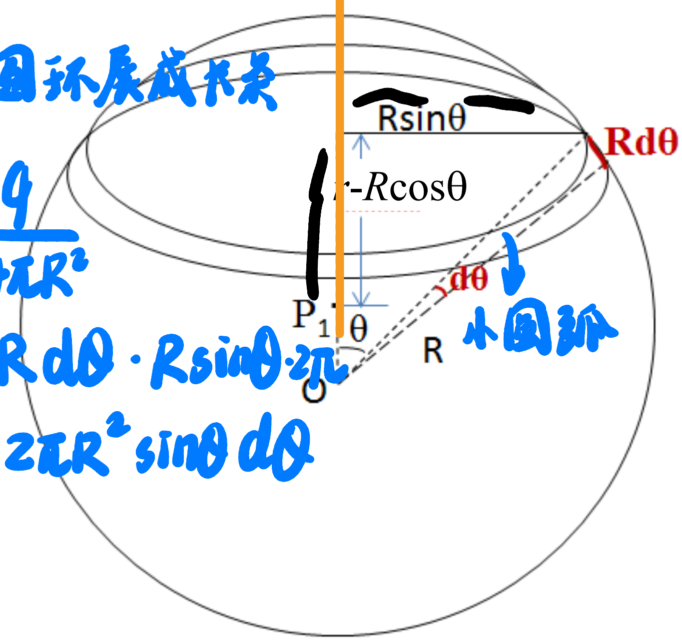
z有正负，直接决定E方向

$$\boldsymbol{dE} = \frac{z\boldsymbol{dq}}{4\pi\varepsilon_0(z^2+\boldsymbol{R}^2)^{3/2}}$$ General expression

$$= \frac{(r-R\cos\theta)dq}{4\pi\varepsilon_0((r-R\cos\theta)^2+(R\sin\theta)^2)^{3/2}}$$

z上距离用θ表示

圆环展成长条

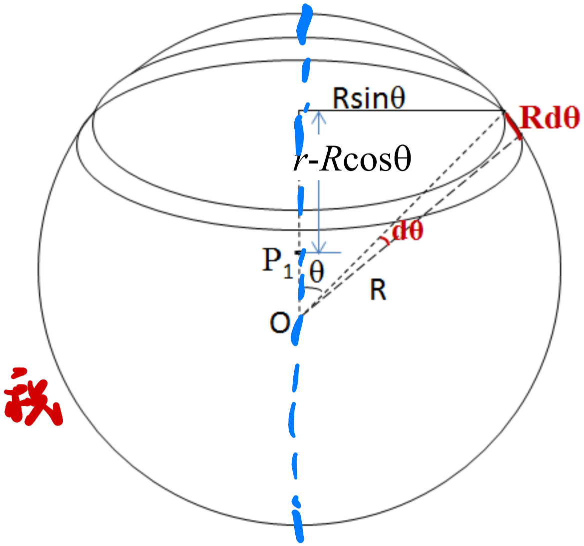


$$\frac{dQ}{dA} = \frac{q}{4\pi R^2}$$

$$dA = Rd\theta \cdot R\sin\theta \cdot 2\pi = 2\pi R^2\sin\theta\, d\theta$$

Problem 2

a) Find E field inside of the shell (at point P_1) ?



$$\sigma = \frac{dq}{dA} \Rightarrow dq = \sigma dA = \sigma(2\pi R\sin\theta)(Rd\theta) = 2\pi R^2\sigma\sin\theta d\theta$$

考虑右侧一半

没有对称性要全积

$$E = \int_A dE = \int_0^\pi \frac{(r - R\cos\theta)2\pi R^2\sigma\sin\theta d\theta}{4\pi\varepsilon_0(R^2 - 2Rr\cos\theta + r^2)^{3/2}}$$

查表

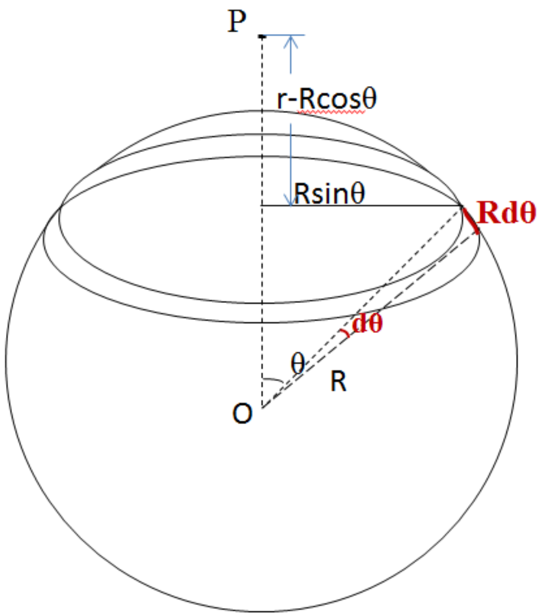
$$\int \frac{\sin x(a\cos x - b)dx}{(a^2 + b^2 - 2ab\cos x)^{3/2}} = \frac{-a + b\cos x}{b^2\sqrt{a^2 + b^2 - 2ab\cos x}}$$

* 球壳定理

$$E = \frac{R^2\sigma(R - r\cos\theta)}{2\varepsilon_0 r^2\sqrt{R^2 - 2Rr\cos\theta + r^2}}\Bigg|_0^\pi = \left(\frac{R^2\sigma(R+r)}{2\varepsilon_0 r^2(R+r)} - \frac{R^2\sigma(R-r)}{2\varepsilon_0 r^2(R-r)}\right) = 0$$

Problem 2

b) Find E field outside of shell (at point P) ?



$$\sigma = \frac{dq}{dA} \Rightarrow dq = \sigma dA = \sigma(2\pi R\sin\theta)(Rd\theta) = 2\pi R^2\sigma\sin\theta d\theta$$

$$E = \int_A dE = \int_0^{\pi} \frac{(r - R\cos\theta)2\pi R^2\sigma\sin\theta d\theta}{4\pi\varepsilon_0(R^2 - 2Rr\cos\theta + r^2)^{3/2}}$$

$$\int \frac{\sin x(a\cos x - b)dx}{(a^2 + b^2 - 2ab\cos x)^{3/2}} = \frac{-a + b\cos x}{b^2\sqrt{a^2 + b^2 - 2ab\cos x}}$$

$$E = \frac{R^2\sigma(R_0 - r\cos\theta)}{2\varepsilon_0 r^2\sqrt{R^2 - 2Rr\cos\theta + r^2}}\Bigg|_0^{\pi} = \frac{R^2\sigma(R + r)}{2\varepsilon_0 r^2|R + r|} - \frac{R_0{}^2\sigma(R - r)}{2\varepsilon_0 r^2|R - r|} \Rightarrow E = \frac{R^2\sigma}{\varepsilon_0 r^2} = \frac{Q}{4\pi\varepsilon_0 r^2}$$