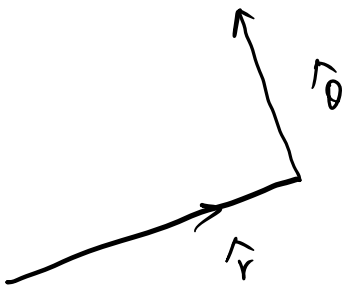
I. Centripetal force → Gravity

向心力

A Centripetal force is that by which bodies are drawn or impelled, or any way tend, towards a point as to centre. << mathematical principles of natural philosophy >>



如何确定矢量的方向？

$$\vec{r} = x\hat{x} + y\hat{y}$$ （位置矢量描述）

projection: $\vec{r}\cdot\hat{x} = x$

$\vec{r}\cdot\hat{y} = y$

$\vec{r}(x,y)$ 也可以写为 $\vec{r}(r,\theta)$

$$\hat{x} = \lim_{\Delta x\to 0} \frac{\vec{r}(x+\Delta x, y) - \vec{r}(x,y)}{\left|\vec{r}(x+\Delta x, y) - \vec{r}(x,y)\right|}$$

x 方向变化量为 Δx

同理定义 $\hat{y}$ （可以考虑极限 partial）

从类比的方式看待

$$\hat{r} = \lim_{\Delta r \to 0} \frac{\vec{r}(r+\Delta r, \theta) - \vec{r}(r, \theta)}{\left|\vec{r}(r+\Delta r, \theta) - \vec{r}(r, \theta)\right|}$$

$$\hat{\theta} = \lim_{\Delta \theta \to 0} \frac{\vec{r}(r, \theta+\Delta\theta) - \vec{r}(r, \theta)}{\left|\vec{r}(r, \theta+\Delta\theta) - \vec{r}(r, \theta)\right|}$$

由此可见 $\hat{\theta}$ 的方向.

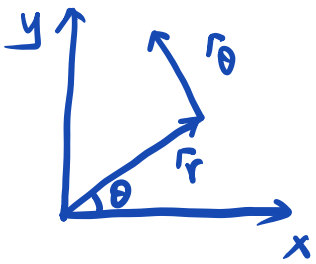
讨论随时间的变化率.

1° 几何作图法

2° 三角函数微分法

$$\vec{r} = x\hat{x} + y\hat{y} = r\hat{r}$$

$$= r\cos\theta\hat{x} + r\sin\theta\hat{y}$$



$$\hat{r} = \cos\theta\,\hat{x} + \sin\theta\,\hat{y}$$

$$\hat{\theta} = -\sin\theta\,\hat{x} + \cos\theta\,\hat{y}$$

以 $\hat{r}$, $\hat{\theta}$ 为基，它们随时间变化

$$\frac{d\hat{r}}{dt} = -\sin\theta\frac{d\theta}{dt}\hat{x} + \cos\theta\frac{d\theta}{dt}\hat{y}$$

$$= \frac{d\theta}{dt}\hat{\theta}$$

$$\frac{d\hat{\theta}}{dt} = -\cos\theta\frac{d\theta}{dt}\hat{x} - \sin\theta\frac{d\theta}{dt}\hat{y}$$

$$= -\frac{d\theta}{dt}\hat{r}$$

推广至一般情形

$\vec{r}(r,\theta)$

$(\hat{r}\cdot\hat{\theta} = 0)$

$$\vec{r} = r\hat{r}$$

$$\frac{d\vec{r}}{dt} = \frac{dr}{dt}\hat{r} + r\frac{d\theta}{dt}\hat{\theta}$$

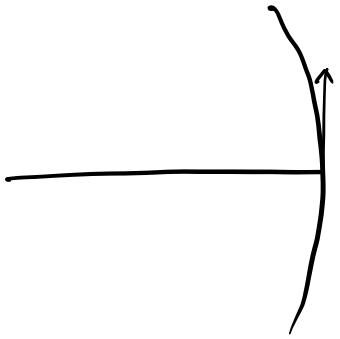
匀速圆周运动 ↓

$$= 0 + wr\hat{\theta}$$

$$= v\hat{\theta} \quad (\text{切向})$$

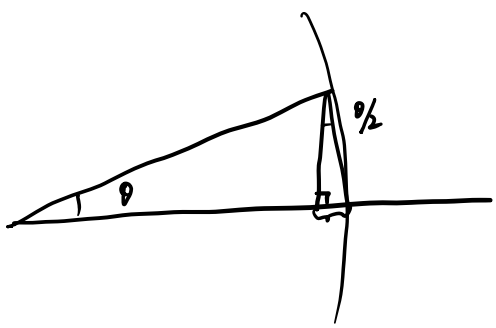
计算 $\vec{a} = \frac{d^2\vec{r}}{dt^2}$

Q: A为什么不掉下来？



Circular motion with a certain speed v falls away from a straight line path by a distance equal to $\frac{1}{2}(V^2/R)t^2$ if t is very small.

If I move on in this way,



Chord : $R\theta$

$R\theta \sin\frac{\theta}{2}$

$Rwt \sin\frac{wt}{2}$

$\approx \frac{1}{2} R w^2 t^2 = \frac{1}{2} a t^2$

$\vec{a}$ is changing

check differential / integral

$$\int_0^t R\,d\theta \sin\theta$$

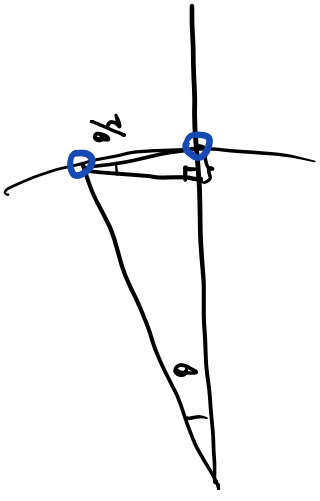
$$= R(1-\cos\omega t)$$

$$= 2R\sin^2\frac{\omega t}{2}$$

$$= \frac{1}{2}\omega^2 R t^2$$

The same reason applies to the moon

It is also the greatness of Newton



被拉一下，月亮就是在往下掉

（是不是很像平抛运动）

II. electro-magnetic

Chap. 12, Feynman Lectures

One ought to stop every once in a while and think, "what do they really mean?"

1° Friction: to begin with a particular force

(static) dry friction / sliding friction

origin: both surfaces of contact are irregular, on an atomic level

frictional force ← $F = \mu N$ (empirically)

μ: coefficient of friction

N: normal force (perpendicular to the surface)

Limitation: V is too big

excessive heat generated

exp: slope

2° 弹性力 (elastic force)

$F = -kx$ (x: displacement) Hooke's law

(restore force)

讨论简谐运动的基础

3° 表面张力

⋮

属于基本相互作用力中的：电磁相互作用

(相互靠近的原子或分子之间作用力的宏观表现)

III: Nuclear force

$\sim 10^{-15}$ m, very small

Comp: $\text{Å} = 10^{-10}$ m (quantum mechanics)

strong / weak (even shorter force range)

↓ ↘ smaller force

keep the objects occur in some reactions

stable (束缚) e.g. β - decay

in the sense of high energy (250 GeV)

Weinberg / Salam / Glashow unification of

(late 1960s) electromagnetic

and weak force

↓ when the energy is decreased

the spontaneous symmetry breaking

电 / 弱

破缺成两种性质极不相同的相互作用

note: In nuclear analysis, we

no longer think in terms of forces,

and in fact we can replace the force

concept with a concept of the energy

of interaction of two particles.

(平方反比力，Newton不是第一个发现但第一个证明)

场限：Fields

$G\frac{m_1 m_2}{r^2}$

vs

$\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$

Rules of reasoning in philosophy

哲学中的推理法则

Rule 1 We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.

除那些真实而已足够说明其现象者外，不必去寻求自然界事物的其他原因

"自然界不做无用之事"

To this purpose the philosophers say that nature does nothing in vain, and more is in vain when less will serve; for

Nature is pleased with simplicity, and affects not the pomp of superfluous causes.

pomp 壮观
/su:'pə:fluəs/ 多余的，不必要的
pompous 浮夸的

少够用多即是无用；自然界喜欢简单化，而不爱用什么多余的原因以夸耀自己。

Rule Ⅱ Therefore to the same natural effects we must, as far as possible, assign the same causes.

所以对于自然界中同一类结果，必须尽可能归之于同一种原因。

例如人和牲畜的呼吸；

陨石在欧洲和美洲的下落；

火户火和太阳的光；

光线在地球和行星上的反射。

Rule III

The qualities of bodies, which admit neither intensification nor remission of degrees, and which are found to (分开为 found to 吗?) belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever.

物体的属性，凡既不能增强也不能减弱者，又为我们实验所能及的范围内的一切物体所具有者，就应视为所有物体的普遍属性。

Rule IV

In experimental philosophy we are to look upon propositions (命题) inferred by general induction from phenomena as accurately or very nearly true, notwithstanding (尽管) any contrary hypotheses that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate, or liable (有责任的) to exceptions.

在实验哲学中，我们必须把那些从各种现象中运用一般归纳而导出的命题看作是完全正确的，或者是非常接近正确的；虽然可以想象出与之相反的假说，但是没有出现其他现象使之变更准确或面临例外前，规归纳命题正确。