1.4 汽车驱动力--行驶阻力平衡图

Balance of driving force and resistances

$$F_t = F_f + F_i + F_w + F_j$$

$$\frac{T_{tq} i_0 i_g \eta_T}{r} = mgf\cos\alpha + mg\sin\alpha + \frac{C_D A u_a}{21.15} + \delta m \frac{\mathrm{d}u}{\mathrm{d}t}$$

汽车行驶方程式反映了汽车行驶时，驱动力和外界阻力之间的普遍情况；若已知汽车结构和使用参数：

$$i_0, i_g, \eta_T, r, \rho, C_D, A$$

便可分析汽车在附着良好的典型路面上的行驶能力。即汽车在油门(加速踏板)全开时可能达到最高速度、加速能力和爬坡能力。

1.4 balance Between MV Traction & resistances

$$F_t = F_f + F_w + F_i + F_j$$

$$\frac{T_{tq} i_0 i_g \eta_T}{r} = mgf\cos\alpha + mg\sin\alpha + \frac{C_D A u_a}{21.15} + \delta m \frac{\mathrm{d}u}{\mathrm{d}t}$$

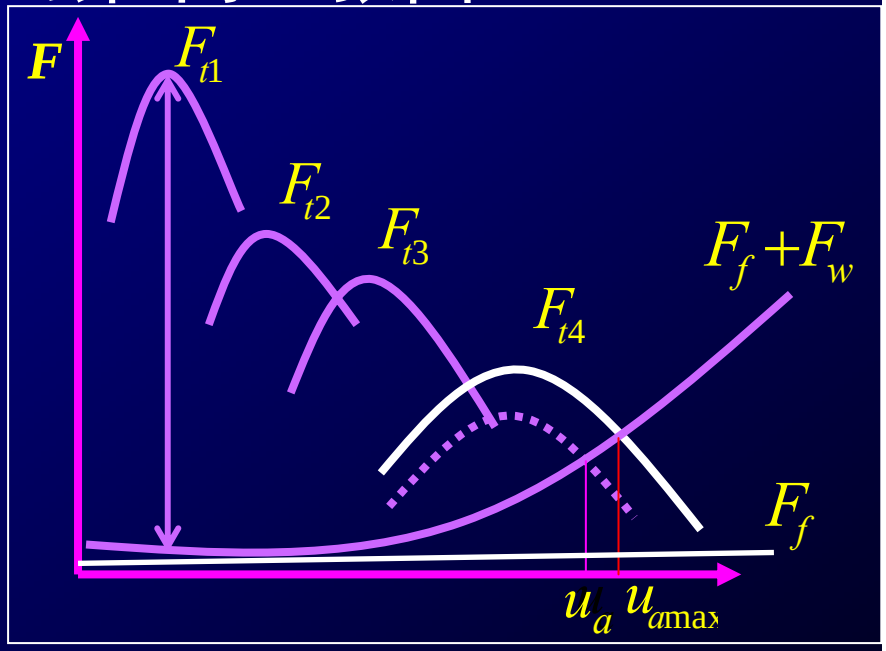
The driving equation shows the correlation between the traction and driving resistance when the MV drives. If

$$i_0, i_g, \eta_T, r, \rho, C_D, A$$

are known, can analyze then the driveability of MV on the good road, namely at full acceleration pedal, the MV may attain the max. speed, acceleration ability and grade ability.

1. 驱动力与行驶阻力平衡图

定义：为了清晰地描述汽车行驶时受力情况及其平衡关系，通常将平衡方程式用图解方式描述，即将驱动力 F_t 和常见行驶阻力 F_w 和 F_f 绘在同一张图上。



① 最大爬坡度

② 最高速度和部分负荷时的力平衡

③ u_{amax}

$$u_a < u_{a\max}, \Rightarrow F_i = mg\sin\alpha$$

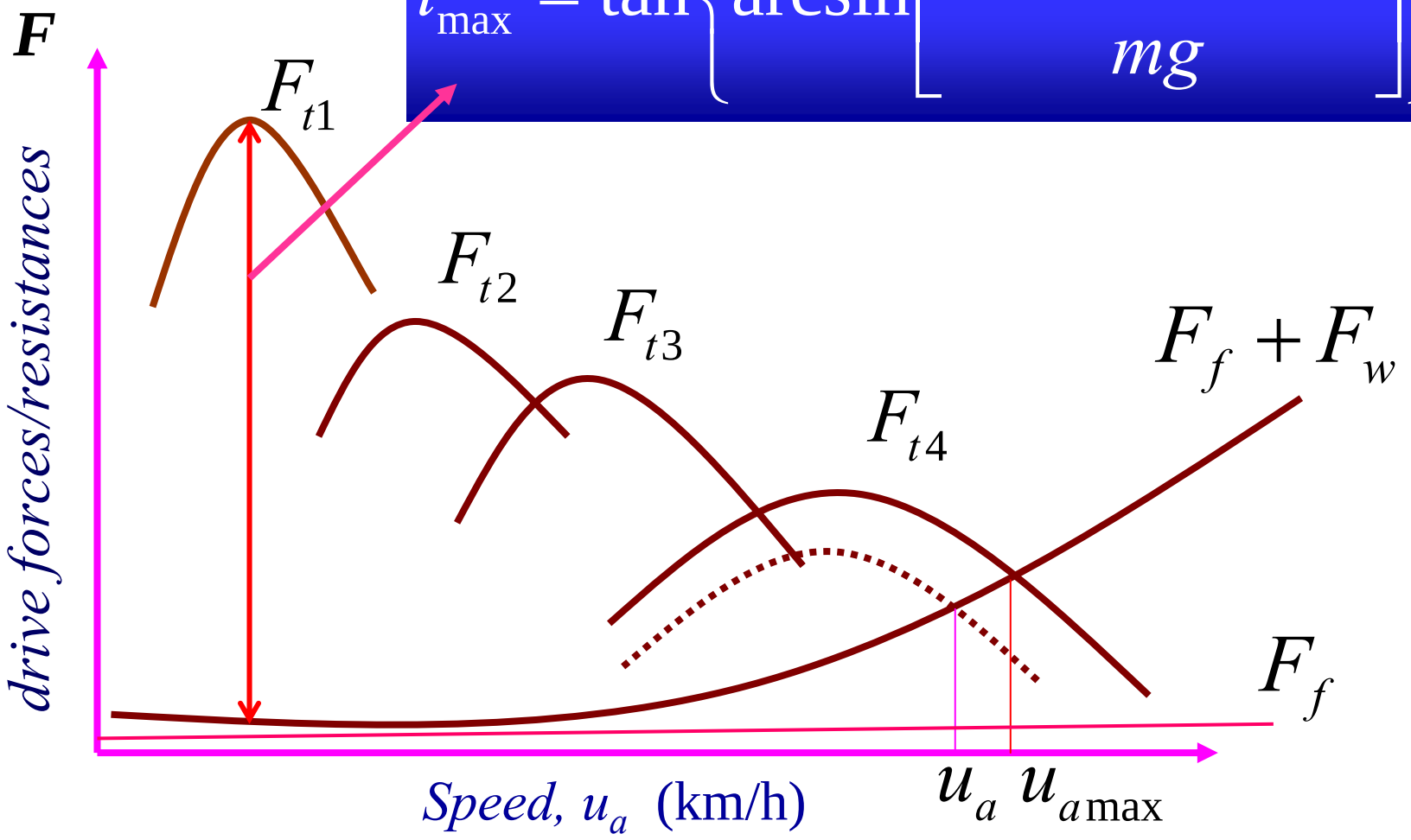
$$i_{\max} = \tan\left\{\arcsin\left(\frac{F_t - F_f - F_w}{mg}\right)\right\}$$

diagram of the equilibrium between drive force and driving resistance

Definition: For describing the automobile to drive clearly be subjected to the reaction and its balance relations, usually draw equilibrium equation to illustrate the way to carry on the description, ie draw the drive force Ft and the driving resistance Fw and Ff in the same diagram.

1. max speed and force balance for part load (see next page)
2. u_{amax}
3. max grade climbing

$$i_{\max} = \tan\left\{\arcsin\left[\frac{F_t - (F_f + F_w)}{mg}\right]\right\}$$



汽车驱动力—行驶阻力平衡图

equilibrium between traction and driving resistances

2. 加速能力，可用a_j评价，但不方便，常用加速时间或加速距离来评价。

$$a_j = \frac{\mathrm{d}u}{\mathrm{d}t} = \frac{1}{\delta m}(F_t - F_f - F_w) \qquad F_j = F_t - F_f - F_w$$

加速度倒数： Acceleration reciprocal

$$\frac{1}{a_j} = \frac{\delta m}{F_t - F_f - F_w} = \frac{\delta m}{F_j}$$

$$a_j = \frac{\mathrm{d}u}{\mathrm{d}t} \Rightarrow \mathrm{d}t = \frac{\mathrm{d}u}{a_j}$$

加速时间 Acceleration time

$$\mathrm{d}t = \frac{\mathrm{d}u}{a_j} \Rightarrow t = \int \frac{\mathrm{d}u}{a_j} \Leftrightarrow t \approx \sum \Delta t = \sum \frac{\Delta u}{a_j}$$

$$a_j = \frac{\mathrm{d}u}{\mathrm{d}t} = \frac{\mathrm{d}s}{\mathrm{d}s}\frac{\mathrm{d}u}{\mathrm{d}t}$$

$$\frac{u\,\mathrm{d}u}{\mathrm{d}s} = \frac{1}{\delta m}\left(F_t - F_f - F_w\right)$$

$$a_j = \frac{\mathrm{d}u}{\mathrm{d}t} \Rightarrow \mathrm{d}t = \frac{\mathrm{d}u}{a_j}$$

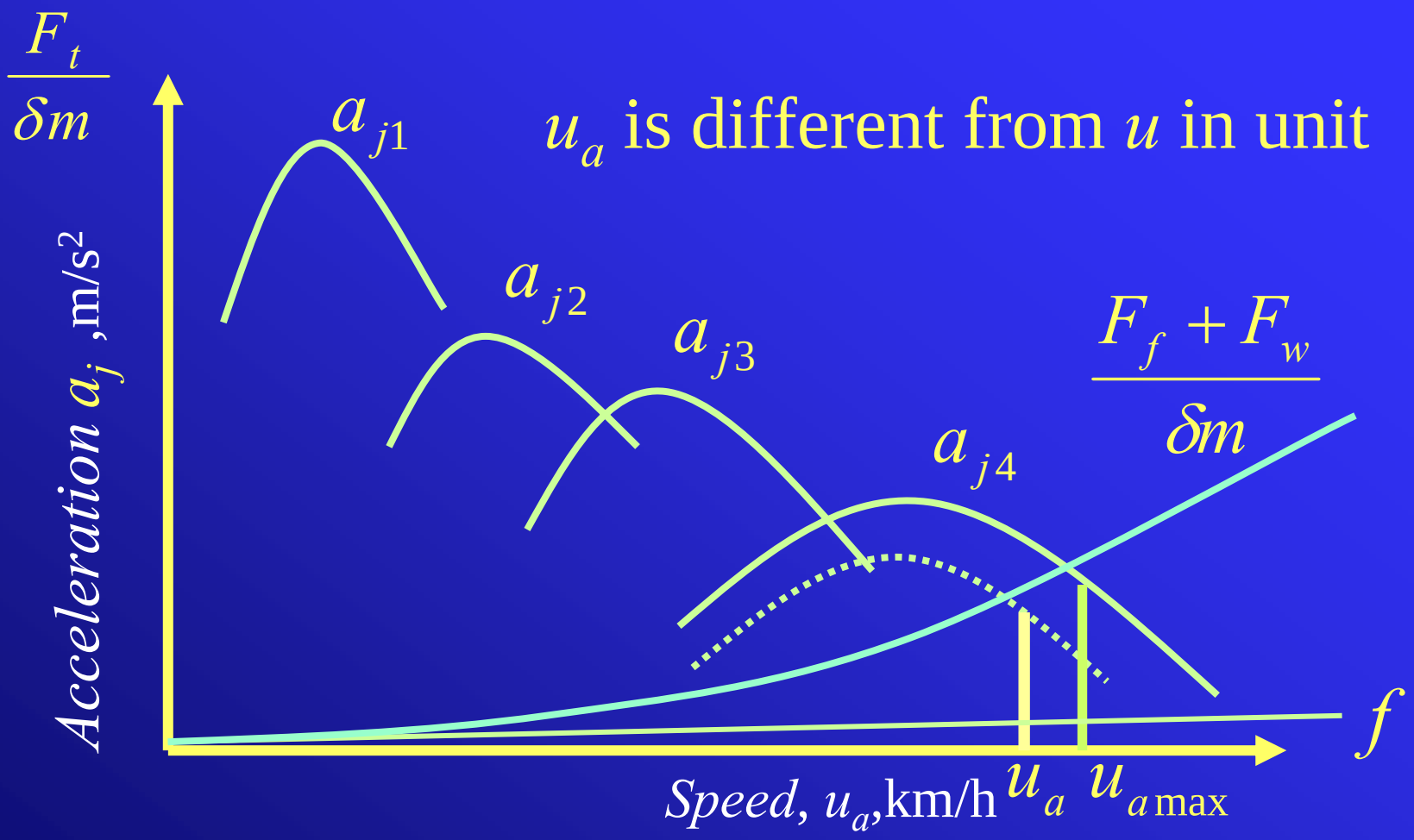
加速距离 Acceleration travel

$$\mathrm{d}s = \frac{u}{a_j}\mathrm{d}u \Rightarrow s = \int \frac{u\,\mathrm{d}u}{a_j}$$

$$s \approx \sum \Delta s = \sum \frac{u\Delta u}{a_j}$$

u_a单位不同于 u

u_a is different from u in unit



汽车加速度—速度图

Diagram of acceleration vs velocity MV

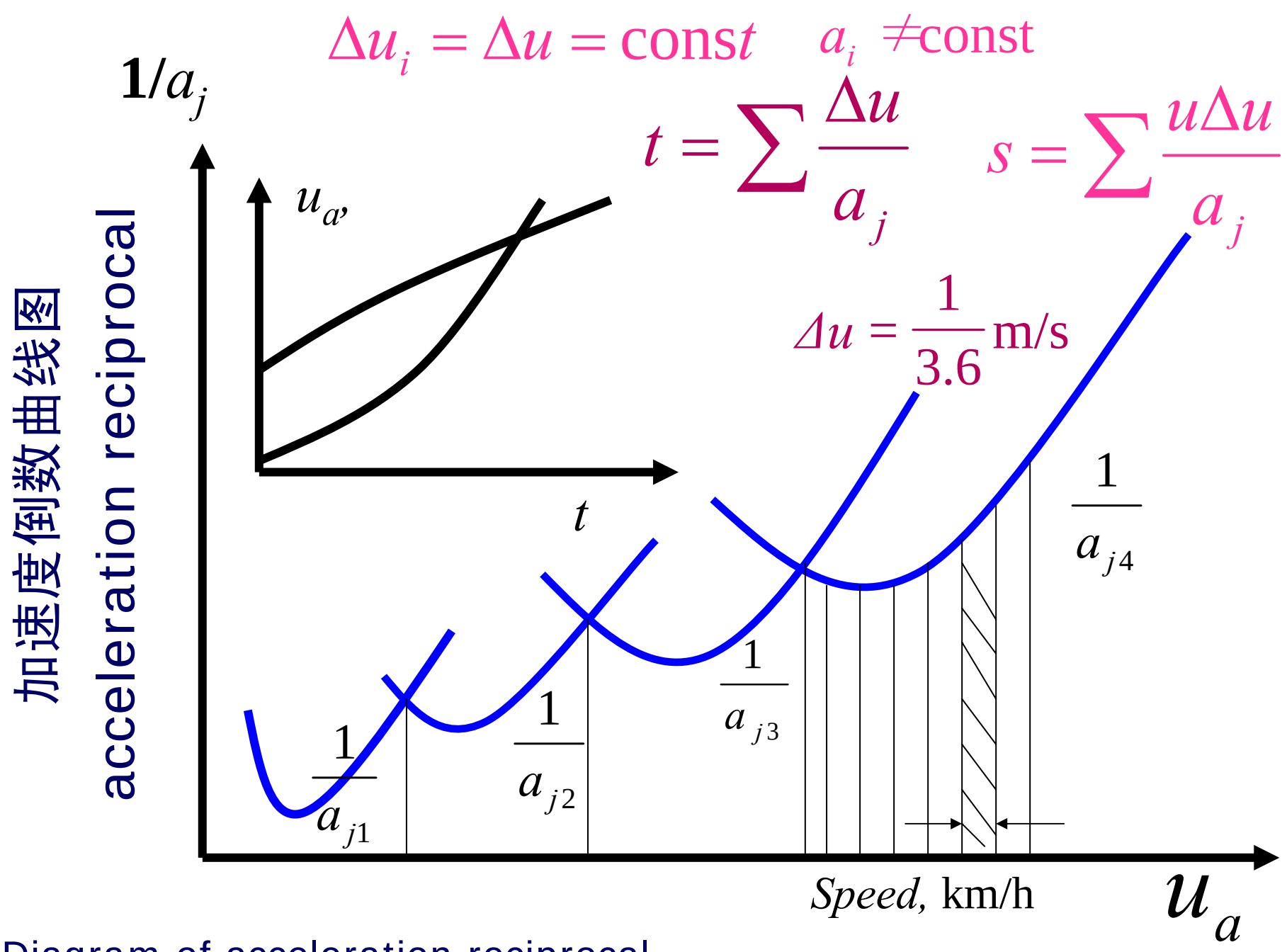


Diagram of acceleration reciprocal

将驱动力、滚动阻力和空气阻力计算出，就可按公式计算加速度及其倒数，从而求得加速时间或者加速距离。

After computing drive force, roll resistance and air resistances, it can be computed the acceleration and its reciprocal according to the formula and get the acceleration time or travel.

T_{tq}	T_{tq1}	T_{tq2}	T_{tq3}	……	T_{tqm}	
n	n_1	n_2	n_3	……	n_{1m}	
F_t	F_{t1}	F_{t2}	F_{t3}	……	F_{tm}	I 档
u_a	u_{a1}	u_{a2}	u_{a3}	……	u_{am}	
F_t	F_{t1}	F_{t2}	F_{t3}	……	F_{tm}	II 档
u_a	u_{a1}	u_{a2}	u_{a3}	……	u_{am}	
F_f	F_f	F_f	F_f	……	F_f	
F_w	F_w	F_w	F_w	……	F_w	

F_j	F_{j1}	F_{j2}	F_{j3}	……	F_{jm}	I 档
a_j	a_1	a_2	a_3	……	a_{1m}	
F_j	F_{j1}	F_{j2}	F_{j3}	……	F_{jm}	II 档
a_j	a_1	a_2	a_3	……	a_{1m}	
t	t_1	t_2	t_3		T_m	

$$a_j = \frac{1}{\delta m}[F_t - (F_f + F_w)]$$

$$dt = \frac{1}{a_j} du \Rightarrow \boxed{\Delta t = \frac{1}{a_j} \Delta u}$$

无穷小到有限小

注　意

- 在手工计算时，一般忽略原地起步过程中离合器的打滑过程，即假设在最初时刻，汽车已具备起步换挡所需的最低车速。
- 换挡时刻的确定：I-II加速度曲线相交，在交点处换挡；I-II加速度曲线不相交，在发动机最高转速处换挡；换挡持续时间一般忽略不计（t=0.2~0.4s, 服从正态分布)。
- 计算加速时间的用途：确定汽车加速能力；分析动力传动系匹配情况；合理选择发动机的排量。

Notice

Generally when handicraft computes, at first ,the slide of clutch at the start process is neglected, then the assumption is in the first time, the MV has already had the lowest speed that start need when shift gear.

Time of shift gear to determine: If the gear 1st-2nd acceleration curves is intersected, then shift gear 1^{st} to 2nd; If the acceleration curves of the gear 1^{st} and 2nd is not intersected, then at max engine speed shift the gear 1^{st} to 2nd; neglect shift gear spending time. (normal distribution t=0.2-0.4 s)

Use of computing acceleration time: to determine MV acceleration ability, trade-off power-train; reasonably choose displacement of the engine.

3. 利用驱动力—行驶阻力平衡图确定汽车爬坡能力

Diagram of equilibrium of drive force - driving resistance to determine grade ability of MV

其前提条件是汽车在良好路面上克服F_w+F_f后的全部驱动力都用于克服坡道阻力。

Its prior condition is a road surface good, except overcoming the F_w+F_f, all drive force is used for overcoming a grade resistance, namely.

$$\frac{\mathrm{d}u}{\mathrm{d}t}=a_j=0$$

$$F_t=F_f+F_w+F_i$$

$$F_f+F_w=mgf+\frac{C_DAu_a^2}{21.15}$$

$$(\cos\alpha\approx 1)$$

$$mg\sin\alpha = F_t - (F_f + F_w) \Rightarrow$$

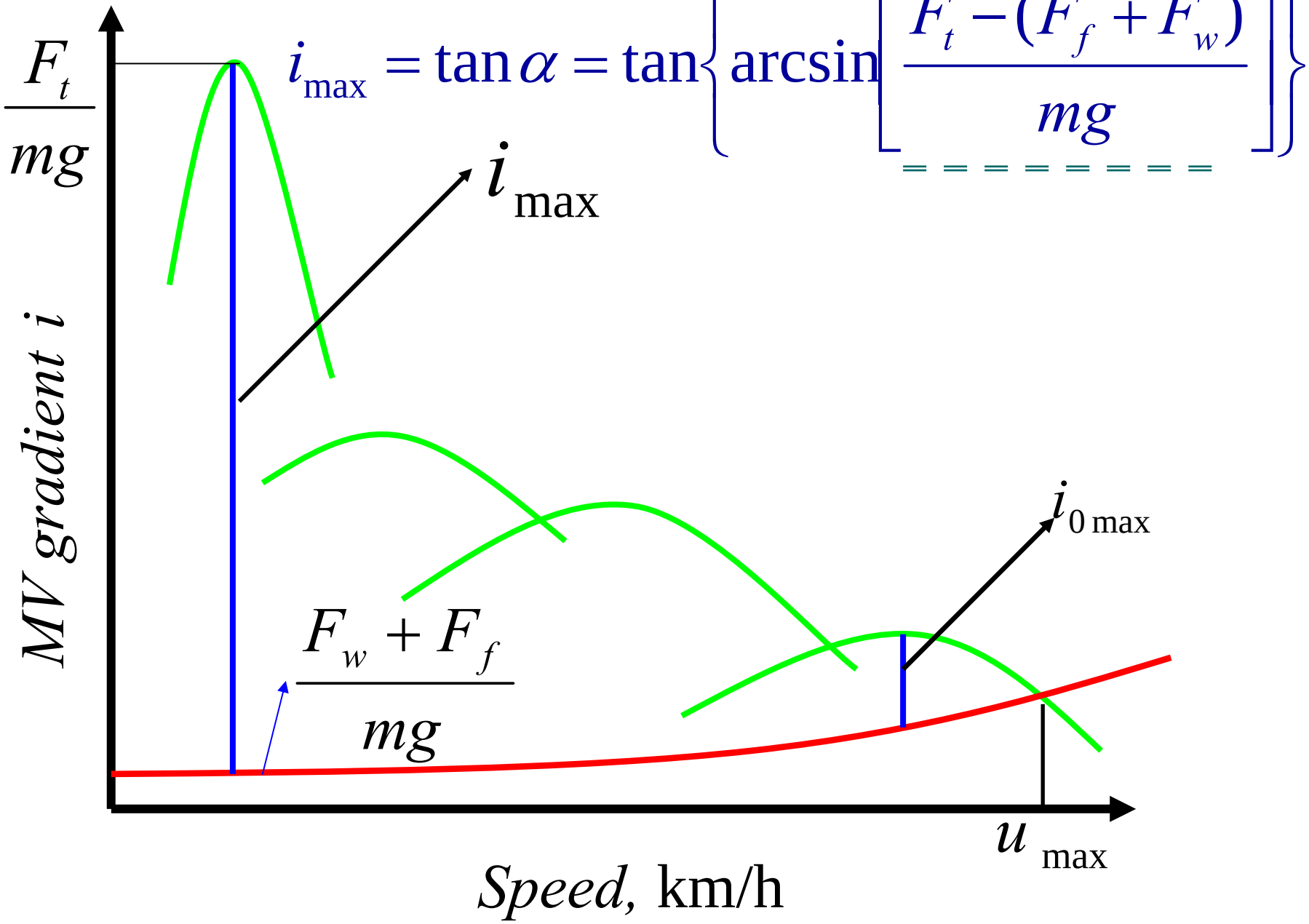
$$\alpha = \arcsin\left[\frac{F_t - (F_f + F_w)}{mg}\right]$$

坡度通常用i表示

i represents grade usually

$$i = \tan\alpha = \tan\left\{\arcsin\left[\frac{F_t - \left(F_f + F_w\right)}{mg}\right]\right\}$$

$$i_{\max} = \tan\alpha = \tan\left\{\arcsin\left[\frac{F_t - (F_f + F_w)}{mg}\right]\right\}$$



$$i_{\max} = \tan\alpha = \tan\left[\arcsin\left(\frac{F_t - F_f - F_w}{mg}\right)\right]$$

$i_{\max} \Rightarrow$ I档

$i_{0\max} \Rightarrow$ 最高档的最大爬坡度，目的是减少常见坡度汽车经常换档，影响汽车运行速度。

$$i_{0\max} \approx \frac{F_t - (F_f + F_w)}{mg}$$

i_{max} is max sloping gradient for 1st gear.

i0max is max sloping gradient for top gear.

Objective: decreasing the number of shift on normal slope, which makes the speed of MV slowly down.

二、用动力特性图评价汽车动力性

unit traction to evaluate MV performance

$$F_t = F_f + F_w + F_i + F_j$$

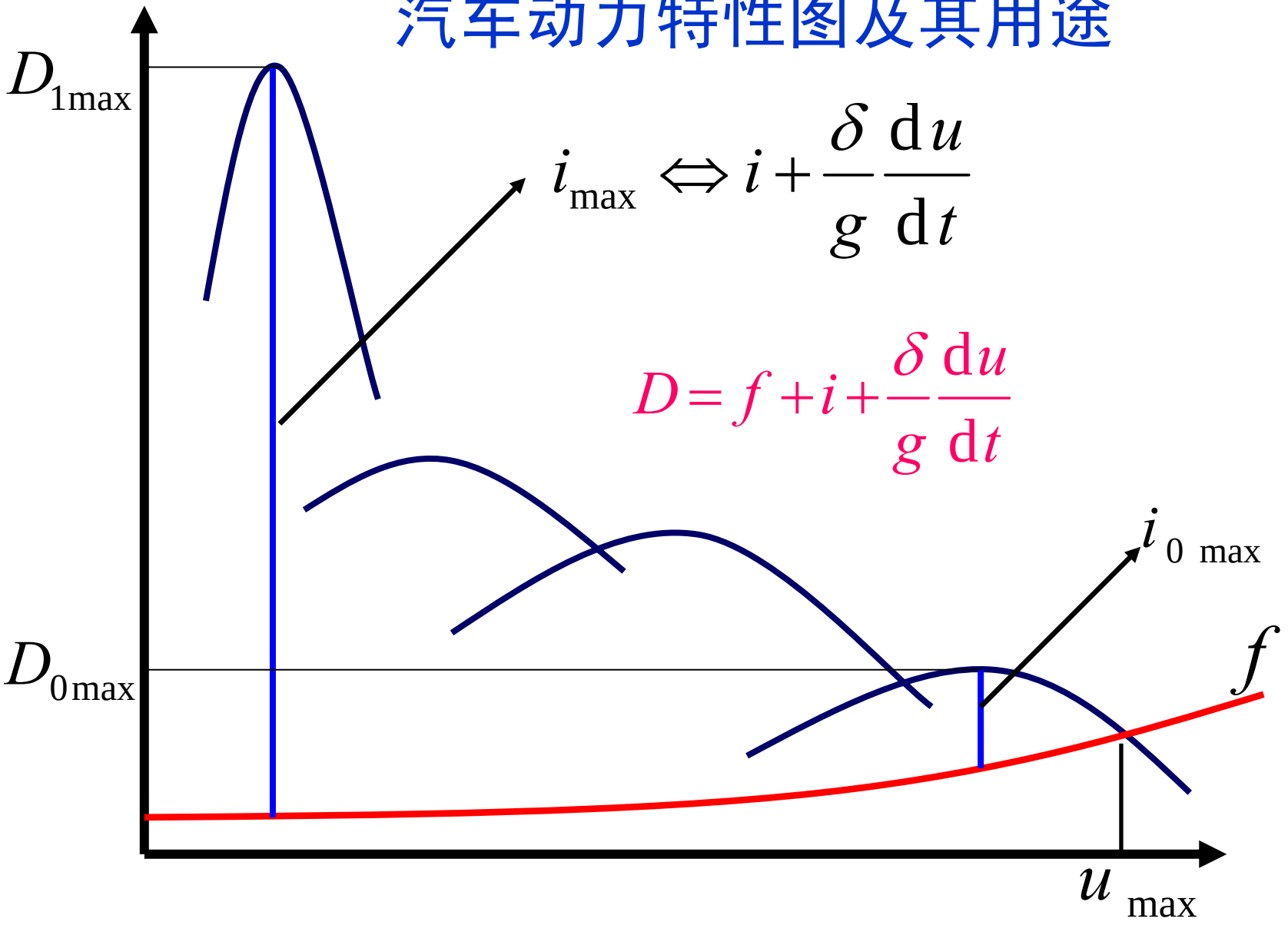
$$\frac{F_t - F_w}{mg} = \frac{F_i + F_f}{mg} + \frac{\delta m}{mg}\frac{\mathrm{d}u}{\mathrm{d}t} = (f + i) + \frac{\delta}{g}\frac{\mathrm{d}u}{\mathrm{d}t}$$

$$D = \frac{F_t - F_w}{mg} = \psi + \frac{\delta}{g}\frac{\mathrm{d}u}{\mathrm{d}t}$$

drive factor

Normalized drive force

汽车动力特性图及其用途



Characteristic of normalized traction and its use

To solve i_{max} ,let $\dfrac{du}{dt} = 0 \Rightarrow D = \psi = f + i$

$$i_{\max} = D_{\mathrm{Im}ax} - f \Rightarrow D_{\mathrm{Im}ax} = f\cos\alpha_{\max} + \sin\alpha_{\max}$$

$$\because \quad \cos\alpha_{\max} = \sqrt{1-\sin^2\alpha_{\max}}$$

$$\therefore \quad \alpha_{\max} = \arcsin\frac{D_{1\max} - f\sqrt{1-D_{1\max}^2 + f^2}}{1+f^2}$$

$$\tan\alpha_{\max} = i_{\max}$$

While MV acceleration, the road must be flatness. i.e.

$$i = 0 \Rightarrow \frac{du}{dt} = \frac{\delta}{g}(D - f)$$