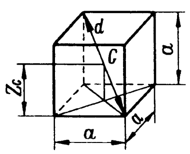
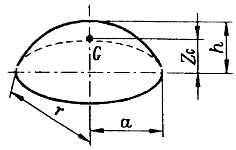
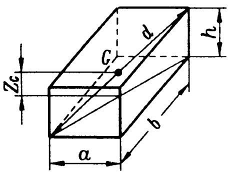
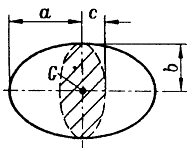
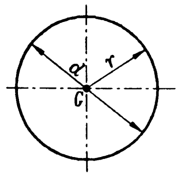
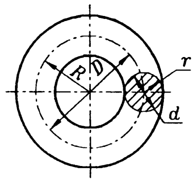
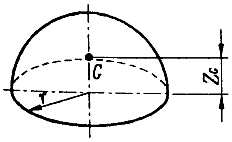
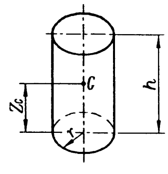
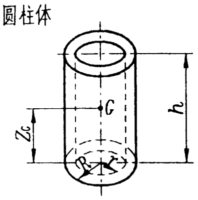
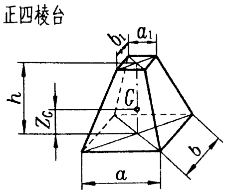
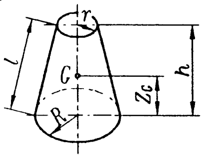
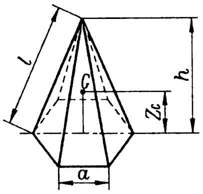
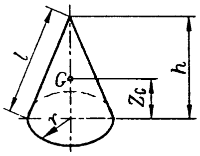
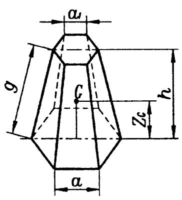
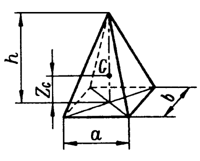
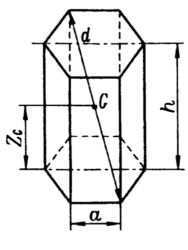
第 1 章　常用资料、数据和一般标准

G1　常用几何体的体积、面积及重心位置（表 G1-1）

表 G1-1　常用几何体的体积、面积及重心位置

图　　形	体积 V、底面积 A、侧面积 A_0、全面积 A_n、重心位置 G 的计算公式	图　　形	体积 V、底面积 A、侧面积 A_0、全面积 A_n、重心位置 G 的计算公式
正方体 	$V=a^3$ $A=a^2$ $A_0=4a^2$ $A_n=6a^2$ $d=\sqrt{3}a$ (d为对角线) $Z_G=\frac{a}{2}$	球缺体 	$V=\frac{\pi}{6}h(3a^2+h^2)$ $=\frac{\pi}{3}h^2(3r-h)$ $A=\pi a^2$ $A_0=2\pi rh=\pi(a^2+h^2)$ $A_n=\pi(2rh+a^2)=\pi(h^2+2a^2)$ $Z_G=\frac{h(4r-h)}{4(3r-h)}$
长方体 	$V=abh$ $A=ab$ $A_0=2h(a+b)$ $A_n=2(ab+ah+bh)$ $d=\sqrt{a^2+b^2+h^2}$ (d为对角线) $Z_G=\frac{h}{2}$	椭球体 	$V=\frac{4}{3}\pi abc$ 重心G在椭球中心
球体 	$V=\frac{4}{3}\pi r^3$ $A_n=4\pi r^2$ 重心G与球心重合	圆环体 	$V=2\pi^2Rr^2=\frac{\pi^2}{4}Dd^2$ $A_n=4\pi^2Rr=\pi^2Dd$ 重心G在圆环中心
半球体 	$V=\frac{2}{3}\pi r^3$ $A=\pi r^2$ $A_0=2\pi r^2$ $A_n=3\pi r^2$ $Z_G=\frac{3}{8}r$	圆柱体 	$V=\pi r^2h$ $A_0=2\pi rh$ $A_n=2\pi r(r+h)$ $Z_G=\frac{h}{2}$

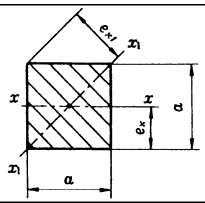
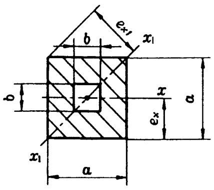
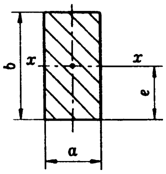
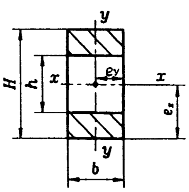
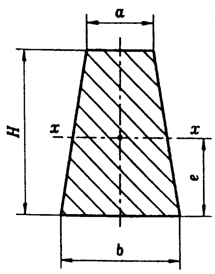
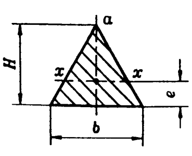
(续)

图　　形	体积 V、底面积 A、侧面积 A_0、全面积 A_n、重心位置 G 的计算公式	图　　形	体积 V、底面积 A、侧面积 A_0、全面积 A_n、重心位置 G 的计算公式
空心圆柱体 	$V=\pi h(R^2-r^2)$ $A=\pi(R^2-r^2)$ $A_0=2\pi h(R+r)$ $A_n=2\pi(R+r)(R-r+h)$ $Z_G=\dfrac{h}{2}$	正四棱台 	$V=\dfrac{h}{6}(2ab+ab_1+a_1b+2a_1b_1)$ $A_1=a_1b_1$ $A=ab$ $A_0=\dfrac{1}{2}[(b_1+b)\sqrt{4h^2+(a-a_1)^2}$ $+(a_1+a)\sqrt{4h^2+(b-b_1)^2}\,]$ $A_n=A+A_1+A_0$ $Z_G=\dfrac{h(ab+ab_1+a_1b+3a_1b_1)}{2(2ab+ab_1+a_1b+2a_1b_1)}$
圆台 	$V=\dfrac{\pi}{3}h(R^2+r^2+Rr)$ $A_0=\pi l(R+r)$ $A_n=\pi(R^2+r^2)+A_0$ $l=\sqrt{(R-r)^2+h^2}$ $Z_G=\dfrac{h(R^2+2Rr+3r^2)}{4(R^2+Rr+r^2)}$	正六棱锥 	$V=\dfrac{1}{3}Ah=\dfrac{\sqrt{3}}{2}a^2h$ $A=\dfrac{3\sqrt{3}}{2}a^2$ $A_0=\dfrac{3}{2}a\sqrt{4l^2-a^2}$ $A_n=A+A_0$ $Z_G=\dfrac{h}{4}$
圆锥体 	$V=\dfrac{1}{3}\pi r^2h$ $A=\pi r^2$ $A_0=\pi rl$ $A_n=\pi r(r+l)$ $l=\sqrt{r^2+h^2}$ $Z_G=\dfrac{h}{4}$	正六棱台 	$V=\dfrac{hA}{3}\left[1+\dfrac{a_1}{a}+\left(\dfrac{a_1}{a}\right)^2\right]$ $A_1=\dfrac{3\sqrt{3}}{2}a_1^2$ $A=\dfrac{3\sqrt{3}}{2}a^2$ $A_0=3g(a_1+a)$ $A_n=A+A_1+A_0$ $Z_G=\dfrac{h(a^2+2a_1a+3a_1^2)}{4(a^2+a_1a+a_1^2)}$ (A_1为顶面积，g 为斜高)
正四棱锥 	$V=\dfrac{1}{3}abh$ $A=ab$ $A_0=\dfrac{1}{2}(b\sqrt{4h^2+a^2}$ $+a\sqrt{4h^2+b^2}\,)$ $A_n=ab+\dfrac{1}{2}(b\sqrt{4h^2+a^2}$ $+a\sqrt{4h^2+b^2}\,)$ $Z_G=\dfrac{h}{4}$	正六棱柱 	$V=\dfrac{3\sqrt{3}}{2}a^2h$ $A=\dfrac{3\sqrt{3}}{2}a^2$ $A_0=6ah$ $A_n=3\sqrt{3}a^2+6ah$ $d=\sqrt{h^2+4a^2}$ (d为对角线) $Z_G=\dfrac{h}{2}$

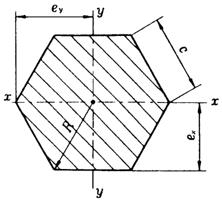
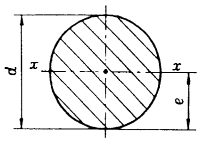
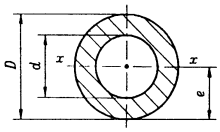
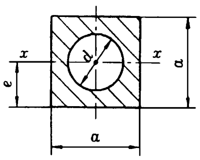
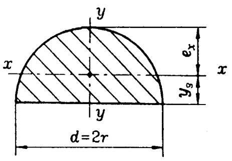
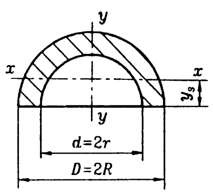
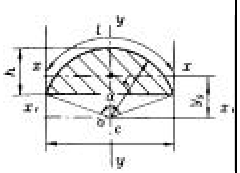
G2 常用力学公式

G2.1 常用截面的力学特性(表 G1-2、表 G1-3)

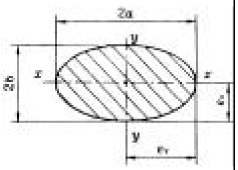
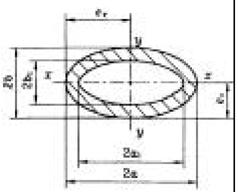
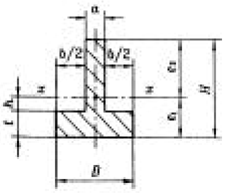
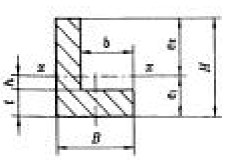
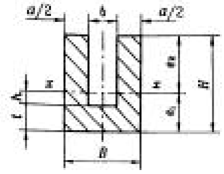
表 G1-2 常用截面的几何及力学特性

截面形状	面积 A	惯性矩 I	截面系数 $W=\frac{I}{e}$	回转半径 $i=\sqrt{\frac{I}{A}}$	形心距离 e
	a^2	$\frac{a^4}{12}$	$W_x=\frac{a^2}{6}$ $W_{x1}=0.1179a^3$	$\frac{a}{\sqrt{12}}=0.289a$	$e_x=\frac{a}{2}$ $e_{x1}=0.7071a$
	a^2-b^2	$\frac{a^4-b^4}{12}$	$W_x=\frac{a^4-b^4}{6a}$ $W_{x1}=0.1179\frac{a^4-b^4}{a}$	$0.289\sqrt{a^2+b^2}$	$e_x=\frac{a}{2}$ $e_{x1}=0.7071a$
	ab	$\frac{ab^3}{12}$	$\frac{ab^2}{6}$	$\frac{b}{\sqrt{12}}=0.289b$	$\frac{b}{2}$
	$b(H-h)$	$I_x=\frac{b(H^3-h^3)}{12}$ $I_y=\frac{b^3(H-h)}{12}$	$W_x=\frac{b(H^3-h^3)}{6H}$ $W_y=\frac{b^2(H-h)}{6}$	$i_x=\sqrt{\frac{H^2+Hh+h^2}{12}}$ $i_y=0.289b$	$e_x=\frac{H}{2}$ $e_y=\frac{b}{2}$
	$\frac{H}{2}(a+b)$	$\frac{a^2+b^2+4ab}{36(a+b)}H^3$	$W_{xa}=\frac{H^2(a^2+4ab+b^2)}{12(a+2b)}$ $W_{xb}=\frac{H^2(a^2+4ab+b^2)}{12(2a+b)}$	$\frac{H}{3(a+b)}\times\sqrt{\frac{a^2+4ab+b^2}{2}}$	$\frac{H(2a+b)}{3(a+b)}$
	$\frac{bH}{2}$	$\frac{bH^3}{36}$	$W_{xa}=\frac{bH^2}{24}$ $W_{xb}=\frac{bH^2}{12}$	$\frac{H}{3\sqrt{2}}=0.236H$	$\frac{H}{3}$

(续)

截面形状	面积A	惯性矩I	截面系数$W=\frac{I}{e}$	回转半径$i=\sqrt{\frac{I}{A}}$	形心距离e
	$A=2.598C^2$ $C=R$	$I_x=0.5413R^4$ $I_y=I_x$	$W_x=0.625R^3$ $W_y=0.5413R^3$	$i_x=0.4566R$	$e_x=0.866R$ $e_y=R$
	$\frac{\pi d^2}{4}$	$\frac{\pi d^4}{64}$	$\frac{\pi d^3}{32}$	$\frac{d}{4}$	$\frac{d}{2}$
	$\frac{\pi}{4}(D^2-d^2)$	$\frac{\pi}{64}(D^4-d^4)$	$\frac{\pi}{32}\left(\frac{D^4-d^4}{D}\right)$	$\frac{\sqrt{D^4+d^4}}{4}$	$\frac{D}{2}$
	$a^2-\frac{\pi d^2}{4}$	$\frac{1}{12}\left(a^4-\frac{3\pi d^4}{16}\right)$	$\frac{1}{6a}\left(a^4-\frac{3\pi d^4}{16}\right)$	$\sqrt{\frac{16a^4-3\pi d^4}{48(4a^2-\pi d^2)}}$	$\frac{a}{2}$
	$\frac{\pi d^2}{8}$	$I_x=0.00686d^4$ $I_y=\frac{\pi d^4}{128}$	$W_x=0.0239d^4$ $W_y=\frac{\pi d^3}{64}$	$i_x=0.1319d$ $i_y=\frac{d}{4}$	$e_x=0.2878d$ $y_s=0.2122d$
	$\frac{\pi(D^2-d^2)}{8}$	$I_x=0.00686(D^4$ $-d^4)$ $I_y=\frac{\pi(D^4-d^4)}{128}$	$W_y=\frac{\pi d^3}{64}\left(1-\frac{d^4}{D^4}\right)$	$i_x=\sqrt{\frac{I_x}{A}}$ $i_y=\sqrt{\frac{I_y}{F}}$ $=\frac{1}{4}\sqrt{D^2+d^2}$	$y_s=$ $\frac{2(D^2+Dd+d^2)}{3\pi(D+d)}$
	$A=\frac{1}{2}[rl-c(r-h)]$；$l=0.01745\alpha$ $c=2\sqrt{h(2r-h)}$；$\alpha=\frac{57.296l}{r}$ $r=\frac{c^2+4h^2}{8h}$；$h=r-\frac{1}{2}\sqrt{4r^2-c^2}$ $I_{x1}=\frac{lr^3}{8}-\frac{r^4}{8}\sin\alpha\cos\alpha$；$J_x=J_{x1}-Ay_s^2$ $I_y=\frac{r^4}{8}\left(\frac{\alpha\pi}{180°}-\sin\alpha-\frac{2}{3}\sin\alpha\sin^2\frac{\alpha}{2}\right)$；$W_x=\frac{J_x}{r-y_s}$			$i_x=\sqrt{\frac{I_x}{A}}$	$y_s=\frac{c^3}{12A}$

(续)

截面形状	面积 A	惯性矩 I	截面系数 $W=\frac{I}{e}$	回转半径 $i=\sqrt{\frac{I}{A}}$	形心距离 e
	pab	$I_x=\frac{pab^3}{4}$ $I_y=\frac{pa^3b}{4}$	$W_x=\frac{pab^2}{4}$ $W_y=\frac{pa^2b}{4}$	$i_x=\frac{b}{2}$ $i_y=\frac{a}{2}$	$e_x=b$ $e_y=a$
	$p(ab-a_1b_1)$	$I_x=\frac{p}{4}(ab^3-a_1b_1^3)$ $I_y=\frac{p}{4}(a^3b-a_1^3b_1)$	$W_x=\frac{p(ab^3-a_1b_1^3)}{4b}$ $W_y=\frac{p(a^3b-a_1^3b_1)}{4a}$	$i_x=\sqrt{\frac{I_x}{A}}$ $i_y=\sqrt{\frac{I_y}{A}}$	$e_x=b$ $e_y=a$
  	$BH-$ $b(e_2+h)$	$I_x=\frac{Be_1^3+ae_2^3-bh^3}{3}$	$W_{x1}=\frac{I_x}{e_1}$ $W_{x2}=\frac{I_x}{e_2}$	$\sqrt{\frac{Be_1^3+ae_2^3-bh^3}{3[HB-b(e_2+h)]}}$	$e_1=\frac{aH^2+bt^2}{2(aH+bt)}$ $e_2=H-e_1$

(续)

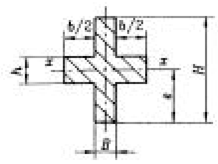
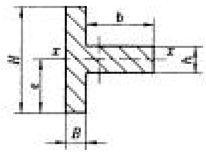
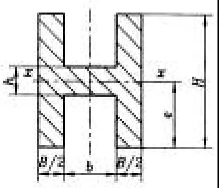
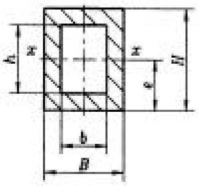
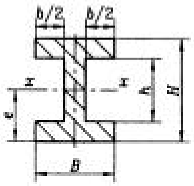
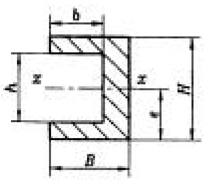
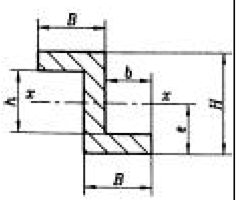
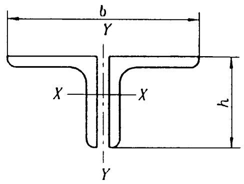
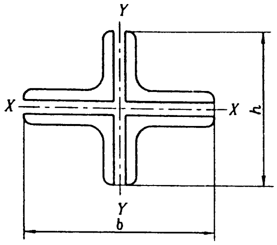
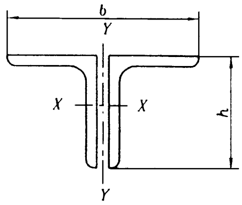
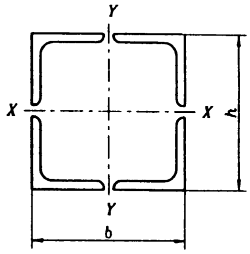
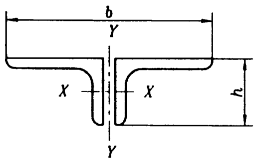
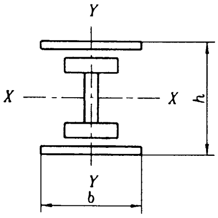
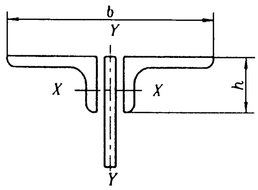
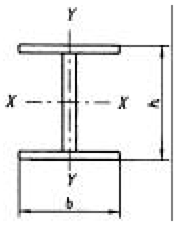
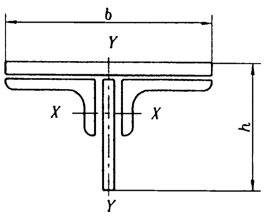
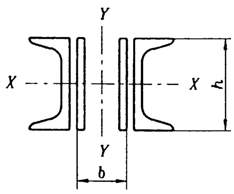
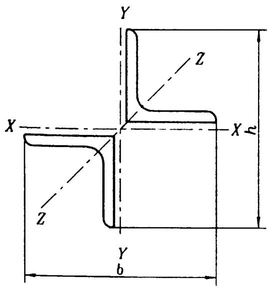
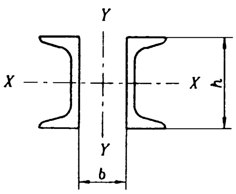
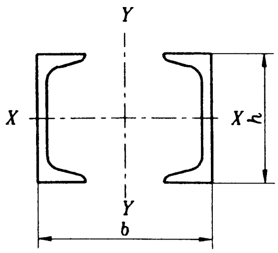
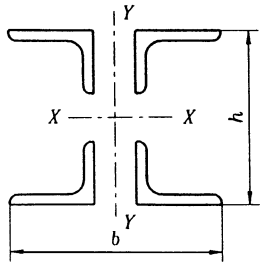
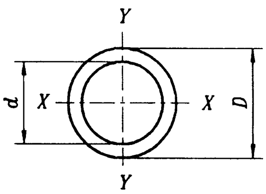
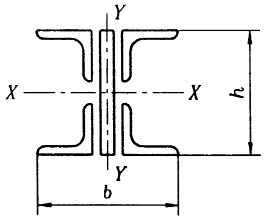
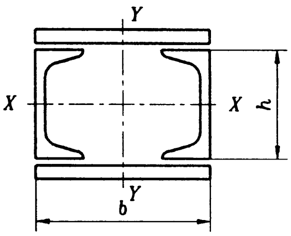
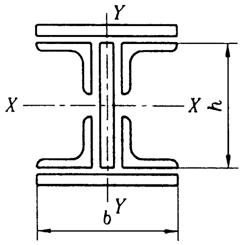
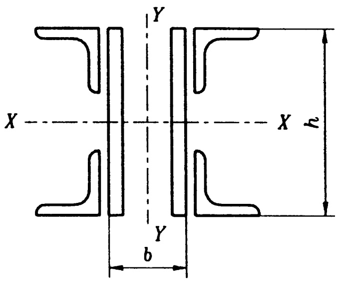
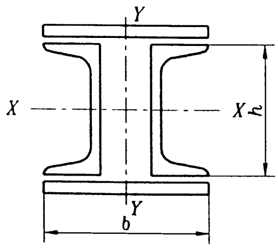
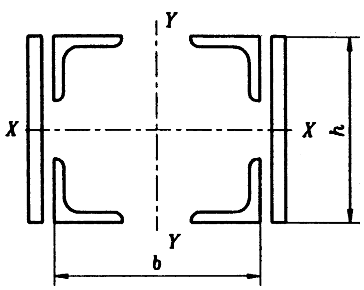
截面形状	面积A	惯性矩I	截面系数$W=\dfrac{I}{e}$	回转半径$i=\sqrt{\dfrac{I}{A}}$	形心距离e
  	$BH+bh$	$I_x=\dfrac{BH^3+bh^3}{12}$	$W_x=\dfrac{BH^3+bh^3}{6H}$	$\sqrt{\dfrac{BH^3+bh^3}{12(BH+bh)}}$	$\dfrac{H}{2}$
   	$BH-bh$	$I_x=\dfrac{BH^3-bh^3}{12}$	$W_x=\dfrac{BH^3-bh^3}{6H}$	$i_x=\sqrt{\dfrac{BH^3-bh^3}{12(BH-bh)}}$	$\dfrac{H}{2}$

表 G1-3　主要组合截面的回转半径

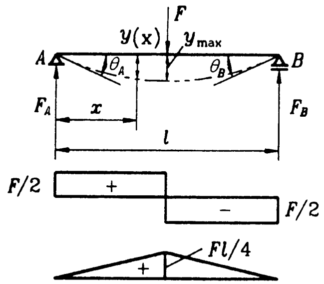
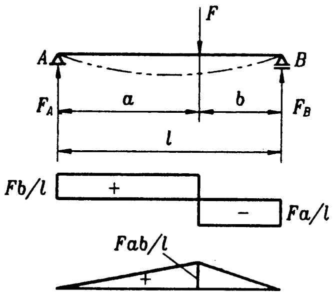
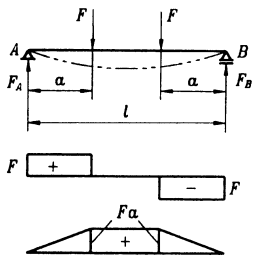
截面形状	回转半径	截面形状	回转半径
	$i_X=0.30h$ $i_Y=0.215h$		$i_X=0.21h$ $i_Y=0.21b$
	$i_X=0.32h$ $i_Y=0.20b$		$i_X=0.43h$ $i_Y=0.43b$
	$i_X=0.28h$ $i_Y=0.24b$		$i_X=0.42h$ $i_Y=0.22b$
	$i_X=0.30h$ $i_Y=0.17b$		$i_X=0.39h$ $i_Y=0.20b$
	$i_X=0.26h$ $i_Y=0.21b$		$i_X=0.35h$ $i_Y=0.56b$
	$i_X=0.21h$ $i_Y=0.21b$ $i_Z=0.185h$		$i_X=0.38h$ $i_Y=0.60b$

(续)

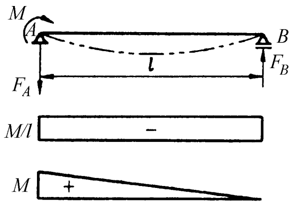
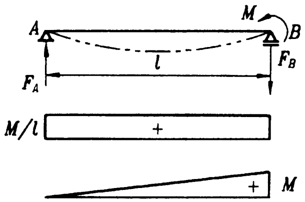
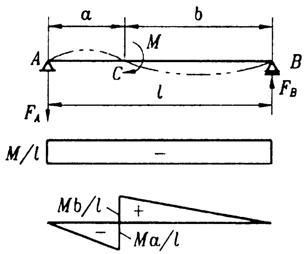
截面形状	回转半径	截面形状	回转半径
	$i_X = 0.38h$ $i_Y = 0.44b$		$i_X = 0.45h$ $i_Y = 0.24b$
	$i_X = 0.35d_{cp}$ $d_{cp} = \frac{D+d}{2}$		$i_X = 0.40h$ $i_Y = 0.21b$
	$i_X = 0.44h$ $i_Y = 0.38b$		$i_X = 0.45h$ $i_Y = 0.235b$
	$i_X = 0.37h$ $i_Y = 0.54b$		$i_X = 0.44h$ $i_Y = 0.32b$
	$i_X = 0.37h$ $i_Y = 0.45b$		

G2.2 受静载荷梁的支点反力、弯矩和变形计算公式（表 G1-4、表 G1-5）

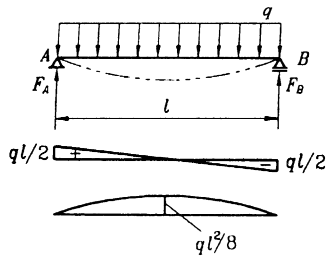
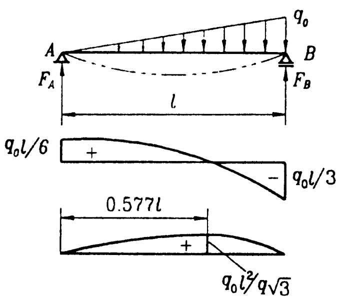
表 G1-4 常用静定梁的支点反力、弯矩和变形计算公式

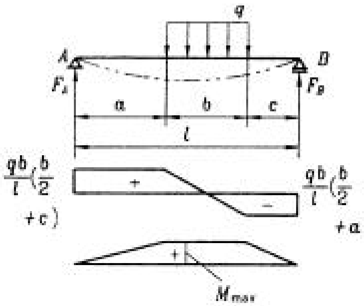
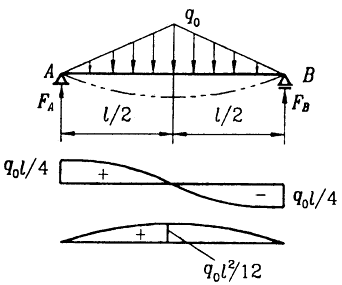
序号	载荷情况及剪力图弯矩图	支点反力	弯矩方程	挠度曲线方程	最大挠度	梁端转角
1		$F_A = F_B = \frac{F}{2}$	$0 \leq x \leq l/2$: $M(x) = \frac{Fx}{2}$	$0 \leq x \leq l/2$: $y = \frac{-Fl^3}{48EI}\left(\frac{3x}{l} - \frac{4x^3}{l^3}\right)$	在$x = l/2$处: $y_{\max} = \frac{-Fl^3}{48EI}$	$q_A = -q_B = \frac{-Fl^2}{16EI}$
2		$F_A = \frac{Fb}{l}$ $F_B = \frac{Fa}{l}$	$0 \leq x \leq a$: $M(x) = \frac{Fbx}{1}$ $a \leq x \leq 1$: $M(x) = \frac{Fbx}{1} - F(x-a)$	$0 \leq x \leq a$: $y = \frac{-Fbx}{6EIl}(l^2 - x^2 - b^2)$ $0 \leq x \leq l$: $y = \frac{-Fb}{6EIl}$ $\times\left[(l^2 - b^2)x - x^3 + \frac{(x-a)^3}{b}\right]$	若$a > b$,在$x = \sqrt{\frac{l^2 - b^2}{3}}$处: $y_{\max} = \frac{-Fb(l^2 - b^2)^{3/2}}{9\sqrt{3}EIl}$ 在$x = l/2$处: $y = \frac{-Fb(3l^2 - 4b^2)}{48EI}$	$q_A = \frac{-Fab(l+b)}{6EIl}$ $q_B = \frac{Fab(l+a)}{6EIl}$
3		$F_A = F_B = F$	$0 \leq x \leq a$: $M(x) = Fx$ $a \leq x \leq l - a$: $M = Fa$	$0 \leq x \leq l$: $y = \frac{-Fx}{6EI}[3a(l-a) - x^2]$ $0 \leq x \leq l - a$: $y = \frac{-Fa}{6EI}[3x(l-x) - a^2]$	在$x = l/2$处: $y_{\max} = \frac{-Fa}{24EI}(3l^2 - 4a^2)$	$q_A = -q_B$ $= \frac{-Fa^2}{2EI}(l-a)$

(续)

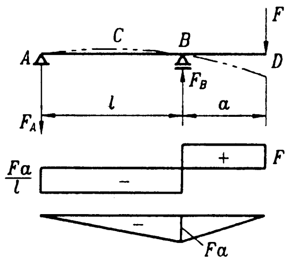
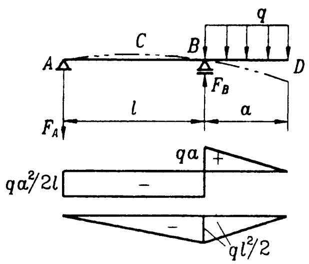
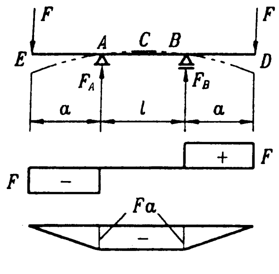
序号	载荷情况及剪力图弯矩图	支点反力	弯矩方程	挠度曲线方程	最大挠度	梁端转角
4		$F_A=F_B=\dfrac{M}{l}$	$M(x)=M\left(1-\dfrac{x}{l}\right)$	$y=\dfrac{-Ml^2}{6EI}\left(\dfrac{2x}{l}-\dfrac{3x^2}{l^2}+\dfrac{x^3}{l^3}\right)$	在$x=\left(1-\dfrac{1}{\sqrt{3}}\right)l$处： $y_{\max}=\dfrac{-Ml^2}{9\sqrt{3}EI}$ 在$x=l/2$处： $y=\dfrac{-Ml^2}{16EI}$	$q_A=\dfrac{-Ml}{3EI}$ $q_B=\dfrac{Ml}{6EI}$
5		$F_A=F_B=\dfrac{M}{l}$	$M(x)=\dfrac{Mx}{l}$	$y=\dfrac{-Ml^2}{6EI}\left(\dfrac{x}{l}-\dfrac{x^3}{l^3}\right)$	在$x=\dfrac{1}{\sqrt{3}}$处： $y_{\max}=\dfrac{-Ml^2}{9\sqrt{3}EI}$ 在$x=l/2$处： $y=\dfrac{-Ml^2}{16EI}$	$q_A=\dfrac{-Ml}{6EI}$ $q_B=\dfrac{Ml}{3EI}$
6		$F_A=F_B=\dfrac{M}{l}$	$0\le x\le a$： $M(x)=\dfrac{-Mx}{l}$ $a\le x\le l$： $M(x)=M\left(1-\dfrac{x}{l}\right)$	$0\le x\le a$： $y=\dfrac{Mx}{6EIl}(l^2-3b^2-x^2)$ $a\le x\le l$： $y=\dfrac{-M(l-x)}{6EIl}[l^2-3a^2$ $-(l-x)^2]$	在$x=\sqrt{(l^2-3b^2)/3}$处： $y_{1\max}=\dfrac{M(l^2-3b^2)^{3/2}}{9\sqrt{3}EIl}$ 在$x=\sqrt{(l^2-3a^2)/3}$处： $y_{2\max}=\dfrac{-M(l^2-3a^2)^{3/2}}{9\sqrt{3}EIl}$	$q_A=\dfrac{M(l^2-3b^2)}{6EIl}$ $q_B=\dfrac{M(l^2-3a^2)}{6EIl}$ $q_C=\dfrac{-M}{6EIl}(3a^2+3b^2-l^2)$

(续)

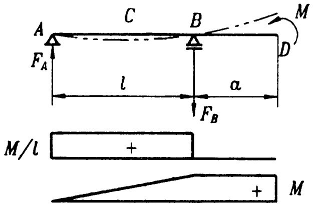
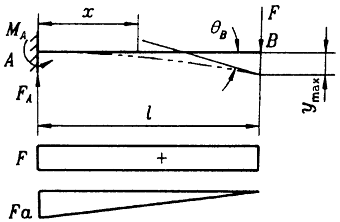
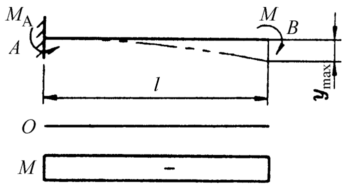
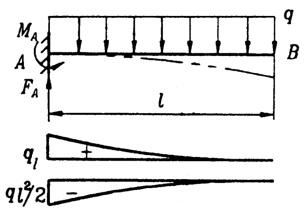
序号	载荷情况及剪力图弯矩图	支点反力	弯矩方程	挠度曲线方程	最大挠度	梁端转角
7		$F_A = F_B = \frac{ql}{2}$	$M(x) = \frac{qx}{2}(l-x)$	$y = \frac{-qx}{24EI}(l^3 - 2lx^2 + x^3)$	在$x = l/2$处: $y_{\max} = \frac{-5ql^4}{384EI}$	$q_A = -q_B = \frac{-ql^3}{24EI}$
8		$F_A = \frac{q_0 l}{6}$ $F_B = \frac{q_0 l}{3}$	$M(x) = \frac{q_0 lx}{6}\left(1 - \frac{x^2}{l^2}\right)$	$y = \frac{-q_0 l^4}{360EI} \times \left(\frac{7x}{l} - \frac{10x^3}{l^3} + \frac{3x^5}{l^5}\right)$	在$x = 0.519l$处: $y_{\max} = -0.00652\frac{q_0 l^3}{EI}$	$q_A = \frac{-7q_0 l^3}{360EI}$ $q_B = \frac{q_0 l^3}{45EI}$

序号	载荷情况及剪力图弯矩图	支点反力	弯矩方程	挠度曲线方程	最大挠度	梁端转角
9		$F_A=\frac{qb}{l}\left(\frac{b}{2}+c\right)$ $F_B=\frac{qb}{l}\left(\frac{b}{2}+c\right)$	$0\le x\le a$: $M(x)=\frac{qb}{l}\left(\frac{b}{2}+c\right)x$ $a\le x\le a+b$: $M(x)=\frac{qb}{l}\left(\frac{b}{2}+c\right)x-\frac{q}{2}(x-a)^2$ 在$x=a+\frac{b}{l}\left(\frac{b}{2}+c\right)$处: $M_{\max}=\frac{qb}{l}\left(\frac{b}{2}+c\right)\times\left[a+\frac{b}{2l}\left(\frac{b}{2}+c\right)\right]$	$0\le x\le a$: $y=\frac{-qbx}{6EIl}\left(\frac{b}{2}+c\right)\times\left[l^2-\left(\frac{b}{2}+c\right)^2-\frac{b^2}{4}-x^2\right]$ $a\le x\le a+b$: $y=\frac{-qb}{6EIl}\left\{\left(\frac{b}{2}+c\right)x\times\left[l^2-\left(\frac{b}{2}+c\right)^2-\frac{b^2}{4}-x^2\right]+\frac{l}{4b}(x-a)^4\right\}$ $a+b\le x\le l$ $y=\frac{-qb}{6EIl}(a+b)(l-x)\times\left[l^2-\left(a+\frac{b}{2}\right)^2-\frac{b^2}{4}-(l-x)^2\right]$	在$a\le x\le a+b$处: 令$y'=0$,求出x的数值解,代入y方程即得$y_{\max}$	$q_A=\frac{-qb}{6EIl}\left(\frac{b}{2}+c\right)\times\left[l^2-\left(\frac{b}{2}+c\right)^2-\frac{b^2}{4}\right]$ $q_B=\frac{qb}{6EIl}(a+b)\times\left[l^2-\left(a+\frac{b}{2}\right)^2-\frac{b^2}{4}\right]$
10		$F_A=F_B=\frac{q_0l}{4}$	$0\le x\le l/2$: $M(x)=\frac{q_0lx}{12}\left(3-\frac{4x^2}{l^2}\right)$	$0\le x\le l/2$: $y=\frac{-q_0l^4}{960EI}\left(\frac{25x}{l}-\frac{40x^3}{l^3}+\frac{16x^5}{l^5}\right)$	在$x=l/2$处: $y_{\max}=\frac{-q_0l^4}{120EI}$	$q_A=-q_B=\frac{-5q_0l}{192EI}$

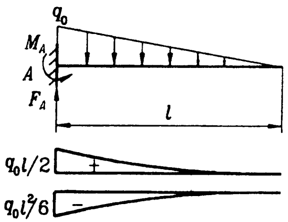
(续)

序号	载荷情况及剪力图弯矩图	支点反力	弯矩方程	挠度曲线方程	最大挠度	梁端转角
11		$F_A=\frac{Fa}{l}$ $F_B=\frac{F(a+l)}{l}$	$0\le x\le l$: $M(x)=\frac{-Fax}{l}$ $l\le x\le l+a$: $M(x)=-F(l+a-x)$	$0\le x\le l$: $y=\frac{Fal^2}{6EI}\left(\frac{x}{l}-\frac{x^3}{l^3}\right)$ $l\le x\le l+a$: $y=\frac{F}{6EIl}[al^2x-ax^3+(a+l)$ $\times(x-l)^3]$	在$x=l+a$处: $y_{max}=\frac{-Fa^2}{3EI}(l+a)$ 在$x=l/2$处: $y=\frac{Fal^2}{16EI}$	$q_A=\frac{Fal}{6EI}$ $q_B=\frac{-Fal}{3EI}$ $q_D=\frac{-Fa}{6EI}(2l+3a)$
12		$F_A=\frac{qa^2}{2l}$ $F_B=qa\left(1+\frac{a}{2l}\right)$	$0\le x\le l$: $M(x)=\frac{-qa^2}{2l}x$ $l\le x\le l+a$: $M(x)=\frac{-q}{2}(l+a-x)^2$	$0\le x\le l$: $y=\frac{qa^2l^2}{12EI}\left(\frac{x}{l}-\frac{x^3}{l^3}\right)$ $l\le x\le l+a$: $y=\frac{-qa^2}{12EIl}\left[-l^2x+x^3-\frac{(a+2l)(x-l)^3}{a}-\frac{l}{2a^2}(x-l)^4\right]$	在$x=l/2$处: $y=\frac{qa^2l^2}{32EI}$ 在$x=l+a$处: $y_{max}=\frac{-qa^3}{24EI}(3a+4l)$	$q_A=\frac{qa^2l}{12EI}$ $q_B=\frac{-qa^2l}{6EI}$ $q_D=\frac{-qa^2}{6EI}(l+a)$
13		$F_A=F_B=F$	$0\le x\le a$: $M(x)=-Fx$ $a\le x\le l+a$: $M=-Fa$	$0\le x\le a$: $y=\frac{-F}{6EI}[a^2(2a+3l)-3a\times(a$ $+l)x+x^2]$ $a\le x\le l+a$: $y=\frac{F}{6EI}[3a(a+l)x-a^2\times(2a$ $+3l)-x^3+(x-a)^3]$	$y_D=y_E=\frac{-Fa^2(2a+3l)}{6EI}$ 在$x=a+l/2$处: $y_C=\frac{Fal^2}{8EI}$	$q_A=-q_B=\frac{Fal}{2EI}$ $q_E=-q_D=\frac{Fa(l+a)}{2EI}$

(续)

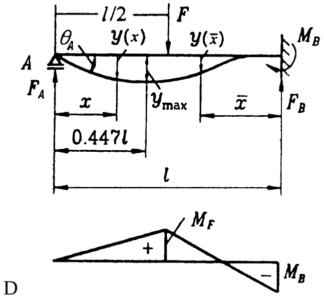
序号	载荷情况及剪力图弯矩图	支点反力	弯矩方程	挠度曲线方程	最大挠度	梁端转角
14		$F_A = F_B = \frac{M}{l}$	$0 \le x \le l$: $M(x) = \frac{M}{l}x$ $l \le x \le l + a$: $M_{\max} = M$	$0 \le x \le l$: $y = \frac{-Ml^2}{6EI}\left[\frac{x}{l} - \frac{x^3}{l^3}\right]$ $l \le x \le l + a$: $y = \frac{M}{6EI}(l-3x)(l-x)$	在$x = l/2$处: $y = \frac{-Ml^2}{16EI}$ $y_D = \frac{M}{6EI}\left(2la + 3a^2\right)$	$q_A = \frac{-Ml}{6EI}$ $q_B = \frac{Ml}{3EI}$ $q_D = \frac{M}{3EI}(l+3a)$
15		$F_A = F$ $M_A = Fl$	$M(x) = F(x-l)$	$y = \frac{-Fl^3}{6EI}\left(\frac{3x^2}{l^2} - \frac{x^3}{l^3}\right)$	在$x = l$ $y_{\max} = \frac{-Fl^3}{3EI}$	$q_B = \frac{-Fl^2}{2EI}$
16		$M_A = M$	$M(x) = -M$	$y = \frac{-Mx^2}{2EI}$	在$x = l$处: $y_{\max} = \frac{-Ml^2}{2EI}$	$q_B = \frac{-Ml}{EI}$
17		$F_A = ql$ $M_A = \frac{ql^2}{2}$	$M(x) = q\left(lx - \frac{l^2 + x^2}{2}\right)$	$y = \frac{-ql^4}{24EI}\left(\frac{6x^2}{l^2} - \frac{4x^3}{l^3} + \frac{x^4}{l^4}\right)$	在$x = l$处: $y_{\max} = \frac{-ql^4}{8EI}$	$q_B = \frac{-ql^3}{6EI}$

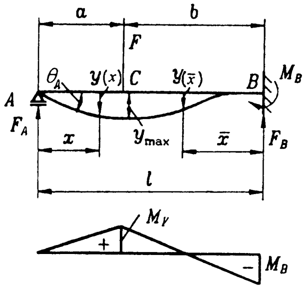
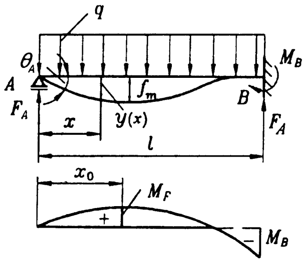
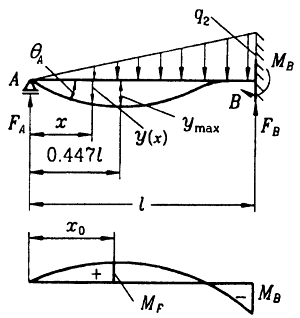
(续)

序号	载荷情况及剪力图弯矩图	支点反力	弯矩方程	挠度曲线方程	最大挠度	梁端转角
18		$F_A=\frac{q_0l}{2}$ $M_A=\frac{q_0l^2}{6}$	$M(x)=\frac{q_0l}{6}\left(\frac{3x}{l}-\frac{3x^2}{l^2}+\frac{x^3}{l^3}-1\right)$	$y=\frac{-q_0l^4}{120EI}\left(\frac{10x^2}{l^2}-\frac{10x^3}{l^3}+\frac{5x^4}{l^4}-\frac{x^5}{l^5}\right)$	在$x=l$处： $y_{\max}=\frac{-q_0l^4}{30EI}$	$q_{\mathrm{B}}=\frac{-q_0l^3}{24EI}$

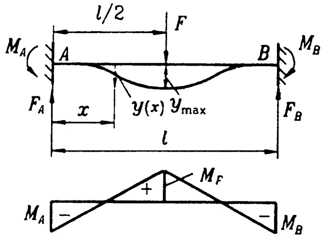
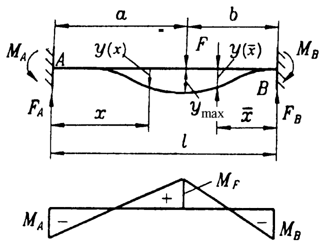
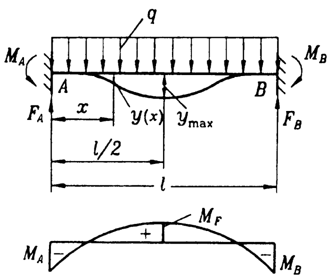
注:式中 x 为从梁左端起量的坐标(参见序号 1.15 图)，E 为材料弹性模量，I 为惯性矩,下同。

表 G1-5　静不定梁的支点反力、弯矩和变形计算公式

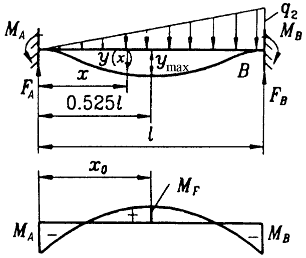
载荷、挠曲线和弯矩图	支点反力、弯矩	挠度曲线方程	挠　　度	梁端转角
 D	$F_A=\frac{5}{16}F, F_B=\frac{11}{16}F$ $M_B=-\frac{3}{16}Fl$ $M_F=\frac{5}{32}Fl$	$0\le x\le l/2$： $y(x)=\frac{-Fl^3}{96EI}\left[3\frac{x}{l}-5\left(\frac{x}{l}\right)^3\right]$ $0\le \bar{x}\le l/2$： $y(\bar{x})=\frac{-Fl^3}{96EI}\left[9\left(\frac{\bar{x}}{l}\right)^2-11\left(\frac{\bar{x}}{l}\right)^3\right]$	在$x=0.447l$处： $y_{\max}=\frac{-Fl^3}{48\sqrt{5}EI}$ 在$x=l/2$处： $y=\frac{-7Fl^3}{768EI}$	$q_{\mathrm{A}}=\frac{Fl^2}{32EI}$

载荷、挠曲线和弯矩图	支点反力、弯矩	挠度曲线方程	挠　　度	梁端转角
	$F_A=F\left(\frac{b}{l}\right)^2\left(1+\frac{a}{2l}\right)$ $F_B=F\left(\frac{a}{l}\right)^2\left(1+\frac{b}{2l}+\frac{3b}{2a}\right)$ $M_B=-F\frac{ab}{l}\left(1-\frac{b}{2l}\right)$ $M_F=F\frac{ab^2}{l^2}\left(1+\frac{a}{2l}\right)$	$0\leqslant x\leqslant a$: $y(x)=\frac{-Flb^2}{4EI}\left[\frac{a}{l}\frac{x}{l}-\frac{2}{3}\left(1+\frac{a}{2l}\right)\left(\frac{x}{l}\right)^3\right]$ $0\leqslant \bar{x}\leqslant b$: $y(\bar{x})=\frac{-Fl^2a}{4EI}\left[\left(1-\frac{a^2}{l^2}\right)\left(\frac{\bar{x}}{l}\right)^2-\left(1-\frac{a^2}{3l^2}\right)\left(\frac{\bar{x}}{l}\right)^3\right]$	当$b=0.586l$时 在C截面处: $y_{max}=-0.0098\frac{Fl^3}{EI}$ 在$x=a$处: $y=\frac{-Fa^2b^3}{4EIl^2}\left(1+\frac{a}{3l}\right)$	$q_A=\frac{Fab^2}{4EIl}$
	$F_A=\frac{3}{8}ql, F_B=\frac{5}{8}ql$ $M_B=-\frac{1}{8}ql^2$ $M_F=\frac{9}{128}ql^2$ 在$x_0=\frac{3}{8}l$	$y(x)=\frac{-ql^4}{48EI}\left[\frac{x}{l}-3\left(\frac{x}{l}\right)^3+2\left(\frac{x}{l}\right)^4\right]$	在$x=0.4215l$处: $y_{max}=\frac{-ql^4}{185EI}$	$q_A=\frac{ql^3}{48EI}$
	$F_A=\frac{1}{10}q_2l, F_B=\frac{4}{10}q_2l$ $M_B=-\frac{1}{15}q_2l^2$ $M_F=0.0298q_2l^2$ 在$x_0=0.447l$	$y(x)=\frac{-q_2l^4}{120EI}\left[\frac{x}{l}-2\left(\frac{x}{l}\right)^3+\left(\frac{x}{l}\right)^5\right]$	在$x=0.447l$处: $y_{max}=\frac{-q_2l^4}{419EI}$	$q_A=\frac{q_2l^3}{120EI}$

(续)

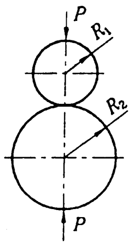
载荷、挠曲线和弯矩图	支点反力、弯矩	挠度曲线方程	挠　　度	梁端转角
	$F_A = F_B = \frac{1}{2}F$ $M_A = M_B = -\frac{1}{8}Fl$ $M_F = \frac{1}{8}Fl$	$0 \leq x \leq l/2$: $y(x) = \frac{-Fl^3}{48EI}\left[3\left(\frac{x}{l}\right)^2 - 4\left(\frac{x}{l}\right)^3\right]$	在$x = l/2$处： $y_{max} = \frac{-Fl^3}{192EI}$	—
	$F_A = F\left(\frac{b}{l}\right)^2\left(1+2\frac{a}{l}\right)$ $F_B = F\left(\frac{a}{l}\right)^2\left(1+2\frac{b}{l}\right)$ $M_A = -Fa\left(\frac{b}{l}\right)^2$ $M_B = -Fb\left(\frac{a}{l}\right)^2$ $M_F = 2Fl\left(\frac{a}{l}\right)^2\left(\frac{b}{l}\right)^2$	$0 \leq x \leq b$: $y(x) = \frac{-Flb^2}{6EI}\left[3\frac{a}{l}\left(\frac{x}{l}\right)^2 - \left(1+\frac{2a}{l}\right)\left(\frac{x}{l}\right)^3\right]$ $0 \leq \bar{x} \leq b$: $y(\bar{x}) = \frac{-Fla^2}{6EI}\left[3\frac{b}{l}\left(\frac{\bar{x}}{l}\right)^2 - \left(1+\frac{2b}{l}\right)\left(\frac{\bar{x}}{l}\right)^3\right]$	若$a > b$， 在$x = \frac{2al}{3a+b}$处： $y_{max} = \frac{-2F}{3EI}\frac{a^3b^2}{(3a+b)^2}$ 在$x = a$处： $y = \frac{-Fa^3b^3}{3EIl^3}$	—
	$F_A = F_B = \frac{1}{2}ql$ $M_A = M_B = -\frac{1}{12}ql^2$ $M_F = \frac{1}{24}ql^2$	$y(x) = \frac{ql^4}{24EI}\left[\left(\frac{x}{l}\right)^2 - 2\left(\frac{x}{l}\right)^3 + \left(\frac{x}{l}\right)^4\right]$	在$x = l/2$处： $y_{max} = \frac{-ql^4}{384EI}$	—

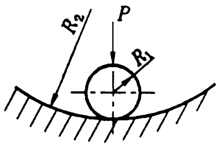
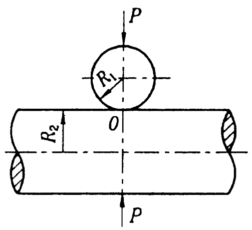
(续)

载荷、挠曲线和弯矩图	支点反力、弯矩	挠度曲线方程	挠　度	梁端转角
	$F_A=\frac{3}{20}q_2l$ $F_B=\frac{7}{20}q_2l$ $M_A=-\frac{1}{30}q_2l^2$ $M_B=-\frac{1}{20}q_2l^2$ $M_F=0.0214q_2l^2$ $x_0=0.548l$	$y(x)=\frac{q_2l^4}{120EI}\left[2\left(\frac{x}{l}\right)^2-3\left(\frac{x}{l}\right)^3+\left(\frac{x}{l}\right)^5\right]$	在$x=0.525l$处： $y_{max}=\frac{-q_2l^4}{764EI}$	—

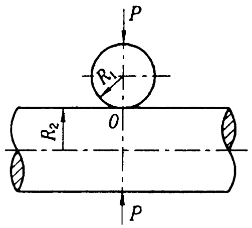
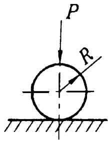
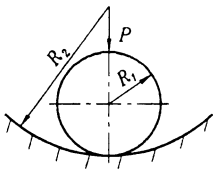
G2.3　常用零件的接触应力和接触变形计算公式（表 G1-6、表 G1-7）

表 G1-6　常用零件接触应力和接触变形计算公式

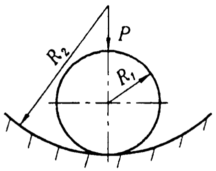
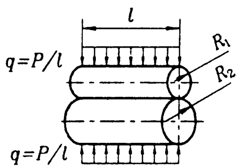
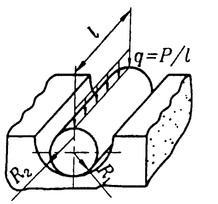
接触情况	接触面积尺寸	最大接触应力 s_{max}	接触物体靠近位移值 Δ
球与球 	$a=b=0.9086\sqrt[3]{P\frac{R_1R_2}{R_1+R_2}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)}$	$0.5784\sqrt[3]{P\frac{\left(\frac{R_1+R_2}{R_1R_2}\right)^2}{\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}}$	$0.8255\sqrt[3]{P^2\frac{R_1+R_2}{R_1R_2}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}$
	当$E_1=E_2=E$，$m_1=m_2=0.3$时		
	$a=b=1.109\sqrt[3]{\frac{P}{E}\frac{R_1R_2}{R_1+R_2}}$	$0.388\sqrt[3]{PE^2\left(\frac{R_1+R_2}{R_1R_2}\right)^2}$ $\tau_{max}=\sigma_{max}/3$　$\sigma_{1max}=0.133\sigma_{max}$	$1.231\sqrt[3]{\left(\frac{P}{E}\right)^2\frac{R_1+R_2}{R_1R_2}}$

接触情况	接触面积尺寸	最大接触应力 $s_{\max}$	接触物体靠近位移值 Δ
球与球形凹面  	$a=b=0.9086\sqrt[3]{P\frac{R_1R_2}{R_2-R_1}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)}$	$0.5784\sqrt[3]{P\frac{\left(\frac{R_2-R_1}{R_1R_2}\right)^2}{\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}}$	$0.8255\sqrt[3]{P^2\frac{R_2-R_1}{R_1R_2}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}$
	当$E_1=E_2=E$，$m_1=m_2=0.3$时		
	$a=b=1.109\sqrt[3]{\frac{P}{E}\frac{R_1R_2}{R_2-R_1}}$	$0.388\sqrt[3]{PE^2\left(\frac{R_2-R_1}{R_1R_2}\right)^2}$ $\tau_{\max}=\sigma_{\max}/3 \quad \sigma_{1\max}=0.133\sigma_{\max}$	$1.231\sqrt[3]{\left(\frac{P}{E}\right)^2\frac{R_2-R_1}{R_1R_2}}$
球与圆柱  	$a=1.145n_a\sqrt[3]{P\frac{R_1R_2}{2R_2+R_1}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)}$ $b=1.145n_b\sqrt[3]{P\frac{R_1R_2}{2R_2+R_1}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)}$ $A=\frac{1}{2R_1} \quad B=\frac{1}{2}\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$	$0.365n_\sigma\sqrt[3]{P\frac{\left(\frac{2R_2+R_1}{R_1R_2}\right)^2}{\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}}$	$0.655n_\delta\sqrt[3]{P^2\frac{2R_2+R_1}{R_1R_2}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}$
	当$E_1=E_2=E$，$m_1=m_2=0.3$时		

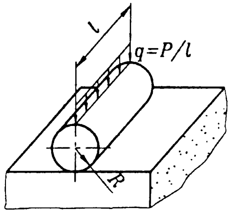
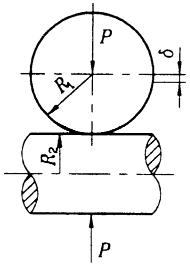
(续)

接触情况	接触面积尺寸	最大接触应力 s max	接触物体靠近位移值Δ
球与圆柱 	$a=1.397n_a\sqrt[3]{\frac{P}{E}\frac{R_1R_2}{2R_2+R_1}}$ $b=1.397n_b\sqrt[3]{\frac{P}{E}\frac{R_1R_2}{2R_2+R_1}}$	$0.245n_\sigma\sqrt[3]{PE^2\left(\frac{2R_2+R_1}{R_1R_2}\right)^2}$	$0.977n_\delta\sqrt[3]{\left(\frac{P}{E}\right)^2\frac{2R_2+R_1}{R_1R_2}}$
球与平面 	$a=b=0.9086\sqrt[3]{PR\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)}$	$0.5784\sqrt[3]{\frac{P}{R^2\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}}$	$0.8255\sqrt[3]{\frac{P^2}{R}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}$
	当$E_1=E_2=E$，$m_1=m_2=0.3$时		
	$a=b=1.109\sqrt[3]{\frac{P}{E}R}$	$0.388\sqrt[3]{PE^2\frac{1}{R^2}}$ $\tau_{max}=\sigma_{max}/3$ $\sigma_{1max}=0.133\sigma_{max}$	$1.231\sqrt[3]{\left(\frac{P}{E}\right)^2\frac{1}{R}}$
球与圆柱凹面 	$a=1.145n_a\sqrt[3]{P\frac{R_1R_2}{2R_2-R_1}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)}$ $b=1.145n_b\sqrt[3]{P\frac{R_1R_2}{2R_2-R_1}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)}$ $A=\frac{1}{2}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ $B=\frac{1}{2R_1}$	$0.365n_\sigma\sqrt[3]{P\frac{\left(\frac{2R_2-R_1}{R_1R_2}\right)^2}{\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}}$	$0.655n_\delta\sqrt[3]{P^2\frac{2R_2-R_1}{R_1R_2}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}$

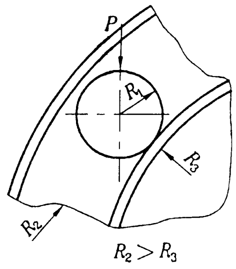
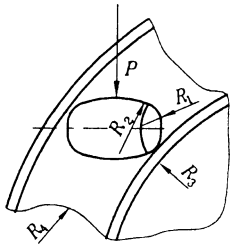
(续)

接触情况	接触面积尺寸	最大接触应力 $s_{\max}$	接触物体靠近位移值 Δ
球与圆柱凹面 	当$E_1=E_2=E$，$m_1=m_2=0.3$时		
	$a=1.397n_a\sqrt[3]{\frac{P}{E}\frac{R_1R_2}{2R_2-R_1}}$ $b=1.397n_b\sqrt[3]{\frac{P}{E}\frac{R_1R_2}{2R_2-R_1}}$	$0.245n_\sigma\sqrt[3]{PE^2\left(\frac{2R_2-R_1}{R_1R_2}\right)^2}$	$0.977n_\delta\sqrt[3]{\left(\frac{P}{E}\right)^2\frac{2R_2-R_1}{R_1R_2}}$
平行圆柱 	接触带半宽 $b=1.128\sqrt{\frac{P}{l}\frac{R_1R_2}{R_1+R_2}\left(\frac{1-m_1^2}{E_1}+\frac{1-m_2^2}{E_2}\right)}$	$0.5642\sqrt{\frac{P}{l}\frac{\frac{R_1+R_2}{R_1R_2}}{\frac{1-m_1^2}{E_1}+\frac{1-m_2^2}{E_2}}}$	$\frac{2P}{\mathbf{p}l}\left[\frac{1-m_1^2}{E_1}\left(\ln\frac{2R_1}{b}+0.407\right)+\frac{1-m_2^2}{E_2}\left(\ln\frac{2R_2}{b}+0.407\right)\right]$
	当$E_1=E_2=E$，$m_1=m_2=0.3$时		
	$b=1.522\sqrt{\frac{P}{lE}\frac{R_1R_2}{R_1+R_2}}$	$0.418\sqrt{\frac{PE}{l}\frac{R_1+R_2}{R_1R_2}}$	$0.5796\frac{P}{lE}\left(\ln\frac{4R_1R_2}{b^2}+0.814\right)$
圆柱与轴线平行的圆柱槽 	接触带半宽 $b=1.128\sqrt{\frac{P}{l}\frac{R_1R_2}{R_2-R_1}\left(\frac{1-m_1^2}{E_1}+\frac{1-m_2^2}{E_2}\right)}$	$0.5642\sqrt{\frac{P}{l}\frac{\frac{R_2-R_1}{R_1R_2}}{\frac{1-m_1^2}{E_1}+\frac{1-m_2^2}{E_2}}}$	
	当$E_1=E_2=E$，$m_1=m_2=0.3$时		
	$b=1.522\sqrt{\frac{P}{lE}\frac{R_1R_2}{R_2-R_1}}$	$0.418\sqrt{\frac{PE}{l}\frac{R_2-R_1}{R_1R_2}}$	$1.82\frac{P}{lE}(1-\ln b)$

(续)

接触情况	接触面积尺寸	最大接触应力 $s_{\max}$	接触物体靠近位移值 Δ
圆柱与平面 	接触带半宽 $b=1.128\sqrt{\frac{PR}{l}\left(\frac{1-m_1^2}{E_1}+\frac{1-m_2^2}{E_2}\right)}$	$0.5642\sqrt{\frac{\frac{P}{lR}}{\frac{1-m_1^2}{E_1}+\frac{1-m_2^2}{E_2}}}$	
	当$E_1=E_2=E$，$m_1=m_2=0.3$时		
	$b=1.522\sqrt{\frac{PR}{lE}}$	$0.418\sqrt{\frac{PE}{lR}}$ $t_{\max}=0.301s_{\max}$	在两挤压面间圆柱直径的减小 $\Delta D=1.159\frac{P}{lE}\left(0.41+\ln\frac{4R}{b}\right)$
垂直圆柱 	$a=1.145n_a\sqrt[3]{P\frac{R_1R_2}{R_2+R_1}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)}$ $b=1.145n_b\sqrt[3]{P\frac{R_1R_2}{R_2+R_1}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)}$ $A=\frac{1}{2R_2}\quad B=\frac{1}{2R_1}$	$0.365n_\sigma\sqrt[3]{P\frac{\left(\frac{R_2+R_1}{R_1R_2}\right)^2}{\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}}$	$0.655n_\delta\sqrt[3]{P^2\frac{R_2+R_1}{R_1R_2}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2}$
	当$E_1=E_2=E$，$m_1=m_2=0.3$时		
	$a=1.397n_a\sqrt[3]{\frac{P}{E}\frac{R_1R_2}{R_2+R_1}}$ $b=1.397n_b\sqrt[3]{\frac{P}{E}\frac{R_1R_2}{R_2+R_1}}$	$0.245n_\sigma\sqrt[3]{PE^2\left(\frac{R_2+R_1}{R_1R_2}\right)^2}$	$0.977n_\delta\sqrt[3]{\left(\frac{P}{E}\right)^2\frac{R_2+R_1}{R_1R_2}}$

(续)

接触情况	接触面积尺寸	最大接触应力 $s_{\max}$	接触物体靠近位移值 Δ
球与圆弧槽（滚珠轴承）  	$a=1.145\,n_a\sqrt[3]{P\dfrac{\dfrac{1-\mu_1^2}{E_1}+\dfrac{1-\mu_2^2}{E_2}}{\dfrac{2}{R_1}-\dfrac{1}{R_2}+\dfrac{1}{R_3}}}$ $b=1.145\,n_b\sqrt[3]{P\dfrac{\dfrac{1-\mu_1^2}{E_1}+\dfrac{1-\mu_2^2}{E_2}}{\dfrac{2}{R_1}-\dfrac{1}{R_2}+\dfrac{1}{R_3}}}$ $\sigma_{\max}=0.365\,n_\sigma\sqrt[3]{P\dfrac{\left(\dfrac{2}{R_1}-\dfrac{1}{R_2}+\dfrac{1}{R_3}\right)^2}{\left(\dfrac{1-\mu_1^2}{E_1}+\dfrac{1-\mu_2^2}{E_2}\right)^2}}$	$A=\dfrac{1}{2}\left(\dfrac{1}{R_1}-\dfrac{1}{R_2}\right)\quad B=\dfrac{1}{2}\left(\dfrac{1}{R_1}+\dfrac{1}{R_3}\right)$ 当$E_1=E_2=E$，$\mu_1=\mu_2=0.3$时 $a=1.397\,n_a\sqrt[3]{\dfrac{\dfrac{P}{E}}{\dfrac{2}{R_1}-\dfrac{1}{R_2}+\dfrac{1}{R_3}}}$ $b=1.397\,n_b\sqrt[3]{\dfrac{\dfrac{P}{E}}{\dfrac{2}{R_1}-\dfrac{1}{R_2}+\dfrac{1}{R_3}}}$ $\sigma_{\max}=0.245\,n_\sigma\sqrt[3]{PE^2\left(\dfrac{2}{R_1}-\dfrac{1}{R_2}+\dfrac{1}{R_3}\right)^2}$	$0.655\,n_\delta\sqrt[3]{P^2\left(\dfrac{1-\mu_1^2}{E_1}+\dfrac{1-\mu_2^2}{E_2}\right)^2}$ $\times\sqrt[3]{\dfrac{2}{R_1}-\dfrac{1}{R_2}+\dfrac{1}{R_3}}$ 当$E_1=E_2=E$，$\mu_1=\mu_2=0.3$时 $\Delta=0.977\,n_\delta\sqrt[3]{\left(\dfrac{P}{E}\right)^2\left(\dfrac{2}{R_1}-\dfrac{1}{R_2}+\dfrac{1}{R_3}\right)^2}$
滚柱轴承  	$a=1.145\,n_a\sqrt[3]{P\dfrac{\dfrac{1-\mu_1^2}{E_1}+\dfrac{1-\mu_2^2}{E_2}}{\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_3}-\dfrac{1}{R_4}}}$ $b=1.145\,n_b\sqrt[3]{P\dfrac{\dfrac{1-\mu_1^2}{E_1}+\dfrac{1-\mu_2^2}{E_2}}{\dfrac{1}{R_1}-\dfrac{1}{R_2}+\dfrac{1}{R_3}-\dfrac{1}{R_4}}}$ $\sigma_{\max}=0.365\,n_\sigma\sqrt[3]{P\dfrac{\left(\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_3}-\dfrac{1}{R_4}\right)^2}{\left(\dfrac{1-\mu_1^2}{E_1}+\dfrac{1-\mu_2^2}{E_2}\right)^2}}$	$A=\left(\dfrac{1}{R_2}-\dfrac{1}{R_4}\right)\quad B=\dfrac{1}{2}\left(\dfrac{1}{R_1}+\dfrac{1}{R_3}\right)$ 当$E_1=E_2=E$，$\mu_1=\mu_2=0.3$时 $a=1.397\,n_a\sqrt[3]{\dfrac{\dfrac{P}{E}}{\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_3}-\dfrac{1}{R_4}}}$ $b=1.397\,n_b\sqrt[3]{\dfrac{\dfrac{P}{E}}{\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_3}-\dfrac{1}{R_4}}}$ $\sigma_{\max}=0.245\,n_\sigma\times\sqrt[3]{PE^2\left(\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_3}-\dfrac{1}{R_4}\right)^2}$	$0.655\,n_\delta\sqrt[3]{P^2\left(\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_3}-\dfrac{1}{R_4}\right)}$ $\times\sqrt[3]{\left(\dfrac{1-\mu_1^2}{E_1}+\dfrac{1-\mu_2^2}{E_2}\right)^2}$ 当$E_1=E_2=E$，$\mu_1=\mu_2=0.3$时 $\Delta=0.977\,n_\delta\times\sqrt[3]{\left(\dfrac{P}{E}\right)^2\left(\dfrac{1}{R_1}+\dfrac{1}{R_2}+\dfrac{1}{R_3}-\dfrac{1}{R_4}\right)}$

注: 1. a—接触时接触面的椭圆长半轴；b—点接触时接触面的椭圆短半轴，线接触时接触面的半宽度；$s_{1\max}$ —最大拉应力。

2. A、B—椭圆方程系数；n_a? n_b? n_s? n_d —接触问题的系数，见表 G1-7。

3. E? m —分别为材料的弹性模量和泊松比。

表 G1-7　接触问题的系数 n_a、n_b、n_o、n_δ

$\frac{A}{B}$	n_a	n_b	n_s	n_d	$\frac{A}{B}$	n_a	n_b	n_s	n_d
1.0000	1.0000	1.0000	1.0000	1.0000	0.1739	1.916	0.6059	0.8614	0.8566
0.9623	1.013	0.9873	0.9999	0.9999	0.1603	1.979	0.5938	0.8504	0.8451
0.9240	1.027	0.9472	0.9997	0.9997	0.1462	2.053	0.5808	0.8386	0.8320
0.8852	1.042	0.9606	0.9992	0.9992	0.1317	2.141	0.5665	0.8246	0.8168
0.8459	1.058	0.9465	0.9985	0.9985	0.1166	2.248	0.5505	0.8082	0.7990
0.8059	1.076	0.9318	0.9974	0.9974	0.1010	2.381	0.5325	0.7887	0.7775
0.7652	1.095	0. 9165	0.9960	0.9960	0.09287	2.463	0.5224	0.7774	0.7650
0.7238	1.117	0.9005	0.9942	0.9942	0.08456	2.557	0.5114	0.7647	0.7509
0.6816	1.141	0.8837	0.9919	0.9919	0.07600	2.669	0.4993	0.7504	0.7349
0.6384	1.168	0.8660	0.9890	0.9889	0.06715	2.805	0.4858	0.7338	0.7163
0.5942	1.198	0.8472	0.9853	0.9852	0.05797	2.975	0.4704	0.7144	0.6943
0.5489	1.233	0.8271	0.9805	0.9804	0.04838	3.199	0.4524	0.6909	0.6675
0.5022	1.274	0.8056	0.9746	0.9744	0.04639	3.253	0.4484	0.6856	0.6613
0.4540	1.322	0.7822	0.9669	0.9667	0.04439	3.311	0.4442	0.6799	0.6549
0.4040	1.381	0.7565	0.9571	0.9566	0.04237	3.373	0.4398	0.6740	0.6481
0.3518	1.456	0.7278	0.9440	0.9432	0.04032	3.441	0.4352	0.6678	0.6409
0.3410	1.473	0.7216	0.9409	0.9400	0.03823	3.514	0.4304	0.6612	0.6333
0.3301	1.491	0.7152	0.9376	0.9366	0.03613	3.594	0.4253	0.6542	0.6251
0.3191	1.511	0.7086	0.9340	0.9329	0.03400	3.683	0.4199	0.6467	0.6164
0.3080	1.532	0.7019	0.9302	0.9290	0.03183	3.781	0.4142	0.6387	0.6071
0.2967	1.554	0.6949	0.9262	0.9248	0.02962	3.890	0.4080	0.6300	0.5970
0.2853	1.578	0.6876	0.9219	0.9203	0.02737	4.014	0.4014	0.6206	0.5860
0.2738	1.603	0.6801	0.9172	0.9155	0.02508	4.156	0.3942	0.6104	0.5741
0.2620	1.631	0.6723	0.9121	0.9102	0.02273	4.320	0.3864	0.5990	0.5608
0.2501	1.660	0.6642	0.9067	0.9045	0.02033	4.515	0.3777	0.5864	0.5460
0.2380	1.693	0.6557	0.9008	0.8983	0.01787	4.750	0.3680	0.5721	0.5292
0.2257	1.729	0.6468	0.8944	0.8916	0.01533	5.046	0.3568	0.5555	0.5096
0.2132	1.768	0.6374	0.8873	0.8841	0.01269	5.432	0.3436	0.5358	0.4864
0.2004	1.812	0.6276	0.8766	0.8759	0.009934	5.976	0.3273	0.5112	0.4574
0.1873	1.861	0.6171	0.8710	0.8668	0.007018	6.837	0.3058	0.4783	0.4186
					0.003850	8.609	0.2722	0.4267	0.3579