GENEL BİLGİLER

BİRİMLER ÇEVRİM ÇİZELGELERİ

Metrik		SI	Anglo Amerikan
Uzunluk			
1.0 m	1000	mm	39.4 in, 3.3 ft
1.0 cm	10	mm	0.394 in, 0.033 ft
1.0 mm	1	mm	0.0394 in
Alan			
1.0 m^2	$1x10^6$	mm^2	1.550 in^2, 10.76 ft^2
1.0 cm^2	100	mm^2	0.155 in^2
1.0 mm^2	1	mm^2	0.00155 in^2
Hacim			
1.0 m^3	$1x10^9$	mm^3	61 000 in^3, 35.3 ft^3
1.0 cm^3	$1x10^3$	mm^3	0.061 in^3
1.0 *l*	$1x10^6$	mm^3	61 in, 0.264 US Galon
Eylemsizlik Momenti			
1.0 m^4	$1x10^{12}$	mm^4	$2.4x10^6$ in^4
1.0 cm^4	$1x10^4$	mm^4	0.024 in^4
Kuvvet, Yük, Gerilme, Basınç			
1.0 t	10	kN	2200 *l* b, 2.2 k
1.0 kg	10	N	2.2 *l* b
1.0 t/m	10	kN/m	0.67 k/ft
1.0 kg/m	10	N/m	0.67 *l* b/ft
1.0 t/m^2	10	kN/m^2	0.205 ksf
1.0 t/cm^2	100	N/mm^2 (MPa)	14.24 ksi
1.0 kg/m^2	10	N/m^2	0.205 psf
1.0 kg/cm^2	0.1	N/mm^2 (MPa)	14.24 psi
Özgül Ağırlık			
1.0 t/m^3	10	kN/m^3	62.5 *l* b/ft^3
1.0 kg/m^3	10	N/m^3	0.0625 *l* b/ft^3
1.0 kg/cm^3	0.01	N/mm^3	36.1 *l* b/in^3
Moment, İş, Enerji			
1.0 tm	10	kNm	86.9 ink, 7.24 ftk
1.0 tcm	0.1	kNm	0.869 ink, 869 in *l* b
1.0 kgm	10	kNmm	86.9 in *l* b
1.0 kgcm	100	Nmm	0.869 in *l* b

SI Uluslararası Birimler Sistemi

Uluslararası ilişkiler, eğitim, bilim ve teknolojide getirdiği kolaylıklar, diğer birim sistemlerinin neden olduğu kavram karışıklığına son vermesi ve kendi içindeki uyumlululuğu SI sisteminin yaygınlaşmasına neden olmuştur. Mühendislik alanında da son derece gerekli olan bu birimler sistemiyle ilgili bilgiler ve mesleğimize ilişkin çevrim çizelgeleri aşağıda sunulmuştur.

Çizelge 1. SI Temel Birimleri

Büyüklük	Adı	Simgesi
uzunluk	metre	m
kütle	kilogram	kg
zaman	saniye	s
elektrik akımı	amper	A
termodinamik sıcaklık	kelvin	K
madde miktarı	mol	mol
ışık şiddeti	kandela	cd

Çizelge 2. Diğer SI Temel Birimleri

Büyüklük	Adı	Simgesi	Tanımı
düzlem açısı	radyan	rad	
uzay açısı	steradyan	sr	
frekans	hertz	Hz	s^{-1}
kuvvet	newton	N	$kg\ m/s^2$
gerilme	pascal	Pa	N/m^2
enerji	joule	J	N.m
güç	watt	W	J/s
elektrik yükü	coulomb	C	A.s
elektrik gerilimi	volt	V	W/A
elektrik direnci	ohm	Ω	V/A
elektrik sığası	farad	F	C/V
elektrik iletkenliği	siemens	S	Ω^{-1}
magnetik akı	weber	Wb	V.s
magnetik akı yoğunluğu	tesla	T	Wb/m^2
indüktans	henry	H	Wb/A
ışık akısı	lümen	lm	cd.sr
aydınlatma	lüks	lx	lm/m^2

Çizelge 3. SI Birimlerinin Örnekleri

Örnek	Simge	Çarpan
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hekto	h	10^{2}
deka	da	10^{1}
desi	d	10^{-1}
santi	c	10^{-2}
mili	m	10^{-3}
mikro	μ	10^{-6}
nano	n	10^{-9}
piko	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Çizelge 4. SI Sistemiyle Birlikte Kullanılabilecek Birimler

Adı	Simgesi	SI cinsinden değeri
dakika	min	60 s
saat	h	3600 s
gün	d	86400 s
derece	°	(π/180) rad
dakika	′	(π/10800) rad
saniye	″	(π/648000) rad
litre	*l*	$10^{-3}m^3$
ton	t	$10^{3}kg$

Çizelge 5 - Çevrimler

Büyüklük adı	Simgesi	SI Birimi adı	SI Birimi simgesi	Diğer birim adı	Diğer birim simgesi	SI birimini elde etmek için diğer birimin çarpılacağı katsayı
uzunluk	l	metre	m	angstrom ayak (foot) inç mikron mil deniz mili yarda	Å ft in μ mi n.mi. yd	10^{-10} 3.048×10^{-1} 2.540×10^{-2} 10^{-6} 1.609×10^{3} 1.852×10^{3} 9.144×10^{-1}
alan	A	metrekare	m^2	acre ar dönüm foot kare hektar inç kare mil kare yarda kare	- a - ft^2 ha in^2 mi^2 yd^2	4.047×10^{3} 10^{2} 9.210×10^{3} 9.29×10^{-2} 10^{4} 6.452×10^{-4} 2.590×10^{6} 8.361×10^{-1}
hacim	V	metreküp	m^3	ons (sıvı) foot küp galon inç küp litre pint quart yarda küp galon (İng.)	fl.oz. ft^3 gal in^3 l - - yd^3 gal (UK)	2.957×10^{-5} 2.832×10^{-2} 3.785×10^{-3} 1.639×10^{-5} 10^{-3} 4.732×10^{-4} 9.464×10^{-4} 7.646×10^{-1} 4.546×10^{-3}
kesit momenti	I_a	metre^4	m^4	foot^4 inç^4		8.631×10^{-3} 4.162×10^{-7}
zaman period -	t T	saniye		dakika saat gün sy yıl	min h d - a	60 3.6×10^{3} 8.64×10^{4} 2.628×10^{6} 3.154×10^{7}

frekans	f, ν	hertz	Hz (1/s)	1/dakika 1/saat 1/gün 1/ay 1/yıl	1/min 1/h 1/d - 1/a	1.667×10^{-2} 2.778×10^{-4} 1.157×10^{-5} 3.805×10^{-7} 3.171×10^{-8}
açısal hız	ω	saniyede radyan	rad/s	dakikada radyan saatte radyan günde radyan yılda radyan saniyede derece saatte derece günde derece yılda derece saniyede devir dakikada devir	rad/min rad/h rad/d rad/a °/s °/h °/d °/a rev/s (Hz) rev/min	1.667×10^{-2} 2.778×10^{-4} 1.157×10^{-5} 3.169×10^{-8} 1.745×10^{-2} 2.909×10^{-4} 4.848×10^{-6} 2.020×10^{-7} 6.283 1.047×10^{-1}
hız	u, v, c	saniyede metre	m/s	saatte foot dakikada foot saniyede foot saatte inç dakikada inç saatte kilometre saatte mil dakikada mil	ft/h ft/min ft/s in/h in/min km/h mi/h mi/min	8.467×10^{-5} 5.080×10^{-3} 3.048×10^{-1} 7.056×10^{-6} 4.233×10^{-4} 2.778×10^{-1} 4.470×10^{-1} 26.822

hacim debisi	qv	saniyede metre küp	m^3/s	saniyede ft^3 dakikada ft^3 saatte ft^3 günde ft^3 saniyede galon saniyede in^3 saniyede litre dakikada litre saatte litre günde litre	ft^3/s ft^3/min ft^3/h ft^3/d gal/s in^3/s l/s l/min l/h l/d	$2.832x10^{-2}$ $4.719x10^{-4}$ $7.866x10^{-6}$ $3.277x10^{-7}$ $3.785x10^{-3}$ $1.639x10^{-5}$ $1.000x10^{-3}$ $1.667x10^{-5}$ $2.778x10^{-7}$ $1.157x10^{-8}$
ivme		metre bölü saniye kare	m/s^2	foot bölü saniye kare inç bölü saniye kare saatte km bölü saniye saatte mil bölü saniye	ft/s^2 in/s^2 km/h.s mil/h.s	$3.048x10^{-1}$ $2.54x10^{-2}$ $2.77x10^{-1}$ $4.470x10^{-1}$
Açısal ivme	α	radyan bölü saniye kare	rad/s^2	derece bölü saniye kare devir bölü saniye kare dakikada derece bölü saniye dakikada	$°/s^2$ rev/s^2 °/min.s rev/min.s	$1.745x10^{-2}$ 6.283 $2.909x10^{-4}$
s	$1.047x10^{-1}$			devir bölü saniye		

kütle	m	kilogram	kg	ons libre slug ton	Oz. lb_m - t	2.834×10^{-2} 4.536×10^{-1} 1.459×10^{1} 1000
yoğunluk	ρ	kilogram bölü metre küp	kg/m^3	kilogram bölü litre	kg/l	1000
				gram bölü santimetre küp	g/cm^3	1000
				ons bölü inç küp	oz/in^3	1.730×10^{3}
				libre bölü foot küp	lb_m/ft^3	1.602×10^{1}
				libre bölü inç küp	lb_m/in^3	2.768×10^{4}
				ton bölü metre küp	t/m^3	1000
özgül hacim	v	metre küp bölü kilogram	m^3/kg	1/(yoğunluk birimleri) ve 1/(yoğunluk katsayıları) kullanılır.		
momentum	p	kilogram metre bölü saniye	$kg.m/s$			
açısal momentum	L	kilogram metre kare bölü saniye	$kg.m^2/s$			
eylemsizlik momenti	I, J	kilogram metre kare	$kg.m^2$			
kuvvet ağırlık	F, P G, W	newton	N	din kilogram kuvvet libre kuvvet ton	dyn kgf lbf -	1.000×10^{-5} 9.807 4.448 9806.65

basınç normal gerilme kayma gerilmesi	p σ τ	paskal	Pa	atmosfer bar din/cm^2 inç su sütunu inç civa sütunu metre su sütunu kilogram kuvvet bölü metre kare kilogram kuvvet bölü santimetre kare torr	atm bar dyn/cm^2 inH2O inHg mH2O kgf/m^2 kgf/cm^2 torr	1.013x10^5 100000 0.1 249.082 3386.38 9806.36 9.807 9.807x10^4 133.322
normal gerilme kayma gerilmesi hacim gerilmesi Poisson Oranı	ε γ θ μ, ν					
Elastik Modülü Hacim Modülü Kayma Modülü	E K G	paskal	Pa	basınç çevirme katsayıları kullanılır.		
Viskozite	η	paskal saniye	Pa.s	poise santipoise	g/cm.s kgf.s/m^2 P cP	0.1 9.807 0.1 0.001
Kinematik viskozite	ν	metrekare bölü saniye	m^2/s	stokes	St	1.000x10^{-4}
enerji iş Potansiyel enerji kinetik enerji ısı	E W Ep, V, ϕ Ek, K Q	Joule	J	İngiliz Isıl Birimi Kalori Erg kilogram kuvvet metre	Btu cal erg kgf.m	1.056x10^3 4.19 1.0x10^{-7} 9.807

güç	*p*	watt	J/s	Beygir gücü (Metrik)	Btu/h Btu/min Btu/s cal/h cal/min cal/s erg/s PS	0.293 17.584 1055.056 $1.163/10^{-3}$ $6.978/10^{-2}$ 4.187 $1.0x10^{-7}$ 735.5
Celsius Sıcaklığı	1,8	derece Celsius	°C	derece Fahrenheit	°F	t=5/9 (t_f - 2)

ÇEŞİTLİ MALZEMELERİN ÖZGÜL AĞIRLIKLARI VE ISI İLETKENLİKLERİ

Malzeme	Özgül Ağırlık (kg/m³)	Isıl İletkenlik (W/m.°C)
Genleştirilmiş polistiren	16-24	0.033 - 0.035
Poliüretan	24-40	0.024 - 0.039
Cam yünü şilte	16-48	0.032 - 0.040
Gazbeton	320-700	0.084 - 0.18
Tuğla	2300	0.6
Fayans	2500	
Cam	2500	0.75
Tuğla duvar	1700	0.73 - 1.45
Mastik asfalt	2100	0.60
Kumtaşı	2500	1.29
Kireçtaşı	2300	1.53
Beton	2300	1.44
Çelik	7850	57
Alüminyum	2700	214

ULUSLARARASI KAĞIT ÖLÇÜLERİ (Ölçüler mm)

Norm	En	Boy	Norm	En	Boy	Norm	En	Boy
B0	1000	1 414	4A0	1 682	2 378	C0	917	1 297
B1	707	1 000	2A0	1 189	1 682	C1	648	917
B2	500	707	A0	841	1 189	C2	458	648
B3	353	500	A1	594	841	C3	324	458
B4	250	353	A2	420	594	C4	229	324
B5	176	250	A3	297	420	C5	162	229
B6	125	176	A4	210	297	C6	114	162
B7	88	125	A5	148	210	C7	81	114
B8	62	88	A6	105	148	C8	57	81
B9	44	62	A7	74	105			
B10	31	44	A8	52	74			
			A9	37	52			
			A10	26	37			

Çevrim Tablosu Milimetre-Inch karşılıkları

mm	in
1	0,039 371
2	0,07874
3	0,11811
4	0,157 484
5	0,196 855
6	0,236 226
7	0,275 597
8	0,314 968
9	0,354 339
10	0,393 71
11	0,433 081
12	0,472452
13	0,511823
14	0,551194
15	0,590 565
16	0,629 936
17	0,669 307
18	0,708 678
19	0,748 049
20	0,78742
21	0,826 791
22	0,866 162
23	0,905 533
24	0,944904
25	0,984 275
26	1,023 646
27	1,063 017
28	1,102 388
29	1,141759
30	1,18113
31	1,220501
32	1,259 872
33	1,299 243
34	1,338614

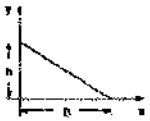
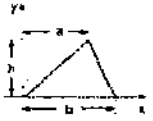
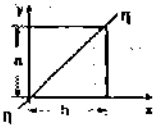
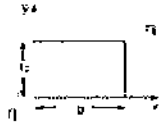
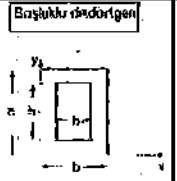
mm	in
35	1,377 985
36	1,417356
37	1,456727
38	1,496 098
39	1,535 469
40	1,574 84
41	1,614 211
42	1,653 582
43	1,692 953
44	1,732 324
45	1,771 695
46	1,811066
47	1,850437
48	1,889808
49	1,929 179
50	1,968 55
51	2,007 921
52	2,047 292
53	2,086 663
54	2,126034
55	2,163 405
56	2,204 776
57	2,244 147
58	2,283518
59	2,322 889
60	2,362 26
61	2,401 631
62	2,441 002
63	2,480373
64	2,519744
65	2,559115
66	2,598 486
67	2,637 857
68	2,677228

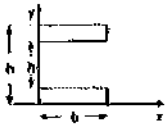
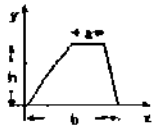
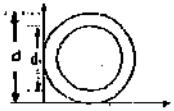
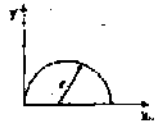
mm	in
69	2,716 599
70	2,75597
71	2,795341
72	2,834 712
73	2,874 083
74	2,913 454
75	2,952 825
76	2,992 196
77	3,031 567
78	3,070 938
79	3,110309
80	3,14968
81	3,189051
82	3,228422
83	3,267 793
84	3,307 164
85	3,346 535
86	3,385 906
87	3,425 277
88	3,464648
89	3,504 019
90	3,543 39
91	3,582 761
92	3,622132
93	3,661 503
94	3,700 874
95	3,740 245
96	3,779 616
97	3,818987
98	3,858358
99	3,897729
100	3,9371

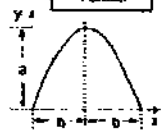
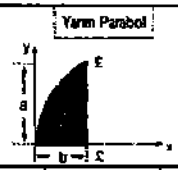
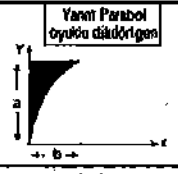
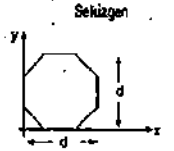
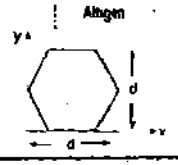
YUNAN ALFABESİ

Alpha	Α	α	Nu	Ν	ν
Beta	Β	β	Xi	Ξ	ξ
Gamma	Γ	γ	Omicron	Ο	ο
Delta	Δ	δ	Pi	Π	π
Epsilon	Ε	ε	Rho	Ρ	ρ
Zeta	Ζ	ζ	Sigma	Σ	σ
Eta	Η	η	Tau	Τ	τ
Theta	Θ	θ	Upsilon	Υ	υ
Iota	Ι	ι	Phi	Φ	φ,φ
Kappa	Κ	κ	Chi	Χ	χ
Lambda	Λ	λ	Psi	Ψ	ψ
Mu	Μ	μ	Omega	Ω	ω

DÜZLEMSEL GEOMETRİK ŞEKİLLERİN ÖZELLİKLERİ

Geometrik Şekil	Alan-geometrik merkez	Eylemsizlik momenti	Dayanım momenti
Dik Üçgen 	$A=\frac{bh}{2}$ $X_c=\frac{b}{3}$ $Y_c=\frac{h}{3}$	$I_{xc}=bh^3/36$ $I_{yc}=hb^3/36$ $I_x=bh^3/12$ $I_y=hb^3/12$	$W_{xc}=\frac{bh^2}{24}$ $W_{yc}=\frac{hb^2}{24}$
Üçgen 	$A=\frac{bh}{2}$ $X_c=\frac{a+b}{3}$ $Y_c=\frac{h}{3}$	$I_{xc}=hb^3/36$ $I_{yc}=\frac{bh}{36}(b^2-ab+a^2)$ $I_x=bh^3/12$ $I_y=\frac{bh}{12}(b^2+ab+a^2)$	$W_{xc}=\frac{bh^2}{24}$
Kare 	$A=h^2$ $X_c=\frac{h}{2}$ $Y_c=\frac{h}{2}$	$I_x=I_{yc}=h^4/12$ $I_{xy}=I_y=h^4/3$ $I_\eta=h^4/12$	$W_{xc}=W_{yc}=\frac{h^3}{6}$
Dikdörtgen 	$A=bh$ $X_c=\frac{b}{2}$ $Y_c=\frac{h}{2}$	$I_{xc}=bh^3/12$ $I_{yc}=hb^3/12$ $I_x=bh^3/3$ $I_y=hb^3/3$ $I_\eta=\frac{bh}{6(b^2+d^2)}$	$W_{xc}=\frac{bh^2}{6}$ $W_{yc}=\frac{hb^2}{6}$
Başlıklı dikdörtgen 	$A=bh-b_1h_1$ $X_c=\frac{b}{2}$ $Y_c=\frac{h}{2}$	$I_{xc}=\left(\frac{bh^3-b_1h_1^3}{12}\right)$ $I_{yc}=\left(\frac{hb^3-h_1b_1^3}{12}\right)$	$W_{xc}=\frac{1}{6}\left(\frac{bh^3-b_1h_1^3}{h}\right)$ $W_{yc}=\frac{1}{6}\left(\frac{hb^3-h_1b_1^3}{b}\right)$

Geometrik Şekil	Alan-geometrik merkez	Eylemsizlik momenti	Dayanım momenti
Eşit Dikdörtgenler 	$A=b(h-h_1)$ $X_c=\frac{b}{2}$ $Y_c=\frac{h}{2}$	$I_{xc}=\frac{(bh^3-h_1^3)}{12}$ $I_{yc}=\frac{b^3(h-h_1)}{12}$	$W_{xc}=\frac{(h^3-h_1^3)}{6h}$ $W_{yc}=\frac{b^2(h-h_1)}{6h}$
Trapez 	$X_c=\frac{h}{2}(a+b)$ $Y_c=\frac{h}{3}\left(\frac{2a+b}{a+b}\right)$	$I_{xc}=\frac{h^3(a^2+4ab+b^2)}{36(a+b)}$ $I_x=\frac{h^3(3a+b)}{12}$	$W_{xc}=\frac{I_{xc}}{h-y_c}$
Daire 	$A=\pi r^2$ $X_c=r$ $Y_c=r$	$I_{xc}=I_{yc}=\frac{\pi r^4}{4}$ $I_x=I_y=\frac{5\pi r^4}{4}$	$W_{xc}=W_{yc}=\frac{\pi r^3}{4}$
Boşluklu Daire 	$A=\frac{\pi(d^2-d_1^2)}{4}$ $X_c=\frac{d}{2}$ $Y_c=\frac{d}{2}$	$I_{xc}=I_{yc}=\frac{\pi(d^4-d_1^4)}{64}$	$W_{xc}=W_{yc}=\frac{\pi(d^4-d_1^4)}{32d}$
Yarım Daire 	$A=\frac{\pi r^2}{2}$ $X_c=r$ $Y_c=\frac{4r}{3\pi}$	$I_{xc}=\frac{r^4(9\pi^2-64)}{72\pi}$ $I_{yc}=\frac{\pi r^4}{8}$ $I_x=\frac{\pi r^4}{8}$ $I_y=\frac{5\pi r^4}{8}$	$W_{xc}=\frac{I_{xc}}{(r-y_c)}$ $W_{yc}=\frac{\pi r^3}{8}$

Geometrik Şekil	Alan-geometrik merkez	Eylemsizlik momenti	Dayanım momenti
Parabol 	$A=\frac{4}{3}ab$ $X_c=b$ $Y_c=\frac{2}{5}a$	$I_{xc}=\frac{16}{175}a^3b$ $I_{yc}=\frac{4}{15}ab^3$ $I_x=\frac{32}{105}a^3b$	$W_{xc}=\frac{16}{105}a^2b$ $W_{yc}=\frac{4}{15}ab^2$
Yarım Parabol 	$A=\frac{2}{3}ab$ $X_c=\frac{5}{8}b$ $Y_c=\frac{2}{5}a$	$I_{xc}=\frac{8}{175}a^3b$ $I_{yc}=\frac{19}{480}ab^3$ $I_y=\frac{16}{105}a^3b$ $=\frac{2}{15}ab^3$	$W_{xc}=\frac{8}{105}a^2b$ $W_{yc}=\frac{19}{300}ab^2$
Yarım Parabol dışındaki dikdörtgen 	$A=\frac{1}{3}ab$ $X_c=\frac{1}{4}b$ $Y_c=\frac{7}{10}a$	$I_{xc}=\frac{37}{2100}a^3b$ $I_{yc}=\frac{1}{80}ab^3$	$W_{xc}=\frac{37}{1470}a^2b$ $W_{yc}=\frac{1}{60}ab^2$
Sekizgen 	$A=0,8284d^2$ $X_c=Y_c=\frac{d}{2}$	$I_{xc}=I_{yc}=0.055d^4$	$W_{xc}=W_{yc}=0.110d^3$
Altıgen 	$A=0.866\ d^2$ $X_c=Y_c=\frac{d}{2}$	$I_{xc}=I_{yc}=0.06\ d^4$	$W_{xc}=W_{yc}=0.120d^3$

A = geometrik şekil alanı

X_c, Yc = alan geometrik merkezinin x ve y koordinatları

I_{xc}, I_{yc} = alanın geometrik merkezden geçen ve x, y koordinat eksenlerine paralel olan eksenler etrafındaki eylemsizlik momentleri.

I_x, I_y = alanın x,y koordinat eksenleri etrafındaki eylemsizlik momentleri

W_{xc}, W_{yc} = alanın geometrik merkezden geçen ve x,y koordinat eksenlerine paralel olan eksenler etrafındaki dayanım momentleri

MUKAVEMET (KESME)

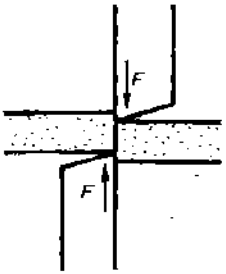
Kesme

Kayma gerilmesi

p 30 $f_q = \frac{F}{A} \leq p_q$ [psi]

Kayma modülü

p 31 $G = \frac{\tau}{\gamma} = 0{\cdot}385\,E$ [psi]



Kayma katsayısı

p 32 $\beta = \frac{1}{G} = \frac{\gamma}{\tau}$ [in.²/lb]

Kayma birim uzaması

p 33 $\gamma = \beta\,\tau$ [-]

Maksimum kayma gerilmesi

p 34 $\tau_f = \frac{F_{max}}{A} = 0{\cdot}8\,\sigma_\beta$ [psi]

Kesme Kuvveti

giyotin kesmesi		kesici aletler (zımba..)	
p 35 $F_S = L s k \tau_f$	[lb]	$F_S = U s k \tau_f$	[lb]

Kayma gerilmesinin pratik uygulaması

Kayma daima eğilmeyle oluşur. Gerilme formülün de kesite bağlı tayin edici bir katsayısı vardır. (Sadece çok kısa kirişlerde, eğilme momenti ihmal edilebilir).

Kesit alanı A				birim
p 36 kayma gerilmesi $\tau =$	$\frac{3}{2}\frac{F}{A}$	$\frac{4}{3}\frac{F}{A}$	$2\frac{F}{A}$	[psi]

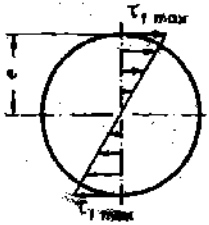
p_q : emniyetli kayma gerilmesi
F : kesme kuvveti
L : kesme boyu
U : kesme genişliği
F_{max} : kırılma yükü
A : kesit alanı
s : malzeme kalınlığı
k : sürtünme katsayısı ($\approx 1{\cdot}7$)

MUKAVEMET (BURULMA)

Burulmadan doğan kayma gerilmesi

Burulma gerilmesi

p 37 $\tau_{gl} = \frac{M_t}{W_t} \leq \tau_{gl}$ [kg/cm²]



Burulma momenti

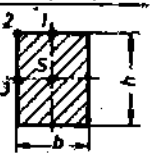
p 38 $M_t = 726{\cdot}2{\cdot}10^3 \frac{P}{n}$ [kg-cm]

Burulma mukavemet momenti

p 39 $W_t = \frac{J}{e}$ [cm³]

e : dış yüzey ile S ağırlık merkezi arasındaki mesafe [cm]

Polar atalet momenti, burulma momenti, ve maksimum kayma gerilmesi

	polar atalet momenti J [in.⁴]	mukavemet momenti W_t [in.³]	max. kayma gerilmesi τ_{gl} [psi]	kesit alanı A [in.²]
p 40	$\frac{\pi d^4}{32}$	$\frac{\pi d^3}{16}$	$\simeq \frac{5{\cdot}1\,M_t}{d^3}$	
p 41	$\frac{\pi}{32}(D^4 - d^4)$	$\frac{\pi}{16}\frac{D^4 - d^4}{D}$	$\simeq \frac{5{\cdot}1\,M_t}{D^3}\frac{1}{1-\delta^4}$	
p 42		in 1: $\frac{2}{9}bh^2$	in 1: $\frac{9\,M_t}{2bh^2}$	
p 43			in 2: 0	
p 44		in 3: $\frac{2}{9}b^2h$	in 3: $\frac{9\,M_t}{2b^2h}$	

δ - tablosu

p 45	$\delta = \frac{d}{D}$	0·5	0·6	0·7	0·8	0·9	0·95
	$\frac{1}{1-\delta^4}$	1·0667	1·1489	1·3159	1·6194	2·6194	5·3908

P : güç [HP] n : dakikada devir sayısı

τ_{gl} : emniyetli burulma gerilmesi [kg/cm²] (bak Z 14)

MUKAVEMET (BURULMA)

Burulma

Değişik mesnet durumları (örnekler)

p 46 | $l_0 = 2l$ | $l_0 = l$ | $l_0 = 0{\cdot}7\,l$ | $l_0 = 0{\cdot}5\,l$

p 47 **Narinlik** $\lambda = l_0 \sqrt{\frac{A}{I}}$

Aşağıda verilen tablo yardımıyla, λ değerine göre ;

λ limitler			
altında ise	basınç formülünü (p 3)	kullanınız
arasında ise	Tetmajer formülünü	
üstünde ise	Euler formülünü	

Burada A alanı bilinmemektedir. Doğrusu atalet momentinden bulunabilir :

p 48 $$I = \frac{F S_f l_0^2}{\pi^2 E} \qquad [\text{in.}^4]$$

Tetmajer formülü

p 49 $$\sigma_k = a(1 - c_1\lambda + c_2\lambda^2) \leqslant S_f \frac{F}{A} = S_f p_c \qquad [\text{psi}]$$

malzeme	a	c_1	c_2	λ - limiti
yumuşak çelik	48 000	0·00185	0	0... 90
pik demir	110 000	0·01546	0·00007	5... 80
kereste	4 200	0·00662	0	2...100

Euler formülü

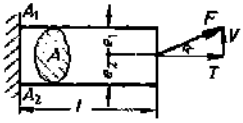
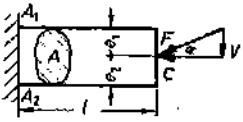
p 50 $$F_{k\,perm} = \frac{\pi^2 E I}{l_0^2} \leqslant S_f F \qquad [\text{lb}]$$

p_c : emniyetli basınç gerilmesi (bak Z 14)
$F_{k\,perm}$: emniyetli flambaj yükü
σ_k : gerçek flambaj gerilmesi
I : atalet momenti
S_f : emniyet katsayısı
F : gerçek yük [lb]
A : kesit alanı [in.²]

MUKAVEMET (BİLEŞİK GERİLMELER)

Normal gerilmelerin bileşkesi

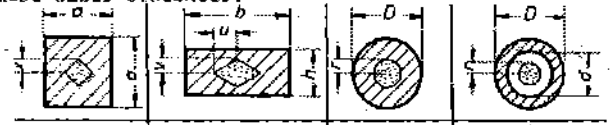
Süperpozisyon yöntemine göre, çekme ve eğilme ve ya basınç ve eğilmeden ötürü meydana gelen gerilmeler, çekme için pozitif ve basınç için negatif işaret kullanılarak cebrik olarak toplanır.

yük noktası	bileşke gerilme: çekme + eğilme	bileşke gerilme: basınç + eğilme
		
p 51 A_1	$+\frac{T}{A}+\frac{Vle_1}{J} \leq p_t$	$-\frac{C}{A}+\frac{Vle_1}{J} \leq p_c$
p 52 A_2	$+\frac{T}{A}+\frac{Vle_2}{J} \leq p_1$	$-\frac{C}{A}-\frac{Vle_2}{J} \leq p_c$
p 53	$T = F\cos\alpha \qquad V = F\sin\alpha$	$C = F\cos\alpha$

Tarafsız eksenî kaydırarak yani kesitin şeklini değiştirerek, A_1 ve A_2 noktalarında eşit çekme ve basınç gerilmeleri elde edilebilir (örneğin: $e_1 \neq e_2$). Uzun kirişleri flambaj işareti için tahkik ediniz.

Benzer gerilmelere ait limit kesitler

Şekilde görülen noktalı küçük alanlara herhangi bir basınç veya çekme kuvveti tatbik edildiğinde aynı tip gerilme bütün kesitte vukubulacaktır. Şayet bu limit alanların dışına tatbik edilirse, eğilme gerilmesi yani hem çekme hem basınç gerilmesi basıl olacaktır.

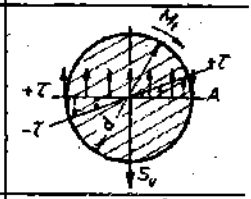
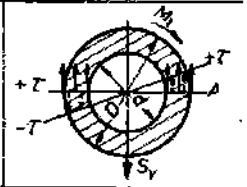
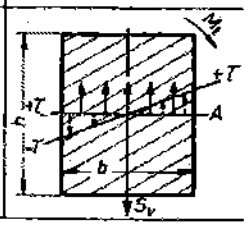


p 54 $x = \frac{a}{6}$ | $u = \frac{b}{6}$; $v = \frac{h}{6}$ | $r = \frac{d}{8}$ | $r = \frac{D}{8}\left[1+\left(\frac{d}{D}\right)^2\right]$

MUKAVEMET (BİLEŞİK GERİLMELER)

Teğetsel gerilmelerin bileşkesi

Süperpozisyon yöntemine göre, kayma ve burulma gerilmeleri cebrik olarak toplanmalıdır.

	A noktasındaki maksimum kayma gerilmesi τ [kg/cm²]	Kesit
p 55	$\frac{5{\cdot}1\,M_t}{d^3} + \frac{1{\cdot}7\,S_v}{d^2} \leqslant p_{at}$	
p 56	$\frac{5{\cdot}1\,M_t D}{D^4 - d^4} + \frac{2{\cdot}55\,S_v}{D^2 - d^2} \leqslant p_{at}$	
p 57	$\frac{4{\cdot}5\,M_t}{b^2 h} + \frac{1{\cdot}5\,S_v}{bh} \leqslant p_{at}$	

Semboller (P 11 için dahil)

p_{bi}: emniyetli eğilme gerilmesi
p_{at}: emniyetli burulma gerilmesi
} bak Z 14

f_{bi}: gerçek eğilme gerilmesi
f_{at}: gerçek burulma gerilmesi.
M_g: gerçek eğilme momenti (bak P3 ve P4)
M_i: ideal eğilme momenti ($M_i = f \cdot M_g$)
M_t: dönme momenti (bak P 7)
S_v: kesme kuvveti

MUKAVEMET (BİLEŞİK GERİLMELER)

Normal ve teğetsel gerilmelerin bileşkesi

Bach'a göre, normal ve teğetsel gerilmelerin sırasıyla bulunduğu yerde σ_r gerilmesi oluşacaktır.

Genel

p 58 $$\sigma_r = 0{\cdot}35\, f_{bi} + 0{\cdot}65\sqrt{f_{bi}^2 + (\alpha_0 2 f_{qi})^2} \leq p_{bi} \quad [kg/cm^2]$$

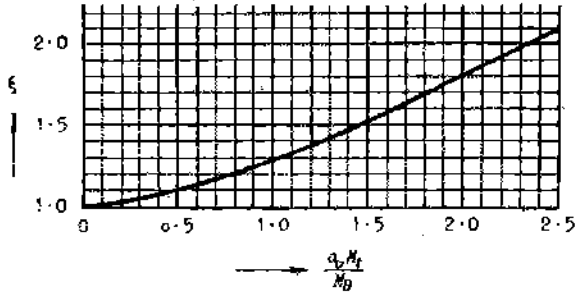
p 59 burada $$\alpha_0 = \frac{p_{bi}}{1{\cdot}3\ p_{qi}} \quad [-]$$

Şaft donanımı için aşağıdaki denklem kullanılır.

p 60 $$\sigma_r = \frac{\xi M_i}{S} \leq p_{bi} \quad [kg/cm^2]$$

p 61 burada $$\xi = 0{\cdot}35 + 0{\cdot}65\sqrt{1 + \left(\frac{\alpha_0 M_t}{M_B}\right)^2}$$

Yukarıdaki denklemi kolayca çizebilmek için aşağıda verilen diyagram kullanılabilir :



p

Alanın bulunması isteniyorsa, mukavemet momentinden şu şekilde hesaplanır.

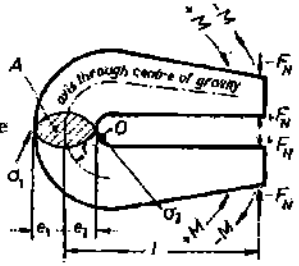
p 62 $$S = \frac{M_i}{p_{bi}} = \frac{\xi M_B}{p_{bi}} \quad [cm^3]$$

S : mukavemet momenti
Diğer terimler için, bak P 10

MUKAVEMET (EĞRİ KİRİŞLER)

Eğri kirişlerde gerilmeler

Eğri kirişlerde en büyük gerilme, normal F kuvveti ve M eğilme momenti tarafından yaratılır. Uçtaki gerilmeler şu şekildedir (tatbik yönüne bağlı olarak M ve F ya pozitif yada negatiftir) :

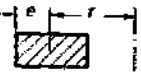


p 63 $$\sigma_1 = \frac{F_N}{A} + \frac{M}{Ar} + \frac{M}{\varkappa A r}\,\frac{e_1}{r + e_1} \leq p_1 \qquad kg/cm^2$$

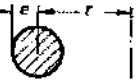
p 64 $$\sigma_2 = \frac{F_N}{A} + \frac{M}{Ar} - \frac{M}{\varkappa A r}\,\frac{e_2}{r - e_2} \leq p_1 \qquad [kg/cm^2]$$

$\varkappa$ için formül

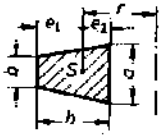
p 65 $$\varkappa = \frac{1}{3}\left(\frac{e}{r}\right)^2 + \frac{1}{5}\left(\frac{e}{r}\right)^4 + \frac{1}{7}\left(\frac{e}{r}\right)^6 + \ldots$$



p 66 $$\varkappa = \frac{1}{4}\left(\frac{e}{r}\right)^2 + \frac{1}{8}\left(\frac{e}{r}\right)^4 + \frac{5}{64}\left(\frac{e}{r}\right)^6 + \ldots$$



p 67 $$\varkappa = \frac{2\pi r}{(a+b)h}\left\{\left[b + \frac{a-b}{h}\,(r+e_1)\right]\ln\frac{r+e_1}{r-e_2} - (a-b)\right\} - 1$$



S ağırlık merkezinin yeri için, bak K 5

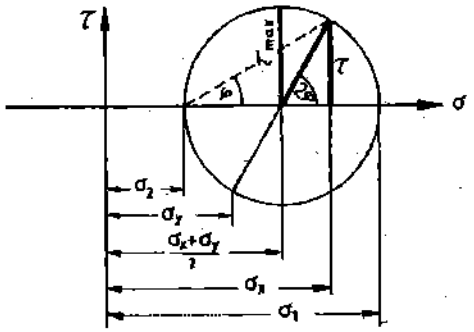
Hesaplanan $\varkappa$ değerleri

$\frac{e}{r}$	0·1	0·3	0·5	0·7	0·8	0·9	0·95
p 68 $\varkappa$ ▨	0·0033	0·0317	0·0986	0·239	0·373	0·636	0·928
p 69 $\varkappa$ ⊘	0·0025	0·0236	0·0718	0·167	0·250	0·393	0·524

p 70 $M = F_N\,l$ | p_1 : emniyetli çekme, bak Z 14

MUKAVEMET (MOHR GERİLME DAİRESİ)

Mohr gerilme dairesi



Asal çekme gerilmeleri

p 71
$$\sigma_1, \sigma_2 = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_y - \sigma_x}{2}\right)^2 + \tau^2}$$

Asal kayma gerilmeleri

p 72
$$\tau_{max} = \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2}$$

Büyük çekme gerilmesi σ_1'in yönü

p 73
$$\tan 2\varphi = \frac{2\tau}{\sigma_x - \sigma_y} \quad +)$$

daima $2\varphi < 90^0$ olmalıdır.

Büyük kayma gerilmesi τ'nun yönü

p 74
$$\cot 2\varphi = \frac{2\tau}{\sigma_y - \sigma_x}$$

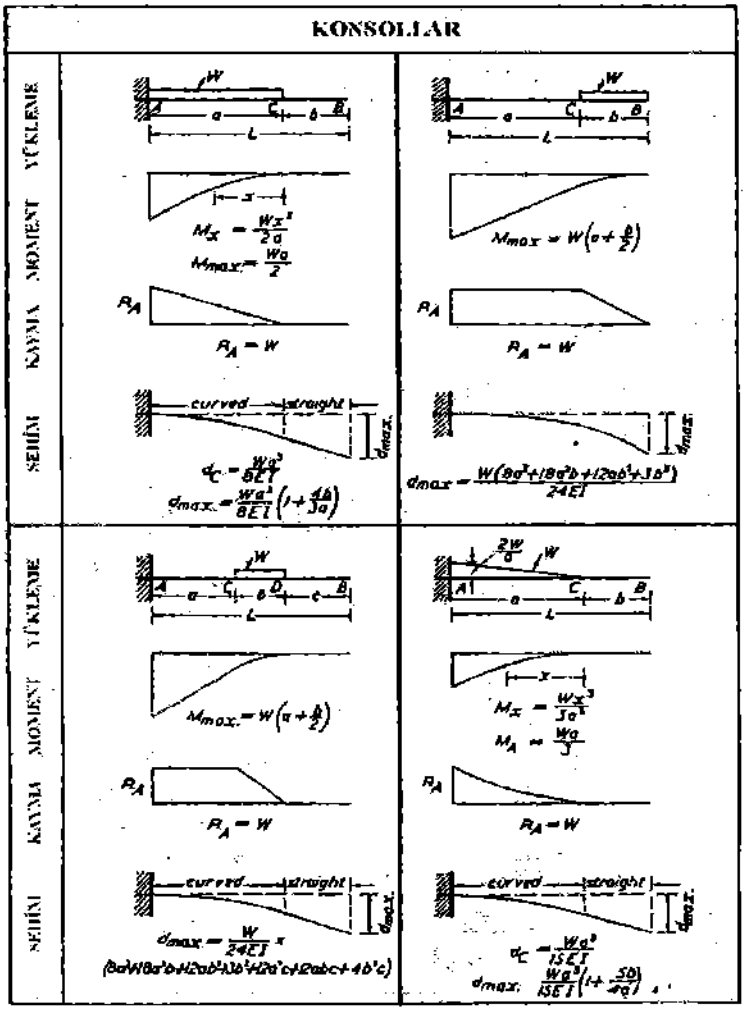
Asal çekme gerilmelerinin kesişme noktalarında kayma gerilmeleri sıfır olur.

Maksimum kayma gerilmesi, asal çekme gerilmelerinin olduğu düzleme 45^0 eğik düzlemde meydana gelir.

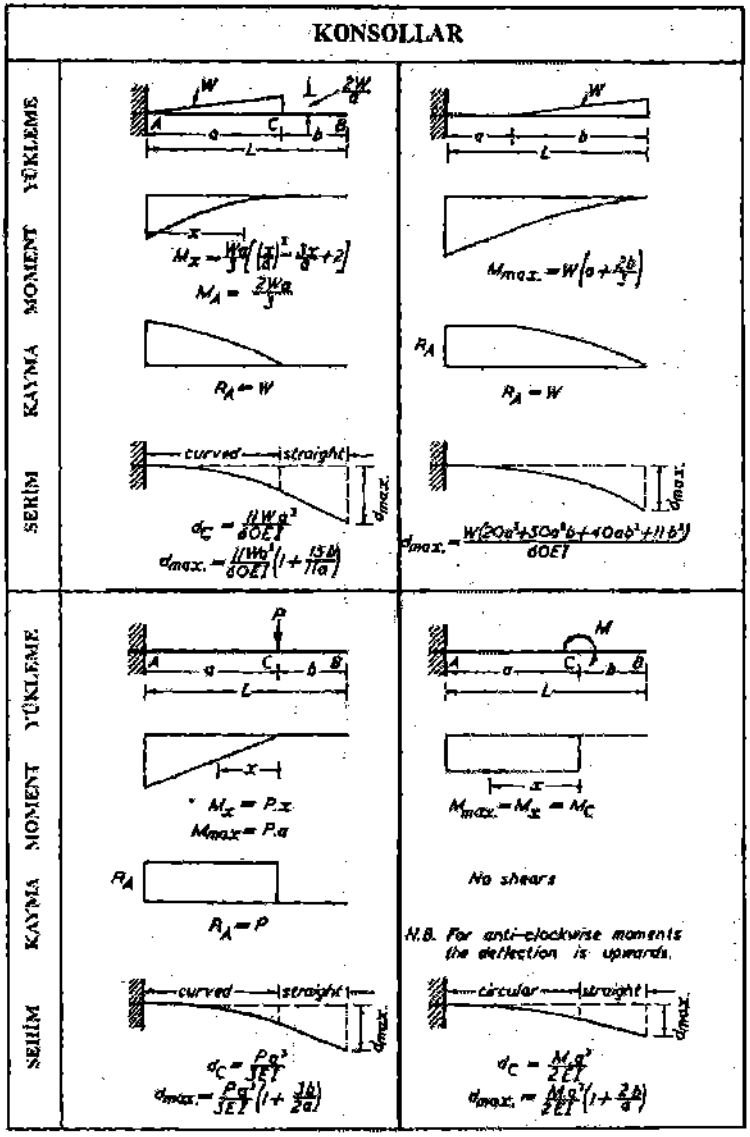
+)Bu denklemin çözümü iki açı verecektir. Bunun anlamı, asal kayma ve çekme gerilmelerinin birbirlerine dik ve aynı noktalarda kesişen düzlemlerde meydana geldiğidir.

KİRİŞLERE AİT YÜKLEME, MOMENT, KAYMA, SEHİM TABLOLARI

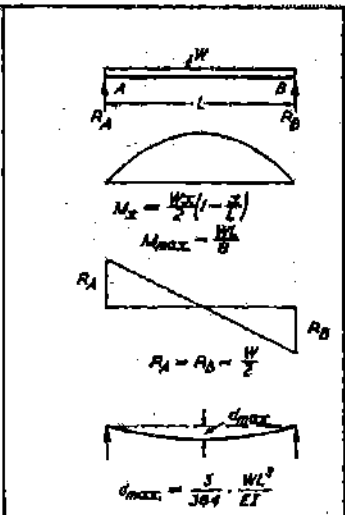
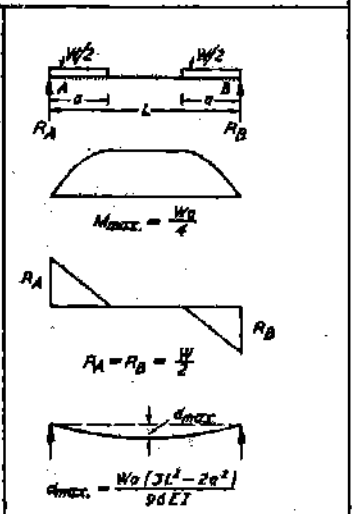
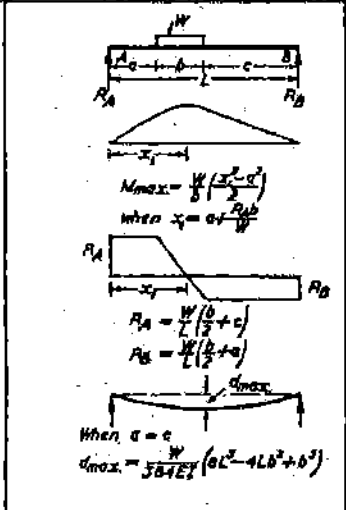
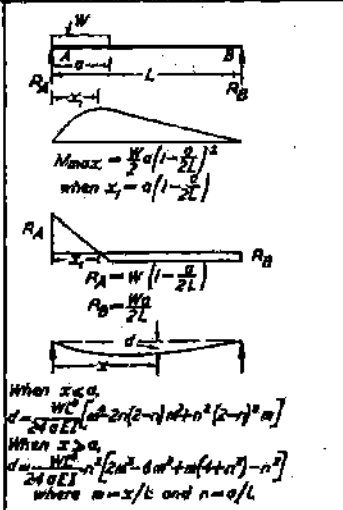
KONSOLLAR



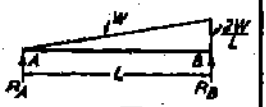
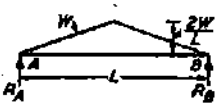
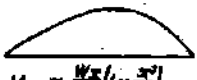
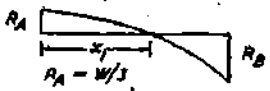
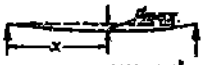
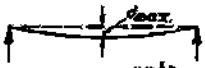
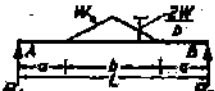
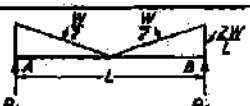
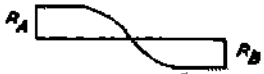
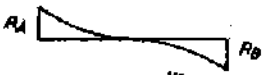
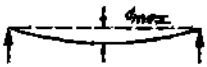
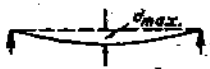
KONSOLLAR


YÜKLEME
MOMENT
KAYMA
SEHİM
W
2W/a
A
C
B
a
b
L
x
$M_x = \frac{Wa}{3}\left[\left(\frac{x}{a}\right)^2 - \frac{3x}{a} + 2\right]$
$M_A = \frac{2Wa}{3}$
$R_A = W$
curved
straight
$d_C = \frac{11Wa^3}{8OEI}$
$d_{max.} = \frac{11Wa^3}{8OEI}\left(1 + \frac{15b}{11a}\right)$
$M_{max.} = W\left(a + \frac{2b}{3}\right)$
$R_A = W$
$d_{max.} = \frac{W(20a^3 + 30a^2b + 10ab^2 + 11b^3)}{8OEI}$
P
$M_x = P.x$
$M_{max} = P.a$
$R_A = P$
$d_C = \frac{Pa^3}{3EI}$
$d_{max.} = \frac{Pa^3}{3EI}\left(1 + \frac{3b}{2a}\right)$
M
$M_{max.} = M_x = M_C$
No shears
N.B. For anti-clockwise moments the deflection is upwards.
circular
$d_C = \frac{Ma^2}{2EI}$
$d_{max.} = \frac{Ma^2}{2EI}\left(1 + \frac{2b}{a}\right)$

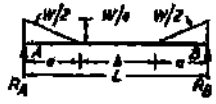
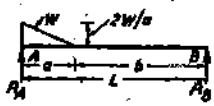
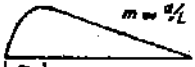
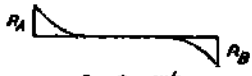
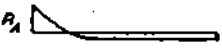
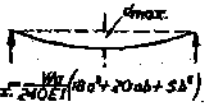
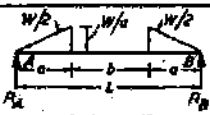
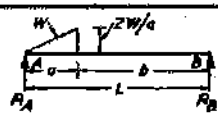
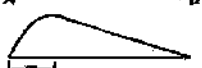
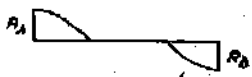
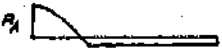
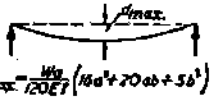
BASİT MESNETLİ KİRİŞLER

YÜKLEME MOMENT KAYMA SEHİM		
YÜKLEME MOMENT KAYMA SEHİM		

BASİT MESNETLİ KİRİŞLER

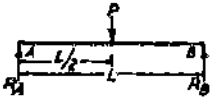
YÜKLEME		
MOMENT	 $M_x = \frac{Wx}{3}\left(1-\frac{x^2}{L^2}\right)$ $M_{max.} = 0.128WL$ when $x_1 = 0.5774L$	 $M_x = Wx\left(\frac{1}{2}-\frac{2x^2}{3L^2}\right)$ $M_{max.} = WL/6$
KAYMA	 $R_A = W/3$ $R_B = 2W/3$	 $R_A = R_B = \frac{W}{2}$
SEHİM	 $d_{max.} = \frac{0.0304WL^3}{EI}$ when $x = 0.5193L$	 $d_{max.} = \frac{WL^3}{60EI}$
YÜKLEME		
MOMENT	 $M_{max.} = \frac{W}{4}\left(L-\frac{b}{3}\right)$	 $M_x = Wx\left(\frac{1}{2}-\frac{x}{L}+\frac{2x^3}{3L^3}\right)$ $M_{max.} = WL/12$
KAYMA	 $R_A = R_B = W/2$	 $R_A = R_B = \frac{W}{2}$
SEHİM	 $d_{max.} = \frac{W}{480EI}\left(8L^3+9bL^2-4a^2L-4a^3\right)$	 $d_{max.} = \frac{7WL^3}{320EI}$

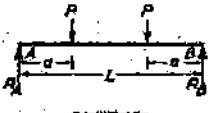
BASİT MESNETLİ KİRİŞLER

YÜKLEME		
MOMENT	 $M_{max.}=\frac{Wa}{6}$	 $m=a/L$ $M_{max.}=\frac{Wa}{3}\left(1-m+\frac{2m}{3}\sqrt{\frac{m}{3}}\right)$ when $x=a\left(1-\sqrt{\frac{m}{3}}\right)$
KAYMA	 $R_A=R_B=W/2$	 $R_A=W\left(1-\frac{m}{3}\right)$ $R_B=\frac{Wm}{3}$
SEHİM	 $d_{max.}=\frac{Wa}{240EI}\left(16a^2+20ab+5b^2\right)$	
YÜKLEME		
MOMENT	 $M_{max.}=\frac{Wa}{3}$	 $M_{max.}=\frac{2Wa}{3}\left(1-\frac{2m}{3}\right)^{3/2}$ when $x=a\sqrt{1-\frac{2m}{3}}$
KAYMA	 $R_A=R_B=W/2$	 $R_A=W\left(1-\frac{2m}{3}\right)$ $R_B=\frac{2Wm}{3}$
SEHİM	 $f_{max.}=\frac{Wa}{120EI}\left(16a^2+20ab+5b^2\right)$	

BASİT MESNETLİ KİRİŞLER

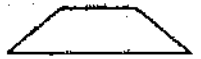
YÜKLEME





MOMENT

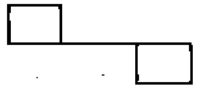
$M_{max} = \frac{PL}{4}$



$M_{max} = Pa$

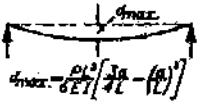
KAYMA

$R_A = R_B = \frac{P}{2}$



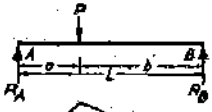
SEHİM

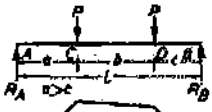
$d_{max.} = \frac{PL^3}{48EI}$



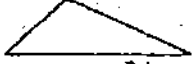
$d_{max.} = \frac{Pa^3}{6EI}\left[\frac{3a}{4L} - \left(\frac{a}{L}\right)^2\right]$

YÜKLEME





MOMENT

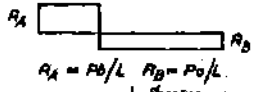


$M_{max.} = \frac{Pab}{L}$

$M_C = \frac{Pa(b+2c)}{L}$

$M_D = \frac{Pc(b+2a)}{L}$

KAYMA

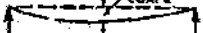


$R_A = Pb/L \quad R_B = Pa/L$

$R_A = \frac{P(b+2c)}{L}$

$R_B = \frac{P(b+2a)}{L}$

SEHİM



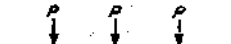
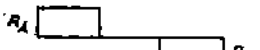
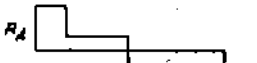
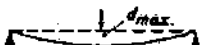
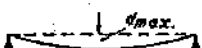
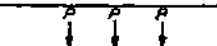
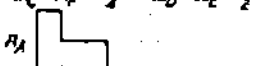
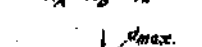
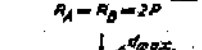
$d_{max.}$ always occurs within $0.0774\,L$ of the centre of the beam. When $b \geq a$,

$d_{centre} = \frac{Pa^3}{48EI}\left[\frac{3b}{L} - 4\left(\frac{a}{L}\right)^2\right]$

This value is always within 2·5 % of the maximum value.

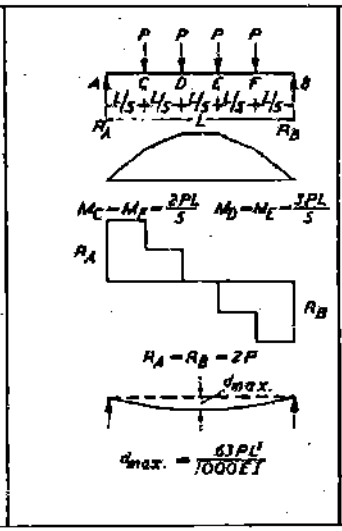
For central deflection add the value for each P derived from the formula in the adjacent diagram.

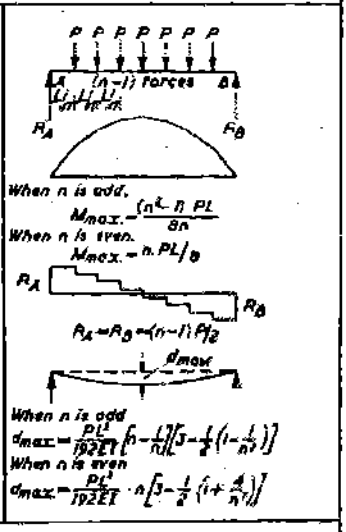
BASİT MESNETLİ KİRİŞLER

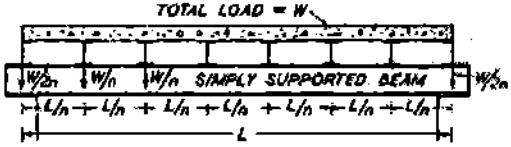
YÜKLEME		
MOMENT	$M_{max.}=\frac{PL}{3}$	$M_C=M_E=\frac{PL}{4}\quad M_D=\frac{5PL}{12}$
KAYMA		
	$R_A=R_B=P$	$R_A=R_B=3P/2$
SEHİM		
	$d_{max.}=\frac{23PL^3}{648EI}$	$d_{max.}=\frac{53PL^3}{1296EI}$
YÜKLEME		
MOMENT	$M_C=M_E=\frac{3PL}{8}\quad M_D=\frac{PL}{2}$	$M_C=M_F=\frac{PL}{4}\quad M_D=M_E=\frac{PL}{2}$
KAYMA		
	$R_A=R_B=\frac{3P}{2}$	$R_A=R_B=2P$
SEHİM		
	$d_{max.}=\frac{19PL^3}{384EI}$	$d_{max.}=\frac{41PL^3}{768EI}$

BASİT MESNETLİ KİRİŞLER

SEHİM KAYMA MOMENT YÜKLEME







When $n > 10$, consider the load uniformly distributed

The reaction at the supports = W/2, but the maximum S.F. at the ends of the beam = $\frac{W(n-1)}{2n} = A.W$

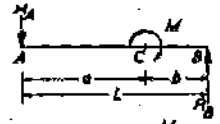
The value of the maximum bending moment = C.WL

The value of the deflection at the centre of the span = $k.\frac{WL^3}{EI}$

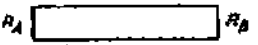
Value of n	A	C	k
2	0·2500	0·1250	0·0105
3	0·3333	0·1111	0·0118
4	0·3750	0·1250	0·0124
5	0·4000	0·1200	0·0126
6	0·4167	0·1250	0·0127
7	0·4286	0·1224	0·0128
8	0·4375	0·1250	0·0128
9	0·4444	0·1236	0·0129
10	0·4500	0·1250	0·0129

BASİT MESNETLİ KİRİŞLER

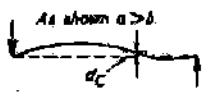
SEHİM — KAYMA — MOMENT — YÜKLEME



$M_{CA} = M \cdot a/L \quad M_{CB} = M \cdot b/L$

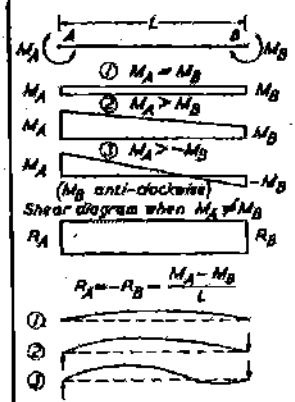


$R_A = R_B = M/L$



$d_C = \frac{M \cdot ab}{3EI}\left(\frac{a}{L} - \frac{b}{L}\right)$

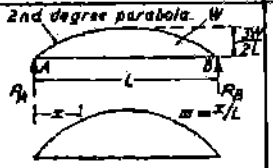
For anti-clockwise moments the deflections are reversed.



$R_A = -R_B = \frac{M_A - M_B}{L}$

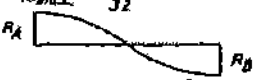
When $M_A = M_B$,

$d_{max} = -\frac{ML^2}{8EI}$

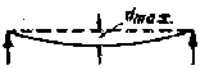


$M_x = \frac{WL}{2}\left(m^3 - 2m^2 + m\right)$

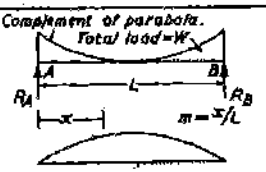
$M_{max.} = \frac{5WL}{32}$



$R_A = R_B = W/2$

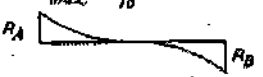


$d_{max} = \frac{0.1WL^3}{384EI}$

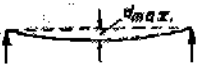


$M_x = \frac{WL}{2}\left(m - 3m^3 + 4m^2 - 2m^4\right)$

$M_{max.} = \frac{WL}{10}$

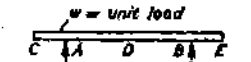
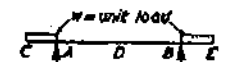
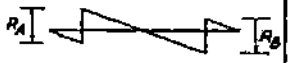
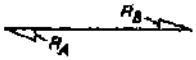
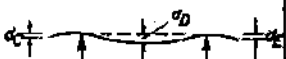
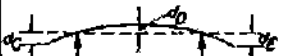
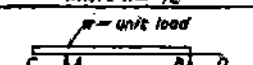
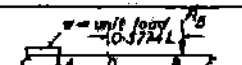
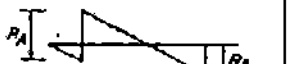
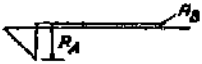
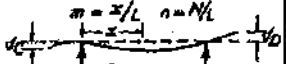
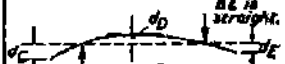


$R_A = R_B = W/2$

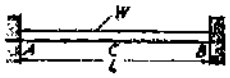
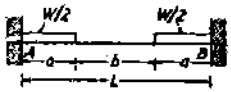
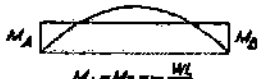
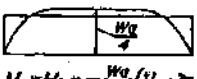
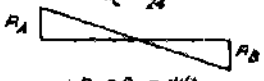
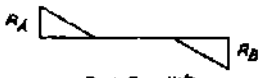
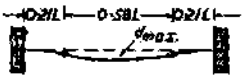
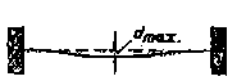
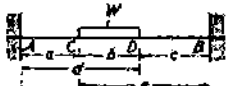
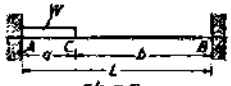
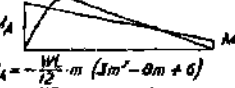
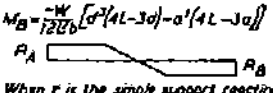
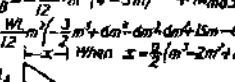
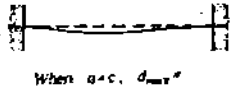
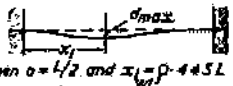


$d_{max.} = \frac{2 \cdot 0WL^3}{384EI}$

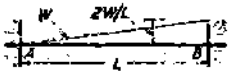
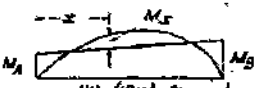
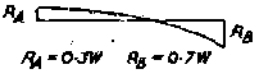
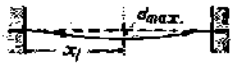
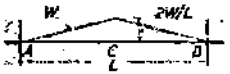
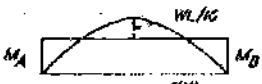
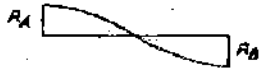
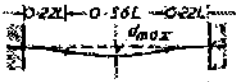
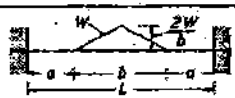
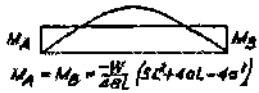
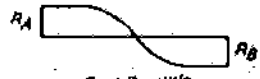
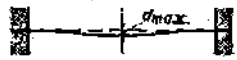
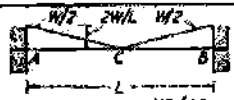
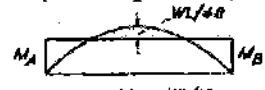
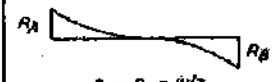
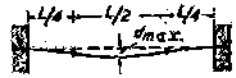
BASİT MESNETLİ KİRİŞLER

YÜKLEME		
MOMENT	$M_A = M_B = -\frac{wN^2}{2}$ $M_D = \frac{wL^2}{8} + M_A$	$M_A = M_B = -\frac{wN^2}{2}$
KAYMA	 $R_A = R_B = w\left(N + \frac{L}{2}\right)$	 $R_A = R_B = wN$
SEHİM	 $d_C = d_E = \frac{wL^3N}{24EI}(3n^2 + 4n^2 - 1)$ $d_D = \frac{wL^4}{384EI}(5 - 24n^2)$ Where $n = N/L$	 $d_C = d_E = \frac{wLN^3}{8EI}\left(2 + \frac{N}{L}\right)$ $d_D = -\frac{wL^2N^2}{16EI}$
YÜKLEME		 Max. upward deflection is at D.
MOMENT	$M_A = -\frac{wN^2}{2}$	$M_A = -\frac{wN^2}{2}$
KAYMA	 $R_A = \frac{w(N+L)^2}{2L}$ $R_B = \frac{wL(L+N)(L-N)}{2L}$	 $R_A = \frac{wN(2L+N)}{2L}$ $R_B = \frac{wN^2}{2L}$
SEHİM	$m = x/L$ $n = N/L$  $d_C = \frac{wL^3N}{24EI}(3n^2 + 4n^2 - 1)$ $d_x = \frac{wL^4}{24EI}\left[m^4 - 2m^3(1-n^2) + m(1-2n^2)\right]$ $d_D = -\frac{wL^3Q}{24EI}(2n^2 - 1)$	EI is straight.  $d_C = \frac{wLN^3}{24EI}\left(4 + 3\frac{N}{L}\right)$ $d_D = -\frac{0.0172wL^2N^2}{EI}$ $d_E = \frac{wLN^2Q}{12EI}$

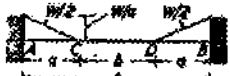
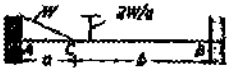
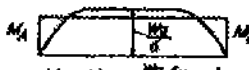
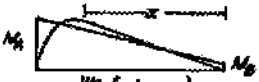
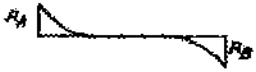
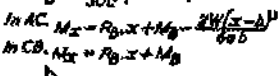
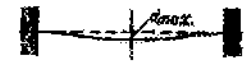
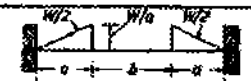
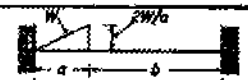
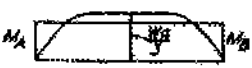
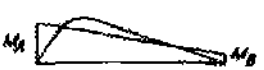
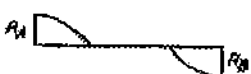
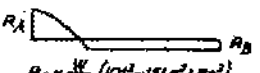
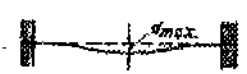
ANKASTRE KİRİŞLER

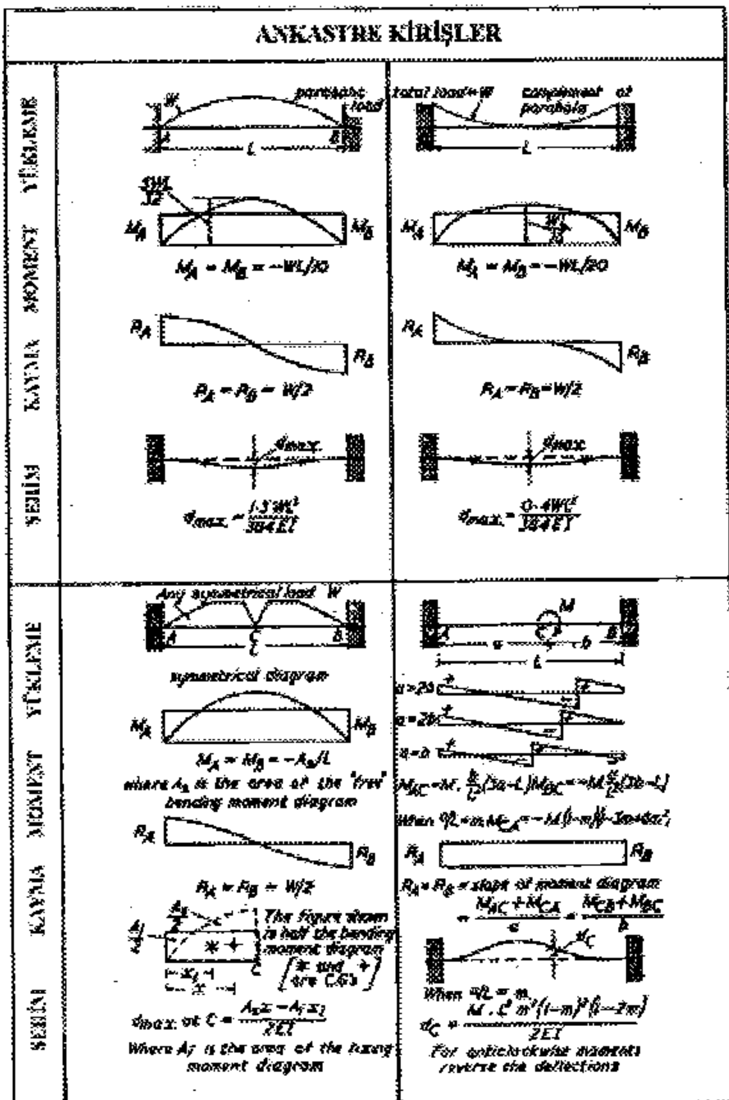
YÜKLEME		
MOMENT	 $M_A = M_B = -\frac{Wl}{12}$ $M_C = \frac{Wl}{24}$	 $M_A = M_B = -\frac{Wa}{12l}(3L-2a)$
KAYMA	 $R_A = R_B = W/2$	 $R_A = R_B = W/2$
SEHİM	 $d_{max.} = \frac{Wl^3}{384EI}$	 $d_{max.} = \frac{Wa^2}{48EI}(L-a)$
YÜKLEME		
MOMENT	 $M_A = \frac{-W}{12L^2b}\left[a^2(4L-3a)-c^2(4L-3c)\right]$ $M_B = \frac{-W}{12L^2b}\left[a^2(4L-3a)-a^2(4L-3a)\right]$	 $M_A = -\frac{Wl}{12}\cdot m\ (3m^2-8m+6)$ $M_B = -\frac{Wl}{12}\cdot m^2(4-3m) \quad + M_{max.}$ $\frac{Wl}{12}m^2\left(-\frac{3}{2}m^2+6m^2-6m^2+6m+15m-8\right)$ When $x = \frac{a}{2}(m^2-2m^2+2)$
KAYMA	 When R is the simple support reaction $R_A = r_A + \frac{M_A - M_B}{l}$ $R_B = r_B + \frac{M_B - M_A}{l}$	 $R_A = \frac{W(m^3-2m^2+2)}{2}$ $R_B = \frac{W.m^2(2-m)}{2m}$
SEHİM	 When $a=c$, $d_{max.} = \frac{W}{384EI}(L^3+2L^2a+4La^2-8a^3)$	 When $a = l/2$ and $x_1 = 0.4215L$ $d_{max.} = \frac{Wl^3}{103EI}$ $d_C = \frac{Wl^3}{384EI}$

ANKASTRE KİRİŞLER

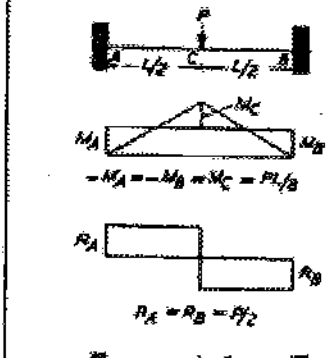
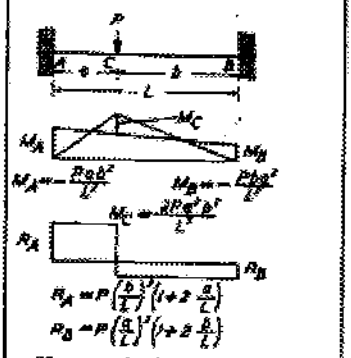
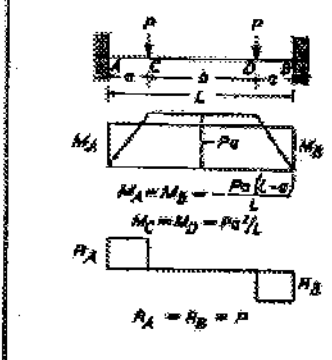
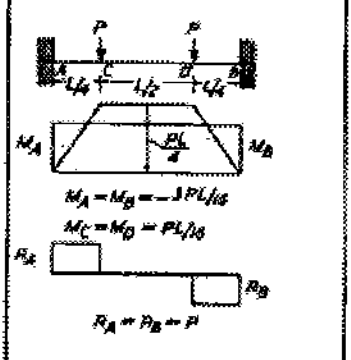
YÜKLEME	MOMENT	KAYMA	SEHİM
	 $M_x = -\frac{WL}{30}\left(\frac{10x^3}{L^3} - \frac{9x}{L} + 2\right)$ $+M_{max.} = WL/23{\cdot}3$ when $x = 0{\cdot}55L$ $M_A = -WL/15 \quad M_B = -WL/10$	 $R_A = 0{\cdot}3W \quad R_B = 0{\cdot}7W$	 $d_{max.} = \frac{WL^3}{382EI}$ when $x_1 = 0{\cdot}525L$
	 $M_A = M_B = -\frac{5WL}{48}$ $M_C = WL/16$	 $R_A = R_B = W/2$	 $d_{max.} = \frac{1{\cdot}4WL^3}{384EI}$
	 $M_A = M_B = -\frac{W}{28L}\left(5L^2 + 4aL - 4a^2\right)$	 $R_A = R_B = W/2$	 $d_{max.} = \frac{W}{1920EI}\left(7L^3 + 8aL^2 + 4a^2L - 16a^3\right)$
	 $M_A = M_B = -WL/16$ $M_C = WL/48$	 $R_A = R_B = W/2$	 $d_{max.} = \frac{0{\cdot}4WL^3}{384EI}$

ANKASTRE KİRİŞLER

YÜKLEME		
MOMENT	 $M_A = M_B = -\frac{Wa}{12L}(2L-a)$	 $M_A = -\frac{Wa}{30L^2}(3a^2+10bL)$ $M_B = -\frac{Wa^2}{30L^2}(5L-3a)$ In AC, $M_x = R_A x + M_B - \frac{2W(x-b)^{1/2}}{3ab}$ In CB, $M_x = R_A x + M_B$
KAYMA	 $R_A = R_B = W/2$	 $R_A = \frac{W}{10L^3}(10L^3-5La^2+2a^3)$ $R_B = \frac{Wa^2}{20L^3}(5L-2a)$
SEHİM	 $d_{max.} = \frac{Wa^2}{48EI}(5L-4a)$	——
YÜKLEME		
MOMENT	 $M_A = M_B = -\frac{Wa}{12L}(4L-3a)$	 $M_A = -\frac{Wa}{15L^2}(10L^2-15aL+6a^2)$ $M_B = -\frac{Wa^2}{10L^2}(5L-6a)$
KAYMA	 $R_A = R_B = W/2$	 $R_A = \frac{W}{20L^3}(10L^3-15La^2+6a^3)$ $R_B = \frac{Wa^2}{20L^3}(15L-8a)$
SEHİM	 $d_{max.} = \frac{Wa^2}{48EI}(15L-16a)$	——

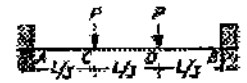

ANKASTRE KİRİŞLER
YÜKLEME
MOMENT
KAYMA
SEHİM
parabolic load
total load=W
complement of parabola
$M_A = M_B = -WL/10$
$M_A = M_B = -WL/20$
$R_A = R_B = W/2$
$R_A = R_B = W/2$
$d_{max} = \frac{1.3WL^3}{384EI}$
$d_{max} = \frac{0.4WL^3}{384EI}$
Any symmetrical load W
symmetrical diagram
$M_A = M_B = -A_s/L$
where A_s is the area of the "free" bending moment diagram
$R_A = R_B = W/2$
The figure shown is half the bending moment diagram
d_{max} at $C = \frac{A_s\bar{x} - A_I x_I}{2EI}$
Where A_I is the area of the fixing moment diagram
$R_A = R_B$ = slope of moment diagram
For anticlockwise moments reverse the deflections

ANKASTRE KİRİŞLER

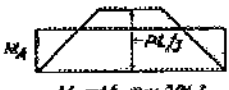
ŞEKİLDİ KAYMA MOMENT YÜKLEME		
ŞEKİLDİ KAYMA MOMENT YÜKLEME		

ANKASTRE KİRİŞLER

YÜKLEME



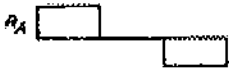
MOMENT



$M_A = M_B = -2PL/9$

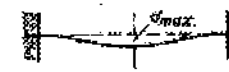
$M_C = M_D = PL/9$

KAYMA



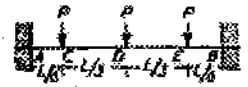
$R_A = R_B = P$

SEHİM

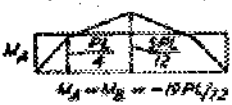


$d_{max.} = \frac{5PL^3}{648EI}$

YÜKLEME



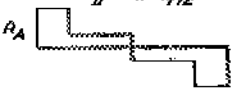
MOMENT



$M_A = M_B = -15PL/72$

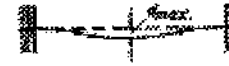
$M_D = 11PL/72$

KAYMA



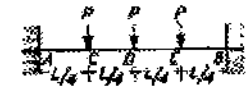
$R_A = R_B = 3P/2$

SEHİM

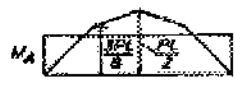


$d_{max.} = \frac{4PL^3}{384EI}$

YÜKLEME



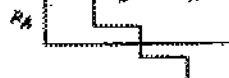
MOMENT



$M_A = M_B = -5PL/16$

$M_D = 3PL/16$

KAYMA

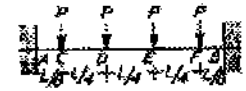


$R_A = R_B = 3P/2$

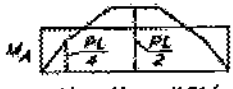
SEHİM

$d_{max.} = \frac{PL^3}{96EI}$

YÜKLEME



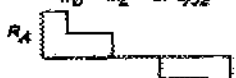
MOMENT



$M_A = M_B = -11PL/32$

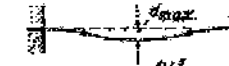
$M_D = M_E = 5PL/32$

KAYMA



$R_A = R_B = 2P$

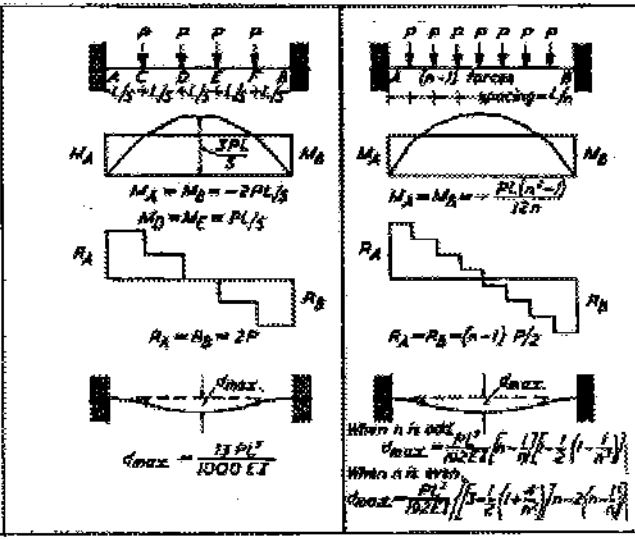
SEHİM

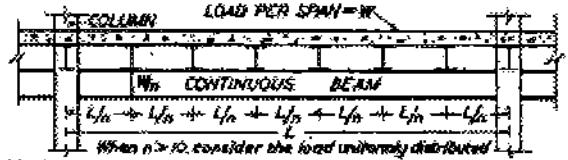


$d_{max.} = \frac{PL^3}{90EI}$

ANKASTRE KİRİŞLER

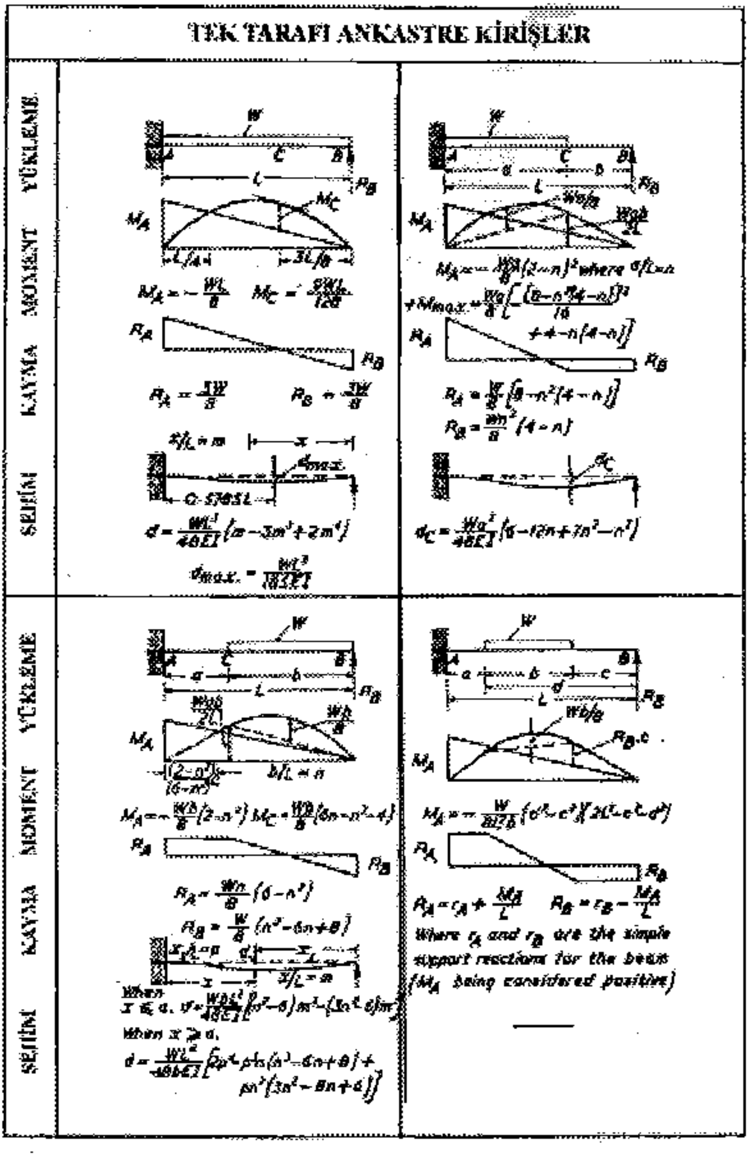
SEHİM · KAYMA MOMENT YÜKLEME





The load on the outside stringers is carried directly by the supports
The continuous beam is assumed to be horizontal at each support
The reaction at the supports for each span = W/2, but the maximum shear force in any span of the continuous beam = $\frac{W(n-1)}{2n} = A.W$
The value of the fixing moment at each support = −B.WL
The value of the maximum positive moment for each span = C.WL
The value of the maximum deflection for each span = 0·0026 $\frac{WL^3}{EI}$

Value of n	A	B	C
2	0·2500	0·0625	0·0625
3	0·3333	0·0741	0·0370
4	0·3750	0·0781	0·0469
5	0·4000	0·0800	0·0400
6	0·4167	0·0811	0·0439
7	0·4286	0·0816	0·0408
8	0·4375	0·0820	0·0430
9	0·4444	0·0823	0·0413
10	0·4500	0·0825	0·0425


TEK TARAFI ANKASTRE KİRİŞLER
YÜKLEME
MOMENT
KAYMA
SEHİM
W
A C B
L
R_B
M_A
M_C
L/4
3L/8
M_A = − WL/8   M_C = 9WL/128
R_A
R_B
R_A = 5W/8   R_B = 3W/8
x/L = m
d_max
0.5785L
d = WL³/48EI (m − 3m³ + 2m⁴)
d_max = WL³/185EI
a b
Wa/8
Wab/2L
M_A = − Wa/8 (2 − n)² where a/L = n
+M_max = Wa/8 [(8 − n(4 − n))² / 16 + 4 − n(4 − n)]
R_A = W/8 [8 − n²(4 − n)]
R_B = Wn²/8 (4 − n)
d_C
d_C = Wa³/48EI (8 − 12n + 7n² − n³)
Wab/2L
Wb/8
b/L = n
M_A = − Wb/8 (2 − n²)   M_C = Wb/8 (6n − n² − 4)
R_A = Wn/8 (6 − n²)
R_B = W/8 (n² − 6n + 8)
x/L = m
When x ≤ a, d = WbL²/48EI [(n² − 6)m³ − (3n² − 6)m]
When x ≥ a,
d = WL³/48bEI [2p⁴ − p³n(n² − 6n + 8) + pn²(3n² − 8n + 6)]
a b c
d
Wb/8
R_B.c
M_A = − W/8L²b (d² − c²)(2L² − c² − d²)
R_A = r_A + M_A/L   R_B = r_B − M_A/L
Where r_A and r_B are the simple support reactions for the beam (M_A being considered positive)

TEK TARAFI ANKASTRE KİRİŞLER

(Satırlar: YÜKLEME – MOMENT – KAYMA – SEHİM)

If $m = a/L$, then between B and D,

$M_x = -\frac{W}{8a L}\left[-2x^2 + xa(4 - 3m + 2m^2)\right]$

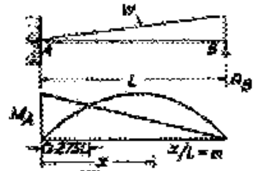
$+M_{max.}$ when $x = \frac{a}{4}(4 - 3m + 2m^2)$

$M_A = -\frac{Wa}{8L}(3L - 2a)$

$R_A = \frac{W}{4L^2}(2L^2 + 3aL - 4a^2)$

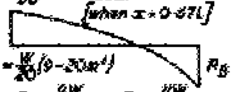
$R_B = \frac{W}{4L^2}(2L^2 - 3aL + 4a^2)$

—



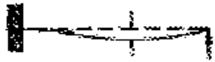
$M_x = -\frac{WL}{60}(20m^3 - 27m + 7)$

$M_A = -\frac{7WL}{60}$ $+M_{max.} = 0.0846WL$ [when $x = 0.67L$]



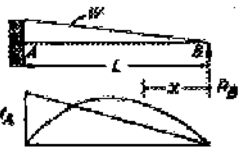
$V_x = \frac{W}{20}(9 - 30m^2)$

$R_A = \frac{9W}{20}$ $R_B = \frac{11W}{20}$



$d_{max.} = \frac{0.0061WL^3}{EI}$

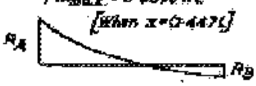
When $x = 0.598L$



$M_A = -\frac{2WL}{15}$

$+M_{max.} = 0.0596WL$

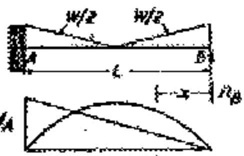
[When $x = 0.447L$]



$R_A = \frac{4W}{5}$ $R_B = \frac{W}{5}$

$d_{max.} = \frac{0.0047WL^3}{EI}$

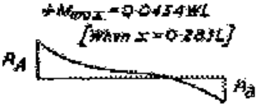
When $x = 0.447L$



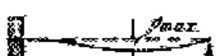
$M_A = -\frac{3WL}{32}$

$+M_{max.} = 0.0454WL$

[When $x = 0.283L$]



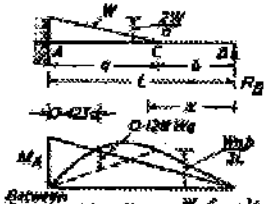
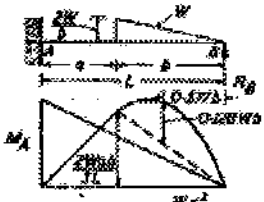
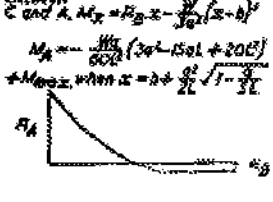
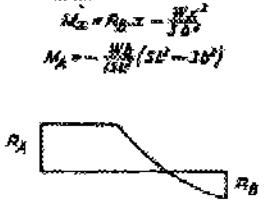
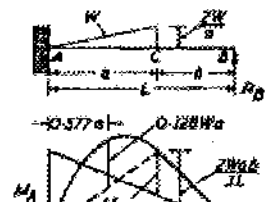
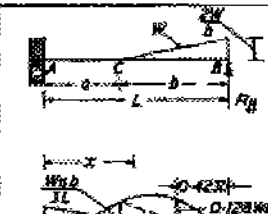
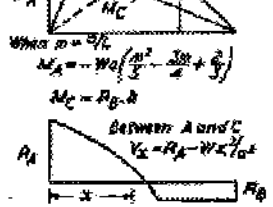
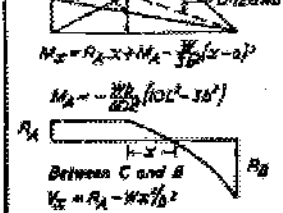
$R_A = \frac{19W}{32}$ $R_B = \frac{13W}{32}$

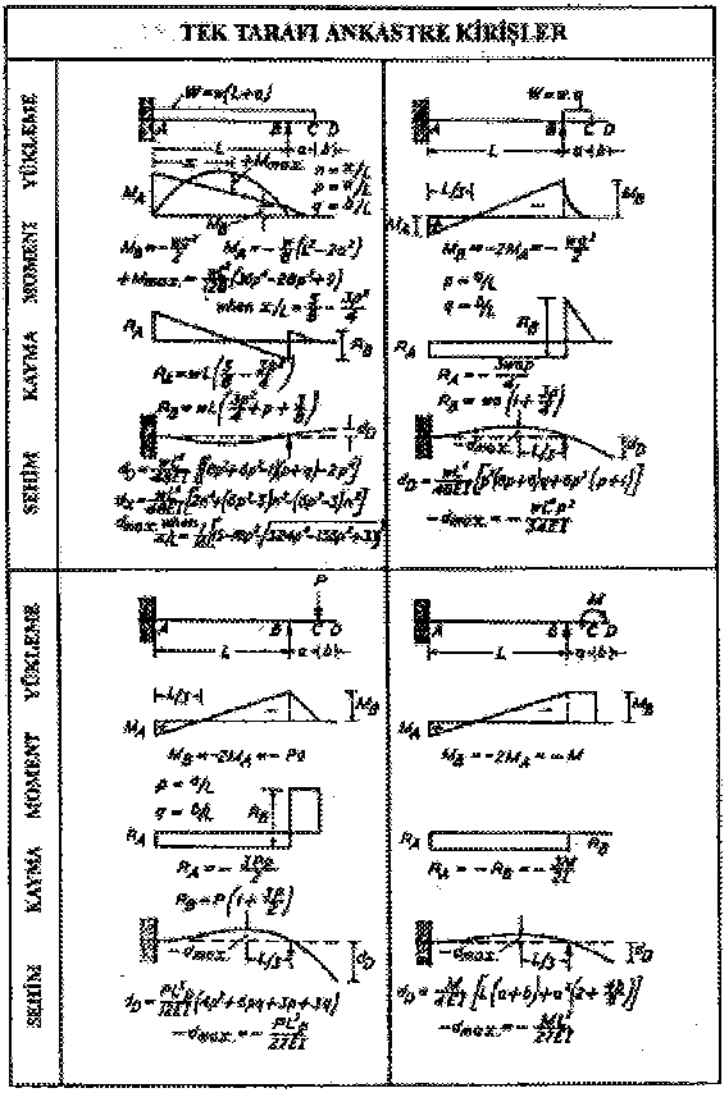


$d_{max.} = \frac{0.0037WL^3}{EI}$

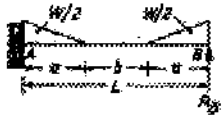
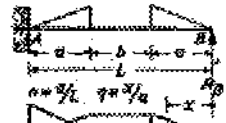
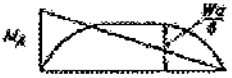
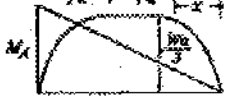
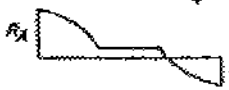
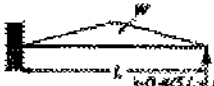
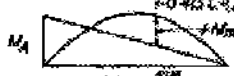
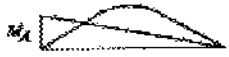
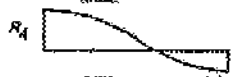
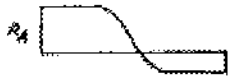
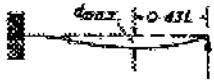
When $x = 0.404L$

TEK TARAFI ANKASTRE KİRİŞLER

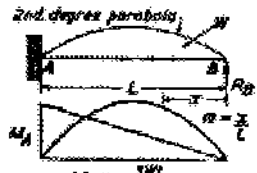
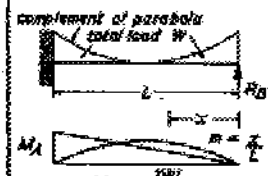
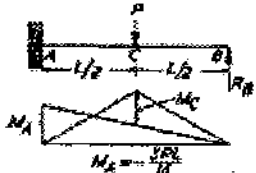
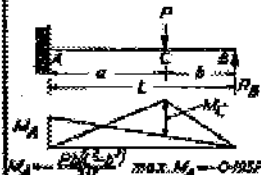
	YÜKLEME	YÜKLEME
MOMENT		
KAYMA		
ŞEKİL	$R_B = \frac{Wa^2}{2L^3}(3L-a)$ $R_A = W - R_B$	$R_A = \frac{Wb}{2L^3}(3L^2-b^2)$ $R_B = \frac{W}{2L^3}(b^3+3a^2L)$
MOMENT		
KAYMA		
ŞEKİL	$R_B = \frac{Wa^2}{2L^3}(3L-a)$ $R_A = W - R_B$	$R_B = \frac{W}{2L^3}\left[b^3(3L-2a)+a^2(3L-a)\right]$ $R_A = W - R_B$


TEK TARAFI ANKASTRE KİRİŞLER
YÜKLEME
MOMENT
KAYMA
SEHİM

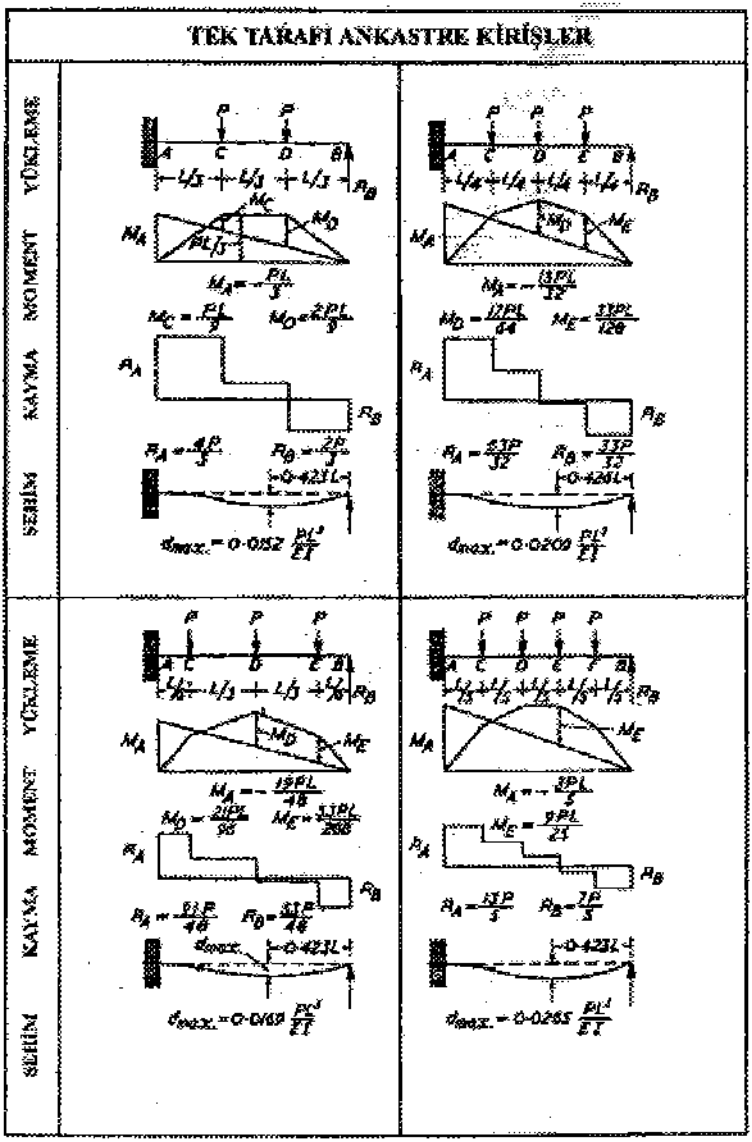
TEK TARAFI ANKASTRE KİRİŞLER

YÜKLEME		
MOMENT		
KAYMA	$M_A=-\frac{Wa}{8L^2}(2L-a)$	$M_A=-\frac{Wa}{8L^2}(4L-3a)$ When $x<a$, $M_x=\frac{W}{2L^3}(2n^2x-6nx+12x-4x\eta^2)$ $+M_{max}$ occurs when $\eta=\sqrt{\frac{3n^2}{4}-n+1}$
SEHİM	 $R_A=\frac{W}{8L^3}(4L^2+2aL-a^2)$ $R_B=W-R_A$	 $R_A=\frac{W}{8L^3}(4L^3+4aL-3a^2)$ $R_B=W-R_A$
YÜKLEME		
MOMENT	 $M_A=-\frac{5WL}{32}$ $+M_{max}=0.0948WL$	 $M_A=\frac{W}{32L}(5L^2+4aL-4a^2)$
KAYMA	 $R_A=\frac{21W}{32}$ $R_B=\frac{11W}{32}$	 $R_A=\frac{W}{32L^3}(21L^3+4aL-4a^2)$ $R_B=W-R_A$
SEHİM	 $\delta_{max}=0.00727\frac{WL^3}{EI}$	

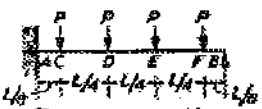
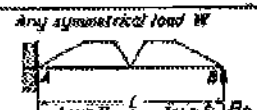
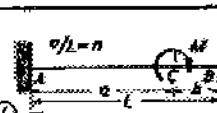
TEK TARAFI ANKASTRE KİRİŞLER

	YÜKLEME	MOMENT	KAYMA	SEHİM
2nd degree parabola				
complement of parabola (total load W)				
P				
P				

TEK TARAFI ANKASTRE KİRİŞLER



TEK TARAFI ANKASTRE KİRİŞLER

YÜKLEME		
MOMENT	$M_A = -\frac{55}{64}PL$ $M_E = \frac{63}{512}PL$	$M_A = -\frac{PL(n^2-1)}{8n}$
KAYMA	$R_A = \frac{55}{64}P \quad R_B = \frac{33}{64}P$	$R_A = \frac{P}{8n}(5n^2-4n-1)$ $R_B = \frac{P}{8n}(3n^2-4n+1)$
SEHİM	$d_{max} = 0.0272\frac{PL^3}{EI}$	when n is large, $d_{max} = \frac{n PL^3}{185EI}$
YÜKLEME		
MOMENT	$M_A = \frac{3AS}{2L}$	$M_A = \frac{M}{2}[2-6n+3n^2]$ $M_{CA} = \frac{M}{2}[2-6n+9n^2-3n^3]$ $M_{CB} = \frac{3M_0}{2}[2-3n+n^2]$
KAYMA	$R_A = \frac{W}{2} + \frac{M_A}{L} \quad R_B = \frac{W}{2} - \frac{M_A}{L}$	$-R_A = R_B = \frac{M+M_A}{L}$
SEHİM	$d_{max} = \frac{\text{Area } SI\,x}{EI}$	In Case I, $R = 3M/2L$ Case J, $R = M/L$