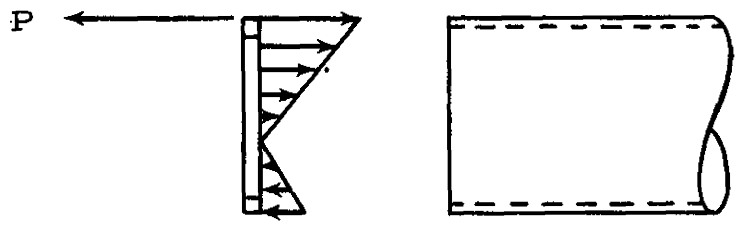
SECTION B6

RINGS

TABLE OF CONTENTS

B 6.0.0 Rings

Charts and tables are presented to facilitate the analysis of rings and ring-supported shells. Section B 6.1.0 deals with rings that are rigid with respect to the resisting medium, i.e., for an out-of-plane loading, the free body of a ring supported by a thin shell is as follows:



Only bending is considered in the deflection curves for the in-plane load cases given on pages 9 through 54. Refer to page 56.1 to include the effects of shear and normal forces.

Section B 6.2.0 deals with circular cylindrical shells supported by "flexible" rings. The choice between the use of this section over section B 6.1.0 for any given problem is left to the analyst. Experience should be gained on both methods.

B 6.1.0 Rigid Rings

In general, four basic loadings are required to define all loads on a ring loaded in the plane of the ring. They are:

1. Loading by a single radial force
2. Loading by a single tangential force
3. Loading by a single moment
4. Loading by a distributed load.

Special cases for out-of-plane loadings are considered in Section B 6.1.2.

The procedure for calculating the Bending Moments of the basic in-plane loading is briefly reviewed in the following discussion. Many other loading conditions may be analyzed by using these basic cases by applying the principal of superposition.

The general equation for the transverse force (shearing force on a cross-section) is

$$S = \frac{dm}{ds} = \frac{dm}{r\,d\phi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

The general equation for the axial force is derived as follows:

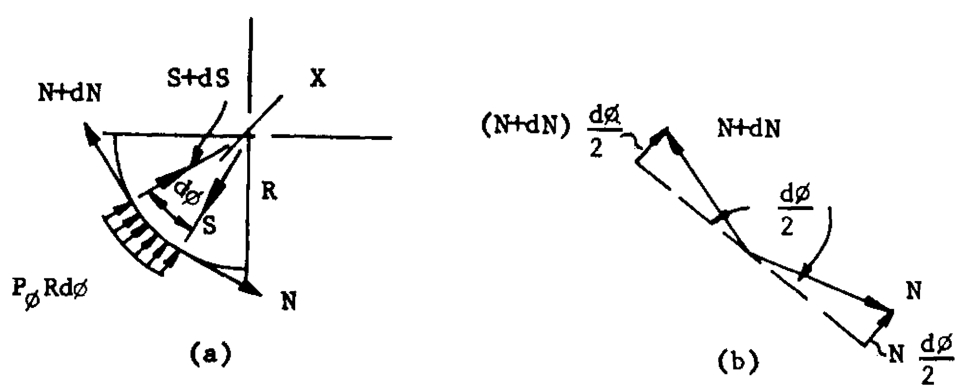


Fig. B 6.1.0-1

B 6.1.0 Rigid Rings (Cont'd)

$$\Sigma Fx = 0 = -S + (S + dS) + (N + dN)\frac{d\phi}{2} + N\frac{d\phi}{2} + P_\phi R d\phi$$

$$= dS + N d\phi + dN\frac{d\phi}{2} + P_\phi R d\phi$$

Neglecting the second order term, $\left(dN\frac{d\phi}{2}\right)$

$$N = -\frac{dS}{d\phi} - P_\phi R \quad \text{.......................................} \quad (2)$$

The second term ($P_\phi R$) occurs in the case of a distributed load.

The procedure to obtain an expression for the bending moment is illustrated by the following specific case:

Load

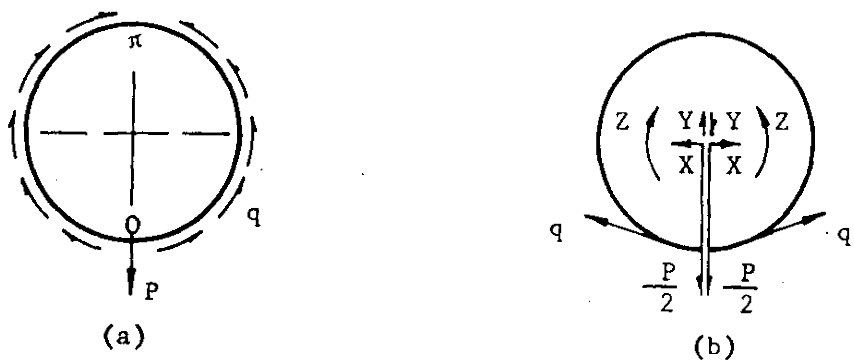


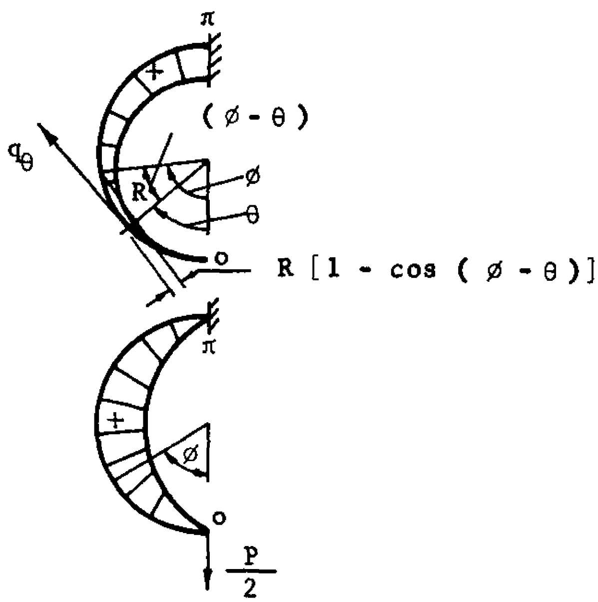
Fig. B 6.1.0-2

Because of symmetry Y = 0

The shear flow distribution is obtained from q = SQ/I, where Q is the static moment of half the ring, S is the shearing force, and I is the moment of inertia of the section.

$$q_\phi = \frac{S}{\pi R^3}\int_0^\phi R d\phi \; R\cos\phi = \frac{S\sin\phi}{\pi R} = \frac{P\sin\phi}{\pi R}$$

B 6.1.0 Rigid Rings (Cont'd)



$$dMq = q_\phi \, R d\theta \quad R\left[1-\cos(\phi-\theta)\right]$$

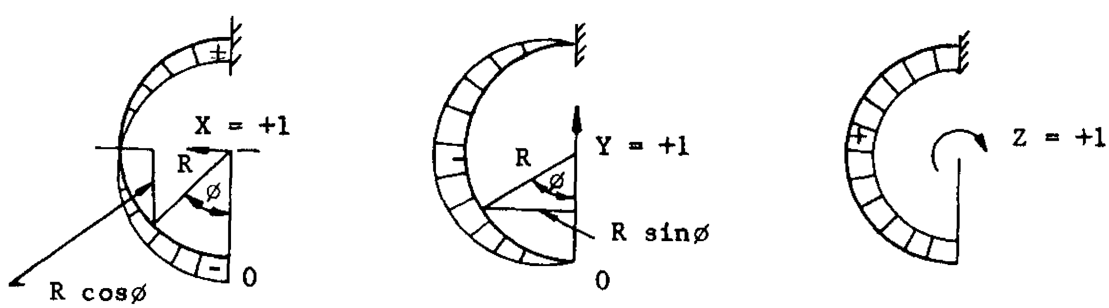
$$= \frac{P}{\pi R} \sin\theta \, R^2 d\theta \left[1-\cos(\phi-\theta)\right]$$

$$Mq_\theta = \frac{PR}{\pi} \int_0^\phi \sin\theta \left[1-\cos(\phi-\theta)\right] d\theta$$

$$= \frac{PR}{\pi} \left(1 - \cos\phi - \frac{\phi \sin \phi}{2}\right)$$

$$M_{P\phi} = -\frac{P}{2} R \sin\phi$$

Fig. B 6.1.0-3



$M_x = -R\cos\phi$ $\qquad M_y = -R\sin\phi$ $\qquad M_z = +1$

Fig.B 6.1.0-4

B 6.1.0 Rigid Rings (Cont'd)

The displacement "i" due to load system "k" = $\delta_{ik} = \int \frac{M_i M_k ds}{EI}$

$$EI \quad \delta_{xx} = \int_0^{\pi} (-R \cos \phi)^2 \, Rd\phi = \frac{\pi R^3}{2}$$

$$EI \quad \delta_{yy} = \int_0^{\pi} (-R \sin \phi)^2 \, Rd\phi = \frac{\pi R^3}{2}$$

$$EI \quad \delta_{zz} = \int_0^{\pi} (+1)^2 \, Rd\phi = \pi R$$

Deflections due to unit loads shown in Fig. B 6.1.0-4

Displacements due to applied forces and reactions

$$EI \quad \delta_{xo} = \int (M_p + M_q) \, M_x ds \qquad \text{Because of symmetry } M_p M_x = 0$$

$$= \int_0^{\pi} \left(\frac{1}{\pi} - \frac{\cos\phi}{\pi} - \frac{\phi \sin \phi}{2 \pi} \right) PR \, (-R \cos\phi) \, Rd\phi = \frac{3PR^3}{8}$$

$$EI \quad \delta_{zo} = \int (M_p + M_q) \, M_z d\phi$$

$$= \int_0^{\pi} PR \left(\frac{\sin\phi}{2} + \frac{1}{\pi} - \frac{\cos\phi}{\pi} - \frac{\phi \sin \phi}{2 \pi} \right) (+1) \, Rd\phi = \frac{3PR^2}{2}$$

$$X = - \frac{\delta_{xo}}{\delta_{xx}} = - \frac{3P}{4\pi}$$

$$Z = - \frac{\delta_{zo}}{\delta_{zz}} = - \frac{3PR}{2\pi}$$

Redundant obtained by equating deflections.

By superposition

$$M = M_p + M_q + XM_x + ZM_z$$

$$= \frac{PR \sin \phi}{2} + \left(\frac{1}{\pi} - \frac{\cos \phi}{\pi} - \frac{\phi \sin \phi}{2 \pi} \right) PR + \left(- \frac{3P}{4\pi} \right) \left(-R \cos \phi \right)$$

$$+ \left(- \frac{3PR}{2\pi} \right) (+1) = \left[(\pi - \phi) \sin \phi - \frac{\cos \phi}{2} - 1 \right] \frac{PR}{2\pi}$$

$$S = \frac{dM}{Rd\phi} = \left[- \frac{\sin \phi}{2} + (\pi - \phi) \cos \phi \right] \frac{P}{2\pi}$$

$$N = - \frac{dS}{d\phi} = \left[(\pi - \phi) \sin\phi + \frac{3 \cos \phi}{2} \right] \frac{P}{2\pi}$$

B 6.1.0 Rigid Rings (Cont'd)

Sign Convention

Moments which produce tension on the inner fibers are positive.

Transverse forces which act upward to the left of the cut are positive.

Axial forces which produce tension in the frame are positive.

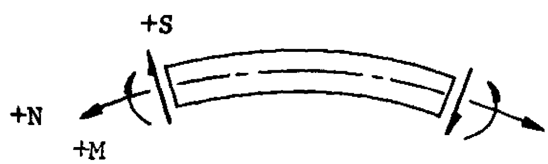


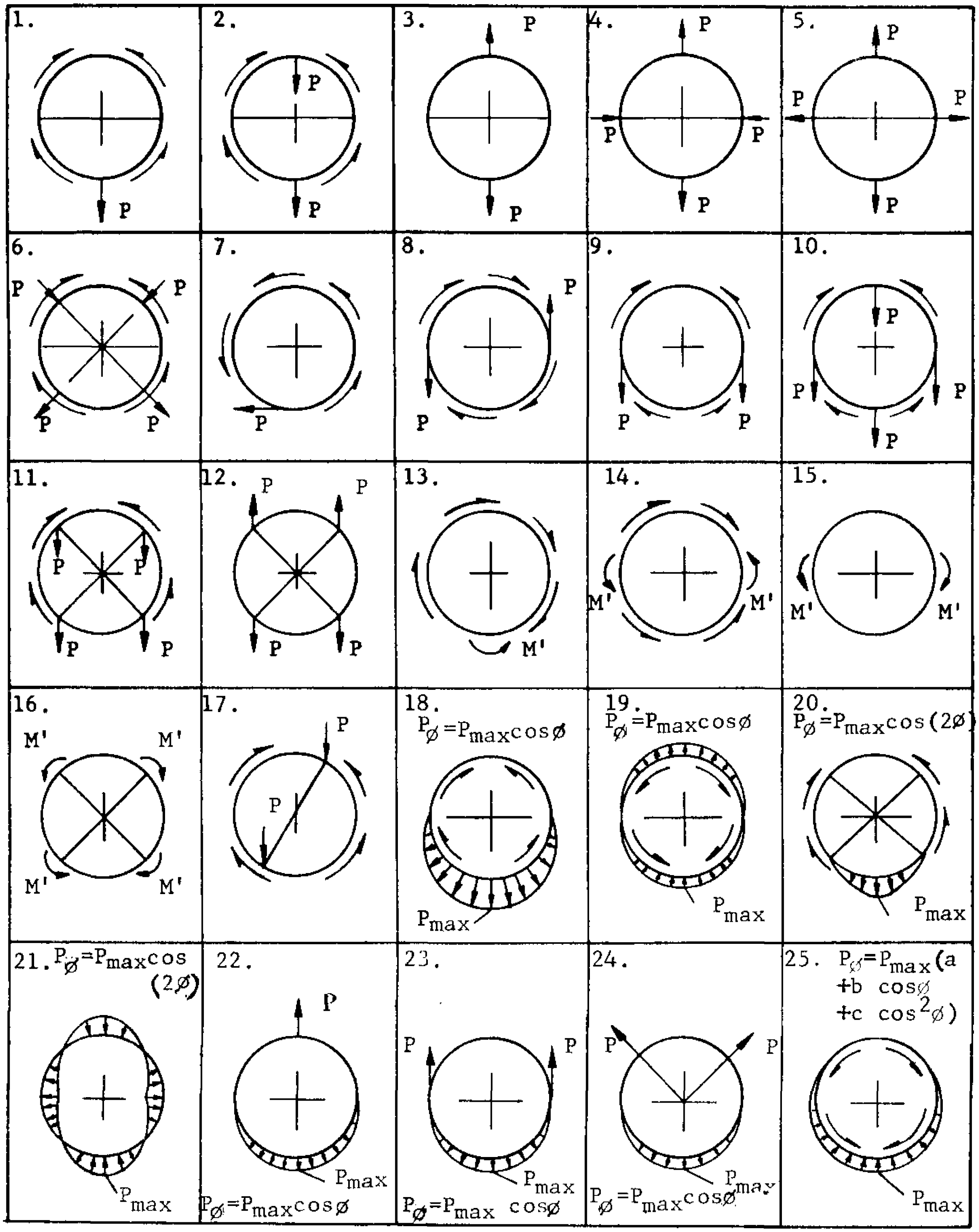
Fig. B 6.1.0-5 Positive Sign Convention

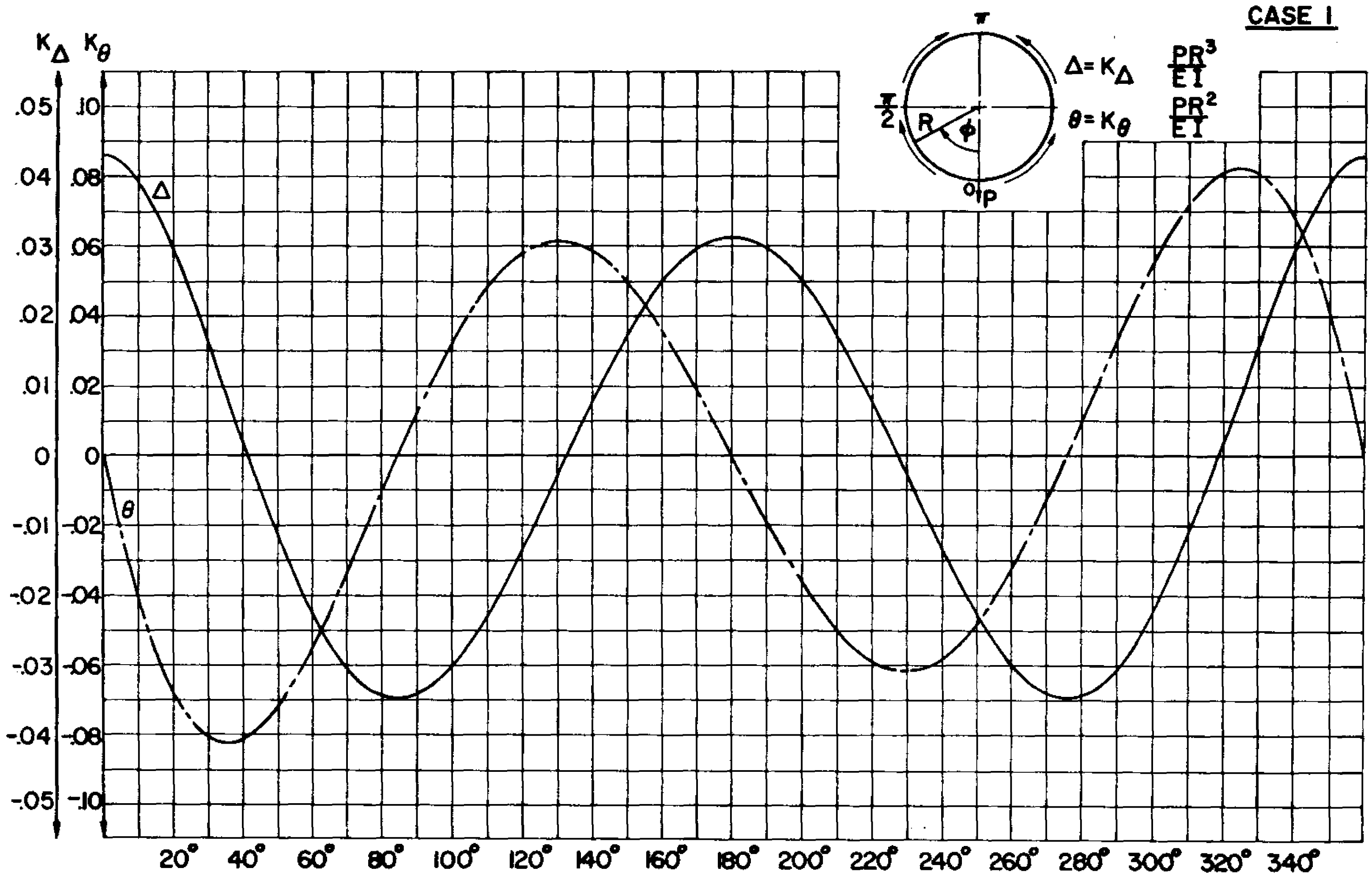
B 6.1.1 In-Plane Load Cases

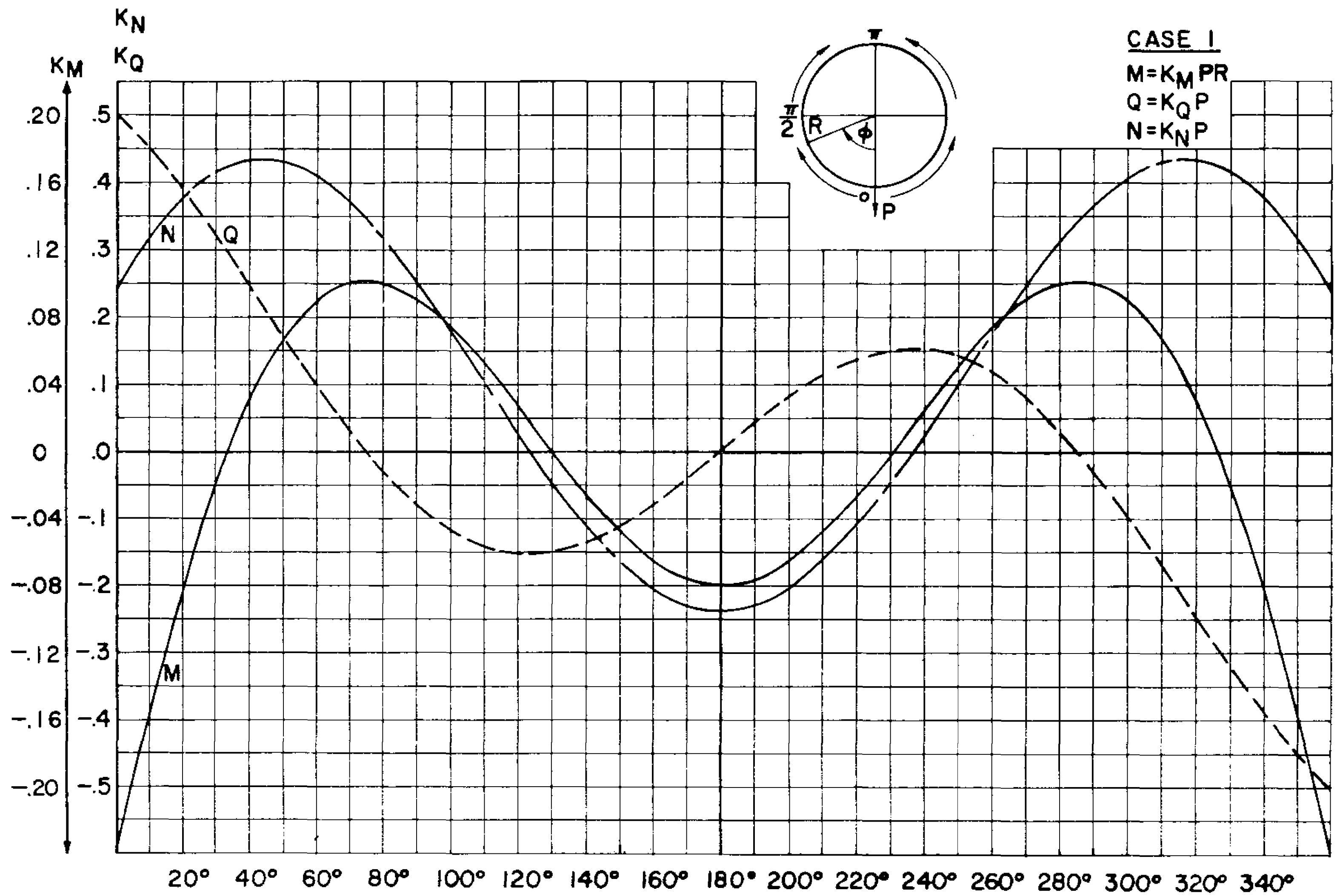
Coefficients to obtain slope, deflection, bending moment, shear, and axial force along with equations for these values are given for some of the frequently occuring load cases.

B 6.1.1 In-Plane Load Cases (Cont'd)

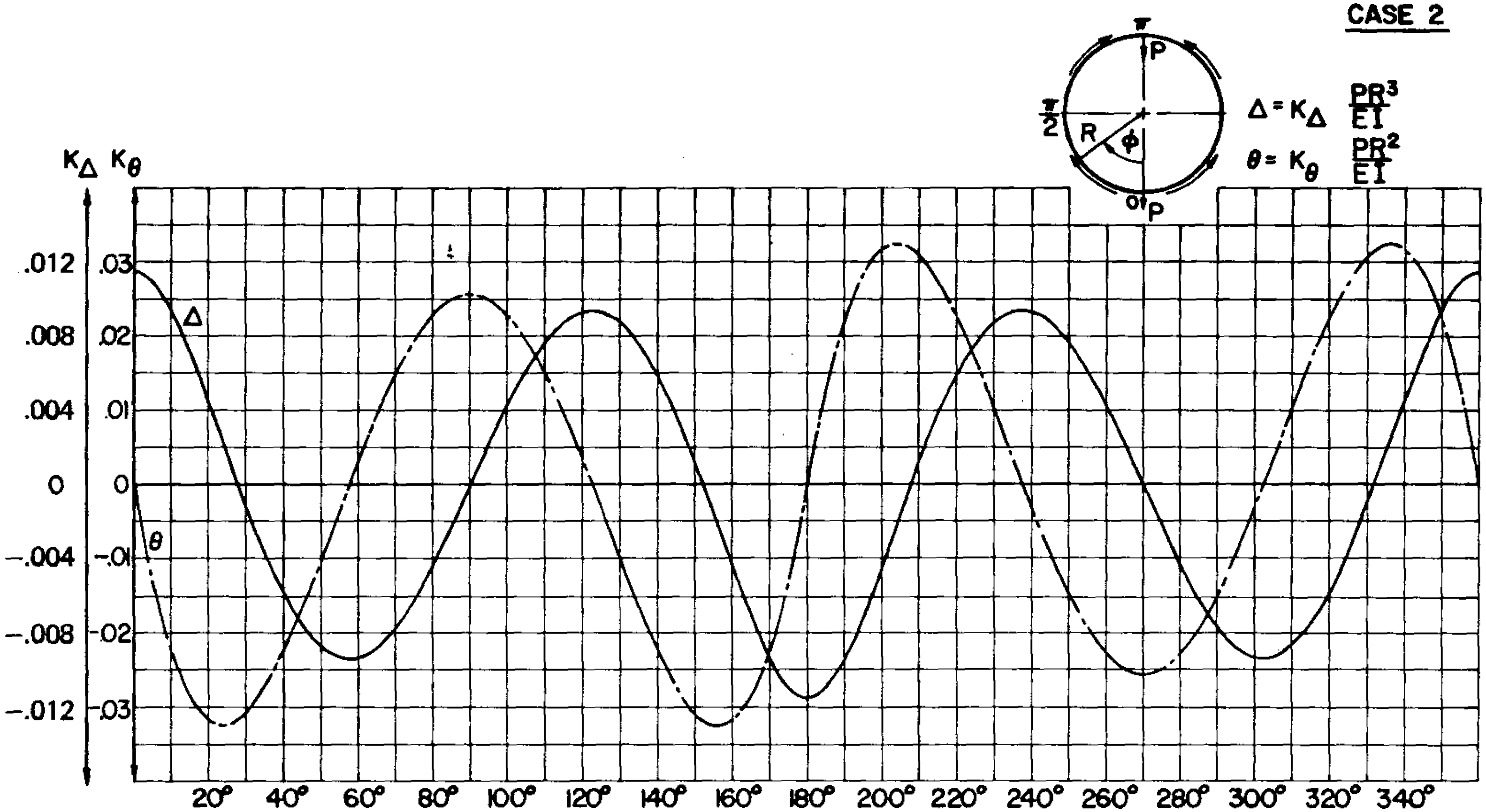
Index



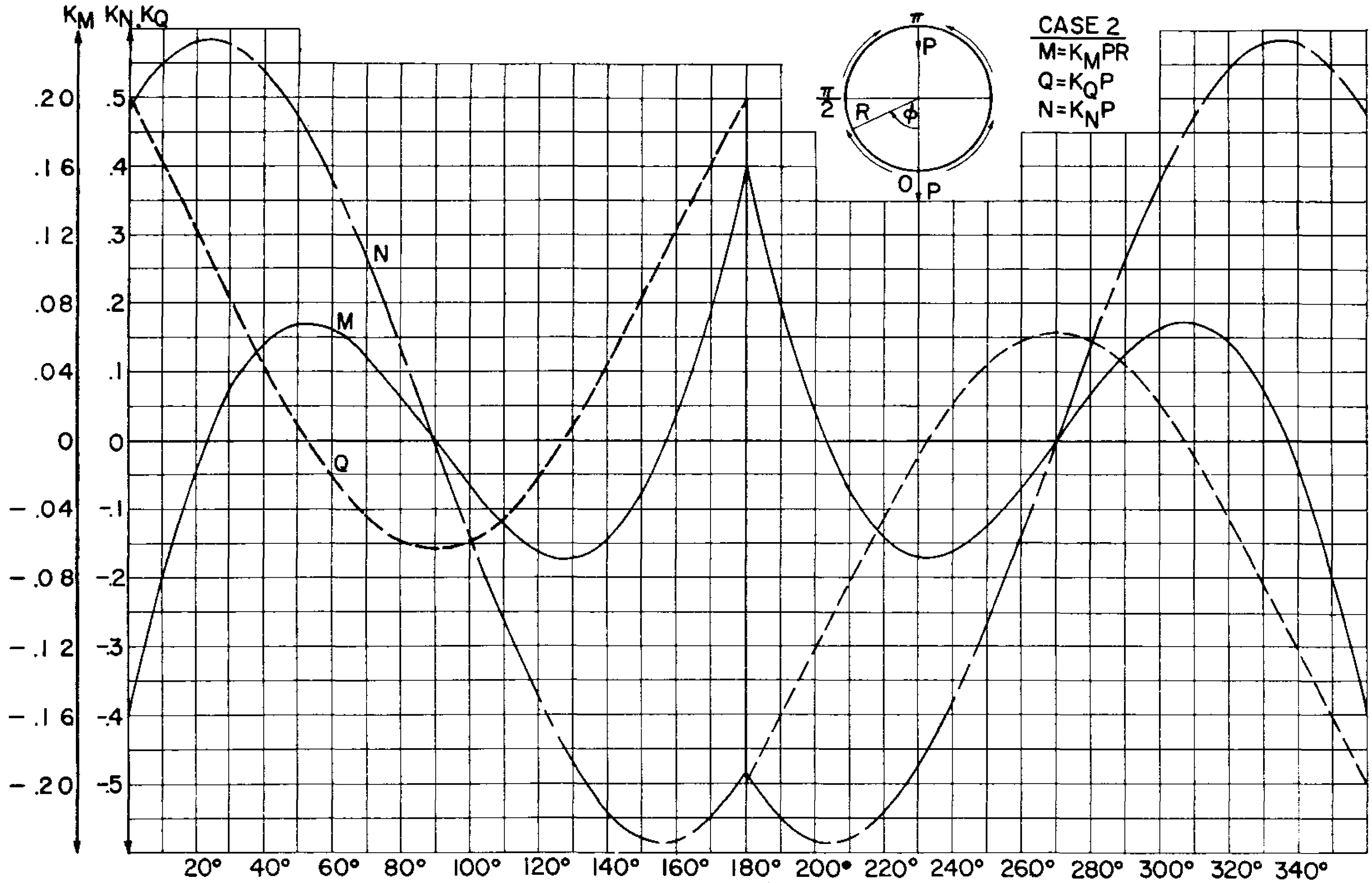

CASE I
K_Δ K_θ
$\Delta = K_\Delta \frac{PR^3}{EI}$
$\theta = K_\theta \frac{PR^2}{EI}$
π
π/2
R
φ
0 P
Δ
θ
.05 .10
.04 .08
.03 .06
.02 .04
.01 .02
0 0
-.01 -.02
-.02 -.04
-.03 -.06
-.04 -.08
-.05 -.10
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°


CASE I
M=K_M PR
Q=K_Q P
N=K_N P
K_N
K_Q
K_M
.20 .5
.16 .4
.12 .3
.08 .2
.04 .1
0 .0
−.04 −.1
−.08 −.2
−.12 −.3
−.16 −.4
−.20 −.5
N
Q
M
π/2
R
φ
π
0
P
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

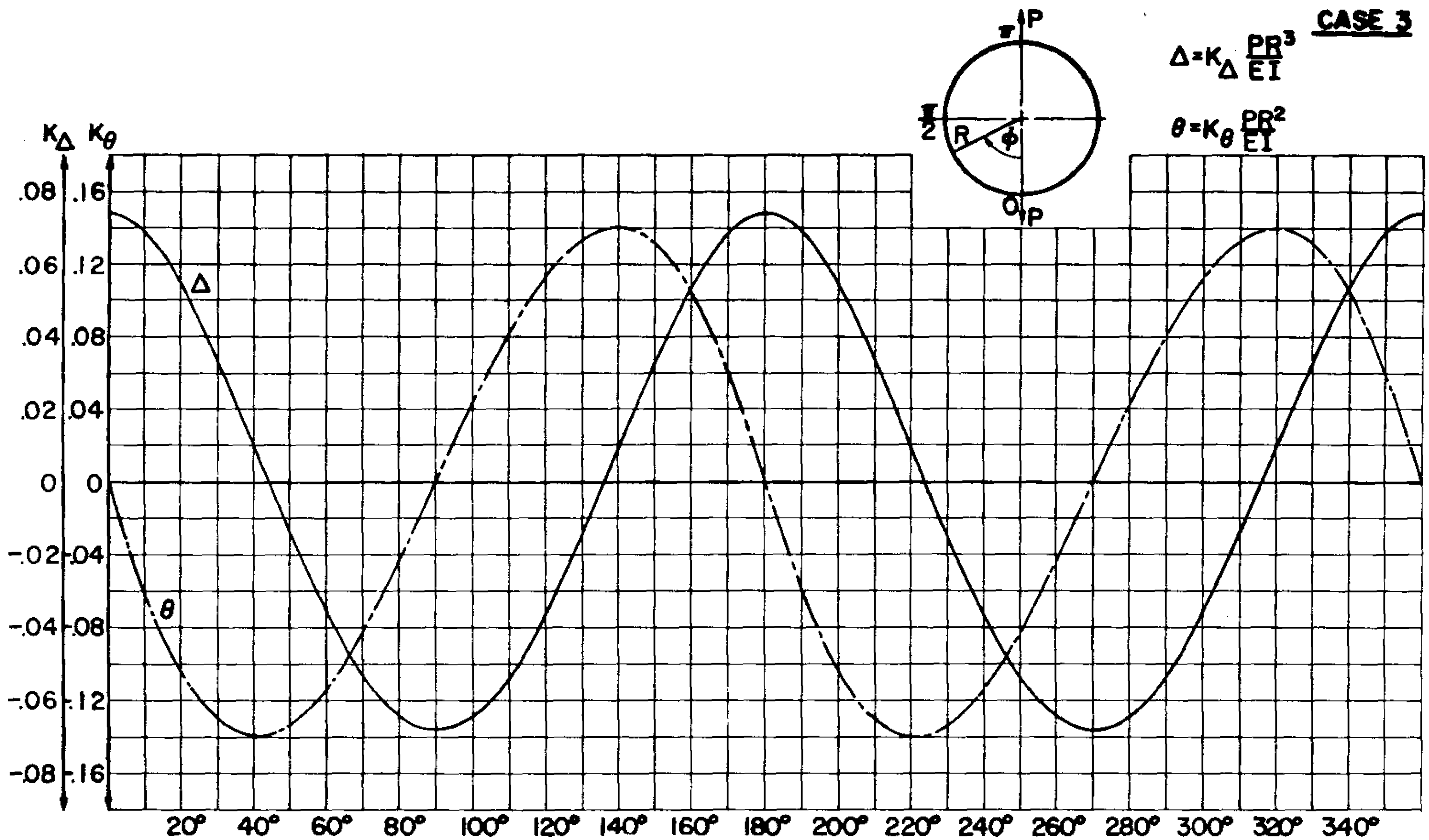
CASE 2

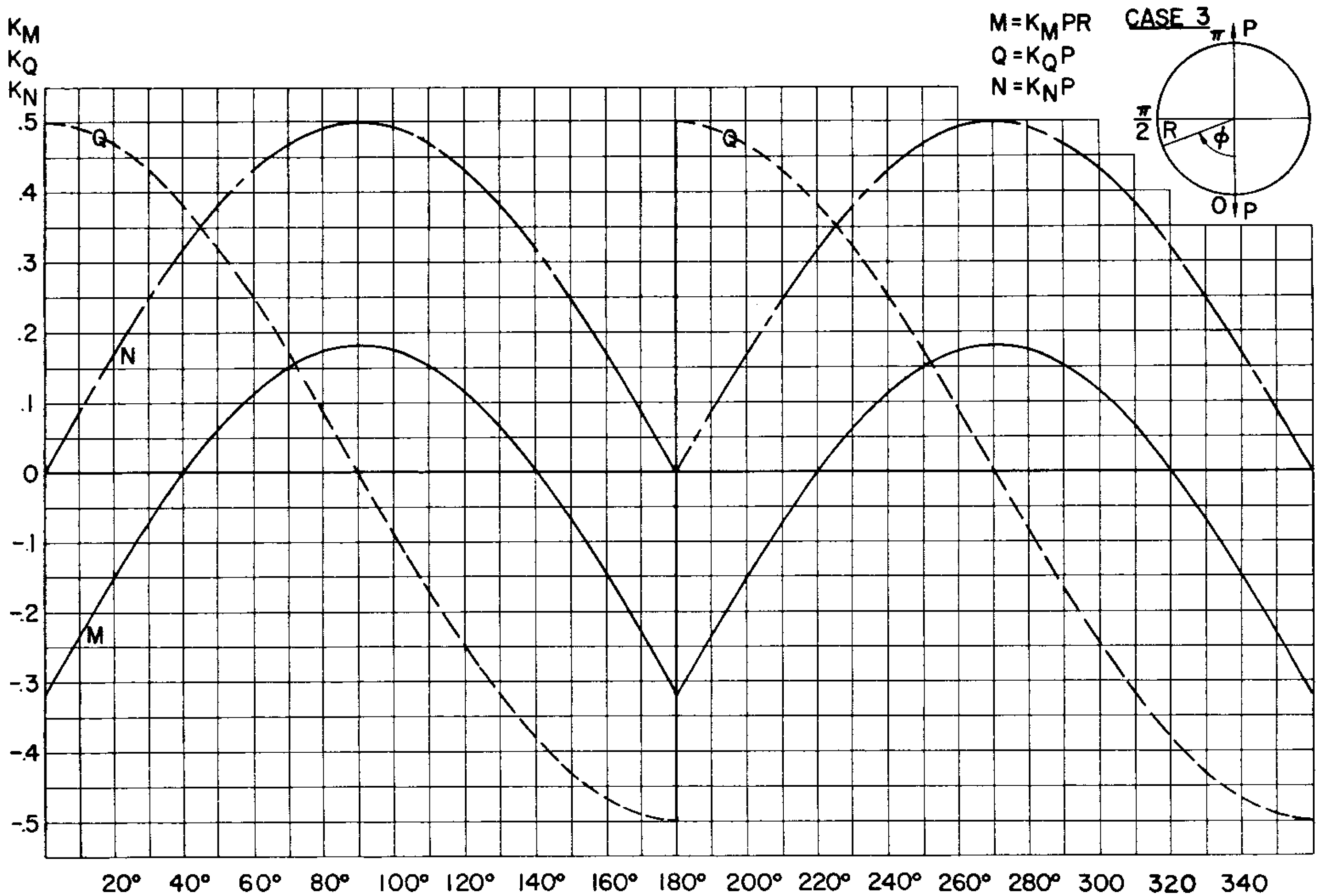


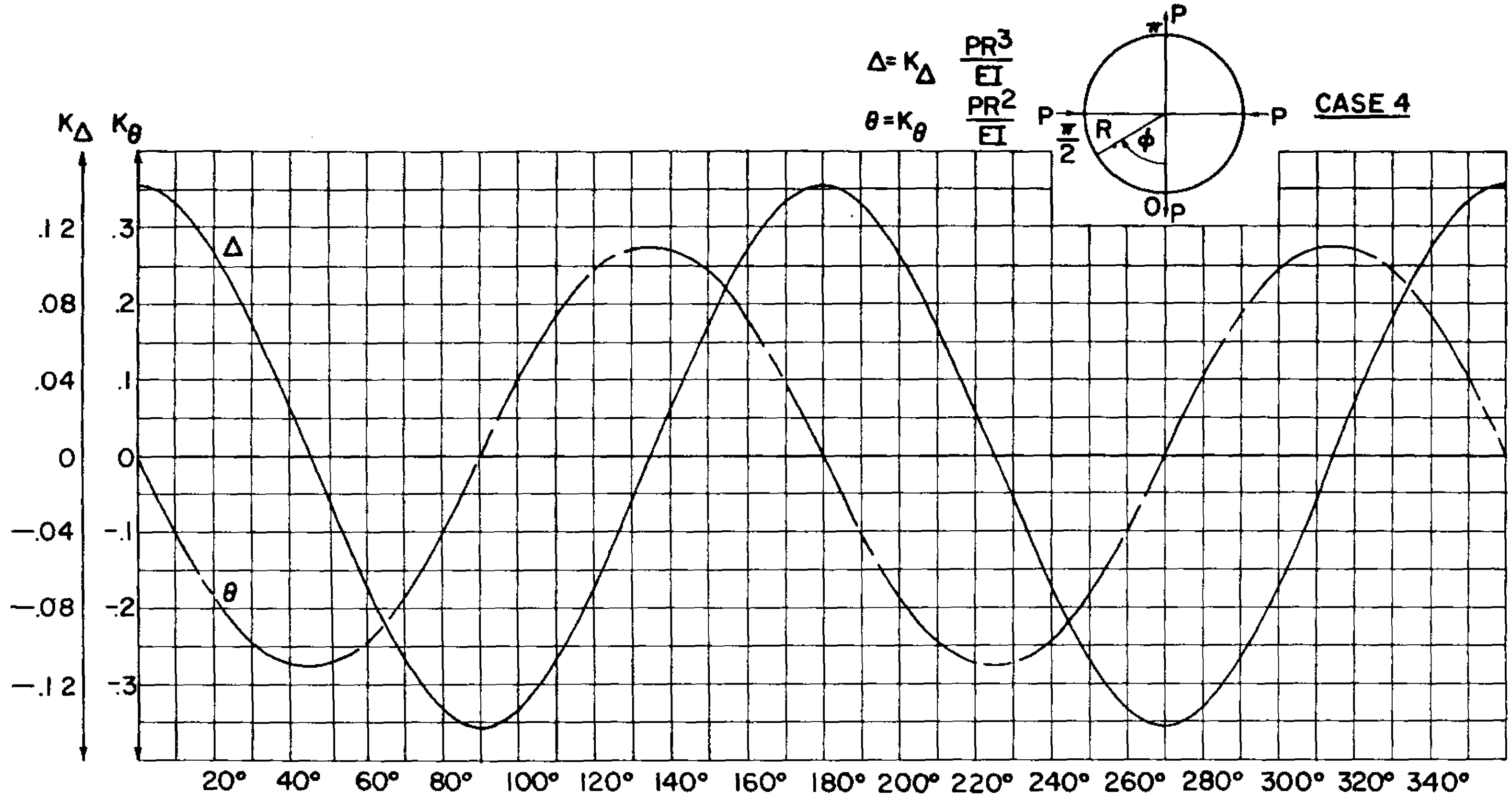
$\Delta = K_\Delta \frac{PR^3}{EI}$
$\theta = K_\theta \frac{PR^2}{EI}$
P
P
R
ϕ
$\frac{\pi}{2}$
π
0
K_Δ K_θ
.012 .03
.008 .02
.004 .01
0 0
-.004 -.01
-.008 -.02
-.012 -.03
Δ
θ
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°



CASE 2
M=K_M PR
Q=K_Q P
N=K_N P
K_M
K_N, K_Q
N
M
Q
P
R
φ
π
π/2
0
.20 .16 .12 .08 .04 0 −.04 −.08 −.12 −.16 −.20
.5 .4 .3 .2 .1 0 -.1 -.2 -.3 -.4 -.5
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

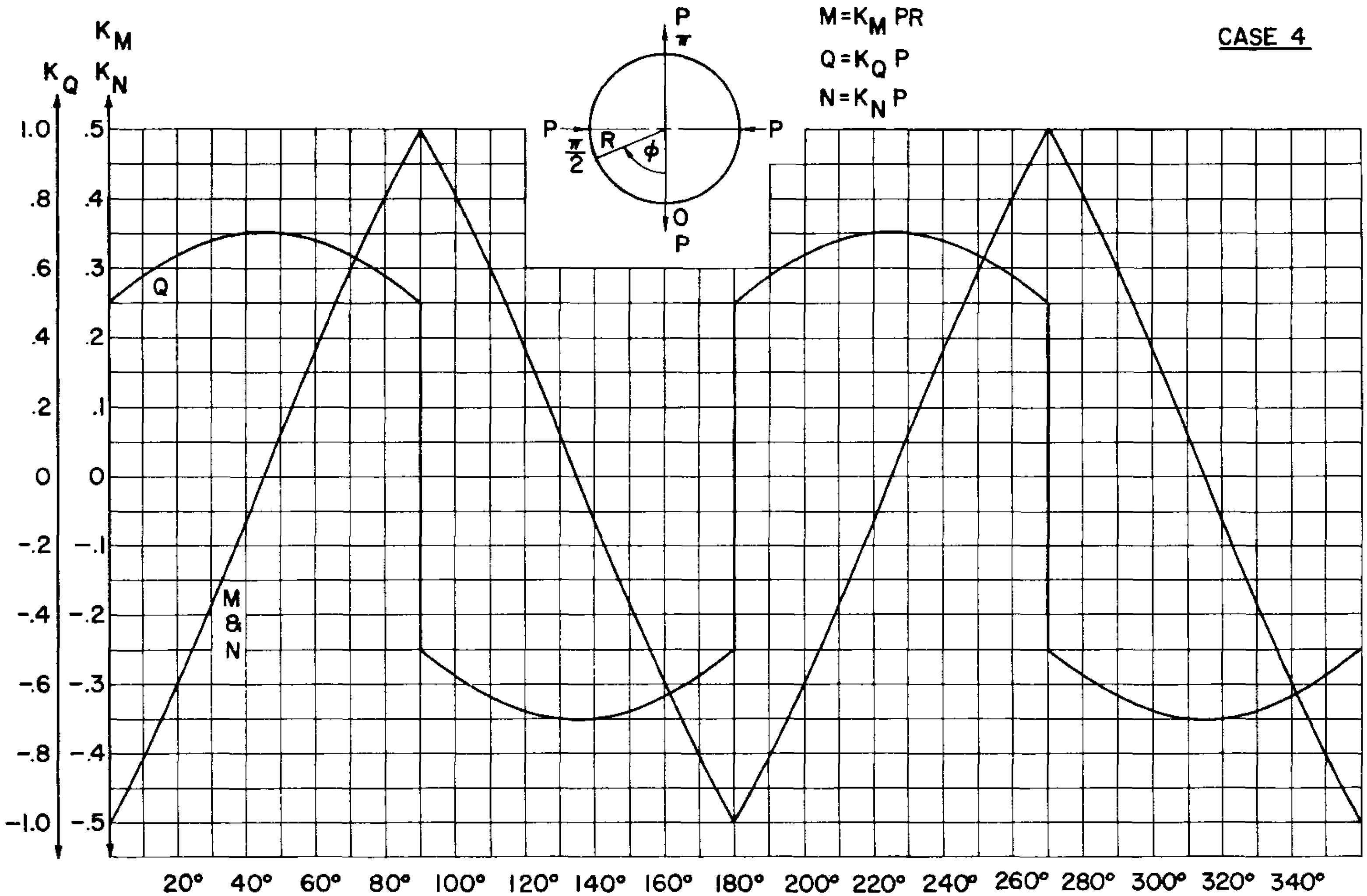

CASE 3
Δ=K_Δ PR³/EI
θ=K_θ PR²/EI
P
π
π/2
R
φ
0
P
K_Δ K_θ
.08 .16
.06 .12
.04 .08
.02 .04
0 0
-.02 -.04
-.04 -.08
-.06 -.12
-.08 -.16
Δ
θ
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

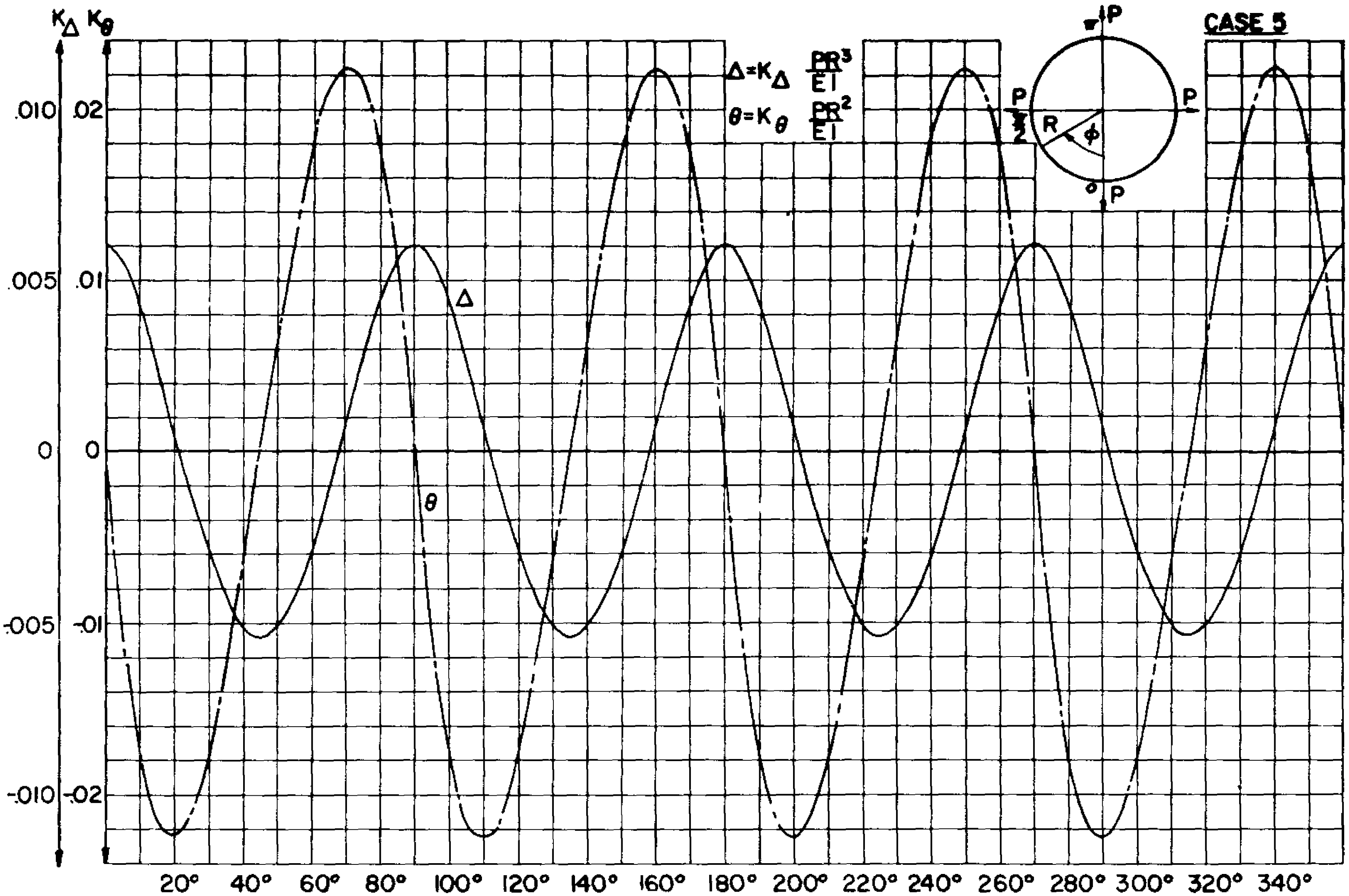

KM
KQ
KN
M = KM PR
Q = KQ P
N = KN P
CASE 3
P
π
π/2
R
φ
0
P
Q
N
M
.5
.4
.3
.2
.1
0
-.1
-.2
-.3
-.4
-.5
20°
40°
60°
80°
100°
120°
140°
160°
180°
200°
220°
240°
260°
280°
300
320
340



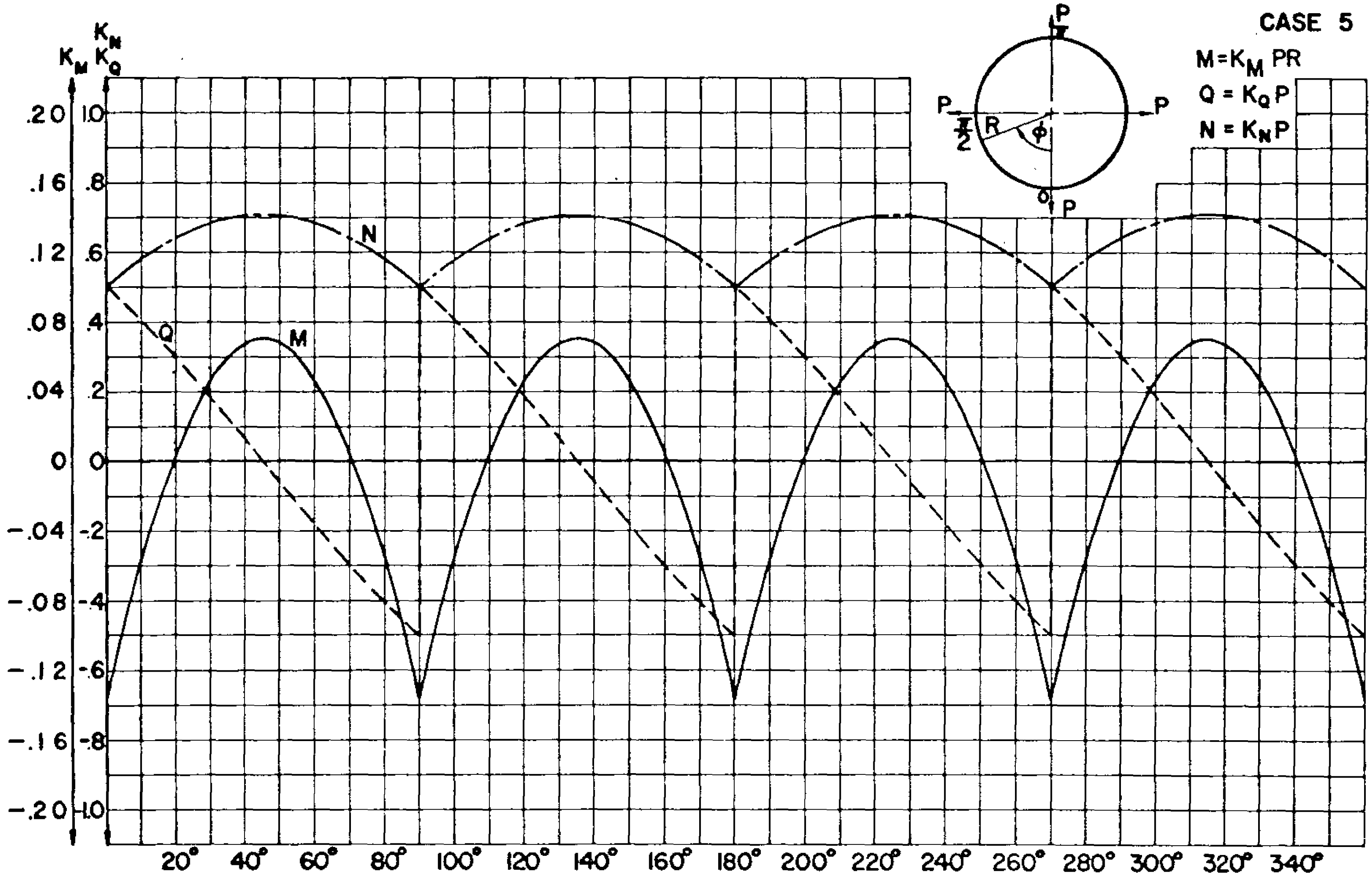
Δ= K_Δ PR³/EI
θ=K_θ PR²/EI
P
π
P
P
π/2
R
φ
O
P
CASE 4
K_Δ K_θ
.12 .3
.08 .2
.04 .1
0 0
−.04 -.1
−.08 -.2
−.12 -.3
Δ
θ
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

CASE 4

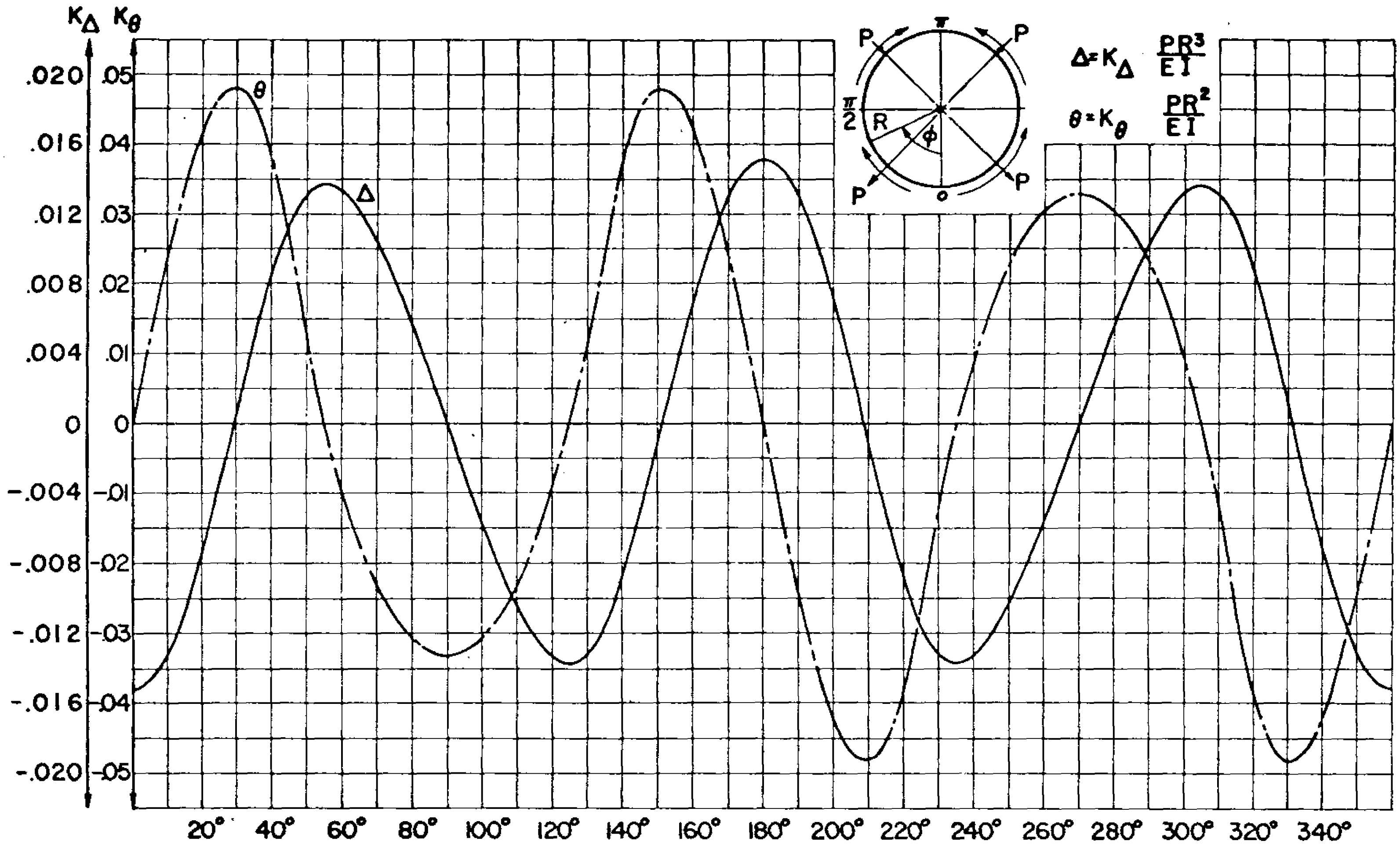

M=K_M PR
Q=K_Q P
N=K_N P
P
π
P
π/2
R
φ
P
O
P
K_Q
K_M
K_N
1.0 .5
.8 .4
.6 .3
.4 .2
.2 .1
0 0
-.2 -.1
-.4 -.2
-.6 -.3
-.8 -.4
-1.0 -.5
Q
M & N
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

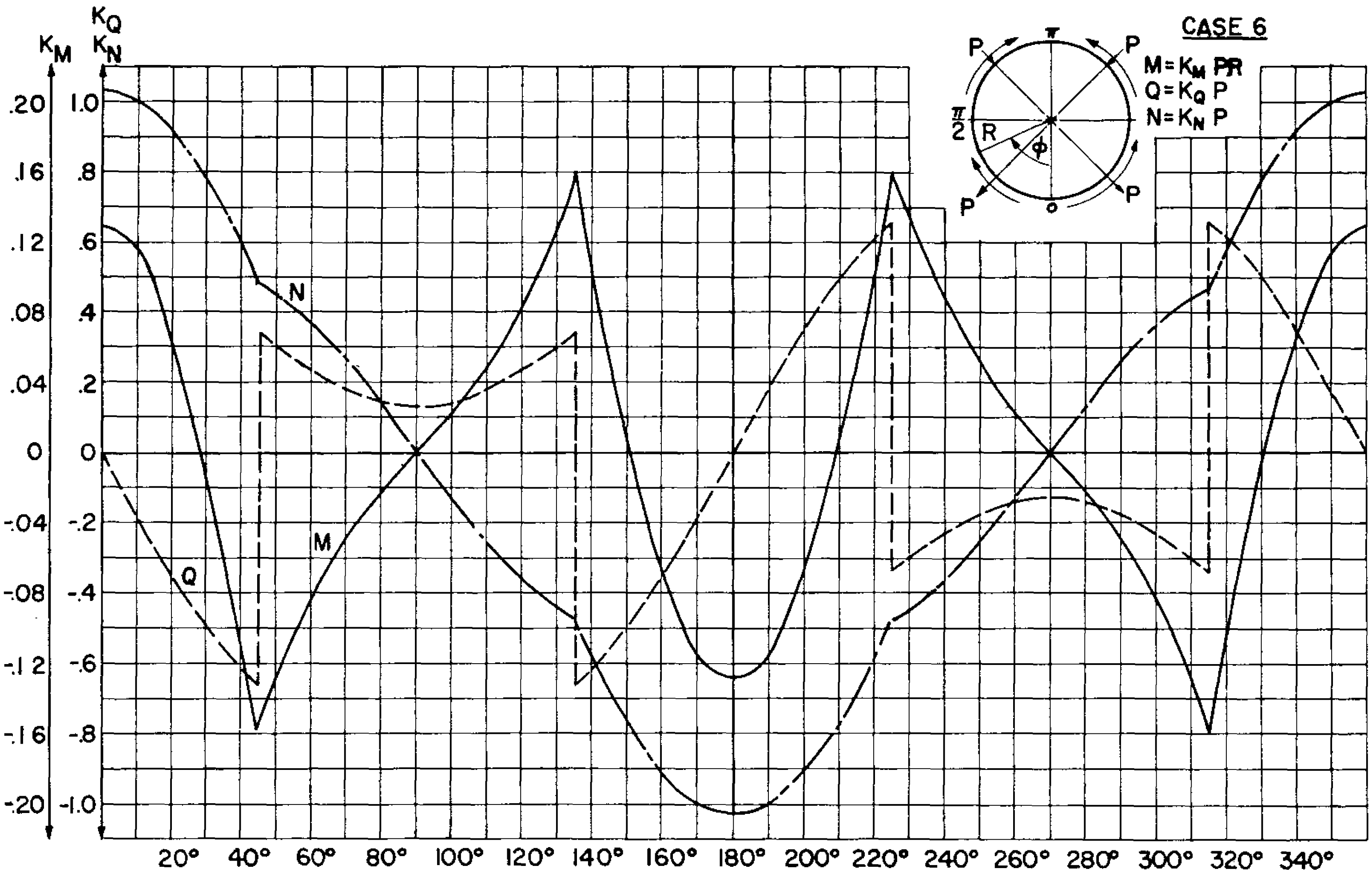


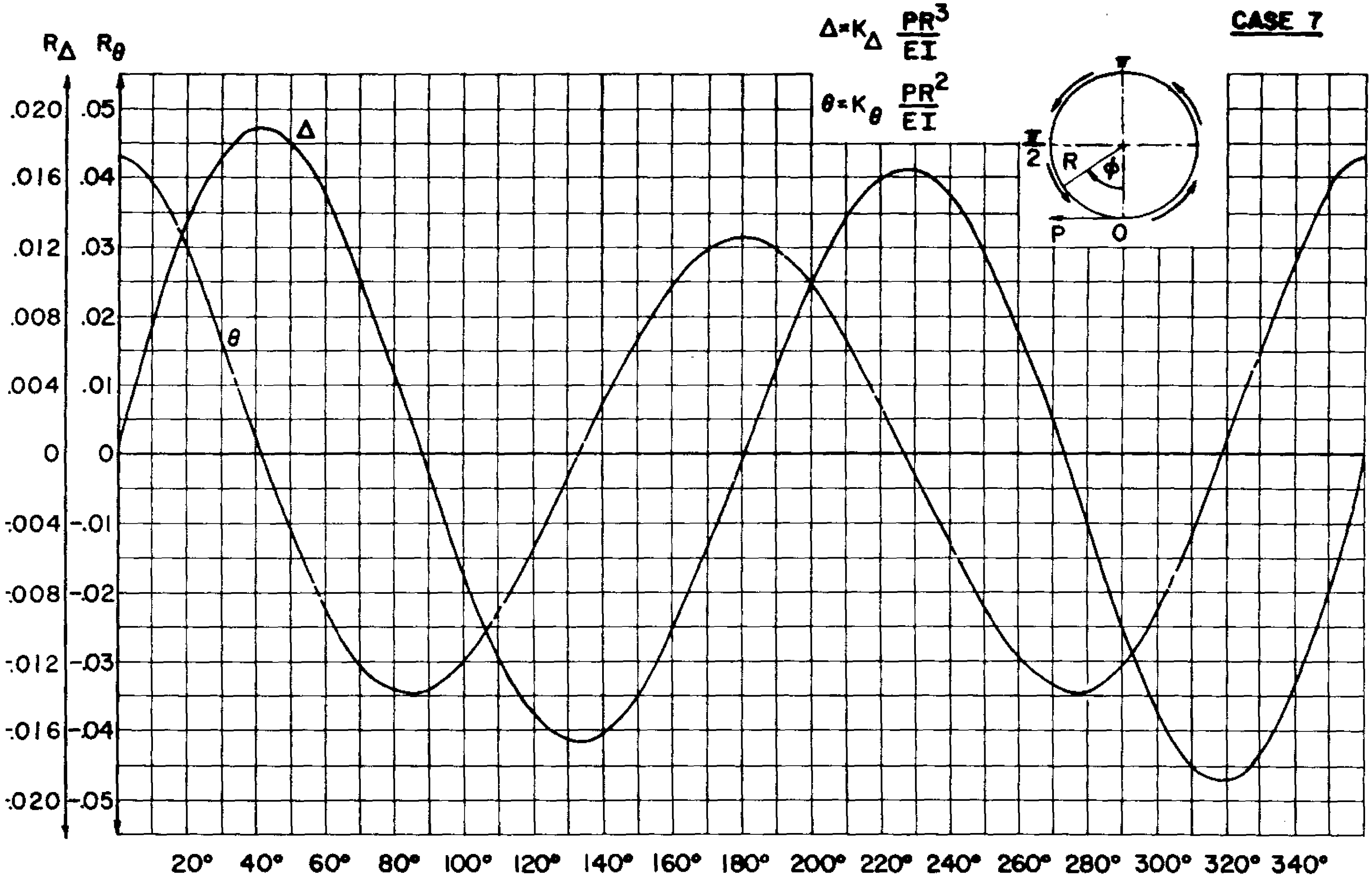
CASE 5
K_Δ K_θ
$\Delta = K_\Delta \frac{PR^3}{EI}$
$\theta = K_\theta \frac{PR^2}{EI}$
P
P
P
P/2
R
ϕ
Δ
θ
.010 .02
.005 .01
0 0
-.005 -.01
-.010 -.02
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°


CASE 5
M = K_M PR
Q = K_Q P
N = K_N P
P
P
P
P
R
π/2
φ
0
K_M
K_N
K_Q
N
Q
M
.20 1.0
.16 .8
.12 .6
.08 .4
.04 .2
0 0
−.04 −.2
−.08 −.4
−.12 −.6
−.16 −.8
−.20 −1.0
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

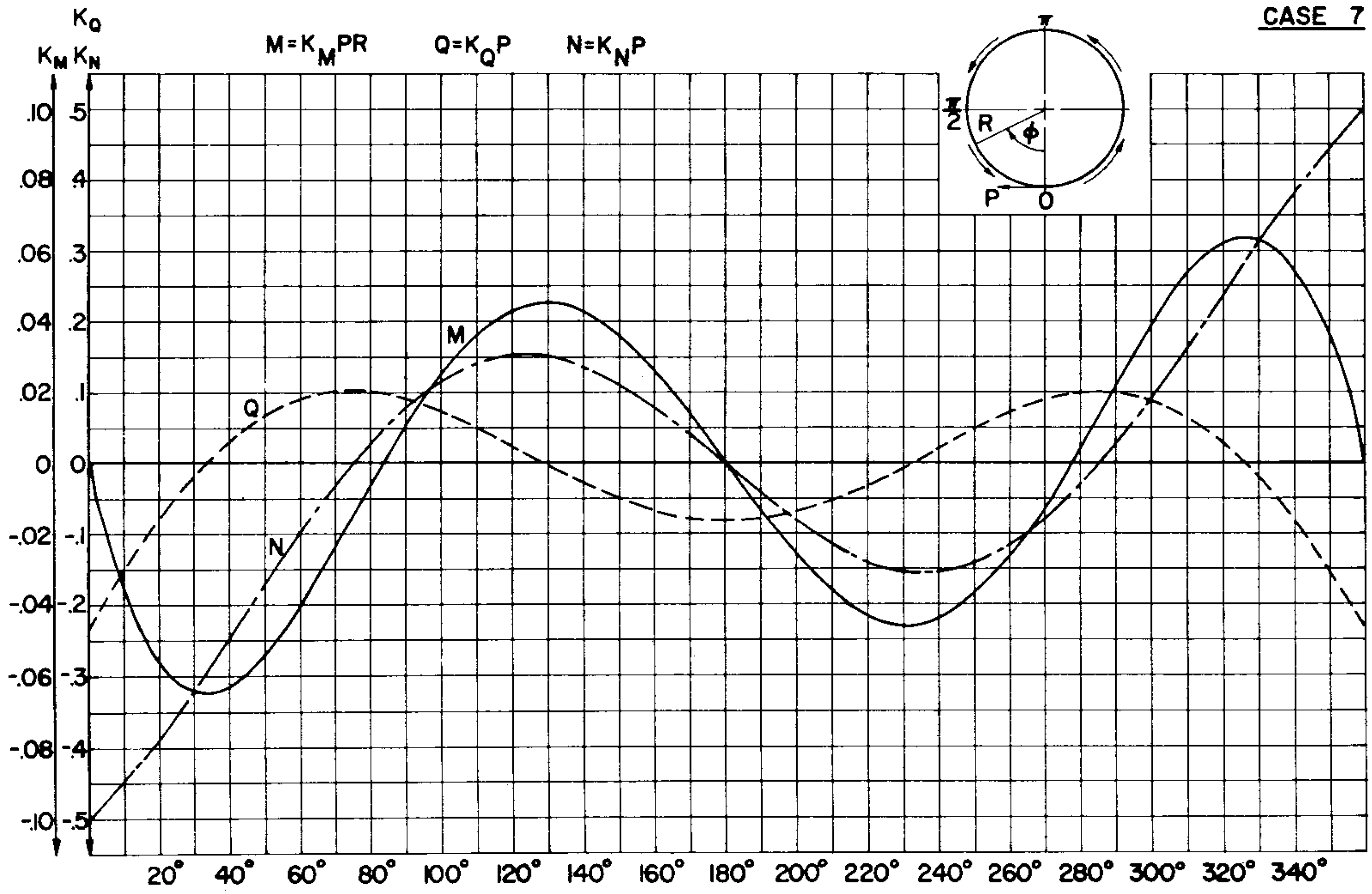
CASE 6


K_Δ K_θ
.020 .05
.016 .04
.012 .03
.008 .02
.004 .01
0 0
-.004 -.01
-.008 -.02
-.012 -.03
-.016 -.04
-.020 -.05
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°
θ
Δ
P
P
P
P
π
$\frac{\pi}{2}$
R
φ
o
$\Delta = K_\Delta \frac{PR^3}{EI}$
$\theta = K_\theta \frac{PR^2}{EI}$

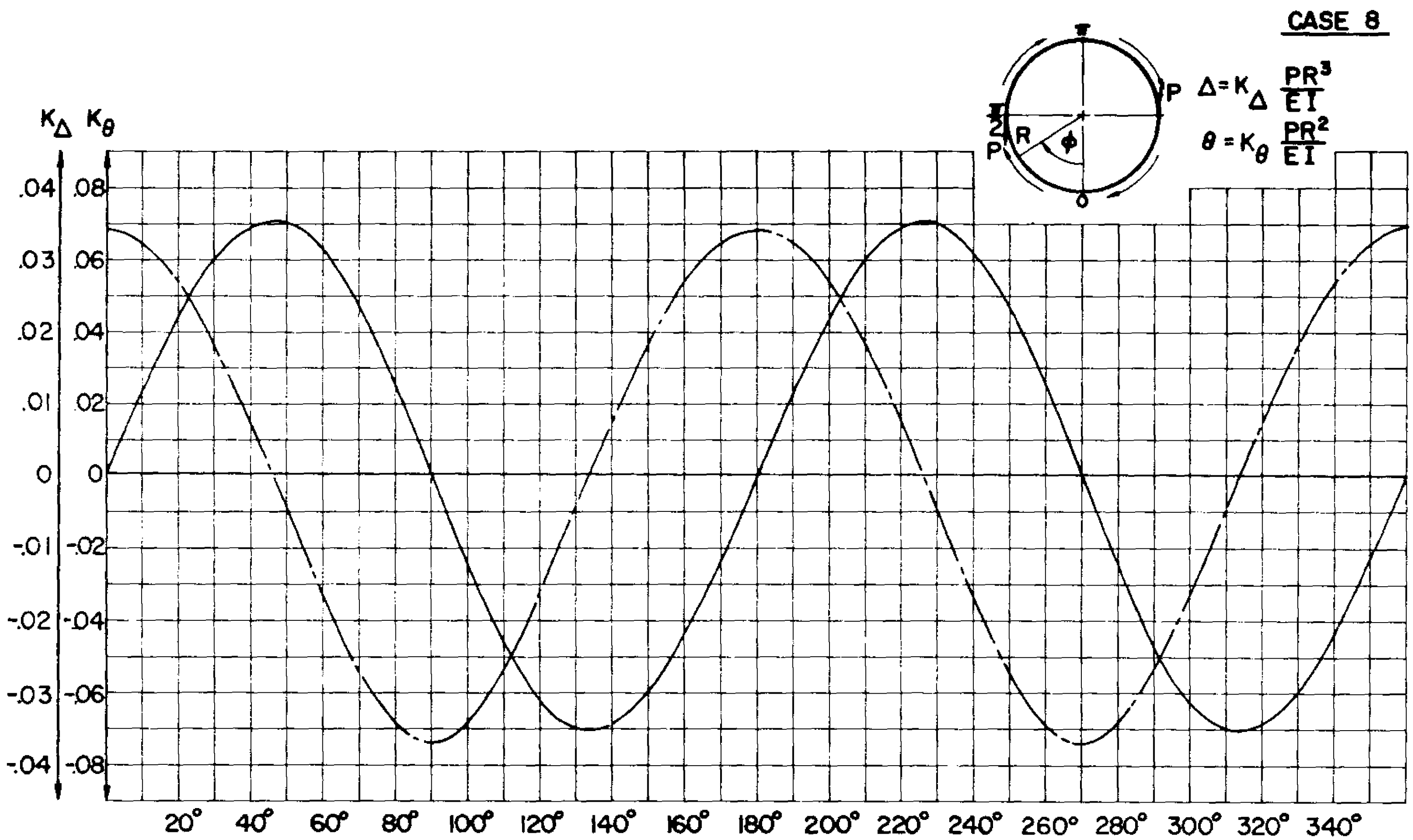

CASE 6
M=K_M PR
Q=K_Q P
N=K_N P
K_M
K_Q
K_N
.20 1.0
.16 .8
.12 .6
.08 .4
.04 .2
0 0
-.04 -.2
-.08 -.4
-.12 -.6
-.16 -.8
-.20 -1.0
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°
N
M
Q
P
R
φ
π
π/2
0


CASE 7
Δ=K_Δ PR³/EI
θ=K_θ PR²/EI
R_Δ R_θ
.020 .05
.016 .04
.012 .03
.008 .02
.004 .01
0 0
-.004 -.01
-.008 -.02
-.012 -.03
-.016 -.04
-.020 -.05
Δ
θ
π/2
R
φ
P
O
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

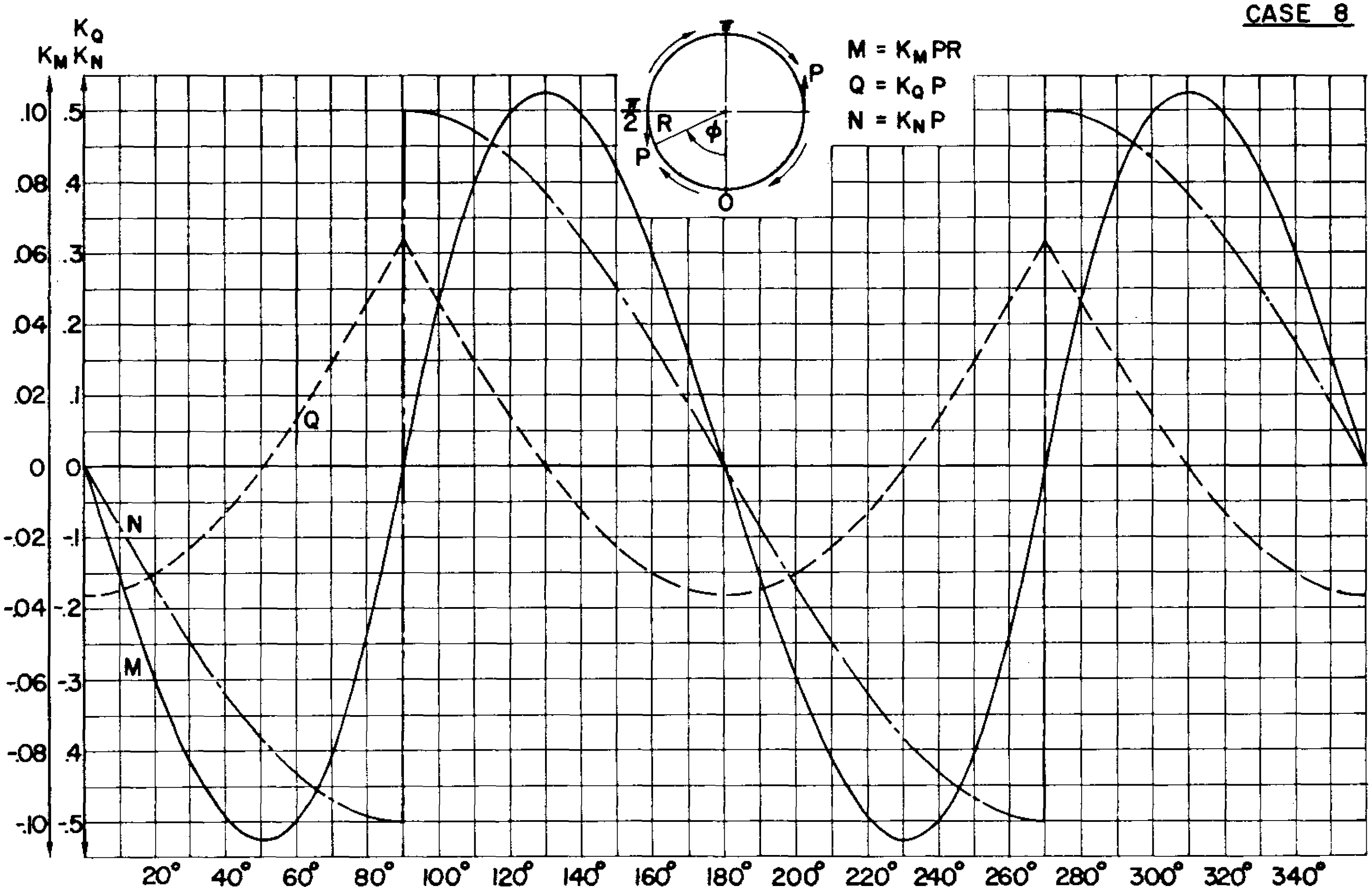
CASE 7



M = K_MPR
Q = K_QP
N = K_NP
K_M
K_Q
K_N
.10 .5
.08 .4
.06 .3
.04 .2
.02 .1
0 0
-.02 -.1
-.04 -.2
-.06 -.3
-.08 -.4
-.10 -.5
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°
M
Q
N
R
φ
P
0

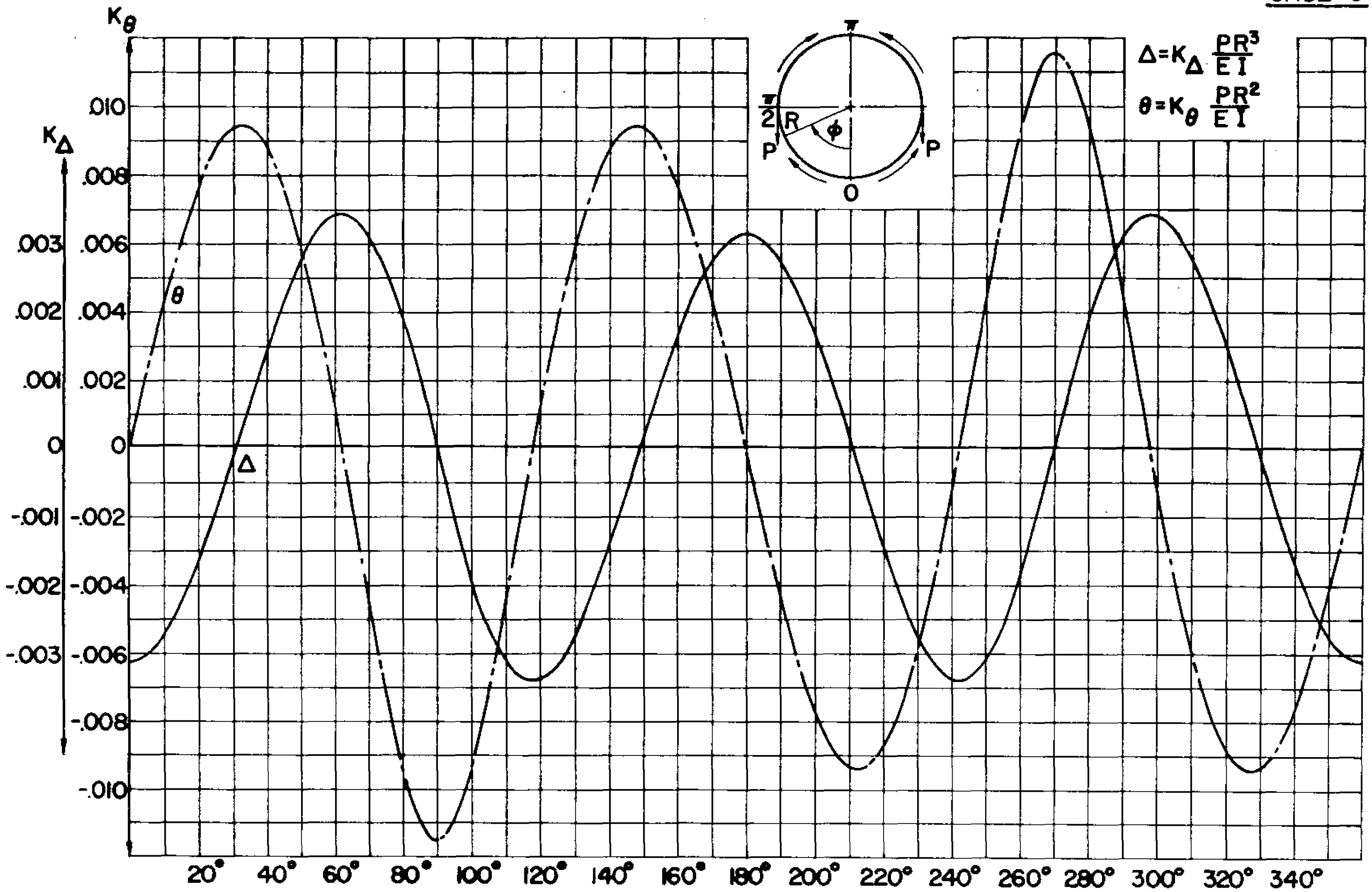

CASE 8
Δ = K_Δ PR³/EI
θ = K_θ PR²/EI
P
P
R
ϕ
π/2
π
0
K_Δ K_θ
.04 .08
.03 .06
.02 .04
.01 .02
0 0
-.01 -.02
-.02 -.04
-.03 -.06
-.04 -.08
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

CASE 8

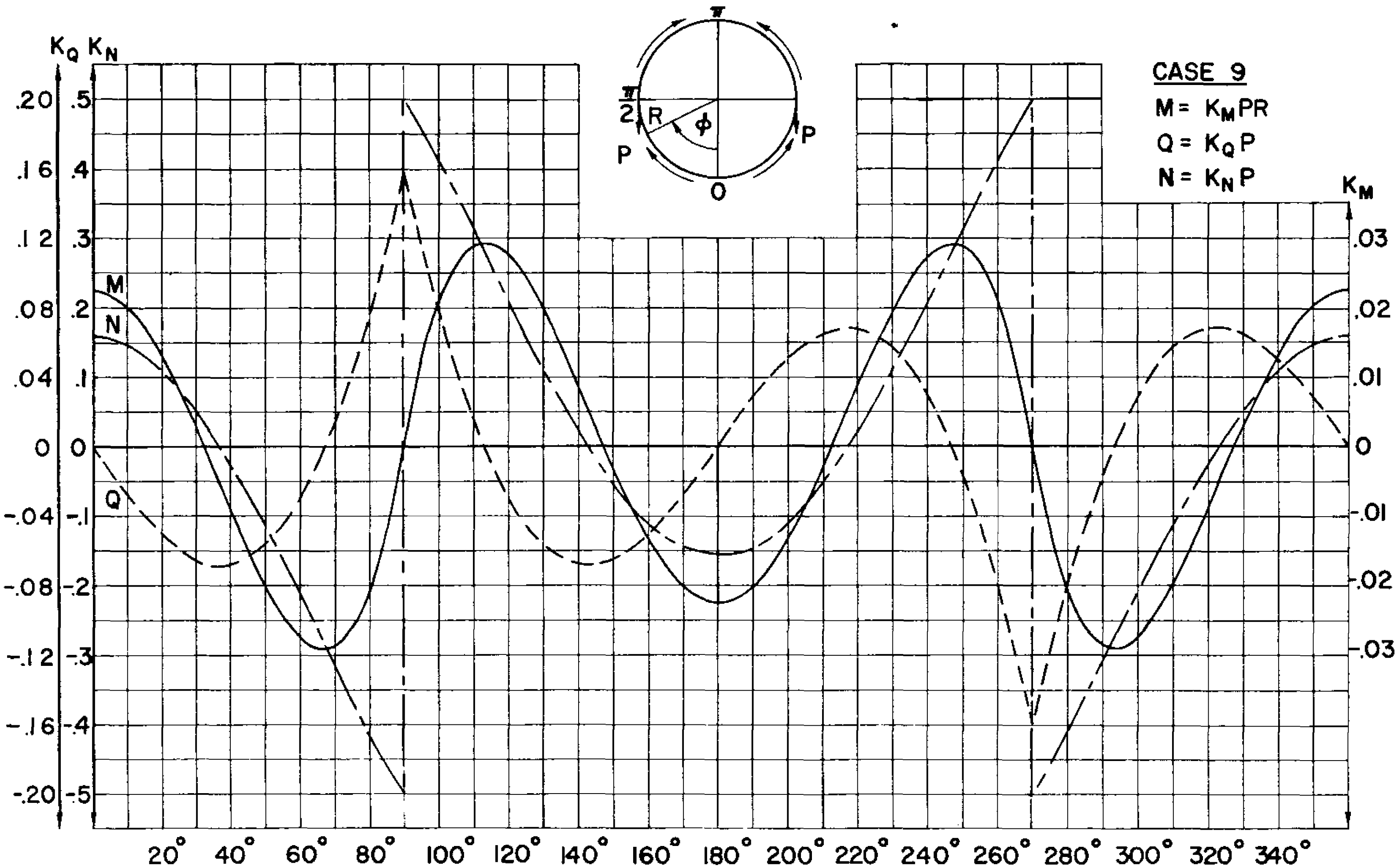


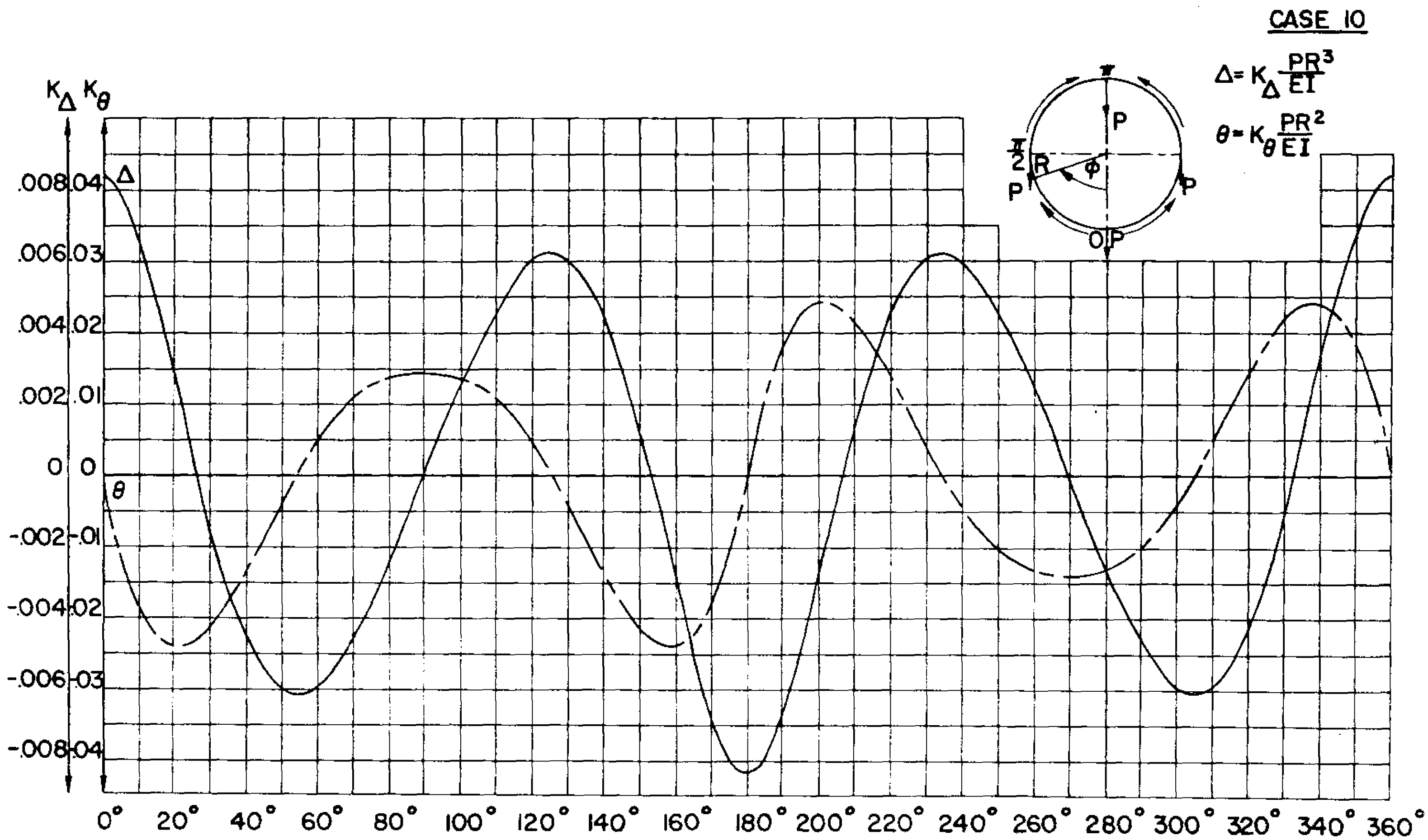
K_M
K_Q K_N
M = K_M PR
Q = K_Q P
N = K_N P
P
P
R
φ
O
Q
N
M
.10 .5
.08 .4
.06 .3
.04 .2
.02 .1
0 0
-.02 -.1
-.04 -.2
-.06 -.3
-.08 .4
-.10 -.5
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

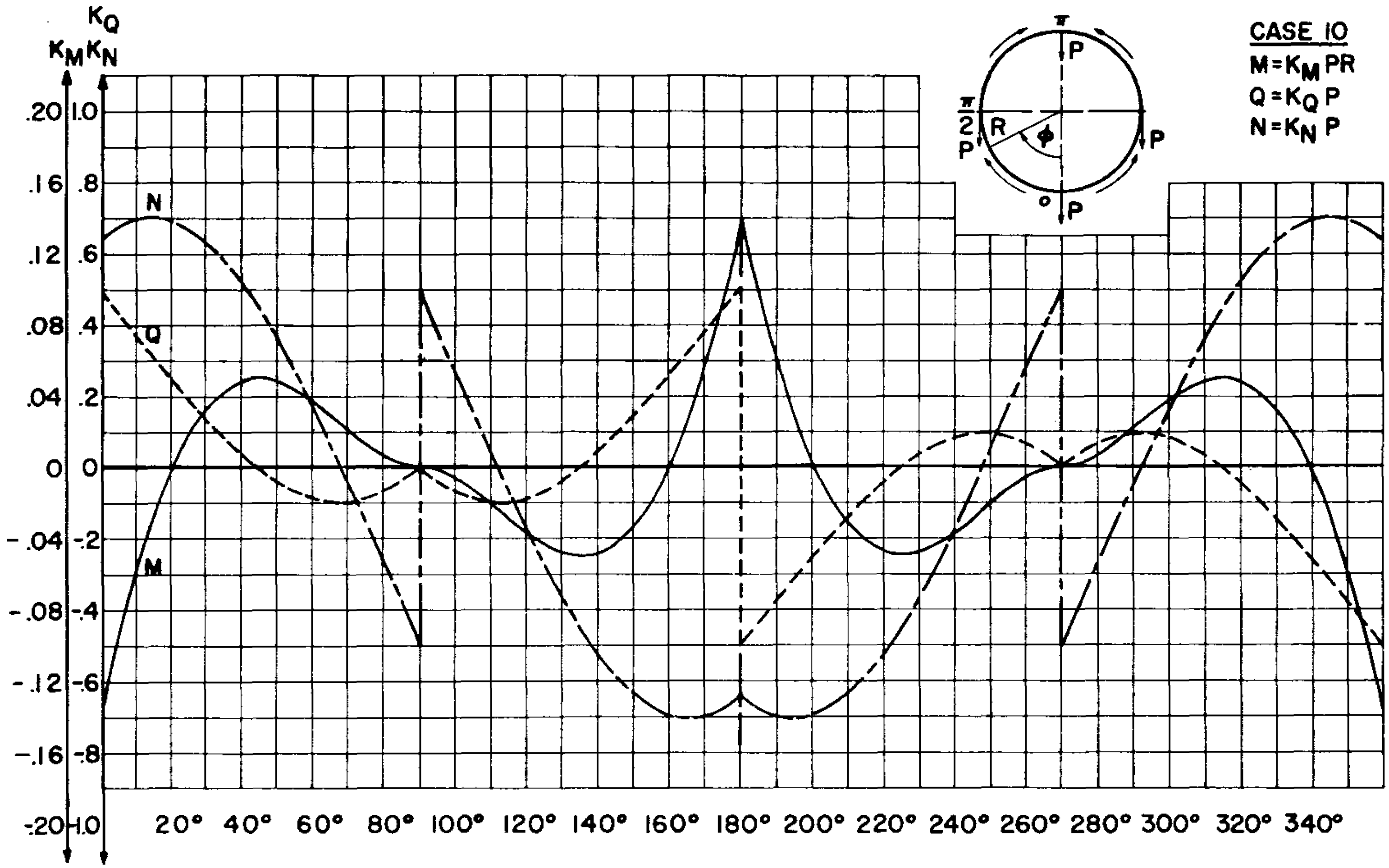
CASE 9

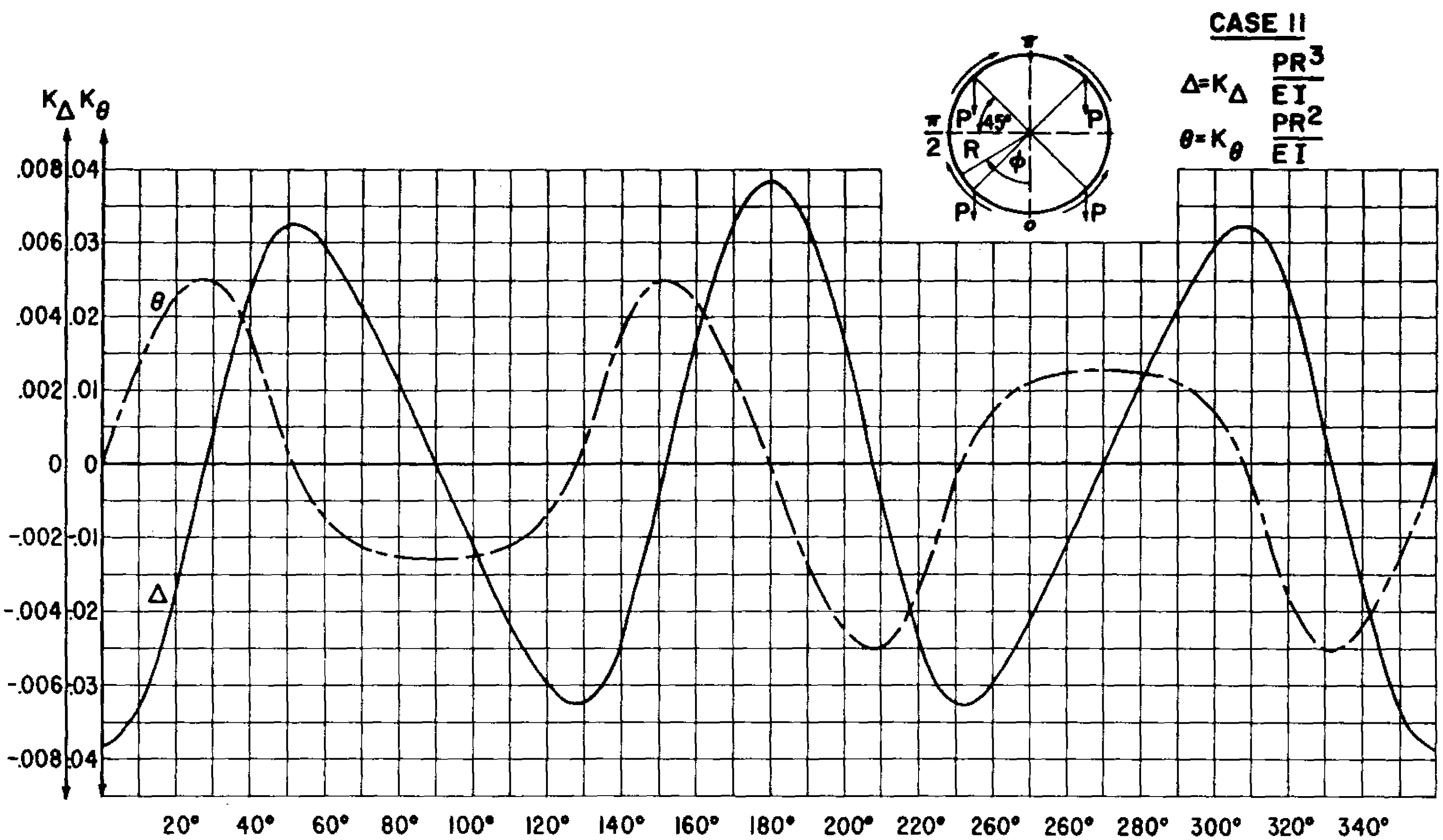


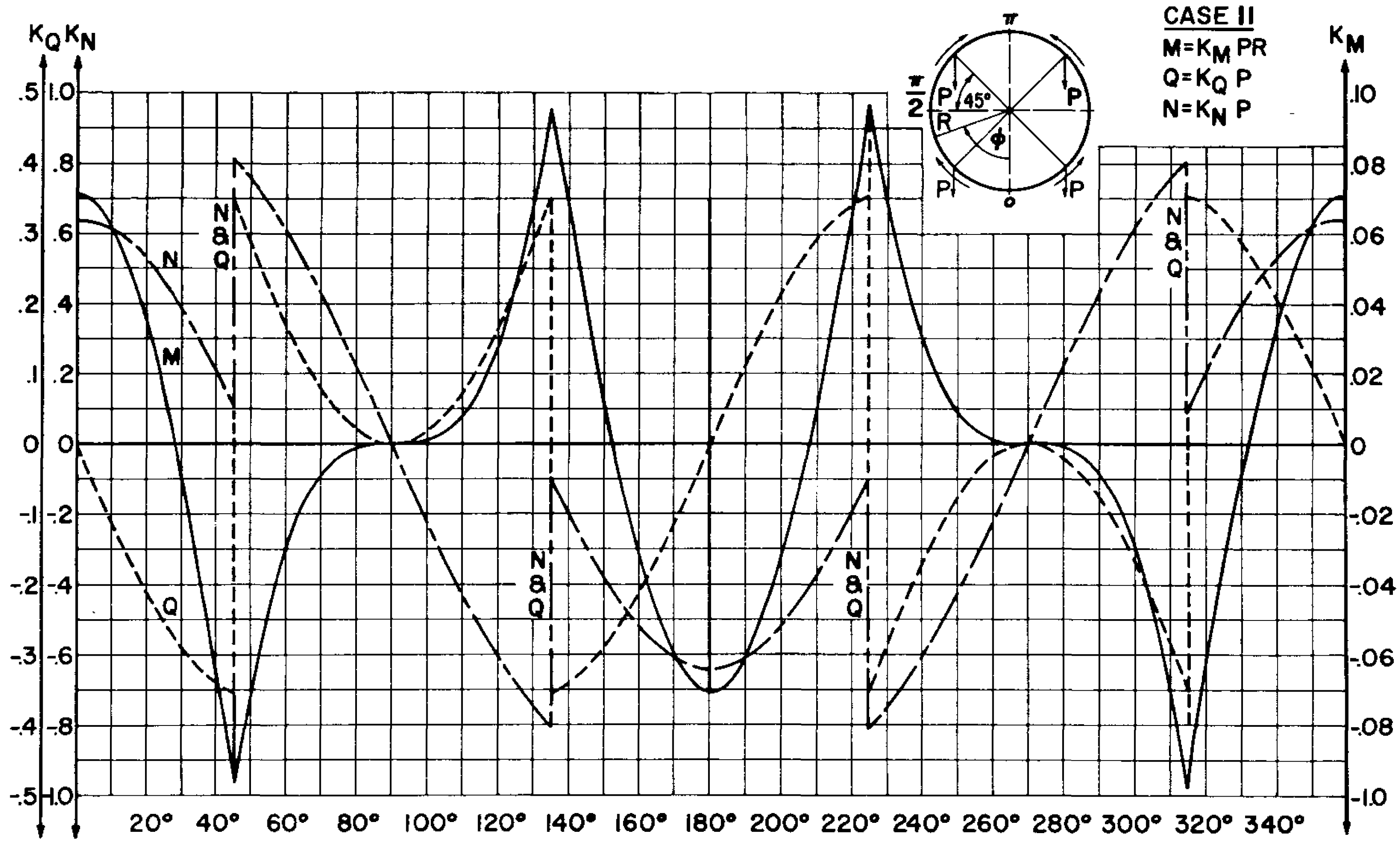
$\Delta = K_\Delta \frac{PR^3}{EI}$
$\theta = K_\theta \frac{PR^2}{EI}$
K_θ
K_Δ
.010
.008
.003 .006
.002 .004
.001 .002
0 0
-.001 -.002
-.002 -.004
-.003 -.006
-.008
-.010
θ
Δ
π
π/2
R
φ
P
P
0
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°


CASE 9
M = $K_M PR$
Q = $K_Q P$
N = $K_N P$
K_Q K_N
K_M
M
N
Q
P
P
R
ϕ
0
π
$\frac{\pi}{2}$
.20 .5
.16 .4
.12 .3
.08 .2
.04 .1
0 0
-.04 -.1
-.08 -.2
-.12 -.3
-.16 -.4
-.20 -.5
.03
.02
.01
0
-.01
-.02
-.03
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

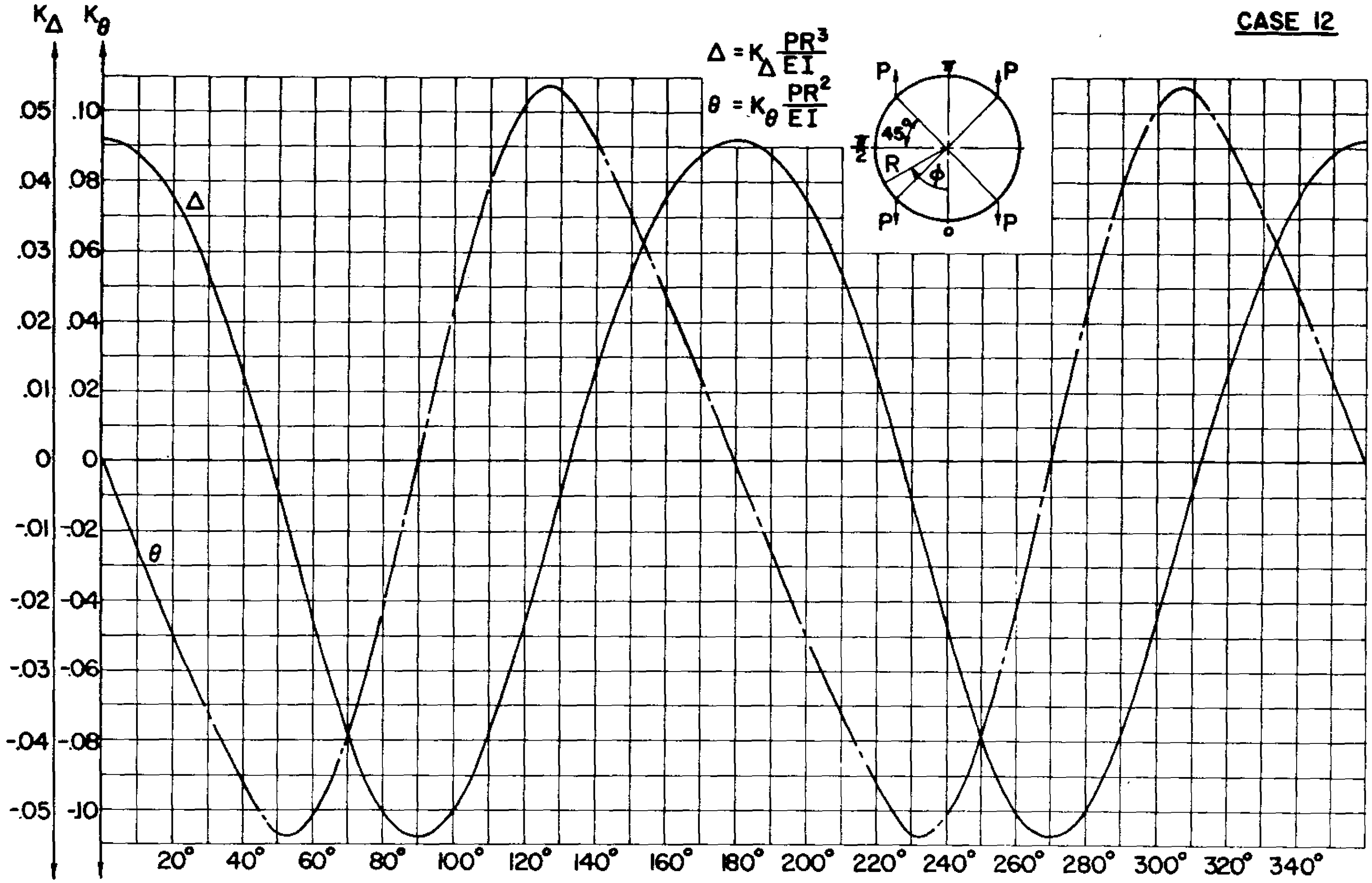

CASE 10
$\Delta = K_\Delta \frac{PR^3}{EI}$
$\theta = K_\theta \frac{PR^2}{EI}$
P
R
φ
0
$\frac{\pi}{2}$
K_Δ K_θ
Δ
θ
.008 .04
.006 .03
.004 .02
.002 .01
0 0
-.002 -.01
-.004 -.02
-.006 -.03
-.008 -.04
0° 20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340° 360°


CASE 10
M = K_M PR
Q = K_Q P
N = K_N P
K_Q
K_M K_N
.20 1.0
.16 .8
.12 .6
.08 .4
.04 .2
0 0
-.04 -.2
-.08 -.4
-.12 -.6
-.16 -.8
-.20 -1.0
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°
N
Q
M
π
P
π/2
R
φ
P
P
o
P


CASE II
Δ=K_Δ PR³/EI
θ=K_θ PR²/EI
π/2
P
45°
R
φ
o
K_Δ K_θ
.008 .04
.006 .03
.004 .02
.002 .01
0 0
-.002 -.01
-.004 -.02
-.006 -.03
-.008 -.04
θ
Δ
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 260° 260° 280° 300° 320° 340°

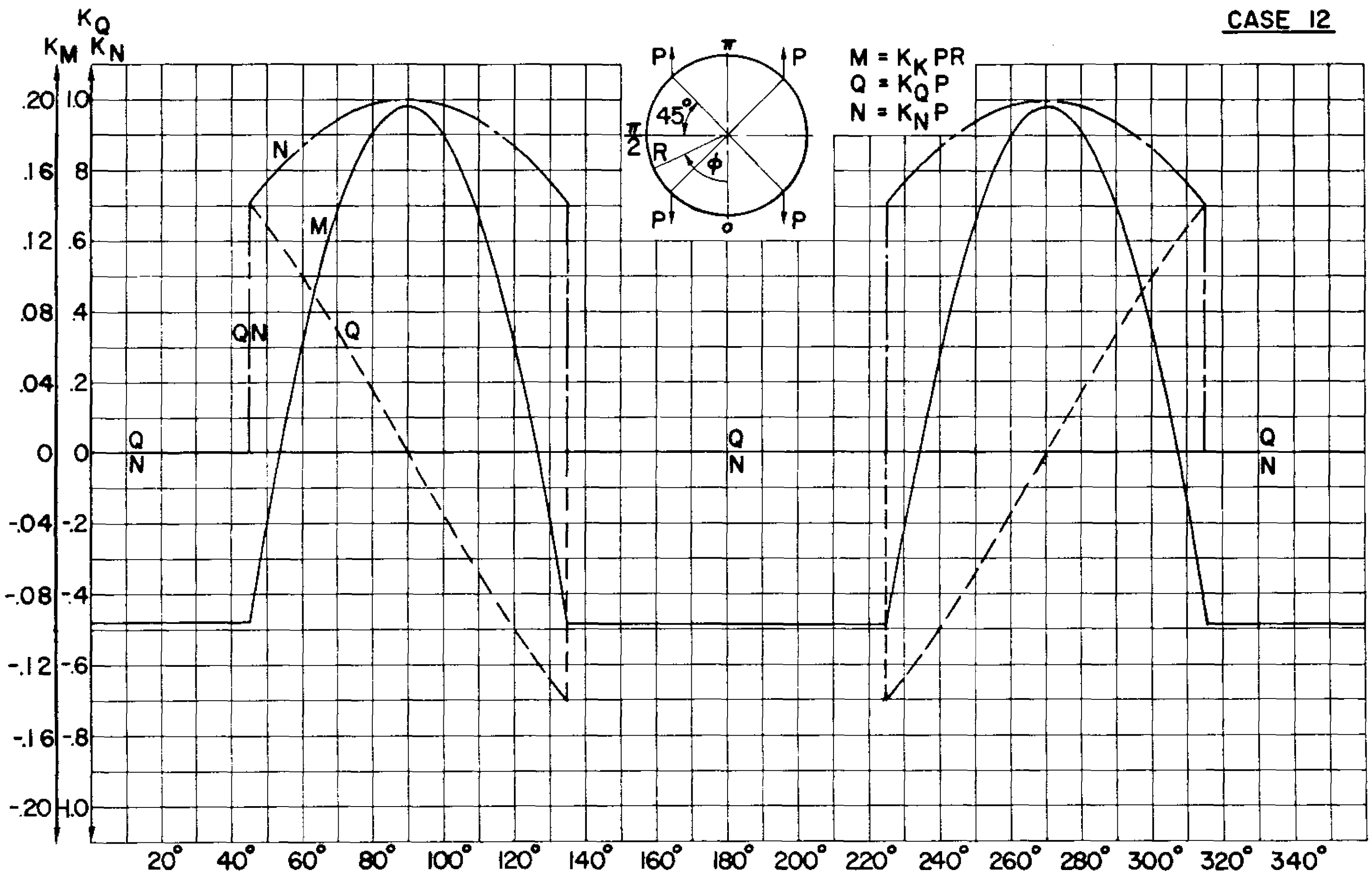

CASE II
M=K_M PR
Q=K_Q P
N=K_N P
K_Q K_N
K_M
N & Q
N
M
Q
P
R
45°
φ
π
π/2
o
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

CASE 12

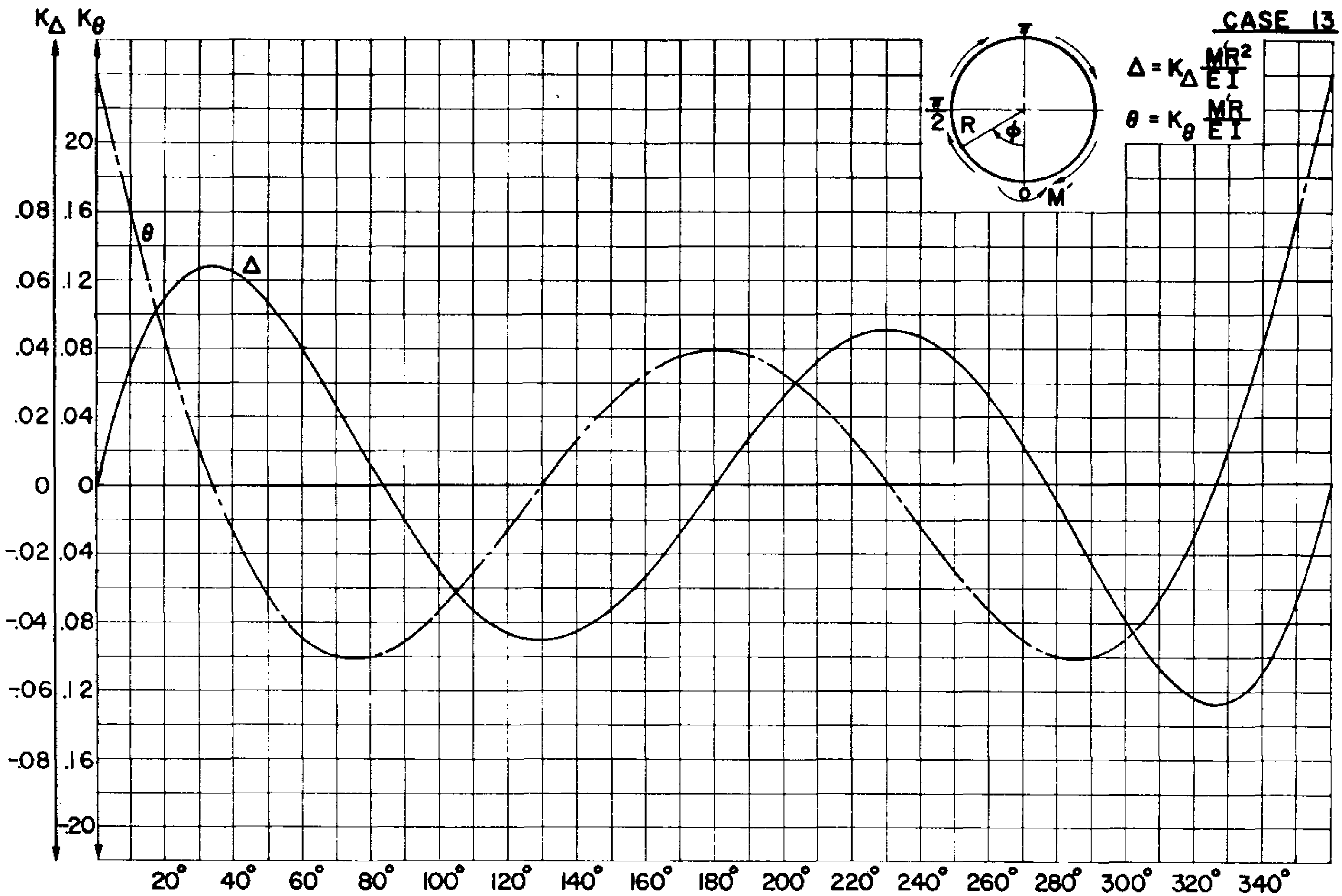


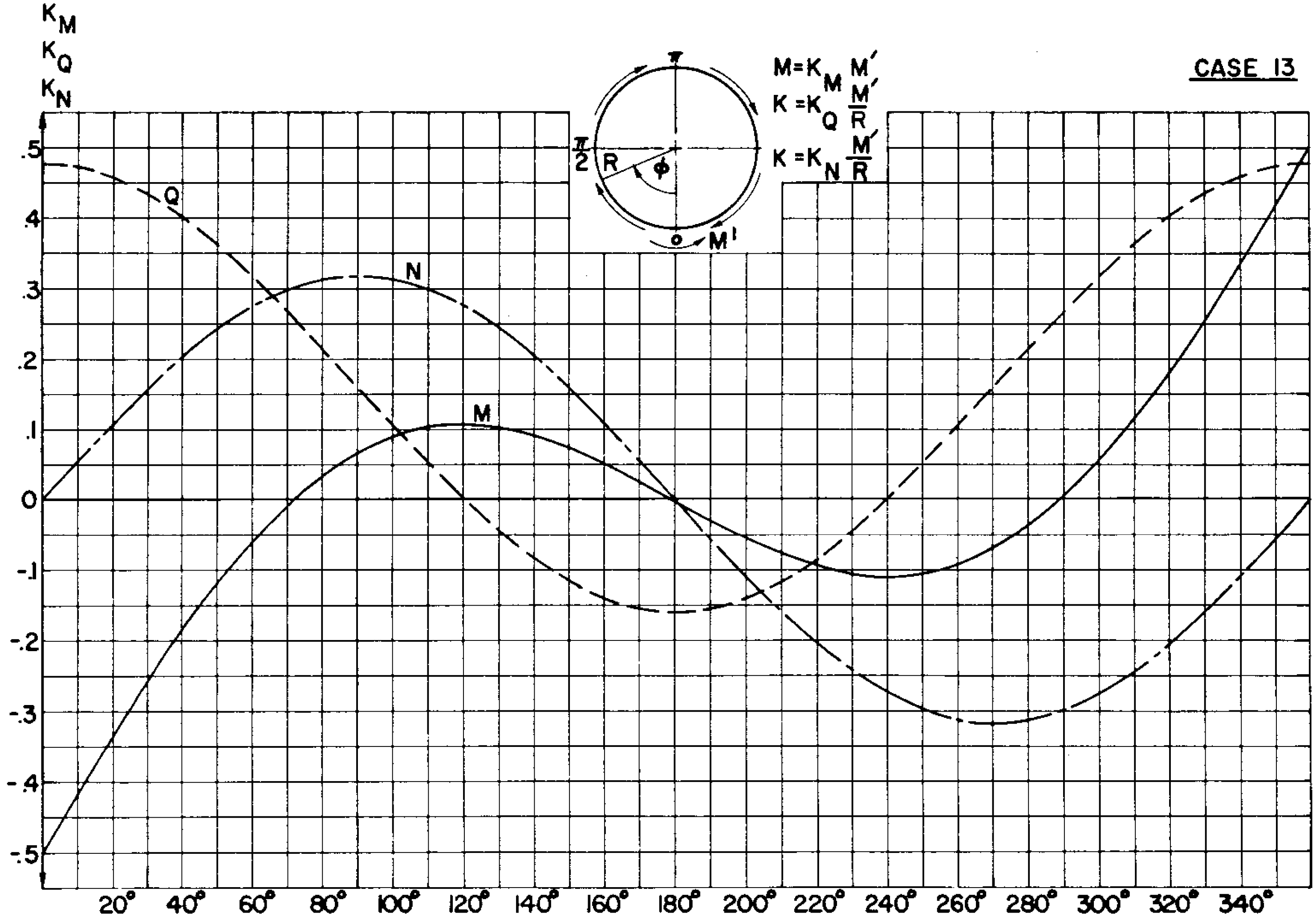
K_Δ K_θ
$\Delta = K_\Delta \frac{PR^3}{EI}$
$\theta = K_\theta \frac{PR^2}{EI}$
P
P
P
P
45°
R
ϕ
$\frac{\pi}{2}$
π
0
Δ
θ
.05 .10
.04 .08
.03 .06
.02 .04
.01 .02
0 0
-.01 -.02
-.02 -.04
-.03 -.06
-.04 -.08
-.05 -.10
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

CASE 12

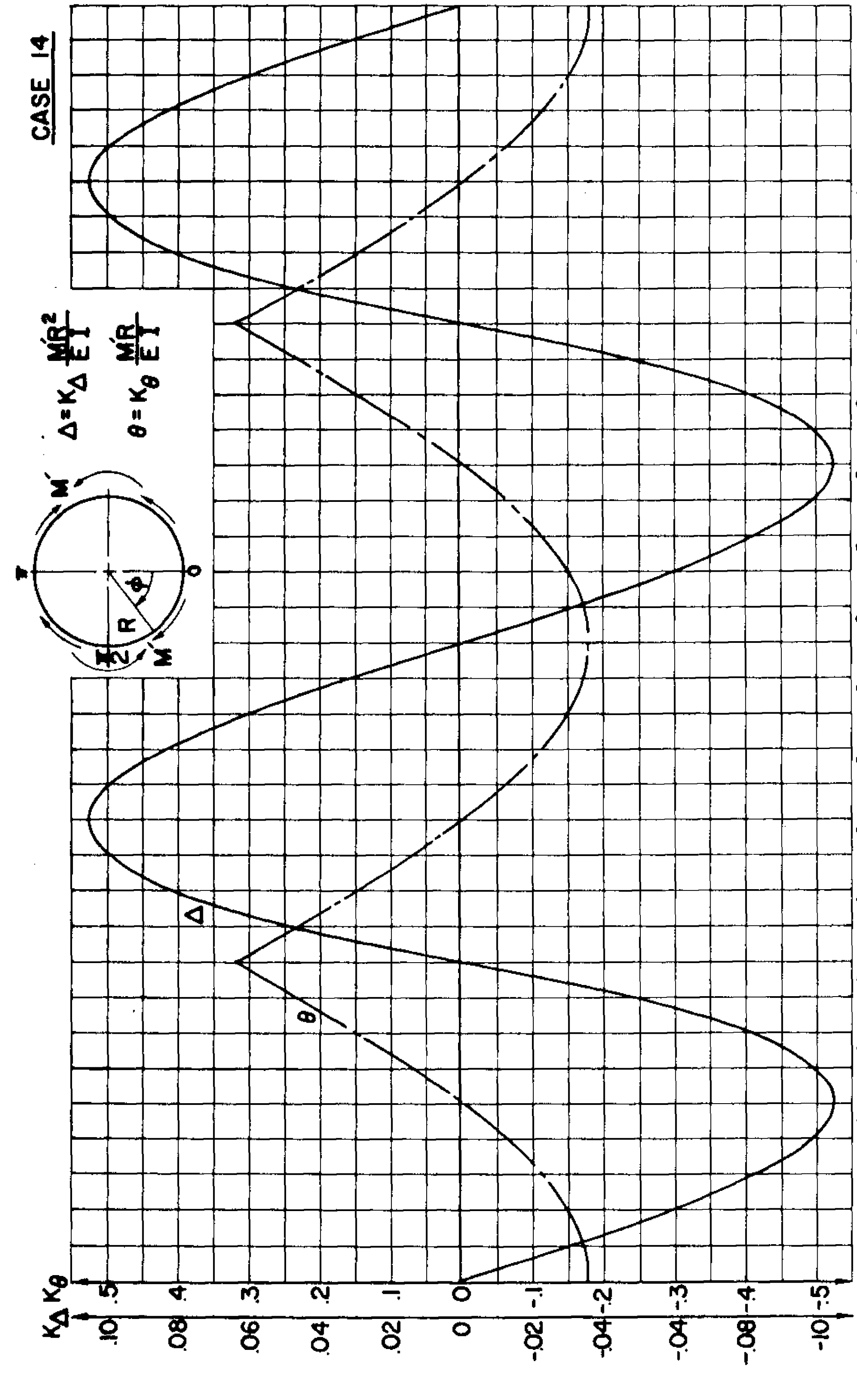


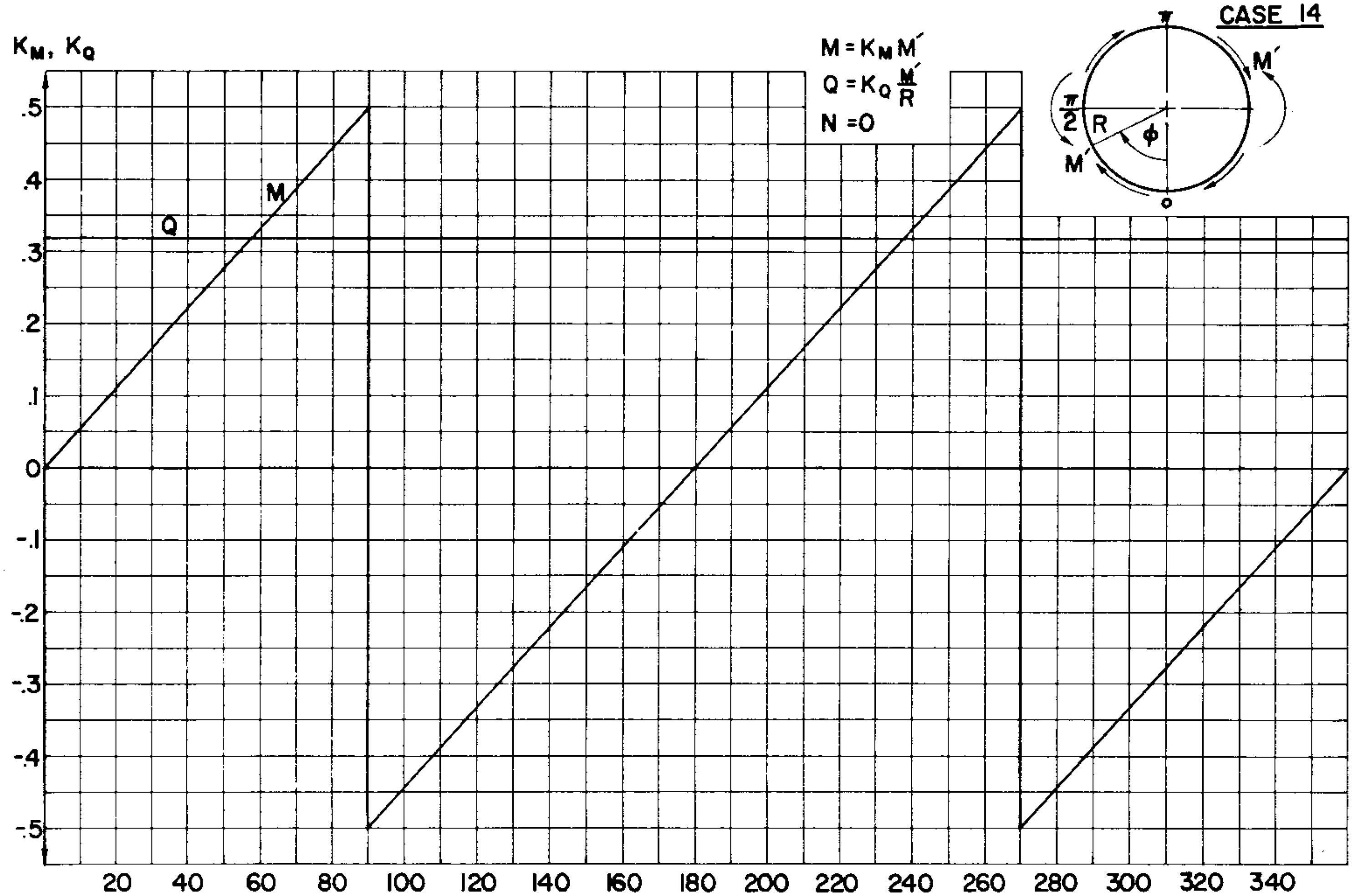
K_M
K_Q
K_N
M = K_K PR
Q = K_Q P
N = K_N P
P
π
π/2
45°
R
φ
o
N
M
Q
QN
Q N
.20 .16 .12 .08 .04 0 -.04 -.08 -.12 -.16 -.20
1.0 8 .6 .4 .2 0 -.2 -.4 -.6 -.8 1.0
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°


CASE 13
$\Delta = K_\Delta \frac{MR^2}{EI}$
$\theta = K_\theta \frac{MR}{EI}$
K_Δ K_θ
θ
Δ
R
φ
M
π/2
π
0
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°
.08 .16
.06 .12
.04 .08
.02 .04
0 0
-.02 .04
-.04 .08
-.06 .12
-.08 .16
20
-20

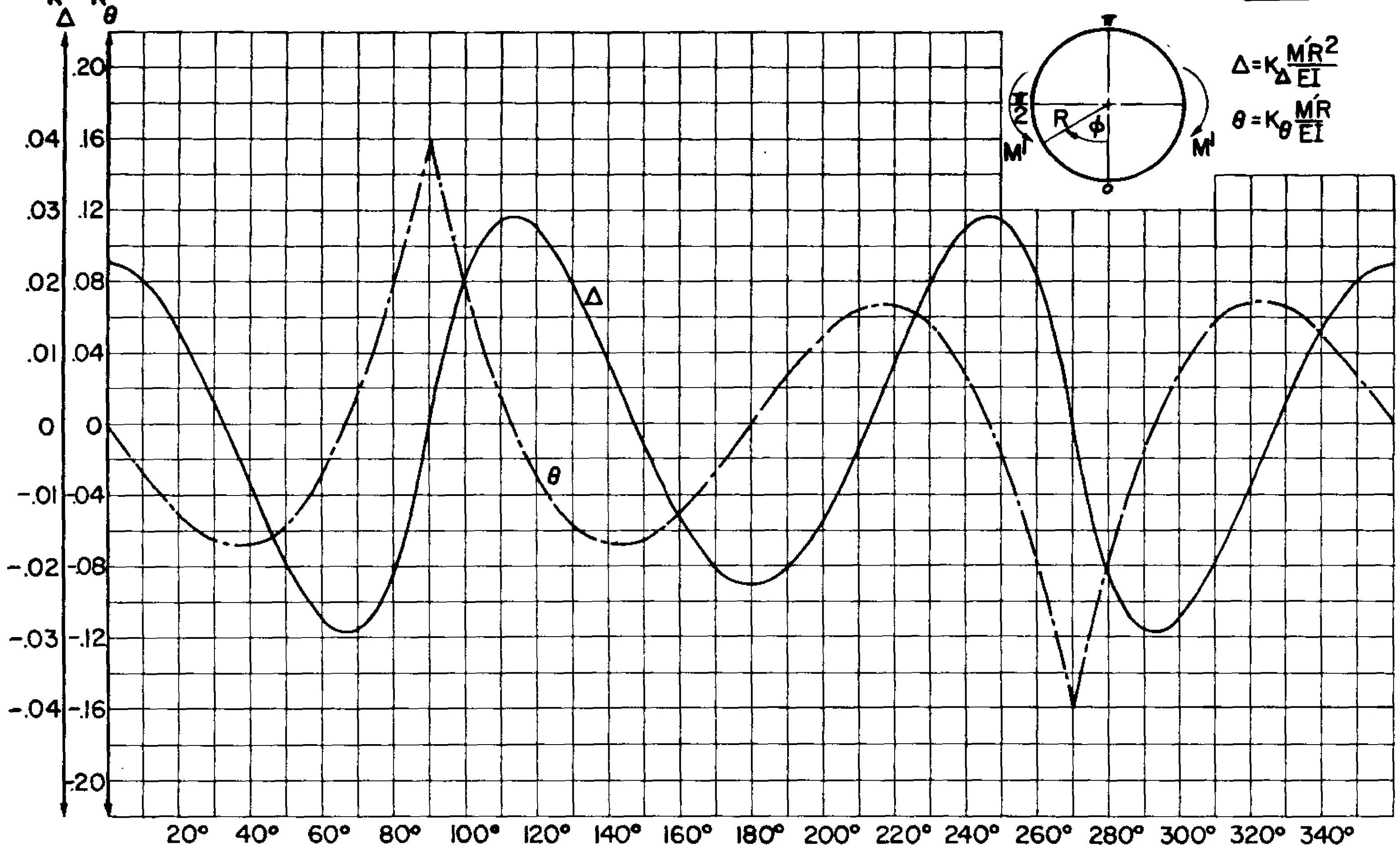

CASE 13
K_M
K_Q
K_N
M=K_M M′
K =K_Q M′/R
K =K_N M′/R
π/2
R
φ
π
o
M′
Q
N
M
.5
.4
.3
.2
.1
0
-.1
-.2
-.3
-.4
-.5
20°
40°
60°
80°
100°
120°
140°
160°
180°
200°
220°
240°
260°
280°
300°
320°
340°

B 6.1.1 In-Plane Load Cases (Cont'd)




CASE 14
$M = K_M M'$
$Q = K_Q \frac{M'}{R}$
N = 0
K_M, K_Q
M
Q
M'
R
φ
π/2
π
0
.5
.4
.3
.2
.1
0
-.1
-.2
-.3
-.4
-.5
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340

CASE 15

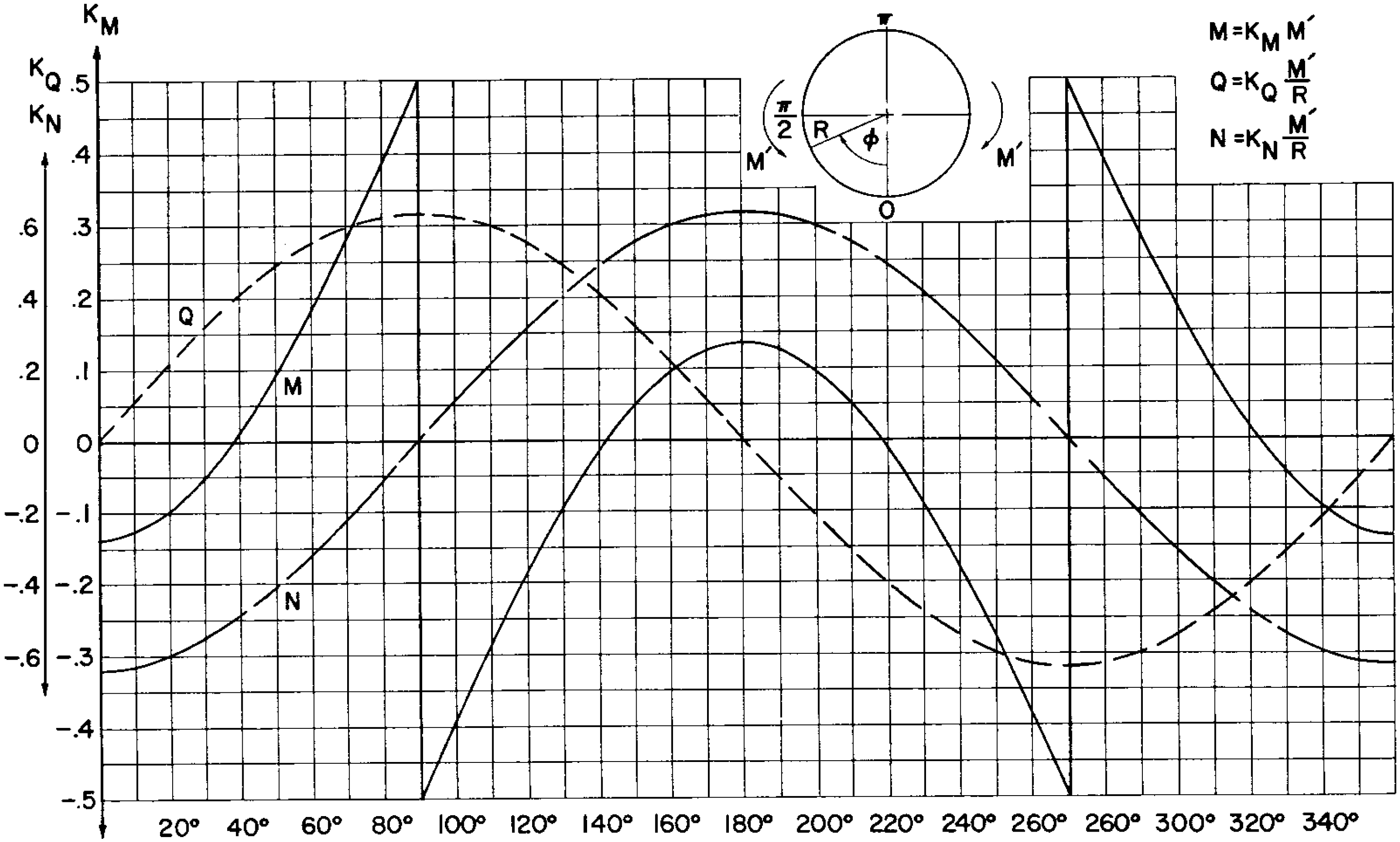

K_Δ K_θ
.20
.04 .16
.03 .12
.02 .08
.01 .04
0 0
-.01 -.04
-.02 -.08
-.03 -.12
-.04 -.16
-.20
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°
Δ
θ
π/2
R
φ
M'
M'
Δ = K_Δ M'R²/EI
θ = K_θ M'R/EI

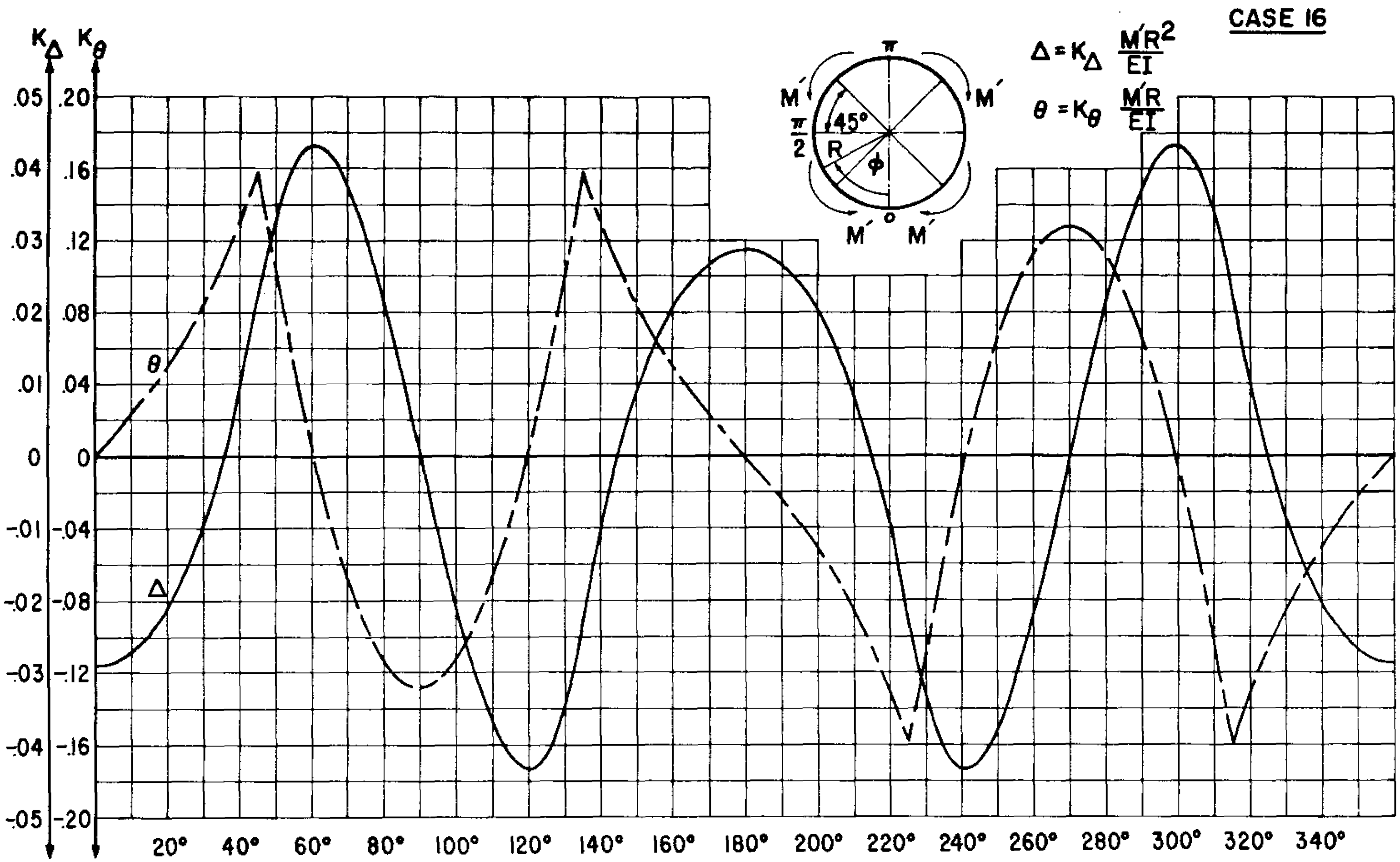
CASE 15

$M = K_M M'$

$Q = K_Q \frac{M'}{R}$

$N = K_N \frac{M'}{R}$



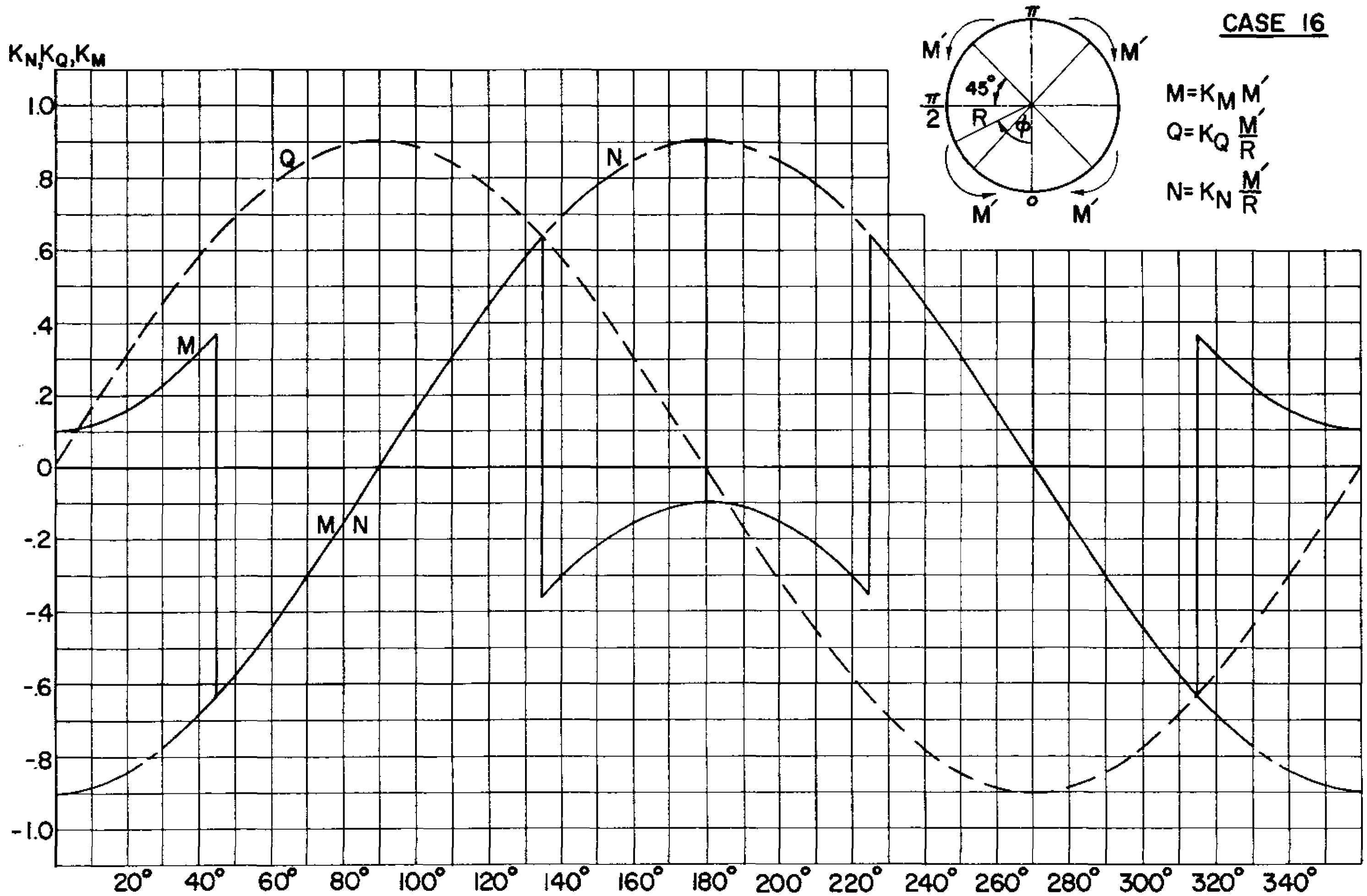

CASE 16
$\Delta = K_\Delta \frac{M'R^2}{EI}$
$\theta = K_\theta \frac{M'R}{EI}$
K_Δ
K_θ
M'
π
π/2
45°
R
φ
o
θ
Δ
.05 .20
.04 .16
.03 .12
.02 .08
.01 .04
0 0
-.01 -.04
-.02 -.08
-.03 -.12
-.04 -.16
-.05 -.20
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

CASE 16

$M = K_M M'$

$Q = K_Q \frac{M'}{R}$

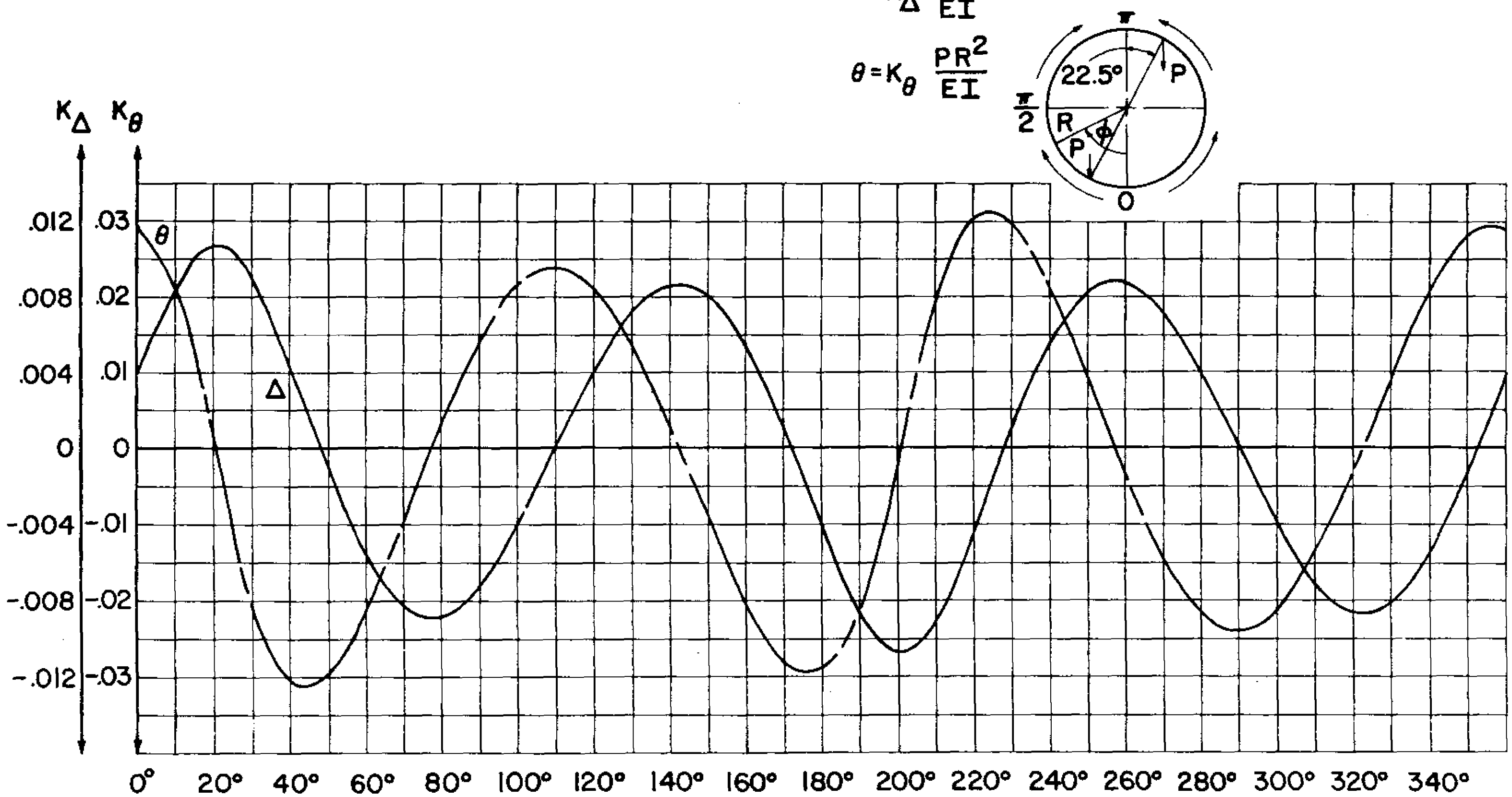
$N = K_N \frac{M'}{R}$

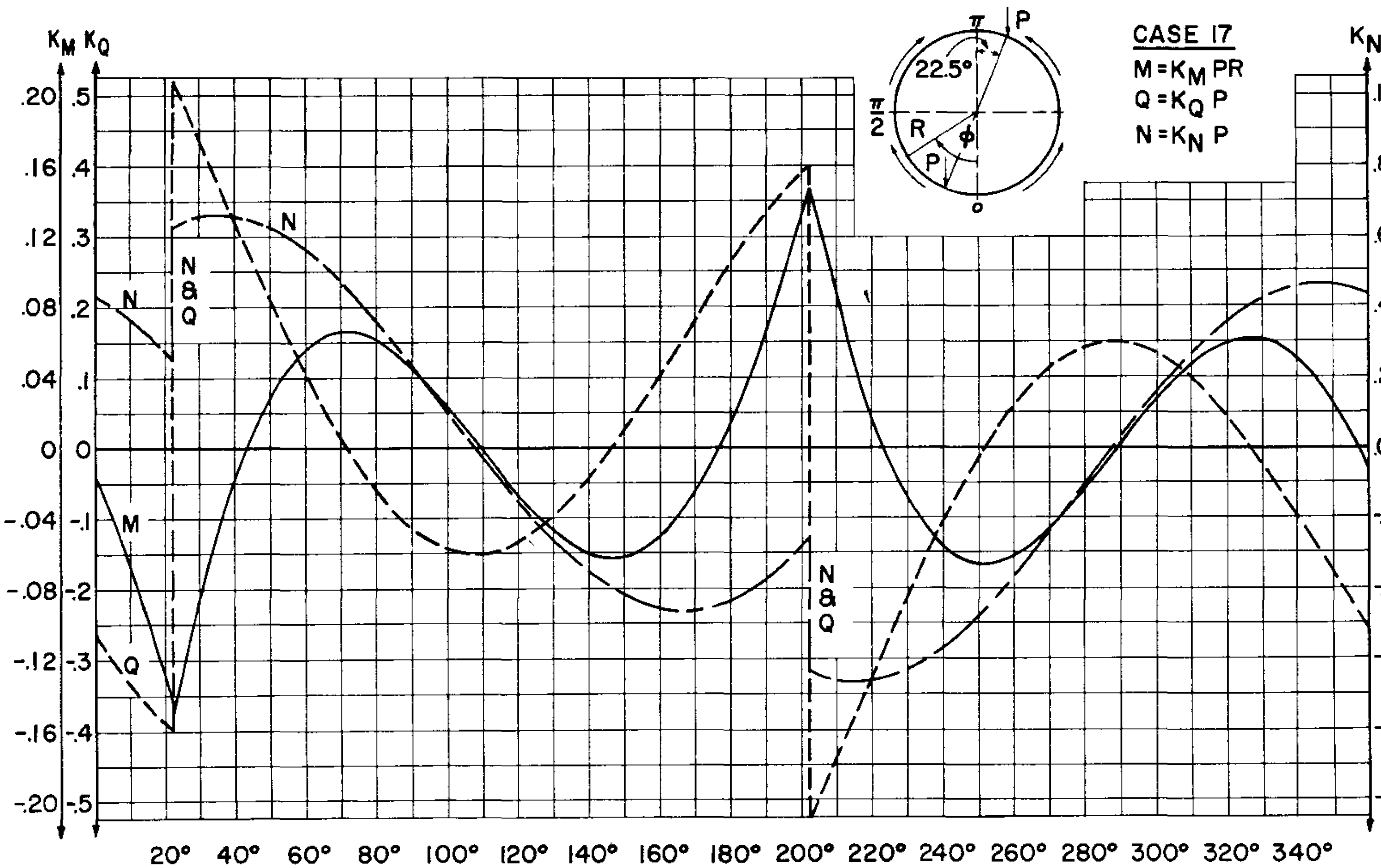


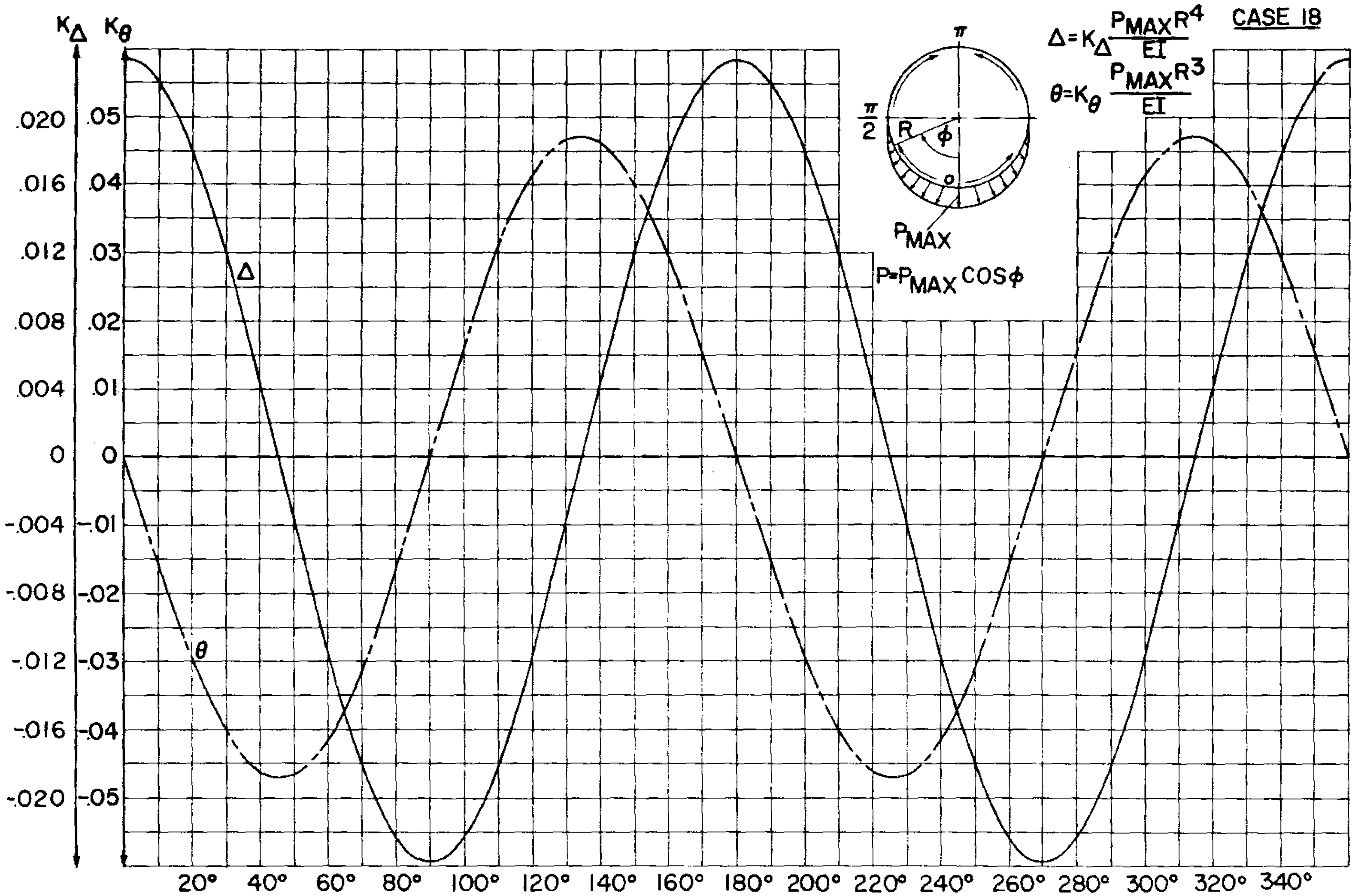
CASE 17

$$\Delta = K_\Delta \frac{PR^3}{EI}$$

$$\theta = K_\theta \frac{PR^2}{EI}$$

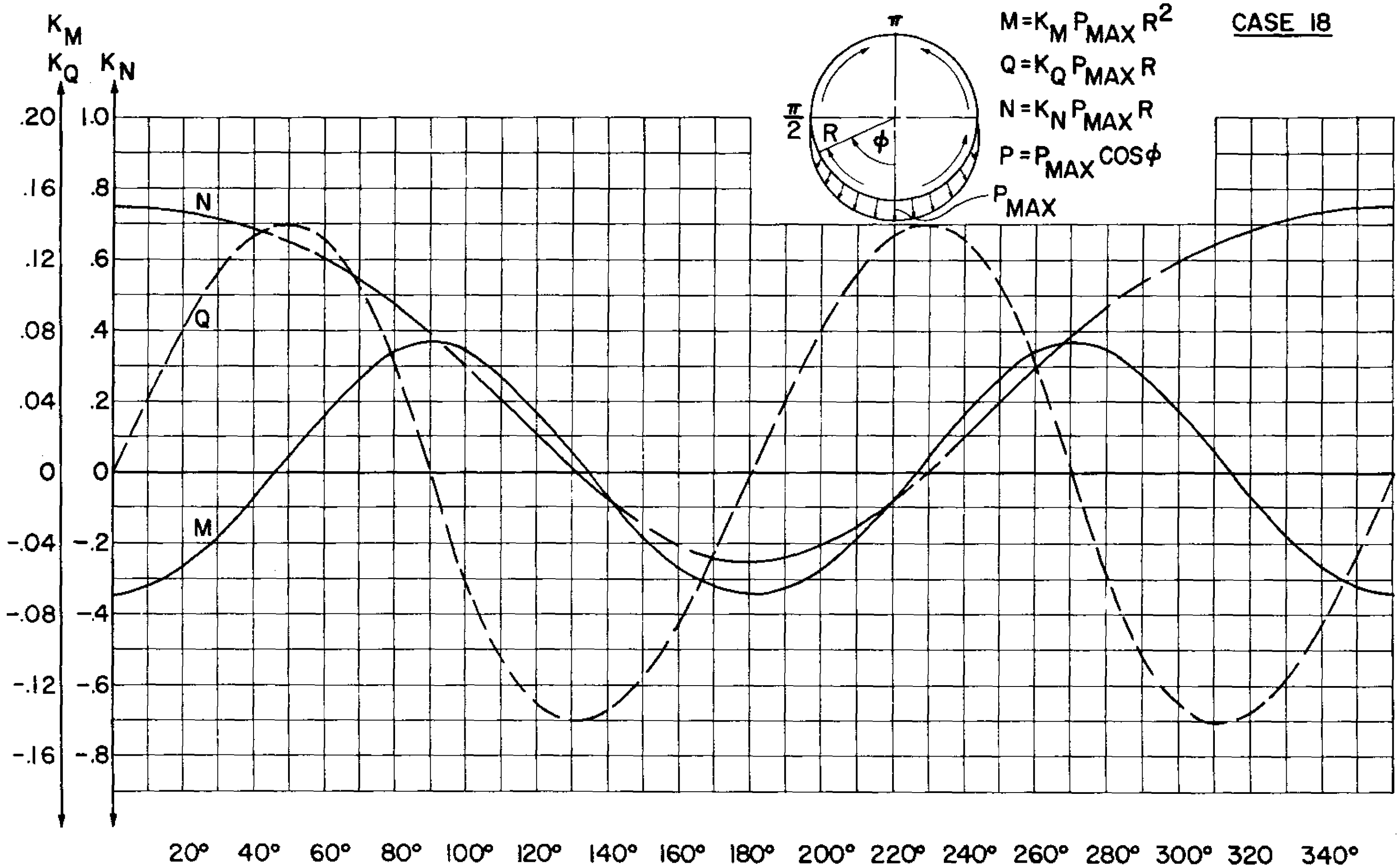



CASE 17
M = K_M PR
Q = K_Q P
N = K_N P
22.5°
π
P
π/2
R
φ
P
o
K_M K_Q
K_N
N
N & Q
M
Q
.20 .5
.16 .4
.12 .3
.08 .2
.04 .1
0 0
-.04 -.1
-.08 -.2
-.12 -.3
-.16 -.4
-.20 -.5
.10
.8
.6
.4
.2
.0
-.2
-.4
-.6
-.8
-.10
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

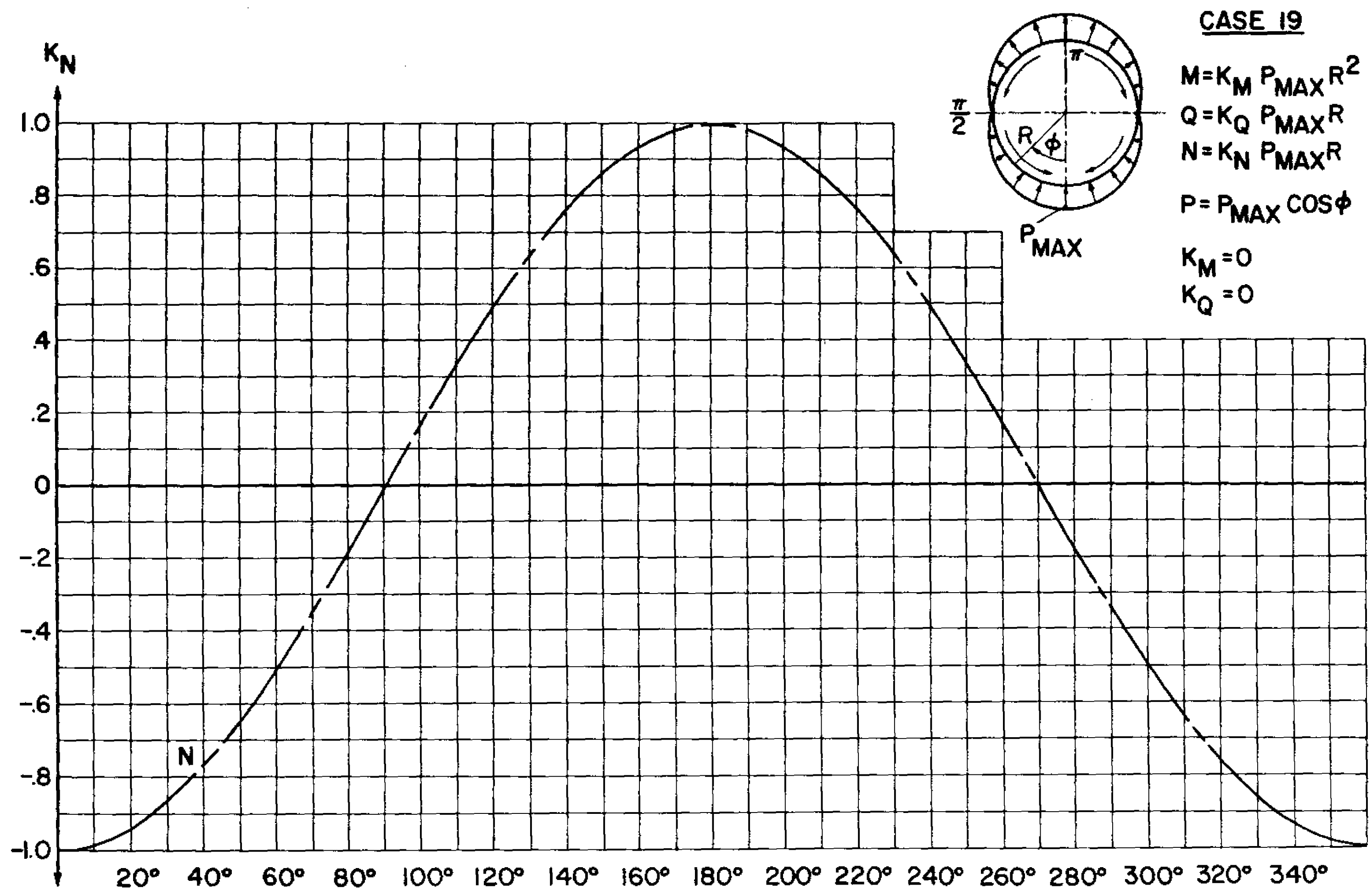


CASE 18
Δ=K_Δ P_MAX R^4 / EI
θ=K_θ P_MAX R^3 / EI
P=P_MAX COSφ
P_MAX
π
π/2
R
φ
o
K_Δ
K_θ
Δ
θ
.020 .05
.016 .04
.012 .03
.008 .02
.004 .01
0 0
-.004 -.01
-.008 -.02
-.012 -.03
-.016 -.04
-.020 -.05
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

CASE 18



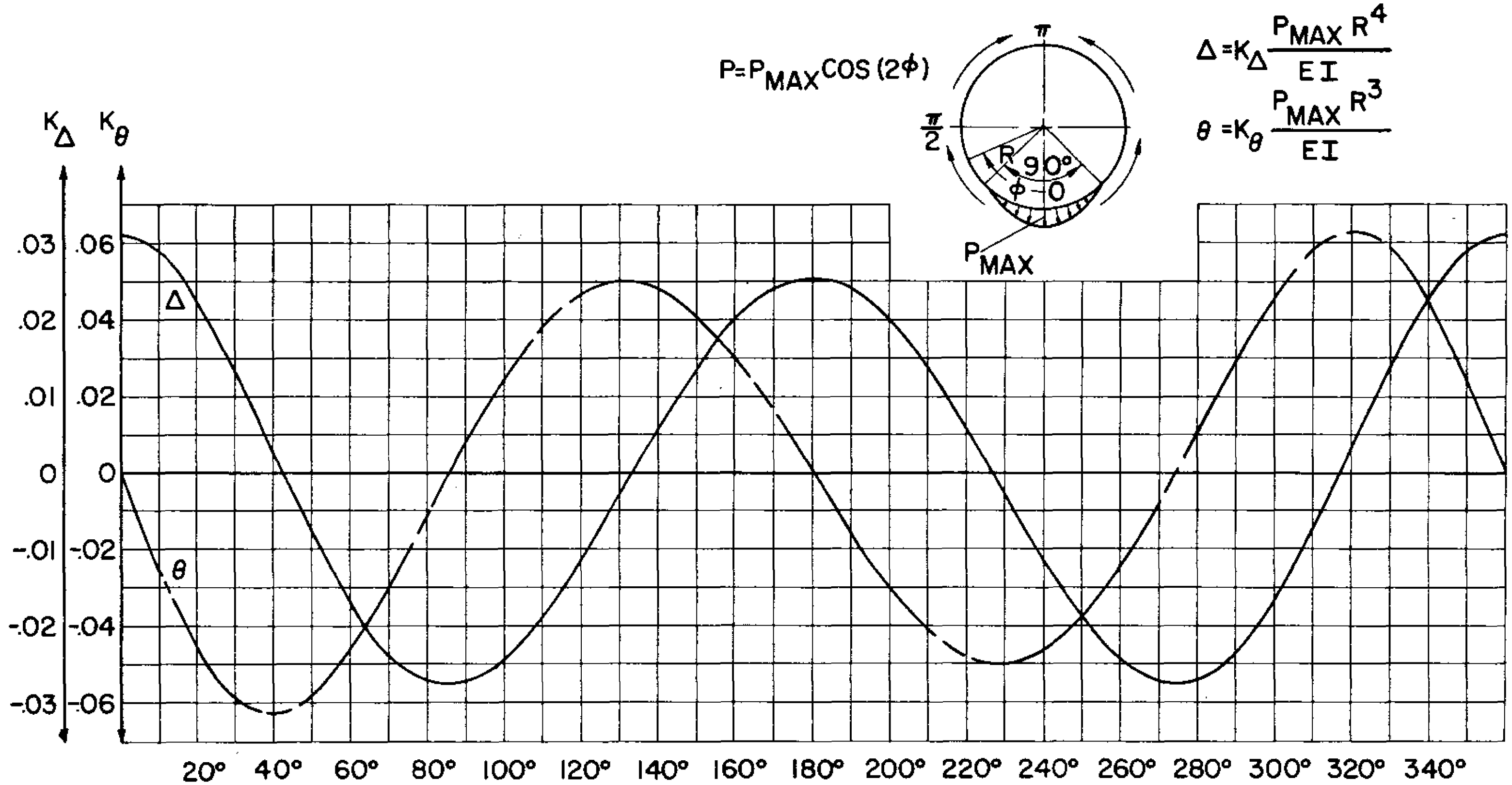
$M = K_M P_{MAX} R^2$
$Q = K_Q P_{MAX} R$
$N = K_N P_{MAX} R$
$P = P_{MAX} \cos\phi$
π
$\frac{\pi}{2}$
R
ϕ
P_{MAX}
K_M
K_Q
K_N
N
Q
M
.20 .16 .12 .08 .04 0 -.04 -.08 -.12 -.16
1.0 .8 .6 .4 .2 0 -.2 -.4 -.6 -.8
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320 340°

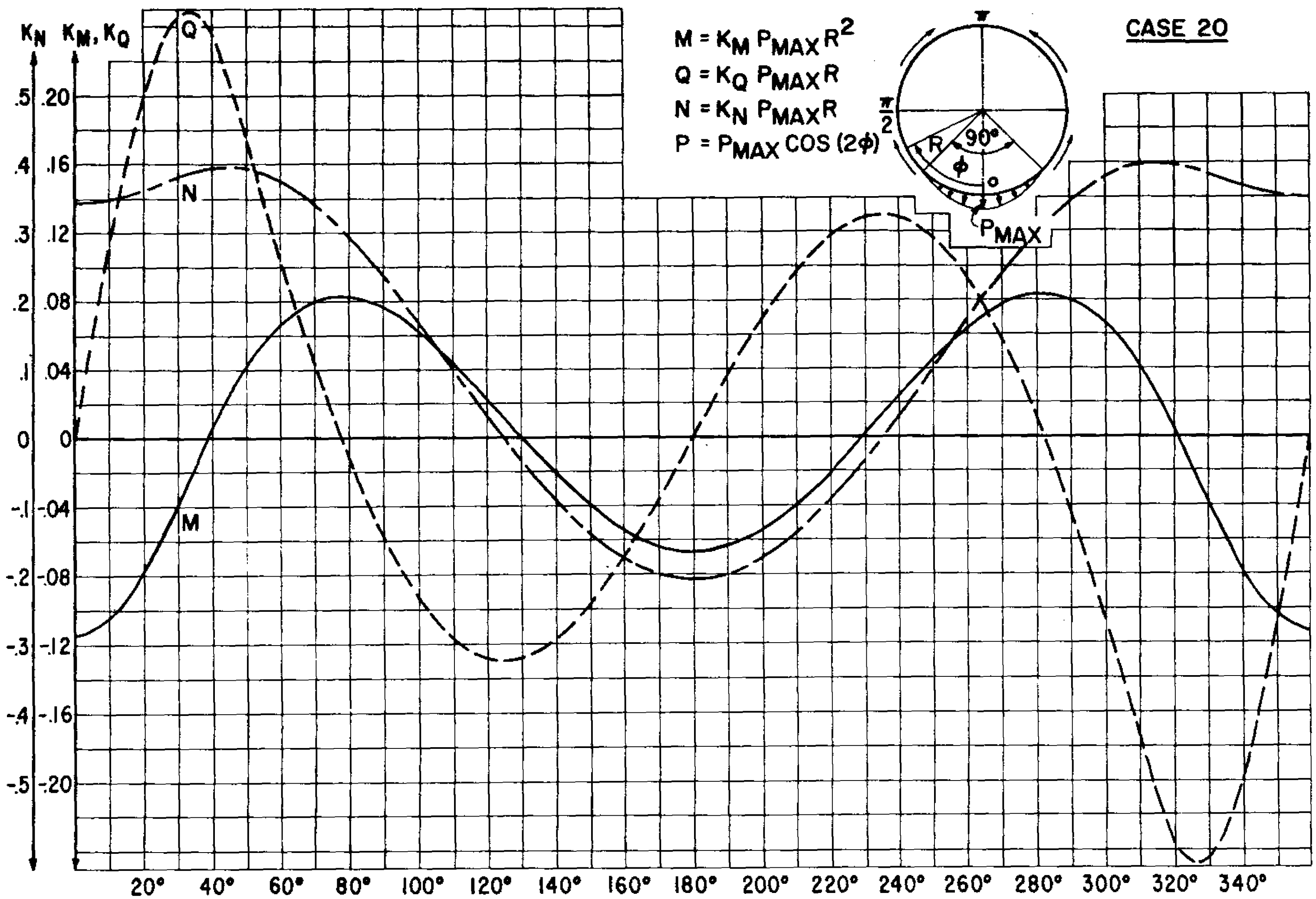

CASE 19
M=K_M P_MAX R^2
Q=K_Q P_MAX R
N=K_N P_MAX R
P=P_MAX COSϕ
K_M=0
K_Q=0
π
π/2
R
ϕ
P_MAX
K_N
1.0
.8
.6
.4
.2
0
-.2
-.4
-.6
-.8
-1.0
N
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

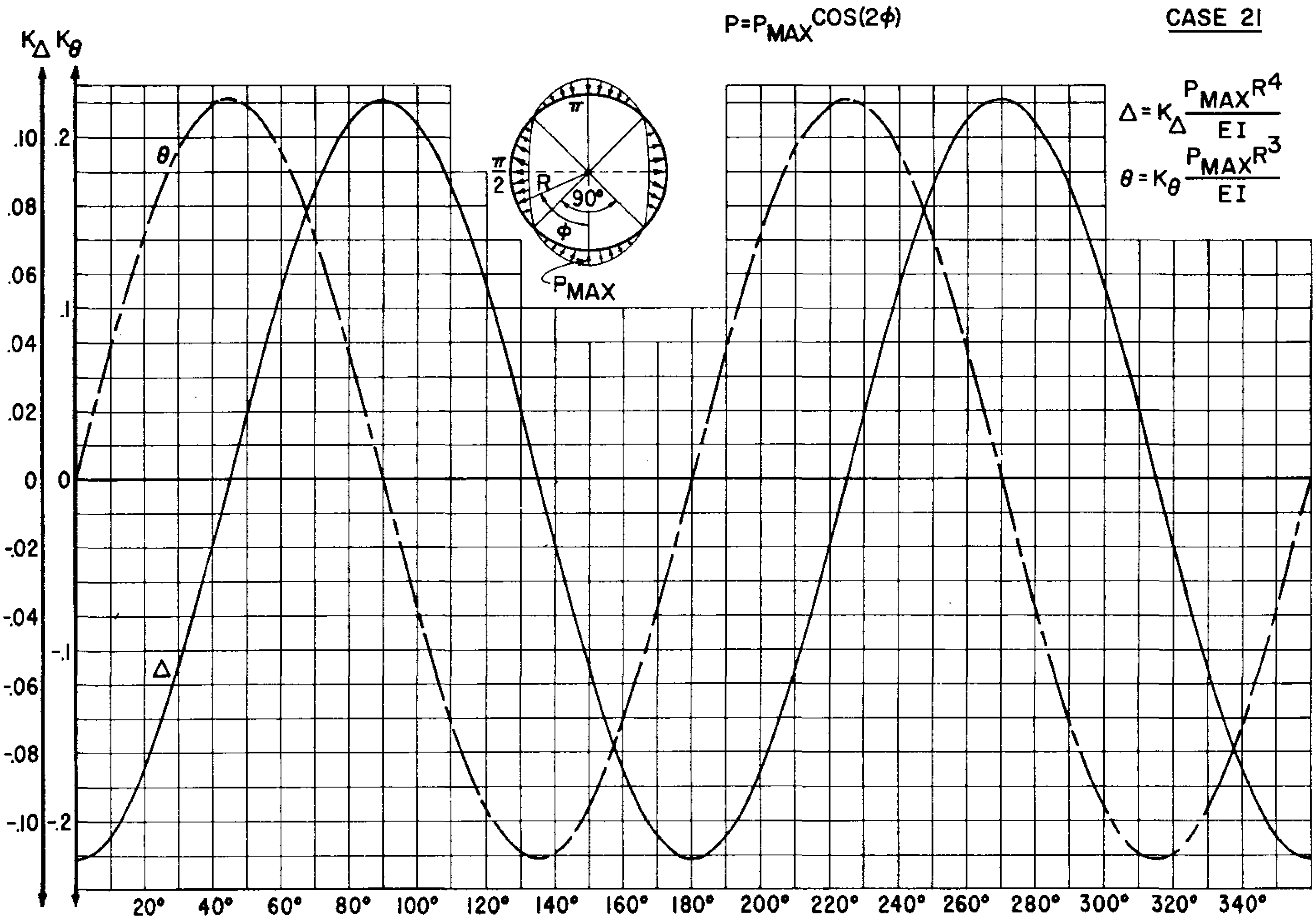
CASE 20

$$\Delta = K_\Delta \frac{P_{MAX} R^4}{EI}$$

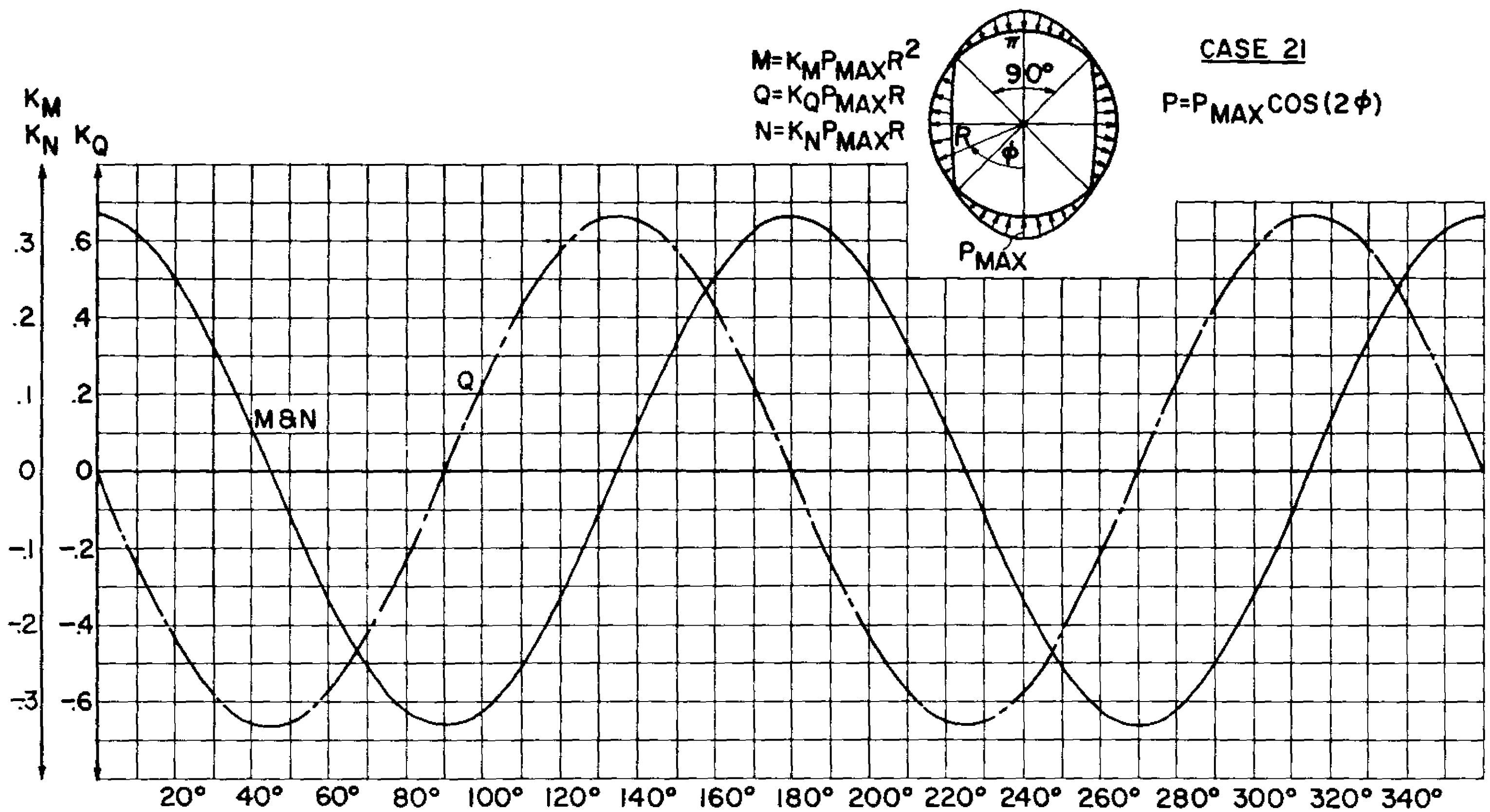
$$\theta = K_\theta \frac{P_{MAX} R^3}{EI}$$



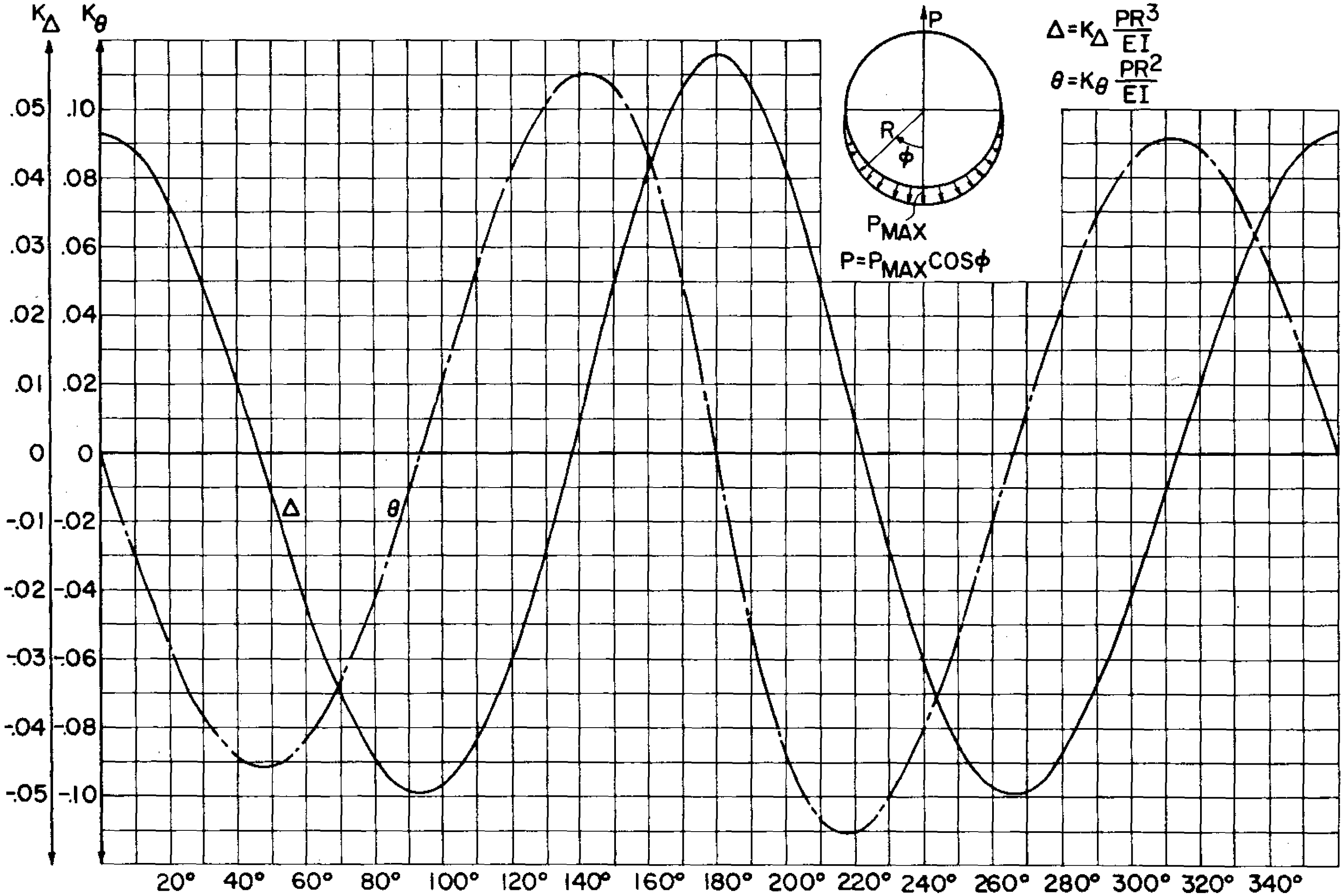

CASE 20
M = K_M P_MAX R^2
Q = K_Q P_MAX R
N = K_N P_MAX R
P = P_MAX COS (2φ)
π
π/2
R
90°
φ
o
P_MAX
K_N
K_M, K_Q
Q
N
M
.5 .20
.4 .16
.3 .12
.2 .08
.1 .04
0 0
-.1 -.04
-.2 -.08
-.3 -.12
-.4 -.16
-.5 -.20
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°



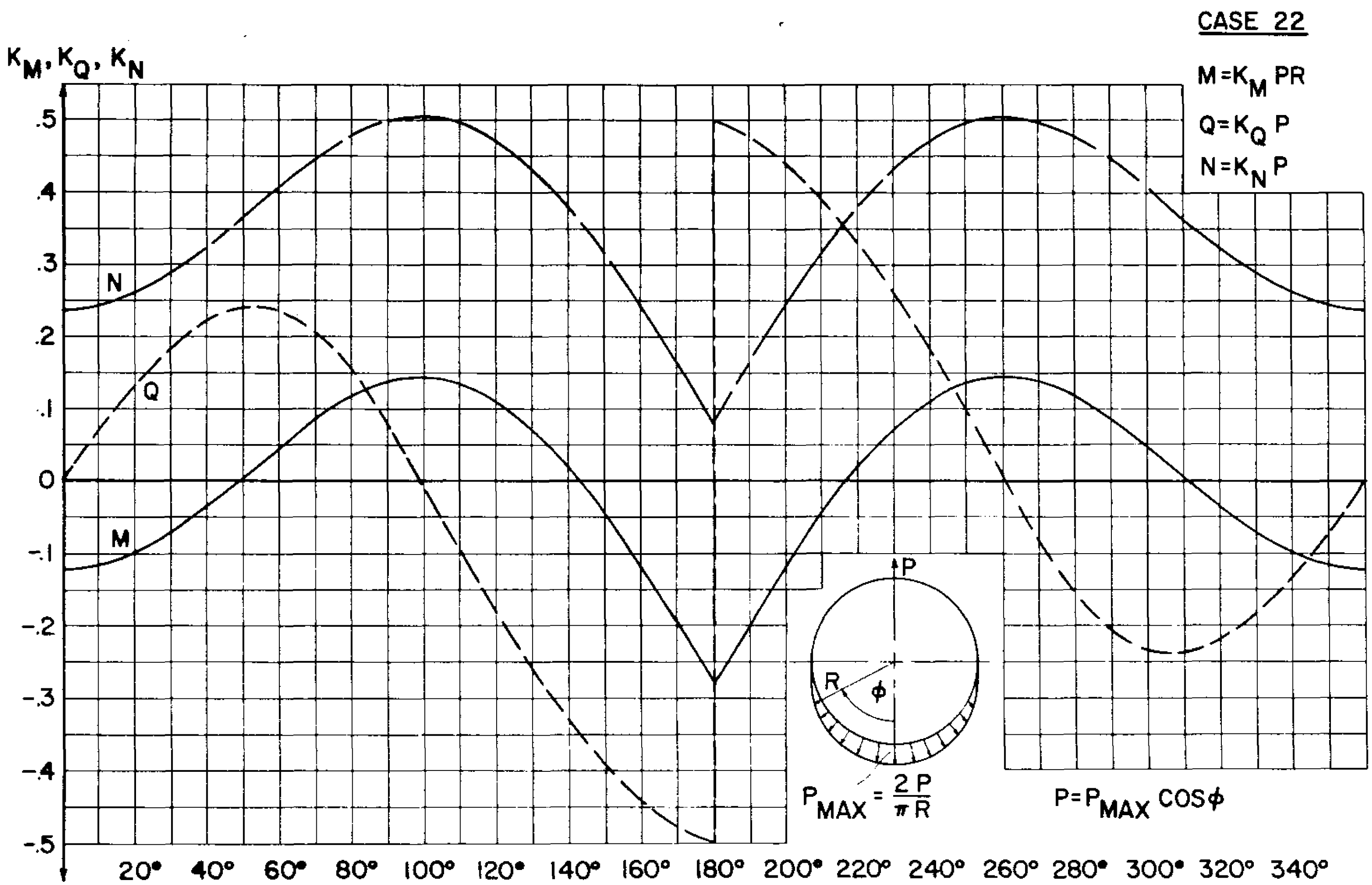
P=P MAX COS(2φ)
CASE 21
Δ = K_Δ P_MAX R^4 / EI
θ = K_θ P_MAX R^3 / EI
K_Δ K_θ
.10 .2
.08
.06
.1
.04
.02
0 0
-.02
-.04
-.1
-.06
-.08
-.10 -.2
θ
Δ
π
π/2
R
90°
φ
P MAX
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

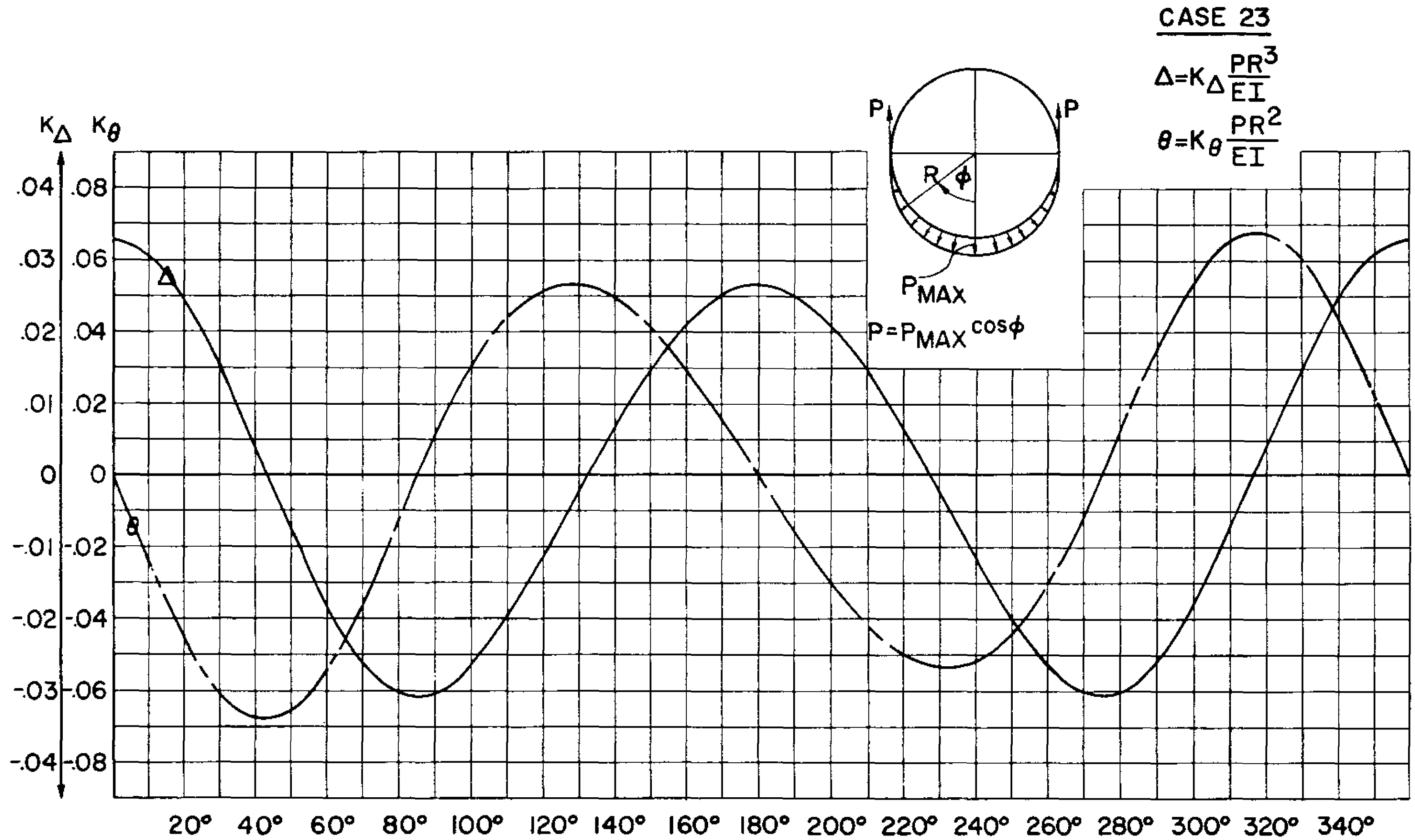

CASE 21
P=P_MAX COS(2φ)
M=K_M P_MAX R^2
Q=K_Q P_MAX R
N=K_N P_MAX R
90°
R
φ
P_MAX
K_M
K_N
K_Q
M&N
Q
.3 .6
.2 .4
.1 .2
0 0
-.1 -.2
-.2 -.4
-.3 -.6
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

CASE 22

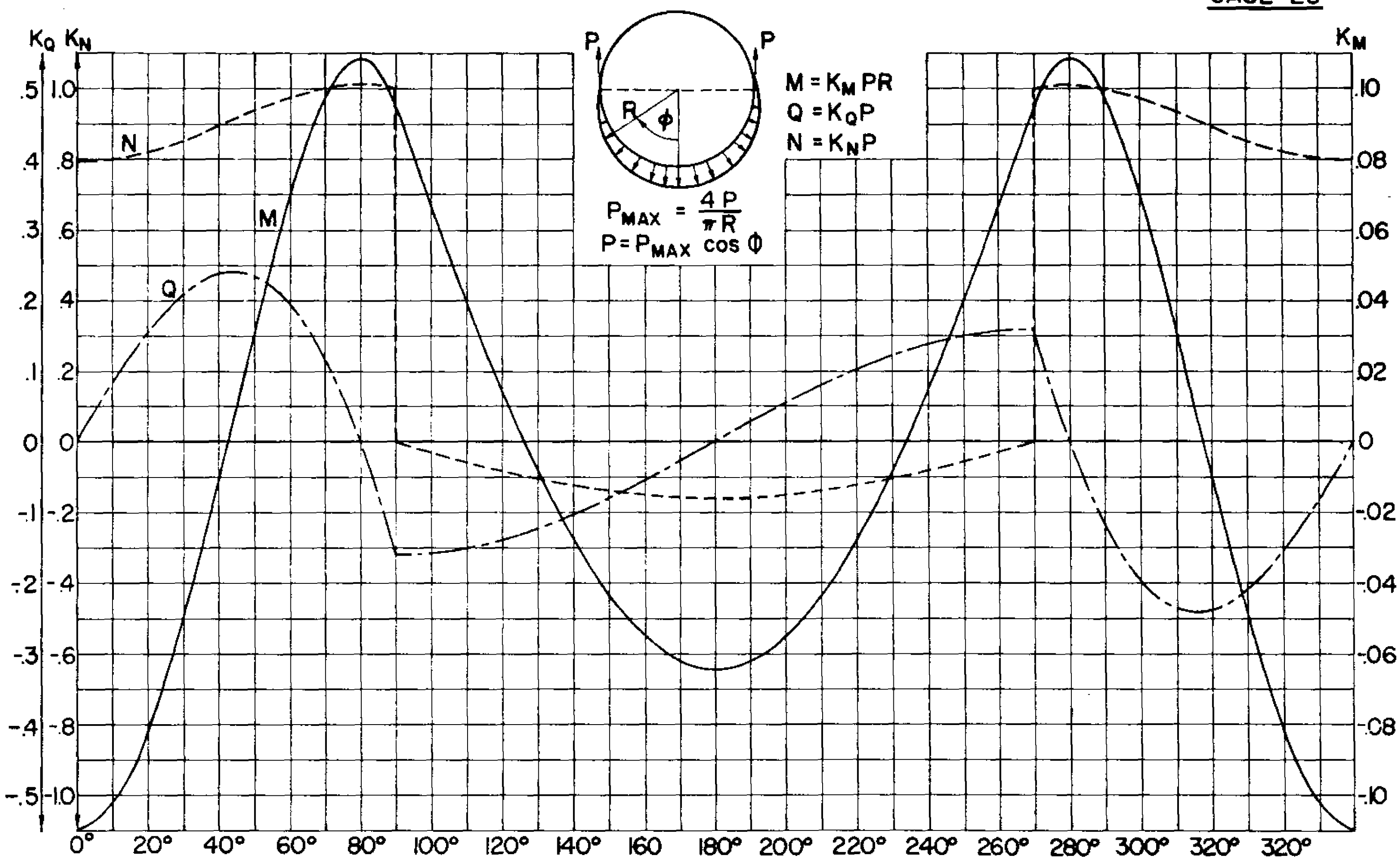


$\Delta = K_\Delta \frac{PR^3}{EI}$
$\theta = K_\theta \frac{PR^2}{EI}$
P
R
ϕ
P_{MAX}
$P = P_{MAX} \cos\phi$
K_Δ
K_θ
.05 .10
.04 .08
.03 .06
.02 .04
.01 .02
0 0
-.01 -.02
-.02 -.04
-.03 -.06
-.04 -.08
-.05 -.10
Δ
θ
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°


CASE 22
M = K_M PR
Q = K_Q P
N = K_N P
K_M, K_Q, K_N
N
Q
M
.5
.4
.3
.2
.1
0
-.1
-.2
-.3
-.4
-.5
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°
P
R
φ
P_MAX = 2P/πR
P = P_MAX COSφ

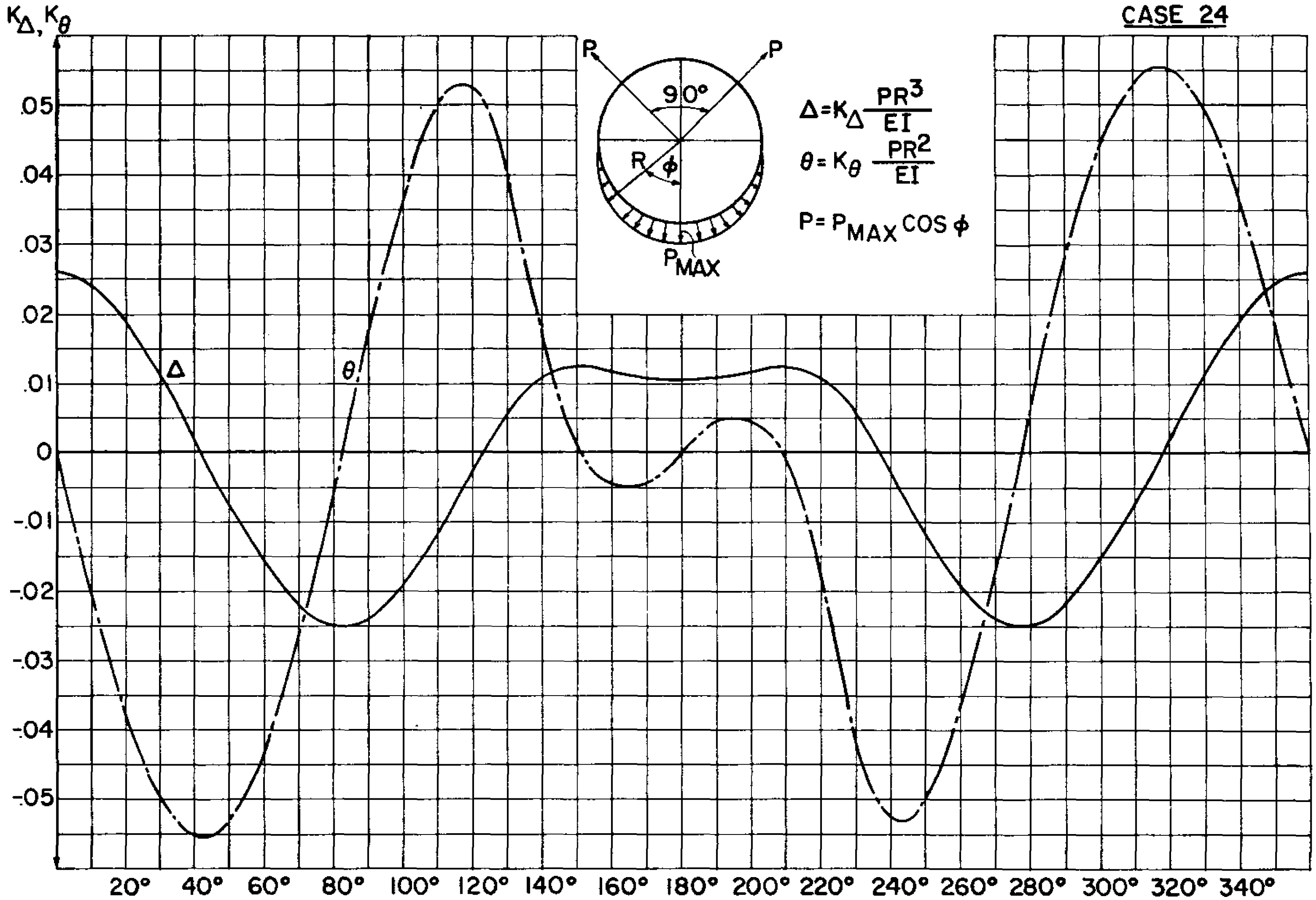

CASE 23
Δ=K$_Δ$ PR^3/EI
θ=K$_θ$ PR^2/EI
P
P
R
φ
P$_{MAX}$
P=P$_{MAX}$ cosφ
K$_Δ$
K$_θ$
.04 .08
.03 .06
.02 .04
.01 .02
0 0
-.01 -.02
-.02 -.04
-.03 -.06
-.04 -.08
Δ
θ
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

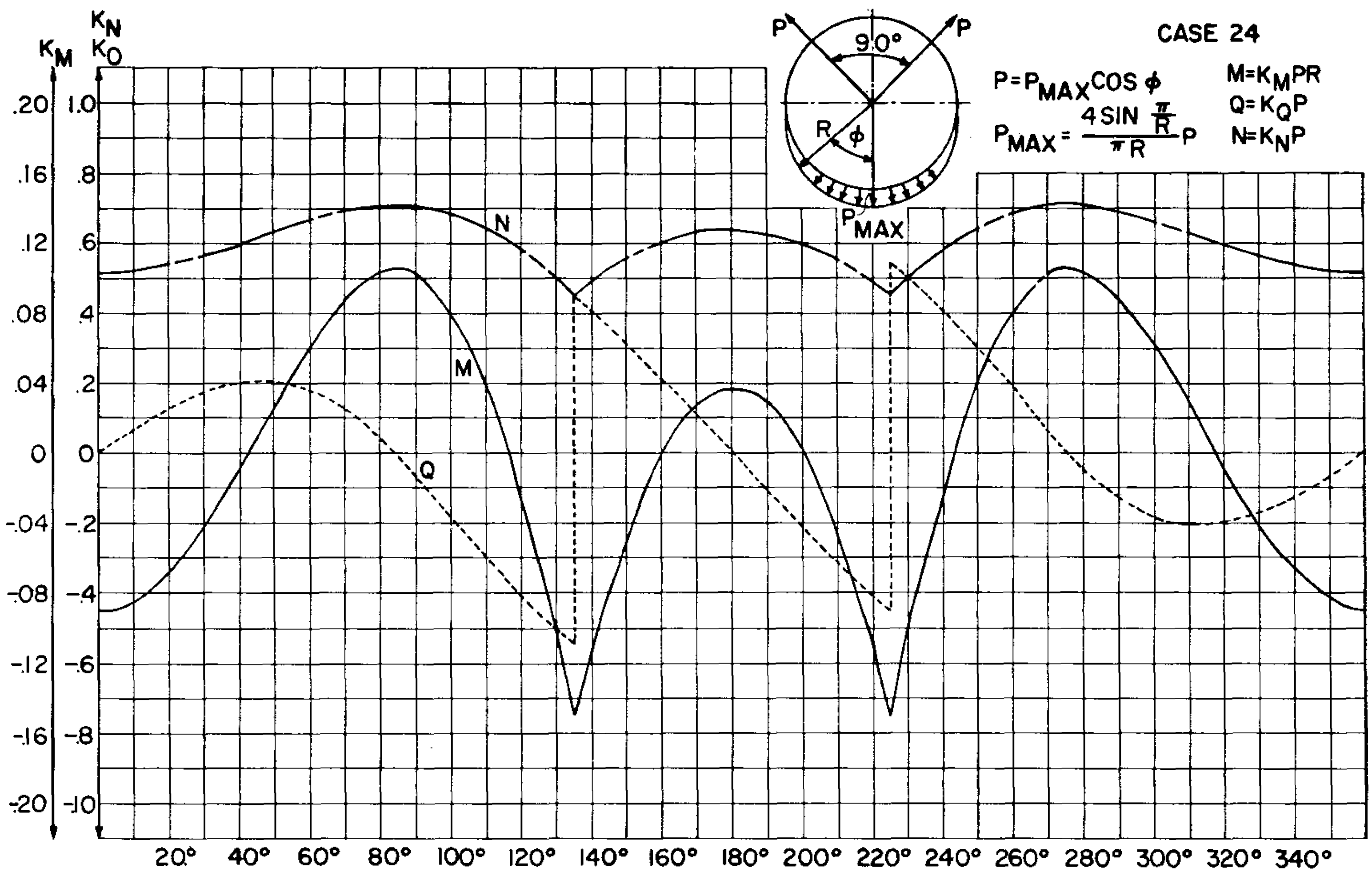
CASE 23



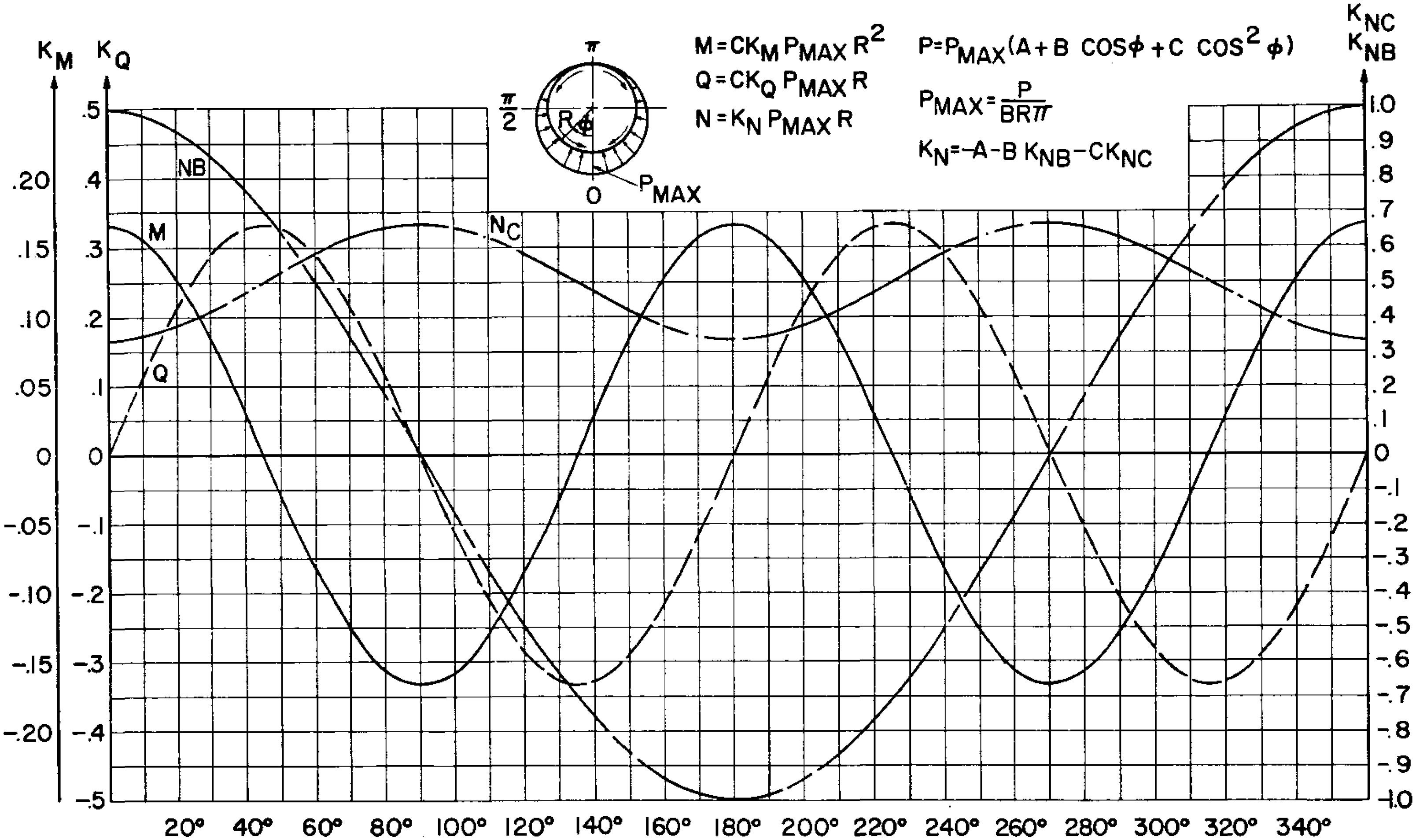
K_Q K_N
K_M
P
P
R
ϕ
$M = K_M PR$
$Q = K_Q P$
$N = K_N P$
$P_{MAX} = \frac{4P}{\pi R}$
$P = P_{MAX} \cos \phi$
N
M
Q
.5 1.0
.4 .8
.3 .6
.2 .4
.1 .2
0 0
-.1 -.2
-.2 -.4
-.3 -.6
-.4 -.8
-.5 -1.0
.10
.08
.06
.04
.02
0
-.02
-.04
-.06
-.08
-.10
0° 20° 40° 60° 80° 100° 120° 140° 160 180° 200° 220° 240° 260° 280° 300° 320° 320°

CASE 24


K_Δ, K_θ
.05
.04
.03
.02
.01
0
-.01
-.02
-.03
-.04
-.05
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°
Δ
θ
R
P
90°
R
φ
P_{MAX}
$\Delta = K_\Delta \frac{PR^3}{EI}$
$\theta = K_\theta \frac{PR^2}{EI}$
$P = P_{MAX} \cos \phi$


CASE 24
P
P
90°
R
φ
P_{MAX}
$P = P_{MAX} \cos\phi$
$P_{MAX} = \frac{4 \sin \frac{\pi}{R}}{\pi R} P$
$M = K_M P R$
$Q = K_Q P$
$N = K_N P$
K_M
K_N
K_Q
.20 .16 .12 .08 .04 0 -.04 -.08 -.12 -.16 -.20
1.0 .8 .6 .4 .2 0 -.2 -.4 -.6 -.8 -1.0
N
M
Q
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

CASE 25


$M = CK_M P_{MAX} R^2$
$Q = CK_Q P_{MAX} R$
$N = K_N P_{MAX} R$
$P = P_{MAX}(A + B \cos\phi + C \cos^2 \phi)$
$P_{MAX} = \frac{P}{BR\pi}$
$K_N = -A - B K_{NB} - CK_{NC}$
K_M
K_Q
K_{NC}
K_{NB}
NB
M
Q
N_C
π
$\frac{\pi}{2}$
R
ϕ
0
P_{MAX}
20° 40° 60° 80° 100° 120° 140° 160° 180° 200° 220° 240° 260° 280° 300° 320° 340°

B 6.1.1 <u>In-plane Load Cases (Cont'd)</u>

Deflection curves for the three basic load cases due to shear and normal forces are displayed on the following pages. A shape factor (β) that is to be used with the curves for shear deflection of various cross-sections is tabulated below.

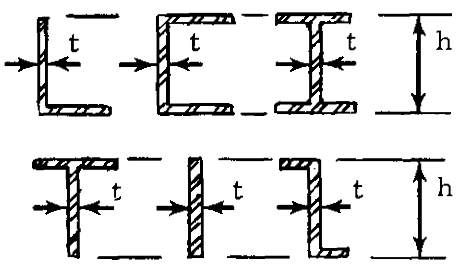
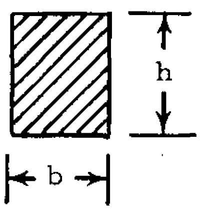
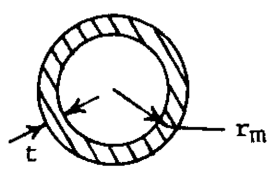
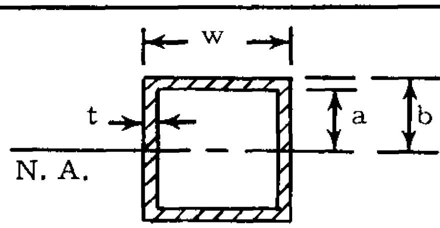
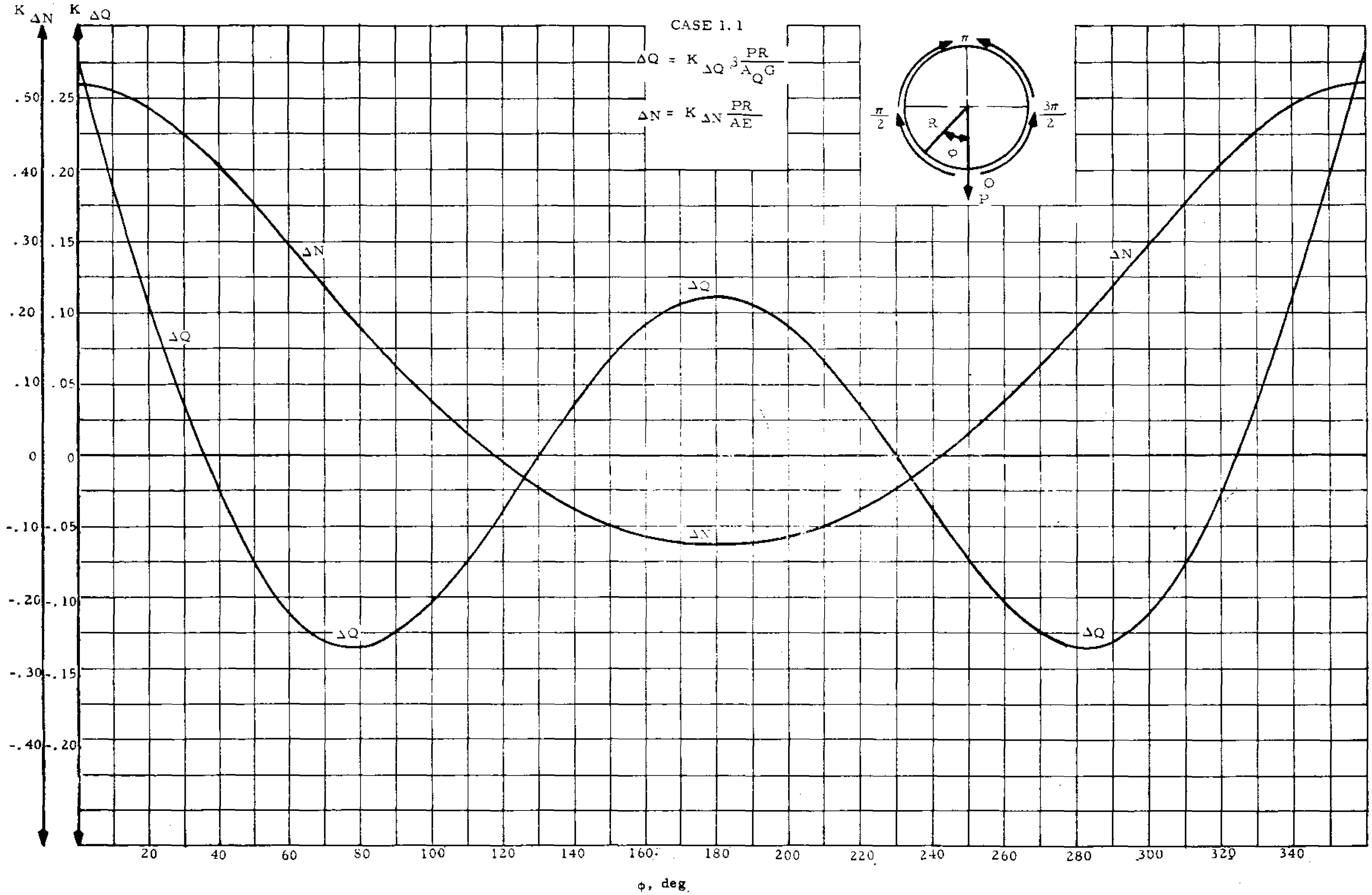
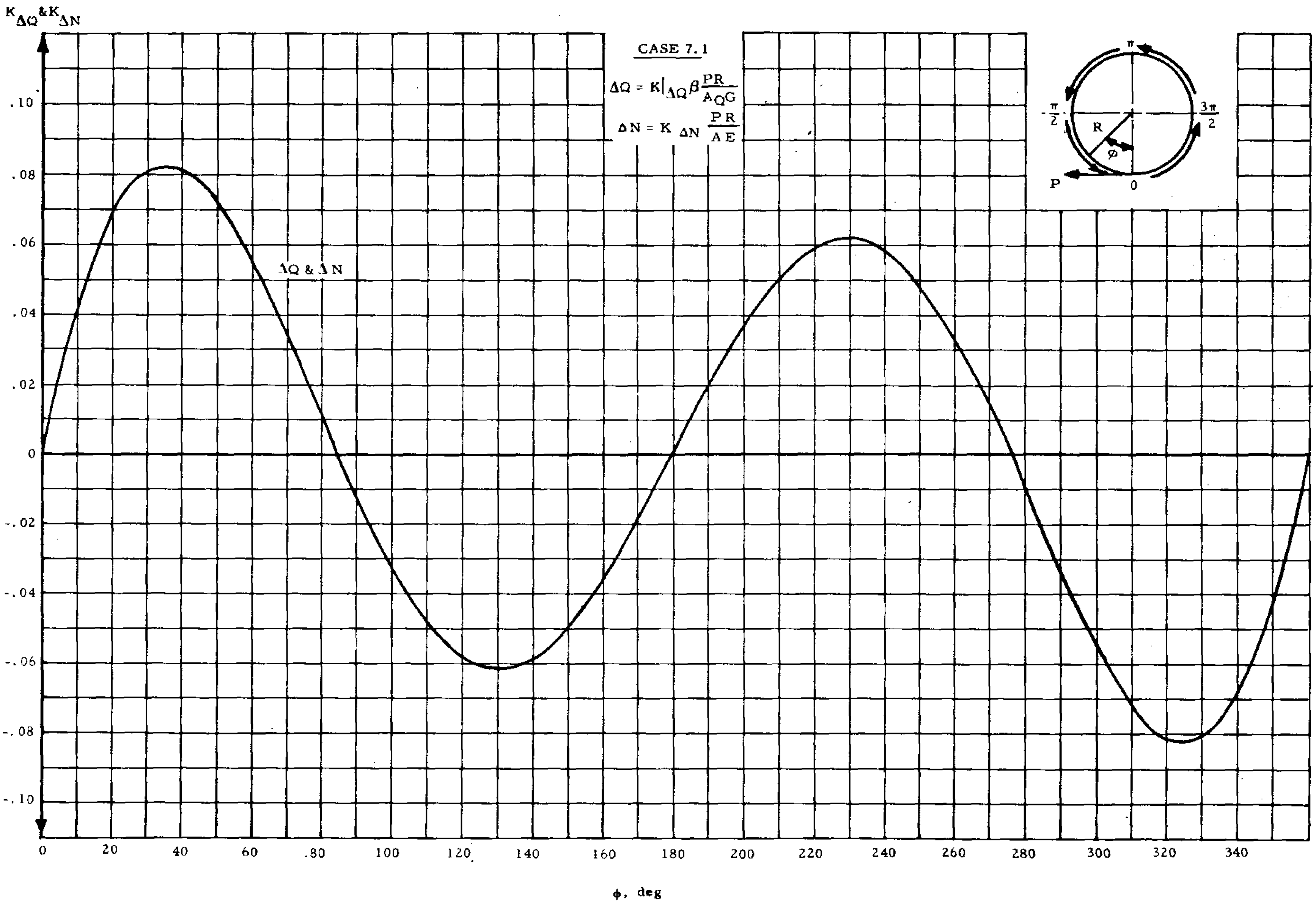
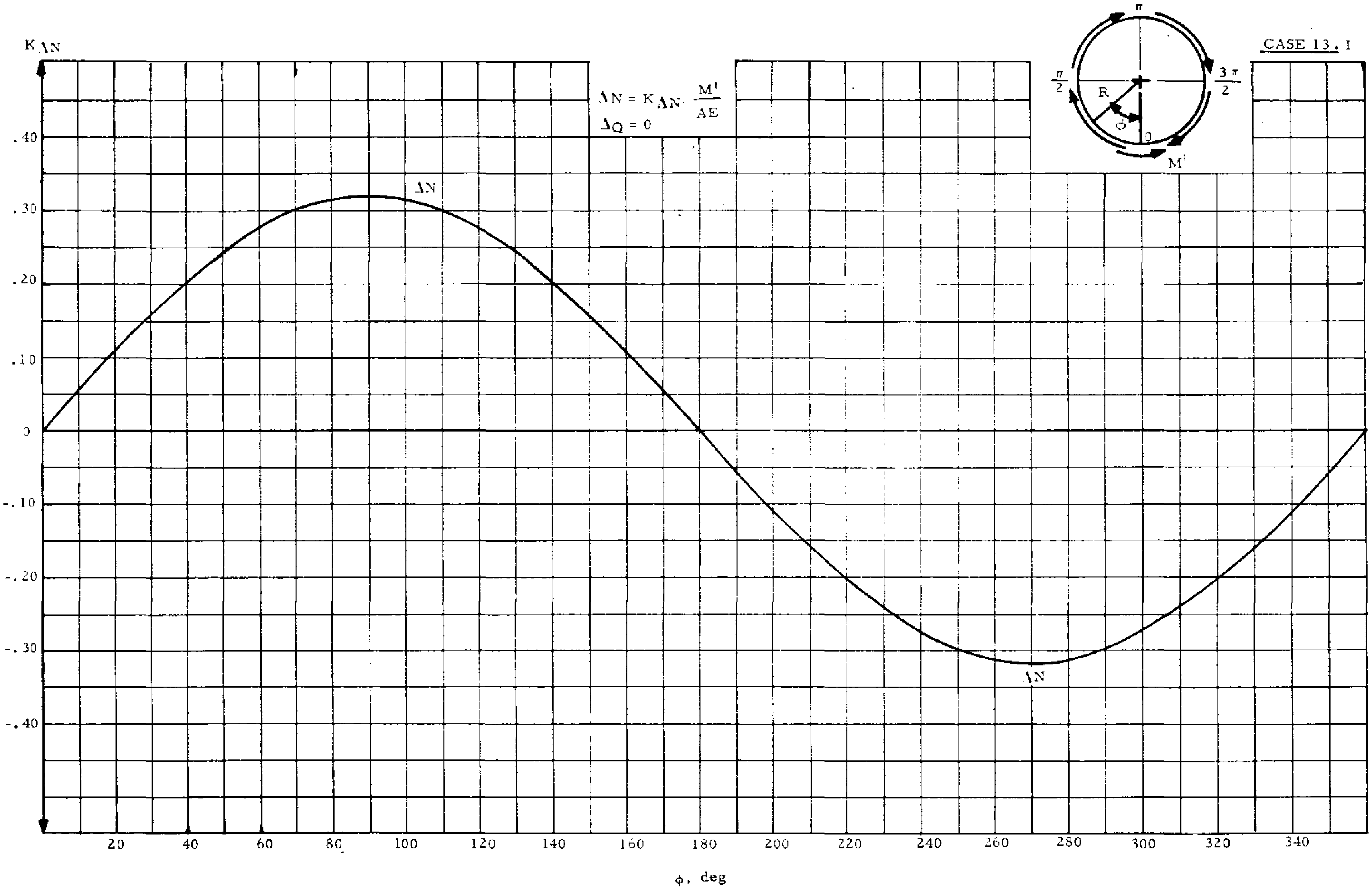
Cross-Section	Shear Area	Shape Factor, β
	Area of Web $A_Q = th$	$\beta = 1.00$
	Entire Area $A_Q = bh$	$\beta = 1.20$ for $b \geq 0.50\,h$ $\beta = 1.00$ for $b < 0.50\,h$
	Entire Area $A_Q = 2\pi r_m t$	$\beta = 2.00$
 ρ = radius of gyration with respect to the neutral axis	Entire Area $A_Q = (w)^2 - (2a)(w-2t)$	$\beta = \left[1 + \frac{3(b^2 - a^2)\,a}{2b^3}\left(\frac{w}{t} - 1\right)\right]\left[\frac{4b^2}{10\rho^2}\right]$ If the flanges are of nonuniform thickness, they may be replaced by an "equivalent" section whose flanges have the same width and area as those of the actual section.

Fig. B6.1.1-1


CASE 1.1
ΔQ = K ΔQ β PR/(A_Q G)
ΔN = K ΔN PR/AE
K ΔN
K ΔQ
.50 .25
.40 .20
.30 .15
.20 .10
.10 .05
0 0
-.10 -.05
-.20 -.10
-.30 -.15
-.40 -.20
ΔN
ΔQ
ΔQ
ΔN
ΔQ
ΔN
ΔQ
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340
φ, deg
π
π/2
3π/2
R
φ
Q
P


$K_{\Delta Q}$ & $K_{\Delta N}$
CASE 7.1
$\Delta Q = K_{\Delta Q} \beta \frac{PR}{A_Q G}$
$\Delta N = K_{\Delta N} \frac{PR}{AE}$
ΔQ & ΔN
.10
.08
.06
.04
.02
0
-.02
-.04
-.06
-.08
-.10
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
φ, deg
π
$-\frac{\pi}{2}$
$\frac{3\pi}{2}$
R
φ
P
0

CASE 13.1


$K_{\Delta N}$
$\Delta N = K_{\Delta N} \cdot \frac{M'}{AE}$
$\Delta_Q = 0$
ΔN
ΔN
.40
.30
.20
.10
0
-.10
-.20
-.30
-.40
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
φ, deg
π
π/2
3π/2
R
φ
0
M'

B 6.1.2 Out-of-plane Load Cases

Sign Convention

The following sign convention is given to define the positive directions for out-of-plane loads.

Moments which produce tension on the inner fibers are positive. Torque "T" and lateral shear "V" are positive as shown in Fig. B 6.1.2-1.

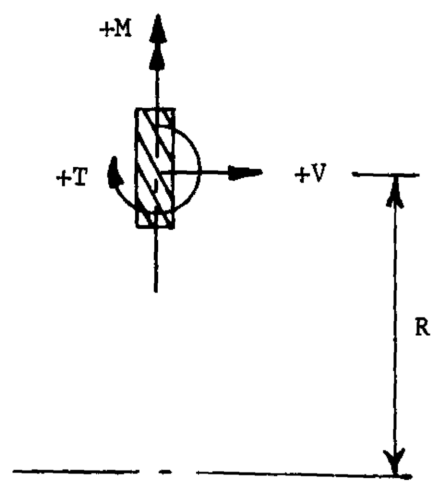


Fig. B 6.1.2-1

B 6.1.2 Out-of-Plane Load Cases (Cont'd)

Index

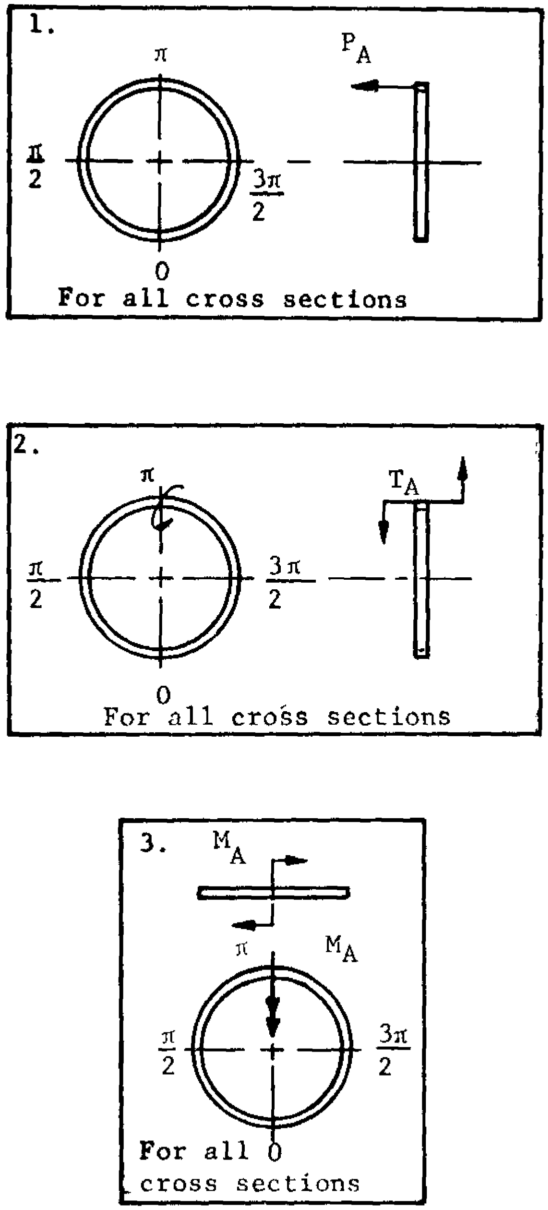
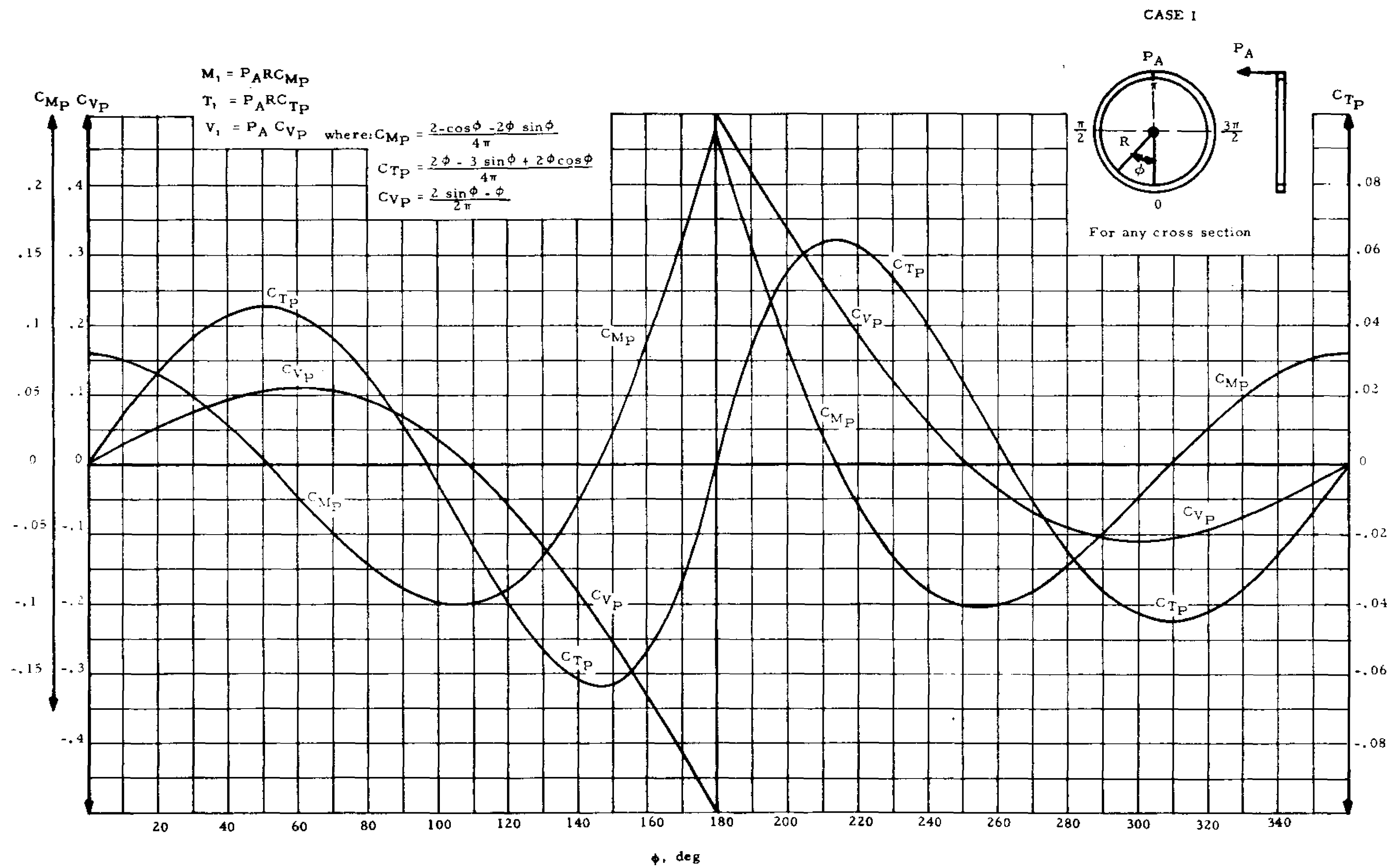
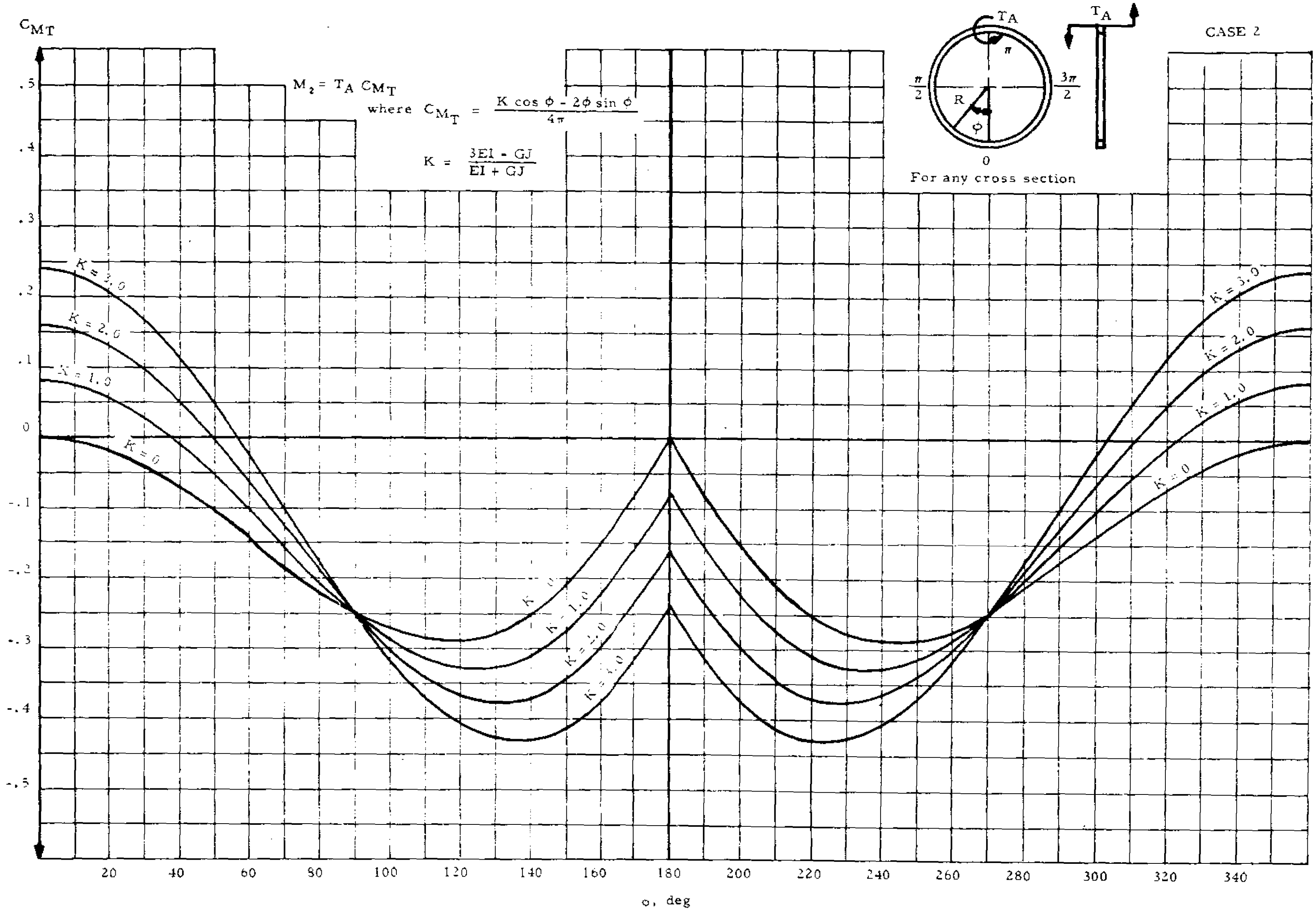
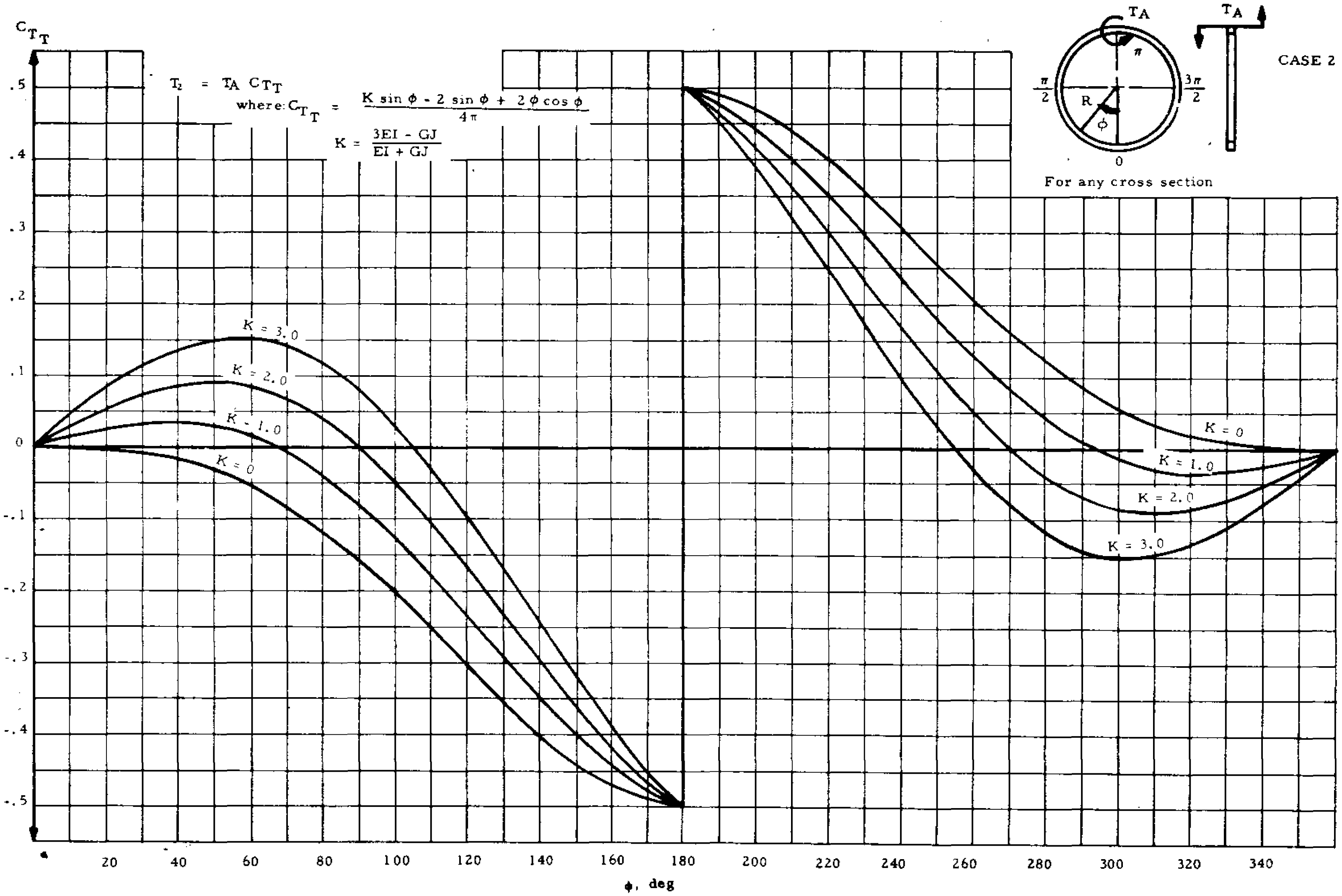


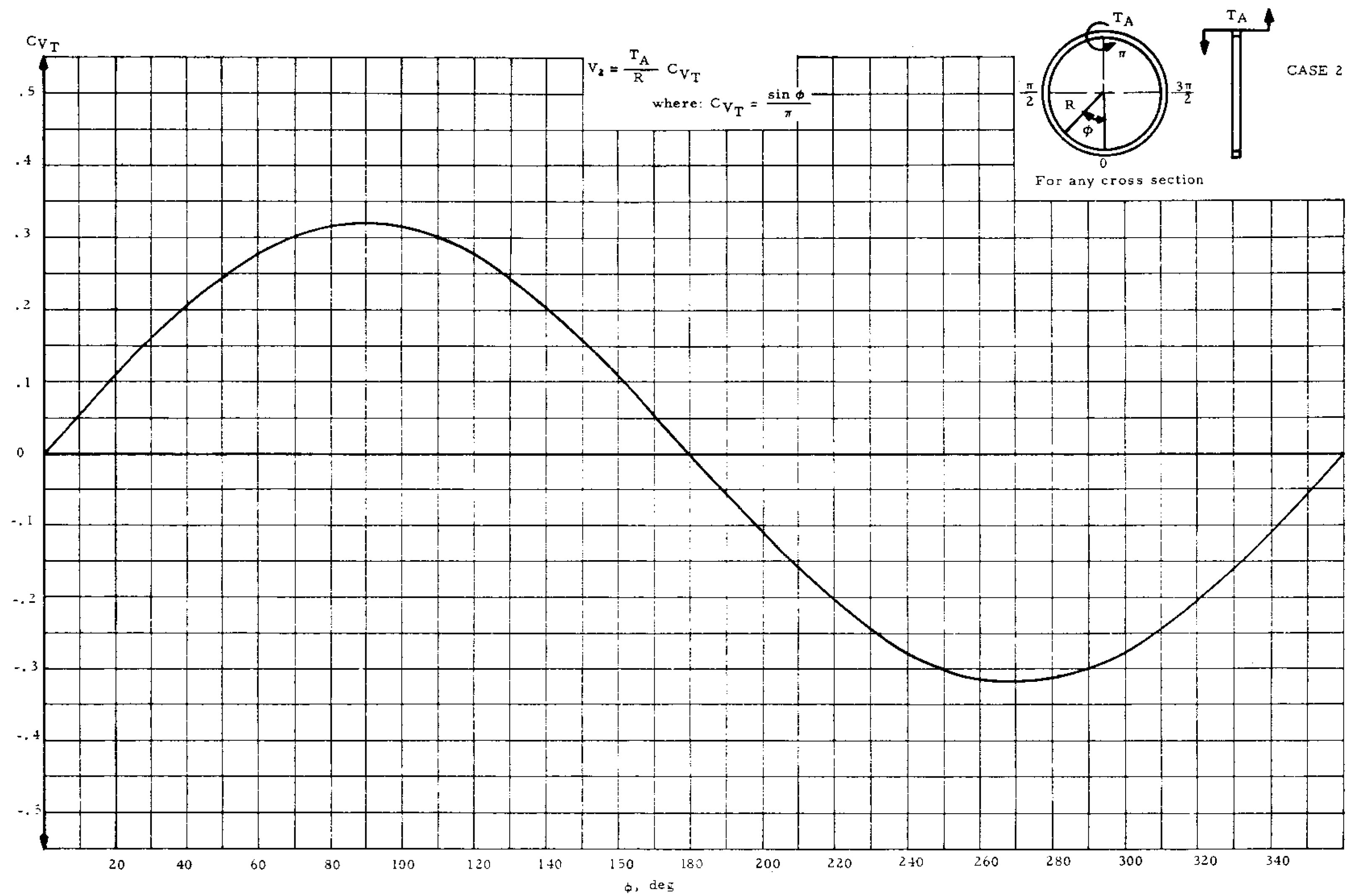
Fig. B 6.1.2-2


CASE I
P_A
P_A
π
$\frac{\pi}{2}$
$\frac{3\pi}{2}$
R
ϕ
0
For any cross section
$M_1 = P_A R C_{M_P}$
$T_1 = P_A R C_{T_P}$
$V_1 = P_A C_{V_P}$ where: $C_{M_P} = \frac{2 - \cos\phi - 2\phi \sin\phi}{4\pi}$
$C_{T_P} = \frac{2\phi - 3\sin\phi + 2\phi\cos\phi}{4\pi}$
$C_{V_P} = \frac{2\sin\phi - \phi}{2\pi}$
C_{M_P} C_{V_P}
C_{T_P}
C_{T_P}
C_{V_P}
C_{M_P}
ϕ, deg

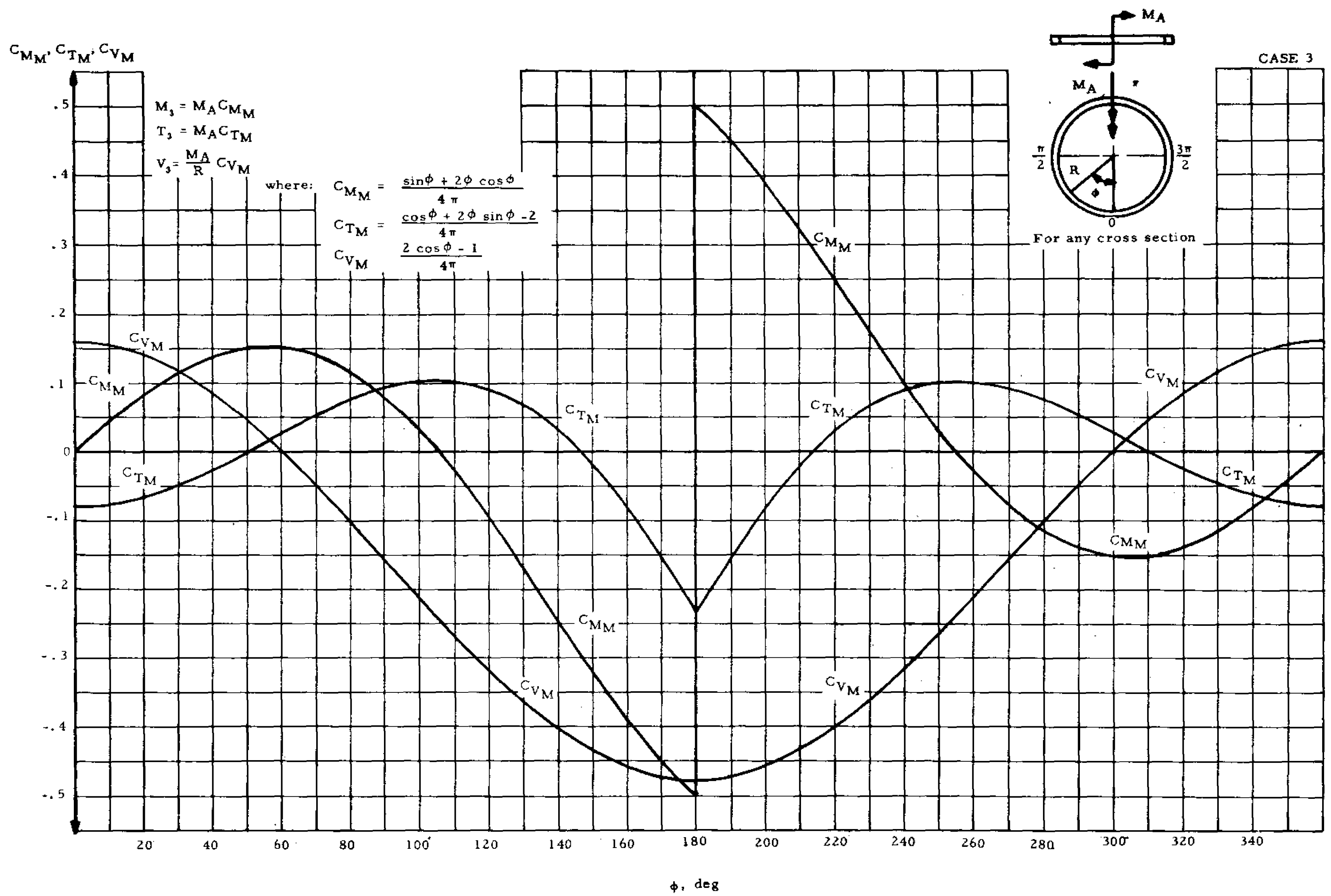
CASE 2


C_{M_T}
$M_2 = T_A C_{M_T}$
where $C_{M_T} = \frac{K \cos \phi - 2\phi \sin \phi}{4\pi}$
$K = \frac{3EI - GJ}{EI + GJ}$
T_A
π
$\frac{\pi}{2}$
$\frac{3\pi}{2}$
R
ϕ
0
For any cross section
K = 3.0
K = 2.0
K = 1.0
K = 0
.5
.4
.3
.2
.1
0
-.1
-.2
-.3
-.4
-.5
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
ϕ, deg


CASE 2
T_A
T_A
π
π/2
3π/2
R
φ
0
For any cross section
$T_2 = T_A\, C_{T_T}$
where: $C_{T_T} = \frac{K \sin\phi - 2\sin\phi + 2\phi\cos\phi}{4\pi}$
$K = \frac{3EI - GJ}{EI + GJ}$
C_{T_T}
K = 3.0
K = 2.0
K = 1.0
K = 0
K = 0
K = 1.0
K = 2.0
K = 3.0
.5
.4
.3
.2
.1
0
-.1
-.2
-.3
-.4
-.5
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
φ, deg



C_{V_T}
.5
.4
.3
.2
.1
0
-.1
-.2
-.3
-.4
-.5
20
40
60
80
100
120
140
150
180
200
220
240
260
280
300
320
340
φ, deg
$V_z = \frac{T_A}{R} C_{V_T}$
where: $C_{V_T} = \frac{\sin\phi}{\pi}$
T_A
π
$\frac{\pi}{2}$
$\frac{3\pi}{2}$
R
φ
0
For any cross section
T_A
CASE 2


CASE 3
$C_{M_M}, C_{T_M}, C_{V_M}$
$M_3 = M_A C_{M_M}$
$T_3 = M_A C_{T_M}$
$V_3 = \frac{M_A}{R} C_{V_M}$
where: $C_{M_M} = \frac{\sin\phi + 2\phi \cos\phi}{4\pi}$
$C_{T_M} = \frac{\cos\phi + 2\phi \sin\phi - 2}{4\pi}$
$C_{V_M} = \frac{2 \cos\phi - 1}{4\pi}$
M_A
$\frac{\pi}{2}$
$\frac{3\pi}{2}$
R
ϕ
0
For any cross section
ϕ, deg

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells

Tables are presented giving the loads and displacements in a flexible frame supported by a circular cylindrical shell and subjected to concentrated radial tangential, and moment loads. Additional tables give the loads in the shell. The solutions are presented in terms of two basic parameters, one of which is of second-order importance. Procedure for modifying the important parameter to account for certain non-uniform properties of the structure are presented.

Notation

A	$\frac{2.25}{\gamma^4}$
B	$\left(\frac{L_r}{L_c}\right)^2 / \gamma^2$
E	Young's modulus ~ lb/in^2
E_f	Young's modulus of unloaded frames ~ lb/in^2
E_o	Young's modulus of loaded frame ~ lb/in^2
E_{sk}	Young's modulus of skin ~ lb/in^2
e	base of natural logarithms
F	axial force in loaded frame ~ lb
G	shear modulus ~ lb/in^2
I	moment of inertia of a typical unloaded frame ~ in^4
I_ℓ	moment of inertia of an unloaded frame, distance "ℓ" from the loaded frame ~ in^4
I_o	moment of inertia of the loaded frame ~ in^4
i	$I/\ell o$ ~ in^3
K_n	$\frac{n\sqrt{n^2-1}}{2\sqrt{3}} \cdot \frac{1 + 2\,\frac{n^2-1}{3}\left(\frac{L_r}{L_c}\right)^2}{\sqrt{1 + \frac{n^2-1}{3}\left(\frac{L_r}{L_c}\right)^2}}$
ℓ	distance from loaded frame to undistorted shell section ~ in

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells (Cont'd)

Notation (Cont'd)

L_c characteristic length (see Glossary) = $\frac{r}{\sqrt{6}} \left[\frac{t'r^2}{\ell} \right]^{1/4}$ ~ in

L_r characteristic length (see Glossary) = $\frac{r}{2} \sqrt{\frac{Et'}{Gt}}$ ~ in

ℓ_o frame spacing ~ in

M bending moment in loaded frame ~ in-lb

M_o externally applied concentrated moment ~ in.lb

P_o externally applied radial load ~ lb

p axial load per inch in the shell ~ lb/in

q shear flow in shell ~ lb/in

r radius of skin line ~ in

S transverse shear force in loaded frame ~ lb

s transverse shear per inch in shell ~ lb/in

T_o externally applied tangential load ~ lb

t skin panel thickness ~ in

t' effective skin panel thickness for axial loads ~ in

t_e weighted average of all the bending material (skin and stiffeners) adjacent to the loaded frame, assumed uniformly distributed around the perimeter ~ in.

u axial displacement of shell ~ in.

v tangential displacement of shell ~ in.

w radial displacement of shell ~ in.

x axial co-ordinate of shell ~ in.

γ "beef up" parameter $I_o/2i\ L_c$

γ_ℓ γ for nearby heavy frame

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells (Cont'd)

Notations (Cont'd)

θ rotational displacement ~ radians

$\emptyset$ polar co-ordinate of frame and shell

Basic Assumptions

In the method of attack with which this section is mainly concerned, a simplified structural model (Fig. B 6.2.0-1) is used to obtain a solution for a uniform shell stretching to infinity on both sides of the loaded frame. Clearly the effects of any frame can be propagated only a finite distance along the shell. In practice, the perturbations from the "elementary beam theory" are, at worst, negligible at some characteristic length "L_c" inches away from the loaded frame. Procedures for modifying the solution to account for discontinuities and non-uniform properties are discussed in the following sections. For the model used, the following assumptions are made:

(1) Concentrated loads are applied to the loaded frame and are reacted an infinite distance away on either one or both sides. The shell extends to infinity on both sides.

(2) The loaded frame has in-plane bending flexibility. It is free to warp out of its plane and to twist. It has no axial or shearing flexibilities. Its moment of inertia for circumferential bending is constant.

(3) The effects of the eccentricity of the skin attachment with respect to the frame neutral axis is ignored for both the loaded and unloaded frames.

(4) The shell consists of skin, longerons, and frames similar to the loaded frame, but possibly with different moments of inertia. The skin and longerons have no bending stiffness. All properties of the shell are uniform.

(5) The longerons are "smeared out" over the circumference giving an equivalent constant thickness, t', (including effective skin), for axial loads.

(6) The shell frames, but not the loaded frame, are "smeared out" in the direction of the shell axis, giving an equivalent moment of inertia per inch, "i", for circumferential bending loads.

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells Cont'd)

Basic Assumptions (Cont'd)

The simplified structural model described by the basic assumptions bear only slight resemblance to practical space vehicle shells, however the difference is compensated by modification of certain parameters as discussed in the following pages.

Glossary of Terminology

Characteristic length - In this section there are two characteristic lengths, defined as follows: L_c is the distance required for the exponential envelope of the lowest order self-equilibrating stress system to decay to 1/e (e ~ base of natural logarithms) of its value at x = o, provided that the skin panels are rigid in shear. L_r is the distance required for the envelope of the lowest order self-equilibrating stress system to decay to 1/e of its value at x = o, provided that the frames are rigid in bending.

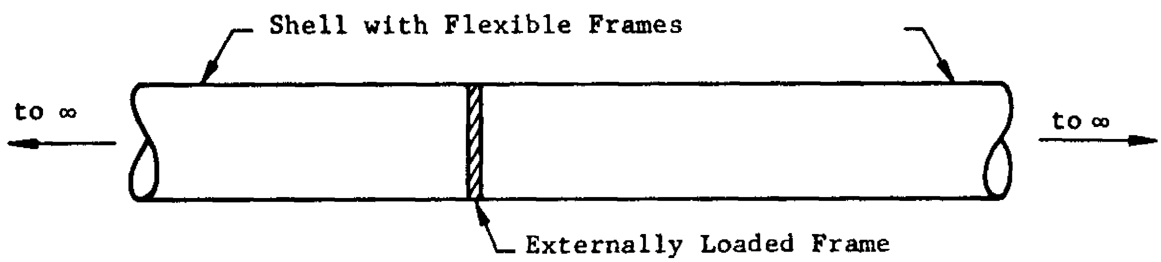


Fig. B 6.2.0-1

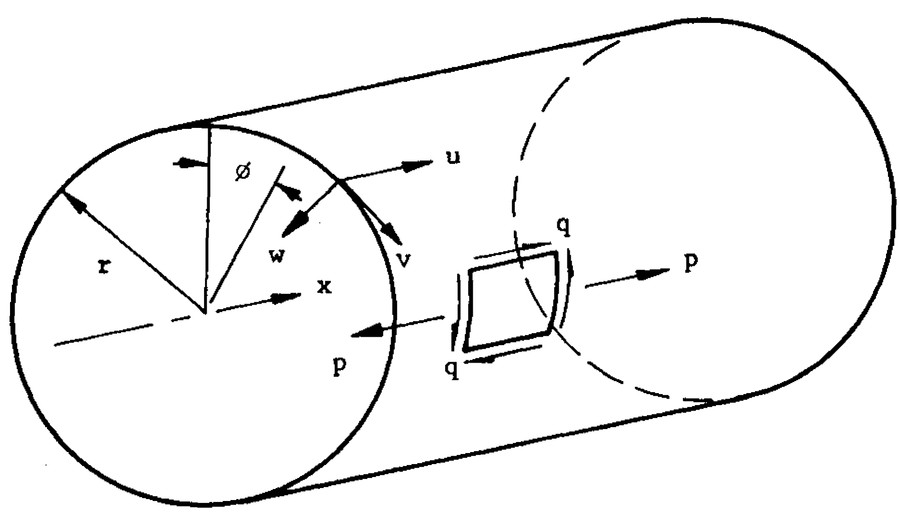


Fig. B 6.2.0-2 Load per inch and displacements in the shell (Loaded frame at x=o)

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells (Cont'd)

Evaluation of Parameters L_r, L_o, and γ

Case of uniform shell

In cases where the shell happens to satisfy all the assumptions listed in the previous pages, and in particular, if the skin thickness, stringer area, and shell-frame moment of inertia are uniform in both the axial and circumferential directions, the following formulas may be used:

$$L_c = \frac{r}{\sqrt{6}} \left[\frac{t' r^2}{i} \right]^{1/4} \quad \ldots\ldots (1)$$

$$L_r = \frac{r}{2} \sqrt{\frac{E\ t'}{Gt}} \quad \ldots\ldots (2)$$

$$\gamma = \frac{I_o}{2iL_c} \quad \ldots\ldots (3)$$

Young's modulus for skin, stiffeners and all frames is assumed equal. Coefficients are obtained by use of these parameters (L_c, L_r, γ) in the tables. These coefficients yield the required loads and deformations when substituted into Eqs. 14 thru 21. In non-uniform shells, use the modified parameters indicated in the following equations:

Case of non-uniform shell

(a) In the case that the shell properties, i, t, and t', vary over the surface of the shell to a moderate degree, the following formulas and definitions are appropriate:

$$L_c = \frac{r}{\sqrt{6}} \left[\frac{E_{sk}\ t_e\ r^2}{E_f\ i} \right]^{1/4} \quad \ldots\ldots (4)$$

$$L_r = \frac{r}{2} \sqrt{\frac{E_{sk}\ t'}{G\ t}} \quad \ldots\ldots (5)$$

$$\gamma = \frac{E_o\ I_o}{2E_f\ i\ L_c} \quad \ldots\ldots (6)$$

The stiffness factors, Gt, E_{sk}, t_e, and $E_f i$, must be averaged in the neighborhood of the loaded frame. The factors Gt and $E_{sk}i$ shall be averaged over a length of shell extending approximately one-half of a characteristic length from the loaded frame in both directions.

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells (Cont'd)

Case of non-uniform shell (Cont'd)

(b) When unloaded frames have unequal moment of inertia or are unequally spaced, the following weighting factor is used for computing $E_f i$:

$$E_f i = (E_f i)_{fwd} + (E_f i)_{aft} \quad \text{......................... (7)}$$

$$(E_f i)_{fwd} = \frac{1}{L_c} \sum_{fwd} (W E_f I_f) \quad \text{.................. (8)}$$

$$(E_f i)_{aft} = \frac{1}{L_c} \sum_{aft} (W E_f I_f) \quad \text{.................. (9)}$$

Where

$$W = 1 - \frac{x}{L_c} \quad \text{for } x < L_c$$

$$= o \quad \text{for } x > L_c$$

(x is measured forward and aft of loaded frame)

The summations in Eqs. (8) and (9) are to be extended over all frames except the loaded frame. The method of calculation gives greater importance to frames closest to the loaded frame and less importance to those farther away. For the case of a single, particular heavy, neighboring frame, or for other neighboring discontinuities such as rigid bulkheads, a free end, or a plane of symmetry, the correction factors to be discussed is applicable. If those corrections are applied, the heavy frame or other discontinuity must be ignored in applying Eqs. (7), (8) and (9). In particular, if the loaded frame is near the end of the shell, the shell must be continued beyond the end, fictitiously, in the summations of Eqs. (7), (8), and (9), as though the shell were symmetric about the loaded frame and extended for a length greater than L_c on both sides of the loaded frame.

The method of calculation indicated in this sub-section exaggerates the effect of frames which are heavier than average when compared with the more accurate method of correction given in the next section. Since L_c depends on $(E_f i)^{1/4}$, an initial estimate of $E_f i$ is required in order to calculate the L_c used in Eqs. (7), (8), and (9).

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells (Cont'd)

Corrections to γ , the "Beef-Up" parameter

The general form of the modified "beef-up" parameter, γ^*, is:

$$\gamma^* = \gamma \cdot f_a \cdot f_b \cdot f_c \cdot \text{, etc.,} \qquad \text{(10)}$$

where γ is computed by the methods of the preceding section, and f_a, f_b, and f_c are factors accounting for effects of nearby heavy frames etc.

Modification for different value of L_r/L_c

The value of L_r/L_c used in the graphs are 0.2, 0.4, and 1.0. To account for values of this parameter between 0.2 and 1.0, graphical interpolation should be used. Otherwise, the following formula may be applied.

$$\gamma^* = \gamma \; \frac{\sqrt{1 + \left[\left(\frac{L_r}{L_c}\right)^*\right]^2}}{1 + 2\left[\left(\frac{L_r}{L_c}\right)^*\right]^2} \; \frac{1 + 2\left[\left(\frac{L_r}{L_c}\right)''\right]^2}{\sqrt{1 + \left[\left(\frac{L_r}{L_c}\right)''\right]^2}} \qquad \text{(11)}$$

where $(L_r/L_c)''$ is the value of the parameter for the shell, and $(L_r/L_c)^*$ is the value of the parameter closest to $(L_r/L_c)''$, for which graphs are available.

Modification for finite frame spacing

The modification for finite frame spacing is as follows:

$$\gamma^* = \gamma \left\{ 1 + \frac{\ell_o}{2 L_c K_2} \left(1 + \frac{1}{2 \gamma K_2} \right) \left[4 \left(\frac{L_r}{L_c} \right)^2 + \frac{1}{1 + \left(\frac{L_r}{L_c} \right)^2} \right] \right\}$$

where

ℓ_o = distance from loaded frame to adjacent frames

$$K_2 = \frac{1 + 2\left(\frac{L_r}{L_c}\right)^2}{\sqrt{1 + \left(\frac{L_r}{L_c}\right)^2}}$$

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells (Cont'd)

Modification for nearby heavy frames and for other similar nearby discontinuities.

The corrections to "γ" in a previous section are not intended to account for discontinuities in circumferential bending stiffness. The form of the correction for these effects is:

$$\gamma^* = \gamma \cdot f(2) \quad \text{.......................................(13)}$$

Fig. B 6.2.0-3 shows f(2) plotted for nearby heavy frames and for nearby rigid bulkheads. Fig. B 6.2.0-4 shows f(2) plotted for a finite length of shell terminated in various ways on one side of the loaded frame. The validity of the correction is considered doubtful for $f(2) < 0.25$, due to the importance of higher order stress systems. Figures B 6.2.0-3 and B 6.2.0-4 are for $L_r/L_c = 0.4$, but their variation with L_r/L_c is negligible for conventional shell-frame structures and adequate in other applications for $L_r/L_c < 0.75$. The corrections for nearby planes of symmetry and antisymmetry can be used to solve problems where two similar frames are simultaneously loaded. To illustrate the method the two following examples are given:

Example 1

A frame of moment of inertia 4.0 in^4 that is subjected to concentrated loads is supported in a uniform shell whose characteristic length, L_c, is 200 inches and moment of inertia per unit length, i, is 0.10 $in.^3$. A heavy frame having a moment of inertia 16.0 in^4 is 50 inches to one side of this frame. The loaded frame and shell loads are required.

The parameters needed are:

$$\gamma = \frac{4.0}{2(.1)(200)} = 0.10 \qquad \text{by Eq. (3)}$$

$$\gamma_\ell = \frac{16}{2(.1)\ 200} = 0.40$$

$$\frac{\ell}{L_c} = \frac{50}{200} = 0.25$$

Using γ_ℓ and ℓ/L_c in Fig. B 6.2.0-3 yields f(2) = 0 75

$$\therefore\ \gamma^* = 0.75\ (0.10) = 0.075 \qquad \text{by Eq. (13)}$$

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells (Cont'd)

Example 1 (Cont'd)

Use γ = 0.075 instead of 0.10 in the curves to account for the presence of the heavy frame on the stresses in and near the loaded frame.

Example 2

A shell whose characteristic length, L_c, is 250 inches is supported by a large number of identical frames whose moments of inertia are 2.0 in^4, spaced 24 inches apart. A pair of frames 96 inches apart are subjected to concentrated loads at the same polar angle, ϕ . The two radial loads are of equal magnitude but opposite sign, while the tangential loads are of the same magnitude and sign. The loads in the loaded frames and shell are to be found.

$$i = \frac{I}{\ell_o} = \frac{2}{24} = .0833$$

$$\gamma = \frac{I_o}{2iL_c} = \frac{2}{2(.0833)(250)} = 0.048 \qquad \text{by Eq. (3)}$$

$$\frac{\ell}{L_c} = \frac{48}{250} = 0.192$$

For the tangential loads there is a plane of symmetry midway between the loaded frames, while for the radial loads a plane of anti-symmetry exists at the same place. From Fig. B 6.2.0-4 it is seen that for the radial load stress system, f(2) = 0.32, while for the tangential loading f(2) = 1.75. Hence, the values of γ^* to be used in the graphs are 0.015 and 0.084, respectively.

Eccentricity between skin line and neutral axis of the loaded frame.

In the three types of perturbation just discussed, it is possible to account for the effects by modifying γ only, since the "elementary - beam-theory" part of the solution is always valid. In the case when the eccentricity between skin line and neutral axis of the loaded frame exists, the "elementary-beam-theory" solution is also affected. This particular aspect is discussed in Appendix E of reference 1.

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells (Cont'd)

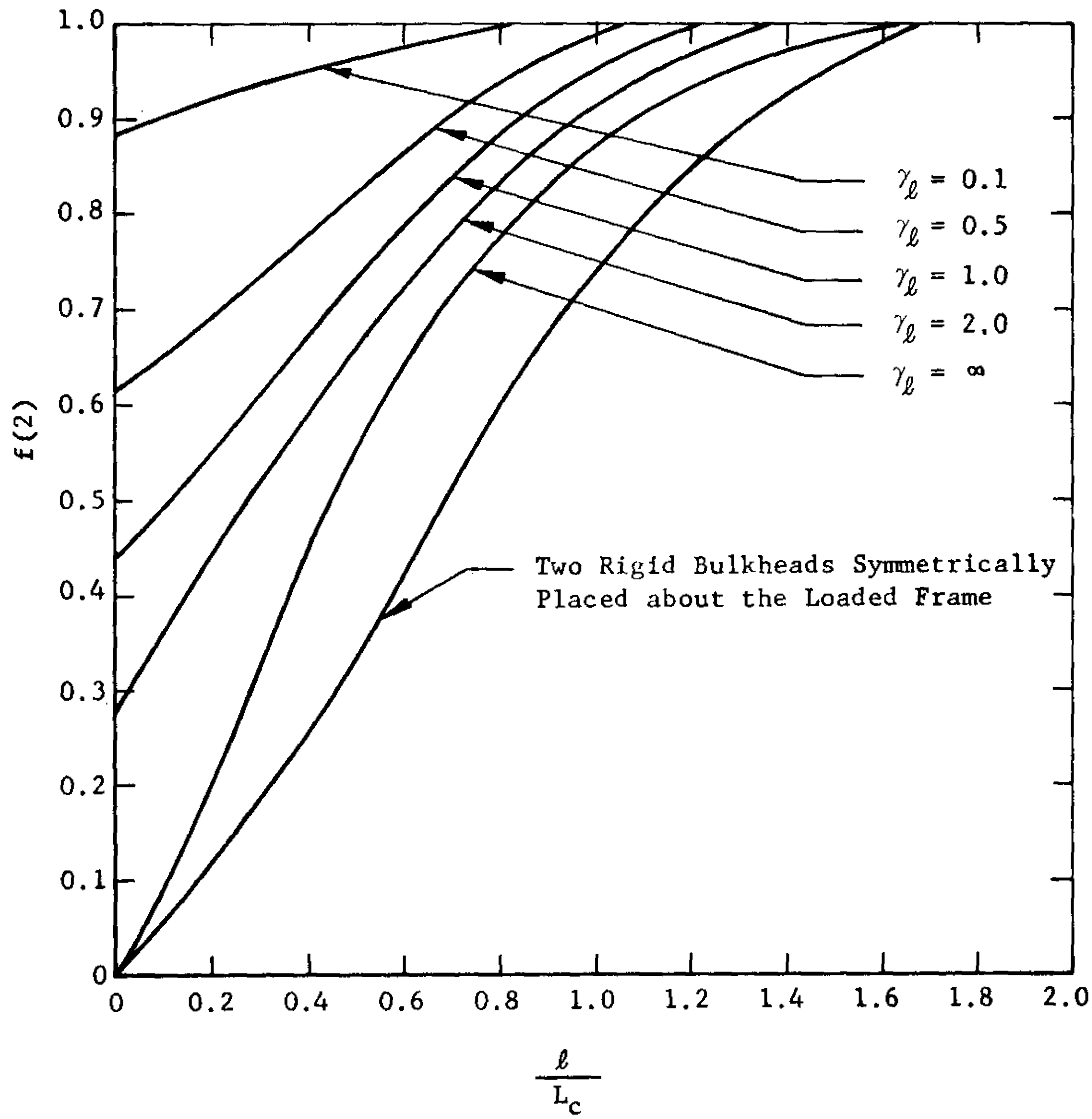


Fig. B 6.2.0-3 A single frame on one side of loaded frame or two rigid bulkheads symmetrically placed about the loaded frame curves of f(2) and f(3). $L_r/L_c = 0.4$.

B 6.2.0 Analysis of Frame-Reinforced Cylindrical Shells (Cont'd)

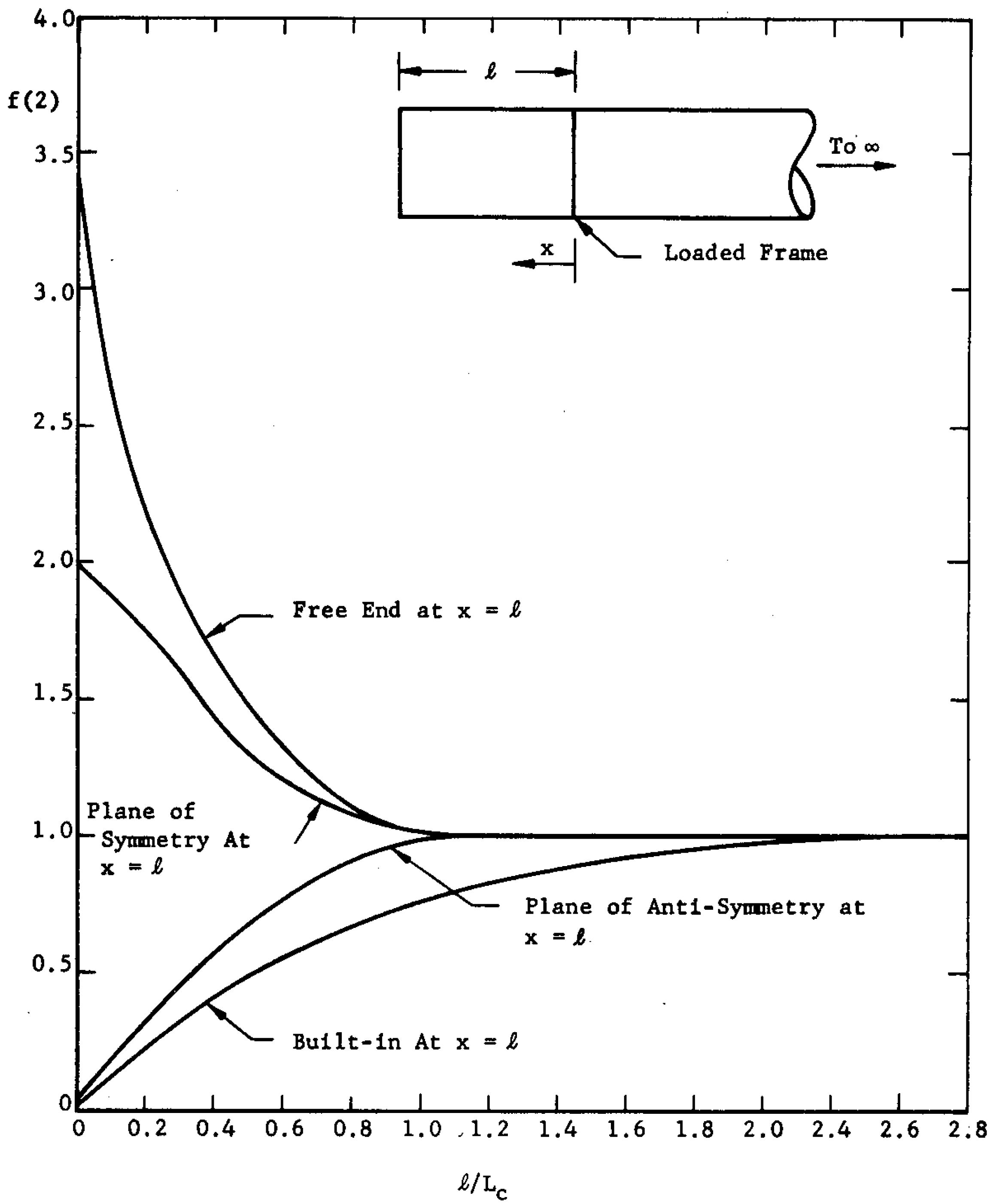


Fig. B 6.2.0-4 Finite length of shell on one side of loaded frame f(2) vs ℓ/L_c for various boundary conditions at $x = \ell$, $L_r/L_c = 0.4$.

B 6.2.1 Calculations by Use of Tables

Eqs. (14) thru (21) are given in this section, by which the effects of a concentrated load or moment on a shell-supported frame may be computed by using the tabulatedcoefficients. The method of computing γ is indicated in a previous section. These enable the shear flow and axial load at all points in the shell and the internal loads and displacements of the loaded frame to be computed.

The following parts of the overall solution are omitted in the tabulated coefficients:

(1) The "elementary-beam-theory" part of skin shear flow which is calculated from beam theory.

(2) The "elementary-beam-theory" part of the axial load intensity in longerons which should be calculated from beam theory.

(3) The rigid translations and rotation of the loaded frame.

As a consequence of items (1) and (2), shear flow and axial load intensity in the shell, as calculated from the tables, can be added directly to the results of an "engineers bending theory" calculation. The shear flow and axial load distributions given in the tables are assumed to be symmetrical with respect to the loaded frame. In a shell that is unsymmetric about the loaded frame, the shear flows and axial loads are not symmetric about the loaded frame. It is not possible to derive a simple correction for this effect, but the exact solutions indicated in reference 2 are applicable.

Distributed load on a frame

The effect of a distributed load on one frame may be obtained by superimposing the effects of the concentrated loads into which the distributed load can be resolved. The axial load and shear flow in the shell can be obtained for loads on several frames by a similar superposition, since "p" and "q" are tabulated in Ref. 3 NASA TN D402 as a function of x/L_c.

Frames adjacent to the loaded frame

At the present time it is not possible by use of tables to compute the internal forces in frames adjacent to the loaded frame. It is, however, a simple matter to tabulate the frame-bending moment per inch, "m", and the other internal forces as a function of x/L_c. The bending moment in an adjacent frame, due to a force applied at the loaded frame, is then obtained by multiplying "m" at the frame station by I_ℓ/i (see Appendix D of reference 1).

B 6.2.1 Calculations by Use of Tables (Cont'd)

Effect of local reinforcement of the loaded frame

It is not practical to attempt to cover, by a set of tables or charts, the many possible reinforcing patterns that can be used to locally strengthen frames in the region of applied concentrated loads. A solution is presented in Appendix A of reference 3, together with a simple example, to illustrate the numerical procedure. A loaded frame, whose moment of inertia varies around the circumference in any manner can be treated as a frame of constant moment of inertia that is reinforced to produce the actual inertia variation.

Tables

The loads and displacements of the loaded frame and loads in the shell are given in terms of the non-dimensional coefficients of the tables by the formulas below. The tables contained in this section are for M, S, F, p, and q at x = o.

Coefficients for displacements v, w, and γ are tabulated in Ref. 3 along with coefficients for "q" and "p" as a function of x/L_c.

$$q = C_{qp} \frac{P_o}{r} + C_{qt} \frac{T_o}{r} + C_{qm} \frac{M_o}{r^2} \quad \ldots\ldots (14)$$

$$p = C_{pp} \frac{P_o}{r} \left(\frac{L_c}{r}\right) + C_{pt} \frac{T_o}{r} \left(\frac{L_c}{r}\right) + C_{pm} \frac{M_o}{r^2} \left(\frac{L_c}{r}\right) \quad (15)$$

$$M = C_{mp} P_o r + C_{mt} T_o r + C_{mm} M_o \quad \ldots\ldots (16)$$

$$S = C_{sp} P_o + C_{st} T_o + C_{sm} \frac{M_o}{r} \quad \ldots\ldots (17)$$

$$F = C_{fp} P_o + C_{tt} T_o + C_{fm} \frac{M_o}{r} \quad \ldots\ldots (18)$$

$$v = C_{vp} P_o \frac{\gamma r^3}{EI_o} + C_{vt} T_o \frac{\gamma r^3}{EI_o} + C_{vm} M_o \frac{\gamma r^2}{EI_o} \quad \ldots\ldots (19)$$

$$W = C_{wp} P_o \frac{\gamma r^3}{EI_o} + C_{wt} T_o \frac{\gamma r^3}{EI_o} + C_{wm} M_o \frac{\gamma r^2}{EI_o} \quad \ldots\ldots (20)$$

$$\theta = C_{\theta p} P_o \frac{\gamma r^2}{EI_o} + C_{\theta t} T_o \frac{\gamma r^2}{EI_o} + C_{\theta m} M_o \frac{\gamma r}{EI_o} \quad \ldots\ldots (21)$$

B 6.2.1 Calculations by Use of Tables (Cont'd)

Sign Convention

Loads, moments, and displacements are positive in the loaded frame as shown in Fig. B 6.2.1-1.

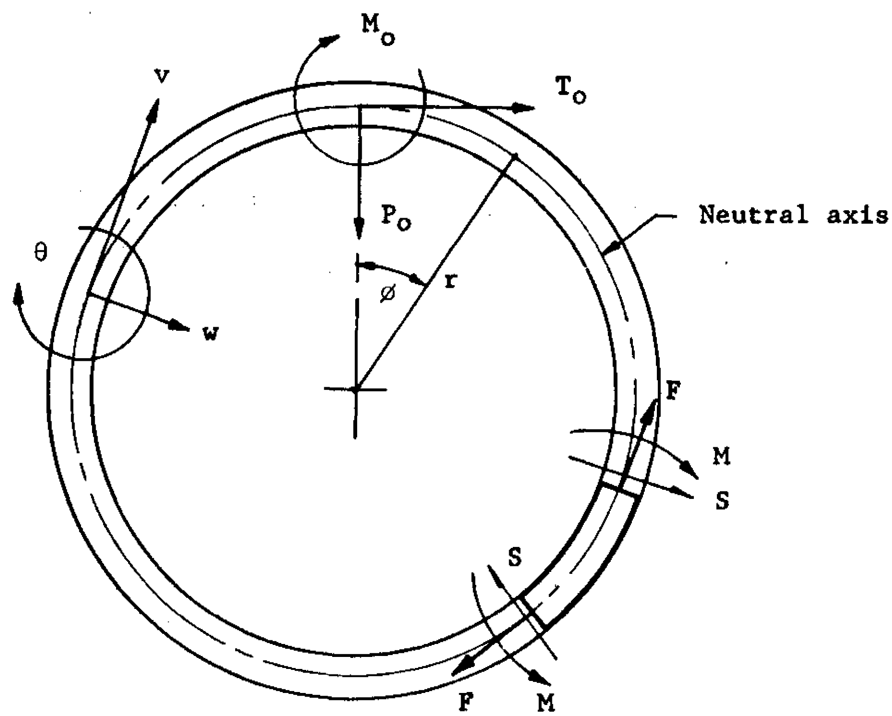


Fig. B 6.2.1-1

B 6.2.1 Calculations by Use of Tables (Cont'd)

Frame Loads		Index of Tables		
	Coefficient	Lr/Lc=.200	Lr/Lc=.400	Lr/Lc=1.000
Bending Moment, M	C_{mp}	B 6.2.1-1	B 6.2.1-5	B 6.2.1-9
	C_{mt}	B 6.2.1-13	B 6.2.1-17	B 6.2.1-21
	C_{mm}	B 6.2.1-25	B 6.2.1-29	B 6.2.1-33
Shear, S	C_{sp}	B 6.2.1-2	B 6.2.1-6	B 6.2.1-10
	C_{st}	B 6.2.1-14	B 6.2.1-18	B 6.2.1-22
	C_{sm}	B 6.2.1-26	B 6.2.1-30	B 6.2.1-34
Axial Load, F	C_{fp}	B 6.2.1-3	B 6.2.1-7	B 6.2.1-11
	C_{ft}	B 6.2.1-15	B 6.2.1-19	B 6.2.1-23
	C_{fm}	B 6.2.1-27	B 6.2.1-31	B 6.2.1-35
Shear Flow, q At Ring	C_{qp}	B 6.2.1-4	B 6.2.1-8	B 6.2.1-12
	C_{qt}	B 6.2.1-16	B 6.2.1-20	B 6.2.1-24
	C_{qm}	B 6.2.1-28	B 6.2.1-32	B 6.2.1-36

TABLE B 6.2.1-1

C_{mp}			L_r/L_c = .200				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ °									
0	.0463	.0536	.0646	.0833	.1066	.1221	.1430	.1713	.2072
5	.0141	.0201	.0296	.0465	.0682	.0829	.1030	.1303	.1652
10	.0004	.0036	.0096	.0219	.0396	.0522	.0698	.0946	.1267
15	-.0038	-.0032	-.0007	.0064	.0189	.0286	.0429	.0638	.0918
20	-.0047	-.0054	-.0055	-.0029	.0043	.0109	.0214	.0376	.0605
25	-.0041	-.0056	-.0073	-.0081	-.0057	-.0022	.0043	.0156	.0327
30	-.0033	-.0050	-.0075	-.0108	-.0122	-.0116	-.0089	-.0028	.0083
35	-.0029	-.0045	-.0072	-.0120	-.0164	-.0182	-.0190	-.0176	-.0128
40	-.0027	-.0041	-.0069	-.0123	-.0189	-.0226	-.0264	-.0295	-.0307
45	-.0024	-.0037	-.0064	-.0122	-.0202	-.0254	-.0317	-.0367	-.0454
50	-.0022	-.0034	-.0059	-.0117	-.0206	-.0269	-.0351	-.0455	-.0572
55	-.0022	-.0033	-.0056	-.0112	-.0205	-.0274	-.0371	-.0503	-.0662
60	-.0021	-.0031	-.0053	-.0106	-.0198	-.0272	-.0379	-.0531	-.0726
65	-.0019	-.0029	-.0049	-.0098	-.0189	-.0263	-.0376	-.0543	-.0766
70	-.0018	-.0027	-.0045	-.0091	-.0177	-.0250	-.0365	-.0540	-.0783
75	-.0017	-.0025	-.0042	-.0083	-.0163	-.0234	-.0347	-.0525	-.0779
80	-.0015	-.0022	-.0037	-.0075	-.0148	-.0214	-.0323	-.0499	-.0757
85	-.0013	-.0020	-.0033	-.0066	-.0132	-.0193	-.0294	-.0464	-.0718
90	-.0012	-.0017	-.0029	-.0058	-.0115	-.0169	-.0262	-.0421	-.0665
100	-.0008	-.0012	-.0020	-.0039	-.0080	-.0119	-.0190	-.0317	-.0523
110	-.0005	-.0006	-.0011	-.0021	-.0044	-.0068	-.0113	-.0200	-.0349
120	-.0000	-.0001	-.0001	-.0004	-.0010	-.0018	-.0036	-.0078	-.0158
130	.0003	.0004	.0007	.0013	.0022	.0029	.0036	.0040	.0033
140	.0006	.0009	.0014	.0027	.0051	.0070	.0101	.0147	.0211
150	.0008	.0012	.0020	.0039	.0074	.0104	.0154	.0237	.0362
160	.0009	.0015	.0025	.0048	.0091	.0130	.0194	.0305	.0478
170	.0011	.0017	.0027	.0053	.0102	.0145	.0219	.0347	.0550
180	.0011	.0017	.0028	.0055	.0105	.0150	.0227	.0361	.0575

TABLE B 6.2.1-2

C_{sp}				$L_r/L_c = .200$				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000
5	-.2464	-.2738	-.3066	-.3467	-.3813	-.3989	-.4182	-.4393	-.4610
10	-.0863	-.1199	-.1637	-.2230	-.2787	-.3085	-.3423	-.3803	-.4204
15	-.0223	-.0449	-.0804	-.1374	-.1988	-.2342	-.2762	-.3256	-.3796
20	.0000	-.0111	-.0342	-.0802	-.1381	-.1744	-.2197	-.2755	-.3390
25	.0098	.0049	-.0087	-.0426	-.0927	-.1269	-.1719	-.2301	-.2991
30	.0080	.0074	.0014	-.0205	-.0602	-.0901	-.1323	-.1894	-.2603
35	.0026	.0045	.0038	-.0082	-.0374	-.0623	-.0994	-.1530	-.2227
40	.0025	.0042	.0052	-.0005	-.0208	-.0405	-.0721	-.1205	-.1865
45	.0032	.0041	.0056	.0039	-.0091	-.0236	-.0494	-.0914	-.1519
50	.0007	.0020	.0042	.0056	-.0011	-.0111	-.0307	-.0657	-.1190
55	.0002	.0014	.0037	.0067	.0048	-.0013	-.0152	-.0428	-.0880
60	.0023	.0028	.0044	.0080	.0093	.0065	-.0023	-.0226	-.0590
65	.0020	.0026	.0043	.0084	.0124	.0125	.0084	-.0049	-.0320
70	.0006	.0018	.0038	.0086	.0146	.0171	.0171	.0106	-.0073
75	.0018	.0027	.0045	.0092	.0166	.0208	.0244	.0240	.0153
80	.0028	.0035	.0051	.0098	.0180	.0238	.0303	.0355	.0355
85	.0016	.0027	.0048	.0099	.0189	.0259	.0349	.0451	.0533
90	.0014	.0026	.0048	.0101	.0197	.0274	.0385	.0530	.0687
100	.0025	.0034	.0054	.0106	.0205	.0293	.0431	.0641	.0922
110	.0021	.0032	.0052	.0104	.0203	.0293	.0445	.0694	.1061
120	.0017	.0028	.0048	.0098	.0192	.0280	.0432	.0696	.1107
130	.0024	.0031	.0047	.0090	.0174	.0254	.0396	.0652	.1069
140	.0009	.0019	.0036	.0074	.0148	.0217	.0341	.0570	.0954
150	.0018	.0022	.0033	.0061	.0117	.0172	.0270	.0456	.0774
160	.0004	.0009	.0019	.0040	.0080	.0118	.0187	.0317	.0545
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-3

C_{fp}				L_r/L_c = .200				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-3.1241	-2.7540	-2.3243	-1.8128	-1.3837	-1.1695	-.9368	-.6856	-.4302
5	-2.4792	-2.2671	-1.9943	-1.6314	-1.2958	-1.1182	-.9180	-.6942	-.4597
10	-1.1964	-1.2557	-1.2662	-1.1891	-1.0445	-.9445	-.8155	-.6537	-.4679
15	-.3940	-.5499	-.6954	-.7949	-.7955	-.7625	-.6996	-.5999	-.4669
20	-.1715	-.2693	-.3960	-.5335	-.6033	-.6121	-.5966	-.5472	-.4617
25	-.0452	-.0990	-.1944	-.3340	-.4412	-.4787	-.4997	-.4932	-.4517
30	.0683	.0250	-.0532	-.1847	-.3089	-.3648	-.4124	-.4406	-.4382
35	.0355	.0235	-.0153	-.1084	-.2212	-.2818	-.3428	-.3944	-.4231
40	-.0207	-.0085	-.0149	-.0690	-.1610	-.2193	-.2858	-.3527	-.4062
45	.0148	.0157	.0087	-.0318	-.1104	-.1659	-.2351	-.3131	-.3869
50	.0284	.0231	.0159	-.0128	-.0764	-.1264	-.1939	-.2776	-.3661
55	-.0182	-.0109	-.0050	-.0147	-.0590	-.1007	-.1625	-.2466	-.3444
60	-.0167	-.0114	-.0064	-.0107	-.0436	-.0786	-.1348	-.2173	-.3211
65	.0197	.0127	.0074	-.0014	-.0290	-.0591	-.1101	-.1897	-.2963
70	.0022	.0005	-.0007	-.0043	-.0233	-.0473	-.0912	-.1652	-.2710
75	-.0223	-.0164	-.0114	-.0091	-.0204	-.0386	-.0756	-.1427	-.2449
80	.0040	.0018	-.0004	-.0030	-.0132	-.0283	-.0599	-.1206	-.2177
85	.0156	.0099	.0048	.0001	-.0084	-.0204	-.0467	-.1001	-.1902
90	-.0125	-.0091	-.0066	-.0051	-.0083	-.0162	-.0365	-.0816	-.1626
100	.0151	.0102	.0060	.0028	.0002	-.0039	-.0157	-.0460	-.1069
110	-.0151	-.0100	-.0056	-.0014	.0020	.0026	-.0006	-.0153	-.0528
120	.0139	.0102	.0076	.0071	.0098	.0124	.0148	.0130	-.0014
130	-.0071	-.0038	-.0003	.0047	.0118	.0176	.0260	.0365	.0450
140	.0044	.0044	.0054	.0090	.0167	.0241	.0366	.0570	.0856
150	.0052	.0052	.0064	.0107	.0199	.0288	.0446	.0730	.1185
160	-.0059	-.0022	.0022	.0094	.0209	.0314	.0500	.0845	.1428
170	.0140	.0115	.0109	.0143	.0245	.0349	.0544	.0920	.1579
180	-.0103	-.0050	.0008	.0094	.0223	.0339	.0546	.0939	.1627

TABLE B 6.2.1-4

C_{qp}				L_r/L_c = .200				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	0	0	0	0	0	0	0	0	0
5	6.8999	5.3381	3.7739	2.2737	1.3216	.9481	.6150	.3339	.1206
10	6.6814	5.4895	4.1517	2.7002	1.6671	1.2306	.8224	.4601	.1711
15	2.4739	2.5437	2.3603	1.6606	1.3094	1.0231	.7232	.4273	.1668
20	.5810	.9941	1.2537	1.2436	1.0055	.8322	.6217	.3870	.1582
25	.7800	.8745	.9778	.9864	.8433	.7205	.5574	.3597	.1521
30	.1713	.2726	.4288	.5741	.5809	.5312	.4381	.3000	.1334
35	-.5612	-.3448	-.0862	.1887	.3234	.3387	.3111	.2325	.1106
40	-.1377	-.1158	-.0359	.1134	.2230	.2483	.2420	.1911	.0952
45	.1709	.0721	.0278	.0709	.1456	.1729	.1800	.1513	.0794
50	-.2963	-.2542	-.1992	-.0968	.0138	.0624	.0965	.0994	.0588
55	-.3463	-.2896	-.2340	-.1492	-.0509	-.0011	.0417	.0613	.0422
60	.0732	-.0008	-.0616	-.0832	-.0473	-.0162	.0171	.0383	.0302
65	-.0570	-.0879	-.1158	-.1236	-.0899	-.0594	-.0230	.0079	.0156
70	-.3732	-.3042	-.2486	-.1985	-.1441	-.1077	-.0645	-.0227	.0010
75	-.1369	-.1430	-.1497	-.1522	-.1324	-.1096	-.0762	-.0377	-.0084
80	.0374	-.0236	-.0761	-.1166	-.1223	-.1104	-.0857	-.0506	-.0169
85	-.2538	-.2231	-.1982	-.1793	-.1591	-.1406	-.1113	-.0706	-.0275
90	-.2942	-.2513	-.2155	-.1879	-.1666	-.1497	-.1226	-.0824	-.0350
100	-.0925	-.1122	-.1287	-.1417	-.1449	-.1397	-.1242	-.0925	-.0443
110	-.1401	-.1429	-.1449	-.1461	-.1447	-.1402	-.1277	-.0996	-.0507
120	-.2095	-.1865	-.1671	-.1515	-.1421	-.1363	-.1250	-.1000	-.0528
130	-.0055	-.0420	-.0724	-.0956	-.1065	-.1083	-.1049	-.0886	-.0492
140	-.2383	-.1952	-.1589	-.1301	-.1145	-.1080	-.0992	-.0817	-.0453
150	.0514	.0103	-.0242	-.0507	-.0636	-.0671	-.0674	-.0597	-.0348
160	-.1563	-.1241	-.0970	-.0756	-.0641	-.0597	-.0547	-.0455	-.0253
170	.0282	.0107	-.0040	-.0154	-.0210	-.0226	-.0232	-.0209	-.0125
180	0	0	0	0	0	0	0	0	0

TABLE 6.2.1-5

C_{mp}			$L_r/L_c = .400$				$X = 0$		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	.0546	.0626	.0744	.0938	.1172	.1325	.1526	.1792	.2116
5	.0206	.0274	.0380	.0558	.0780	.0926	.1120	.1379	.1695
10	.0028	.0071	.0145	.0284	.0472	.0600	.0775	.1012	.1306
15	-.0048	-.0033	.0005	.0096	.0237	.0341	.0487	.0691	.0951
20	-.0073	-.0077	-.0070	-.0026	.0064	.0138	.0250	.0414	.0630
25	-.0071	-.0088	-.0103	-.0101	-.0060	-.0015	.0059	.0178	.0344
30	-.0060	-.0083	-.0112	-.0142	-.0144	-.0129	-.0091	-.0019	.0092
35	-.0049	-.0072	-.0109	-.0160	-.0199	-.0209	-.0207	-.0182	-.0127
40	-.0040	-.0062	-.0100	-.0165	-.0231	-.0264	-.0293	-.0312	-.0312
45	-.0032	-.0052	-.0089	-.0160	-.0247	-.0297	-.0354	-.0413	-.0466
50	-.0027	-.0044	-.0078	-.0151	-.0250	-.0315	-.0394	-.0489	-.0589
55	-.0024	-.0039	-.0069	-.0140	-.0246	-.0319	-.0417	-.0541	-.0683
60	-.0022	-.0034	-.0061	-.0127	-.0235	-.0315	-.0424	-.0572	-.0750
65	-.0020	-.0030	-.0054	-.0115	-.0220	-.0302	-.0420	-.0585	-.0792
70	-.0018	-.0028	-.0048	-.0103	-.0203	-.0285	-.0406	-.0582	-.0810
75	-.0017	-.0025	-.0043	-.0091	-.0184	-.0263	-.0384	-.0565	-.0807
80	-.0015	-.0022	-.0038	-.0080	-.0164	-.0238	-.0356	-.0537	-.0784
85	-.0013	-.0019	-.0033	-.0069	-.0144	-.0212	-.0323	-.0498	-.0744
90	-.0011	-.0017	-.0028	-.0058	-.0123	-.0184	-.0286	-.0451	-.0689
100	-.0007	-.0011	-.0018	-.0038	-.0082	-.0126	-.0204	-.0339	-.0542
110	-.0004	-.0006	-.0009	-.0019	-.0043	-.0069	-.0119	-.0213	-.0361
120	.0000	.0000	.0000	-.0001	-.0005	-.0014	-.0035	-.0082	-.0164
130	.0003	.0005	.0008	.0016	.0028	.0036	.0043	.0045	.0034
140	.0007	.0010	.0016	.0031	.0057	.0079	.0112	.0159	.0218
150	.0009	.0013	.0022	.0043	.0081	.0115	.0169	.0254	.0375
160	.0011	.0016	.0027	.0052	.0099	.0141	.0211	.0326	.0495
170	.0012	.0018	.0029	.0057	.0110	.0157	.0237	.0370	.0570
180	.0012	.0018	.0030	.0059	.0113	.0163	.0245	.0385	.0595

TABLE B 6.2.1-6

	C_{sp}		L_r/L_c = .400				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ °									
0	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000
5	-.2862	-.3103	-.3382	-.3715	-.3998	-.4141	-.4298	-.4469	-.4644
10	-.1334	-.1664	-.2075	-.2605	-.3084	-.3336	-.3619	-.3936	-.4265
15	-.0508	-.0784	-.1175	-.1744	-.2313	-.2629	-.2997	-.3421	-.3875
20	-.0096	-.0279	-.0585	-.1101	-.1680	-.2023	-.2438	-.2933	-.3479
25	.0100	-.0003	-.0214	-.0636	-.1173	-.1514	-.1944	-.2477	-.3083
30	.0141	.0105	-.0014	-.0322	-.0782	-.1098	-.1516	-.2056	-.2693
35	.0113	.0122	.0078	-.0120	-.0486	-.0763	-.1149	-.1672	-.2311
40	.0093	.0119	.0119	.0009	-.0264	-.0495	-.0836	-.1322	-.1940
45	.0074	.0103	.0128	.0085	-.0102	-.0284	-.0572	-.1007	-.1583
50	.0042	.0074	.0113	.0121	.0012	-.0121	-.0351	-.0724	-.1243
55	.0026	.0054	.0097	.0138	.0092	.0005	-.0168	-.0472	-.0921
60	.0029	.0048	.0087	.0145	.0149	.0102	-.0015	-.0249	-.0619
65	.0023	.0039	.0075	.0142	.0185	.0174	.0109	-.0053	-.0339
70	.0014	.0029	.0063	.0136	.0208	.0227	.0210	.0117	-.0081
75	.0019	.0031	.0060	.0132	.0224	.0267	.0291	.0264	.0154
80	.0025	.0034	.0059	.0128	.0233	.0295	.0355	.0389	.0364
85	.0018	.0029	.0054	.0122	.0236	.0313	.0404	.0492	.0550
90	.0018	.0029	.0053	.0118	.0237	.0325	.0441	.0577	.0710
100	.0024	.0034	.0055	.0114	.0232	.0333	.0482	.0694	.0955
110	.0022	.0032	.0053	.0108	.0221	.0323	.0489	.0747	.1099
120	.0019	.0029	.0050	.0100	.0203	.0302	.0468	.0745	.1147
130	.0021	.0030	.0047	.0091	.0181	.0269	.0425	.0695	.1107
140	.0012	.0021	.0038	.0076	.0152	.0227	.0362	.0605	.0987
150	.0016	.0021	.0032	.0061	.0120	.0178	.0285	.0483	.0801
160	.0006	.0011	.0020	.0041	.0082	.0122	.0196	.0336	.0564
170	.0006	.0008	.0011	.0022	.0042	.0062	.0100	.0172	.0291
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-7

C_{fp}			L_r/L_c = .400				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ø°									
0	-2.5833	-2.2692	-1.9132	-1.4981	-1.1540	-.9826	-.7962	-.5944	-.3897
5	-2.1796	-1.9745	-1.7225	-1.4023	-1.1162	-.9672	-.8006	-.6156	-.4238
10	-1.3098	-1.3065	-1.2558	-1.1296	-.9685	-.8695	-.7484	-.6028	-.4422
15	-.6505	-.7536	-.8308	-.8520	-.8017	-.7514	-.6773	-.5753	-.4514
20	-.3303	-.4325	-.5401	-.6297	-.6514	-.6384	-.6039	-.5418	-.4543
25	-.1256	-.2088	-.3175	-.4404	-.5120	-.5286	-.5280	-.5028	-.4513
30	.0134	-.0537	-.1529	-.2867	-.3888	-.4273	-.4541	-.4611	-.4433
35	.0334	-.0013	-.0689	-.1840	-.2930	-.3433	-.3884	-.4205	-.4319
40	.0152	.0080	-.0279	-.1150	-.2180	-.2732	-.3299	-.3811	-.4173
45	.0322	.0293	.0069	-.0607	-.1555	-.2123	-.2764	-.3423	-.3996
50	.0334	.0330	.0212	-.0271	-.1088	-.1635	-.2302	-.3057	-.3796
55	.0027	.0115	.0136	-.0130	-.0773	-.1265	-.1917	-.2719	-.3578
60	-.0017	.0062	.0119	-.0024	-.0525	-.0958	-.1577	-.2397	-.3341
65	.0138	.0143	.0161	.0066	-.0328	-.0705	-.1280	-.2092	-.3088
70	.0027	.0047	.0087	.0065	-.0213	-.0523	-.1036	-.1814	-.2824
75	-.0113	-.0062	.0004	.0038	-.0139	-.0386	-.0830	-.1555	-.2551
80	.0019	.0017	.0037	.0059	-.0065	-.0262	-.0644	-.1307	-.2268
85	.0078	.0052	.0047	.0062	-.0016	-.0167	-.0485	-.1077	-.1981
90	-.0068	-.0049	-.0021	.0024	-.0001	-.0104	-.0356	-.0867	-.1692
100	.0078	.0051	.0035	.0046	.0056	.0015	-.0127	-.0476	-.1111
110	-.0077	-.0049	-.0023	.0019	.0073	.0085	.0042	-.0141	-.0547
120	.0077	.0059	.0049	.0064	.0121	.0162	.0192	.0157	-.0014
130	-.0030	-.0010	.0015	.0058	.0141	.0211	.0305	.0406	.0469
140	.0032	.0036	.0049	.0088	.0178	.0264	.0404	.0614	.0887
150	.0037	.0042	.0058	.0105	.0205	.0304	.0479	.0780	.1227
160	-.0020	.0006	.0040	.0104	.0219	.0330	.0532	.0898	.1478
170	.0085	.0078	.0086	.0133	.0243	.0356	.0569	.0972	.1633
180	-.0042	-.0007	.0035	.0109	.0235	.0354	.0575	.0993	.1684

TABLE B 6.2.1-8

	C_{qp}			L_r/L_c = .400				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	0	0	0	0	0	0	0	0	0
5	4.5167	3.4237	2.3731	1.4049	.8096	.5797	.3761	.2046	.0742
10	4.8735	3.8926	2.8593	1.8075	1.0973	.8055	.5364	.2998	.1115
15	2.6158	2.4071	2.0290	1.4710	.9846	.7551	.5254	.3066	.1186
20	1.2698	1.4050	1.3858	1.1586	.8536	.6825	.4948	.3004	.1203
25	.9842	1.0669	1.0863	.9696	.7586	.6247	.4669	.2923	.1203
30	.3646	.5031	.6291	.6717	.5895	.5094	.3990	.2609	.1115
35	-.2178	-.0112	.2055	.3780	.4094	.3808	.3182	.2202	.0985
40	-.1082	-.0244	.1032	.2464	.3036	.2973	.2609	.1888	.0877
45	.0058	-.0028	.0447	.1448	.2106	.2197	.2043	.1557	.0754
50	-.2519	-.2087	-.1306	-.0042	.0948	.1257	.1361	.1152	.0599
55	-.2785	-.2426	-.1841	-.0793	.0194	.0585	.0831	.0813	.0460
60	-.0536	-.0965	-.1150	-.0804	-.0141	.0199	.0470	.0550	.0342
65	-.1146	-.1384	-.1505	-.1240	-.0638	-.0282	.0054	.0257	.0211
70	-.2757	-.2460	-.2202	-.1765	-.1128	-.0742	-.0342	-.0026	.0081
75	-.1503	-.1593	-.1687	-.1615	-.1229	.0924	-.0561	-.0218	-.0019
80	-.0576	-.0946	-.1285	-.1473	-.1291	-.1062	-.0742	-.0386	-.0111
85	-.2088	-.1952	-.1878	-.1800	-.1551	-.1313	-.0977	-.0576	-.0208
90	-.2300	-.2084	-.1939	-.1836	-.1632	-.1428	-.1118	-.0710	-.0285
100	-.1227	-.1337	-.1443	-.1554	-.1545	-.1446	-.1231	-.0869	-.0394
110	-.1445	-.1458	-.1474	-.1509	-.1509	-.1447	-.1285	-.0962	-.0465
120	-.1750	-.1625	-.1523	-.1458	-.1427	-.1380	-.1256	-.0977	-.0493
130	-.0610	-.0805	-.0962	-.1086	-.1156	-.1160	-.1100	-.0895	-.0471
140	-.1732	-.1500	-.1308	-.1160	-.1090	-.1058	-.0988	-.0806	-.0429
150	-.0111	-.0332	-.0510	-.0645	-.0716	-.0736	-.0723	-.0617	-.0340
160	-.1076	-.0903	-.0760	-.0648	-.0592	-.0572	-.0539	-.0450	-.0246
170	.0016	-.0078	-.0155	-.0212	-.0242	-.0251	-.0251	-.0218	-.0123
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-9

C_{mp}				L_r/L_c = 1.000				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
$\phi°$									
0	.0713	.0811	.0951	.1171	.1421	.1574	.1763	.1988	.2222
5	.0349	.0438	.0568	.0777	.1017	.1166	.1350	.1569	.1799
10	.0117	.0183	.0287	.0465	.0678	.0813	.0983	.1187	.1403
15	-.0018	.0021	.0091	.0225	.0400	.0515	.0662	.0834	.1036
20	-.0087	-.0075	-.0040	.0047	.0176	.0267	.0387	.0538	.0701
25	-.0115	-.0123	-.0119	-.0080	.0001	.0064	.0153	.0269	.0398
30	-.0117	-.0141	-.0162	-.0166	-.0133	-.0097	-.0042	.0037	.0129
35	-.0108	-.0141	-.0181	-.0220	-.0230	-.0222	-.0200	-.0160	-.0108
40	-.0094	-.0131	-.0182	-.0249	-.0298	-.0315	-.0324	-.0323	-.0311
45	-.0079	-.0116	-.0173	-.0260	-.0341	-.0380	-.0420	-.0455	-.0482
50	-.0065	-.0100	-.0159	-.0258	-.0364	-.0423	-.0488	-.0557	-.0621
55	-.0053	-.0085	-.0141	-.0246	-.0371	-.0445	-.0533	-.0632	-.0730
60	-.0043	-.0071	-.0123	-.0229	-.0365	-.0451	-.0557	-.0682	-.0809
65	-.0035	-.0059	-.0106	-.0208	-.0350	-.0444	-.0564	-.0708	-.0860
70	-.0029	-.0048	-.0090	-.0185	-.0328	-.0426	-.0555	-.0714	-.0885
75	-.0024	-.0040	-.0075	-.0162	-.0300	-.0399	-.0533	-.0702	-.0887
80	-.0020	-.0032	-.0062	-.0139	-.0269	-.0366	-.0500	-.0674	-.0866
85	-.0016	-.0026	-.0050	-.0116	-.0235	-.0328	-.0459	-.0632	-.0825
90	-.0013	-.0020	-.0039	-.0095	-.0201	-.0287	-.0411	-.0578	-.0768
100	-.0007	-.0011	-.0021	-.0055	-.0131	-.0199	-.0300	-.0443	-.0609
110	-.0002	-.0003	-.0006	-.0021	-.0065	-.0109	-.0180	-.0285	-.0411
120	.0003	.0005	.0007	.0008	-.0005	-.0024	-.0060	-.0118	-.0191
130	.0007	.0011	.0018	.0033	.0048	.0052	.0053	.0045	.0030
140	.0011	.0016	.0027	.0053	.0091	.0118	.0152	.0194	.0237
150	.0014	.0021	.0035	.0068	.0126	.0171	.0234	.0319	.0415
160	.0016	.0024	.0040	.0079	.0151	.0209	.0295	.0413	.0551
170	.0017	.0026	.0043	.0086	.0166	.0233	.0332	.0472	.0636
180	.0018	.0027	.0044	.0088	.0171	.0241	.0345	.0492	.0665

TABLE B 6.2.1-10

C_{sp}			L_r/L_c = 1.000				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ø°									
0	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000
5	-.3359	-.3556	-.3778	-.4037	-.4251	-.4357	-.4471	-.4589	-.4700
10	-.2032	-.2338	-.2700	-.3145	-.3526	-.3723	-.3935	-.4159	-.4371
15	-.1117	-.1433	-.1839	-.2374	-.2867	-.3125	-.3413	-.3723	-.4022
20	-.0517	-.0791	-.1174	-.1728	-.2275	-.2574	-.2915	-.3290	-.3657
25	-.0143	-.0352	-.0679	-.1199	-.1756	-.2074	-.2446	-.2865	-.3281
30	.0055	-.0082	-.0331	-.0782	-.1311	-.1630	-.2012	-.2454	-.2901
35	.0141	.0069	-.0099	-.0461	-.0937	-.1239	-.1615	-.2060	-.2521
40	.0174	.0151	.0052	-.0218	-.0625	-.0900	-.1255	-.1687	-.2144
45	.0173	.0183	.0142	-.0041	-.0369	-.0610	-.0931	-.1336	-.1774
50	.0148	.0182	.0186	.0084	-.0164	-.0364	-.0644	-.1010	-.1416
55	.0122	.0167	.0204	.0168	-.0002	-.0158	-.0391	-.0709	-.1071
60	.0103	.0150	.0205	.0222	.0125	.0012	-.0170	-.0433	-.0743
65	.0082	.0129	.0194	.0253	.0220	.0150	.0019	-.0184	-.0435
70	.0063	.0107	.0178	.0266	.0290	.0260	.0181	.0040	-.0148
75	.0053	.0092	.0161	.0269	.0340	.0345	.0316	.0237	.0116
80	.0047	.0080	.0145	.0264	.0372	.0410	.0427	.0409	.0355
85	.0039	.0068	.0129	.0254	.0391	.0457	.0516	.0555	.0568
90	.0034	.0059	.0115	.0241	.0399	.0489	.0585	.0678	.0753
100	.0032	.0050	.0095	.0211	.0392	.0515	.0670	.0854	.1041
110	.0028	.0044	.0079	.0181	.0364	.0504	.0696	.0943	.1216
120	.0025	.0038	.0067	.0153	.0324	.0466	.0674	.0957	.1281
130	.0024	.0035	.0058	.0127	.0277	.0410	.0614	.0902	.1244
140	.0018	.0027	.0047	.0101	.0225	.0341	.0524	.0791	.1114
150	.0016	.0023	.0037	.0077	.0171	.0263	.0412	.0634	.0908
160	.0009	.0015	.0025	.0051	.0115	.0178	.0283	.0442	.0640
170	.0006	.0008	.0013	.0026	.0058	.0090	.0144	.0227	.0331
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-11

C_{fp}			L_r/L_c = 1.000				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
φ°									
0	-1.9400	-1.6935	-1.4193	-1.1056	-.8503	-.7251	-.5917	-.4532	-.3238
5	-1.7475	-1.5619	-1.3438	-1.0794	-.8532	-.7392	-.6155	-.4850	-.3618
10	-1.2762	-1.2137	-1.1129	-.9562	-.7967	-.7086	-.6082	-.4978	-.3900
15	-.8448	-.8724	-.8677	-.8103	-.7190	-.6594	-.5857	-.4992	-.4107
20	-.5472	-.6122	-.6608	0.6724	-.6371	-.6034	-.5553	-.4931	-.4252
25	-.3183	-.3983	-.4781	-.5399	-.5517	-.5415	-.5179	-.4800	-.4337
30	-.1485	-.2305	-.3245	-.4190	-.4678	-.4777	-.4763	-.4616	-.4366
35	-.0607	-.1268	-.2147	-.3201	-.3922	-.4173	-.4341	-.4398	-.4347
40	-.0174	-.0631	-.1358	-.2392	-.3243	-.3604	-.3919	-.4153	-.4284
45	.0185	-.0139	-.0732	-.1704	-.2624	-.3065	-.3496	-.3882	-.4178
50	.0329	.0129	-.0317	-.1168	-.2090	-.2576	-.3090	-.3598	-.4034
55	.0248	.0180	-.0097	-.0782	-.1645	-.2146	-.2710	-.3307	-.3858
60	.0221	.0220	.0059	-.0476	-.1262	-.1757	-.2347	-.3008	-.3651
65	.0251	.0266	.0174	-.0236	-.0935	-.1410	-.2006	-.2706	-.3416
70	.0164	.0213	.0195	-.0085	-.0675	-.1115	-.1695	-.2408	-.3159
75	.0068	.0142	.0179	.0013	-.0466	-.0860	-.1408	-.2114	-.2882
80	.0090	.0143	.0190	.0095	-.0288	-.0634	-.1142	-.1823	-.2589
85	.0089	.0128	.0180	.0144	-.0147	-.0443	-.0900	-.1541	-.2283
90	.0011	.0061	.0133	.0155	-.0044	-.0285	-.0684	-.1269	-.1968
100	.0051	.0067	.0115	.0181	.0114	-.0028	-.0304	-.0753	-.1324
110	-.0019	.0008	.0062	.0160	.0198	.0147	-.0002	-.0287	-.0684
120	.0044	.0046	.0073	.0161	.0257	.0277	.0245	.0128	-.0072
130	.0001	.0017	.0050	.0143	.0284	.0363	.0436	.0483	.0489
140	.0028	.0037	.0062	.0145	.0305	.0426	.0586	.0779	.0977
150	.0032	.0043	.0067	.0145	.0318	.0469	.0696	.1011	.1377
160	.0010	.0030	.0061	.0142	.0323	.0495	.0771	.1177	.1672
170	.0054	.0060	.0082	.0152	.0332	.0514	.0817	.1279	.1854
180	.0003	.0026	.0062	.0143	.0328	.0515	.0829	.1312	.1915

TABLE B 6.2.1-12

C_{qp}			L_r/L_c = 1.000				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	0	0	0	0	0	0	0	0	0
5	2.3911	1.7706	1.1976	.6909	.3905	.2770	.1778	.0954	.0340
10	2.8901	2.2299	1.5779	.9578	.5636	.4076	.2669	.1461	.0529
15	2.0653	1.7386	1.3439	.8934	.5626	.4195	.2832	.1596	.0593
20	1.4211	1.3108	1.1070	.8040	.5387	.4130	.2865	.1657	.0628
25	1.1162	1.0708	.9505	.7324	.5142	.4028	.2855	.1685	.0650
30	.6514	.7014	.6937	.5926	.4465	.3605	.2631	.1595	.0629
35	.2195	.3460	.4322	.4374	.3633	.3050	.2308	.1443	.0583
40	.1100	.2086	.2973	.3371	.3016	.2612	.2035	.1307	.0539
45	.0457	.1095	.1864	.2444	.2392	.2148	.1731	.1144	.0482
50	-.1338	-.0564	.0398	.1328	.1643	.1584	.1352	.0936	.0407
55	-.1900	-.1289	-.0439	.0540	.1043	.1107	.1015	.0740	.0334
60	-.1221	-.1085	-.0642	.0099	.0611	.0735	.0732	.0566	.0265
65	-.1581	-.1494	-.1142	-.0451	.0129	.0325	.0421	.0372	.0188
70	-.2275	-.2065	-.1675	-.0973	-.0328	-.0068	.0118	.0180	.0109
75	-.1753	-.1774	-.1631	-.1161	-.0601	-.0336	-.0112	.0022	.0042
80	-.1343	-.1524	-.1568	-.1295	-.0827	-.0568	-.0318	-.0124	-.0023
85	-.1929	-.1921	-.1857	-.1566	-.1099	-.0825	-.0536	-.0275	-.0089
90	-.1981	-.1946	-.1896	-.1676	-.1268	-.1004	-.0703	-.0399	-.0146
100	-.1472	-.1565	-.1658	-.1648	-.1416	-.1208	-.0925	-.0582	-.0235
110	-.1493	-.1527	-.1585	-.1615	-.1479	-.1317	-.1060	-.0703	-.0298
120	-.1537	-.1500	-.1497	-.1516	-.1441	-.1320	-.1099	-.0756	-.0330
130	-.0972	-.1059	-.1148	-.1249	-.1263	-.1196	-.1030	-.0731	-.0327
140	-.1315	-.1220	-.1154	-.1137	-.1122	-.1066	-.0929	-.0659	-.0303
150	-.0515	-.0607	-.0687	-.0773	-.0825	-.0809	-.0725	-.0535	-.0247
160	-.0763	-.0690	-.0634	-.0608	-.0607	-.0587	-.0523	-.0386	-.0179
170	-.0157	-.0196	-.0228	-.0261	-.0285	-.0284	-.0259	-.0195	-.0091
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-13

C_{mt}				L_r/L_c = .200			X = 0		
γ	.20	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ°									
0	0	0	0	0	0	0	0	0	0
5	-.0025	-.0031	-.0040	-.0056	-.0076	-.0089	-.0107	-.0131	-.0162
10	-.0030	-.0040	-.0056	-.0085	-.0122	-.0147	-.0182	-.0229	-.0289
15	-.0028	-.0040	-.0059	-.0097	-.0147	-.0182	-.0231	-.0298	-.0385
20	-.0024	-.0036	-.0056	-.0098	-.0157	-.0199	-.0258	-.0342	-.0451
25	-.0020	-.0031	-.0051	-.0093	-.0156	-.0202	-.0269	-.0365	-.0491
30	-.0017	-.0026	-.0044	-.0084	-.0148	-.0196	-.0267	-.0370	-.0509
35	-.0015	-.0022	-.0038	-.0074	-.0135	-.0183	-.0255	-.0361	-.0506
40	-.0012	-.0019	-.0037	-.0064	-.0120	-.0165	-.0235	-.0340	-.0487
45	-.0010	-.0015	-.0026	-.0053	-.0102	-.0144	-.0209	-.0310	-.0454
50	-.0008	-.0012	-.0021	-.0043	-.0085	-.0121	-.0180	-.0273	-.0409
55	-.0006	-.0009	-.0015	-.0033	-.0067	-.0097	-.0148	-.0231	-.0355
60	-.0004	-.0006	-.0011	-.0023	-.0049	-.0074	-.0115	-.0186	-.0294
65	-.0002	-.0004	-.0006	-.0014	-.0032	-.0050	-.0082	-.0139	-.0229
70	-.0001	-.0001	-.0002	-.0006	-.0016	-.0028	-.0050	-.0092	-.0161
75	.0001	.0001	.0002	.0002	-.0001	-.0007	-.0019	-.0045	-.0093
80	.0002	.0003	.0005	.0009	.0012	.0013	.0010	-.0001	-.0026
85	.0003	.0005	.0008	.0015	.0025	.0031	.0037	.0042	.0039
90	.0005	.0007	.0011	.0020	.0035	.0047	.0062	.0080	.0099
100	.0006	.0009	.0015	.0029	.0053	.0072	.0101	.0145	.0204
110	.0007	.0011	.0018	.0034	.0063	.0088	.0128	.0190	.0280
120	.0008	.0011	.0019	.0036	.0068	.0096	.0141	.0214	.0324
130	.0007	.0011	.0018	.0035	.0067	.0095	.0141	.0218	.0335
140	.0007	.0010	.0016	.0032	.0061	.0086	.0129	.0201	.0314
150	.0005	.0008	.0013	.0026	.0050	.0071	.0106	.0167	.0263
160	.0004	.0006	.0009	.0018	.0035	.0050	.0075	.0120	.0189
170	.0002	.0003	.0005	.0010	.0018	.0026	.0039	.0062	.0099
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-14

C_{st}			L_r/L_c = .200					X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-.0463	-.0536	-.0646	-.0833	-.1066	-.1221	-.1430	-.1713	-.2072
5	-.0141	-.0201	-.0296	-.0465	-.0682	-.0829	-.1030	-.1303	-.1652
10	-.0004	-.0036	-.0096	-.0219	-.0396	-.0522	-.0698	-.0946	-.1267
15	.0038	.0032	.0007	-.0064	-.0189	-.0286	-.0429	-.0638	-.0918
20	.0047	.0054	.0055	.0029	-.0043	-.0109	-.0214	-.0376	-.0605
25	.0041	.0056	.0073	.0081	.0057	.0022	-.0043	-.0156	-.0327
30	.0033	.0050	.0075	.0108	.0122	.0116	.0089	.0027	-.0083
35	.0029	.0045	.0072	.0020	.0164	.0182	.0190	.0176	.0128
40	.0027	.0041	.0069	.0123	.0189	.0226	.0264	.0295	.0307
45	.0024	.0037	.0064	.0122	.0202	.0254	.0317	.0387	.0454
50	.0022	.0034	.0059	.0117	.0206	.0269	.0351	.0455	.0572
55	.0022	.0033	.0056	.0112	.0205	.0274	.0371	.0503	.0662
60	.0021	.0031	.0053	.0106	.0198	.0272	.0379	.0531	.0726
65	.0019	.0029	.0049	.0098	.0189	.0263	.0376	.0543	.0766
70	.0018	.0027	.0045	.0091	.0177	.0250	.0365	.0540	.0783
75	.0017	.0025	.0042	.0083	.0163	.0234	.0347	.0525	.0779
80	.0015	.0022	.0037	.0075	.0148	.0214	.0323	.0499	.0757
85	.0013	.0020	.0033	.0066	.0132	.0193	.0294	.0464	.0718
90	.0012	.0017	.0029	.0058	.0115	.0169	.0262	.0421	.0665
100	.0008	.0012	.0020	.0039	.0080	.0119	.0190	.0317	.0523
110	.0005	.0006	.0011	.0021	.0044	.0068	.0113	.0200	.0349
120	.0000	.0001	.0001	.0004	.0010	.0018	.0036	.0078	.0158
130	-.0003	-.0004	-.0007	-.0013	-.0022	-.0029	-.0036	-.0040	-.0033
140	-.0006	-.0009	-.0014	-.0027	-.0051	-.0070	-.0101	-.0147	-.0211
150	-.0008	-.0012	-.0020	-.0039	-.0074	-.0104	-.0154	-.0237	-.0362
160	-.0010	-.0015	-.0025	-.0048	-.0091	-.0130	-.0194	-.0305	-.0478
170	-.0011	-.0017	-.0027	-.0053	-.0102	-.0145	-.0219	-.0347	-.0550
180	-.0011	-.0017	-.0028	-.0055	-.0105	-.0150	-.0227	-.0361	-.0575

TABLE B 6.2.1-15

C_{ft}			L_r/L_c = .200				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000
5	-.2464	-.2738	-.3066	-.3467	-.3813	-.3989	-.4182	-.4393	-.4610
10	-.0863	-.1199	-.1637	-.2230	-.2787	-.3085	-.3423	-.3803	-.4204
15	-.0223	-.0449	-.0804	-.1374	-.1988	-.2342	-.2762	-.3256	-.3796
20	.0000	-.0111	-.0342	-.0802	-.1381	-.1744	-.2197	-.2755	-.3390
25	.0098	.0049	-.0087	-.0426	-.0927	-.1269	-.1719	-.2301	-.2991
30	.0080	.0074	.0014	-.0205	-.0602	-.0903	-.1323	-.1894	-.2603
35	.0026	.0045	.0038	-.0082	-.0374	-.0623	-.0994	-.1530	-.2227
40	.0025	.0042	.0052	-.0005	-.0208	-.0405	-.0721	-.1205	-.1865
45	.0032	.0041	.0056	.0039	-.0091	-.0238	-.0494	-.0914	-.1519
50	.0007	.0020	.0042	.0056	-.0011	-.0111	-.0307	-.0657	-.1190
55	.0002	.0014	.0037	.0067	.0048	-.0013	-.0152	-.0428	-.0880
60	.0023	.0028	.0044	.0080	.0093	.0065	-.0023	-.0226	-.0590
65	.0020	.0026	.0043	.0084	.0124	.0125	.0084	-.0049	-.0320
70	.0006	.0018	.0038	.0086	.0146	.0171	.0171	.0106	-.0073
75	.0018	.0027	.0045	.0092	.0166	.0208	.0244	.0240	.0153
80	.0028	.0035	.0051	.0098	.0180	.0238	.0303	.0355	.0355
85	.0016	.0027	.0048	.0099	.0189	.0259	.0349	.0451	.0533
90	.0014	.0026	.0048	.0101	.0197	.0274	.0385	.0530	.0687
100	.0025	.0034	.0054	.0106	.0205	.0293	.0431	.0641	.0922
110	.0021	.0032	.0052	.0104	.0203	.0293	.0445	.0694	.1061
120	.0017	.0028	.0048	.0098	.0192	.0280	.0432	.0696	.1107
130	.0024	.0031	.0047	.0090	.0174	.0254	.0396	.0652	.1069
140	.0009	.0019	.0036	.0074	.0148	.0217	.0341	.0570	.0934
150	.0018	.0022	.0033	.0061	.0117	.0172	.0270	.0456	.0774
160	.0004	.0009	.0019	.0040	.0080	.0118	.0187	.0317	.0545
170	.0007	.0008	.0012	.0022	.0041	.0061	.0096	.0163	.0281
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-16

C_{gt}			L_r/L_c = .400			X = 0			
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	1.3464	1.1650	.9557	.7093	.5064	.4071	.3012	.1897	.0799
5	1.0085	.9055	.7738	.6008	.4439	.3624	.2723	.1741	.0743
10	.3621	.3933	.4016	.3692	.3057	.2620	.2063	.1378	.0610
15	-.0382	.0401	.1140	.1674	.1739	.1623	.1379	.0986	.0461
20	-.1457	-.0972	-.0339	.0362	.0747	.0824	.0798	.0633	.0320
25	-.2033	-.1771	-.1303	-.0609	-.0061	.0145	.0282	.0306	.0184
30	-.2532	-.2324	-.1946	-.1304	-.0691	-.0408	-.0157	.0015	.0058
35	-.2291	-.2239	-.2059	-.1618	-.1076	-.0781	-.0480	-.0216	-.0048
40	-.1925	-.1993	-.1975	-.1732	-.1305	-.1032	-.0718	-.0399	-.0137
45	-.2007	-.2018	-.1997	-.1823	-.1470	-.1219	-.0904	-.0549	-.0214
50	-.1972	-.1952	-.1928	-.1814	-.1540	-.1321	-.1025	-.0659	-.0274
55	-.1629	-.1671	-.1712	-.1691	-.1516	-.1342	-.1082	-.0727	-.0318
60	-.1519	-.1550	-.1586	-.1591	-.1473	-.1335	-.1107	-.0771	-.0349
65	-.1576	-.1546	-.1530	-.1511	-.1418	-.1304	-.1106	-.0791	-.0370
70	-.1360	-.1356	-.1359	-.1364	-.1312	-.1229	-.1067	-.0784	-.0377
75	-.1105	-.1139	-.1171	-.1204	-.1188	-.1131	-.1003	-.0757	-.0373
80	-.1100	-.1092	-.1089	-.1094	-.1080	-.1038	-.0934	-.0719	-.0362
85	-.1019	-.0994	-.0975	-.0968	-.0959	-.0929	-.0848	-.0666	-.0343
90	-.0739	-.0759	-.0777	-.0799	-.0812	-.0799	-.0744	-.0598	-.0315
100	-.0599	-.0576	-.0559	-.0553	-.0560	-.0559	-.0536	-.0448	-.0247
110	-.0178	-.0204	-.0229	-.0255	-.0283	-.0299	-.0305	-.0275	-.0162
120	-.0069	-.0051	-.0039	-.0037	-.0054	-.0071	-.0092	-.0104	-.0072
130	.0264	.0248	.0232	.0210	.0180	.0154	.0115	.0065	.0019
140	.0404	.0406	.0404	.0392	.0365	.0338	.0291	.0212	.0101
150	.0561	.0563	.0561	.0549	.0520	.0491	.0437	.0336	.0171
160	.0734	.0718	.0701	.0677	.0641	.0608	.0547	.0430	.0225
170	.0708	.0722	.0731	.0727	.0700	.0670	.0609	.0485	.0257
180	.0853	.0830	.0806	.0776	.0737	.0702	.0637	.0507	.0270

TABLE B 6.2.1-17

C_{mt}				L_r/L_c = .400				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^{o}									
0	0	0	0	0	0	0	0	0	0
5	-.0031	-.0038	-.0048	-.0065	-.0085	-.0098	-.0115	-.0138	-.0166
10	-.0041	-.0052	-.0070	-.0101	-.0139	-.0164	-.0197	-.0242	-.0297
15	-.0039	-.0053	-.0076	-.0117	-.0169	-.0204	-.0252	-.0316	-.0395
20	-.0034	-.0048	-.0073	-.0119	-.0182	-.0225	-.0284	-.0364	-.0464
25	-.0027	-.0041	-.0065	-.0113	-.0182	-.0230	-.0297	-.0389	-.0506
30	-.0022	-.0033	-.0056	-.0103	-.0172	-.0223	-.0295	-.0396	-.0525
35	-.0017	-.0027	-.0046	-.0089	-.0157	-.0208	-.0282	-.0387	-.0523
40	-.0013	-.0021	-.0037	-.0075	-.0138	-.0188	-.0260	-.0365	-.0504
45	-.0010	-.0016	-.0029	-.0061	-.0117	-.0163	-.0232	-.0334	-.0469
50	-.0007	-.0012	-.0021	-.0047	-.0096	-.0136	-.0199	-.0294	-.0423
55	-.0005	-.0008	-.0015	-.0035	-.0074	-.0109	-.0163	-.0249	-.0368
60	-.0003	-.0005	-.0009	-.0023	-.0053	-.0081	-.0127	-.0200	-.0305
65	-.0001	-.0002	-.0004	-.0012	-.0033	-.0054	-.0090	-.0150	-.0237
70	.0000	.0000	.0000	-.0003	-.0015	-.0028	-.0054	-.0099	-.0167
75	.0002	.0003	.0004	.0006	.0002	-.0004	-.0019	-.0048	-.0096
80	.0003	.0005	.0008	.0013	.0018	.0018	.0013	.0000	-.0027
85	.0004	.0007	.0011	.0020	.0031	.0037	.0043	.0045	.0040
90	.0006	.0008	.0013	.0025	.0043	.0055	.0070	.0087	.0102
100	.0007	.0011	.0017	.0034	.0061	.0082	.0112	.0156	.0210
110	.0008	.0012	.0020	.0039	.0071	.0099	.0141	.0204	.0290
120	.0008	.0013	.0021	.0040	.0076	.0106	.0154	.0230	.0336
130	.0008	.0012	.0020	.0039	.0074	.0104	.0153	.0233	.0347
140	.0007	.0011	.0018	.0035	.0066	.0094	.0140	.0215	.0325
150	.0006	.0009	.0014	.0028	.0054	.0077	.0115	.0179	.0272
160	.0004	.0006	.0010	.0020	.0038	.0054	.0082	.0128	.0196
170	.0002	.0003	.0005	.0010	.0020	.0028	.0042	.0066	.0102
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-18

	C_{st}		L_r/L_c = .400				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-.0546	-.0626	-.0744	-.0938	-.1172	-.1325	-.1526	-.1792	-.2116
5	-.0206	-.0274	-.0380	-.0558	-.0780	-.0926	-.1120	-.1379	-.1695
10	-.0028	-.0071	-.0145	-.0284	-.0472	-.0600	-.0775	-.1012	-.1306
15	.0048	.0033	-.0005	-.0096	-.0237	-.0341	-.0487	-.0691	-.0951
20	.0073	.0077	.0070	.0026	-.0064	-.0138	-.0250	-.0414	-.0630
25	.0071	.0088	.0103	.0101	.0060	.0015	-.0059	-.0178	-.0344
30	.0060	.0083	.0112	.0142	.0144	.0129	.0091	.0019	-.0092
35	.0049	.0072	.0109	.0160	.0199	.0209	.0207	.0182	.0127
40	.0040	.0062	.0100	.0165	.0231	.0264	.0293	.0312	.0312
45	.0032	.0052	.0089	.0160	.0247	.0297	.0354	.0413	.0466
50	.0027	.0044	.0078	.0151	.0250	.0315	.0394	.0489	.0589
55	.0024	.0039	.0069	.0140	.0246	.0319	.0417	.0541	.0683
60	.0022	.0034	.0061	.0127	.0235	.0315	.0424	.0572	.0750
65	.0020	.0030	.0054	.0115	.0220	.0302	.0420	.0585	.0792
70	.0018	.0028	.0048	.0103	.0203	.0285	.0406	.0582	.0810
75	.0017	.0025	.0043	.0091	.0184	.0263	.0384	.0565	.0807
80	.0015	.0022	.0038	.0080	.0164	.0238	.0356	.0537	.0784
85	.0013	.0019	.0033	.0069	.0144	.0212	.0323	.0498	.0744
90	.0011	.0017	.0028	.0058	.0123	.0184	.0286	.0451	.0689
100	.0007	.0011	.0018	.0038	.0082	.0126	.0204	.0339	.0542
110	.0004	.0006	.0009	.0019	.0043	.0069	.0119	.0213	.0361
120	.0000	.0000	.0000	.0001	.0005	.0014	.0035	.0082	.0164
130	-.0003	-.0005	-.0008	-.0016	-.0028	-.0036	-.0043	-.0045	-.0034
140	-.0007	-.0010	-.0016	-.0031	-.0057	-.0079	-.0112	-.0159	-.0218
150	-.0009	-.0013	-.0022	-.0043	-.0081	-.0115	-.0169	-.0254	-.0375
160	-.0011	-.0016	-.0027	-.0052	-.0099	-.0141	-.0211	-.0326	-.0495
170	-.0012	-.0018	-.0029	-.0057	-.0110	-.0157	-.0237	-.0370	-.0570
180	-.0012	-.0018	-.0030	-.0059	-.0113	-.0163	-.0245	-.0385	-.0595

TABLE B 6.2.1-19

C_{ft}			L_r/L_c = .400				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000
5	-.2862	-.3103	-.3382	-.3715	-.3998	-.4141	-.4298	-.4469	-.4644
10	-.1334	-.1664	-.2075	-.2605	-.3084	-.3336	-.3619	-.3936	-.4265
15	-.0508	-.0784	-.1175	-.1744	-.2313	-.2629	-.2997	-.3421	-.3875
20	-.0096	-.0279	-.0585	-.1101	-.1680	-.2023	-.2438	-.2933	-.3479
25	.0100	-.0003	-.0214	-.0636	-.1173	-.1514	-.1944	-.2477	-.3083
30	.0141	.0105	-.0014	-.0322	-.0782	-.1098	-.1516	-.2056	-.2693
35	.0113	.0122	.0078	-.0120	-.0486	-.0763	-.1149	-.1672	-.2311
40	.0093	.0119	.0119	.0009	-.0264	-.0495	-.0836	-.1322	-.1940
45	.0074	.0103	.0128	.0085	-.0102	-.0284	-.0572	-.1007	-.1583
50	.0042	.0074	.0113	.0121	.0012	-.0121	-.0351	-.0724	-.1243
55	.0026	.0054	.0097	.0138	.0092	.0005	-.0168	-.0472	-.0921
60	.0029	.0048	.0087	.0145	.0149	.0102	-.0015	-.0249	-.0619
65	.0023	.0039	.0075	.0142	.0185	.0174	.0109	-.0053	-.0339
70	.0014	.0029	.0063	.0136	.0208	.0227	.0210	.0117	-.0081
75	.0019	.0031	.0060	.0132	.0224	.0267	.0291	.0264	.0154
80	.0025	.0034	.0059	.0128	.0233	.0295	.0355	.0389	.0364
85	.0018	.0029	.0054	.0122	.0236	.0313	.0404	.0492	.0550
90	.0018	.0029	.0053	.0118	.0237	.0325	.0441	.0577	.0710
100	.0024	.0034	.0055	.0114	.0232	.0333	.0482	.0694	.0955
110	.0022	.0032	.0053	.0108	.0221	.0323	.0489	.0747	.1099
120	.0019	.0029	.0050	.0100	.0203	.0302	.0468	.0745	.1147
130	.0021	.0030	.0047	.0091	.0181	.0269	.0425	.0695	.1107
140	.0012	.0021	.0038	.0076	.0152	.0227	.0362	.0605	.0987
150	.0006	.0021	.0032	.0061	.0120	.0178	.0285	.0483	.0801
160	.0006	.0011	.0020	.0041	.0082	.0122	.0196	.0336	.0564
170	.0006	.0008	.0011	.0022	.0042	.0062	.0100	.0172	.0291
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-20

C_{qt}				L_r/L_c = .400			X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	1.0802	.9271	.7551	.5572	.3969	.3188	.2357	.1481	.0619
5	.8619	.7629	.6421	.4909	.3590	.2918	.2182	.1386	.0585
10	.4200	.4205	.3988	.3427	.2715	.2285	.1766	.1157	.0501
15	.0895	.1419	.1824	.1975	.1794	.1594	.1297	.0889	.0399
20	-.0676	-.0167	.0374	.0844	.0998	.0970	.0853	.0625	.0295
25	-.1646	-.1238	-.0702	-.0087	.0292	.0397	.0432	.0365	.0190
30	-.2271	-.1947	-.1465	-.0812	-.0302	-.0102	.0051	.0122	.0088
35	-.2291	-.2129	-.1809	-.1260	-.0734	-.0488	-.0261	-.0088	-.0004
40	-.2111	-.2086	-.1925	-.1523	-.1040	-.0781	-.0512	-.0266	-.0086
45	-.2098	-.2094	-.2000	-.1698	-.1267	-.1008	-.0716	-.0417	-.0156
50	-.2000	-.2006	-.1964	-.1759	-.1400	-.1159	-.0865	-.0535	-.0215
55	-.1735	-.1785	-.1811	-.1714	-.1445	-.1236	-.0959	-.0620	-.0281
60	-.1594	-.1640	-.1681	-.1644	-.1447	-.1270	-.1015	-.0679	-.0296
65	-.1547	-.1555	-.1576	-.1559	-.1415	-.1267	-.1039	-.0715	-.0320
70	-.1363	-.1378	-.1408	-.1424	-.1335	-.1221	-.1025	-.0724	-.0333
75	-.1160	-.1189	-.1231	-.1272	-.1230	-.1146	-.0985	-.0713	-.0336
80	-.1089	-.1092	-.1109	-.1141	-.1122	-.1061	-.0928	-.0687	-.0330
85	-.0980	-.0970	-.0974	-.1000	-.0998	-.0957	-.0853	-.0645	-.0316
90	-.0767	-.0780	-.0799	-.0837	-.0857	-.0836	-.0761	-.0588	-.0294
100	-.0562	-.0551	-.0546	-.0562	-.0589	-.0590	-.0558	-.0451	-.0235
110	-.0215	-.0230	-.0244	-.0270	-.0309	-.0329	-.0332	-.0287	-.0159
120	-.0038	-.0029	-.0025	-.0032	-.0063	-.0088	-.0114	-.0119	-.0075
130	.0244	.0235	.0224	.0206	.0171	.0140	.0096	.0047	.0010
140	.0411	.0410	.0407	.0395	.0363	.0331	.0278	.0195	.0089
150	.0568	.0568	.0565	.0552	.0521	.0488	.0427	.0320	.0156
160	.0715	.0705	.0693	.0674	.0640	.0605	.0539	.0414	.0208
170	.0735	.0742	.0743	.0734	.0705	.0672	.0605	.0471	.0240
180	.0823	.0809	.0793	.0771	.0735	.0700	.0631	.0492	.0251

TABLE B 6.2.1-21

C_{mt}			L_r/L_c = 1.000				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	0	0	0	0	0	0	0	0	0
5	-.0045	-.0054	-.0066	-.0084	-.0106	-.0119	-.0136	-.0155	-.0175
10	-.0065	-.0080	-.0102	-.0138	-.0179	-.0205	-.0237	-.0275	-.0315
15	-.0069	-.0088	-.0118	-.0168	-.0226	-.0263	-.0308	-.0363	-.0421
20	-.0064	-.0086	-.0120	-.0179	-.0251	-.0296	-.0354	-.0423	-.0497
25	-.0055	-.0077	-.0113	-.0177	-.0258	-.0311	-.0377	-.0458	-.0544
30	-.0044	-.0065	-.0100	-.0166	-.0252	-.0309	-.0382	-.0471	-.0567
35	-.0034	-.0053	-.0085	-.0149	-.0236	-.0295	-.0371	-.0466	-.0568
40	-.0026	-.0041	-.0069	-.0129	-.0213	-.0271	-.0348	-.0444	-.0550
45	-.0018	-.0030	-.0054	-.0106	-.0185	-.0241	-.0315	-.0410	-.0514
50	-.0012	-.0020	-.0039	-.0084	-.0154	-.0205	-.0275	-.0366	-.0466
55	-.0007	-.0012	-.0026	-.0062	-.0122	-.0167	-.0231	-.0314	-.0407
60	-.0002	-.0006	-.0014	-.0041	-.0090	-.0128	-.0183	-.0256	-.0339
65	.0001	.0000	-.0004	-.0022	-.0058	-.0089	-.0134	-.0196	-.0266
70	.0004	.0005	.0004	-.0005	-.0029	-.0051	-.0085	-.0133	-.0190
75	.0006	.0009	.0011	.0011	-.0001	-.0015	-.0038	-.0071	-.0113
80	.0008	.0012	.0017	.0024	.0024	.0019	.0008	-.0011	-.0036
85	.0010	.0014	.0022	.0035	.0046	.0049	.0050	.0046	.0038
90	.0011	.0016	.0026	.0044	.0065	.0076	.0088	.0099	.0108
100	.0013	.0019	.0031	.0057	.0094	.0118	.0150	.0188	.0229
110	.0013	.0021	.0033	.0064	.0111	.0145	.0192	.0252	.0318
120	.0013	.0020	.0033	.0065	.0117	.0157	.0213	.0287	.0371
130	.0012	.0019	.0031	.0061	.0113	.0154	.0213	.0293	.0385
140	.0011	.0016	.0027	.0053	.0101	.0139	.0195	.0272	.0361
150	.0009	.0013	.0022	.0043	.0082	.0114	.0161	.0227	.0304
160	.0006	.0009	.0015	.0030	.0057	.0080	.0115	.0163	.0219
170	.0003	.0005	.0008	.0015	.0030	.0042	.0060	.0085	.0114
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-22

C_{st}			L_r/L_c = 1.000				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-.0713	-.0811	-.0951	-.1171	-.1421	-.1574	-.1763	-.1988	-.2222
5	-.0349	-.0438	-.0568	-.0777	-.1017	-.1166	-.1350	-.1569	-.1799
10	-.0117	-.0183	-.0287	-.0465	-.0678	-.0813	-.0983	-.1187	-.1403
15	.0018	-.0021	-.0091	-.0225	-.0400	-.0515	-.0662	-.0843	-.1036
20	.0087	.0075	.0040	-.0047	-.0176	-.0267	-.0387	-.0538	-.0701
25	.0115	.0123	.0119	.0080	-.0001	-.0064	-.0153	-.0269	-.0398
30	.0117	.0141	.0162	.0166	.0133	.0097	.0042	-.0037	-.0129
35	.0108	.0141	.0181	.0220	.0230	.0222	.0200	.0160	.0108
40	.0094	.0131	.0182	.0249	.0298	.0315	.0324	.0323	.0311
45	.0079	.0116	.0173	.0260	.0341	.0380	.0420	.0455	.0482
50	.0065	.0010	.0159	.0258	.0364	.0423	.0488	.0557	.0621
55	.0053	.0085	.0141	.0246	.0371	.0445	.0533	.0632	.0730
60	.0043	.0071	.0123	.0229	.0365	.0451	.0557	.0682	.0809
65	.0035	.0059	.0106	.0208	.0350	.0444	.0564	.0708	.0860
70	.0029	.0048	.0090	.0185	.0328	.0426	.0555	.0714	.0885
75	.0024	.0040	.0075	.0162	.0300	.0399	.0533	.0702	.0887
80	.0020	.0032	.0062	.0139	.0269	.0366	.0500	.0674	.0866
85	.0016	.0026	.0050	.0116	.0235	.0328	.0459	.0632	.0825
90	.0013	.0020	.0039	.0095	.0201	.0287	.0411	.0578	.0768
100	.0007	.0011	.0021	.0055	.0131	.0199	.0300	.0443	.0609
110	.0002	.0003	.0006	.0021	.0065	.0109	.0180	.0285	.0411
120	-.0003	-.0005	-.0007	-.0008	.0005	.0024	.0060	.0118	.0191
130	-.0007	-.0011	-.0018	-.0033	-.0048	-.0052	-.0053	-.0045	-.0030
140	-.0011	-.0016	-.0027	-.0053	-.0091	-.0118	-.0152	-.0194	-.0237
150	-.0014	-.0021	-.0035	-.0068	-.0126	-.0171	-.0234	-.0319	-.0415
160	-.0016	-.0024	-.0040	-.0079	-.0151	-.0209	-.0295	-.0413	-.0551
170	-.0017	-.0026	-.0043	-.0086	-.0166	-.0233	-.0332	-.0472	-.0636
180	-.0018	-.0027	-.0044	-.0088	-.0171	-.0241	-.0345	-.0492	-.0665

TABLE B 6.2.1-23

C_{ft}				L_r/L_c = 1.000				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000	-.5000
5	-.3359	-.3556	-.3778	-.4037	-.4251	-.4357	-.4471	-.4589	-.4700
10	-.2032	-.2338	-.2700	-.3145	-.3528	-.3723	-.3935	-.4159	-.4371
15	-.1117	-.1433	-.1839	-.2374	-.2867	-.3125	-.3413	-.3723	-.4022
20	-.0517	-.0791	-.1174	-.1728	-.2275	-.2574	-.2915	-.3290	-.3656
25	-.0143	-.0352	-.0679	-.1199	-.1756	-.2074	-.2446	-.2865	-.3281
30	.0055	-.0082	-.0332	-.0782	-.1311	-.1630	-.2012	-.2454	-.2901
35	.0141	.0069	-.0099	-.0461	-.0937	-.1239	-.1615	-.2060	-.2521
40	.0174	.0151	.0052	-.0218	-.0625	-.0900	-.1255	-.1687	-.2144
45	.0173	.0183	.0142	-.0041	-.0369	-.0610	-.0931	-.1336	-.1774
50	.0148	.0182	.0186	.0084	-.0164	-.0364	-.0644	-.1010	-.1416
55	.0122	.0167	.0204	.0168	-.0002	-.0158	-.0391	-.0709	-.1071
60	.0103	.0150	.0205	.0222	.0125	.0012	-.0170	-.0433	-.0743
65	.0082	.0129	.0194	.0253	.0220	.0150	.0019	-.0184	-.0435
70	.0063	.0107	.0178	.0266	.0290	.0260	.0181	.0040	-.0148
75	.0053	.0092	.0161	.0269	.0340	.0345	.0316	.0237	.0116
80	.0047	.0080	.0145	.0264	.0372	.0410	.0427	.0409	.0355
85	.0039	.0068	.0129	.0254	.0391	.0457	.0516	.0555	.0568
90	.0034	.0059	.0115	.0241	.0399	.0489	.0585	.0678	.0753
100	.0032	.0050	.0095	.0211	.0392	.0515	.0670	.0854	.1041
110	.0028	.0044	.0079	.0181	.0364	.0504	.0696	.0943	.1216
120	.0025	.0038	.0067	.0153	.0324	.0466	.0674	.0957	.1281
130	.0024	.0035	.0058	.0127	.0277	.0410	.0614	.0902	.1244
140	.0018	.0027	.0047	.0101	.0225	.0341	.0524	.0791	.1114
150	.0016	.0023	.0037	.0077	.0171	.0263	.0412	.0634	.0908
160	.0009	.0015	.0025	.0051	.0115	.0178	.0283	.0442	.0640
170	.0006	.0008	.0013	.0026	.0058	.0090	.0144	.0227	.0331
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-24

C_{qt}				L_r/L_c = 1.000				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ°o									
0	.7669	.6485	.5185	.3726	.2574	.2025	.1453	.0872	.0343
5	.6531	.5647	.4622	.3404	.2393	.1897	.1371	.0829	.0327
10	.4076	.3797	.3345	.2650	.1959	.1587	.1170	.0719	.0288
15	.1882	.2039	.2051	.1831	.1462	.1221	.0927	.0585	.0239
20	.0401	.0732	.0993	.1094	.0982	.0859	.0678	.0443	.0185
25	-.0704	-.0308	.0093	.0421	.0521	.0501	.0428	.0296	.0129
30	-.1490	-.1092	-.0633	-.0162	.0099	.0165	.0187	.0152	.0073
35	-.1855	-.1536	-.1116	-.0609	-.0254	-.0124	-.0029	.0020	.0020
40	-.1975	-.1765	-.1427	-.0943	-.0543	-.0370	-.0218	-.0100	-.0029
45	-.2053	-.1910	-.1642	-.1199	-.0780	-.0579	-.0383	-.0208	-.0073
50	-.2016	-.1933	-.1740	-.1363	-.9560	-.0742	-.0518	-.0299	-.0112
55	-.1859	-.1841	-.1731	-.1441	-.1071	-.0858	-.0620	-.0371	-.0145
60	-.1724	-.1737	-.1683	-.1468	-.1143	-.0939	-.0696	-.0428	-.0171
65	-.1611	-.1631	-.1608	-.1454	-.1176	-.0985	-.0747	-.0469	-.0191
70	-.1437	-.1471	-.1482	-.1390	-.1166	-.0996	-.0770	-.0493	-.0203
75	-.1254	-.1298	-.1335	-.1295	-.1125	-.0977	-.0770	-.0502	-.0210
80	-.1127	-.1160	-.1198	-.1189	-.1063	-.0938	-.0751	-.0497	-.0211
85	-.0987	-.1011	-.1049	-.1064	-.0979	-.0877	-.0714	-.0480	-.0206
90	-.0808	-.0837	-.0882	-.0921	-.0874	-.0797	-.0659	-.0450	-.0196
100	-.0549	-.0558	-.0587	-.0637	-.0642	-.0605	-.0517	-.0364	-.0162
110	-.0243	-.0257	-.0285	-.0342	-.0383	-.0379	-.0341	-.0250	-.0115
120	-.0020	-.0021	-.0033	-.0076	-.0131	-.0151	-.0153	-.0123	-.0060
130	.0230	.0224	.0211	.0172	.0109	.0072	.0036	-.0009	-.0002
140	.0415	.0413	.0406	.0378	.0317	.0269	.0207	.0131	.0054
150	.0573	.0572	.0567	.0544	.0487	.0434	.0352	.0237	.0102
160	.0703	.0697	.0689	.0669	.0614	.0557	.0462	.0318	.0139
170	.0753	.0755	.0752	.0739	.0689	.0631	.0529	.0368	.0163
180	.0803	.0796	.0787	.0769	.0717	.0659	.0554	.0386	.0171

TABLE B 6.2.1-25

C_{mm}			L_r/L_c = .200				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
φ°									
0	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000
5	.2439	.2708	.3026	.3411	.3737	.3900	.4075	.4262	.4448
10	.0833	.1159	.1581	.2145	.2665	.2937	.3241	.3574	.3915
15	.0195	.0409	.0745	.1278	.1841	.2160	.2532	.2958	.3411
20	-.0024	.0075	.0285	.0704	.1224	.1545	.1939	.2414	.2940
25	-.0119	-.0080	.0036	.0334	.0771	.1067	.1450	.1937	.2500
30	-.0098	-.0100	-.0059	.0121	.0455	.0707	.1056	.1524	.2094
35	-.0040	-.0067	-.0075	.0008	.0239	.0440	.0740	.1169	.1721
40	-.0037	-.0060	-.0083	-.0059	.0089	.0240	.0486	.0864	.1378
45	-.0042	-.0056	-.0081	-.0092	-.0012	.0094	.0285	.0604	.1065
50	-.0015	-.0032	-.0062	-.0098	-.0074	-.0010	.0128	.0384	.0781
55	-.0008	-.0023	-.0052	-.0100	-.0114	-.0084	.0004	.0197	.0525
60	-.0027	-.0034	-.0055	-.0102	-.0142	-.0139	-.0093	.0040	.0296
65	-.0022	-.0030	-.0049	-.0098	-.0156	-.0175	-.0166	-.0091	.0091
70	-.0007	-.0019	-.0041	-.0092	-.0162	-.0199	-.0221	-.0198	-.0088
75	-.0017	-.0026	-.0044	-.0091	-.0167	-.0215	-.0263	-.0286	-.0245
80	-.0026	-.0032	-.0046	-.0090	-.0168	-.0225	-.0293	-.0356	-.0380
85	-.0013	-.0022	-.0040	-.0084	-.0165	-.0228	-.0312	-.0410	-.0494
90	-.0010	-.0020	-.0038	-.0080	-.0161	-.0228	-.0324	-.0450	-.0587
100	-.0019	-.0025	-.0039	-.0077	-.0152	-.0221	-.0330	-.0497	-.0718
110	-.0014	-.0021	-.0035	-.0070	-.0140	-.0205	-.0317	-.0504	-.0781
120	-.0009	-.0016	-.0030	-.0061	-.0124	-.0184	-.0291	-.0481	-.0783
130	-.0016	-.0020	-.0029	-.0055	-.0107	-.0160	-.0256	-.0435	-.0733
140	-.0002	-.0009	-.0019	-.0043	-.0087	-.0131	-.0212	-.0369	-.0640
150	-.0013	-.0014	-.0019	-.0035	-.0068	-.0101	-.0164	-.0289	-.0511
160	.0000	-.0004	-.0009	-.0022	-.0045	-.0068	-.0111	-.0198	-.0356
170	-.0005	-.0005	-.0007	-.0012	-.0023	-.0035	-.0056	-.0101	-.0182
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-26

C_{sm}			L_r/L_c = .200				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-3.1704	-2.8075	-2.3889	-1.8961	-1.4903	-1.2916	-1.0799	-.8569	-.6374
5	-2.4933	-2.2873	-2.0239	-1.6779	-1.3640	-1.2011	-1.0209	-.8245	-.6249
10	-1.1968	-1.2592	-1.2758	-1.2111	-1.0840	-.9967	-.8853	-.7483	-.5946
15	-.3902	-.5468	-.6947	-.8013	-.8144	-.7911	-.7425	-.6638	-.5588
20	-.1669	-.2639	-.3905	-.5306	-.6077	-.6230	-.6179	-.5848	-.5222
25	-.0411	-.0934	-.1871	-.3259	-.4355	-.4766	-.5041	-.5088	-.4844
30	.0716	.0299	-.0457	-.1740	-.2967	-.3532	-.4035	-.4379	-.4464
35	.0383	.0279	-.0081	-.0964	-.2048	-.2636	-.3239	-.3768	-.4103
40	-.0180	-.0044	-.0080	-.0566	-.1421	-.1967	-.2594	-.3232	-.3755
45	.0172	.0194	.0150	-.0196	-.0902	-.1405	-.2034	-.2744	-.3414
50	.0306	.0266	.0218	-.0010	-.0557	-.0995	-.1588	-.2320	-.3089
55	-.0160	-.0076	.0006	-.0035	-.0386	-.0733	-.1254	-.1963	-.2782
60	-.0146	-.0082	-.0011	-.0002	-.0237	-.0514	-.0969	-.1642	-.2484
65	.0216	.0156	.0123	.0085	-.0102	-.0328	-.0725	-.1354	-.2198
70	.0040	.0032	.0038	.0048	-.0056	-.0222	-.0548	-.1112	-.1927
75	-.0206	-.0138	-.0073	-.0008	-.0041	-.0153	-.0409	-.0902	-.1669
80	.0055	.0040	.0034	.0045	.0016	-.0069	-.0277	-.0707	-.1420
85	.0169	.0119	.0081	.0067	.0048	-.0011	-.0173	-.0537	-.1184
90	-.0113	-.0073	-.0037	.0007	.0032	.0007	-.0103	-.0395	-.0961
100	.0159	.0114	.0080	.0067	.0082	.0080	.0033	-.0142	-.0546
110	-.0147	-.0094	-.0045	.0007	.0064	.0094	.0108	.0047	-.0180
120	.0139	.0103	.0078	.0074	.0107	.0141	.0185	.0208	.0144
130	-.0074	-.0042	-.0009	.0034	.0095	.0147	.0224	.0325	.0417
140	.0038	.0035	.0040	.0063	.0117	.0171	.0265	.0422	.0645
150	.0044	.0040	.0044	.0068	.0125	.0184	.0292	.0493	.0823
160	-.0069	-.0037	-.0003	.0046	.0118	.0185	.0306	.0540	.0950
170	.0128	.0099	.0081	.0090	.0143	.0204	.0325	.0573	.1028
180	-.0114	-.0067	-.0020	.0039	.0119	.0189	.0319	.0577	.1052

TABLE B 6.2.1-27

C_{fm}			L_r/L_c = .200				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	0	0	0	0	0	0	0	0	0
5	-13.8275	-10.7039	-7.5756	-4.5751	-2.6709	-1.9239	-1.2578	-.6955	-.2691
10	-13.4182	-11.0342	-8.3587	-5.4556	-3.3895	-2.5165	-1.7000	-.9755	-.3975
15	-5.0301	-5.1699	-4.8030	-3.8036	-2.7011	-2.1287	-1.5289	-.9369	-.4161
20	-1.2709	-2.0970	-2.6162	-2.5961	-2.1198	-1.7732	-1.3523	-.8830	-.4253
25	-1.6945	-1.8835	-2.0901	-2.1072	-1.8211	-1.5756	-1.2492	-.8539	-.4387
30	-.5018	-.7044	-1.0167	-1.3074	-1.3210	-1.2216	-1.0354	-.7591	-.4259
35	.9398	.5070	-.0102	-.5600	-.8293	-.8600	-.8049	-.6476	-.4038
40	.0709	.0269	-.1329	-.4314	-.6506	-.7012	-.6886	-.5867	-.3951
45	-.5668	-.3693	-.2806	-.3669	-.5163	-.5709	-.5851	-.5276	-.3839
50	.3487	.2645	.1546	-.0503	-.2714	-.3686	-.4368	-.4426	-.3613
55	.4319	.3185	.2072	.0377	-.1590	-.2586	-.3441	-.3834	-.3451
60	-.4221	-.2741	-.1525	-.1092	-.1811	-.2434	-.3098	-.3523	-.3361
65	-.1745	-.1127	-.0568	-.0413	-.1087	-.1697	-.2425	-.3042	-.3197
70	.4473	.3093	.1982	.0979	-.0110	-.0837	-.1702	-.2537	-.3010
75	-.0336	-.0216	-.0080	-.0030	-.0427	-.0884	-.1550	-.2321	-.2906
80	-.3882	-.2663	-.1613	-.0803	-.0688	-.0927	-.1421	-.2123	-.2796
85	.1905	.1292	.0794	.0414	.0012	-.0358	-.0946	-.1759	-.2621
90	.2702	.1844	.1126	.0575	.0149	-.0188	-.0732	-.1534	-.2483
100	-.1285	-.0891	-.0561	-.0301	-.0236	-.0341	-.0650	-.1284	-.2249
110	-.0190	-.0134	-.0094	-.0070	-.0097	-.0188	-.0437	-.0999	-.1978
120	.1433	.0974	.0585	.0272	.0086	-.0030	-.0257	-.0756	-.1700
130	-.2329	-.1599	-.0990	-.0526	-.0309	-.0272	-.0340	-.0667	-.1455
140	.2719	.1858	.1131	.0556	.0244	.0114	-.0061	-.0412	-.1141
150	-.2619	-.1797	-.1108	-.0578	-.0320	-.0250	-.0242	-.0398	-.0895
160	.2038	.1394	.0851	.0423	.0194	.0106	.0005	-.0178	-.0573
170	-.1116	-.0766	-.0472	-.0245	-.0134	-.0101	-.0090	-.0134	-.0303
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-28

C_{qm}			L_r/L_c = .200				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ø°									
0	-97.7290	-74.4364	-51.6332	-30.3642	-17.2652	-12.2413	-7.8356	-4.1889	-1.4893
5	-41.7926	-34.0444	-25.4518	-16.2837	-9.8887	-7.2309	-4.7779	-2.6374	-.9661
10	40.2106	26.5155	14.7833	5.9408	1.9823	.9005	.2249	-.0799	-.0984
15	42.0065	31.0848	20.2264	10.4161	4.9552	3.1130	1.6913	.7197	.1872
20	2.8684	5.1413	5.4306	3.9087	2.2096	1.4673	.8248	.3489	.0828
25	-.5785	2.1281	3.5464	3.3068	2.2199	1.6092	1.0069	.4945	.1494
30	11.7559	9.6871	7.7161	5.3971	3.4144	2.4917	1.6068	.8383	.2800
35	1.2469	1.7724	2.3110	2.4197	1.9284	1.5390	1.0773	.6052	.2152
40	-7.9488	-5.0669	-2.3947	-.2853	.4982	.5901	.5280	.3514	.1408
45	2.0650	1.4856	1.2581	1.2770	1.1823	1.0331	.7994	.4997	.1979
50	5.0499	3.4313	2.2455	1.5479	1.2076	1.0236	.7873	.4990	.2028
55	-4.3005	-3.0045	-1.8179	-.6911	-.0276	.1653	.2573	.2332	.1173
60	-2.9426	-2.0933	-1.3235	-.5619	-.0555	.1126	.2073	.2037	.1088
65	4.5897	3.0818	1.8342	.9697	.6422	.5471	.4486	.3173	.1466
70	.4406	.2655	.1117	.0524	.1224	.1709	.2022	.1849	.1012
75	-4.4378	-3.0739	-1.9354	-1.0138	-.4589	-.2426	-.0658	.0406	.0508
80	1.2554	.8245	.4588	.1911	.1172	.1218	.1356	.1309	.0780
85	3.2939	2.2316	1.3312	.6320	.3181	.2394	.1905	.1479	.0802
90	-2.6982	-1.8694	-1.1800	-.6454	-.3409	-.2145	-.0965	-.0060	.0251
100	3.1751	2.1480	1.2849	.6090	.2751	.1787	.1178	.0826	.0464
110	-3.3286	-2.3047	-1.4447	-.7765	-.4300	-.3035	-.1879	-.0864	-.0184
120	2.6050	1.7598	1.0489	.4929	.2079	.1170	.0543	.0220	.0098
130	-1.7893	-1.2520	-.7998	-.4472	-.2669	-.2037	-.1458	-.0883	-.0341
140	.4320	.2718	.1362	.0294	-.0266	-.0447	-.0547	-.0504	-.0276
150	.6222	.3999	.2137	.0684	-.0071	-.0325	-.0504	-.0537	-.0335
160	-1.8151	-1.2679	-.8087	-.4512	-.2690	-.2081	-.1577	-.1113	-.0562
170	2.3464	1.5815	.9388	.4373	.1790	.0912	.0214	-.0237	-.0292
180	-2.7488	-1.9078	-1.2014	-.6510	-.3698	-.2758	-.1996	-.1351	-.0671

TABLE B 6.2.1-29

C_{mm}			L_r/L_c = .400				X = 0		
7	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000
5	.2831	.3065	.3334	.3651	.3914	.4043	.4183	.4331	.4478
10	.1294	.1612	.2005	.2504	.2946	.3172	.3422	.3694	.3968
15	.0469	.0731	.1099	.1627	.2144	.2425	.2745	.3105	.3480
20	.0063	.0231	.0512	.0982	.1498	.1798	.2154	.2569	.3015
25	-.0127	-.0038	.0149	.0522	.0991	.1284	.1647	.2088	.2577
30	-.0162	-.0138	-.0042	.0219	.0609	.0875	.1220	.1660	.2168
35	-.0130	-.0149	-.0124	.0031	.0329	.0555	.0867	.1285	.1788
40	-.0107	-.0140	-.0156	-.0084	.0125	.0307	.0576	.0957	.1436
45	-.0084	-.0119	-.0156	-.0145	-.0015	.0121	.0340	.0673	.1114
50	-.0050	-.0085	-.0134	-.0168	-.0108	-.0016	.0152	.0430	.0820
55	-.0032	-.0062	-.0112	-.0172	-.0166	-.0114	.0004	.0223	.0554
60	-.0032	-.0053	-.0096	-.0167	-.0202	-.0183	-.0111	.0049	.0315
65	-.0024	-.0041	-.0079	-.0155	-.0218	-.0228	-.0199	-.0096	.0101
70	-.0013	-.0029	-.0063	-.0139	-.0223	-.0255	-.0263	-.0216	-.0087
75	-.0017	-.0028	-.0056	-.0126	-.0221	-.0271	-.0310	-.0312	-.0250
80	-.0021	-.0029	-.0051	-.0115	-.0215	-.0277	-.0342	-.0339	-.0391
85	-.0014	-.0023	-.0043	-.0102	-.0205	-.0276	-.0361	-.0448	-.0510
90	-.0012	-.0021	-.0040	-.0093	-.0194	-.0270	-.0371	-.0491	-.0608
100	-.0016	-.0023	-.0037	-.0080	-.0172	-.0251	-.0370	-.0538	-.0744
110	-.0014	-.0020	-.0033	-.0069	-.0149	-.0225	-.0349	-.0543	-.0809
120	-.0010	-.0017	-.0029	-.0060	-.0128	-.0196	-.0314	-.0515	-.0812
130	-.0013	-.0018	-.0027	-.0052	-.0108	-.0165	-.0272	-.0463	-.0760
140	-.0005	-.0011	-.0020	-.0042	-.0087	-.0133	-.0223	-.0391	-.0663
150	-.0010	-.0012	-.0018	-.0033	-.0066	-.0101	-.0170	-.0305	-.0529
160	-.0002	-.0005	-.0010	-.0022	-.0044	-.0068	-.0115	-.0208	-.0368
170	-.0004	-.0004	-.0006	-.0011	-.0022	-.0034	-.0058	-.0106	-.0189
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-30

C_{sm}			L_r/L_c = .400				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-2.6379	-2.3318	-1.9876	-1.5919	-1.2712	-1.1151	-.9488	-.7736	-.6013
5	-2.2001	-2.0020	-1.7604	-1.4581	-1.1942	-1.0598	-.9126	-.7534	-.5933
10	-1.3126	-1.3136	-1.2703	-1.1581	-1.0157	-.9295	-.8259	-.7040	-.5728
15	-.6457	-.7503	-.8313	-.8616	-.8254	-.7854	-.7260	-.6444	-.5465
20	-.3231	-.4248	-.5332	-.6270	-.6578	-.6523	-.6289	-.5832	-.5173
25	-.1184	-.2000	-.3072	-.4303	-.5060	-.5271	-.5340	-.5206	-.4856
30	.0193	-.0455	-.1418	-.2725	-.3744	-.4145	-.4450	-.4592	-.4524
35	.0383	.0060	-.0581	-.1679	-.2731	-.3223	-.3677	-.4024	-.4192
40	.0192	.0142	-.0179	-.0985	-.1949	-.2468	-.3006	-.3499	-.3861
45	.0354	.0345	.0158	-.0447	-.1308	-.1826	-.2410	-.3009	-.3530
50	.0361	.0374	.0290	-.0120	-.0838	-.1320	-.1908	-.2568	-.3207
55	.0052	.0153	.0205	.0010	-.0527	-.0946	-.1500	-.2178	-.2895
60	.0005	.0097	.0180	.0104	-.0290	-.0644	-.1153	-.1825	-.2591
65	.0158	.0173	.0215	.0181	-.0108	-.0403	-.0860	-.1508	-.2296
70	.0045	.0075	.0135	.0168	-.0010	-.0239	-.0630	-.1232	-.2014
75	-.0096	-.0037	.0046	.0129	.0045	-.0123	-.0446	-.0989	-.1744
80	.0034	.0039	.0074	.0139	.0099	-.0023	-.0288	-.0771	-.1484
85	.0091	.0072	.0080	.0131	.0127	.0045	-.0163	-.0579	-.1237
90	-.0057	-.0032	.0007	.0082	.0122	.0080	-.0071	-.0416	-.1003
100	.0085	.0062	.0053	.0084	.0138	.0142	.0077	-.0137	-.0569
110	-.0073	-.0044	-.0014	.0038	.0116	.0154	.0161	.0072	-.0186
120	.0077	.0059	.0049	.0064	.0126	.0176	.0227	.0239	.0150
130	-.0034	-.0015	.0006	.0042	.0113	.0175	.0262	.0361	.0435
140	.0025	.0026	.0033	.0058	.0120	.0185	.0292	.0457	.0670
150	.0028	.0029	.0036	.0062	.0124	.0189	.0311	.0526	.0853
160	-.0030	-.0010	.0014	.0053	.0121	.0189	.0321	.0572	.0984
170	.0073	.0060	.0057	.0076	.0133	.0199	.0332	.0601	.1064
180	-.0054	-.0026	.0005	.0050	.0121	.0191	.0330	.0608	.1089

TABLE B 6.2.1-31

C_{fm}				L_r/L_c = .400				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	0	0	0	0	0	0	0	0	0
5	-9.0612	-6.8751	-4.7739	-2.8376	-1.6469	-1.1871	-.7799	-.4370	-.1762
10	-9.8022	-7.8404	-5.7738	-3.6703	-2.2499	-1.6663	-1.1281	-.6548	-.2783
15	-5.3140	-4.8966	-4.1404	-3.0243	-2.0515	-1.5926	-1.1332	-.6955	-.3195
20	-2.6485	-2.9189	-2.8804	-2.4261	-1.8161	-1.4739	-1.0985	-.7097	-.3495
25	-2.1029	-2.2682	-2.3070	-2.0737	-1.6518	-1.3838	-1.0684	-.7191	-.3752
30	-.8884	-1.1654	-1.4174	-1.5025	-1.3381	-1.1780	-.9571	-.6809	-.3822
35	.2531	-.1602	-.5935	-.9386	-1.0014	-.9441	-.8189	-.6230	-.3796
40	.0117	-.1559	-.4110	-.6975	-.8119	-.7992	-.7263	-.5822	-.3799
45	-.2367	-.2195	-.3144	-.5146	-.6462	-.6645	-.6337	-.5365	-.3758
50	.2599	.1735	.0174	-.2354	-.4334	-.4952	-.5161	-.4743	-.3636
55	.2962	.2245	.1075	-.1022	-.2996	-.3777	-.4269	-.4233	-.3527
60	-.1686	-.0826	-.0458	-.1148	-.2474	-.3154	-.3696	-.3857	-.3441
65	-.0594	-.0118	.0125	-.0405	-.1609	-.2321	-.2993	-.3400	-.3307
70	.2523	.1928	.1413	.0539	-.0736	-.1507	-.2308	-.2940	-.3154
75	-.0068	.0112	.0298	.0154	-.0617	-.1226	-.1953	-.2639	-.3037
80	-.1984	-.1243	-.0566	-.0189	-.0552	-.1011	-.1652	-.2362	-.2913
85	.1005	.0734	.0585	.0429	-.0069	-.0545	-.1216	-.2019	-.2755
90	.1416	.0985	.0694	.0488	.0082	-.0327	-.0947	-.1763	-.2613
100	-.0681	-.0462	-.0248	-.0026	-.0044	-.0243	-.0673	-.1396	-.2348
110	-.0101	-.0075	-.0044	.0028	.0027	-.0097	-.0420	-.1067	-.2062
120	.0742	.0494	.0290	.0159	.0097	.0004	-.0244	-.0803	-.1771
130	-.1218	-.0829	-.0514	-.0266	-.0126	-.0118	-.0238	-.0648	-.1497
140	.1417	.0954	.0569	.0273	.0134	.0069	-.0070	-.0434	-.1187
150	-.1370	-.0929	-.0571	-.0302	-.0160	-.0120	-.0146	-.0358	-.0911
160	.1064	.0717	.0431	.0206	.0095	.0055	-.0012	-.0190	-.0596
170	-.0584	-.0396	-.0243	-.0128	-.0070	-.0051	-.0052	-.0116	-.0306
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-32

C_{qm}				L_r/L_c = .400				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-62.1528	-46.3842	-31.5480	-18.2282	-10.2682	-7.2619	-4.6437	-2.4849	-.8858
5	-30.0038	-23.7304	-17.2080	-10.6842	-6.3692	-4.6271	-3.0428	-1.6754	-.6134
10	19.1109	11.5482	5.5868	1.5718	.0654	-.2490	-.3649	-.3128	-.1526
15	25.0324	17.4571	10.5683	4.9268	2.0886	1.2067	.5730	.1873	.0233
20	6.1706	5.6958	4.3340	2.4420	1.1474	.6816	.3233	.0958	.0031
25	3.6888	4.2100	3.8175	2.5915	1.4597	.9794	.5626	.2483	.0647
30	8.9015	7.5251	5.8716	3.8263	2.2428	1.5726	.9705	.4823	.1530
35	2.2920	2.6892	2.7776	2.3028	1.5709	1.1743	.7718	.4086	.1379
40	-3.4110	-1.5650	-.0631	.7956	.8480	.7225	.5297	.3081	.1128
45	1.2677	1.2710	1.3908	1.3967	1.1408	.9323	.6746	.3963	.1492
50	2.6000	1.9523	1.5795	1.3423	1.0762	.8906	.6592	.3995	.1559
55	-2.3734	-1.5494	-.7206	.0362	.3662	.4083	.3715	.2621	.1143
60	-1.7017	-1.1773	-.6211	-.0429	.2650	.3257	.3180	.2380	.1092
65	2.2585	1.4671	.9048	.6225	.5377	.4889	.4077	.2824	.1256
70	.1360	.0268	-.0130	.0807	.2086	.2485	.2520	.2015	.0992
75	-2.3966	-1.6838	-1.0745	-.5123	-.1398	-.0050	.0867	.1136	.0694
80	.5871	.3399	.1448	.0634	.1067	.1396	.1596	.1435	.0781
85	1.6735	1.0854	.5987	.2682	.1751	.1670	.1620	.1372	.0739
90	-1.4478	-1.0169	-.6725	-.3869	-.1809	-.0869	-.0041	.0460	.0409
100	1.6180	1.0633	.5998	.2455	.1013	.0756	.0693	.0658	.0411
110	-1.7763	-1.2274	-.7822	-.4489	-.2648	-.1861	-.1076	-.0388	-.0010
120	1.3239	.8695	.4944	.2001	.0544	.0162	-.0007	.0004	.0046
130	-.9743	-.6848	-.4476	-.2709	-.1835	-.1486	-.1101	-.0663	-.0246
140	.1891	.1023	.0308	-.0268	-.0600	-.0691	-.0693	-.0553	-.0271
150	.2857	.1670	.0697	-.0059	-.0481	-.0624	-.0697	-.0625	-.0346
160	-.9856	-.6922	-.4515	-.2681	-.1784	-.1498	-.1248	-.0950	-.0491
170	1.1873	.7766	.4396	.1815	.0481	.0014	-.0353	-.0530	-.0374
180	-1.4738	-1.0224	-.6521	-.3690	-.2280	-.1829	-.1465	-.1096	-.0571

TABLE B 6.2.1-33

C_{mm}			L_r/L_c = 1.000				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000	.5000
5	.3314	.3502	.3713	.3953	.4145	.4238	.4335	.4434	.4525
10	.1968	.2258	.2598	.3007	.3349	.3518	.3698	.3864	.4057
15	.1049	.1345	.1721	.2207	.2640	.2863	.3105	.3360	.3601
20	.0454	.0705	.1054	.1549	.2024	.2277	.2561	.2867	.3160
25	.0089	.0276	.0566	.1022	.1497	.1764	.2069	.2407	.2737
30	-.0099	.0017	.0231	.0616	.1059	.1321	.1631	.1983	.2334
35	-.0175	-.0122	.0014	.0312	.0701	.0945	.1244	.1595	.1953
40	-.0199	-.0191	-.0121	.0090	.0412	.0629	.0907	.1243	.1595
45	-.0191	-.0213	-.0196	-.0066	.0184	.0369	.0616	.0926	.1260
50	-.0160	-.0202	-.0225	-.0167	.0010	.0159	.0369	.0644	.0950
55	-.0129	-.0180	-.0229	-.0229	-.0120	-.0009	.0160	.0395	.0664
60	-.0105	-.0156	-.0219	-.0263	-.0214	-.0140	-.0013	.0177	.0404
65	-.0081	-.0129	-.0199	-.0274	-.0278	-.0239	-.0153	-.0012	.0168
70	-.0059	-.0102	-.0173	-.0271	-.0319	-.0310	-.0266	-.0173	-.0042
75	-.0048	-.0083	-.0150	-.0259	-.0341	-.0360	-.0353	-.0308	-.0229
80	-.0040	-.0068	-.0128	-.0241	-.0349	-.0392	-.0419	-.0420	-.0391
85	-.0029	-.0053	-.0107	-.0219	-.0345	-.0408	-.0466	-.0509	-.0530
90	-.0023	-.0043	-.0089	-.0196	-.0334	-.0413	-.0497	-.0579	-.0645
100	-.0019	-.0031	-.0064	-.0154	-.0298	-.0397	-.0520	-.0665	-.0812
110	-.0015	-.0024	-.0046	-.0118	-.0253	-.0359	-.0504	-.0692	-.0898
120	-.0012	-.0018	-.0034	-.0088	-.0207	-.0309	-.0461	-.0670	-.0910
130	-.0012	-.0016	-.0027	-.0066	-.0164	-.0256	-.0400	-.0609	-.0859
140	-.0007	-.0011	-.0020	-.0048	-.0124	-.0202	-.0329	-.0519	-.0753
150	-.0008	-.0010	-.0016	-.0034	-.0089	-.0149	-.0251	-.0407	-.0604
160	-.0003	-.0006	-.0010	-.0021	-.0057	-.0098	-.0168	-.0280	-.0421
170	-.0003	-.0004	-.0005	-.0011	-.0028	-.0048	-.0085	-.0142	-.0216
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-34

C_{sm}				L_r/L_c = 1.000				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-2.0112	-1.7745	-1.5144	-1.2227	-.9924	-.8826	-.7680	-.6519	-.5460
5	-1.7824	-1.6057	-1.4006	-1.1571	-.9549	-.8557	-.7504	-.6420	-.5417
10	-1.2879	-1.2320	-1.1416	-1.0027	-.8645	-.7900	-.7065	-.6165	-.5302
15	-.8430	-.8744	-.8768	-.8328	-.7589	-.7109	-.6520	-.5835	-.5143
20	-.5385	-.6047	-.6569	-.6771	-.6547	-.6300	-.5940	-.5468	-.4953
25	-.3068	-.3860	-.4662	-.5318	-.5518	-.5479	-.5332	-.5069	-.4735
30	-.1368	-.2164	-.3083	-.4023	-.4545	-.4680	-.4722	-.4653	-.4495
35	-.0499	-.1127	-.1966	-.2981	-.3691	-.3951	-.4142	-.4238	-.4240
40	-.0079	-.0500	-.1176	-.2143	-.2945	-.3289	-.3594	-.3829	-.3973
45	.0264	-.0023	-.0559	-.1444	-.2283	-.2684	-.3077	-.3427	-.3696
50	.0394	.0228	-.0158	-.0911	-.1726	-.2153	-.2602	-.3041	-.3413
55	.0301	.0265	.0044	-.0535	-.1275	-.1701	-.2177	-.2675	-.3128
60	.0264	.0291	.0183	-.0247	-.0897	-.1306	-.1790	-.2327	-.2842
65	.0286	.0325	.0280	-.0028	-.0585	-.0966	-.1443	-.1998	-.2556
70	.0193	.0262	.0284	.0100	-.0348	-.0689	-.1140	-.1694	-.2273
75	.0092	.0181	.0254	.0175	-.0166	-.0461	-.0876	-.1412	-.1996
80	.0109	.0175	.0251	.0234	-.0019	-.0268	-.0642	-.1149	-.1723
85	.0105	.0153	.0229	.0260	.0088	-.0114	-.0441	-.0909	-.1457
90	.0024	.0082	.0172	.0250	.0157	.0002	-.0273	-.0691	-.1201
100	.0058	.0077	.0136	.0236	.0245	.0170	-.0004	-.0310	-.0715
110	-.0017	.0011	.0067	.0181	.0263	.0256	.0179	-.0002	-.0273
120	.0040	.0041	.0065	.0152	.0262	.0301	.0305	.0246	.0120
130	-.0006	.0006	.0032	.0111	.0236	.0310	.0383	.0438	.0458
140	.0018	.0021	.0035	.0092	.0214	.0308	.0433	.0585	.0740
150	.0019	.0022	.0032	.0077	.0192	.0298	.0461	.0692	.0962
160	-.0006	.0006	.0021	.0063	.0172	.0286	.0476	.0764	.1121
170	.0037	.0034	.0038	.0066	.0166	.0281	.0484	.0807	.1218
180	-.0015	.0000	.0017	.0054	.0157	.0275	.0484	.0820	.1250

TABLE B 6.2.1-35

C_{fm}			L_r/L_c = 1.000				X = 0		
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
δ^o									
0	0	0	0	0	0	0	0	0	0
5	-4.8099	-3.5690	-2.4230	-1.4096	-.8087	-.5818	-.3834	-.2186	-.0957
10	-5.8355	-4.5150	-3.2111	-1.9708	-1.1825	-.8704	-.5890	-.3474	-.1611
15	-4.2130	-3.5595	-2.7701	-1.8701	-1.2076	-.9213	-.6487	-.4016	-.2009
20	-2.9511	-2.7305	-2.3228	-1.7169	-1.1863	-.9349	-.6819	-.4402	-.2345
25	-2.3889	-2.2761	-2.0355	-1.5994	-1.1629	-.9400	-.7056	-.4715	-.2645
30	-1.4619	-1.5620	-1.5465	-1.3444	-1.0521	-.8801	-.6854	-.4781	-.2849
35	-.6217	-.8746	-1.0471	-1.0573	-.9092	-.7925	-.6441	-.4713	-.2992
40	-.4247	-.6219	-.7992	-.8787	-.8078	-.7270	-.6116	-.4660	-.3123
45	-.3165	-.4441	-.5978	-.7140	-.7035	-.6547	-.5712	-.4539	-.3215
50	.0238	-.1310	-.3234	-.5094	-.5725	-.5607	-.5143	-.4310	-.3253
55	.1192	-.0029	-.1729	-.3687	-.4692	-.4822	-.4637	-.4087	-.3275
60	-.0314	-.0587	-.1473	-.2955	-.3979	-.4227	-.4221	-.3888	-.3286
65	.0276	.0103	-.0601	-.1983	-.3143	-.3536	-.3728	-.3630	-.3261
70	.1560	.1139	.0358	-.1045	-.2335	-.2856	-.3226	-.3350	-.3210
75	.0432	.0473	.0188	-.0752	-.1873	-.2403	-.2851	-.3119	-.3158
80	-.0448	-.0086	.0001	-.0545	-.1482	-.1999	-.2499	-.2886	-.3089
85	.0686	.0670	.0544	-.0039	-.0973	-.1523	-.2100	-.2620	-.2993
90	.0779	.0709	.0610	.0168	-.0647	-.1176	-.1778	-.2385	-.8891
100	-.0191	-.0005	.0182	.0160	-.0303	-.0719	-.1285	-.1971	-.2665
110	-.0005	.0064	.0180	.0238	-.0033	-.0358	-.0871	-.1584	-.2395
120	.0317	.0243	.0237	.0275	.0125	-.0117	-.0558	-.1245	-.2097
130	-.0495	-.0321	-.0142	.0060	.0088	-.0047	-.0378	-.0976	-.1784
140	.0583	.0393	.0262	.0228	.0198	.0086	-.0189	-.0709	-.1440
150	-.0561	-.0377	-.0217	-.0045	.0058	.0026	-.0141	-.0522	-.1098
160	.0437	.0292	.0179	.0127	.0125	.0085	-.0042	-.0317	-.0732
170	-.0239	-.0161	-.0097	-.0031	.0016	.0015	-.0034	-.0163	-.0371
180	0	0	0	0	0	0	0	0	0

TABLE B 6.2.1-36

C_{qm}				$L_r/L_c = 1.000$				X = 0	
γ	.02	.03	.05	.10	.20	.30	.50	1.00	3.00
ϕ^o									
0	-31.7536	-23.1673	-15.3880	-8.6690	-4.7950	-3.3572	-2.1254	-1.1238	-.3945
5	-17.3813	-13.2664	-9.2573	-5.5108	-3.1804	-2.2751	-1.4713	-.7945	-.2841
10	5.4898	2.7088	.7776	-.2647	-.4778	-.4507	-.3635	-.2345	-.0958
15	10.5519	6.8034	3.7189	1.4750	.4932	.2270	.0611	-.0137	-.0197
20	4.3776	3.1981	1.9501	.8392	.2789	.1171	.0155	-.0264	-.0210
25	3.8961	3.1934	2.2354	1.1908	.5517	.3318	.1654	.0593	.0109
30	5.9630	4.7197	3.3307	1.8966	.9885	.6535	.3788	.1769	.0534
35	2.8636	2.6501	2.1608	1.4126	.8125	.5626	.3428	.1692	.0543
40	.0075	.6560	.9600	.8644	.5864	.4335	.2815	.1481	.0504
45	1.4429	1.4980	1.4191	1.1099	.7410	.5534	.3670	.1992	.0704
50	1.6132	1.4836	1.3352	1.0542	.7298	.5579	.3804	.2130	.0777
55	-.7033	-.1903	.2395	.4707	.4416	.3731	.2772	.1671	.0646
60	-.6161	-.2349	.1258	.3677	.3841	.3380	.2612	.1635	.0652
65	.9018	.7029	.6127	.5607	.4674	.3934	.2971	.1843	.0736
70	-.0213	.0260	.1382	.2707	.3036	.2812	.2301	.1524	.0693
75	-1.0856	-.7279	-.3703	-.0338	.1293	.1598	.1556	.1156	.0521
80	.1333	.0683	.0656	.1403	.1932	.1955	.1738	.1240	.0550
85	.5879	.3548	.2110	.1747	.1869	.1833	.1620	.1164	.0522
90	-.6825	-.5034	-.3270	-.1275	.0127	.0584	.0815	.0736	.0373
100	.5932	.3512	.1670	.0736	.0727	.0804	.0818	.0667	.0329
110	-.7865	-.5678	-.3917	-.2333	-.1134	-.0609	-.0170	.0086	.0104
120	.4923	.2955	.1312	.0163	-.0118	-.0081	.0011	.0082	.0067
130	-.4488	-.3315	-.2423	-.1753	-.1236	-.0948	-.0633	-.0333	-.0110
140	.0303	-.0078	-.0431	-.0750	-.0831	-.0772	-.0632	-.0417	-.0174
150	.0696	.0195	-.0238	-.0631	-.0828	-.0837	-.0754	-.0549	-.0249
160	-.4516	-.3294	-.2323	-.1654	-.1369	-.1243	-.1057	-.0753	-.0341
170	.4398	.2684	.1270	.0175	-.0465	-.0666	-.0746	-.0631	-.0316
180	-.6521	-.4636	-.3120	-.2032	-.1574	-.1414	-.1206	-.0872	-.0401

References

1. MacNeal, Richard H., and John A. Bailie, Analysis of Frame-Reinforced Cylindrical Shells, Part I - Basic Theory. NASA TN D-400, 1960.

2. MacNeal, Richard H., and John A. Bailie, Analysis of Frame-Reinforced Cylindrical Shells, Part II - Discontinuities of Circumferential-Bending Stiffness in the Axial Directions. NASA TN D-401, 1960.

3. MacNeal, Richard H., and John A. Bailie, Analysis of Frame-Reinforced Cylindrical Shells, Part III - Applications. NASA TN D-402, 1960.

APPROVAL

ASTRONAUTIC STRUCTURES MANUAL
VOLUME I

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

A. A. McCOOL
Director, Structures and Propulsion Laboratory

☆ U.S. GOVERNMENT PRINTING OFFICE 1976-641-255/446 REGION NO. 4