DESIGN DATA SHEET
DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

DDS 116-1
15 MAY 1984

STEM SHAPE DESIGN

CONTENTS

FIGURES (continued)

116-1-a. References

(a) "A Manual for Calculation of Inception of Cavitation on Two- and Three-Dimensional Forms," SNAME Technical and Research Bulletin No. 1-21, J.P. Breslin and L. Landweber, October 1961.

(b) "Establishment of the Design Practice for Shaft Fairing Shape and Dimensions," NAVSEC Report 6136-75-162, December 1975.

(c) "Derivation of Equations for Elliptical Stem Shapes," NAVSEC Report 6136-78-29, Sept. 1978.

116-1-b. Scope

The purpose of DDS 116-1 is to establish a standard design practice for high-speed surface ship stem section shape to minimize cavitation. Reduced cavitation results in decreased flow noise interference with transducers (such as bow sonar), in decreased noise signature, and in decreased stem erosion.

The design method presented herein focuses on the application of an elliptical section shape to waterlines at, above, and below the design waterline. The ellipsoidal stem shape has been shown to have superior cavitation-resisting characteristics in Reference (a).

Two aproaches are presented for developing the ellipse proportions and offsets. The first approach, presented in paragraph 116-1-d, is useful for developing the stem shape on new designs when the waterline half angle of entrance and half siding (each defined herein) are known. The second approach, presented in paragraph 116-1-e, is useful for modifying the stem shape of an existing ship when the entrance angle and point of tangency between the curved stem shape and the flatter portion of the bow shell plating can be established.

The above two methods are related as shown in paragraph 116-1-f.

Guidance for selecting some of the required numerical values for stemshape parameters is presented in paragraphs 116-1-g and 116-1-h. Sample calculations both for new designs and for design modifications are provided in paragraphs 116-1-i and 116-1-j, respectively.

116-1-c. Symbols and abbreviations

See figure 1 for pictorial description of the physical parameters.

Symbol	Definition
a	semi-major axis of ellipse
b	semi-minor axis of ellipse
a/b	elliptical aspect of ratio
c_p	pressure coefficient
d	longitudinal distance from stem leading edge to transverse line at point of tangency, measured along ship centerline for any specified waterline
f	x/d, x defined below
h	half siding to outside of shell plating, the athwartships distance from the ship centerline to the intersection of the extended waterline and a transverse line through the stem leading edge

Symbol	Definition
n	d/h
x	longitudinal distance measured along ship centerline from point of tangency (positive forward)
x_t	that particular longitudinal distance from center of ellipse to point of tangency
y	any transverse offset of ellipse
y_t	that particular transverse offset at point of tangency
θ	waterline half angle of entrance, or the acute angle between the extended waterline and the ship centerline

116-1-d. Approach for new design

The use of the waterline slope-half siding approach described herein, can be easily used during new design lines development to fit an elliptical waterline ending at the stem. The method assumes that the stem profile and waterlines have been developed to the point where the waterline half angle of entrance (θ) or waterline slope ($\tan \theta$) and half siding (h) can be measured directly. The objectives are to select the desired longitudinal extent of the elliptical ending, and to determine the ellipse offsets at convenient points. These parameters are calculated for waterlines at, above, and below the design waterline, the vertical extent being dependent upon the ship's speed and displacement variability, as governed by its mission.

The general problem and configuration of a typical waterline ending is illustrated in figure 1. The half siding for any waterline is established by the intersection of the extended waterline with a transverse line at the point where the stem leading edge intersects the plane of the waterline. The longitudinal extent of the elliptical ending is selected next, that is, the ratio (n) of the distance from the stem leading edge to the point of tangency (d) over the half siding (h). Once d has been selected the proportions of the ellipse have been uniquely determined and the offsets can be calculated for convenient locations along the centerline.

The following steps, derived in Reference (c), are presented as a guide to determining the proportions of the ellipse (semi-major and semi-minor axes a and b, respectively) and the ellipse offsets. The equations are developed from the basic equation for an ellipse, and the equation for a straight line tangent to the ellipse.

1. Measure θ and h from lines plan

2. Select extent of elliptical ending by selecting n or d, $n = d/h$. The following limits are applicable to n:

$$1 < n < \frac{1}{\tan\theta}$$

3. Calculate

$$x_t = \frac{nh}{\frac{1}{n\tan\theta} - 1} \qquad (1)$$

4. Compute a, the semi-major axis of the ellipse:

$$a = nh + x_t = d + x_t \qquad (2)$$

5. Compute b, the semi-minor axis of the ellipse:

$$b = \sqrt{h^2 + 2ha\tan\theta} \qquad (3)$$

6. Calculate offsets for convenient values of x:

$$y = (b/a)\sqrt{a^2 - (x + x_t)^2} \qquad (4)$$

As a convenience for checking computation errors and for quickly evaluating the effect of several values of d (or n) on ellipse shape, the equations for x_t, a, b, and y can be made non-dimensional on d and can be expressed solely in terms of n and θ. They are presented graphically in figures 2 through 14, as derived in reference (c).

$$x_t/d = \frac{n\tan\theta}{1 - n\tan\theta} \qquad (5)$$

$$a/d = \frac{1}{1 - n\tan\theta} \qquad (6)$$

$$b/d = (1/n)\sqrt{\frac{1 + n\tan\theta}{1 - n\tan\theta}} \qquad (7)$$

$$y/d = (1/n)\sqrt{(1 + n\tan\theta)(1 - f)[(1 + f) + (1 - f)n\tan\theta]} \qquad (8)$$

where,

$f = x/d$ and $0 \leq f \leq 1.0$

116-1-e. Approach for design modification

The use of the waterline slope and point of tangency approach is used when the point of tangency and waterline slope are known and the stem shape is not fixed. This method can easily be used when the stem of an existing ship is to be modified and the elliptical stem is to be attached to existing structure having a known offset and slope. Figure 15 illustrates the general problem.

Once θ (or $\tan\theta$) and y_t have been determined, the elliptical aspect ratio, a/b is selected. Recommended design ranges for a/b are discussed in paragraph 116-1-g. The elliptical ending is now uniquely specified and the offsets can be calculated for convenient values of x.

The following steps, derived in reference (c), are presented as a guide for developing the proportions of the ellipse (a and b) and the offsets:

1. Measure θ and $\tan\theta$ and y_t from lines, structural detail plan, or directly from the ship.
2. Select elliptical aspect ratio, a/b
3. Compute

$$x_t = (a/b)^2 \, y_t \tan\theta \qquad (9)$$

In this document x_t is always taken to be a positive quantity, for the sake of consistency. In the mathematical development of the ellipse equations for the slope-tangency method shown in reference (c), including the Nose computer program, the coordinate system chosen requires that x_t be a negative quantity.

4. Calculate a, the semi-major axis of the ellipse: (10)

$$a = (a/b) y_t \sqrt{1 + (a/b)^2 \tan^2\theta}$$

5. Calculate b, the semi-minor axis of the ellipse: (11)

$$b = (b/a)\, a$$

6. Compute offsets for convenient values of x:

$$y = (b/a) \sqrt{a^2 - (x + x_t)^2} \qquad (12)$$

where,

x = distance from point of tangency (positive forward)

Similar to the slope-half siding method described in paragraph 116-1-d, the equations for x_t, a, b, and y can be made non-dimensional on y_t and expressed solely in terms of a/b and θ. As a convenience for checking errors in computation the equations below are presented in graphical form in figures 16 through 27:

$$x_t/y_t = (a/b)^2 \tan\theta \qquad (13)$$

$$a/y_t = (a/b)\sqrt{1 + (a/b)^2 \tan^2\theta} \qquad (14)$$

$$b/y_t = \sqrt{1 + (a/b)^2 \tan^2\theta} \qquad (15)$$

$$y/y_t = (b/a)\sqrt{(1 - f)[A^2 - X_T^2 + f(A - X_T)^2]} \qquad (16)$$

where,

$A = a/y_t$

$X_T = x_t/y_t$

$f = \dfrac{x}{a - x_t}$ and $0 \leq f \leq 1.0$

116-1-f. <u>Equation relationships between new-design aproach and design-modification approach</u>

Because the general problem of fitting an elliptical waterline ending to the stem involves finding an ellipse of the correct proportions which is tangent to a line with a known slope and offset, the two methods presented in paragraphs 116-1-d and 116-1-e are related. The following equations are presented which relate the slope-half siding method to the slope-tangency method. The derivation of these equations is found in Reference (c).

The following equations relate y_t and a/b to n, h, and θ:

$$y_t = h(1 + n\tan\theta) \qquad (17)$$

$$a/b = \frac{n}{\sqrt{1 - n^2 \tan^2\theta}} \qquad (18)$$

Figures 28 and 29 show these equations graphically.

The following equations relate n and h to a/b, y_t, and θ:

$$n = \frac{a/b}{\sqrt{1 + (a/b)^2 \tan^2\theta}} \qquad (19)$$

$$h = \frac{y_t \sqrt{1 + (a/b)^2 \tan^2 \theta}}{\sqrt{1 + (a/b)^2 \tan^2 \theta} + (a/b) \tan \theta} \qquad (20)$$

Figures 30 and 31 show these equations graphically.

111-1-g. Selection of stem characteristics ratios

Consideration of the cavitation characteristics of streamlined axisymmetric bodies in Reference (b) has resulted in recommended design ranges for a/b and n.

The David W. Taylor Naval Ship Research and Development Center has calculated the pressure distribution about two-dimensional bodies having wedge-shaped forebodies with elliptical leading edges. The minimum value of pressure coefficient (C_p) for a given shape at some angle of yaw is indicative of a body's susceptibility to cavitation; the more negative C_p becomes, the greater the susceptibility to cavitation.

For the fine entrance angles of interest with combatant and other high-speed ships (generally those having a design speed of 15 knots or more), these calculations show that for eliptical aspect ratios (a/b) greater than 2, the selection of a specific value for a/b is not important, as long as the yaw angle is zero degrees. However, for angles of yaw as small as one degree, the C_p becomes increasingly negative as a/b increases above a/b = 5. For a/b less than 3, C_p also becomes increasingly negative very rapidly. Also, as yaw angle increases, C_p becomes increasingly negative. Experience shows that ships characteristically operate with some yaw angle. Thus, these calculations show that a/b normally should be in the range of 3 to 5, and circular stems (a/b = 1) should be avoided. Based on these considerations, a/b = 4 is recommended as the elliptical aspect ratio to be used for combatant and other high-speed ships, the ellipse being defined by the outside of the stem plating.

For very bluff forms (large entrance angles), the calculations show that C_p is somewhat insensitive to elliptical aspect ratio. Thus, for instance, for an auxiliary ship well above the waterline, an a/b as low as 1 (circular shape) is acceptable.

For each combination of a/b and θ there is a corresponding value of n which is always less than a/b and expressed by equation (19) and shown in figure 30. It is shown in Reference (c) that as a/b approaches infinity, then n approaches $1/\tan \theta$. Therefore, n must always be less than $1/\tan \theta$.

116-1-h. Selection of half-siding

From a practical standpoint the half-siding is determined by the stem profile shape and the waterline entrance angles. Other than overall drag considerations for the ship, there is no upper limit on h. A lower limit on h of approximately 1/2 inch is recommended from a construction and fabrication point of view.

116-1-i. Sample calculation for new-design approach

The offsets for the waterline endings of three waterlines of the Sea Control Ship were calculated using the slope-half siding method. The stem profile and the three waterlines under consideration are shown in figure 32. The method of measuring the half-siding and slope is shown for the 16-, 20-, and 24-foot waterlines.

The values of θ, h, d, n, and the corresponding values of a/b for each of the three waterline are summarized below:

WATERLINE ENDING PROPORTIONS SUMMARY

WL	h	d	n	θ	a/b
24 ft	1 in	4-3/4 in	4.75	6.0	5.482
20 ft	1 in	4-1/2 in	4.50	7.0	5.399
16 ft	4-1/2 in	24 in	5.33	5.5	6.216

h and θ were measured from the lines; d was selected such that the resulting value of n, computed using the relation n = d/h given in paragraph 116-1-d, would lie within the required limits; a/b was calculated using equation (18) or figure 29. For the 24-foot waterline:

$$h = 1 \text{ in} = 0.08333 \text{ ft}$$
$$d = 4\text{-}3/4 \text{ in} = 0.39583 \text{ ft}$$
$$n = d/h = 0.39583/0.08333 = 4.75$$
$$\theta = 6 \text{ degrees}$$

$$\frac{1}{\tan \theta} = \frac{1}{0.10510} = 9.51436$$

Since 4.750 < 9.514, n is within the required limits.

$$a/b = \frac{n}{\sqrt{1 - n^2 \tan^2 \theta}}$$

$$= \frac{4.75}{\sqrt{1 - 4.75^2 \tan^2 6°}}$$

$$= \frac{4.75}{\sqrt{1 - (22.5625)(0.01105)}}$$

$$= 5.4820$$

or using figure 29 for $n = 4.75$ and $\theta = 6$ degrees, $a/b = 5.48$.

To calculate the offsets of the elipse, equations (1), (2), (3), and (4) are used. For the 24-foot waterline:

$$x_t = \frac{nh}{[1/(n \tan \theta)] - 1}$$

$$= \frac{(4.75)(0.0833)}{[1/(4.75 \tan 6°)] - 1}$$

$$= 0.3946 \text{ ft}$$

$$a = nh + x_t$$

$$= (4.75)(0.08333) + 0.39462$$

$$= 0.7904 \text{ ft}$$

$$b = \sqrt{h^2 + 2ha \tan \theta}$$

$$= \sqrt{0.0833^2 + (2)(0.0833)(0.7904)(\tan 6°)}$$

$$= 0.1442 \text{ ft}$$

$$y = (b/a) \sqrt{a^2 - (x + x_t)^2}$$

$$= (1/5.4820) \sqrt{0.7904^2 - (x + 0.3946)^2}$$

$$= 0.1824 \sqrt{0.6527 - (x + 0.3946)^2}$$

For values of $x = 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0$, each multiplied by d, the following values of y result:

x	0	.0396	.0792	.1188	.1583	.1979	.2375	.2771	.3167	.3563	.3958
y	.1249	.1204	.1153	.1095	.1029	.0953	.0865	.0759	.0628	.0450	0

The value of y for x = 0 should be the same as y_t in the slope and tangency method. Using equation (17):

$$\begin{aligned} y_t &= h(1 + n \tan \theta) \\ &= 0.08333\ (1 + 4.75 \tan 6°) \\ &= 0.1249 \text{ ft} \end{aligned}$$

This agrees with the value calculated above.

The values of x_t, a, b, and y, in feet, for each of the three waterlines are summarized in the table below.

Waterline Ending Offset Summary

WL													x_t	a	b
24	x	.0	.0396	.0792	.1188	.1583	.1979	.2375	.2771	.3167	.3563	.3958	.3946	.7904	.1442
	y	.1249	.1204	.1153	.1095	.1029	.0953	.0865	.0759	.0628	.0450	.0			
20	x	.0	.0375	.0750	.1125	.1500	.1875	.2250	.2625	.3000	.3375	.3750	.4631	.8381	.1552
	y	.1294	.1267	.1237	.1206	.1166	.1130	.1091	.1049	.0995	.0946	.0			
16	x	.0	.2	.4	.6	.8	1.0	1.2	1.4	1.6	1.8	2.0	2.1113	4.1113	.6615
	y	.5676	.5470	.5237	.4972	.4671	.4324	.3921	.3441	.2846	.2038	.0			

As an alternative, the non-dimensional expressions for x_t, a, b, and y (equations (5), (6), (7), and (8)) could be used to read the values for x_t/d, a/d, b/d, and y/d directly from figures 2 through 14. This approach is illustrated for the 24-foot waterline:

$$\begin{aligned} d &= 0.3958 \text{ ft} \\ n &= 4.75 \\ \theta &= 6 \text{ degrees} \\ x_t/d &= 0.99 && \text{Figure 2} \\ x_t &= (0.99)(0.3958) = 0.39 \text{ ft} \\ a/d &= 2 && \text{Figure 3} \\ a &= (2)(0.3958) = 0.79 \text{ ft} \\ b/a &= 0.365 && \text{Figure 4} \\ b &= (0.365)(0.3958) = 0.144 \text{ ft} \end{aligned}$$

and for the offsets y:

f	y/d	d	y	Figure
.0	.316	.3958	.125	5
.1	.303	.3958	.120	6
.2	.292	.3958	.115	7
.3	.276	.3958	.109	8
.4	.261	.3958	.103	9
.5	.240	.3958	.095	10
.6	.221	.3958	.087	11
.7	.192	.3958	.076	12
.8	.158	.3958	.062	13
.9	.114	.3958	.045	14
1.0	.0	.3958	.0	-

The values for x_t, a, b, and y are the same as those calculated using equations (1) through (4).

116-1-j. Sample calculation for design-modification approach

The use of the slope-tangency method is illustrated by the modification made to the FFG 7 stem.

The original stem section shape is shown in figure 33. The slope of the waterline, tan θ, was determined to be 0.233 and the offset at the point of tangency, y_t, was calculated to be 1.948. The elliptical aspect ratio, a/b, chosen is 4 based on discussion in paragraph 116-1-g.

Using equations (9), (10), (11), and (12) the ellipse proportions and offsets can be calculated.

$$x_t = (a/b)^2\, y_t \tan\theta$$

$$= 4^2(1.948)(0.233)$$

$$= 7.262 \text{ in}$$

$$a = (a/b)y_t \sqrt{1 + (a/b)^2 \tan^2\theta}$$

$$= (4)(1.948) \sqrt{1 + 4^2(0.233^2)}$$

$$= 10.651 \text{ in}$$

$$b = (b/a)a$$

$$= (0.25)(10.651)$$

$$= 2.663 \text{ in}$$

$$y = (b/a) \sqrt{a^2 - (x + x_t)^2}$$

$$= 0.25 \sqrt{(10.651)^2 - (x + 7.262)^2}$$

where,

x values are taken as 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0, each multiplied by d.

$$d = a - x_t = 10.651 - 7.262 = 3.389 \text{ in}$$

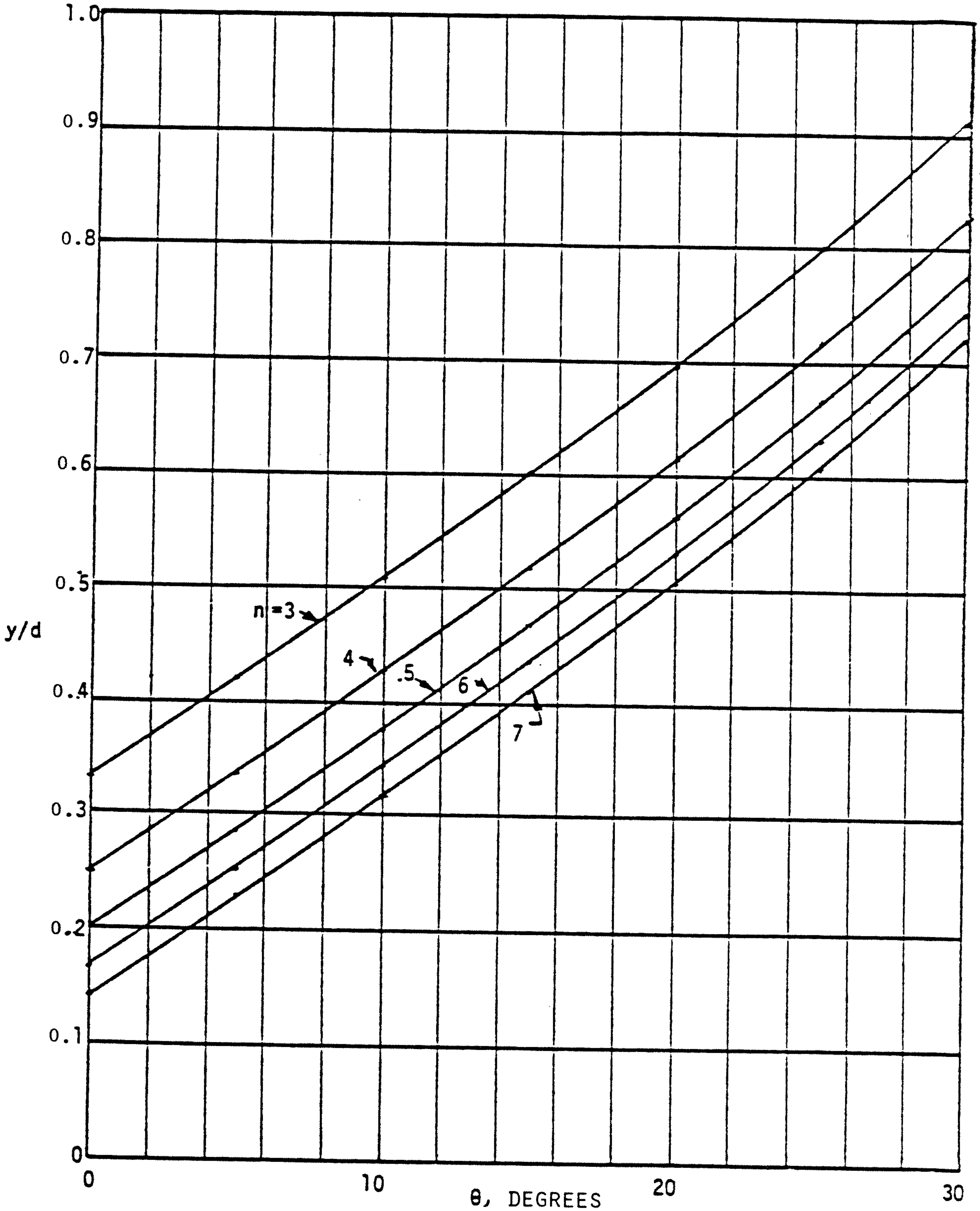

Figure 5. Non-dimensional elliptical offset, y/d, as a function of n and θ for f = 0

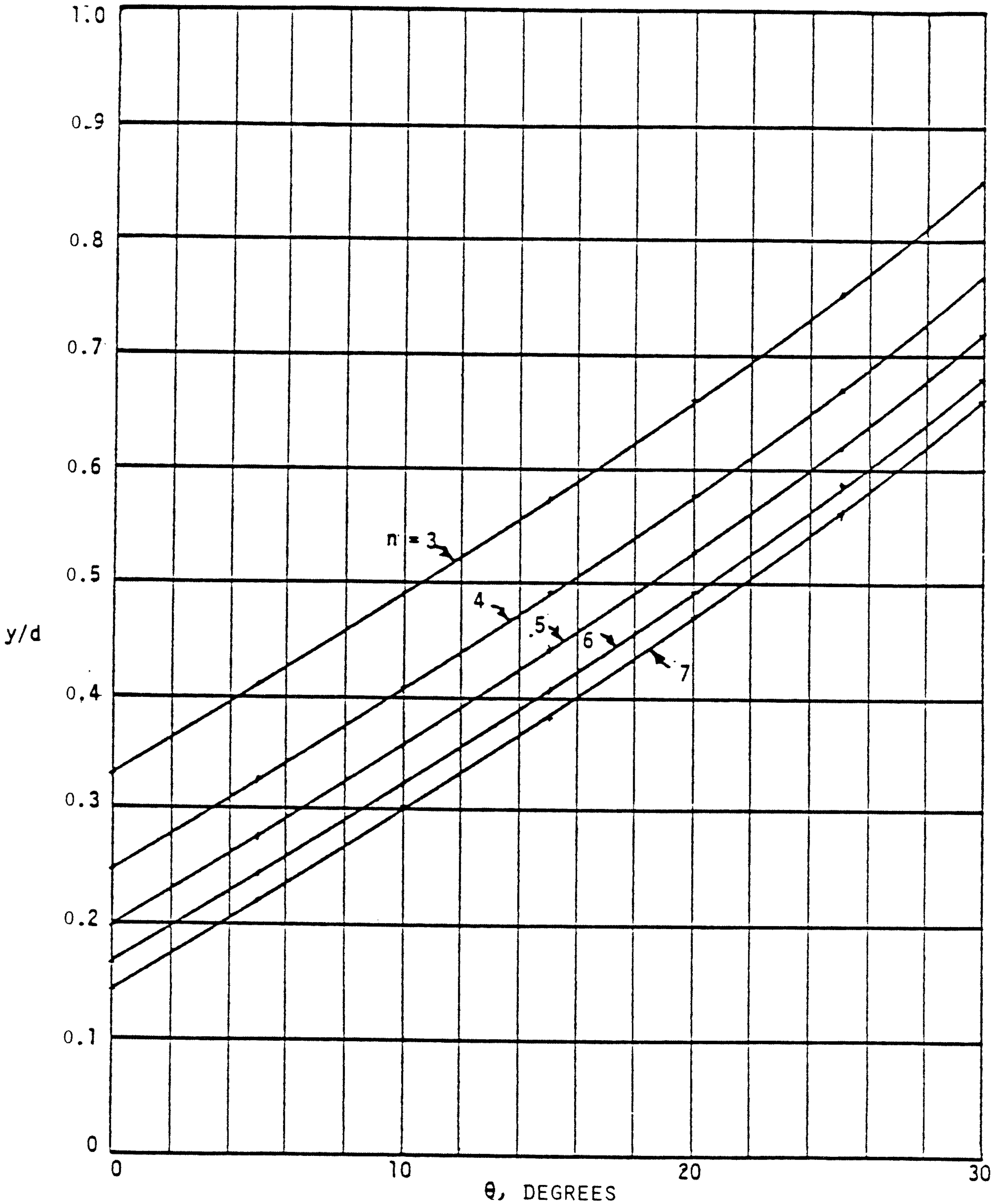

Figure 6. Non-dimensional elliptical offset, y/d, as a function of n and θ for f =0.1

The calculated offsets y, in inches, are summarized below:

x	0.0	0.339	0.678	1.017	1.356	1.695	2.033	2.372	2.711	3.050	3.389
y	1.948	1.865	1.775	1.675	1.565	1.441	1.300	1.136	0.935	0.666	0.0

An alternative approach to calculating x_t, a, b, and y is to use the non-dimensional expressions for x_t/y_t, a/y_t, b/y_t, and y/y_t given in equations (13), (14), (15), and (16) and presented graphically in figures 16 through 27. For a/b = 4, y_t = 1.948, and tan θ = 0.233 (θ = 13.1 degrees):

$x_t/y_t = 3.73$ Figure 16

$x_t = (3.73)(1.948) = 7.27$ in

$a/y_t = 5.47$ Figure 17

$a = (5.47)(1.948) = 10.66$ in

$b/y_t = 1.365$ Figure 18

$b = (1.365)(1.948) = 2.66$ in

The offsets y, in inches, are summarized below:

f	y/y_t	y_t	y	Figure
.0	1.000[1]	1.948	1.948	-
.1	.957	1.948	1.86	19
.2	.910	1.948	1.77	20
.3	.859	1.948	1.67	21
.4	.803	1.948	1.56	22
.5	.739	1.948	1.44	23
.6	.667	1.948	1.30	24
.7	.582	1.948	1.13	25
.8	.480	1.948	.93	26
.9	.342	1.948	.67	27
1.0	.0	1.948	.0	-

[1] $y/y_t = 1.0$ for f = 0 for all a/b and θ

It can be seen that the offsets are the same as those calculated using equations (9), (10), (11), and (12).

The values of n and h corresponding to a/b = 4, y_t = 1.948, and θ = 13.1 are calculated using equations (19) and (20) or figures 30 and 31.

$$n = \frac{a/b}{\sqrt{1 + (a/b)^2 \tan^2 \theta}}$$

$$= \frac{4}{\sqrt{1 + 4^2(0.233)^2}}$$

$= 2.926$

or $n = 2.93$ from figure 30

$$h = \frac{y_t \sqrt{1 + (a/b)^2 \tan^2 \theta}}{\sqrt{1 + (a/b)^2 \tan^2 \theta} + (a/b) \tan \theta}$$

$$= \frac{1.948 \sqrt{1 + (4^2)(0.233^2)}}{\sqrt{1 + (4^2)(0.233^2)} + (4)(0.233)}$$

$= 1.158$ in

or $h = 1.16$ inches from figure 31.

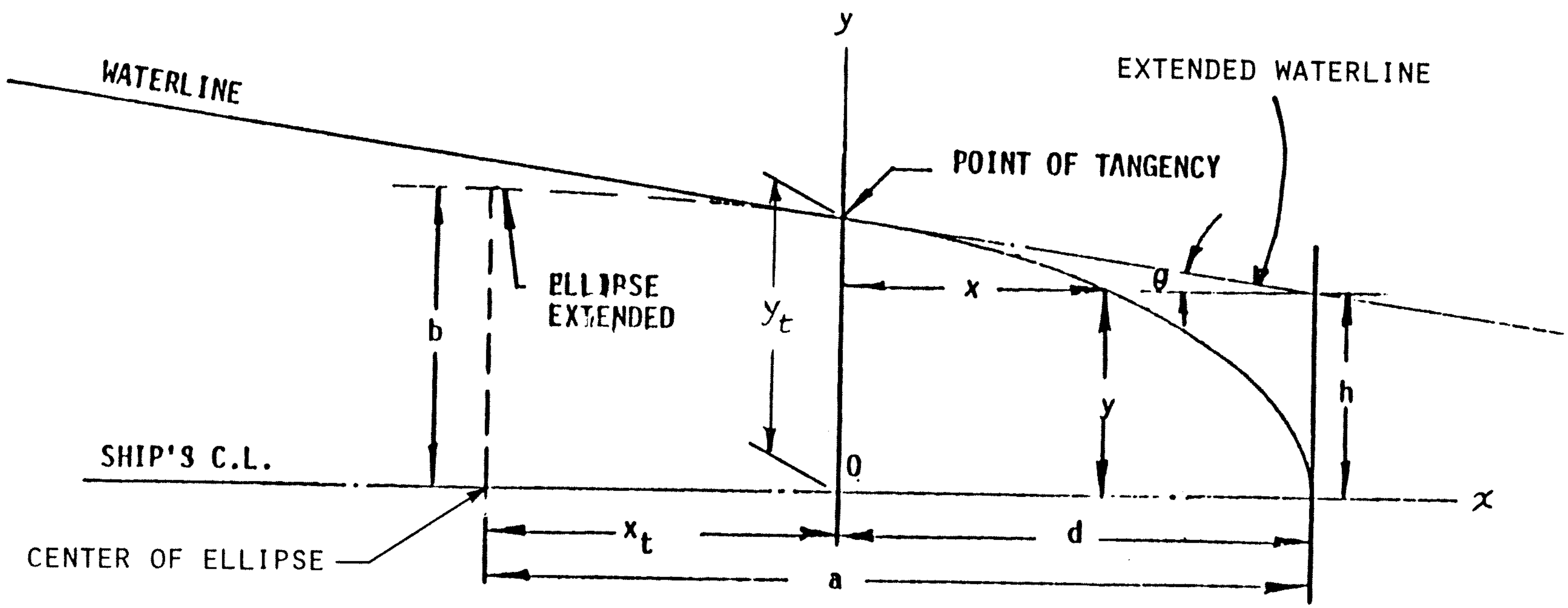

Figure 1. Typical waterline ending illustrating parameters involved in slope-half siding method

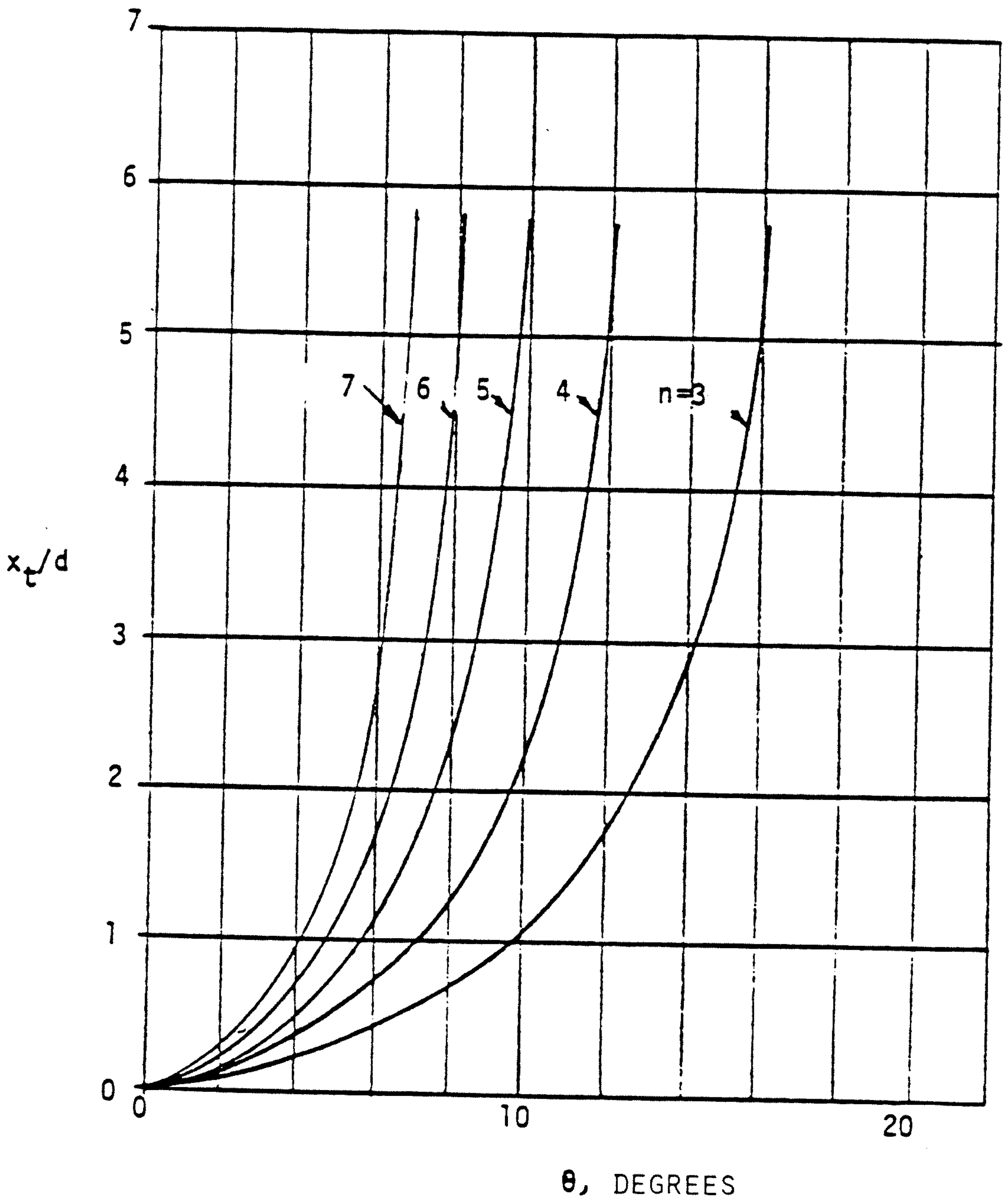

Figure 2. Non-dimensional x_t/d as a function of n and θ

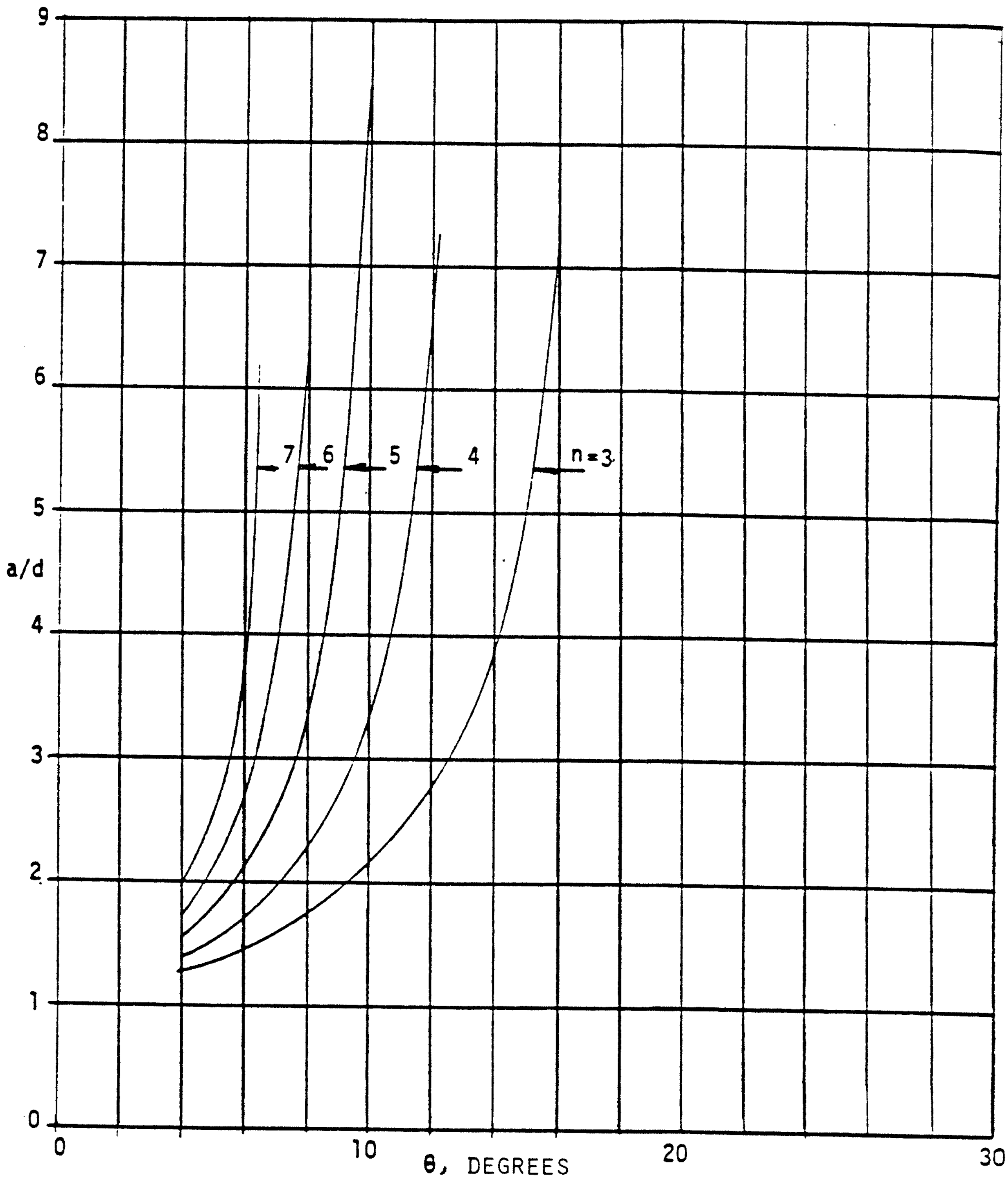

Figure 3. Non-dimensional semi-major axis, a/d, as a function of n and θ

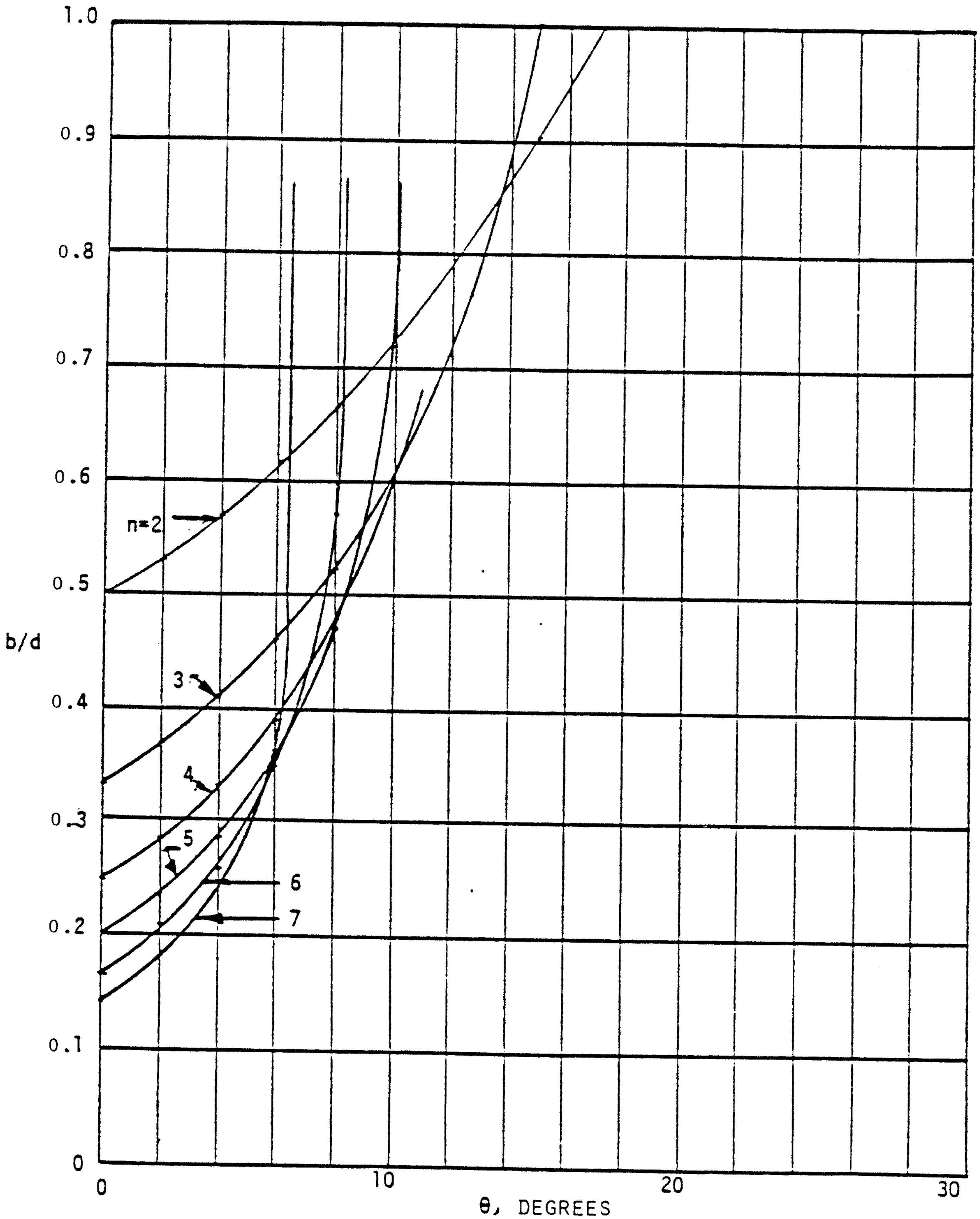

Figure 4. Non-dimensional semi-minor axis, b/d, as a function of n and θ

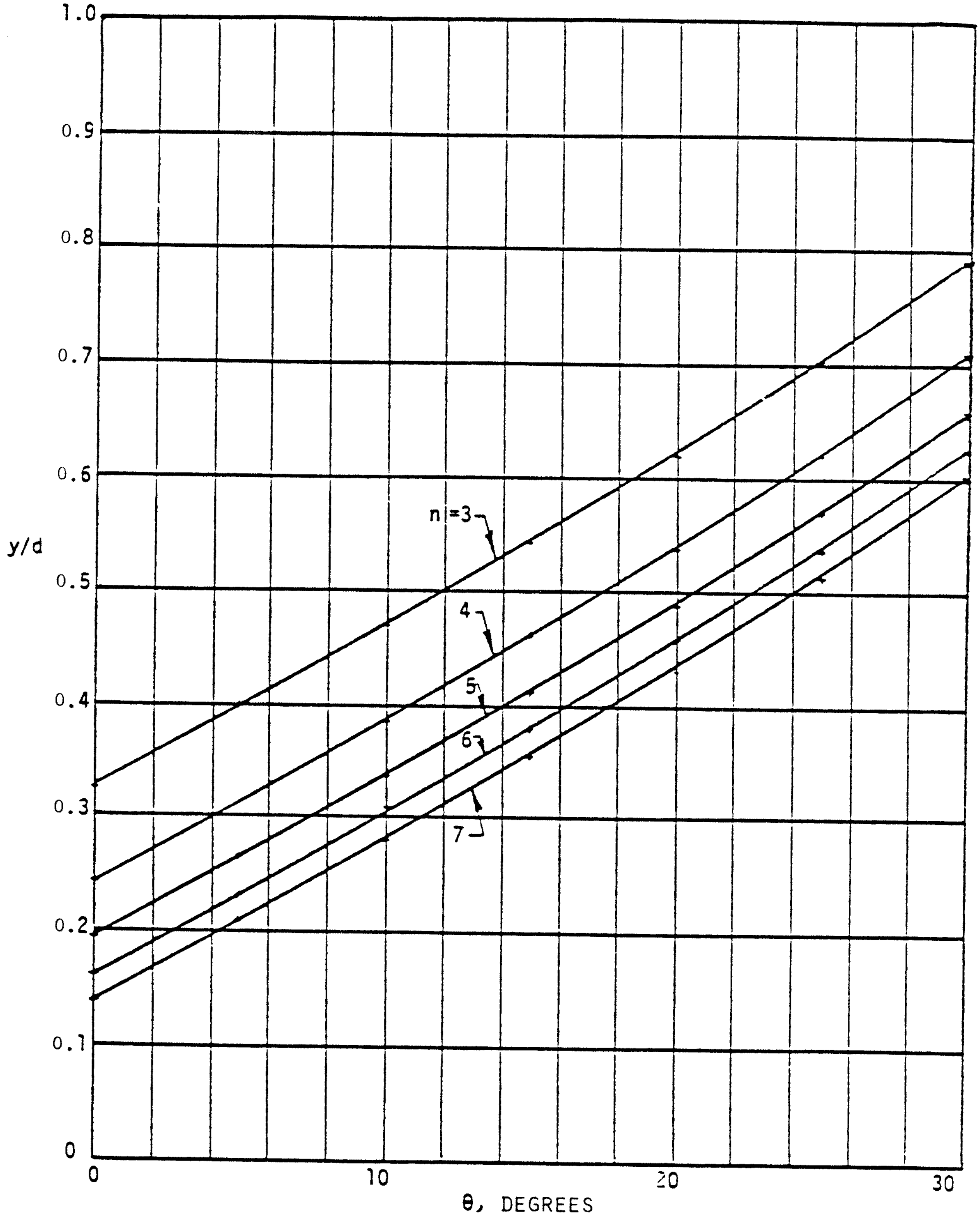

Figure 7. Non-dimensional elliptical offset, y/d, as a function of n and θ for f =0.2

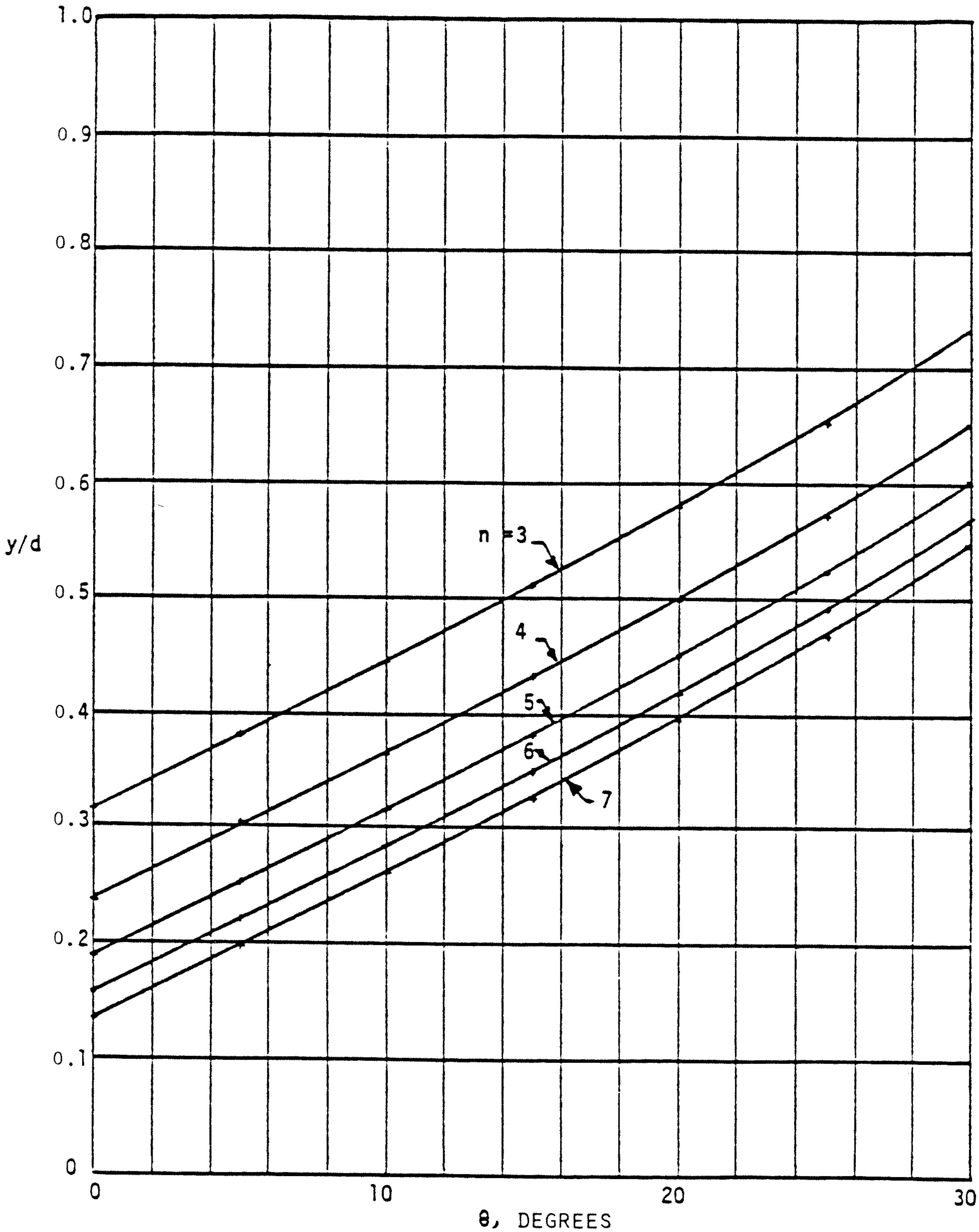

Figure 8. Non-dimensional elliptical offset, y/d, as a function of n and θ for f = 0.3

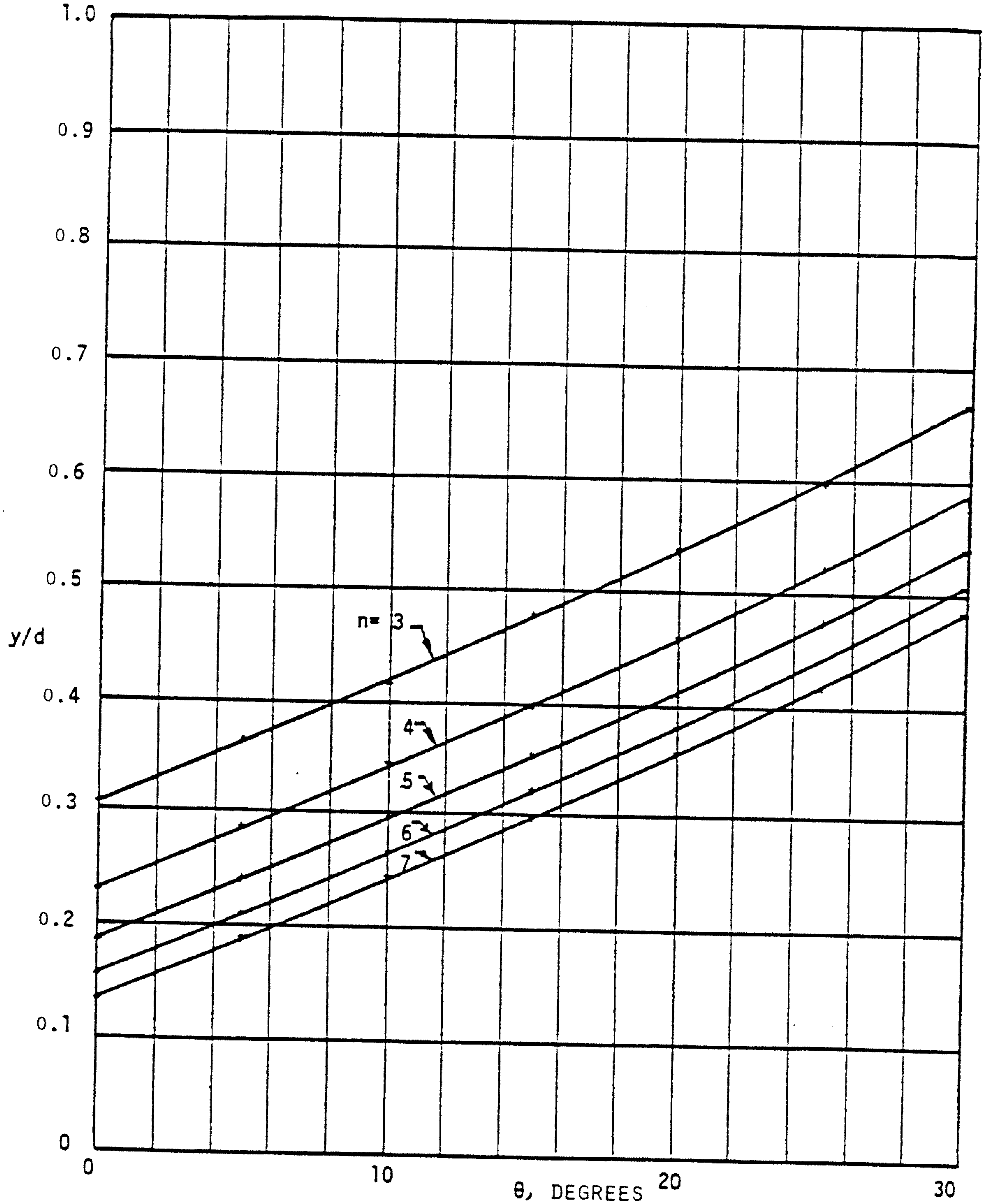

Figure 9. Non-dimensional elliptical offset, y/d, as a function of n and θ for f =0.4

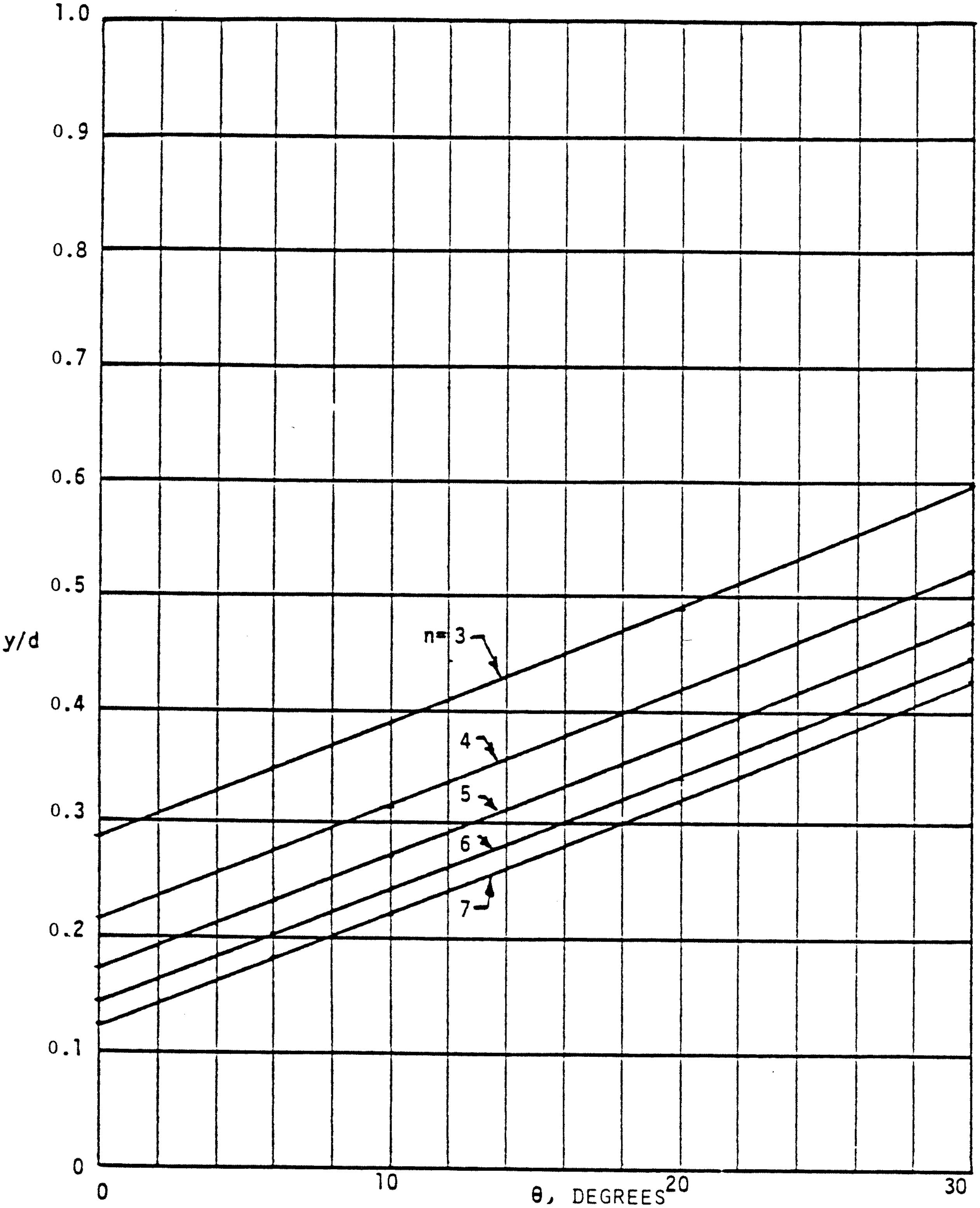

Figure 10. Non-dimensional elliptical offset, y/d, as a function of n and θ for f =0.5

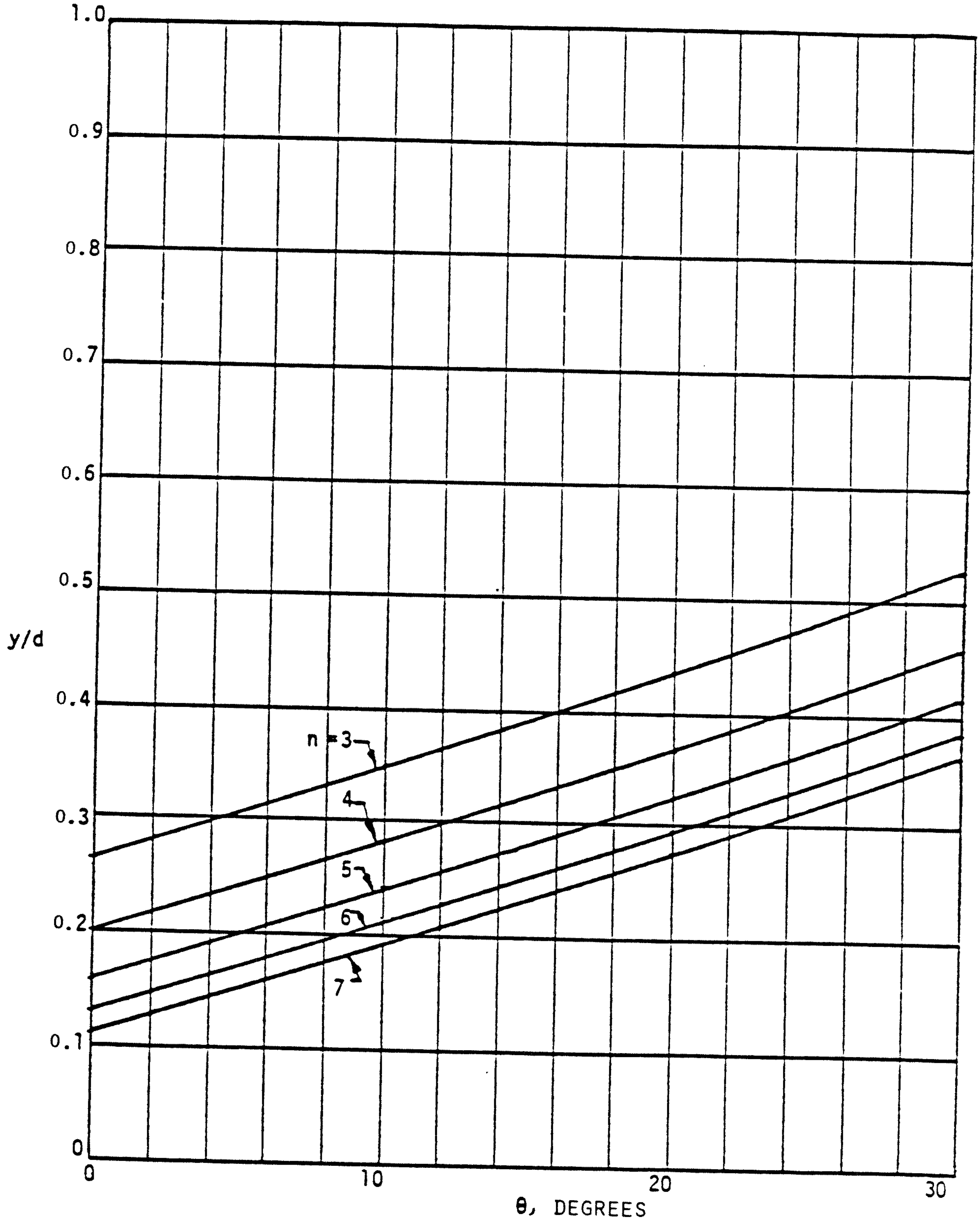

Figure 11. Non-dimensional elliptical offset, y/d, as a function of n and θ for f =0.6

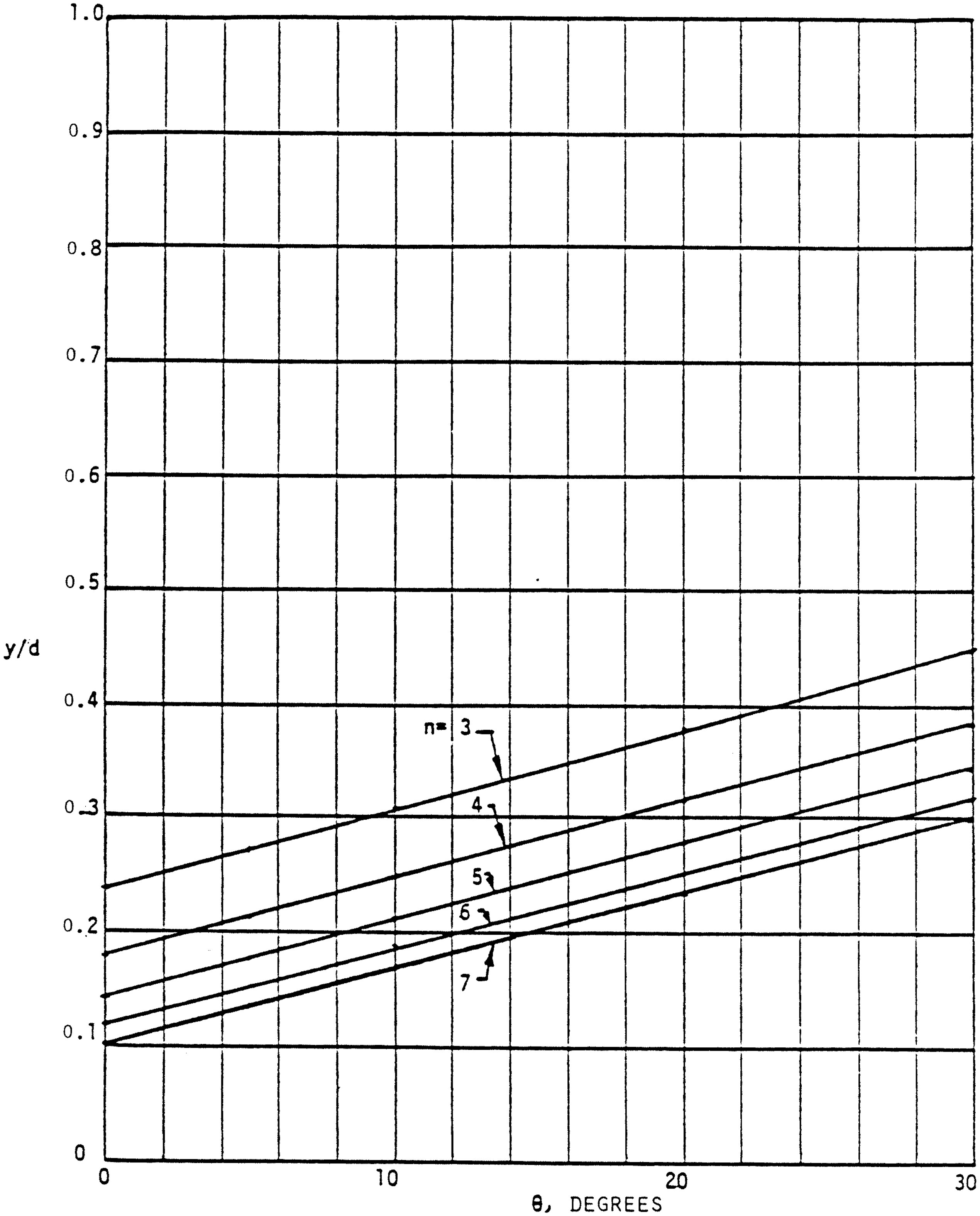

Figure 12. Non-dimensional elliptical offset, y/d, as a function of n and θ for f =0.7

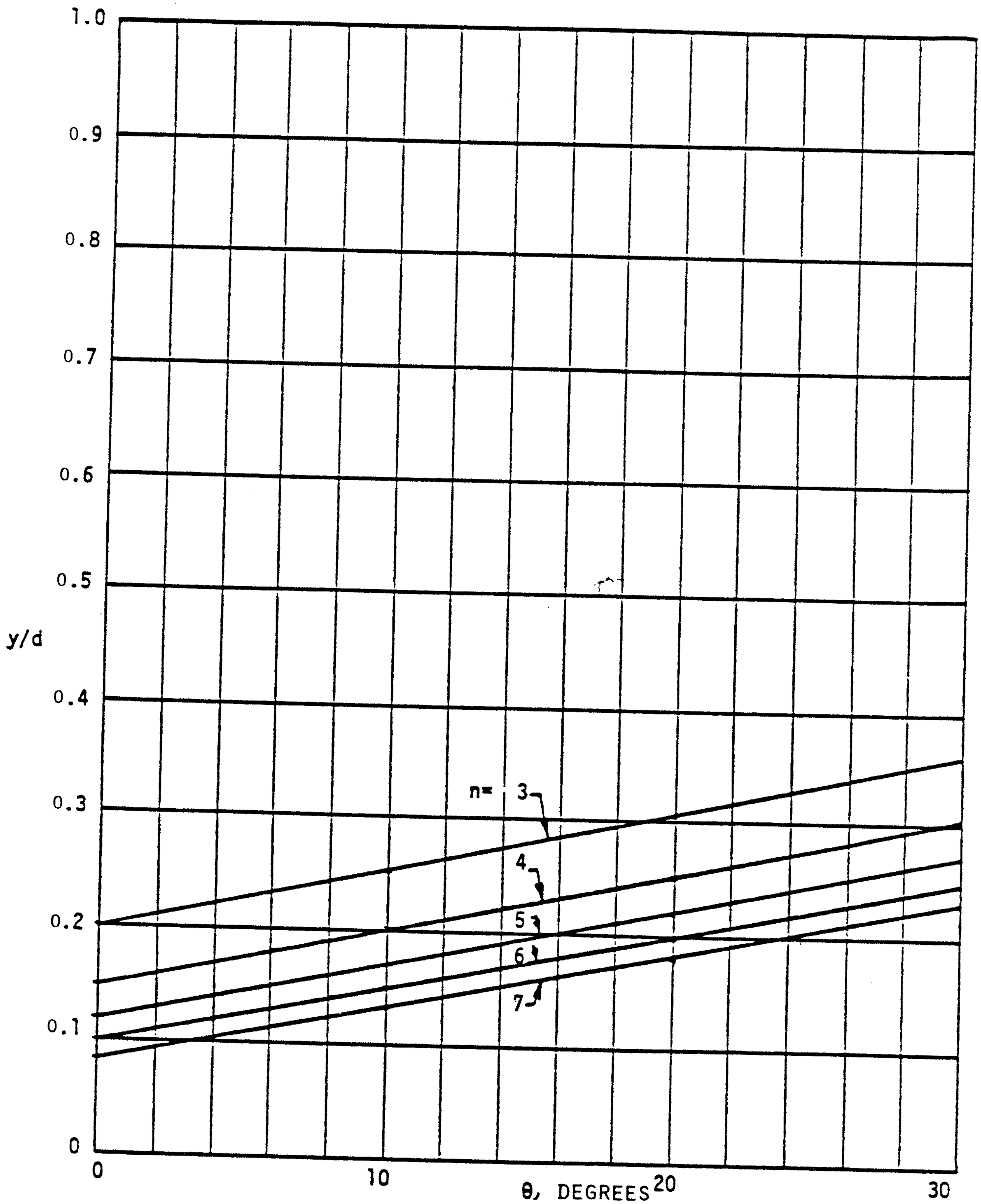

Figure 13. Non-dimensional elliptical offset, y/d, as a function of n and θ for f =0.8

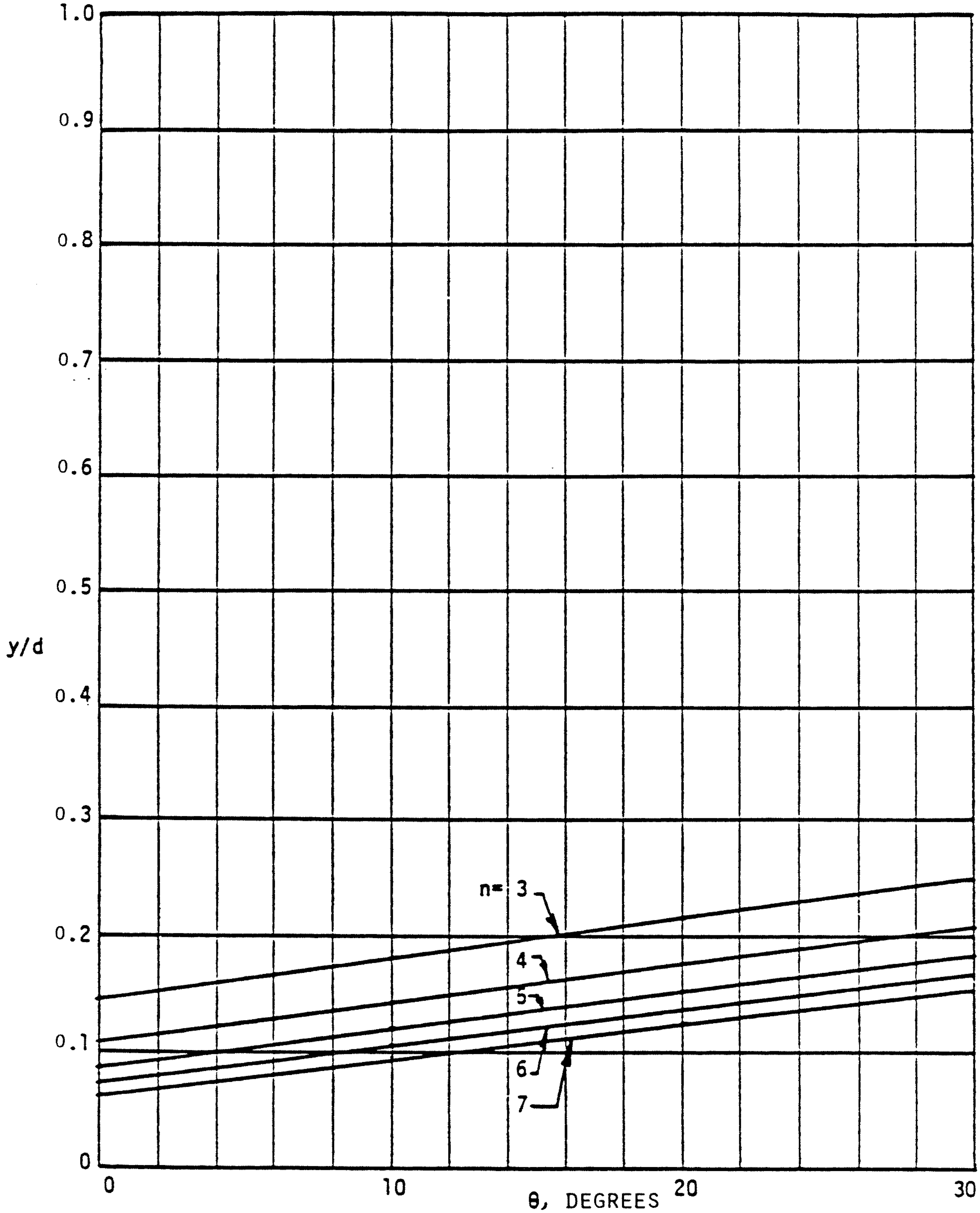

Figure 14. Non-dimensional elliptical offset, y/d, as a function of n and θ for f =0.9

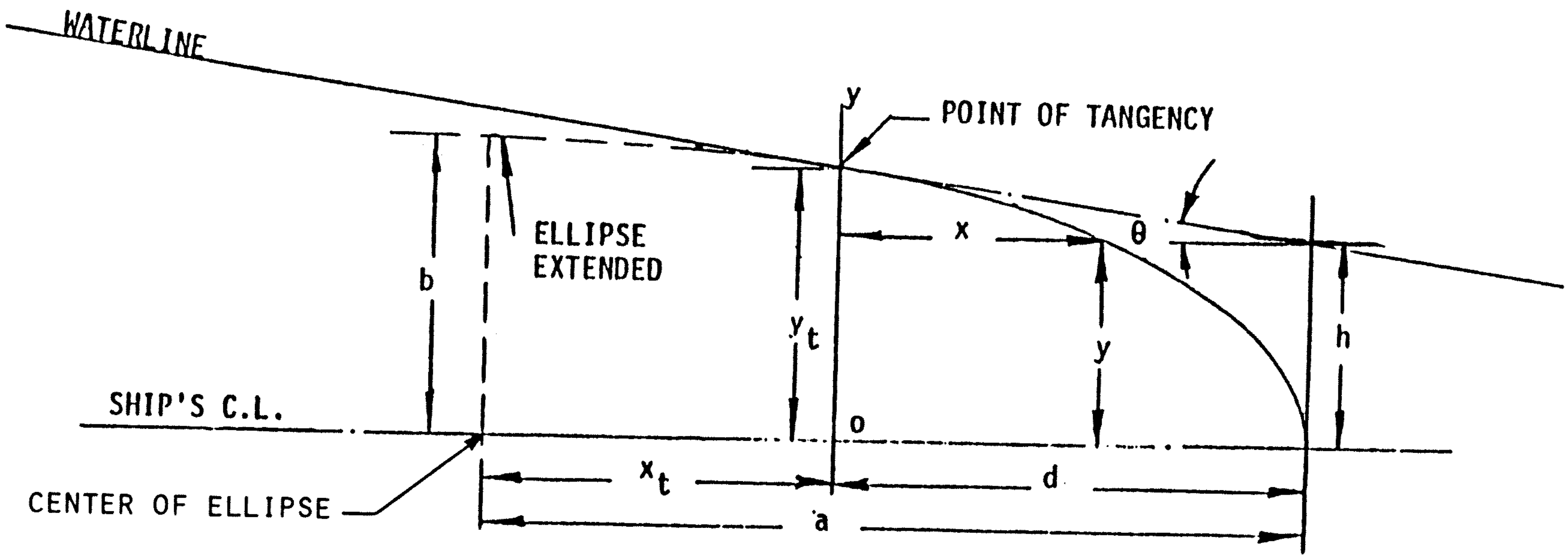

Figure 15. Typical waterline ending illustrating parameters involved in slope-tangency method

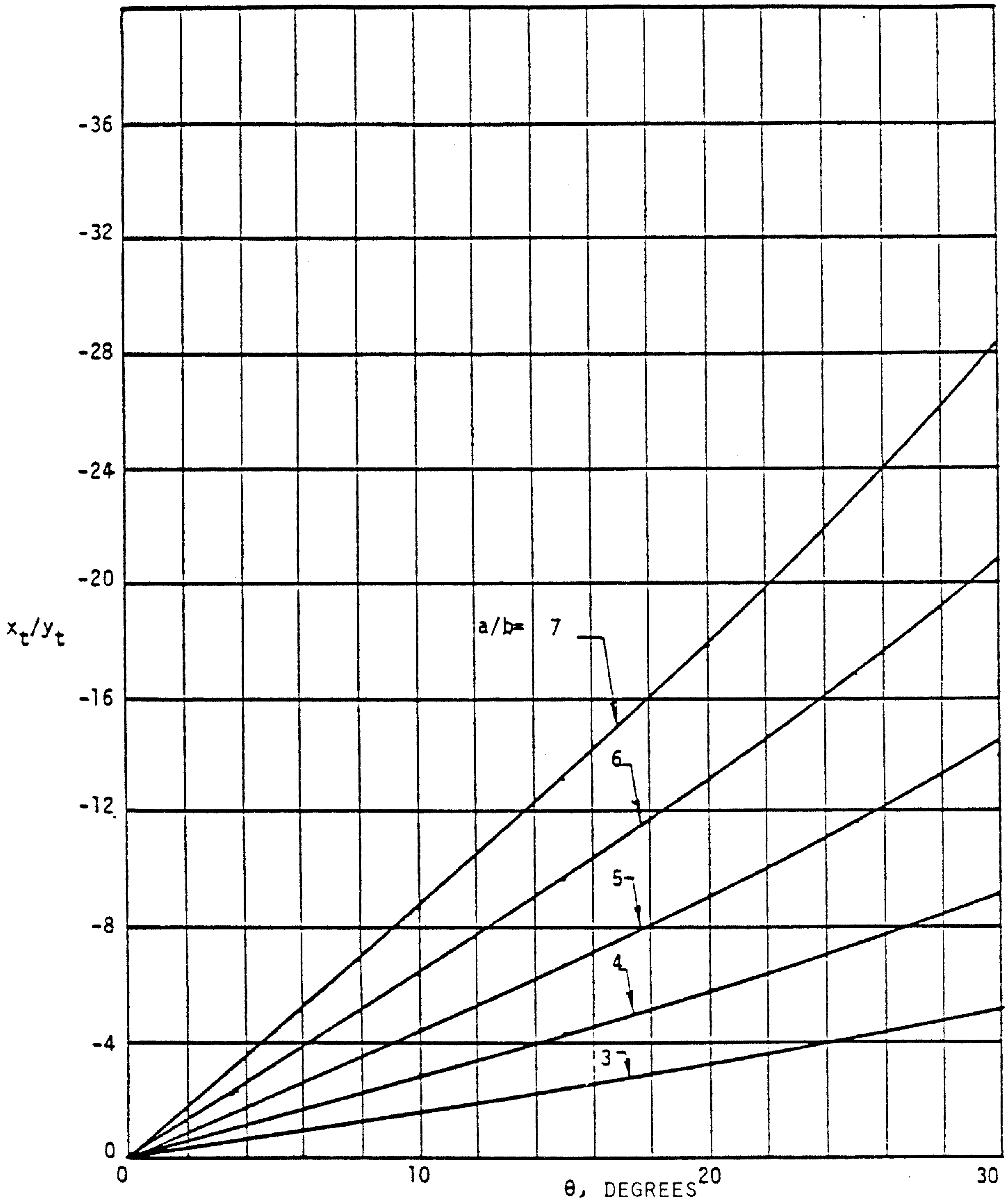

Figure 16. Non-dimensional x_t/y_t as a function of a/b and θ

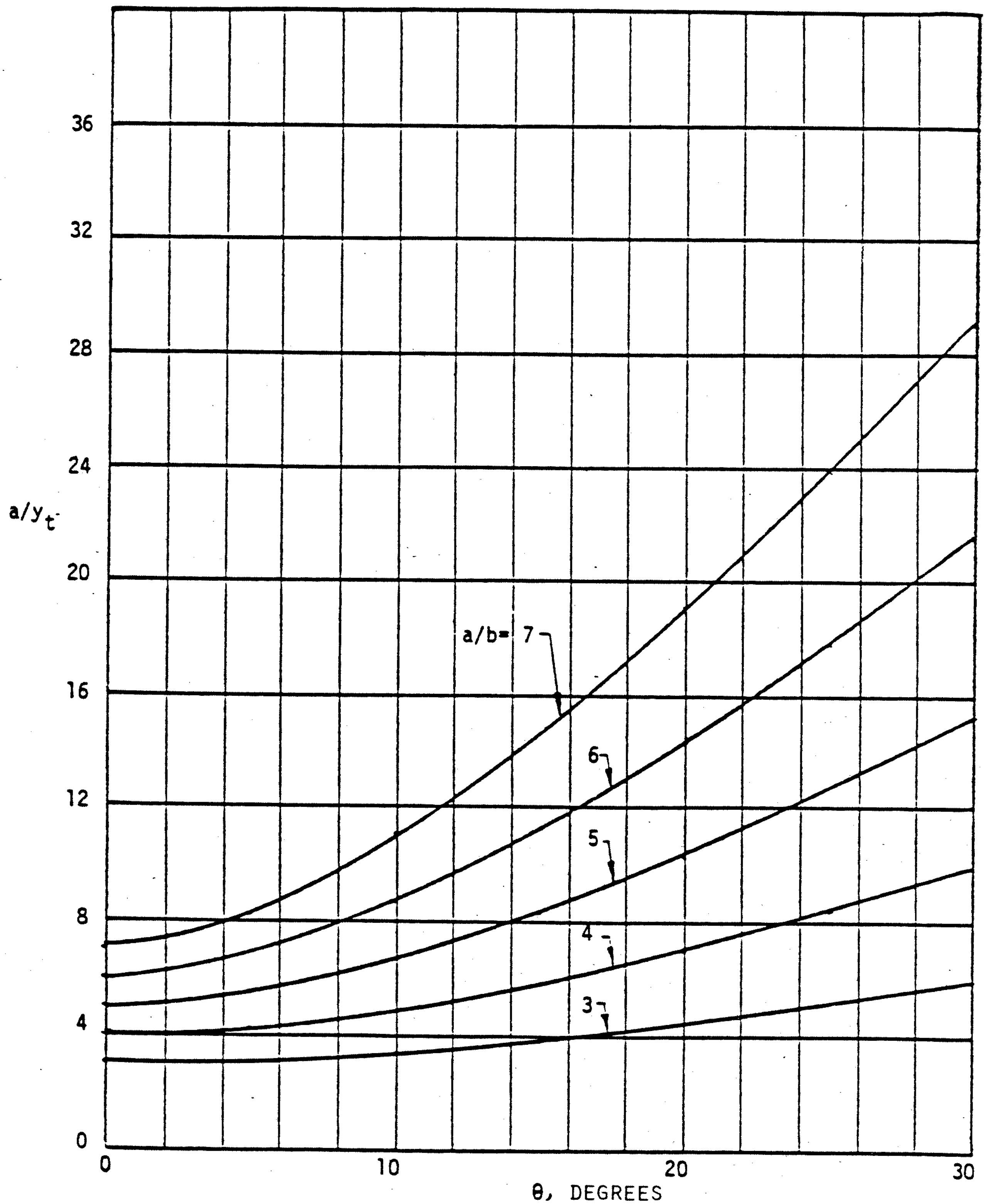

Figure 17. Non-dimensional ellipse semi-major axis, a/y_t, as a function of a/b and θ

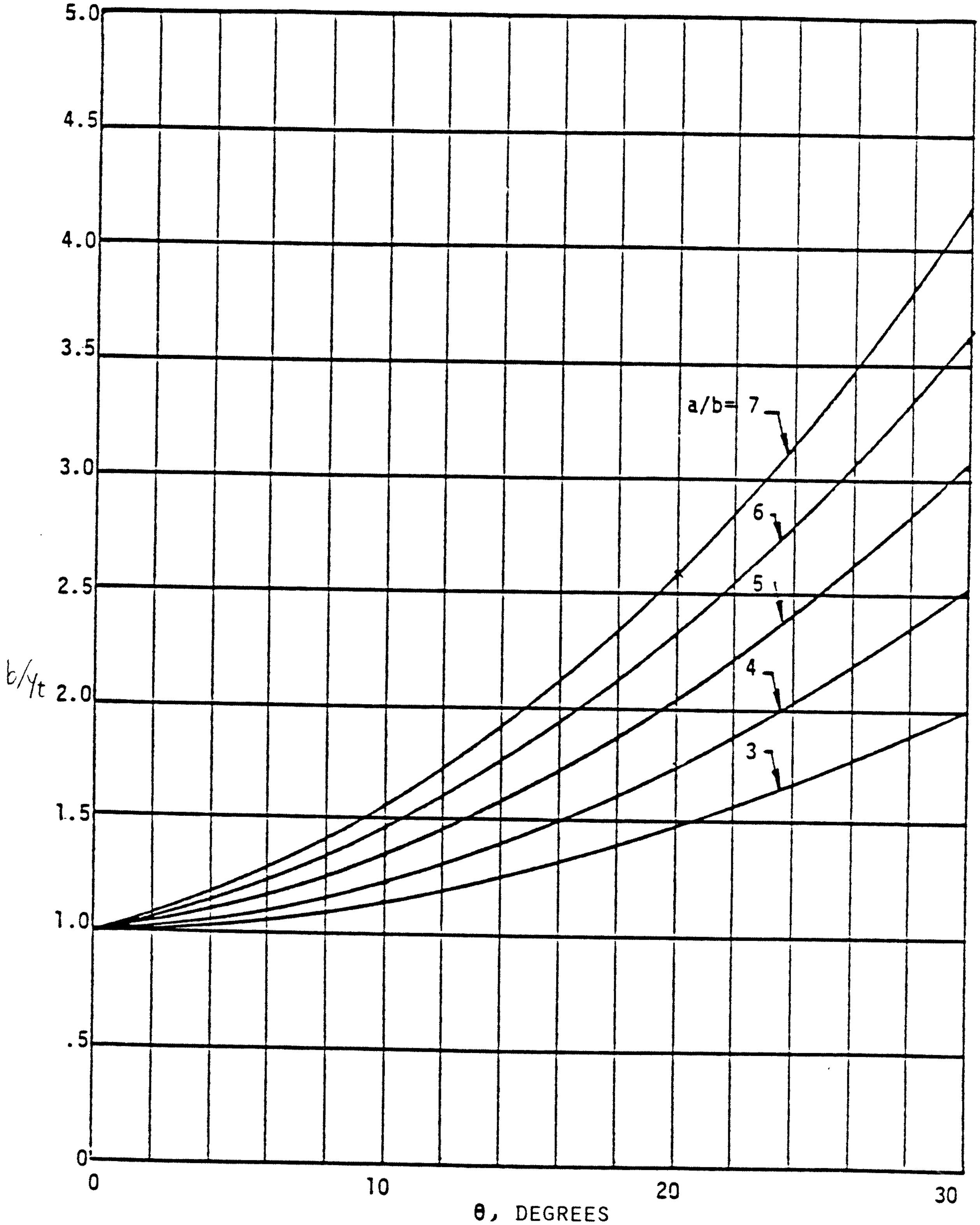

Figure 18. Non-dimensional ellipse semi-minor axis, b/y_t, as a function of a/b and θ

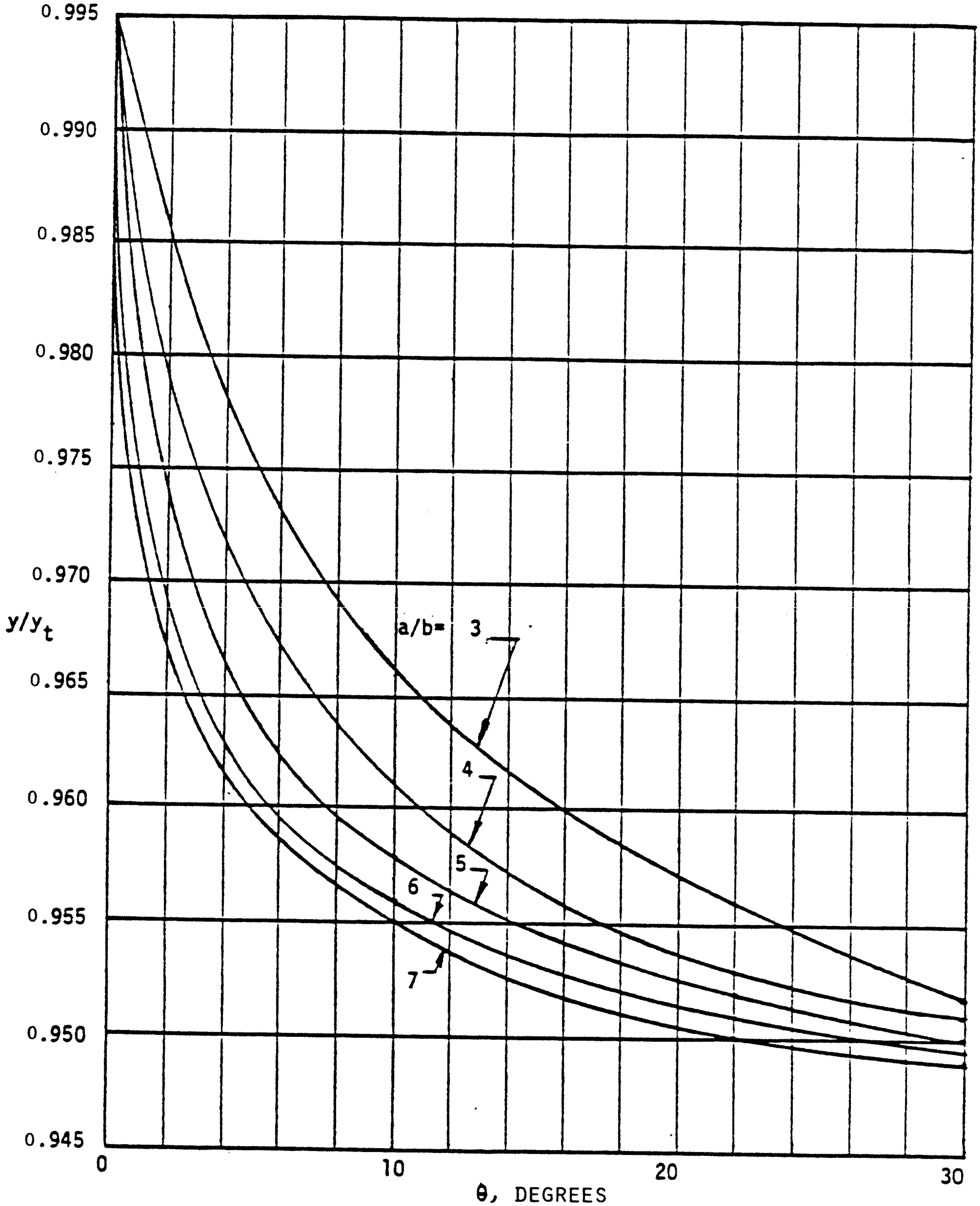

Figure 19. Non-dimensional elliptical offset, y/y_t, as a function of a/b and θ for f =0.1

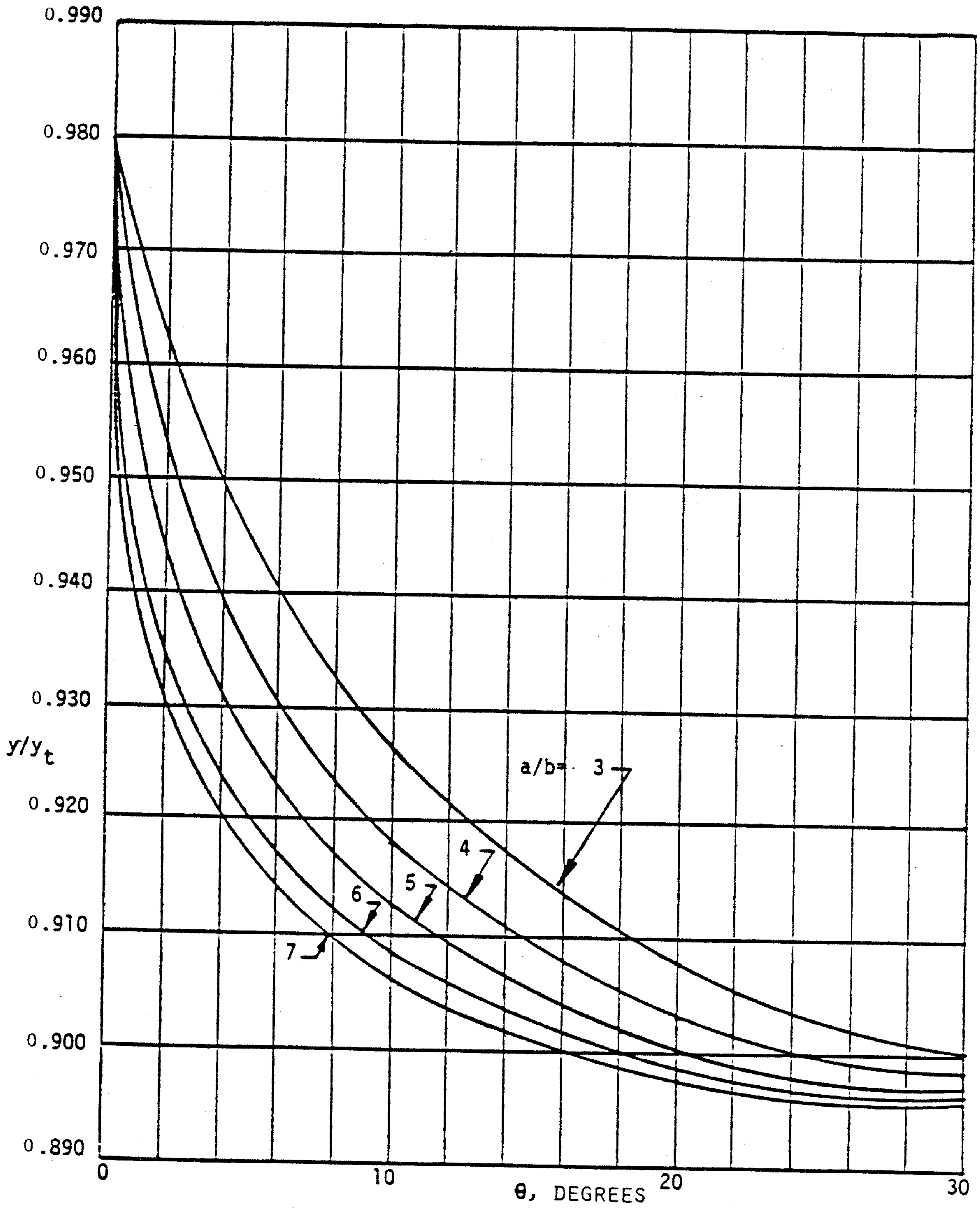

Figure 20. Non-dimensional elliptical offset, y/y_t, as a function of a/b and θ for f =0.2

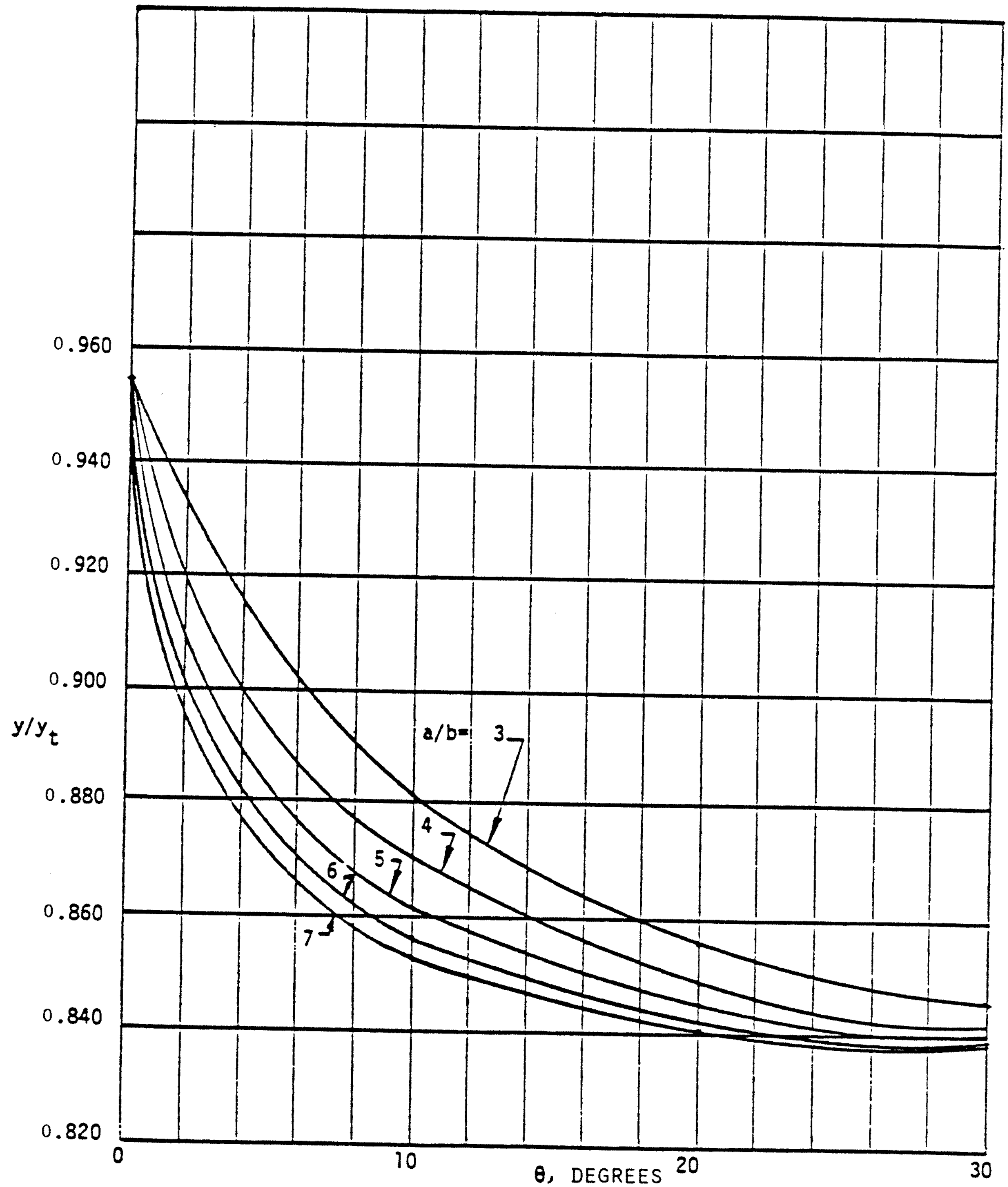

Figure 21. Non-dimensional elliptical offset, y/y_t, as a function of a/b and θ for f =0.3

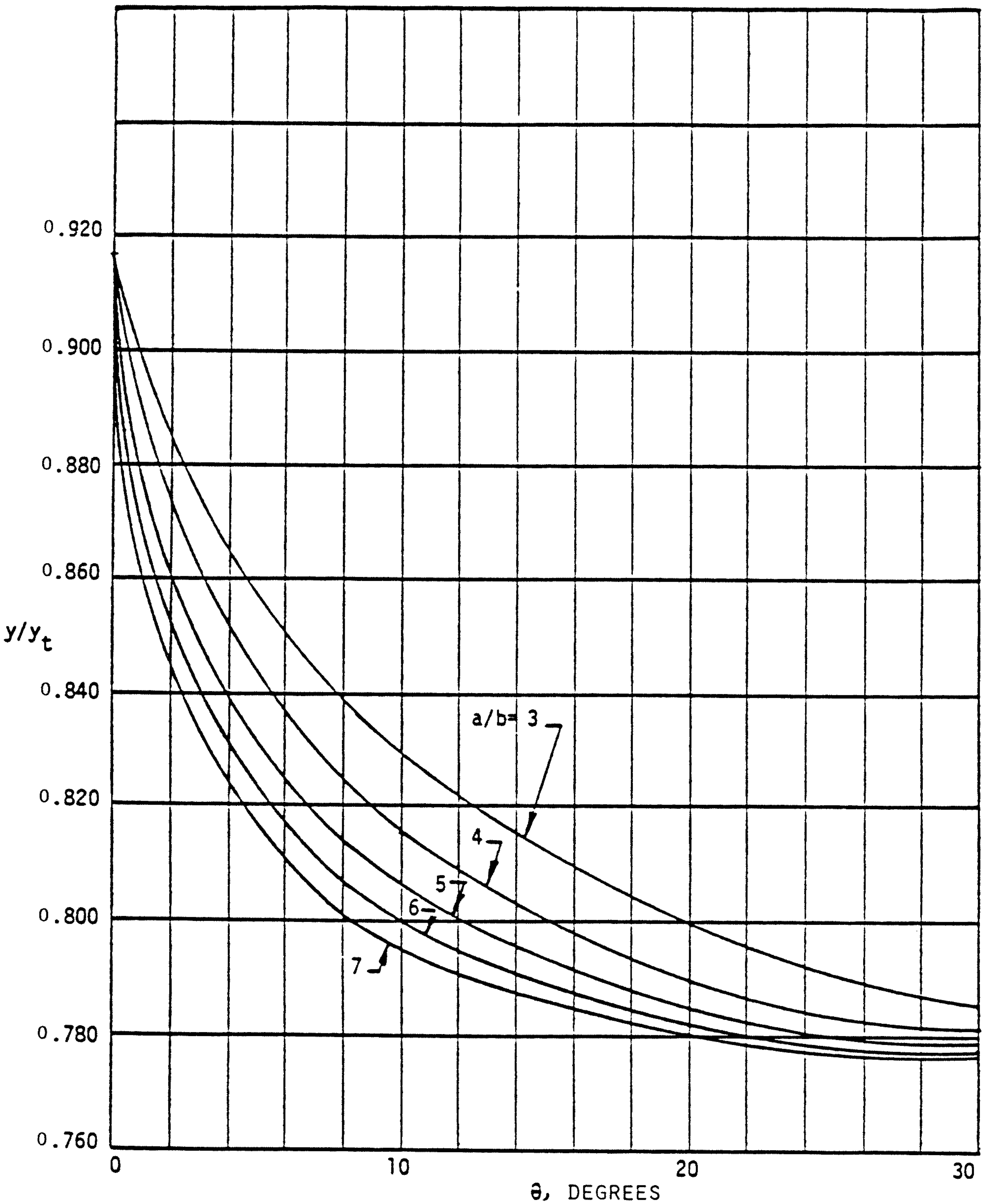

Figure 22. Non-dimensional elliptical offset, y/y_t, as a function of a/b and θ for f =0.4

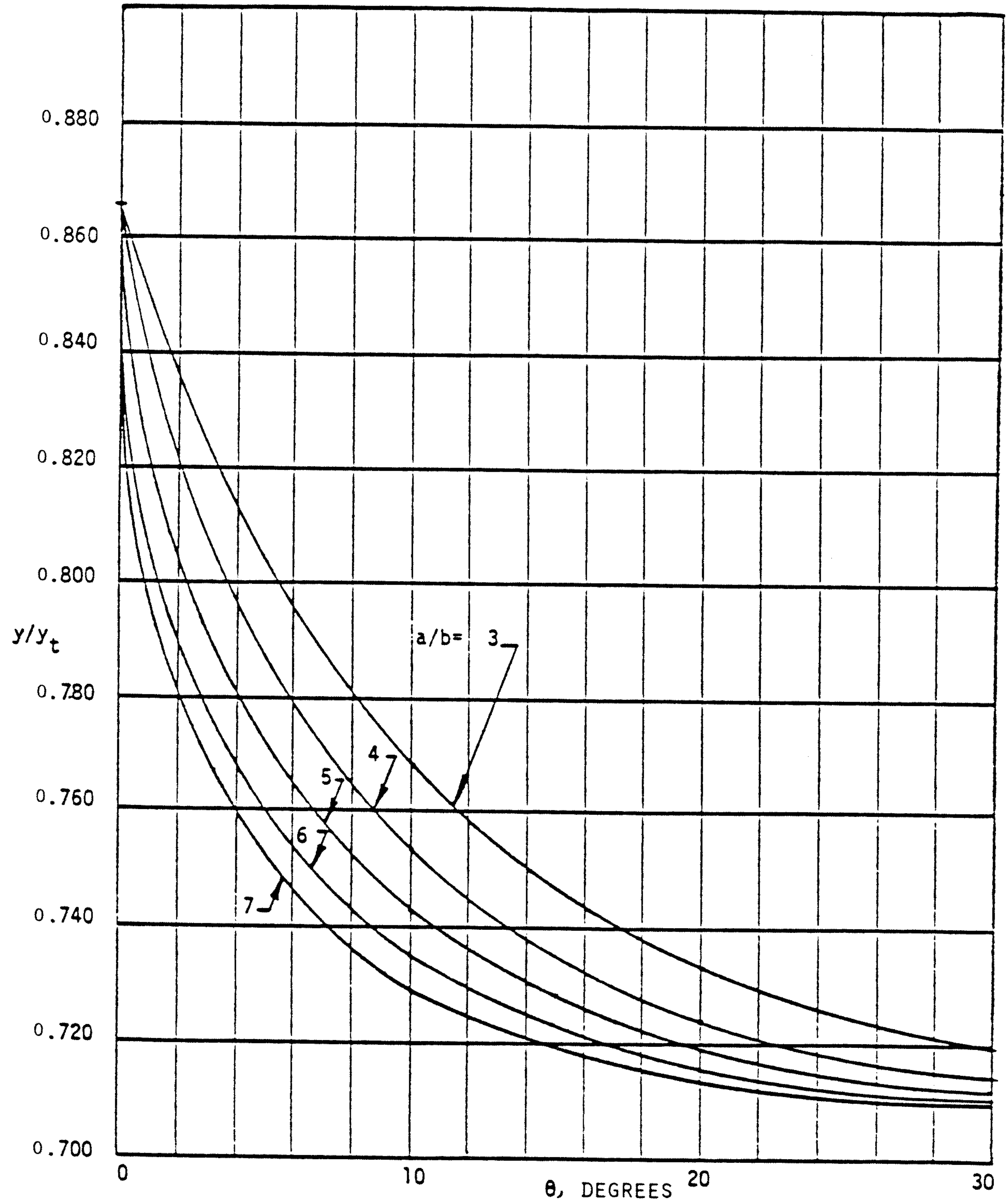

Figure 23. Non-dimensional elliptical offset, y/y_r, as a function of a/b and θ for f =0.5

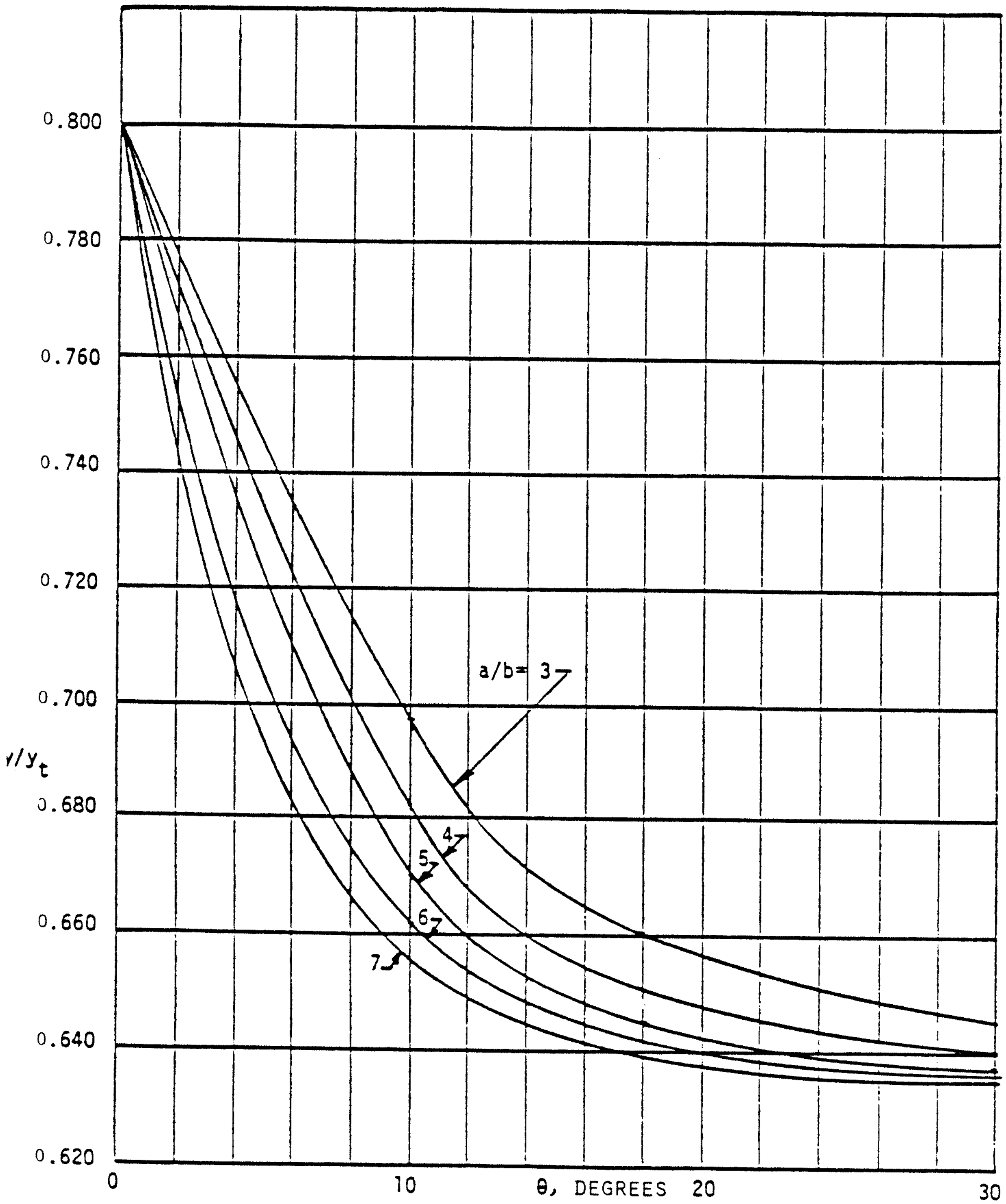

Figure 24. Non-dimensional elliptical offset, y/y_t, as a function of a/b and θ for f =0.6

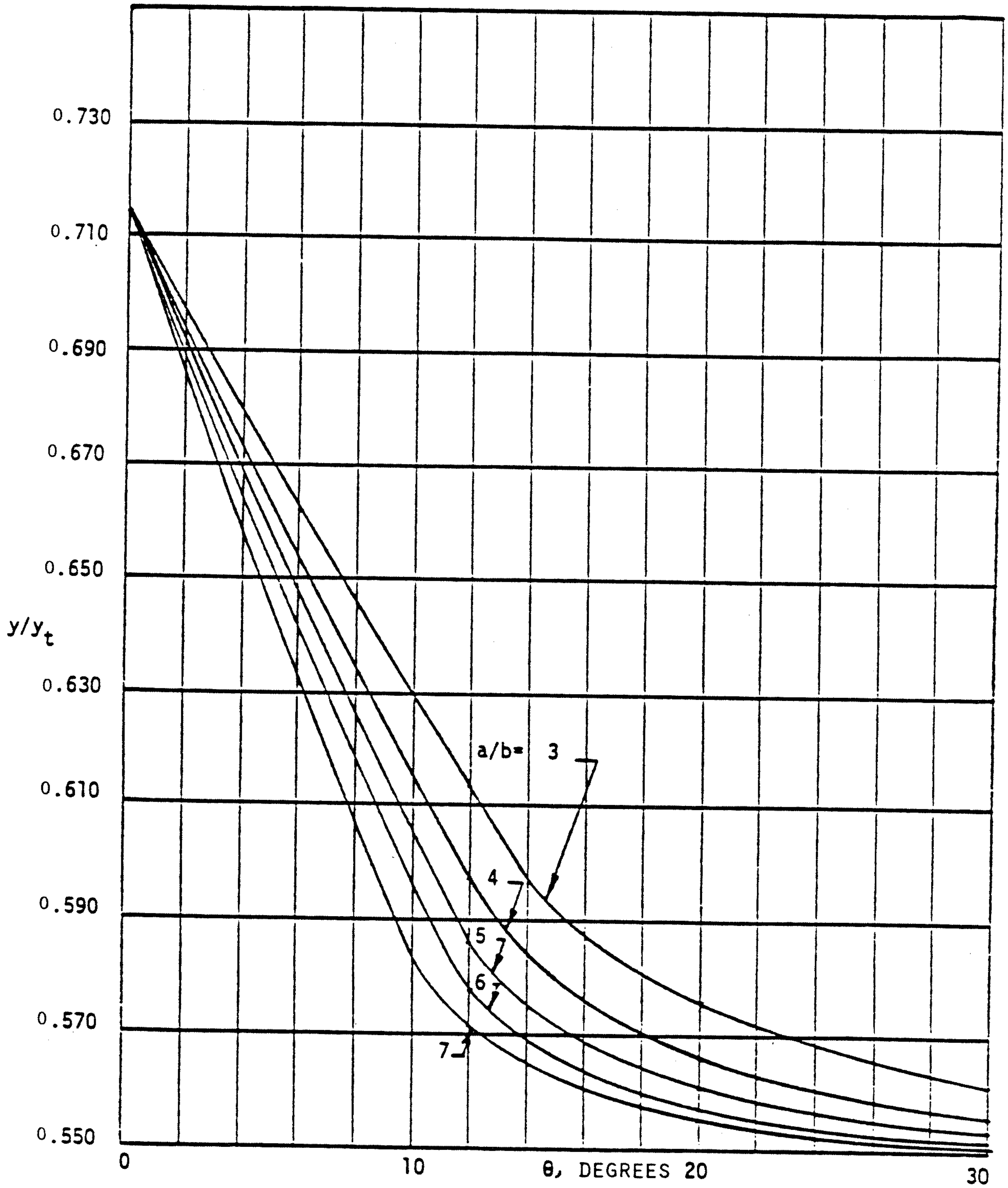

Figure 25. Non-dimensional elliptical offset, y/y_t, as a function of a/b and θ for f =0.7

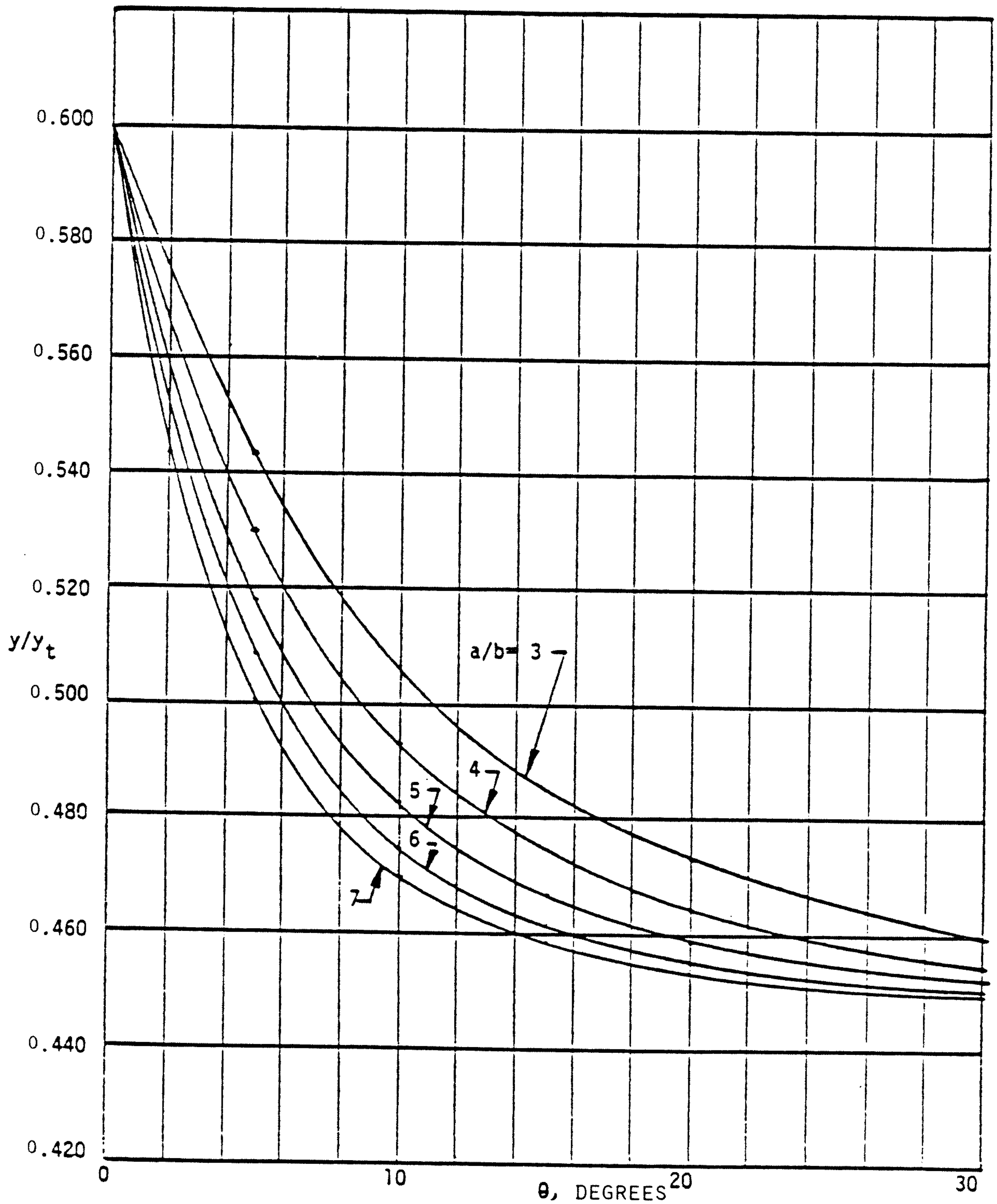

Figure 26. Non-dimensional elliptical offset, y/y_t, as a function of a/b and θ for f =0.8

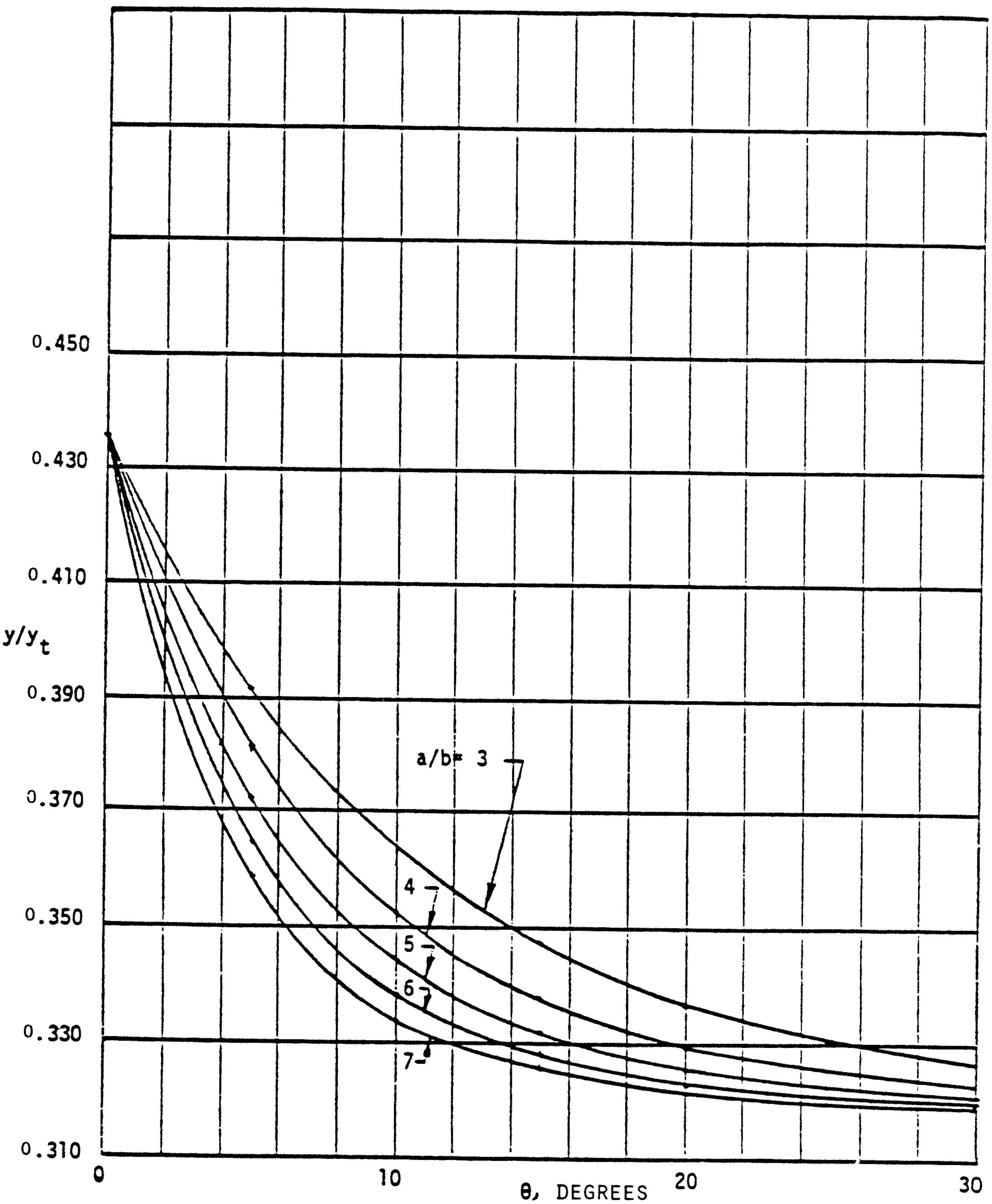

Figure 27. Non-dimensional elliptical offset, y/y_r, as a function of a/b and θ for f =0.9

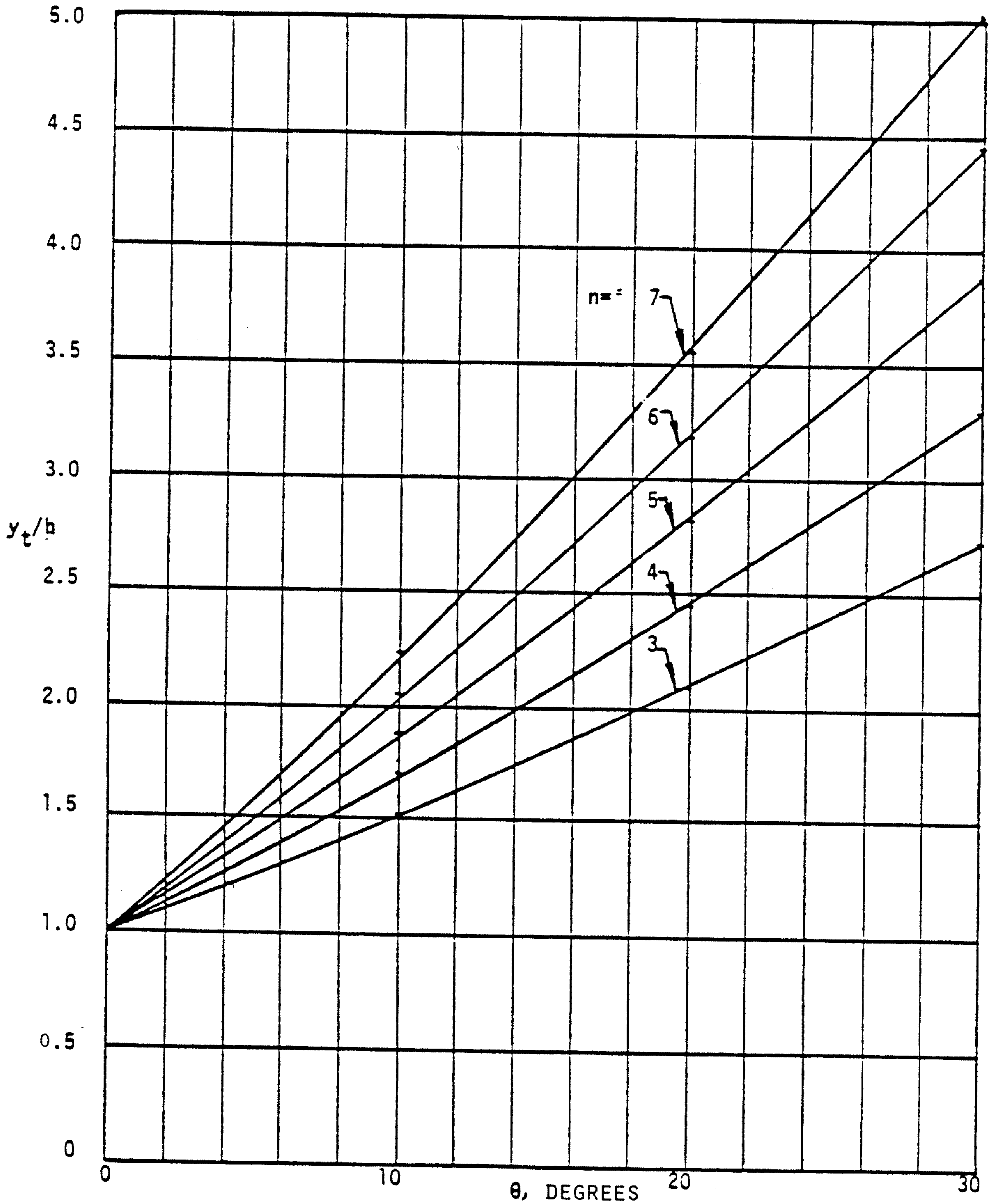

Figure 28. Non-dimensional tangency offset, y_t/h, as a function of n and θ

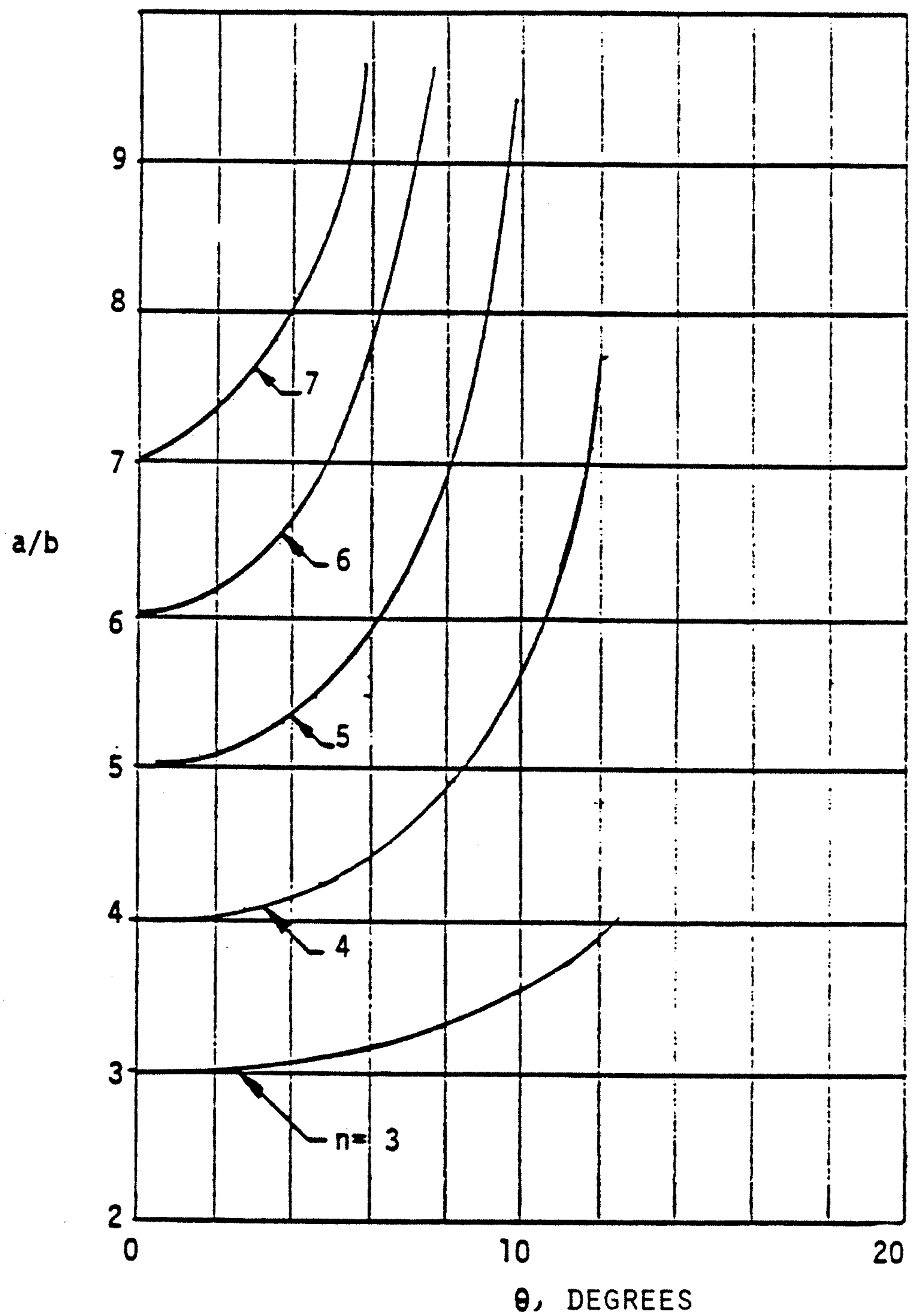

Figure 29. Elliptical aspect ratio, a/b, as a function of n and θ

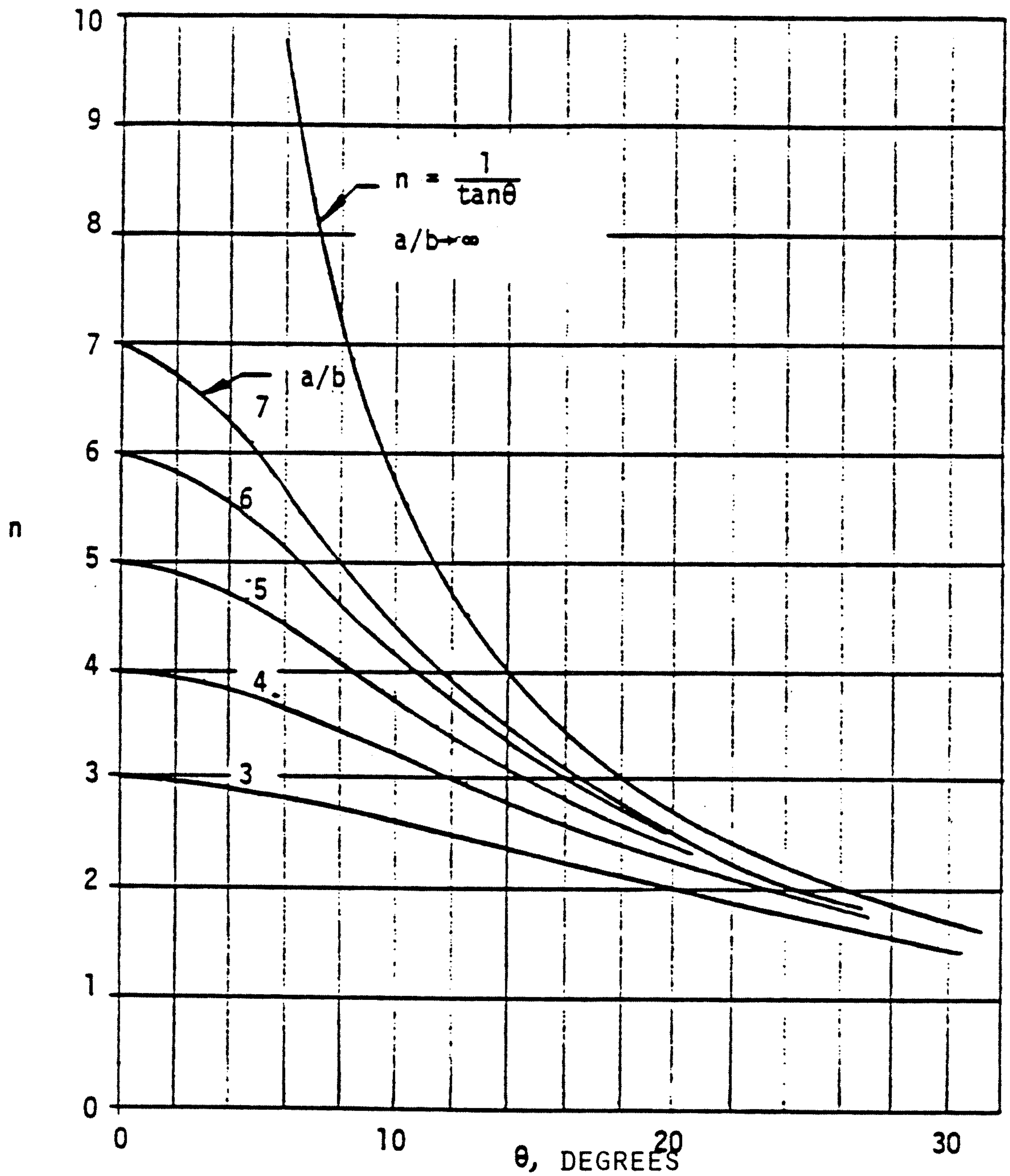

Figure 30. Parameter n as a function of a/b and θ

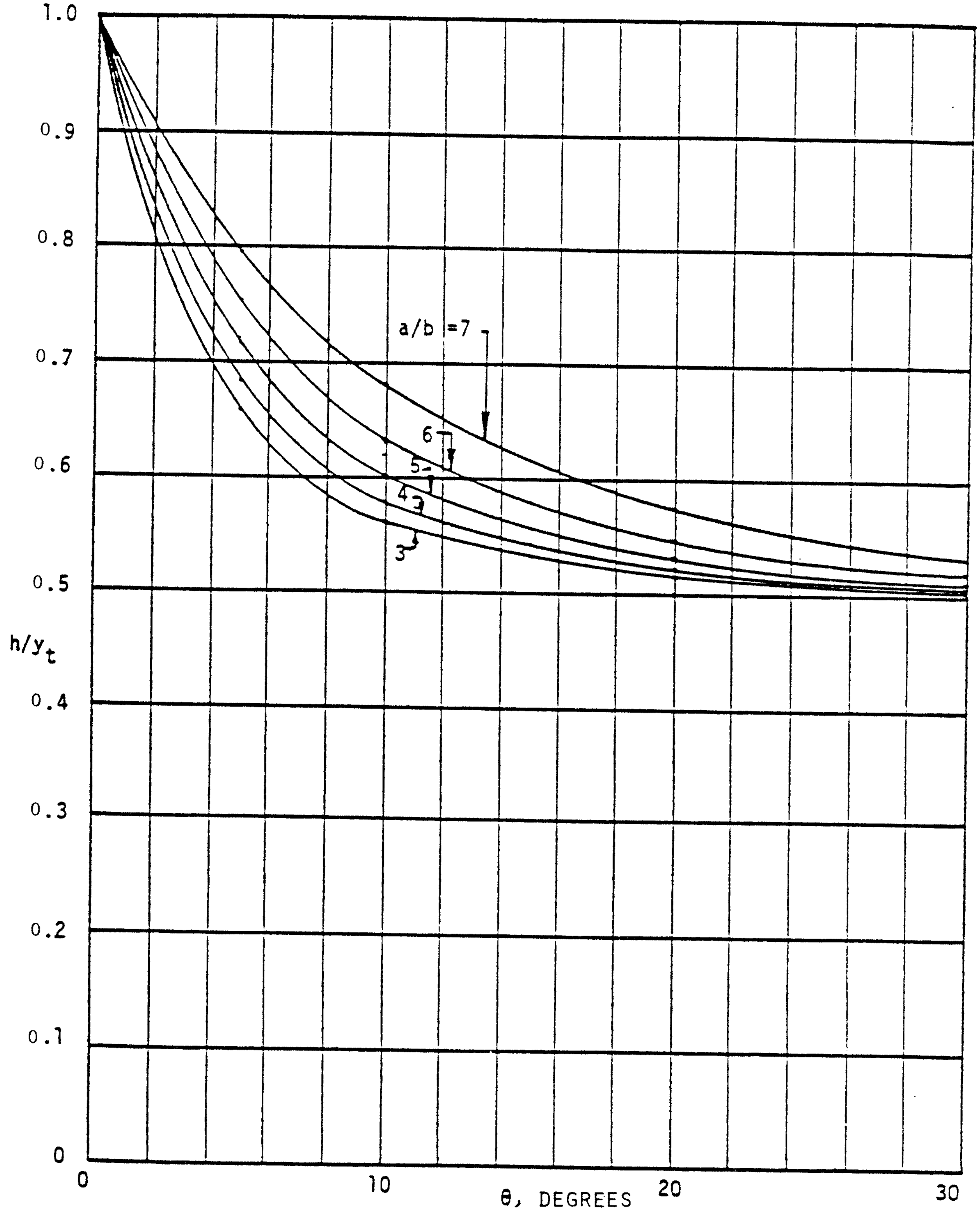

Figure 31. Non-dimensional half siding, h/y_t, as a function of a/b and θ

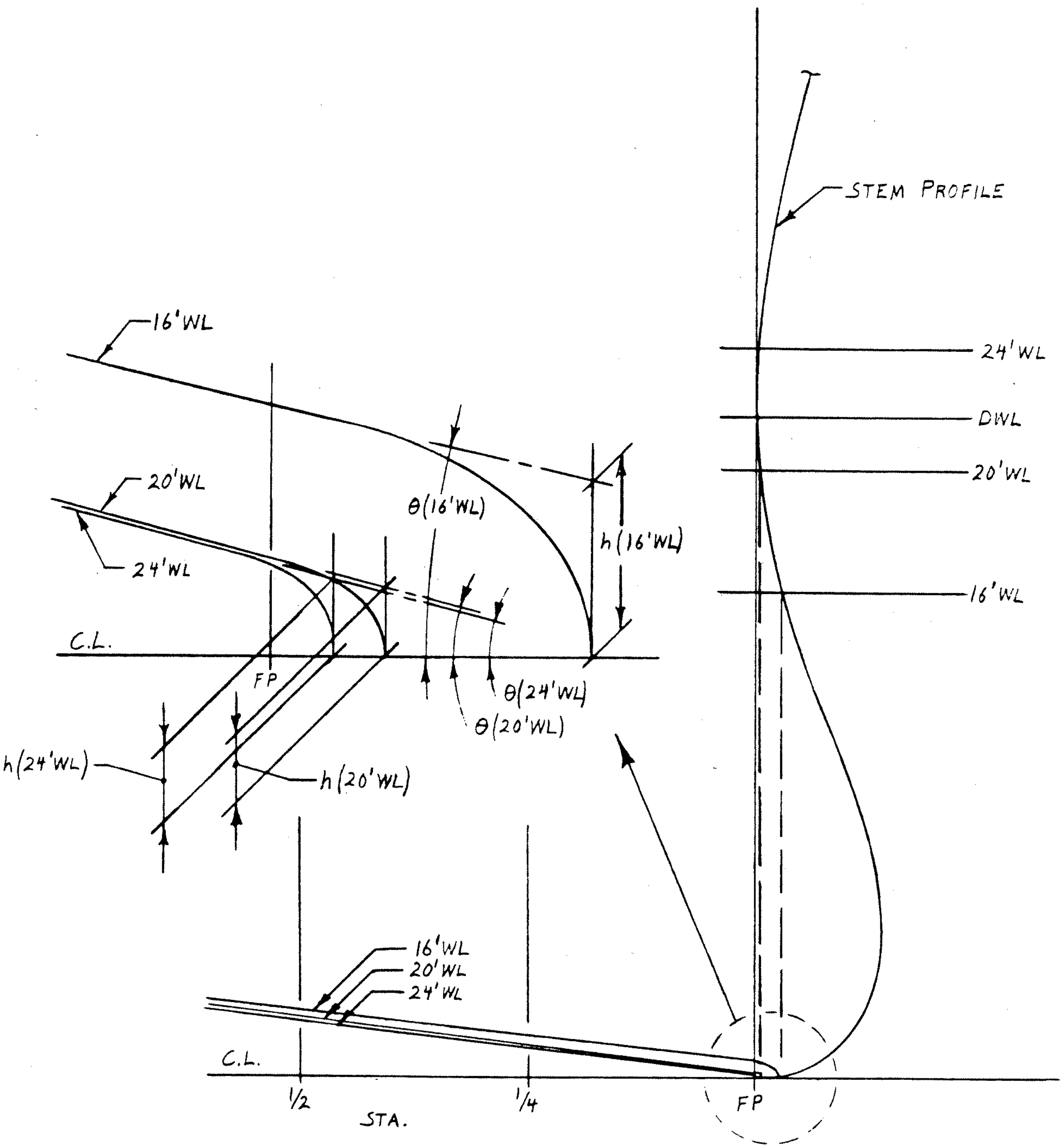

Figure 32. Sea Control Ship stem shape and waterline endings

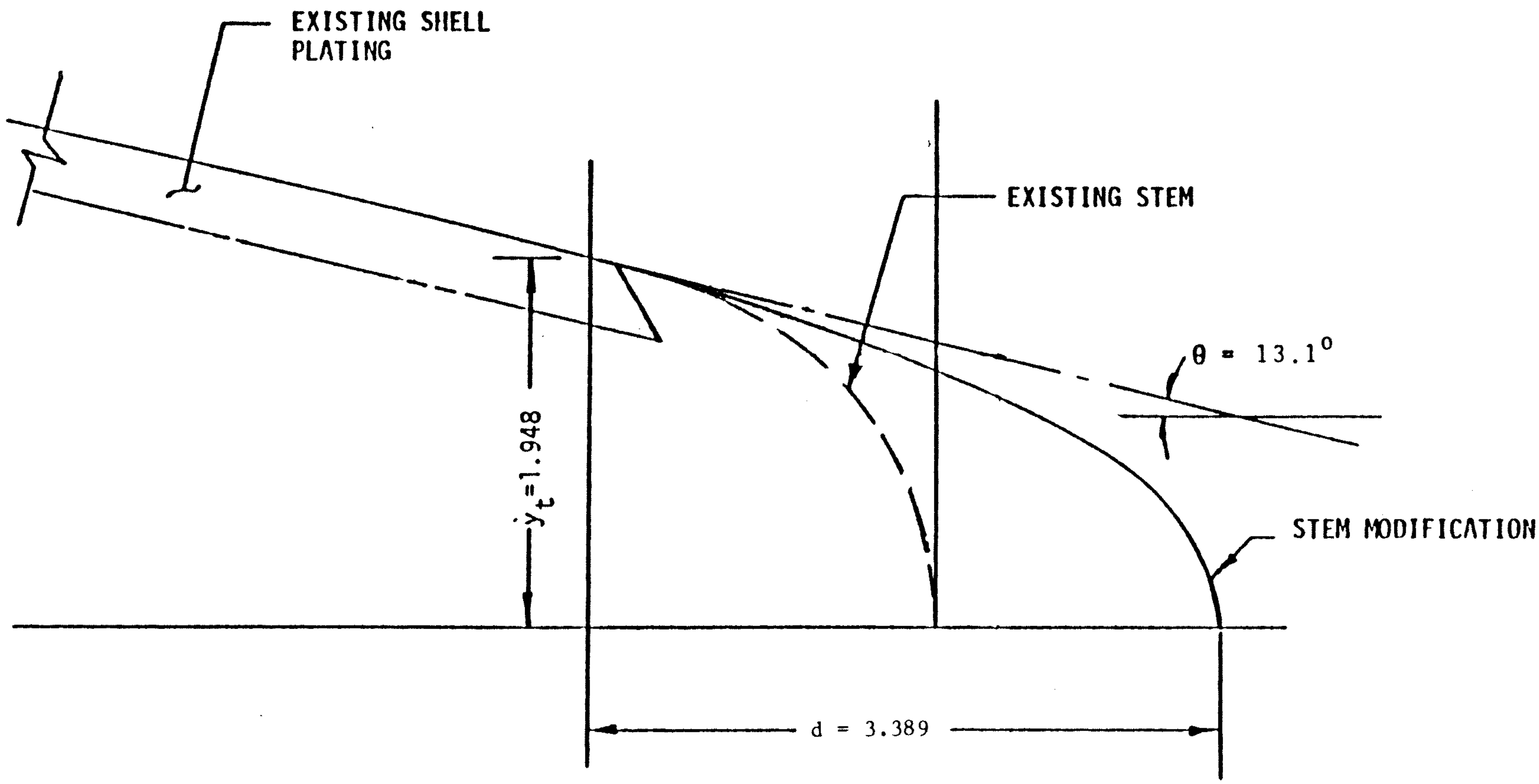

Figure 33. Illustration of stem section shape modification to existing ship (FFG 7)