

THE RANGE OF ALIGNMENT
AND ITS CORRELATION TO:
VERGENCE FINDINGS
AND
THE FIXATION DISPARITY CURVE

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In the research of binocular vision, many tests have been developed to aid in the diagnosis and treatment of oculomotor related anomalies. These include phoria measurements, vergences, and fixation disparity. Through the efforts of Donders, Morgan, Ogle, Percival, Sheard, Saladin and Sheedy, as well as many others, the results of these tests have been organized and correlated to aid in the analysis of oculomotor related symptoms.^{1,4}

The purpose of this study was to bring forward another type of oculomotor test, and correlate the results with the results of other, more familiar tests, in which the diagnostic implications have already been established.

The test that I am referring to is a form of forced vergence test, utilizing a polarized fixation disparity target.

The test is conducted, such that the patient observes the fixation disparity target through polarizing filters as the examiner gradually introduces lateral prism, bilaterally, until a misalignment of the upper and lower nonius lines is perceived. I will refer to this point as the point of "just noticeable misalignment". Following this reading, the amount of prism is reduced until the nonius lines again appear aligned. I will refer to this point as the point of "fixation realignment". The amount of prism required to elicit the point of just noticeable misalignment will be termed "the range of alignment".

METHODS

The sample used in this study consisted of 26 subjects. These subjects came from a mixed clinical and non-clinical population. All of the subjects were pre-presbyopic with ages ranging from 12 to 33 years of age.

All tests were performed through a refractor, with the subjects refractive correction in place. Stereo acuity testing was performed both at distance and near to demonstrate binocularity at the respective testing distance. All subjects exhibited stereo acuity of at least 60 seconds of arc at both distance and near. The following tests were performed on each subject at distance (4M) and near (40cm): phorias, positive and negative relative vergences, and the positive and negative ranges of alignment, as well as the respective fixation realignment. The fixation disparity curve was plotted for each subject at a testing distance of 40 cm.

The phoria reading was taken at distance and near using the von Graefe technique. Positive and negative relative vergence readings were obtained by having the subject fixate a vertical line of letters as lateral prism was slowly introduced bilaterally. The subject reported when the target was perceived to blur, break apart, and (as the amount of prism was reduced) form back into one. Base in measurements were taken first.

The points of just noticeable misalignment and fixation realignment were obtained as previously described. At distance the target used was the fixation disparity target on the A.O. vectographic slide. The Borish card, with its' fixation disparity target, was used at near. Again, base in readings were taken before the base out readings. The fixation disparity curve was plotted, utilizing a target which contained two vertical lines, polarized perpendicular to each other, one placed above the other. By rotating a dial the horizontal separation of these lines could be varied in increments of one minute of arc. On either side of this central target, a small chart of letters was located, to aid in the control of accommodation. In performing the test, polarizers were placed in front of the subjects eyes so that each vertical line was seen by only one eye. Different pairs of lines were presented to the subject until they reported that the lines were horizontally aligned. The test was then repeated introducing lateral prism in increments of 3pd. Measurements were taken in this manner until the amount of prism had been introduced which elicited diplopia. The sequence of introducing prism was again, base in before base out.

CALCULATIONS²

For all calculations, and graphs, the points of just noticeable misalignment (JNM) and the points of fixation realignment (FR) were assigned values on the X axis. The correlations were all calculated on the basis of predicting Y from the value of X.

The coefficient of correlation (r) was calculated utilizing the Deviation Score Formula:

$$r_{xy} = \frac{\sum xy}{n S_x S_y}$$

$$\text{WHERE: } x = (X - \bar{X})$$

$$y = (Y - \bar{Y})$$

$S_y = S_x = \text{STD. DEVIATIONS OF THE DISTRIBUTION}$

r^2 = the coefficient of determination. This value gives the proportion of variance in Y which is associated with changes in X. $100r^2$ gives this value as a percentage.

The standard error of estimate of Y based on the value of X (S_{YX}) is given by the following formula: $S_{YX} = S_y \sqrt{1 - r^2}$

$\left. \begin{array}{l} \text{WHEN } r = 0; S_{YX} = S_y \\ \text{WHEN } r = 1; S_{YX} = 0 \end{array} \right\} \text{ ASSUMES A NORMAL DISTRIBUTION}$

This value acts as the standard deviation for predicting Y from X. 68% of obtained Y values fall within the limits of $\pm 1 S_{YX}$ from the line of best fit (of Y on X)

The slope of the fixation disparity graph was calculated by the Method of Least Squares, utilizing the points associated with 3pd BI, Opd, and 3pd BO. The slopes calculated for either the base in or base out side of the graph were calculated by the same method, utilizing all plotted points between Opd and the break point.

Name Deanna Stinger

11/6
Age 21

Refraction -0.25 sph
OVER CL'S -0.25 sph
PD 56

BVA 20/20 - 20/20 - 20/15

Stereo Acuity: Distance 60 sec Near 40 sec (PCY)

Phoria: Distance ∅ Near ∅ 1 BI
VERT ∅

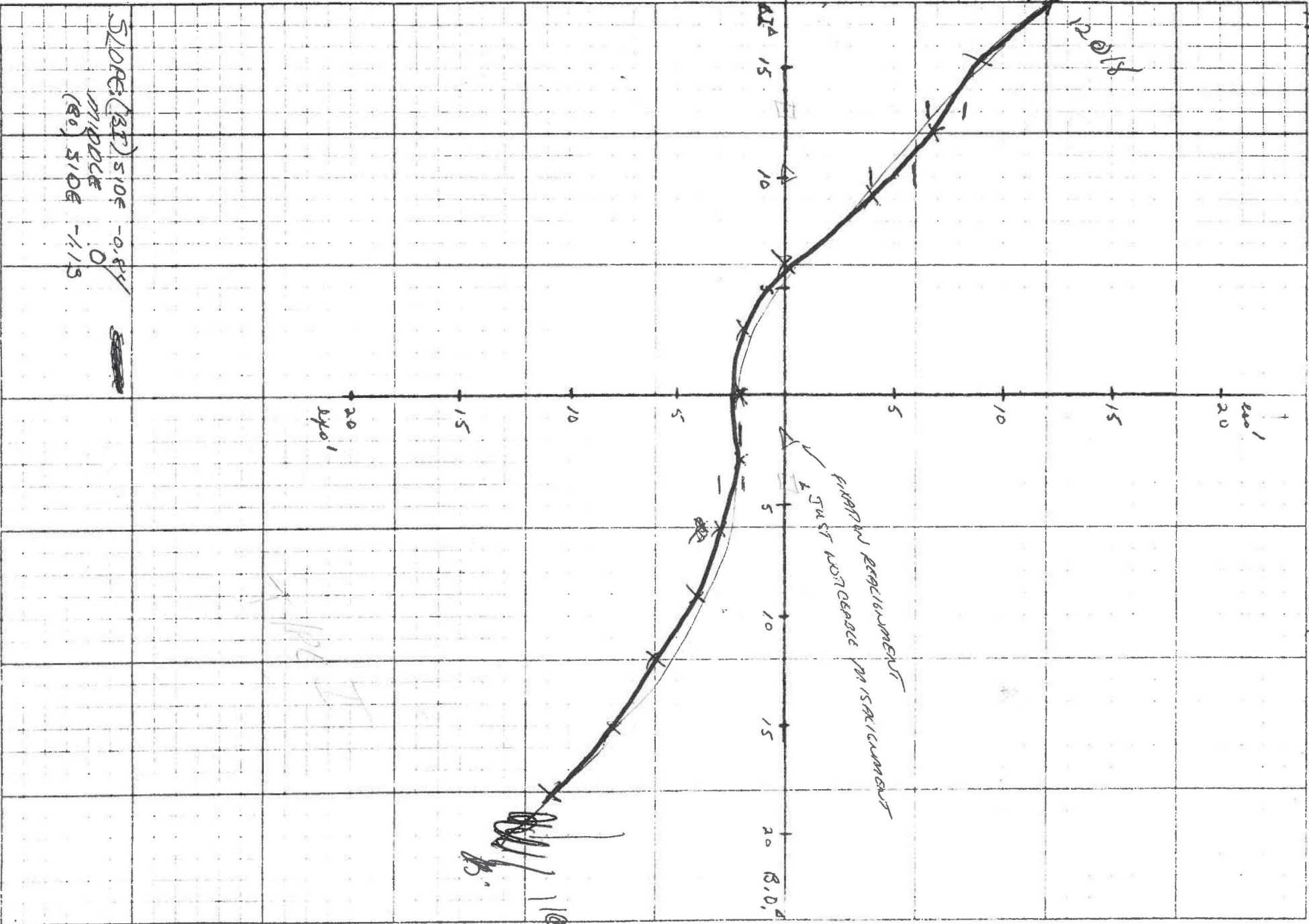
Vergences: BI BO
Distance X 117/9 19
119/12
Near 18 18
120/15 120/10
(40 cm)

Range of Alignment: BI BO
(ABSOLUTE)
Distance 6/4 1/2 5.31
~~4.2~~
Near 13/10 1 4 13 1
(40 cm)

FIX DISP. NEAR 2 BI
DIST 2 BI

Name: _____

Date: _____



10000

18

110

Name Doug Lee

Age 22

Refraction pl

BVA 20/15

Stereo Acuity: Distance 2min Near 40

Phoria: Distance ϕ Near 180

Vergences: BI BO

Distance	<u>4 17 14</u>	<u>2 11 21 8</u>
Near (40 cm)	<u>6 11 24 5</u>	<u>4 20 1 7</u>

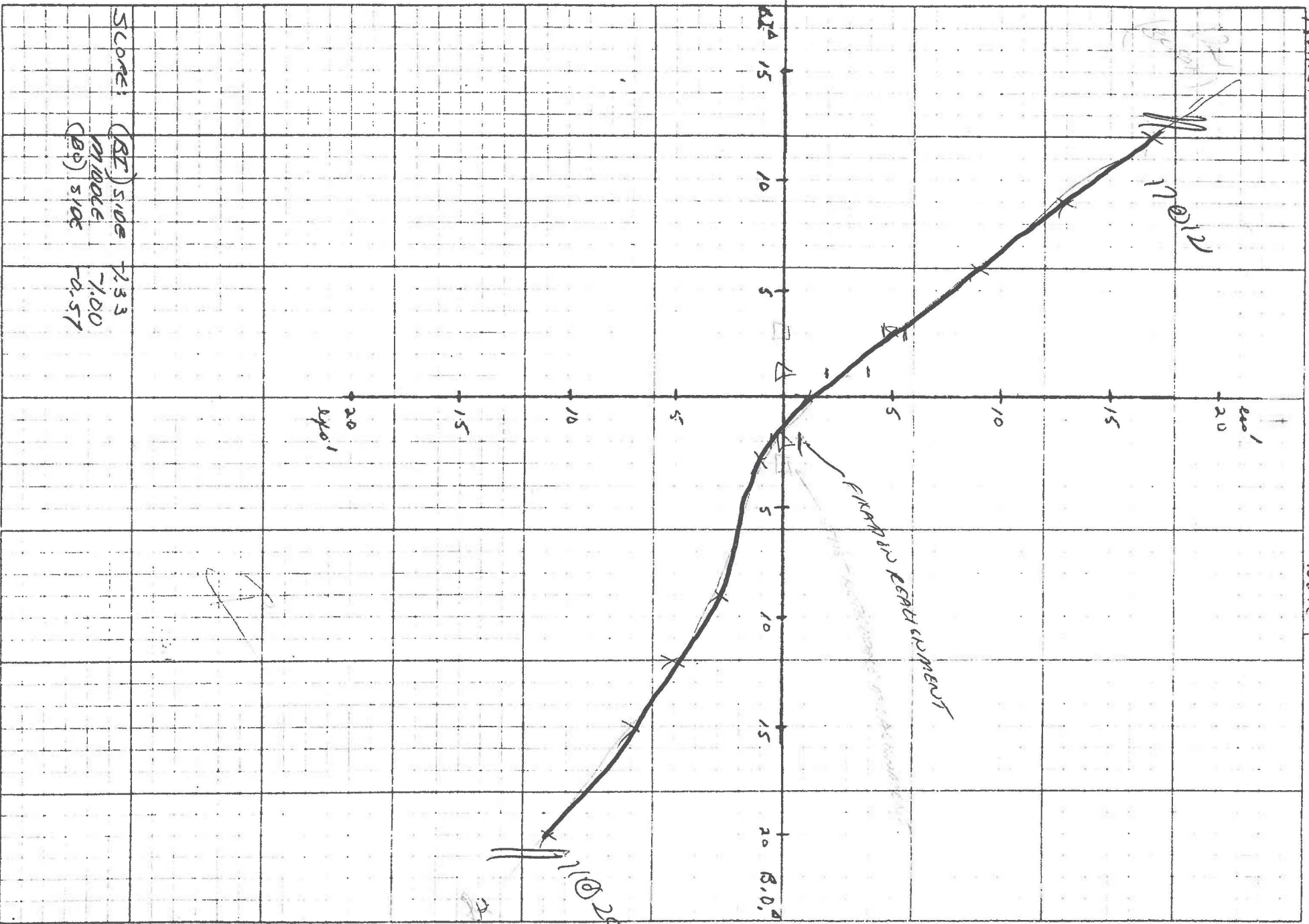
Range of Alignment: BI BO

Distance	<u>13 1 2</u>	<u>15 1 2</u>
Near (40 cm)	<u>13 1 1</u>	<u>13 1 2</u>

FD @ NEAR 180

Name:

Date:



Name Pat Shelen

Age 22

Refraction PD 64
-3.00
-2.25 -0.50 x 160

BVA 20/15

Stereo Acuity: Distance 2 min Near ~~60 sec~~ 40 sec

Phoria: Distance 0 Near 6 BE
VERT 0

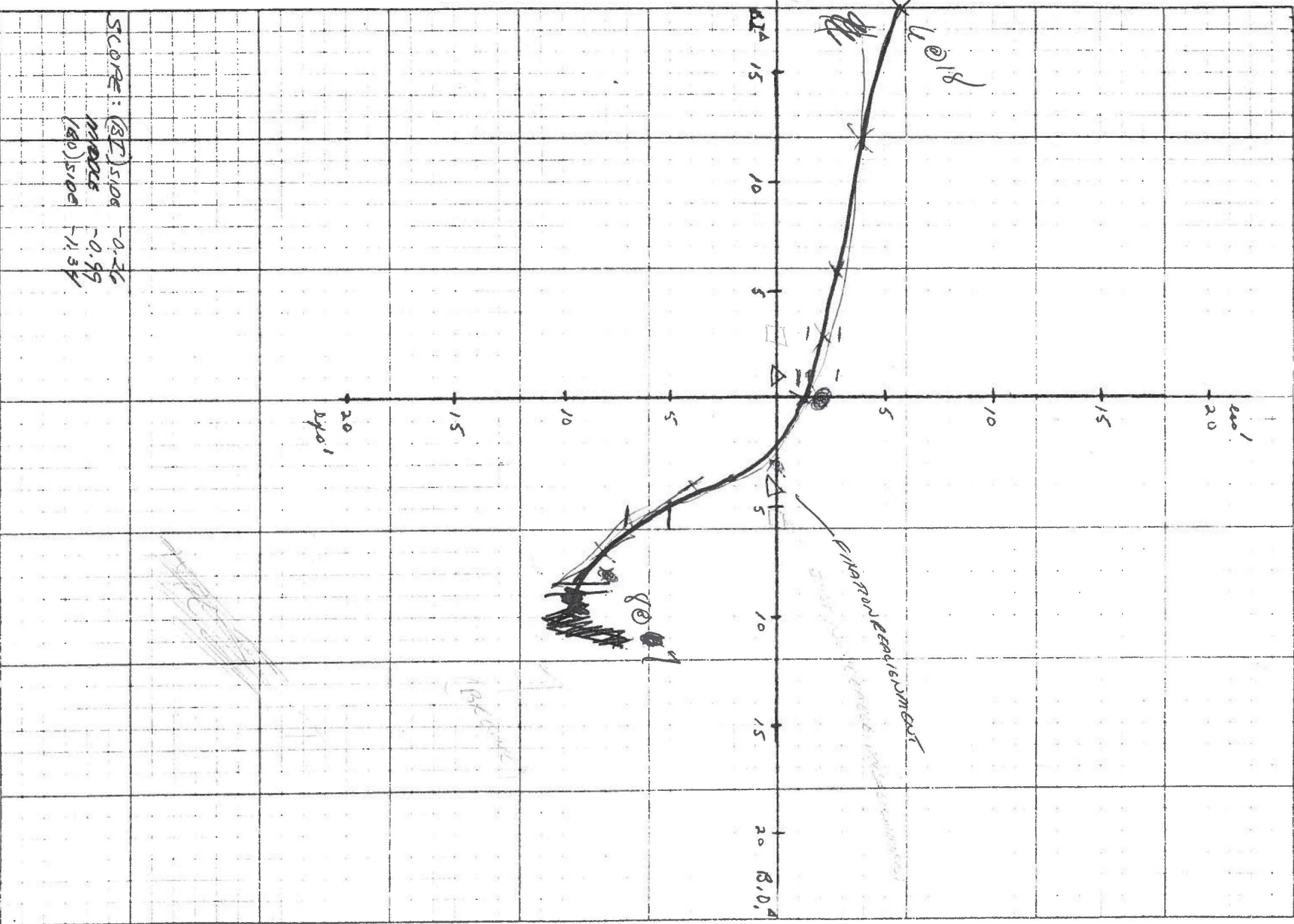
Vergences:	BI	BO
Distance	<u>1613</u>	<u>41815</u>
Near (40 cm)	<u>611916</u>	<u>61714</u>

Range of Alignment:	BI	BO
Distance	<u>1412</u>	<u>1311</u>
Near (40 cm)	<u>611916</u> <u>3/1</u>	<u>61714</u> <u>5 1/2 / 4</u>

FD @ DIS - 1/2 BO
NEAR

Name:

Date:



SCORE: (87) 5100

MAKES
180) 5100

-0.36

-0.98

-11.34

Name Spirella Ciranna

Age 21

Refraction

+0.75 sph
+0.75 sph

BVA

PD 60

Stereo Acuity:

Distance 60

Near 40

Phoria:

Distance 2BI

Near 2BI

VERT

Vergences:

BI

BO

Distance R1/D14 : 61/214

Near 12° 114 101/211
(40 cm)

Range of Alignment:

BI

BO

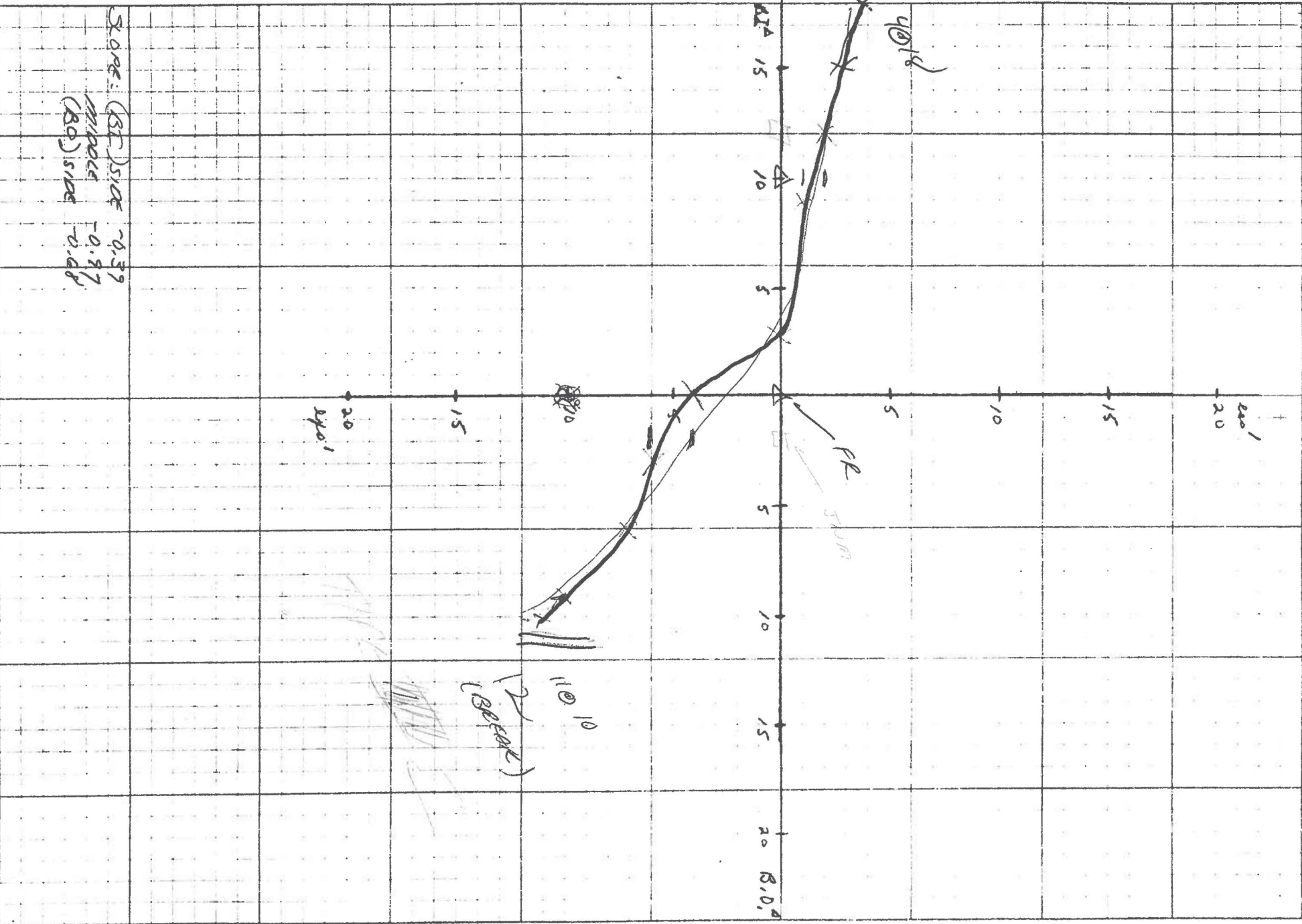
Distance 2111 1/10

Near 121101 1210
(40 cm)

F.D. DIST 1/2 BR
NEAR 1 BF

Name: _____

Date: _____



SCALE: (B.I.) SIDE -0.59
MIDDLE -0.87
(B.O.) SIDE -0.88

Name Gene Shidler

Age 23

Refraction -0.50
-0.50 -0.25 x 30

BVA ^{20/15}
64
PA

Stereo Acuity: Distance 60 Near 40

Phoria: Distance 0 Near 1/2 BI
VERT

Vergences: BI BO

Distance X1614 71123

Near 118116 11315
(40 cm)

Range of Alignment: BI BO

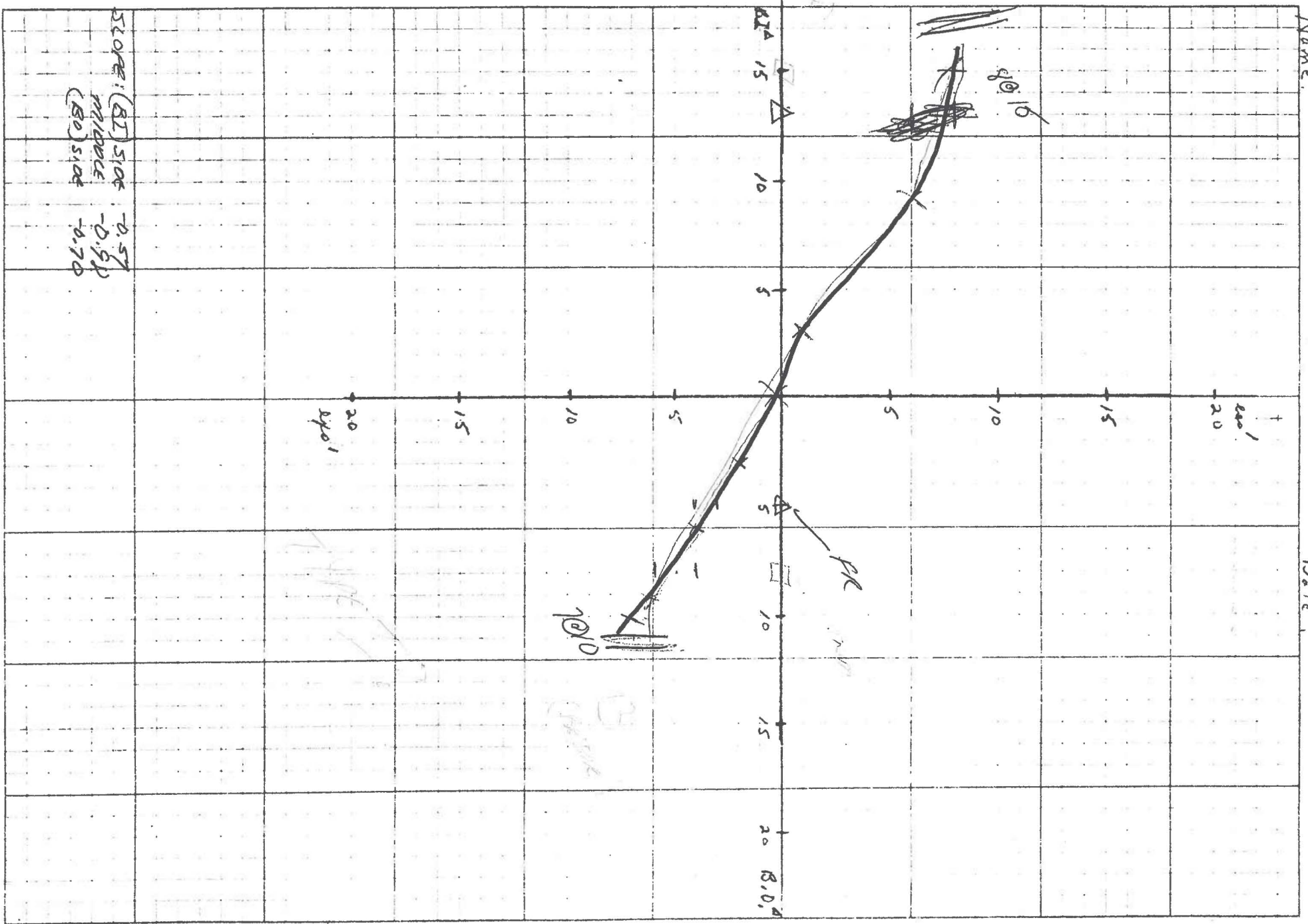
Distance 1312 1312

Near 115113 181~~15~~
(40 cm)

F.D. DIST 0
NEAR 0

Name:

Date:



Name Tom Lapp

Age 15

Refraction -2.25 -0.50 x 175
-2.25 -0.50 x 180

BVA 20/15

Stereo Acuity: Distance 60

Near 40

Phoria: Distance 0

Near 1/2 50

Vergences:

BI

BO

Distance X 16 14 5 12 14

Near 12 13 11 12 14 15
(40 cm)

Range of Alignment:

BI

BO

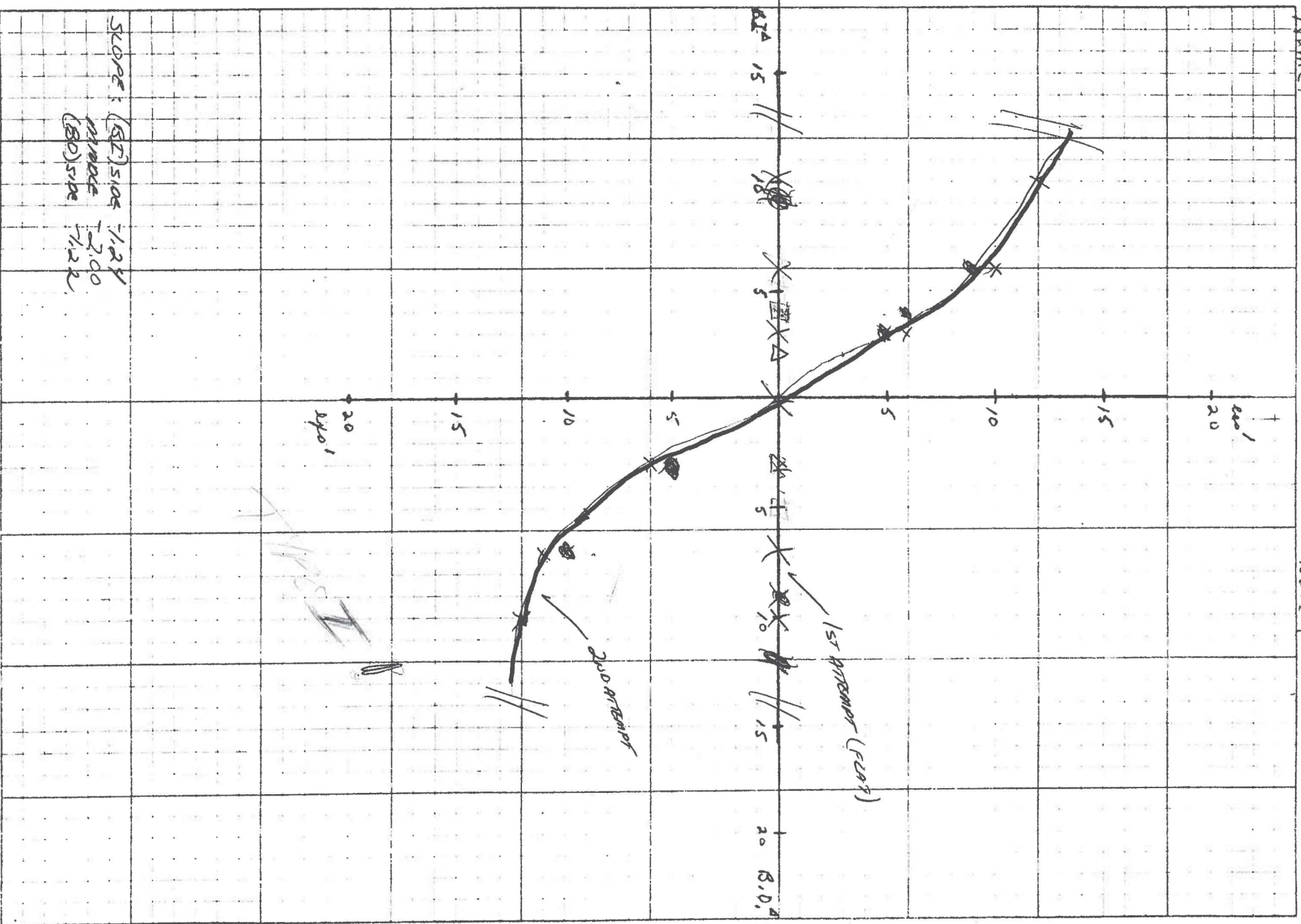
Distance 10 11 30 13 12

Near 14 12 15 10 2
(40 cm)

FD DIST 180
NEAR 0

Name: _____

Date: _____



SLOPE: (80) SIDE = 1.24
 (100) SIDE = 2.00
 (80) SIDE = 1.22

Beard

Beard

Name MARY KNATH

Age 15

Refraction $+0.50 = 0.50 \times 95$
 $+0.75 - 0.50 \times 85$

BVA 20/15

Stereo Acuity: Distance 60 Near 40

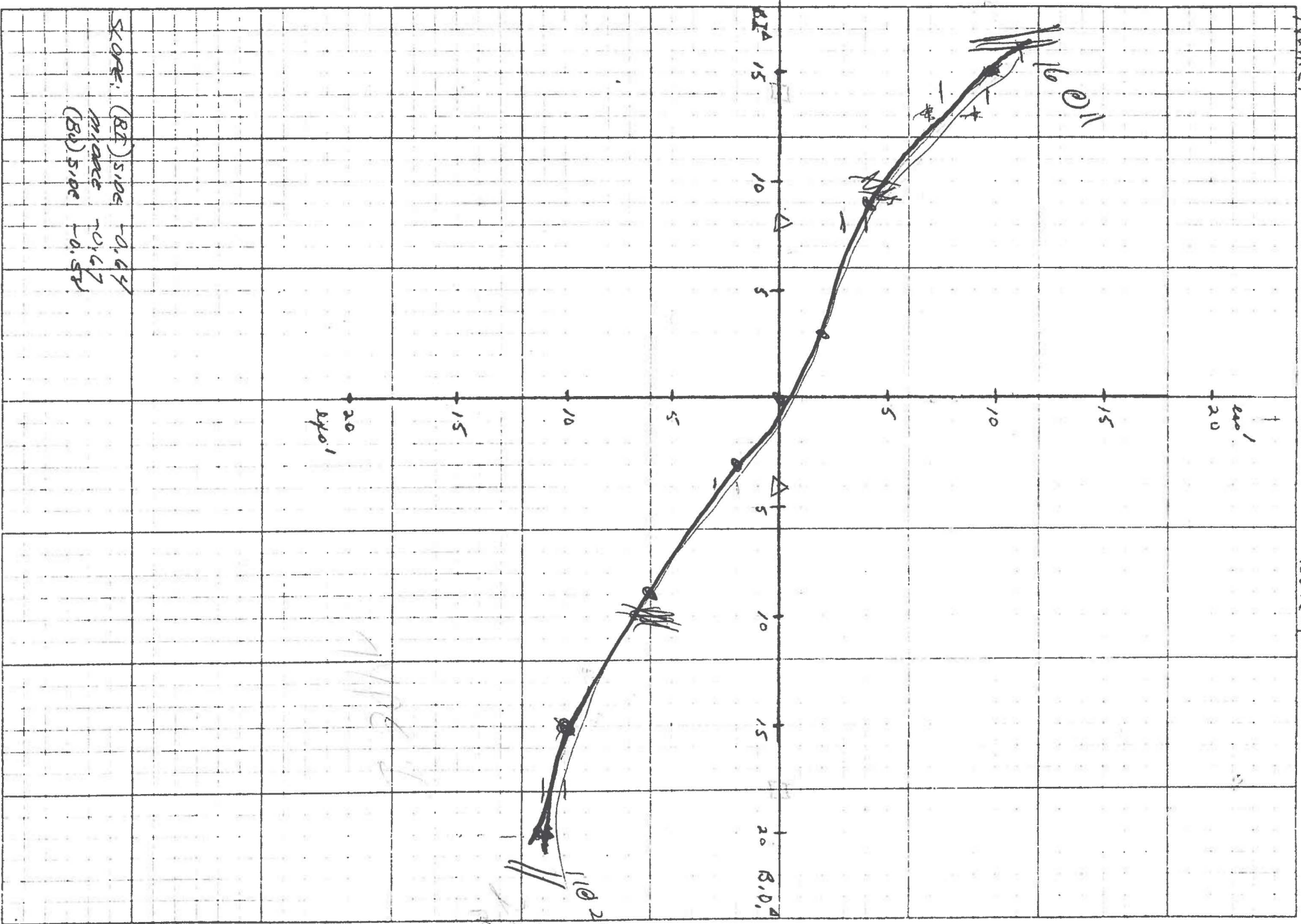
Phoria: Distance 2 BO Near 0

Vergences:	BI	BO
Distance	<u>X 18 14</u>	<u>7 130 12</u>
Near (40 cm)	<u>4 18 8</u>	<u>10 122 16</u>

Range of Alignment:	BI	BO
Distance	<u>16 10</u>	<u>11 4 12</u>
Near (40 cm)	<u>11 4 8</u>	<u>11 4 14</u>

Name:

Date:



SCORE: (RT) SIDE -0.64
 (L) SIDE -0.67
 (B) SIDE -0.57

Name SANDY HILTBREAN

Age 25

Refraction +0.75
+1.00

BVA 20/20

Stereo Acuity:

Distance 60

Near 80

Phoria:

Distance 200

Near 10BI

Vergences:

BI

BO

Distance 14 13

10 12 14

Near 10 12 21 18
(40 cm)

4 17 1 - 2

Range of Alignment:

BI

BO

Distance

12 1 1

10 1 - 1

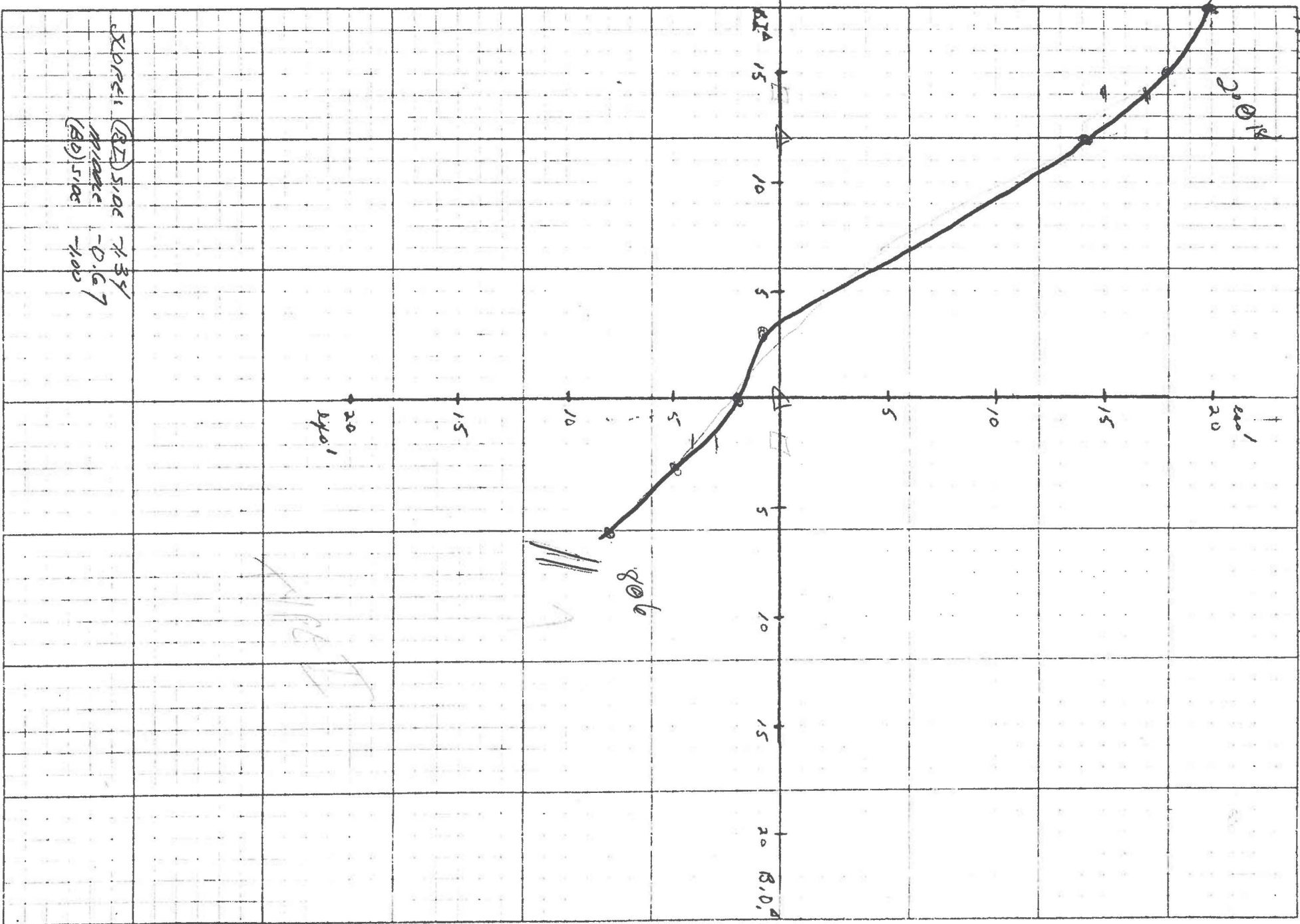
Near
(40 cm)

11 4 1 13

12 1 0

Name:

Date:



Name Helen Noel

Age 21

Refraction pl. oc.

BVA 20/15

PD 60

Stereo Acuity: Distance Near 40

Phoria: Distance 0 Near 8x

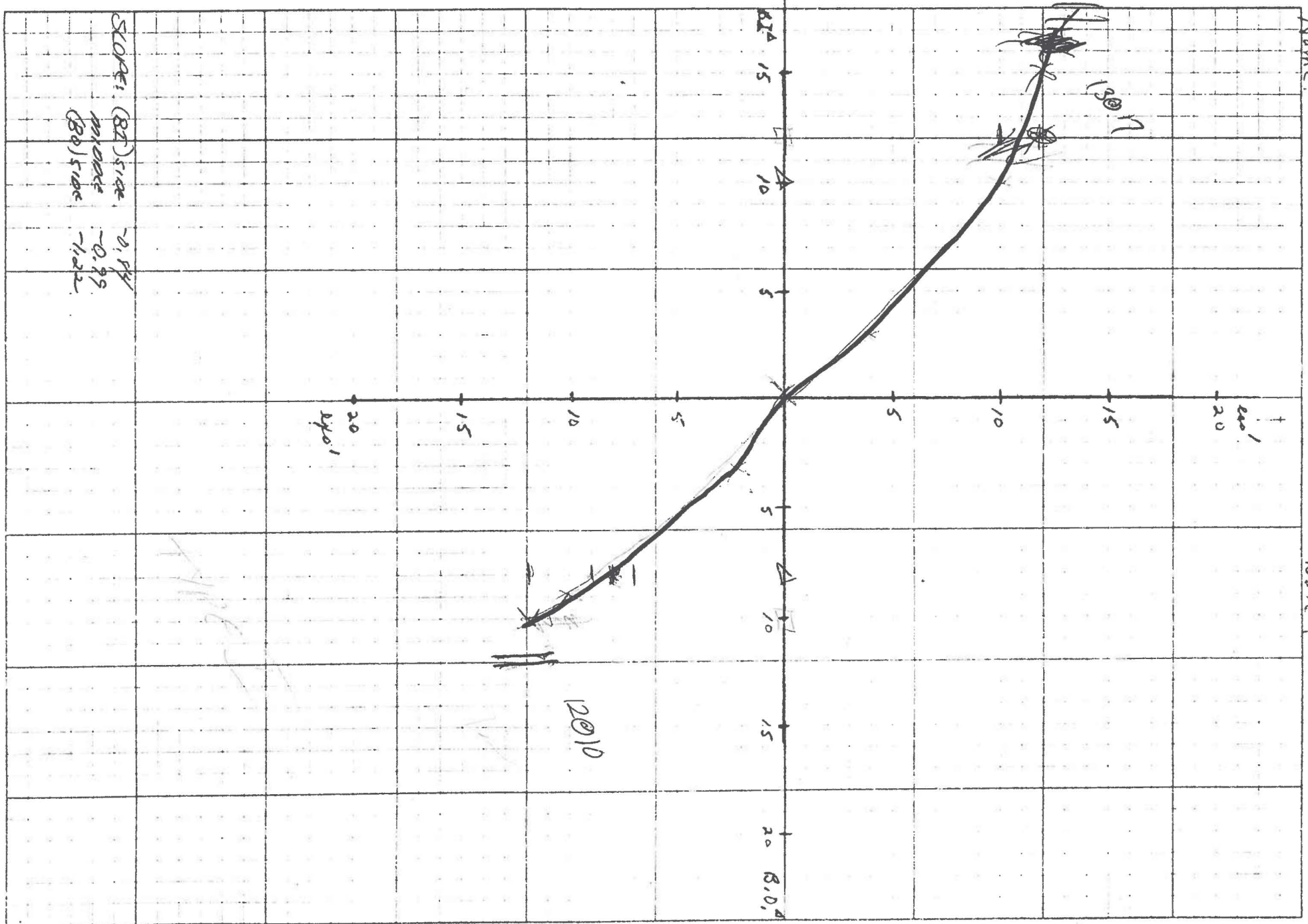
Vergences:	BI	BO
Distance	<u>6/12/4</u>	<u>8/12/7</u>
Near (40 cm)	<u>17/18/12</u>	<u>10/12/8</u>

FD of
D.K.W.

Range of Alignment:	BI	BO
Distance	<u>13/12</u>	<u>8/7</u>
Near (40 cm)	<u>12/10</u>	<u>10/8</u>

Name: _____

Date: _____



130 N

2010

11/11/10

SCORE: (BI) 5.00
 -0.99
 (BO) 5.00
 -1.22

Name Rick Boghi

Age 24

Refraction +1.25
+0.75 OVER CC'S

BVA 20/15

PD 64

Stereo Acuity: Distance 60 Near 40

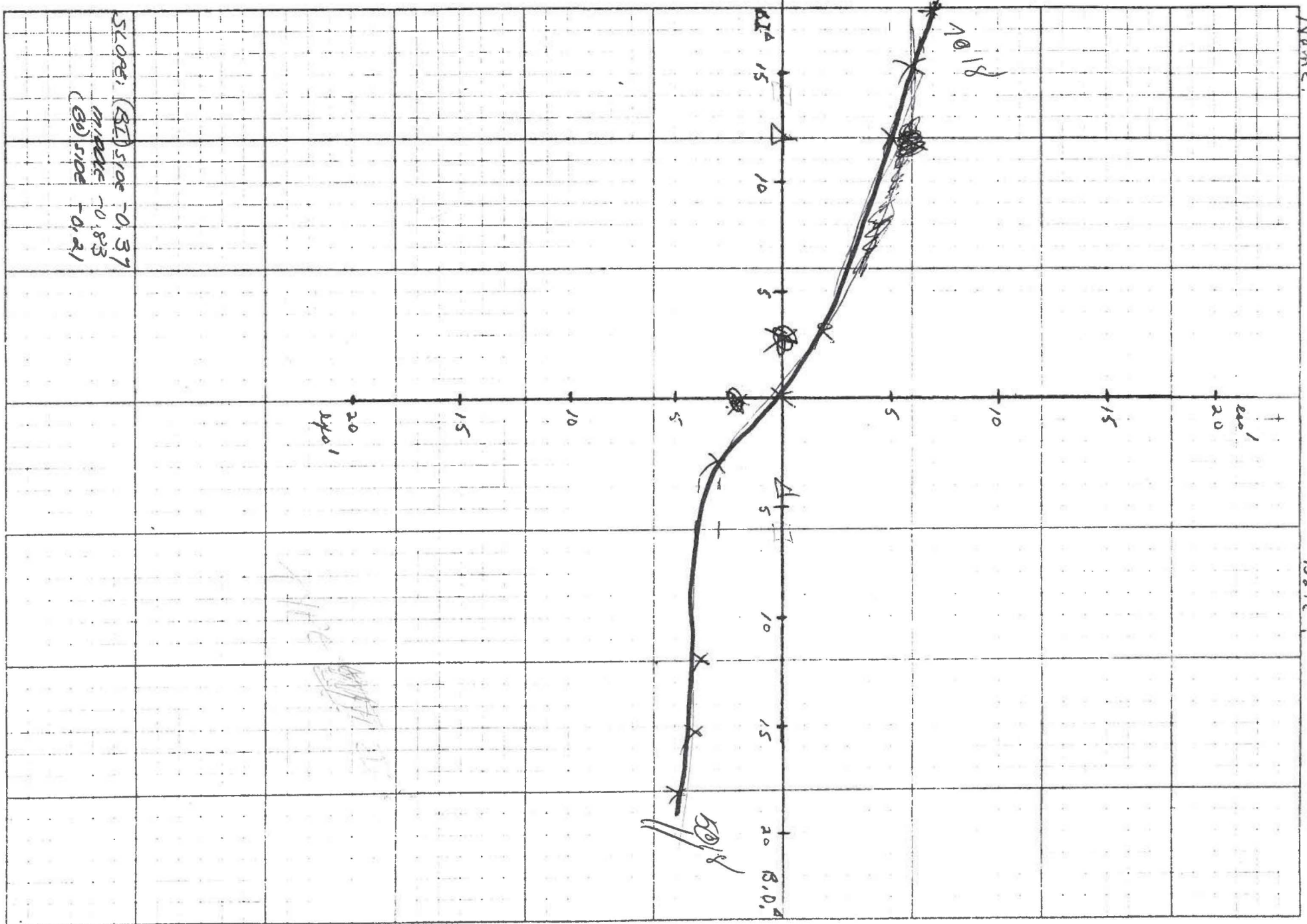
Phoria: Distance ϕ Near 150

Vergences:	BI	BO
Distance	<u>X 18 14</u>	<u>20 12 11 12</u>
Near (40 cm)	<u>18 12 20 18</u>	<u>18 12 20 13</u>

Range of Alignment:	BI	BO
Distance	<u>13 12</u>	<u>14 13</u>
Near (40 cm)	<u>X 18 18</u> <u>14 12</u>	<u>6 14</u>
	<u>FD</u>	<u>D - ϕ</u> <u>N - ϕ</u>

Name:

Date:



SCORE: (SD) SIDE 70.37
 (MD) SIDE 70.83
 (GD) SIDE 70.21

Name Linda Cooley

Age 33

Refraction +0.50

BVA 20/20

+ 0.50 - 0.50 x 80

63

Stereo Acuity:

Distance 60

Near 40

Phoria:

Distance ∅

Near 8 BI

Vergences:

BI

BO

Distance x 18 13

51 17 6

Near 22 12 4 18
(40 cm)

12 1 6 1 10

Range of Alignment:

BI

BO

Distance

13 12

17 6

Near
(40 cm)

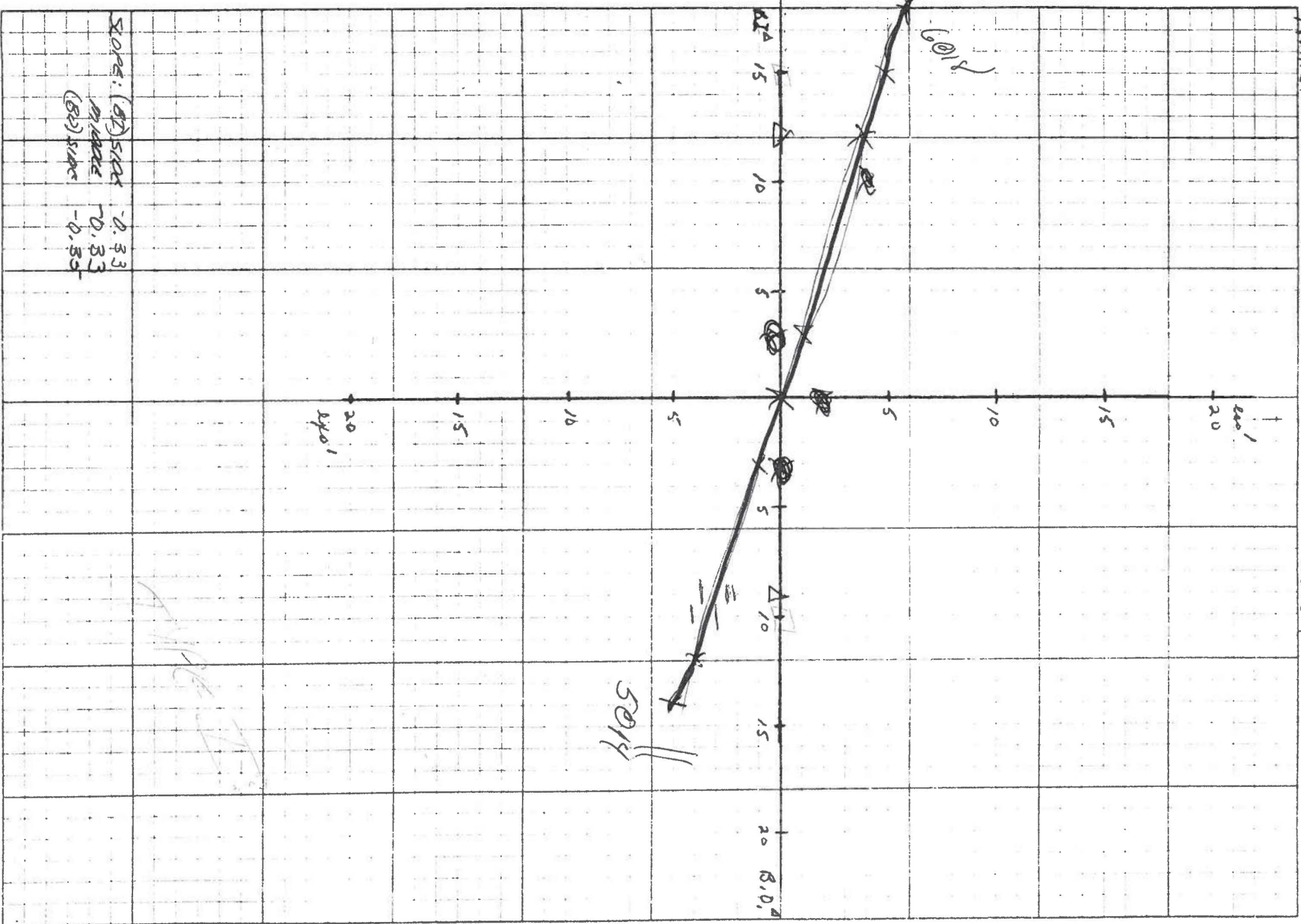
22 15 13

17 0 19

FD = ∅ DKN

Name:

Date:



SLOPE: (87) 5112 -0.33
 (11) 1112 -0.33
 (52) 5112 -0.33

Name John Marcin

Age 23

Refraction -2.25 -1.00 x 20
-2.00 -0.75 x 155

BVA 29/18

PD 66

Stereo Acuity: Distance 60 Near 40

Phoria: Distance 1BI Near 7BI

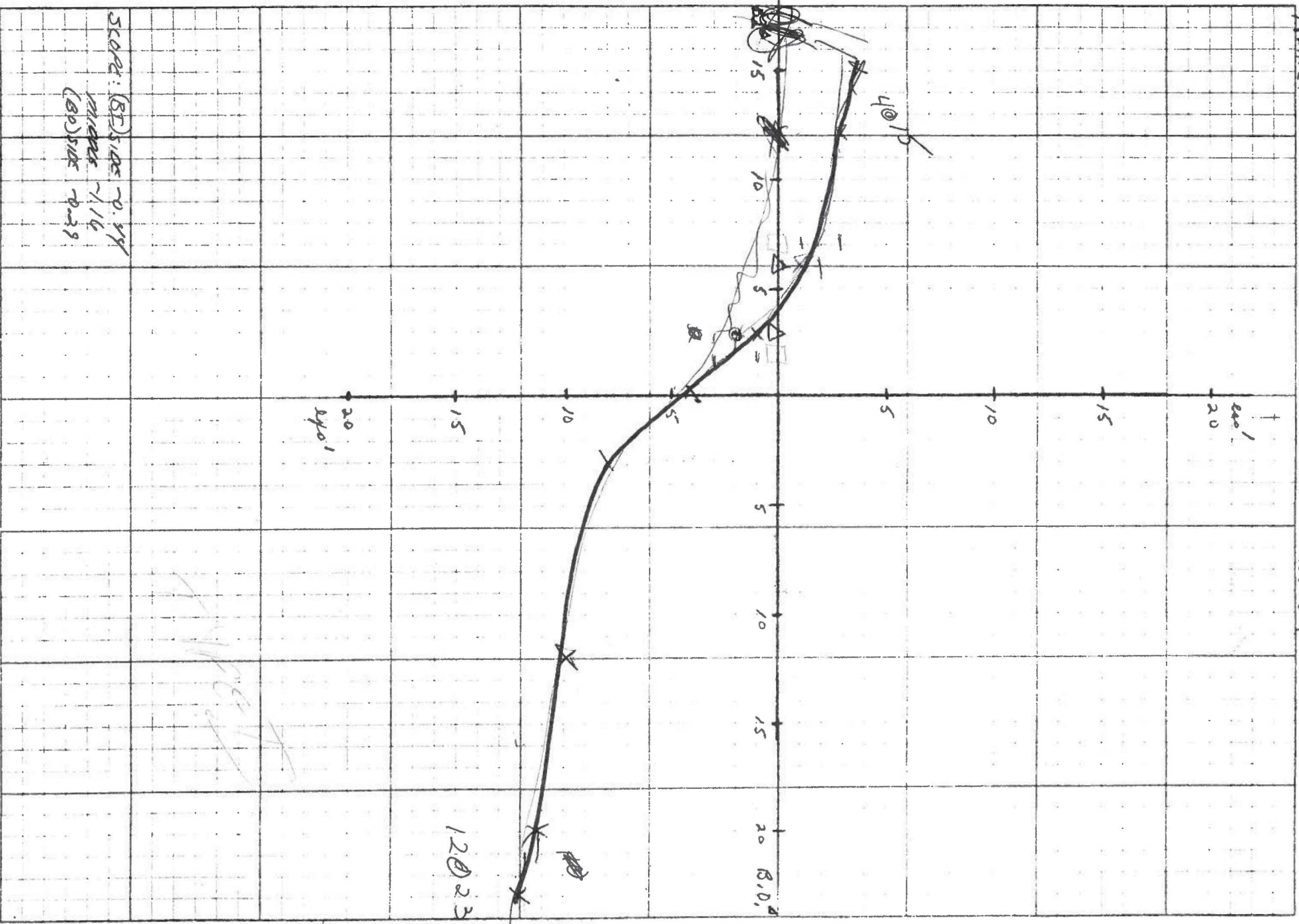
Vergences:	BI	BO
Distance	<u>X 151 3</u>	<u>161 27 25</u>
Near (40 cm)	<u>10 11 71 13</u>	<u>24 26 11</u>

Range of Alignment:	BI	BO
Distance	<u>17 10</u>	<u>12 1 1</u>
Near (40 cm)	<u>17 16</u>	<u>1-2 1-3</u>

FD @ Dist ϕ
 " @ Near 3BI

Name: _____

Date: _____



SCORE: (BI) SIDE 0.54
 (MI) SIDE ~1/14
 (BO) SIDE 0.29

Name Dan Flick

Age 25

Refraction pl - 0.75 x 90
-0.25 - 0.50 x 85

BVA 20/15

PD 63

Stereo Acuity: Distance 60 Near 40

Phoria: Distance 2 BI Near ∅

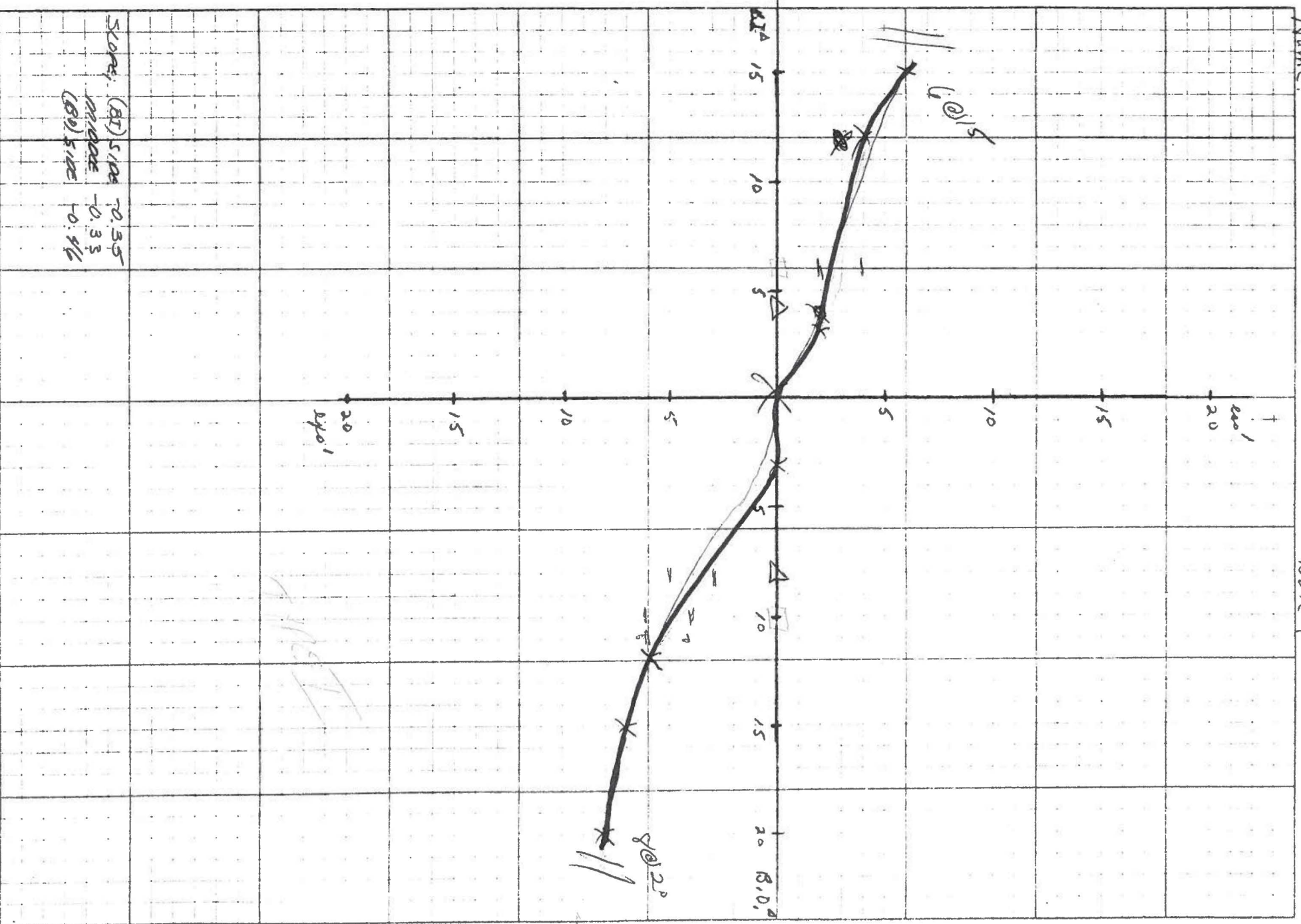
Vergences:	BI	BO
Distance	<u>x 10 16</u>	<u>30/31/15</u>
Near	<u>16 118/12</u>	<u>20/22/18</u>
(40 cm)		

Range of Alignment:	BI	BO
Distance	<u>12/1</u>	<u>15/4</u>
Near	<u>16/4</u>	<u>110/8</u>
(40 cm)		

PD @ DIST ∅
" @ NEAR ∅

Name: _____

Date: _____



Score: (BT) 5.108 -0.35
 (MD) 5.108 -0.33
 (SD) 5.108 -0.416

Name Joe Kosterich

Age 26

Refraction $-2.00 -0.50 \times 140$
 $-2.00 -0.75 \times 10$

BVA $20/15$

Stereo Acuity: Distance 60 Near 40 PD ~~65~~ 65

Phoria: Distance 2R Near 11 BO

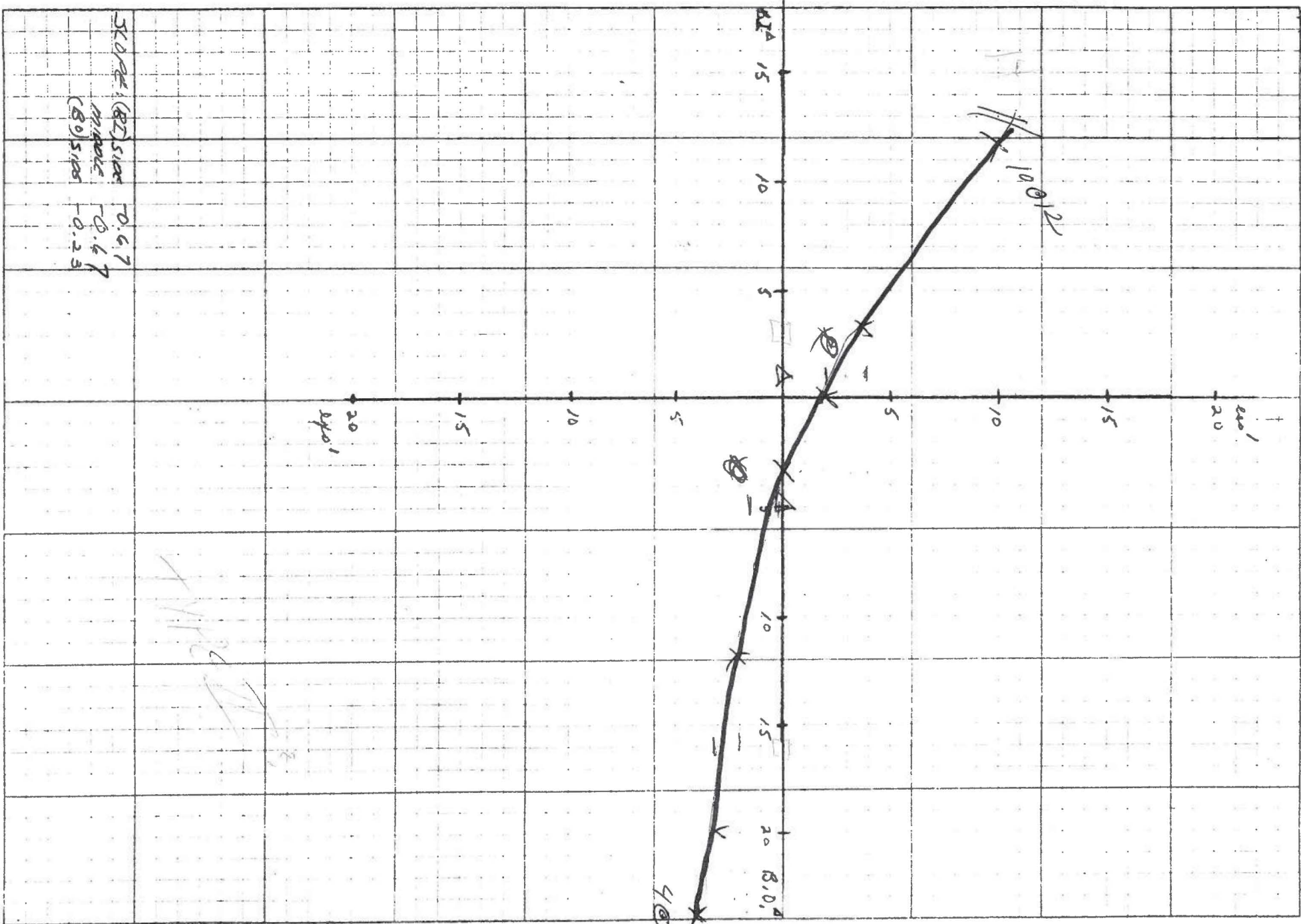
Vergences: BI BO
Distance 6 18 17 20 34/15
Near 12 14 13 18 13 20
(40 cm)

Range of Alignment: BI BO
Distance 14 13 14 13
Near 13 12 11 6 15
(40 cm)

FD @ NEAR ~~20~~ I BO
@ DIST - ~~10~~

Name: _____

Date: _____



SCORE: (82) 5100
 (80) 5100
 (80) 5100

0.47
 0.47
 0.23

TYPE II

Name Thomas Ben

Age 20

Refraction
-0.50
-0.75

BVA 24/15

64

Stereo Acuity: Distance 60 Near 60

Phoria: Distance 2 ES Near 3 BE

Vergences: BI BO

Distance X 1/2/3 20 12/17

Near 18/26/12 19/32/17
(40 cm)

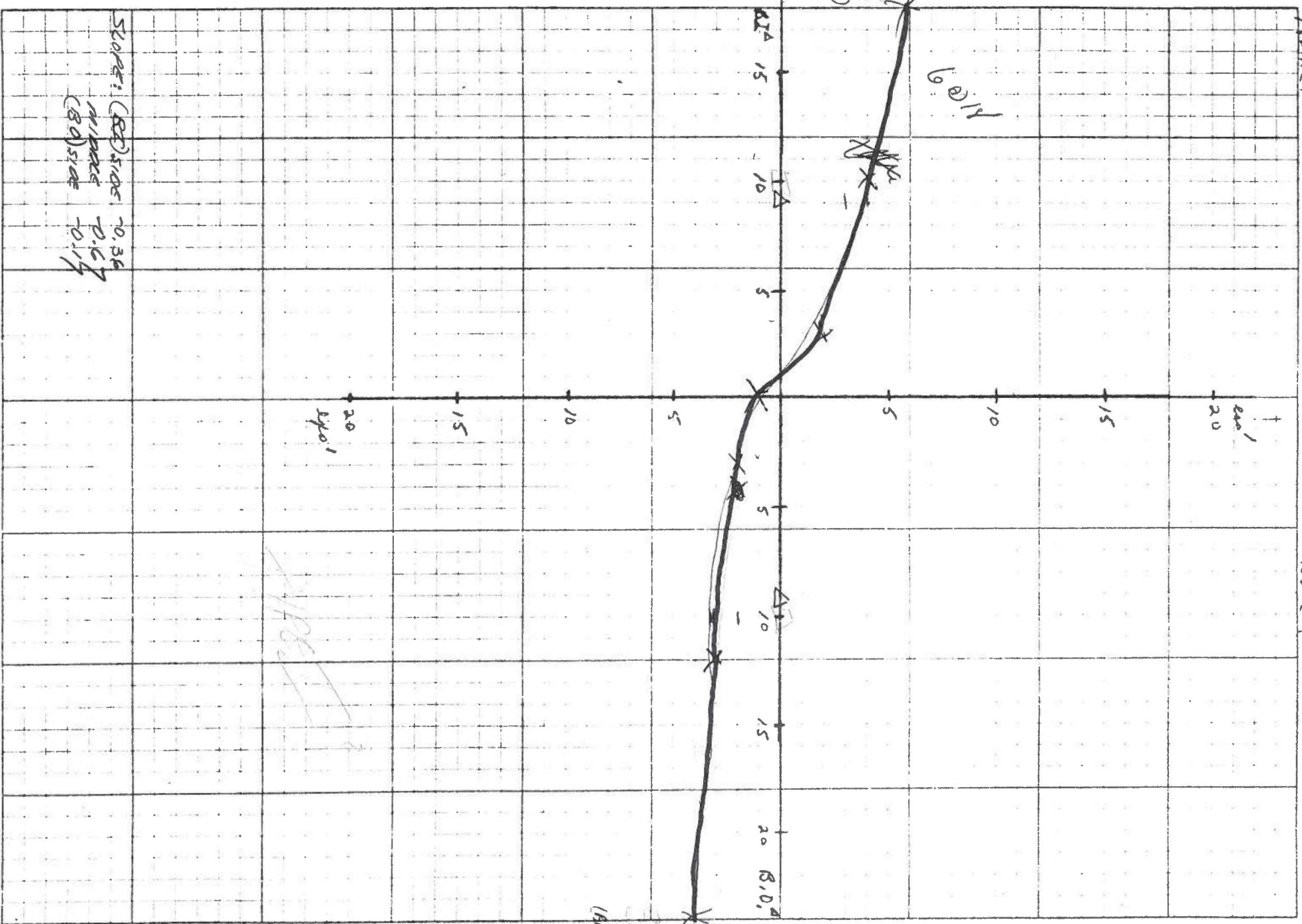
Range of Alignment: BI BO

Distance 14/3 18/7

Near 10/9 10/9
(40 cm)

Name:

Date:



SLOPE: (BE) SIDE 70.36
 (M) SIDE 70.67
 (BD) SIDE 70.17

Name Pat Lyons

Age 29

Refraction -1.75 -1.25 x 113
-1.00 - 1.50 x 60

BVA 20/15

Stereo Acuity: Distance 60 Near 40

Phoria: Distance 180 Near 680

1 LH
(No F.O.)

Vergences: BI BO

Distance X18 16 15, 24, 35

Near 18, 21, 14 21, 24, 35
(40 cm)

Range of Alignment: BI BO

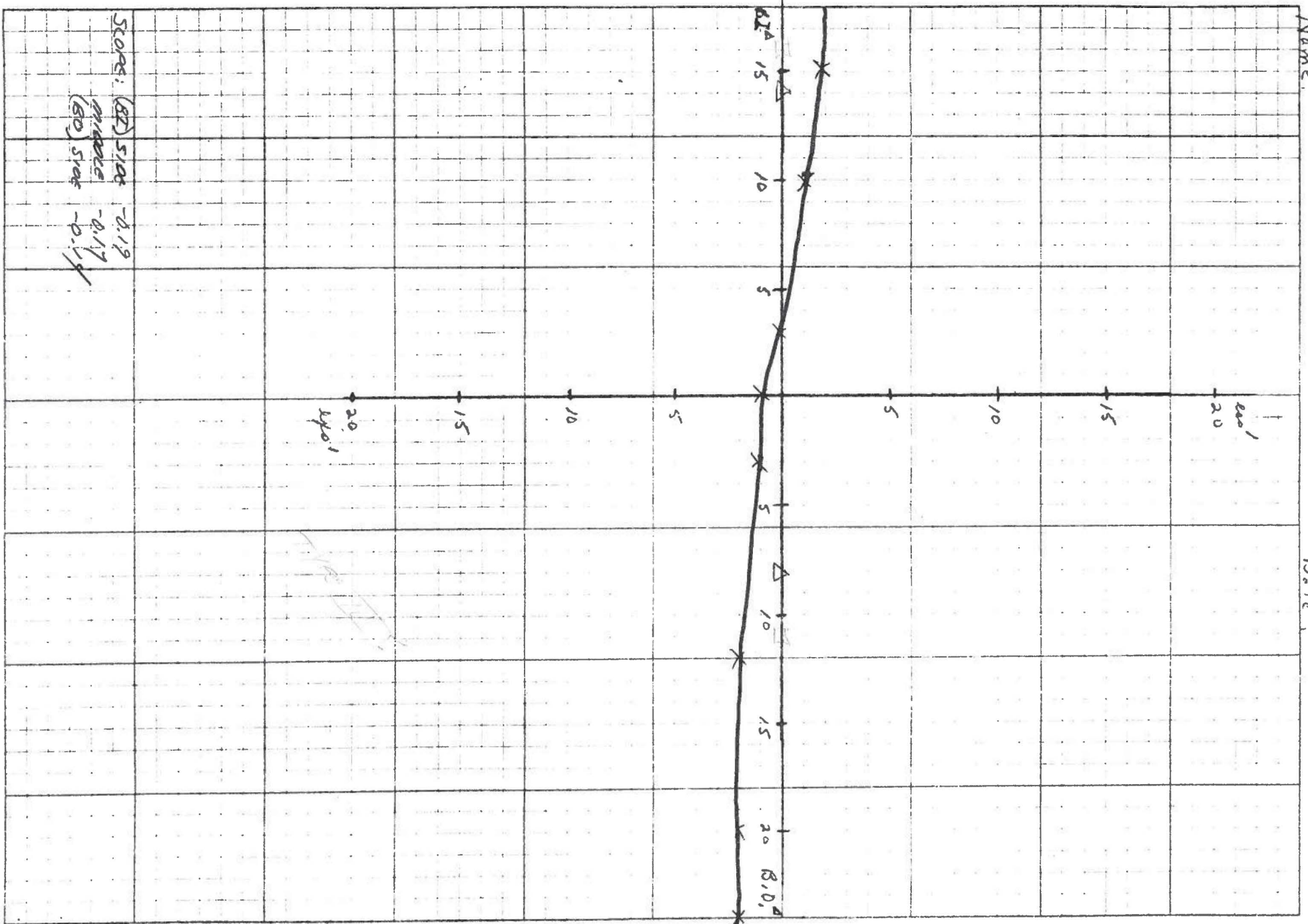
Distance 210 1 312 1

Near 16 14 1 11 18 1
(40 cm)

F.O. @ NEAR ϕ

Name: _____

Date: _____



SCORE: (B.I.) 5.00 -0.19
 (B.D.) 5.00 -0.17
 (B.O.) 5.00 -0.17

Name Suzanne Maystead

Age 24

Refraction -0.25
+0.25 -0.25 x 11
OVER CL'S

BVA 20/15
PO 65

Stereo Acuity: Distance 60 Near 40

Phoria: Distance 380 Near 980

Vergences: BI BO

Distance 41714 12124111
Near 6121116 11133126
(40 cm)

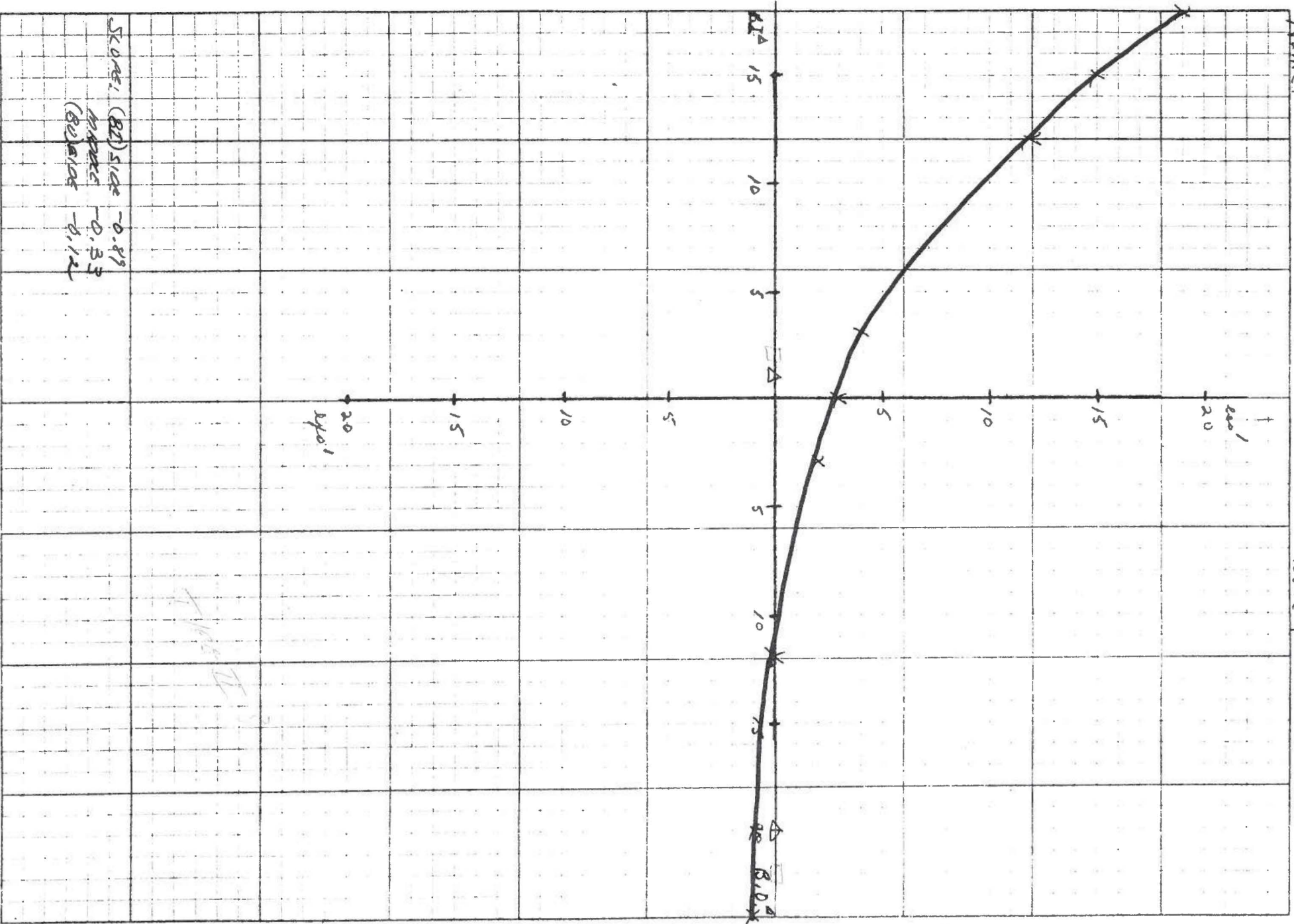
Range of Alignment: BI BO

Distance 2111 9181
Near 2111 221201
(40 cm)

F.D. @ DIST; 380
@ NEAR; 280

Name: _____

Date: _____



SCALE: (R.D.) SIDE - 0.89
 (B.D.) SIDE - 0.33
 (B.D.) SIDE - 0.12

Figure II

Name Germaine Sautorelli

Age 18

Refraction

OVER CC'S PL -0.50 x 95
P -0.50 x 45

BVA 20/

PD - 60

Stereo Acuity:

Distance 60

Near 60

Phoria:

Distance 7 BU

Near 11 BU

Vergences:

BI

BO

Distance X 17 14

20 26 20

Near ~~10~~ 10 0
(40 cm)

~~31~~ 32 ~~20~~ 24

Range of Alignment:

BI

BO

Distance 2 1-31

2 12 01

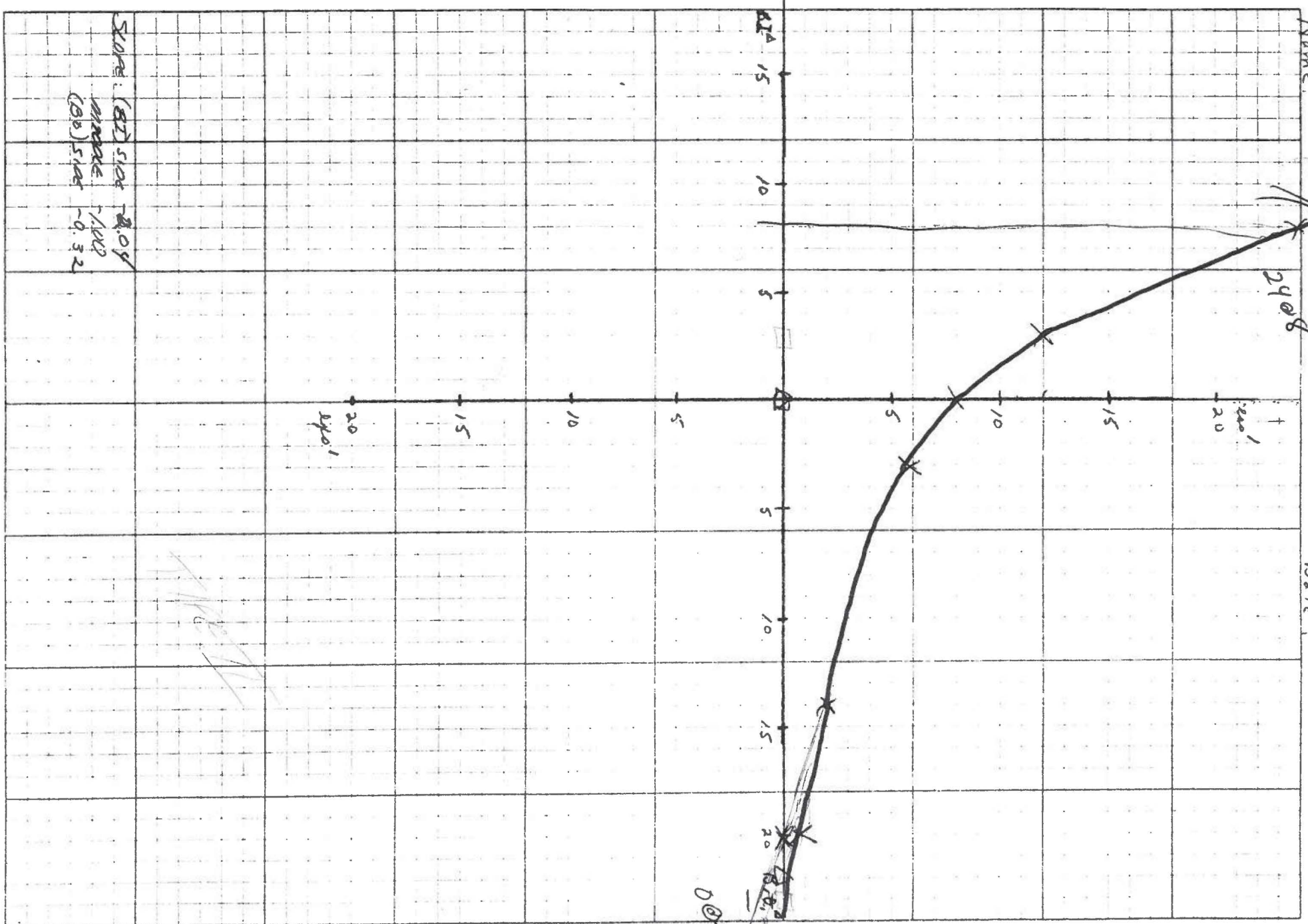
Near 3 10 1
(40 cm)

~~03~~ 22
~~1~~ 1 1

FD @ DIST 380
@ NEAR

Name: _____

Date: _____



SCORE: (BT) side 24.09
 (GB) side 1.009
 (GB) side -0.32

[Handwritten scribbles]

2000
 20
 ATA

Name Clare Tomaszki

Age 18

Refraction ~~4.00~~ -4.25
~~2.75~~ -2.50

BVA 20/15

PD 62

Stereo Acuity: Distance ⁶⁰~~60~~ Near 40

Phoria: Distance ~~5BE~~ Near ~~3BE~~

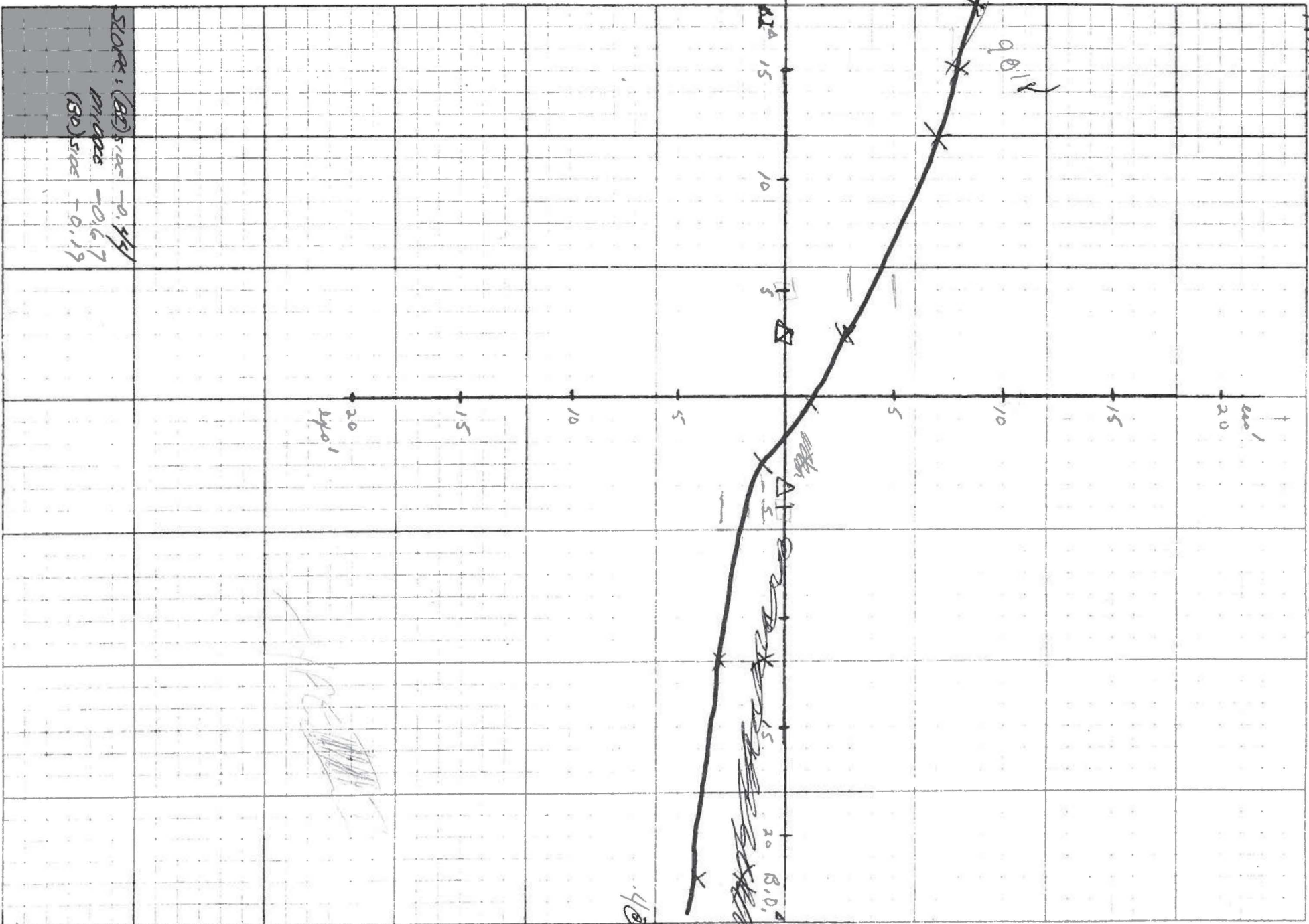
Vergences:	BI	BO
Distance	X 11018	11 12416
Near (40 cm)	18 126113	18 126117

Range of Alignment:	BI	BO
Distance	1513	1311
Near (40 cm)	1513	1514

FOO @ DIST 1 BE

Name: _____

Date: _____



STORE: (BP) 5.145 -0.44
 (130) 5.145 -0.617
 (130) 5.145 -0.119

Name Dale Massigman

Age 22

Refraction
OVER CL'S +0.75 sph
 +0.50

BVA 20/15

PD 64

Stereo Acuity: Distance 60

Near 40

Phoria: Distance 0

Near 1BI

Vergences:

BI

BO

Distance X 18/15 16/17/12

Near ~~20~~ 12/14 ~~24~~ 12/20
(40 cm)

Range of Alignment:

BI

BO

Distance 13/12

11/21/11

Near 16/15
(40 cm)

~~13/15~~
16/15

Name:

Date:

22

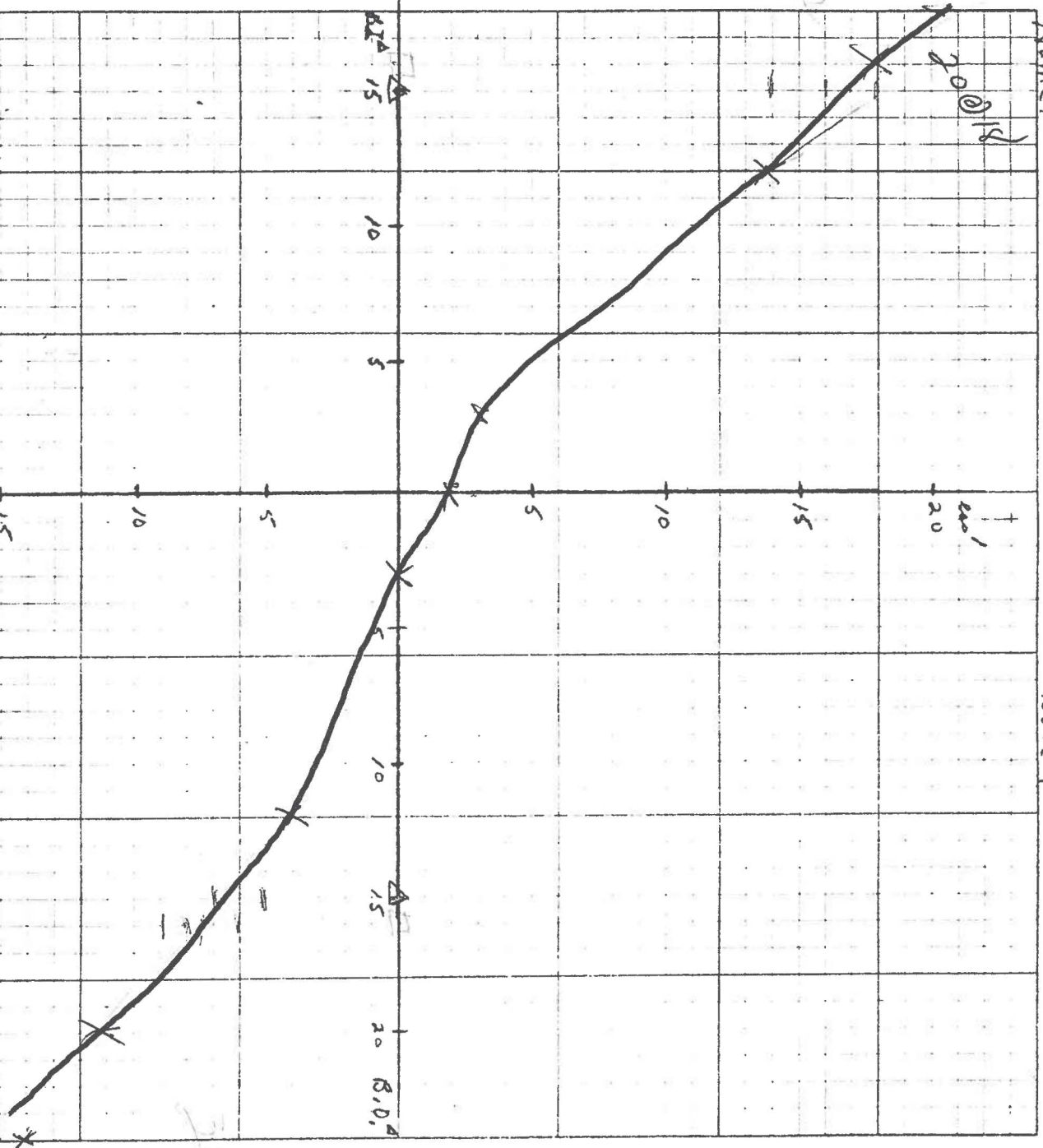
20014

200'

140

15 10 5 5 10 15 20 B.O.D

20 15 10 5 5 10 15 20



SONE: (BT) 5.106 7.05
 (80) 5.106 7.05
 (80) 5.106 7.05

140
 140
 140

30

Name Joe Jambirshaw

Age 22

Refraction
OVER ec's pl corr.

BVA 20/15
60

Stereo Acuity: Distance 60

Near 40

Phoria:

Distance 2BO

Near 5BO

Vergences:

BI

BO

Distance x16 14 18 129 129
Near 7 18 104 22 127 18
(40 cm)

Range of Alignment:

BI

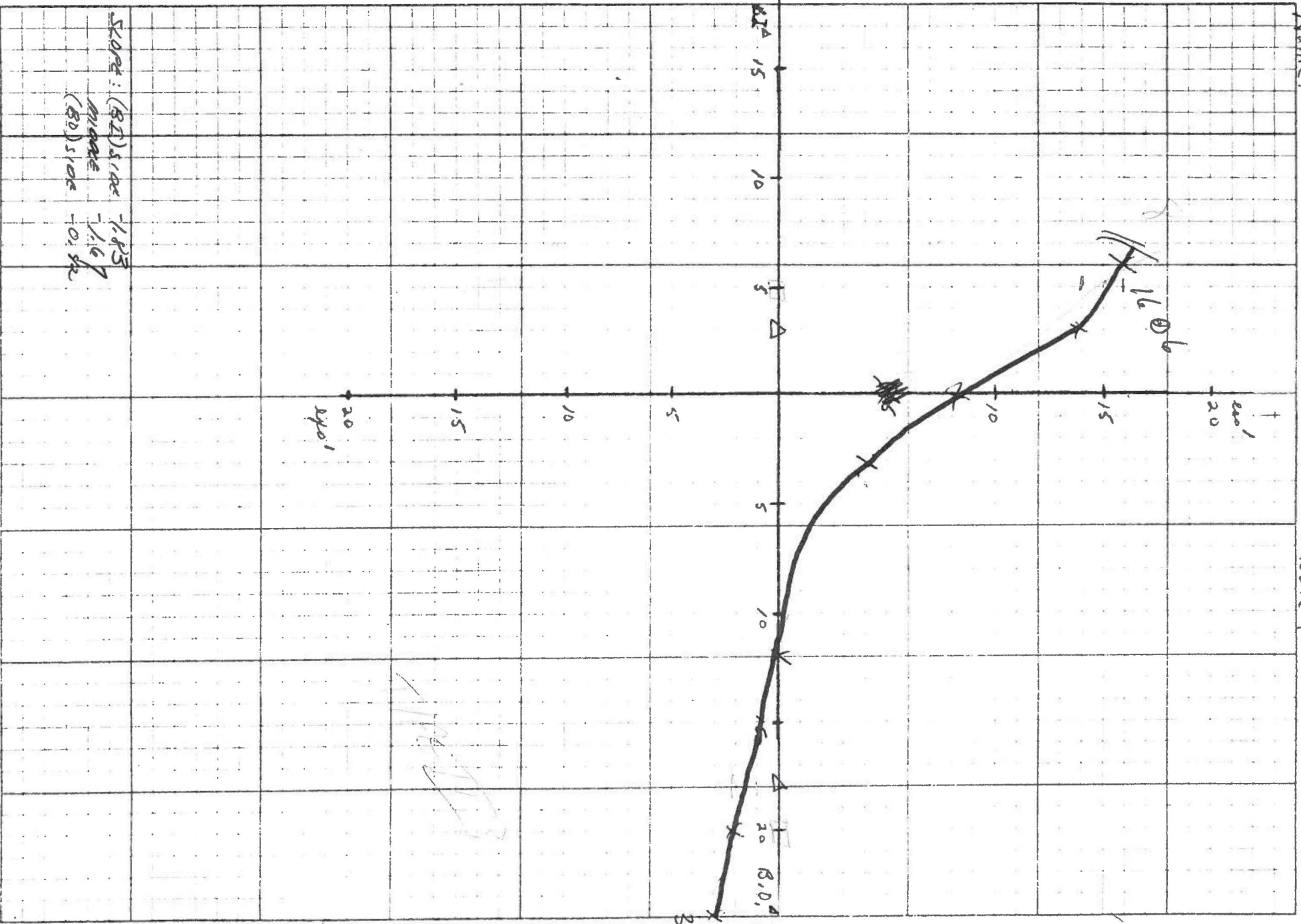
BO

Distance 13 12 129 26
Near 15 13
(40 cm) ~~129 26~~
20/15

FD @ DIST 180
O NEAR 180

Name:

Date:



SLOPE: (81) 5.00 -1.85
 (100) 5.00 -1.67
 (80) 5.00 -0.82

Name Mike Patterson

Age 25

Refraction +1.00
OVER CL'S +0.75

BVA 20/15

Stereo Acuity: Distance 60 Near 40

Phoria: Distance ϕ Near 1 BO

Vergences: BI BO

Distance X 18 16 18 19 19
Near 17 124 120 28 130 115
(40 cm)

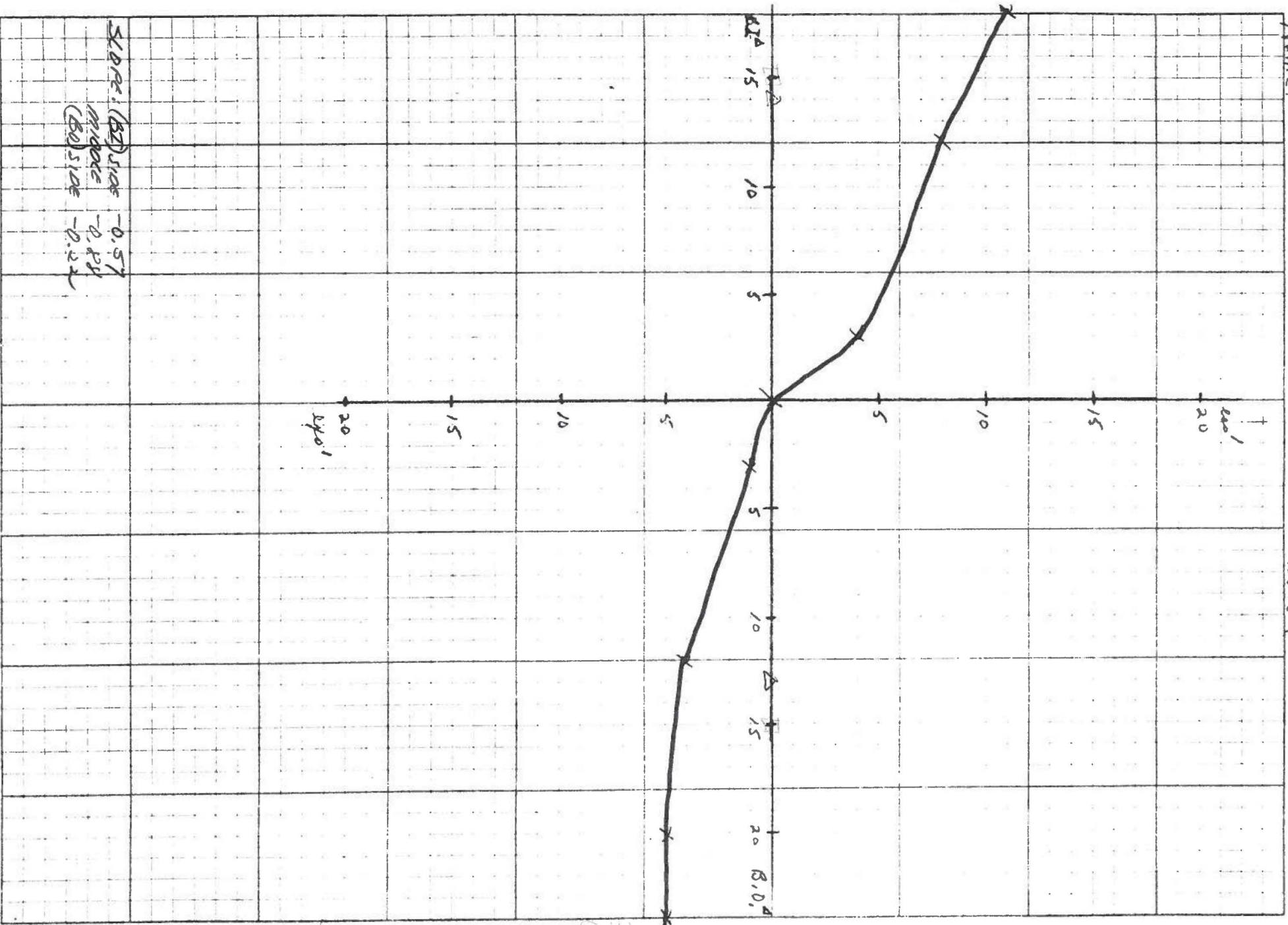
Range of Alignment: BI BO

Distance 3 12 1 10 17 1
Near 15 14 1 15 13 1
(40 cm)

F.D. @ NEAR ϕ

Name:

Date:



SLOPE: (62) SIDE -0.57
 (60) SIDE -0.84
 (50) SIDE -0.22

30
1981

Name Greg Nicholas

Age 22

Refraction pl
OVER CL'S -0.25

BVA 20/15

Stereo Acuity: Distance 60 Near 40

Phoria: Distance 1BI Near 5BO

Vergences: BI BO

Distance X18 16 16 1321 26

Near 12 122 118 24 135 30
(40 cm)

Range of Alignment: BI BO

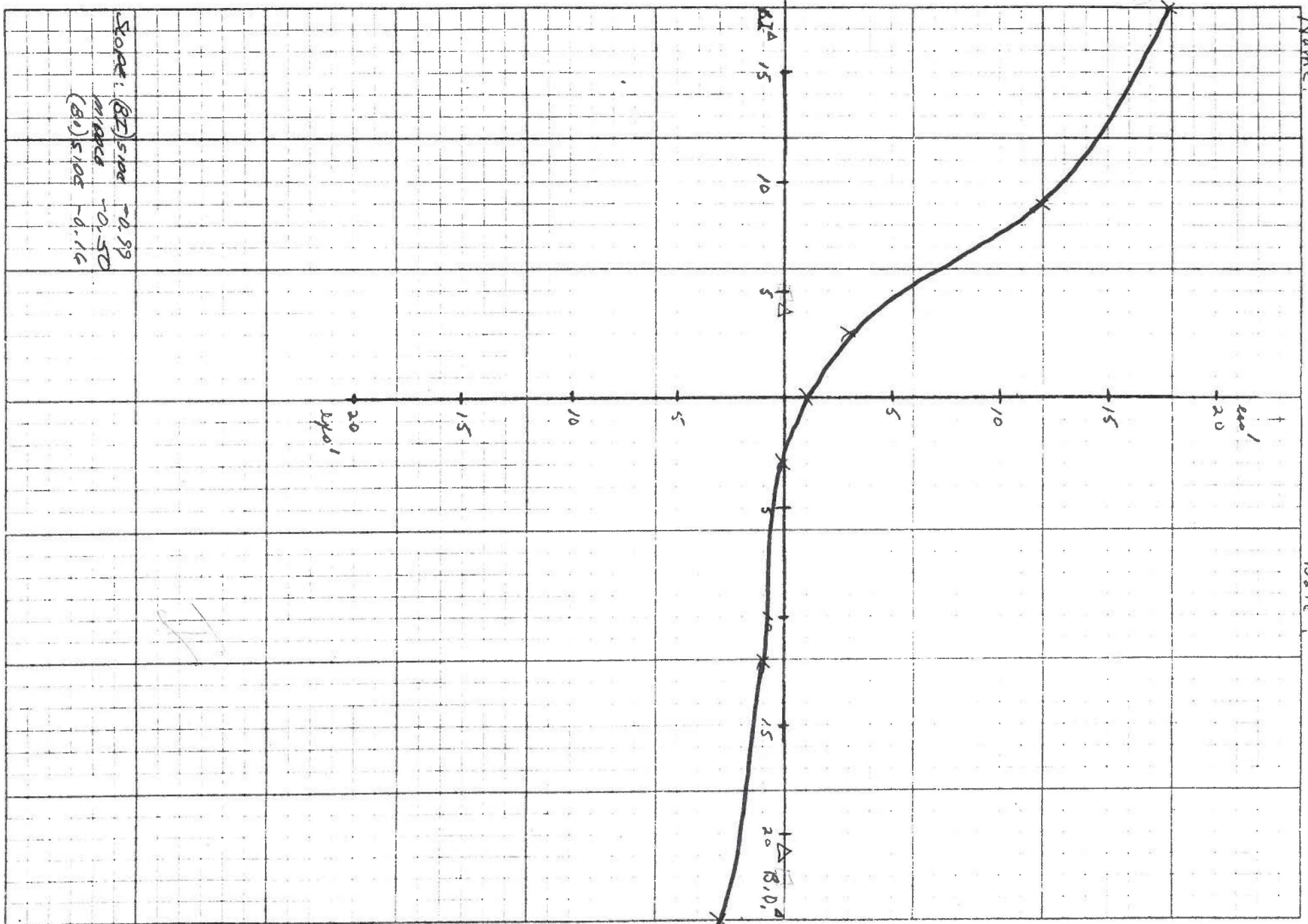
Distance 13 12 14 13

Near 15 14 122, 21
(40 cm)

F.D. @ NEAR 180

Name: _____

Date: _____



Slope: (BZ) slope -0.99
 (B1) slope -0.50
 (B0) slope -0.16