Ann Street School
Golf Team 2001

Sitting: from left to right:, Alexei Yegorov, Christina Burgess, Ana Ferreira, Diogenes Lourenço
Standing: from left to right: Rosalie Barbosa, Mario Fuentes, Ana Cristina Peña, Carlos Martins, Diane Castelo-Branco, Vice Principal Carmen E. Salgueiro, Teacher Manuel Oliveira, Vice Principal Jacquelyn Keene-Owens, Principal Joseph N. Maccia, Alexis Gonzalez, Daniel Barroqueiro, Jakub Wresilo, Jorge Abrantes, & Peter Brandao

Mathletics

Given the theme "Mathletics", our 8th grade class chose to find out how math permeates the game of golf.

We started out by researching golf courses for our study. When doing our research we found that the word Weequahic is a Lenni Lenape name which means boundary. Since Weequahic Park is in our own backyard and its name is associated with math, we decided to use it for our project. We contacted Mr. Joseph Lanzara from the Department of Parks at Essex County who faxed us a scale model of the park. We then drew a larger model using scale drawing where we incorporated ratios, proportions, conversion factors, and perimeters. Next we constructed a model of the golf course.

The second phase was to incorporate the topography of the park by creating a 3-D model representing land elevations. We did this by incorporating what we learned about slopes and plotting them on an X, Y grid.

The third phrase was to illustrate the trajectory and distance of how far a ball can be hit. As we all know individual strength varies, therefore, we needed to create a scenario where both strength and speed would be near constant. We created a mechanical golfer, which works similar to a pendulum. We set the mechanical golfer into motion to find the velocity, angles and the loft of the clubs. We recorded the data and used it to solve for the trajectory path of the ball.

The fourth phase was to take a site visit to the United States Golf Association in Far Hills, NJ where we took a tour of their facility and interviewed Mr. John M. Spitzer Assistant Technical Director. He offered us the formulas needed to solve for the trajectory of the ball.

The final phase was to put our theory to practice. We visited Weequahic and conducted our field test research. Golf instructors, Mr. Ed Wadood, Mr. Nelson Tejada, and Mr. Donnell Redding assisted us with our golf stance, grip, and swing. We then had the opportunity to put our theory into practice and play a game of golf.

COUNTY OF ESSEX
DEPARTMENT OF PARKS, RECREATION AND CULTURAL AFFAIRS
115 CLIFTON AVENUE
NEWARK, NEW JERSEY 07104
TELEPHONE: 973-268-3500
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DANIEL K. SALVANTE
DIRECTOR

JAMES W. TREFFINGER
COUNTY EXECUTIVE

FAX TRANSMITTAL

TO: FAX NUMBER 465-4185

NAME MANNY OLIVERA

LOCATION ANN ST. SCHOOL

FROM: JOSEPH LANZARA

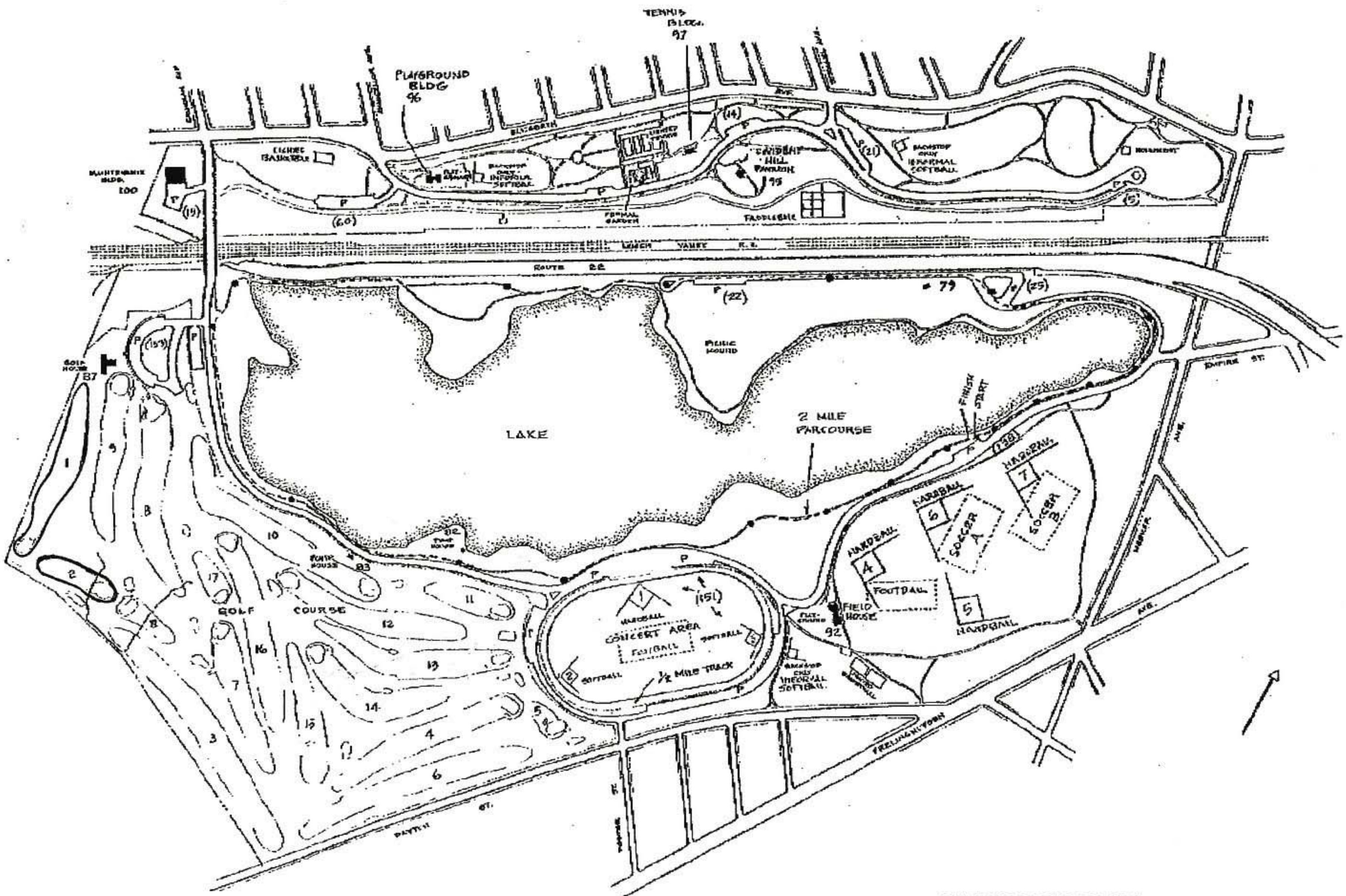
PHONE: (973) 268-3500 Ext. 238

FAX: (973) 481-5302

DATE: 3-27-01

TOTAL NUMBER OF PAGES INCLUDING COVER LETTER 2

MESSAGE: WEEQUAHIC PARK - 311.33 ACRES (INCLUDING GOLF C.)
WEEQUAHIC GOLF COURSE - 69.90 ACRES
PLEASE CALL IF YOU NEED MORE
INFORMATION.



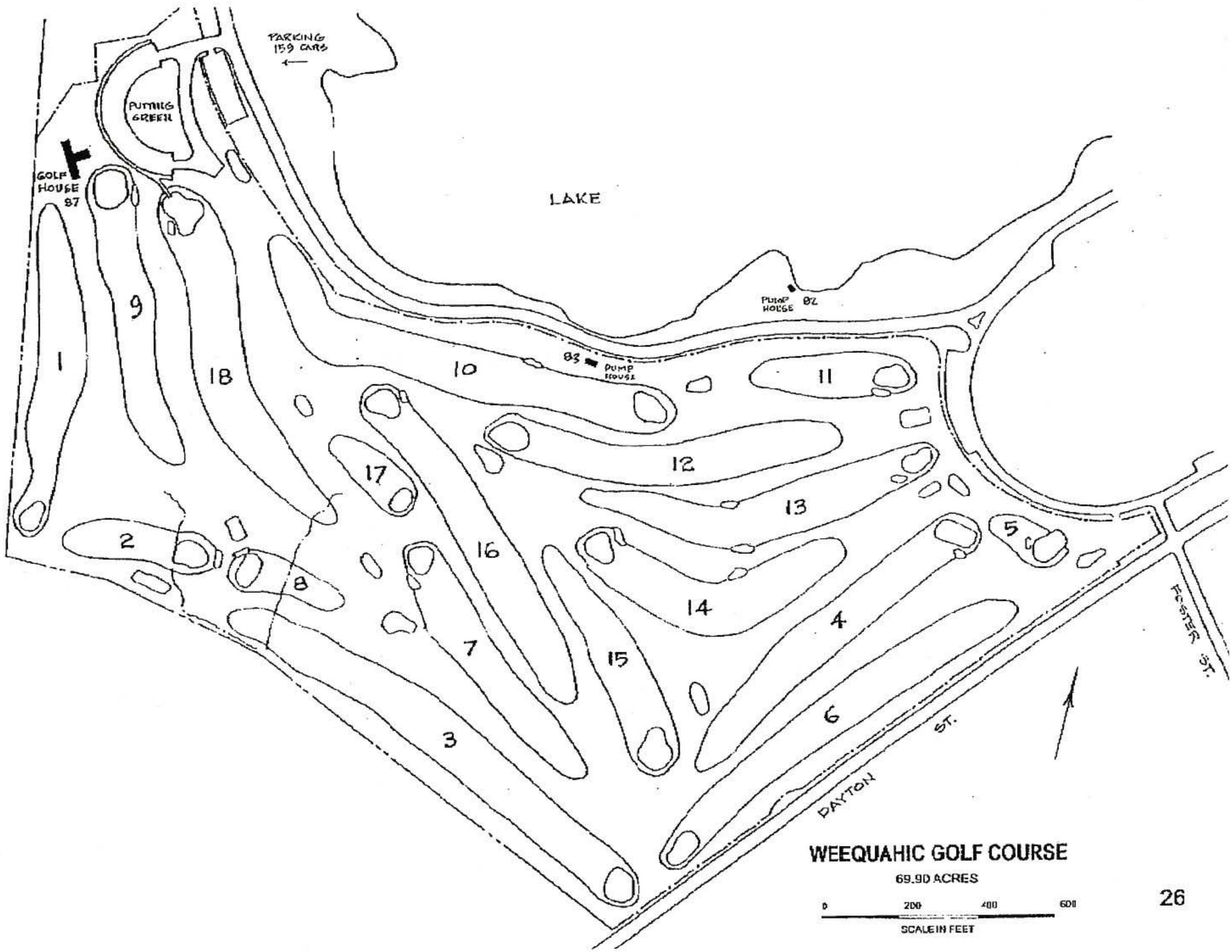
P = PARKING AREA
( ) = NO. OF SPACES

WEEQUAHIC PARK

311.33 ACRES

0 400 800 1200
SCALE IN FEET

Golf course
69.90 acres



WEEQUAHIC GOLF COURSE

69.90 ACRES

0 200 400 600

SCALE IN FEET

Mathletics

Scale:
1in.=360ft.

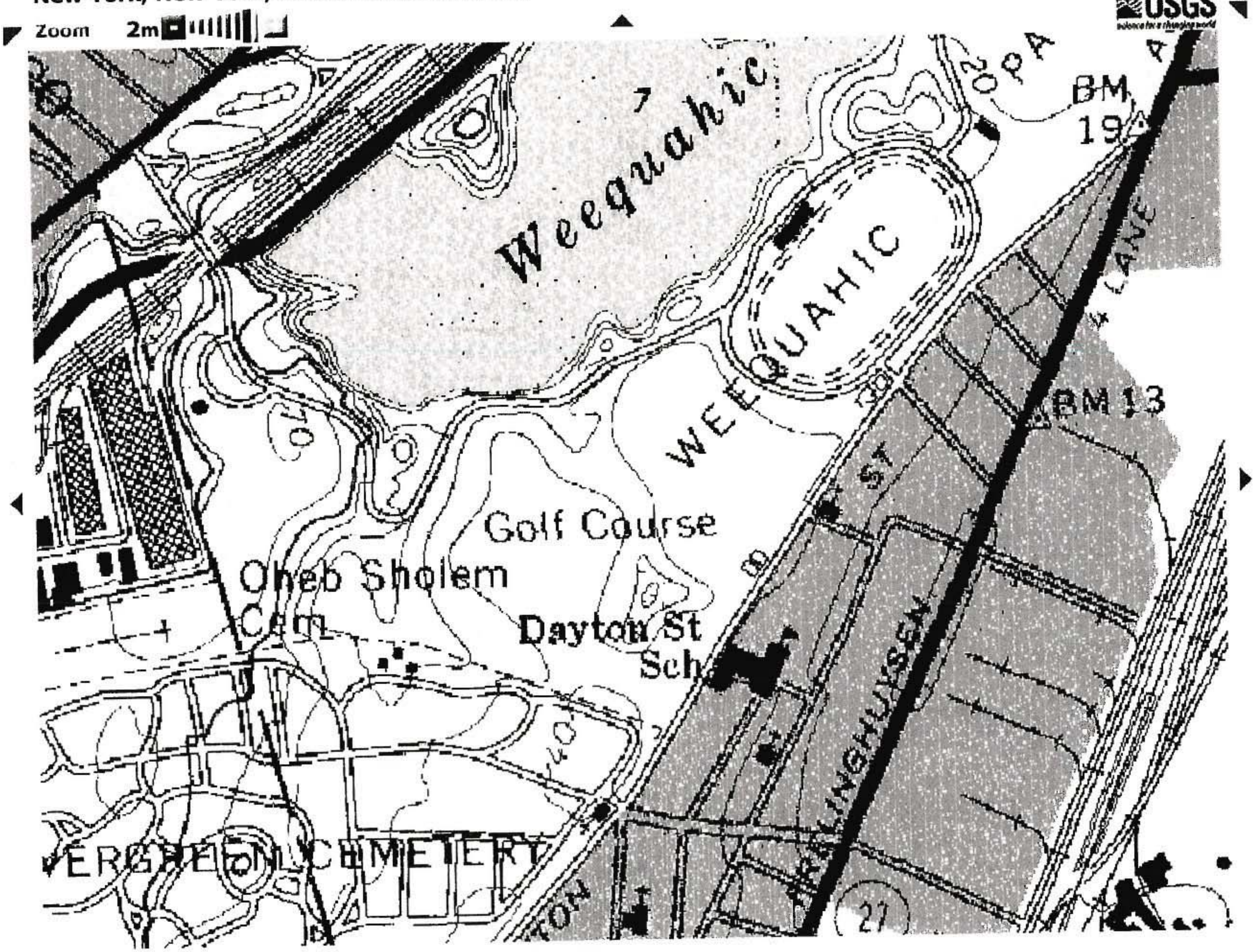
Hole #	Measurements in inches	Conversion Factor for feet	Total distance in feet	Conversion Factor for yards	Approx. Distance of the Hole
1	$2 \frac{11}{16}$ in.	$\frac{360ft.}{1in.}$	967.5ft.	$\frac{1yd.}{3ft.}$	322.5yds.
2	1.25in	$\frac{360ft}{1in.}$	450ft.	$\frac{1yd.}{3ft.}$	150yds.
3	$4 \frac{1}{16}$ in.	$\frac{360ft.}{1in.}$	1,462.5ft	$\frac{1yd.}{3ft.}$	487.5yds.
4	$3 \frac{3}{16}$ in.	$\frac{360ft.}{1in.}$	1,147ft.	$\frac{1yd.}{3ft.}$	382.5yds.
5	$\frac{14}{16}$ in.	$\frac{360ft.}{1in.}$	315ft.	$\frac{1yd.}{3ft.}$	105yds.
6	4in.	$\frac{360ft.}{1in.}$	1,440ft.	$\frac{1yd.}{3ft.}$	480yds.
7	2.5in.	$\frac{360ft.}{1in.}$	900ft.	$\frac{1yd.}{3ft.}$	300yds.
8	$1 \frac{3}{16}$ in.	$\frac{360ft.}{1in.}$	427.5ft	$\frac{1yd.}{3ft.}$	142.5yds.
9	2.75in.	$\frac{360ft.}{1in.}$	990ft.	$\frac{1yd.}{3ft.}$	330yds.
10	$3 \frac{14}{16}$ in.	$\frac{360ft.}{1in.}$	1,395ft.	$\frac{1yd.}{3ft.}$	465yds.
11	$1 \frac{7}{16}$ in.	$\frac{360ft.}{1in.}$	517.5ft	$\frac{1yd.}{3ft.}$	172.5yds.
12	$3 \frac{2}{16}$ in.	$\frac{360ft.}{1in.}$	1,125ft	$\frac{1yd.}{3ft.}$	375yds.

Mathletics

Hole #	Measurements in inches	Conversion Factor for feet	Total distance in feet	Conversion Factor for yards	Approx. Distance of the Hole
13	$3\frac{6}{16}$ in.	$\frac{360 \text{ ft.}}{1 \text{ in.}}$	1,215 ft.	$\frac{1 \text{ yd.}}{3 \text{ ft.}}$	405 yds.
14	2.75 in.	$\frac{360 \text{ ft.}}{1 \text{ in.}}$	990 ft.	$\frac{1 \text{ yd.}}{3 \text{ ft.}}$	330 yds.
15	$2\frac{1}{16}$ in.	$\frac{360 \text{ ft.}}{1 \text{ in.}}$	742 ft.	$\frac{1 \text{ yd.}}{3 \text{ ft.}}$	247.5 yds.
16	$3\frac{5}{16}$ in.	$\frac{360 \text{ ft.}}{1 \text{ in.}}$	1,192.5 ft.	$\frac{1 \text{ yd.}}{3 \text{ ft.}}$	397.5 yds.
17	$1\frac{1}{16}$ in.	$\frac{360 \text{ ft.}}{1 \text{ in.}}$	382.5 ft.	$\frac{1 \text{ yd.}}{3 \text{ ft.}}$	127.5 yds.
18	3 in.	$\frac{360 \text{ ft.}}{1 \text{ in.}}$	1,080 ft.	$\frac{1 \text{ yd.}}{3 \text{ ft.}}$	360 yds.

New York, New York, United States 01 Jul 1981

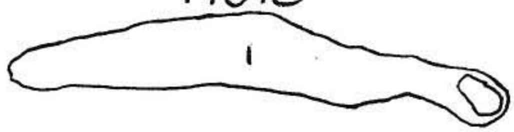
Zoom 2m



Weequahic Golf Course

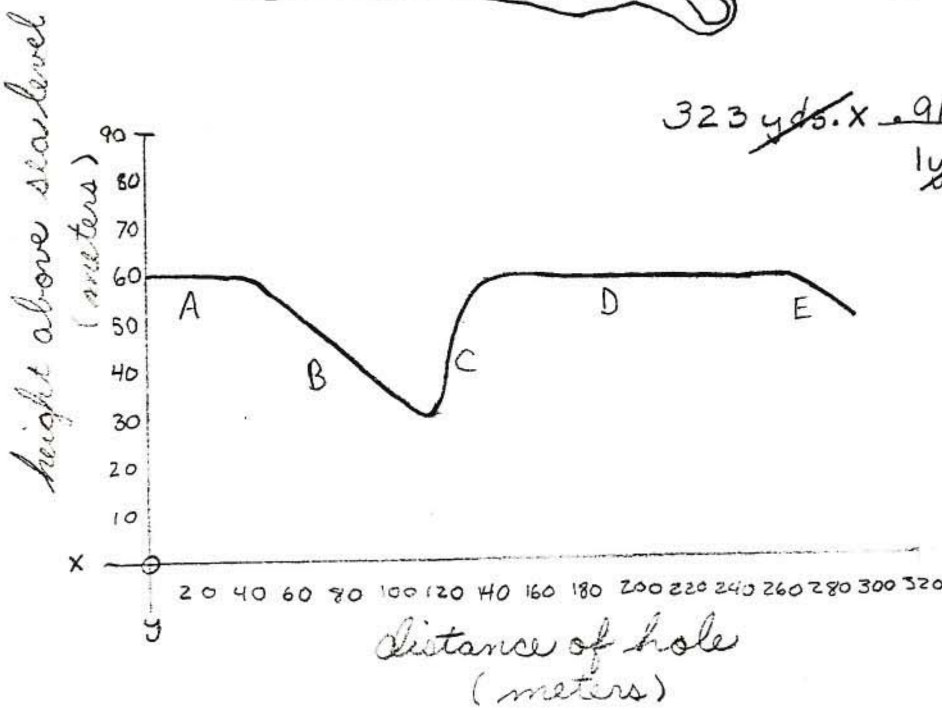
Topography/Slope

Hole



323yds.

$323 \cancel{yds.} \times \frac{.914m}{1\cancel{yd.}} \approx 295.2\ m$



A- Slope = 0

B- Vertical Change = -30

Horizontal Change = 80

Slope = $-\frac{30}{80} = -\frac{3}{8}$

C- Vertical Change = 30

Horizontal Chage = 20

Slope = $\frac{30}{20} = \frac{3}{2} = 1\frac{1}{2}$

D- Slope = 0

E- Vertical Change = -10

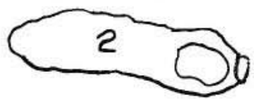
Horizontal Change = 30

Slope = $-\frac{10}{30} = -\frac{1}{3}$

Weequahic Golf Course

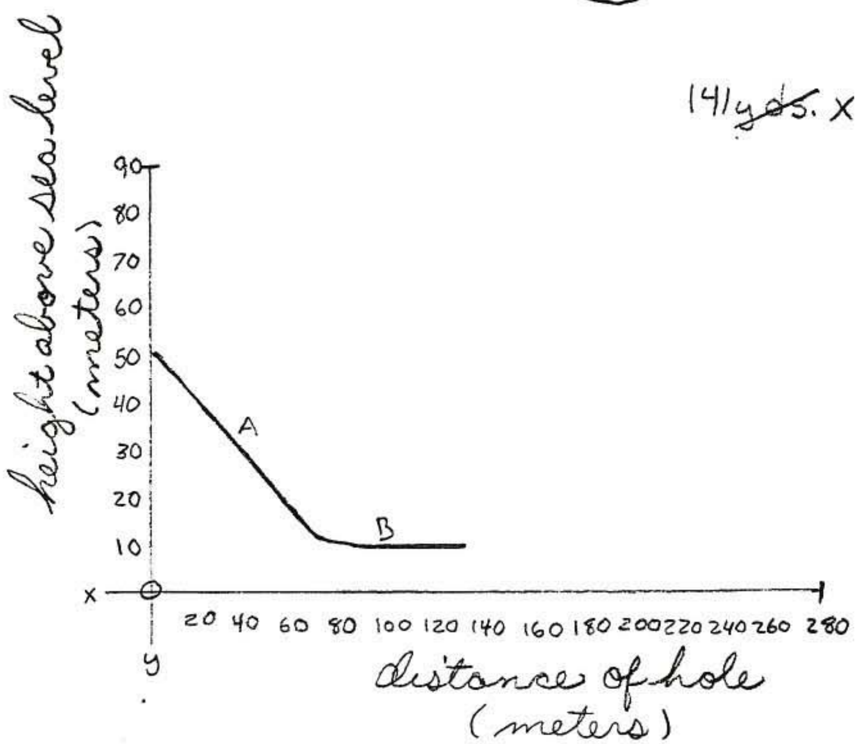
Topography/ Slope

Hole



141yds.

$141\cancel{yds.} \times \frac{.914m}{1\cancel{yd}} \approx 129m.$



A = Vertical Change = - 40

Horizontal Change = 70

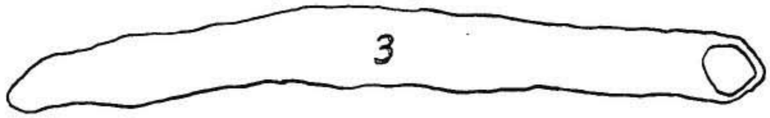
Slope $= -\frac{40}{70} = -\frac{4}{7}$

B = Slope = 0

Weequahic Golf Course

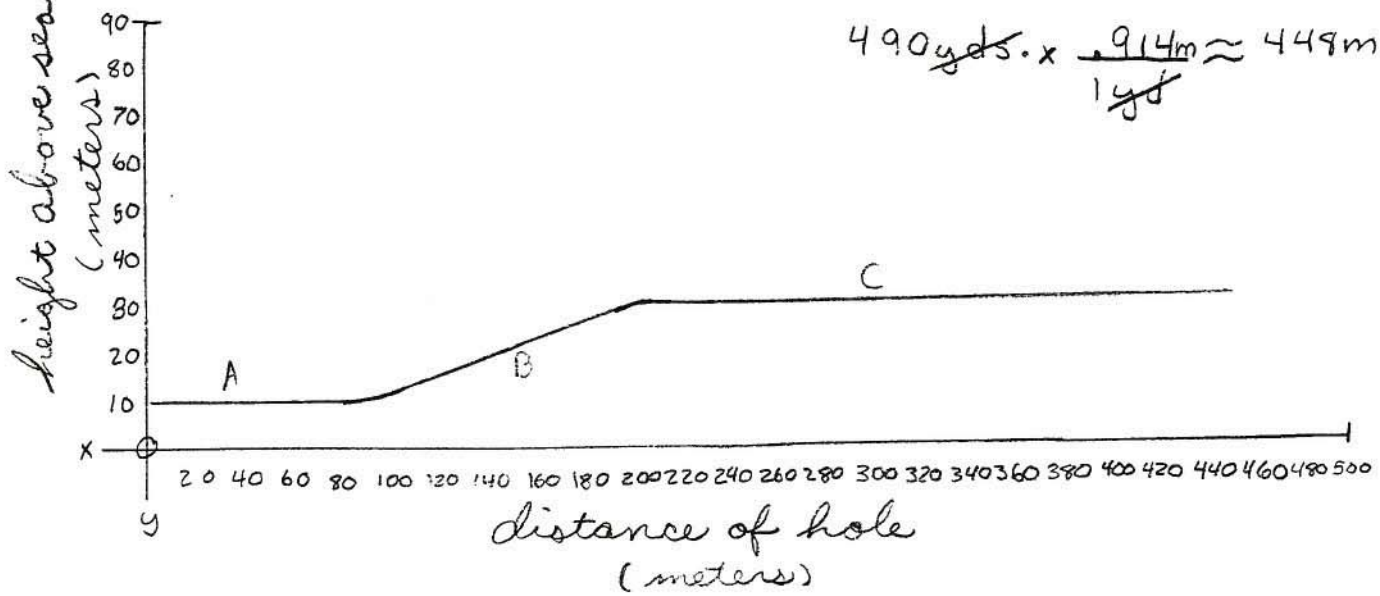
Topography / Slope

Hole



490 yds.

$490\,\cancel{yds.} \times \frac{.914m}{1\,\cancel{yd}} \approx 449m.$



A- Slope = 0

B- Vertical Change = 20

Horizontal Change = 100

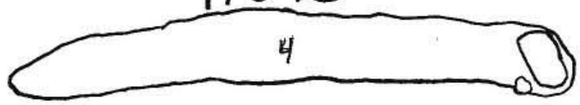
Slope = $\frac{20}{100} = \frac{2}{10} = \frac{1}{5}$

C- Slope = 0

Weequahic Golf Course

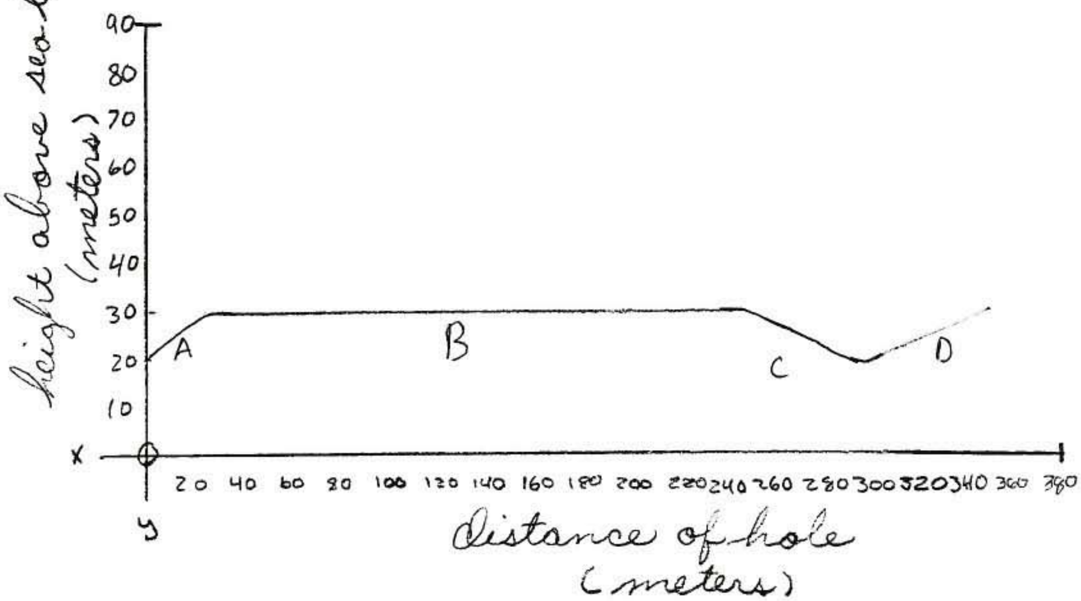
Topography / Slope

Hole



383 yds.

383 $\cancel{yds.}$ × $\frac{.914m}{1\cancel{yd}}$ ≈ 350 m.



A- Vertical Change = 10

Horizontal Change = 20

Slope = $\frac{10}{20} = \frac{1}{2}$

D- Vertical Change = 10

Horizontal Change = 50

Slope = $\frac{10}{50} = \frac{1}{5}$

B- Slope = 0

C- Vertical Change = -10

Horizontal Change = 50

Slope = $-\frac{10}{50} = -\frac{1}{5}$

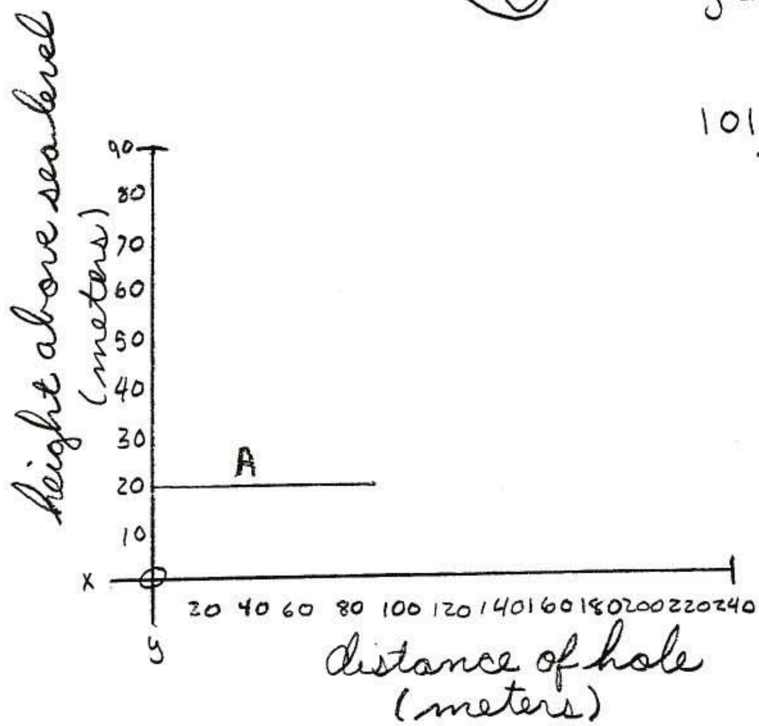
Weequahic Golf Course

Topography / Slope

Hole

5 101 yds.

$101\,\cancel{yds} \times \frac{.914\,m}{1\,\cancel{yd}} \approx 92.3\,m.$

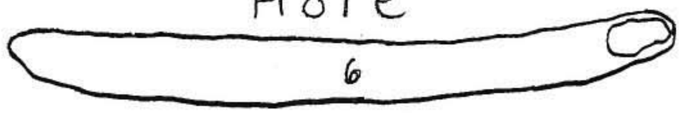


A - Slope = 0

Weequahic Golf Course

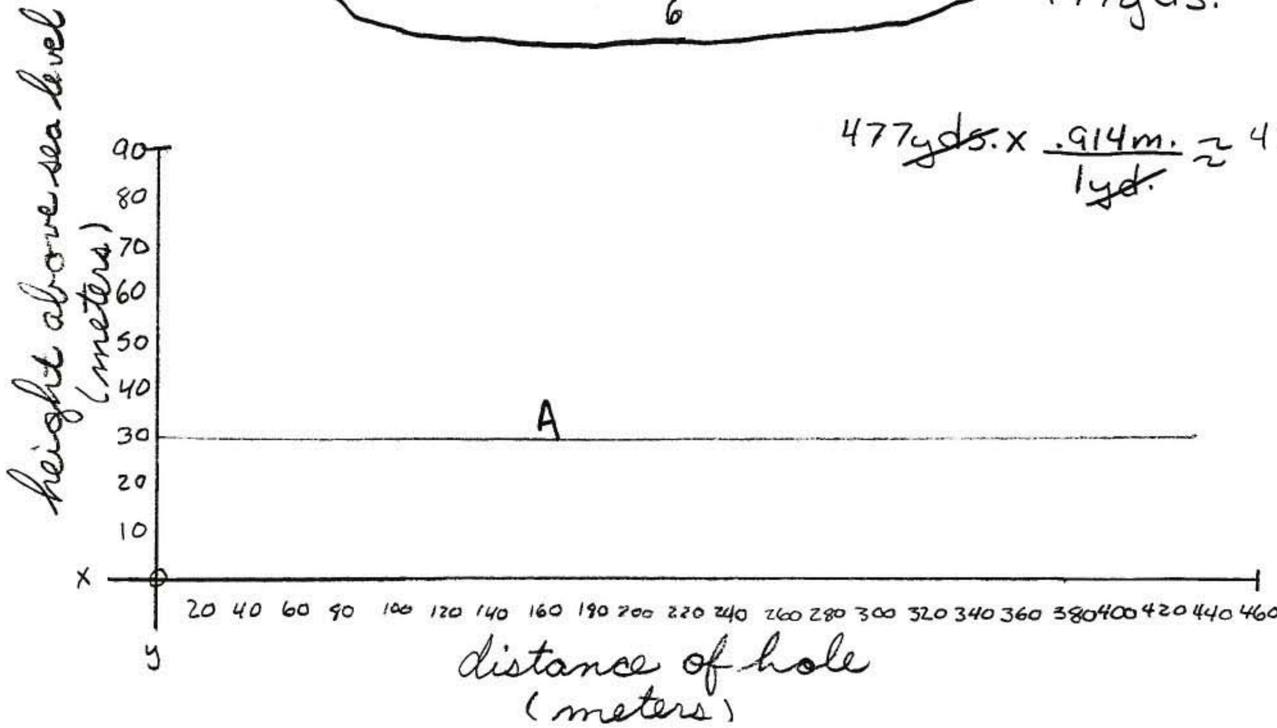
Topography / Slope

Hole



477yds.

$477\cancel{yds.} \times \frac{.914m.}{1\cancel{yd.}} \approx 436m.$

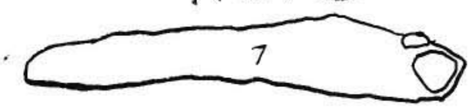


A - Slope = 0

Weequahic Golf Course

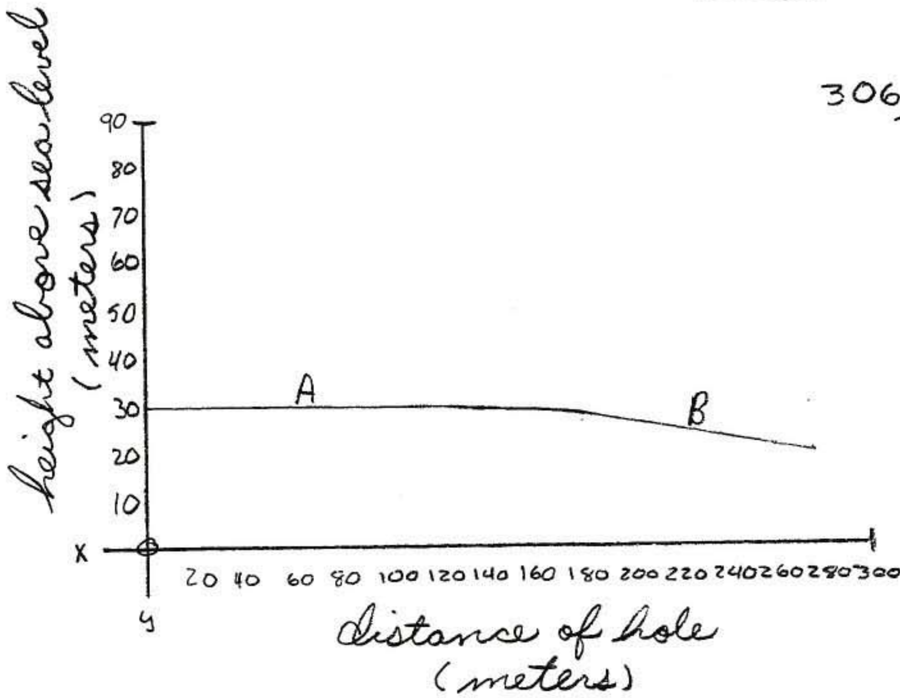
Topography / Slope

Hole



306yds.

$306 \cancel{yds.} \times \frac{.914m}{1 \cancel{yd.}} \approx 275m.$



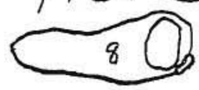
A - Slope = 0

B - Vertical Change = −10

Horizontal Change = 100

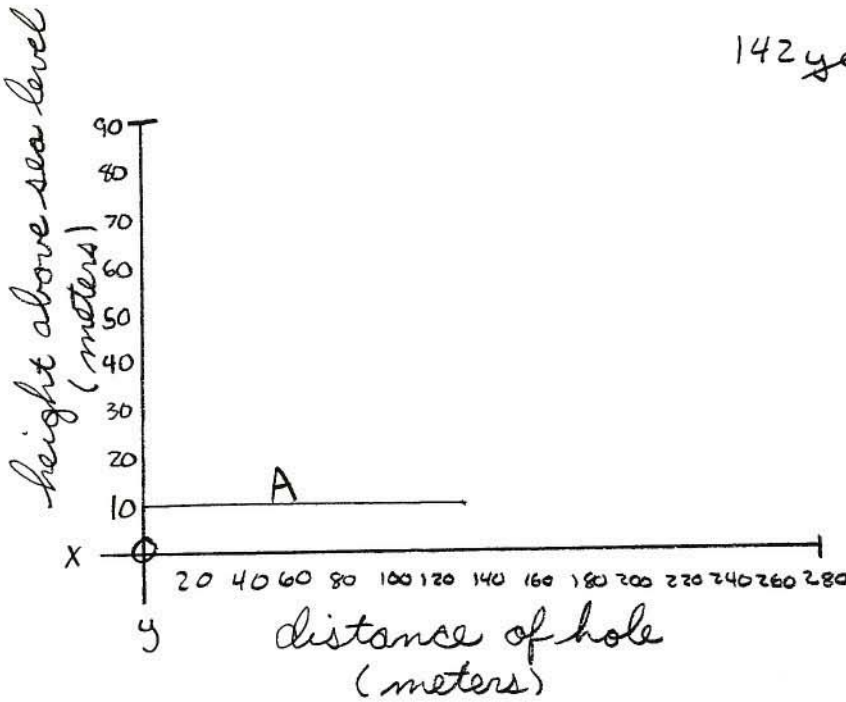
Slope $= -\frac{10}{100} = -\frac{1}{10}$

Weequahic Golf Course
Topography / Slope
Hole



142yds.

$142 \cancel{yds.} \times \frac{.914m}{1 \cancel{yd.}} \approx 130m.$



A - Slope = 0

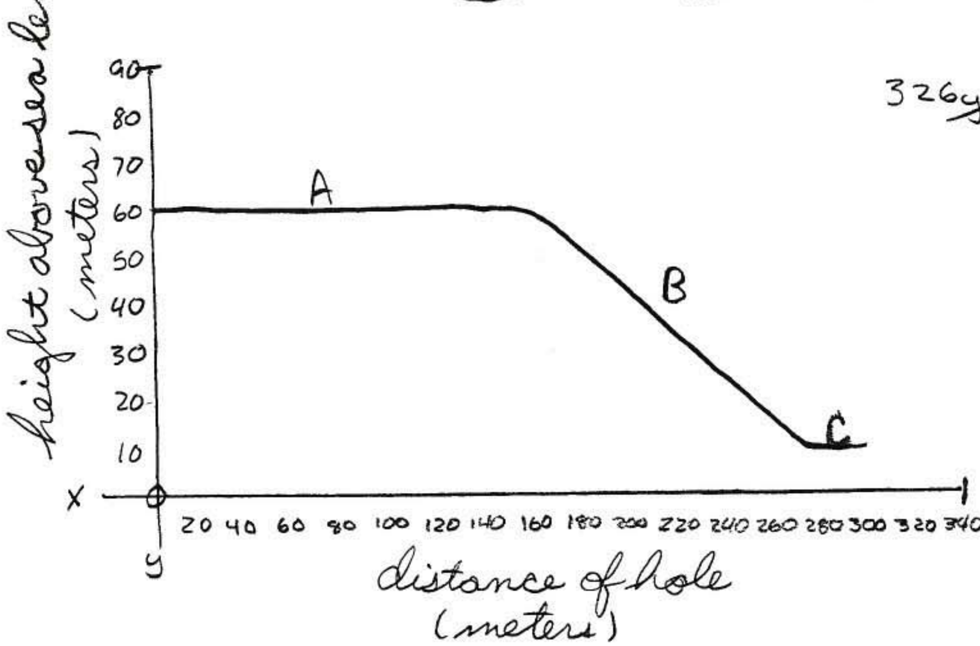
Weequahic Golf Course

Topography / Slope

Hole

326yds.

$326\cancel{yds.} \times \frac{.914m}{1\cancel{yd.}} \approx 298m.$



A - Slope = 0

B - Vertical Change = -50

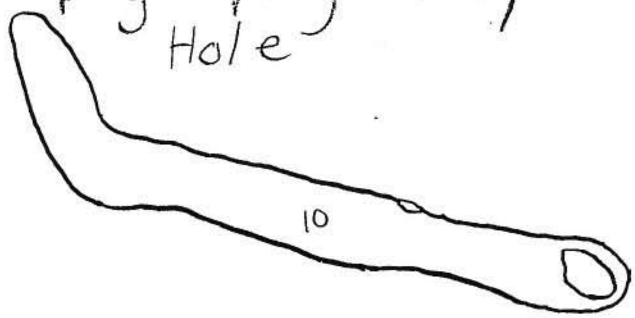
Horizontal Change = 110

Slope = $-\frac{50}{110} = -\frac{5}{11}$

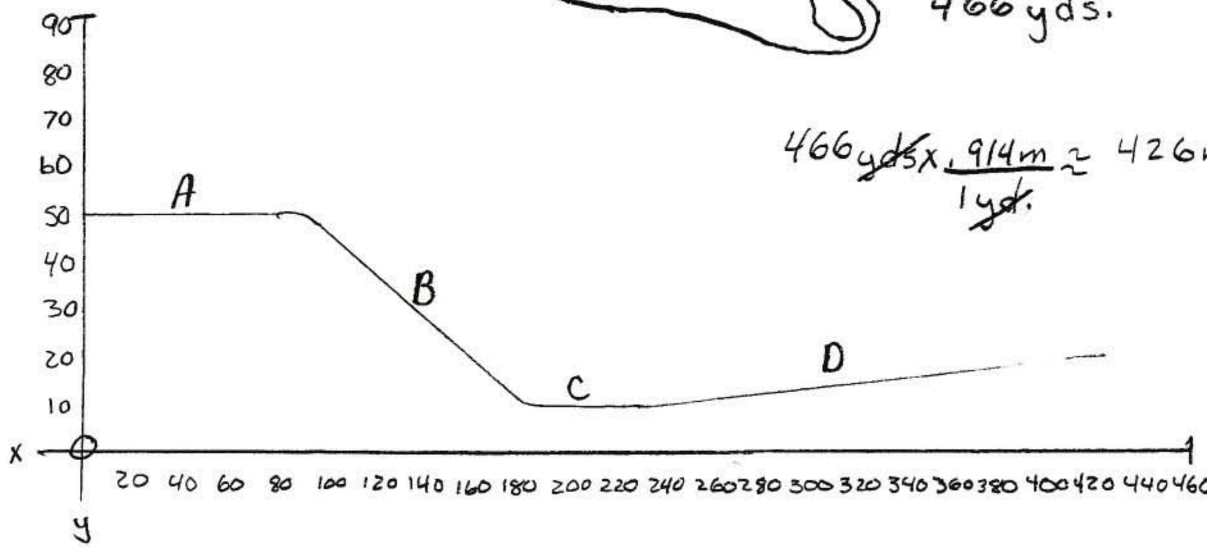
C - Slope = 0

Weequahic Golf Course

Topography / Slope
Hole



$466 \cancel{yds} \times \frac{.914m}{1 \cancel{yd.}} \approx 426m.$



A - Slope = 0

B - Vertical Change = -40

Horizontal Change = 80

Slope = $-\frac{40}{80} = -\frac{4}{8}$

C - Slope = 0

D. Vertical Change = 10

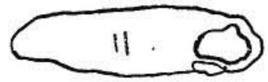
Horizontal Change = 200

Slope = $\frac{10}{200} = \frac{1}{20}$

Weequahic Golf Course

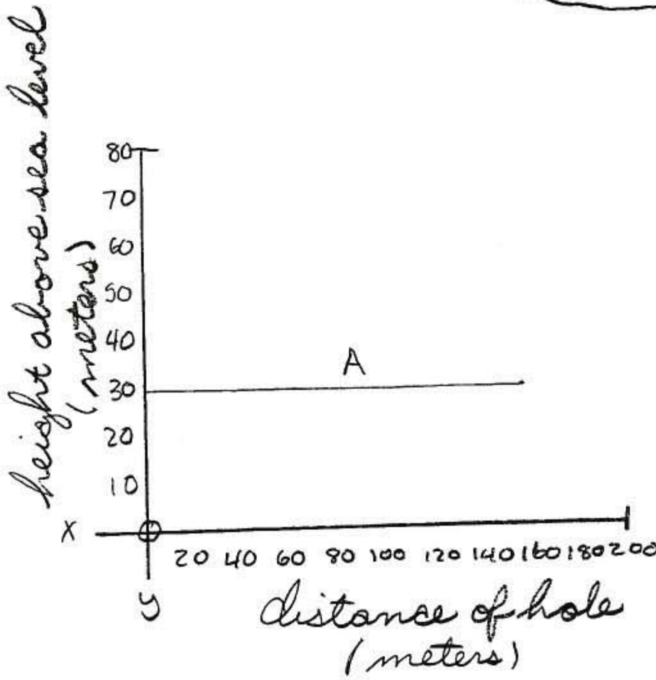
Topography/Slope

Hole



173yds.

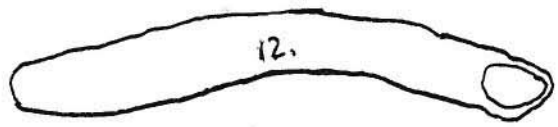
$173 \cancel{yds.} \times \frac{.914m.}{1 \cancel{yd.}} \approx 158.1m.$



A - Slope = 0

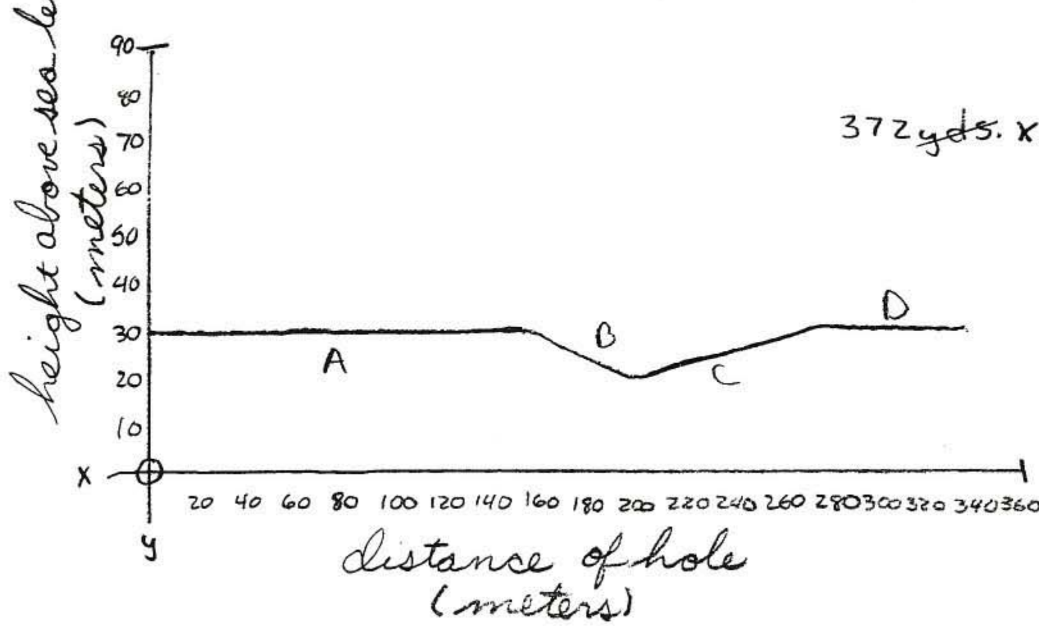
Weequahic Golf Course

Topography / Slope
Hole



372 yds.

$372 \cancel{yds.} \times \frac{.914m}{1 \cancel{yd.}} \approx 340m.$



A – Slope = 0

B – Vertical Change = −10

Horizontal Change = 40

Slope = $-\frac{10}{40} = -\frac{1}{4}$

C – Vertical Change = 10

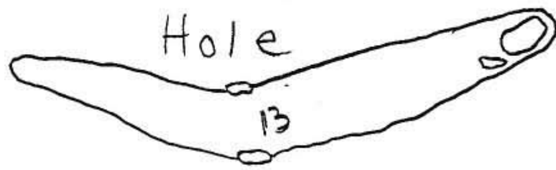
Horizontal Change = 80

Slope = $\frac{10}{80} = \frac{1}{8}$

D – Slope = 0

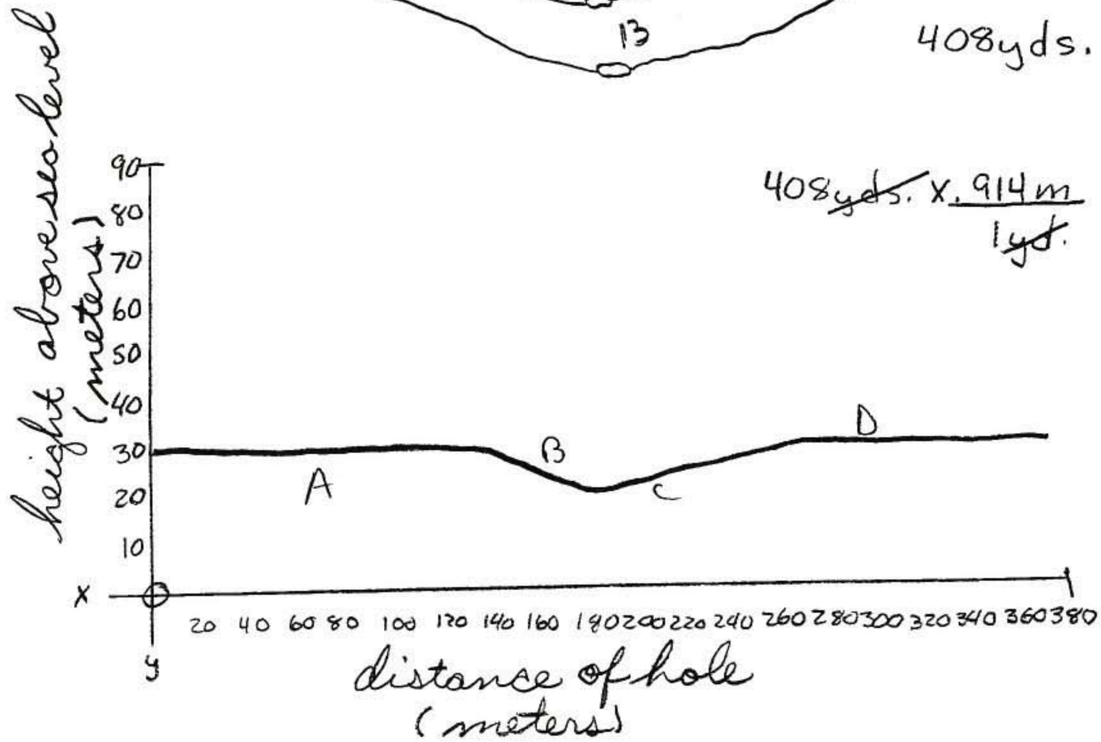
Weequahic Golf Course

Topography / Slope



408yds.

$$408\cancel{yds.} \times \frac{.914m}{1\cancel{yd.}} \approx 373m.$$



A - Slope = 0

B - Vertical Change = 10

Horizontal Change = 40

Slope $= -\frac{10}{40} = -\frac{1}{4}$

C - Vertical Change = 10

Horizontal Change = 80

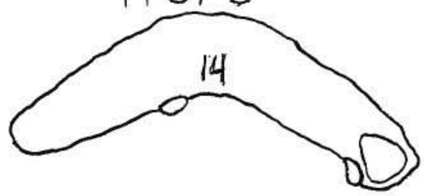
Slope $= \frac{10}{80} = \frac{1}{8}$

D - Slope = 0

Weequahic Golf Course

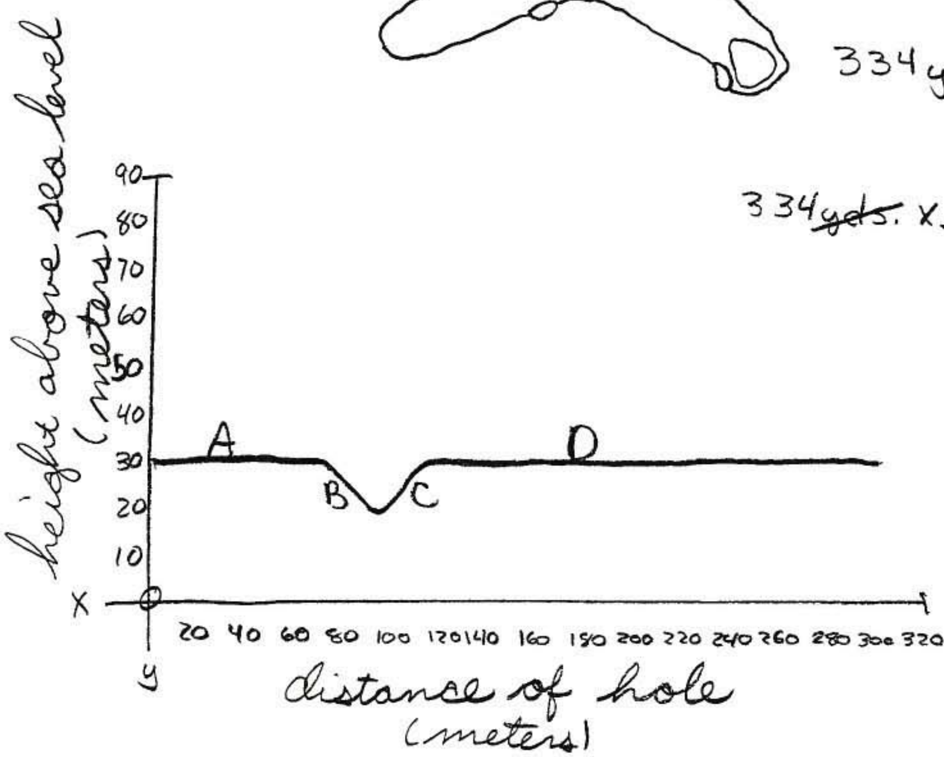
Topography / Slope

Hole



334 yds.

$334 \cancel{yds.} \times \frac{.914m}{1 \cancel{yd}} \approx 305.3\ m.$



A - Slope = 0

B - Vertical Change = -10

Horizontal Change = 20

Slope $= -\frac{10}{20} = -\frac{1}{2}$

C - Vertical Change = 10

Horizontal Change = 20

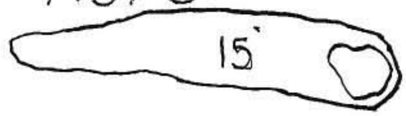
Slope $= \frac{10}{20} = \frac{1}{2}$

D - Slope = 0

Weequahic Golf Course

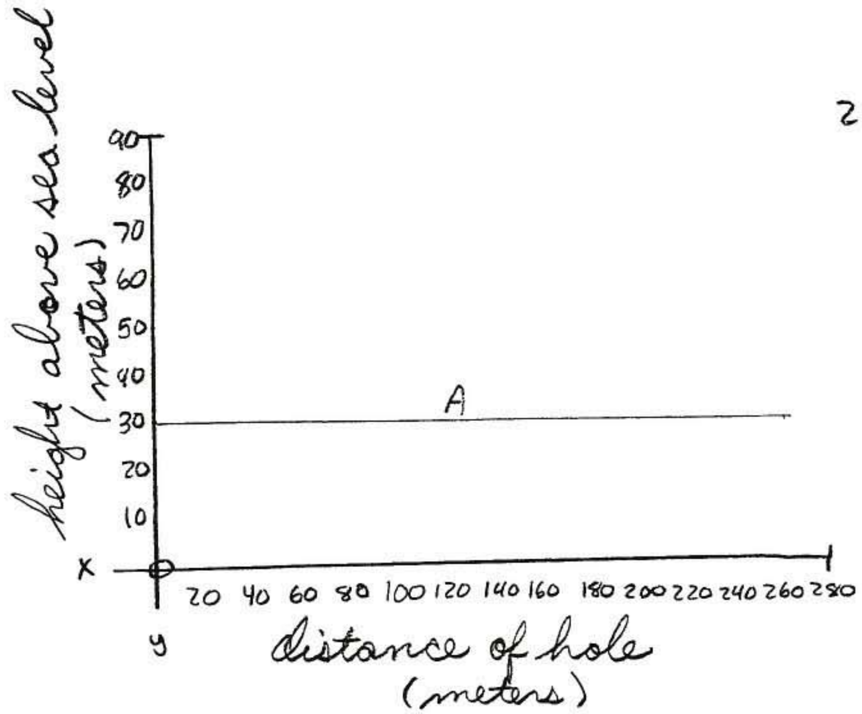
Topography / Slope

Hole



285yds.

$$285\cancel{yds.} \times \frac{.914m}{1\cancel{yd.}} \approx 261m.$$

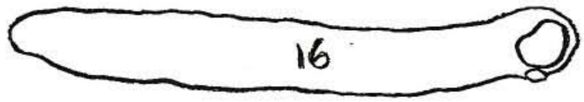


A - Slope = 0

Weequahic Golf Course

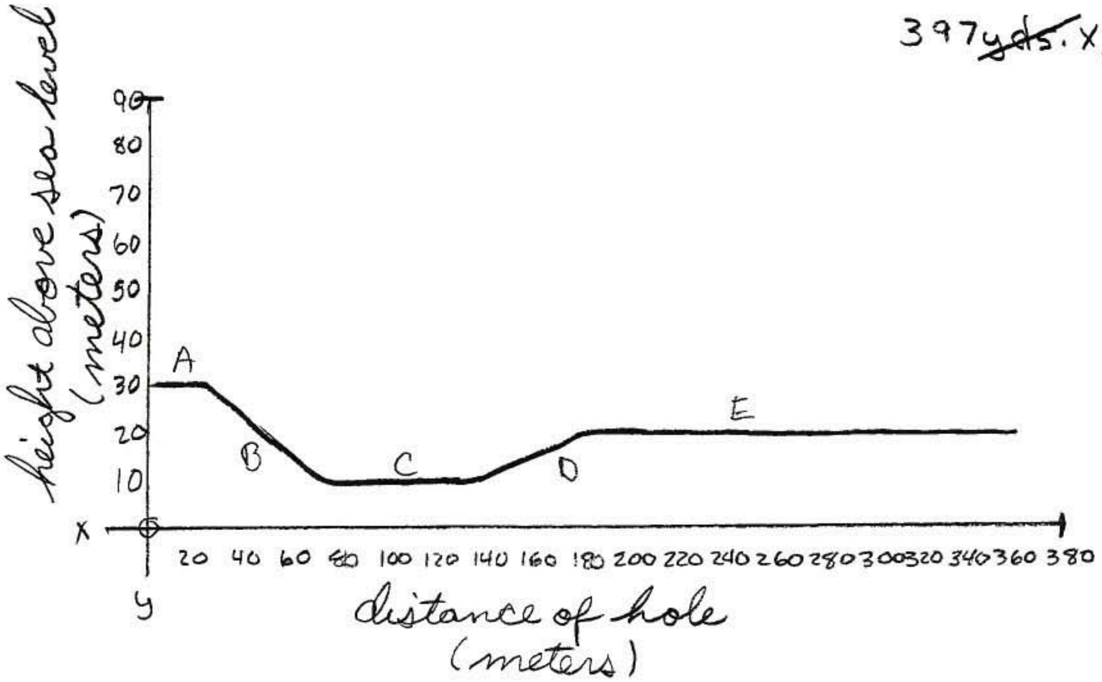
Topography/Slope

Hole



397yds.

$397\cancel{yds.} \times \frac{.914m}{1\cancel{yd.}} \approx 363m.$



A- Slope = 0

B- Vertical Change = -20

Horizontal Change = 50

Slope $= -\frac{20}{50} = -\frac{2}{5}$

C- Slope = 0

D- Vertical Change = 10

Horizontal Change = 20

Slope $= \frac{10}{20} = \frac{1}{2}$

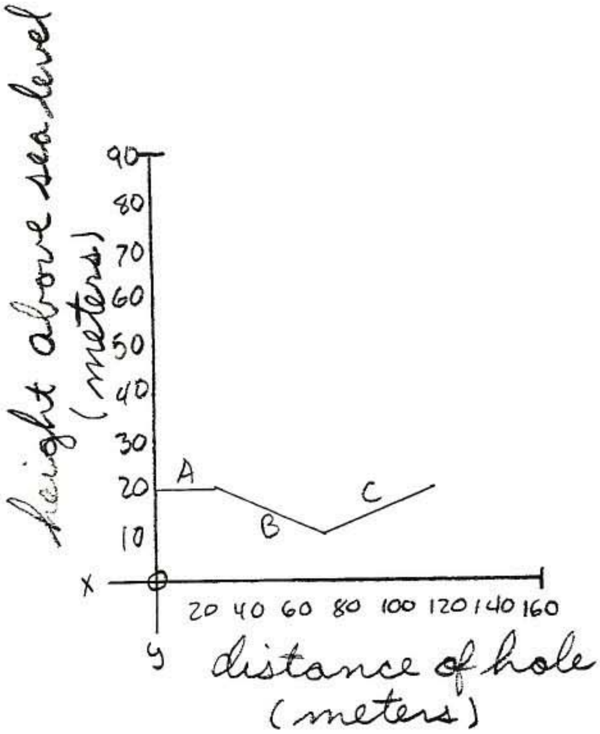
E- Slope = 0

Weequahic Golf Course

Topography / Slope

Hole

17 127yds.



$127\,\cancel{yds} \times \frac{.914\,m}{1\,\cancel{yd}} \approx 116\,m.$

A- Slope = 0

B- Vertical Change = -10

Horizontal Change = 40

Slope $= -\frac{10}{40} = -\frac{1}{4}$

C- Vertical Change = 10

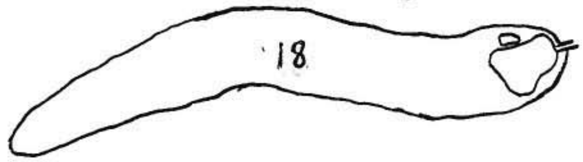
Horizontal Change = 40

Slope $= \frac{10}{40} = \frac{1}{4}$

Weequahic Golf Course

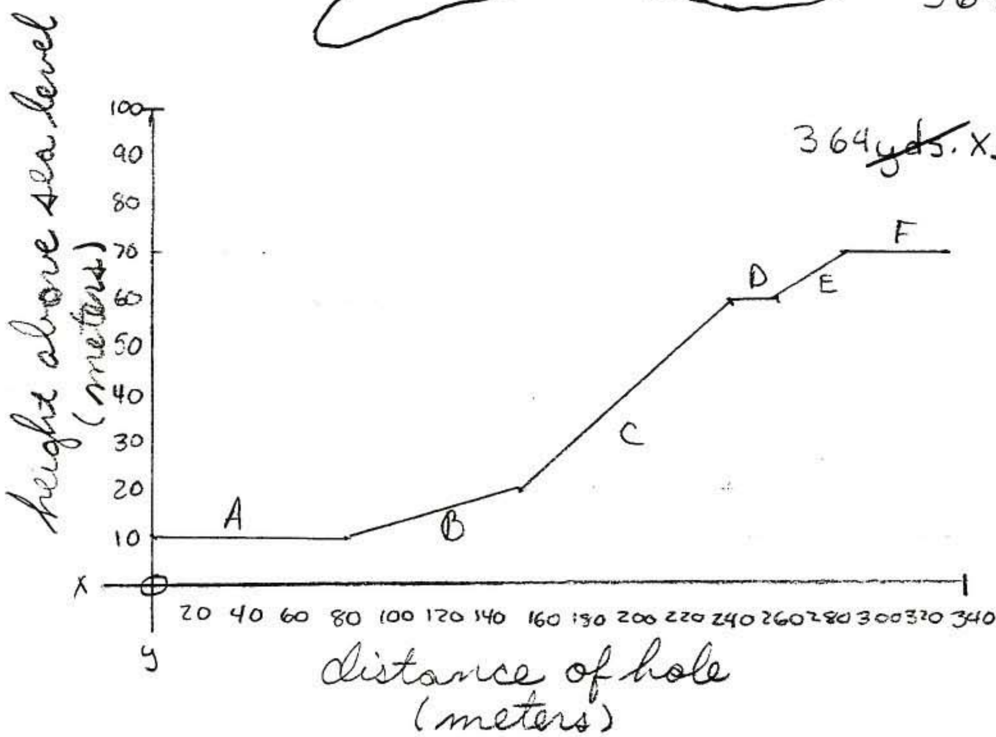
Topography / Slope

Hole



364yds.

$364 \cancel{\text{yds.}} \times \frac{.914\text{m}}{1 \cancel{\text{yd}}} \approx 333\text{m.}$



A - Slope = 0

B - Vertical Change = 10

Horizontal Change = 70

Slope = $\frac{10}{70} = \frac{1}{7}$

C - Vertical Change = 40

Horizontal Change = 90

Slope = $\frac{40}{90} = \frac{4}{9}$

D - Slope = 0

E - Vertical Change = 10

Horizontal Change = 30

Slope = $\frac{10}{30} = \frac{1}{3}$

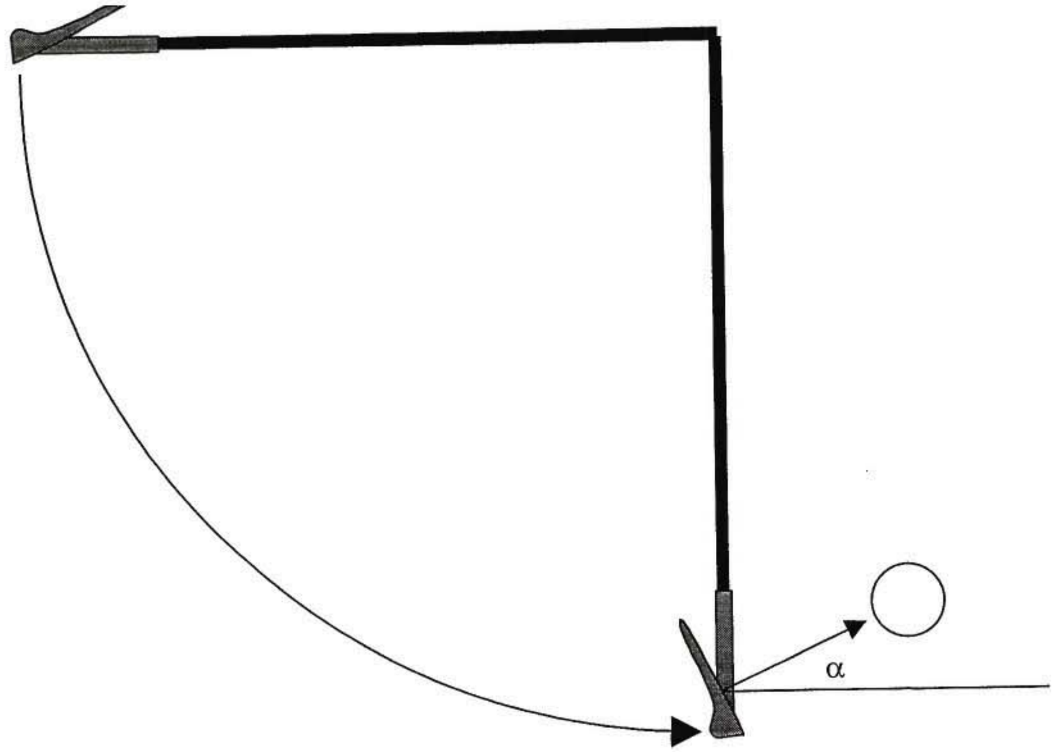
F - Slope = 0

From: John Spitzer <JSpitzer@USGA.org> | **Block Address** | **Add to Address Book**
To: "'Oliveira401@yahoo.com'" <Oliveira401@yahoo.com>
Subject: Ann Street exp.doc
Date: Wed, 2 May 2001 10:47:23 -0400

Manny,

It was nice meeting you and your students the other day. Attached is a document with some basic equations. They include some simplifying assumptions that make them not exactly correct but they probably are not unreasonable for the grade level. Call if you have questions.

Good luck!
John



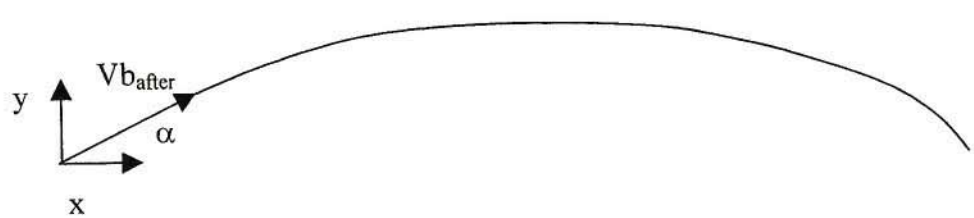
In your experiment you've released the club from 90° and timed how long it takes until impact. Knowing the time and distance traveled (calculated from the club length and the arc it makes with your "Wooden Byron) you can estimate an impact velocity, Vi.

The ball will leave the lofted club as some angle, α. That portion of Vi that propels the ball could be calculated as $Vi*\cos(\alpha)$.

This is a little tricky but we could estimate the ball's velocity using the following formula, provided we know the mass of the ball Mb,
and the mass of the clubhead, Mc (if you tell me the brand I can probably get that info for you so you don't have to take the shaft out
of the club) and assume the ball has a coefficient of restitution, e, of 0.85 (which is not unreasonable)

$Vb_{after}=(McVi*(1+e))/(Mc+Mb)$ [1]

If we then use the equations of motion we can estimate a distance from the initial launch (neglecting any aerodynamic effects)



The intial velocity of the ball in the y direction is:

$Vb_{y0}=Vb_{after}*\sin(\alpha)$ [2]

Gravity pulls the ball down so the velocity of the ball in the y direction at any time is:

$Vb_y= Vb_{y0} + a*t$ where a is the acceleration of gravity and t is time.

We can find the position in y using the following equation:

$y= Vb_{y0} *t +1/2\ a*t^2$ [3]

Eventually the vertical velocity upwards goes to zero and the ball begins to fall to the ground. The acceleration of the ball in the y direction at any time is:

$Vb_y^2= (Vb_{y0})^2 + a*y$ [4]
where a is the acceleration of gravity and t is time.

The horizontal direction is given by:

$Vb_{x0}=Vb_{after}*\cos(\alpha)$ [5]

We can find the position in x using the following equation (gravity doesn't act in this direction):

$x= Vb_{x0} *t$ [6]

and the maximum height by using equation [4] with $Vb_y^2=0$.

You measured the time, distance and maximum height. When you calculate x using [6] and the measured time does it agree with the distance measured? (probably not) When you calculate the maximum height, y, using [4] does it agree with your measurement? (Again probably not) This is OK because you neglected aerodynamics and estimated the velocity. Next year you can add these features.

Mathletics

Distance (in inches) ~ Time (in seconds) that the ball traveled.
Ball: Top Flight ~ Weight: 46 grams

Pitching Wedge- 45°

	D	T	D	T
1)	30	.31	38	.41
2)	33	.36	31	.33
3)	32	.35	37	.40
4)	36	.39	35	.38
5)	32	.34	36	.39

Avg. distance the ball traveled: 34 inches in .37 seconds

9 iron- 41°

1)	38	.37	34	.35
2)	46	.41	46	.42
3)	41	.39	38	.36
4)	43	.39	44	.40
5)	50	.43	40	.38

Avg. distance the ball traveled: 42 inches in .39 seconds

8 iron- 37°

1)	45	.40	47	.42
2)	50	.43	47	.42
3)	36	.40	47	.42
4)	54	.44	45	.40
5)	42	.39	41	.38

Avg. distance the ball traveled: 45 inches in .41 seconds

7 iron- 34°

1)	44	.36	48	.41
2)	48	.37	50	.41
3)	48	.37	48	.38
4)	45	.37	51	.41
5)	48	.40	52	.42

Avg. distance the ball traveled: 48 inches in .39 seconds

Mathletics

6 iron- 31°

	D T	D T
1)	55 ~ .38	62 ~ .41
2)	40 ~ .36	47 ~ .38
3)	38 ~ .35	42 ~ .37
4)	60 ~ .40	58 ~ .39
5)	53 ~ .38	45 ~ .38

Avg. distance the ball traveled: 50 inches in .38 seconds

5 iron- 28°

1)	36 ~ .30	38 ~ .32
2)	40 ~ .32	46 ~ .35
3)	42 ~ .33	42 ~ .33
4)	40 ~ .32	52 ~ .40

Avg. distance the ball traveled: 44 inches in .35 seconds

4 iron- 25°

1)	46 ~ .30	56 ~ .36
2)	50 ~ .32	52 ~ .35
3)	48 ~ .31	55 ~ .35
4)	51 ~ .33	58 ~ .37
5)	51 ~ .33	60 ~ .38

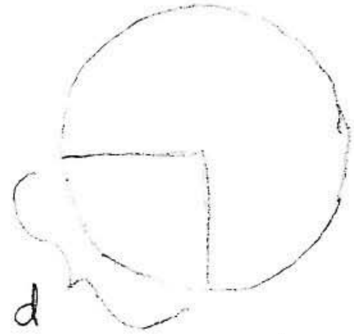
Avg. distance the ball traveled: 53 inches in .34 seconds

3 iron- 22°

1)	36 ~ .26	39 ~ .30
2)	37 ~ .28	38 ~ .30
3)	40 ~ .32	37 ~ .27
4)	38 ~ .31	38 ~ .29
5)	39 ~ .31	39 ~ .30

Avg. distance the ball traveled: 38 inches in .29 seconds

Pitching wedge



Angle is 45°
Club Length is 36 in. = .914 m.
Mass of ball is 46 g (M_b)
Mass of the clubhead is 280 g (M_c)

Circumfrence = $2\pi r$
Distance = $\frac{1}{4}(2\pi r) = \frac{1}{4}(2)(3.14)(36 in) = 56.52 = 1.44 m$
Time = .555 (T)
Acceleration of Gravity = 9.8 m/s/s

Time ball is in flight from initial launch to landing + varying from .01 s to .37 s
At maximum time of .37 s the ball traveled in x direction:
34 in = .86 m

Calculations
Impact Velocity (V_i) = d/t = 1.44 m/.555 s = 2.68 m/s = 5.86 mph
Partial V_i is the portion of V_i that propels the ball
$V_i^*(\cos 45°) = 2.62 m/s(.707) = 1.85 m/s = 4.14 mph$
① Velocity of the ball after impact
$Vb_{after} = (M_c V_i^*(1+e))/(M_c + M_b)$
$Vb_{after} = [280g(1.85 m/s)(1+.85)]/(280g+46g) = 2.94 m/s = 6.58 mp$

② Initial Velocity of the ball in the y direction
$Vb_{y0} = Vb_{after} * \sin(\alpha) = 2.94 m/s (.707) = 2.08 m/s = 4.65 mph$

③ Find position of y using the following equation
$y = Vb_{y0} * (T) + \frac{1}{2} a * t^2$
$y = 2.08 m/s (t) + \frac{1}{2}(-9.8 m/s/s (t^2))$
for t = .01 s y = .02 m = .79 in
for t = .37 s y = .09 m = 3.54 in

④ The acceleration of the ball in the y direction at any time is $Vb_y^2 = (Vb_{y0})^2 + a * y$
to get the maximum height, $Vb_y^2 = 0$
$y = (-Vb_{y0}^2)/a = (-2.08 m/s)^2/(-9.8 m/s/s) = .44 m = 17.32 in$

⑤ $Vb_{x0} = Vb_{after} * \cos(\alpha) = 2.94 m/s (.707) = 2.08 m/s = 4.65 mp$

⑥ Since gravity does not act in this direction, the followin equation will give us the position of x

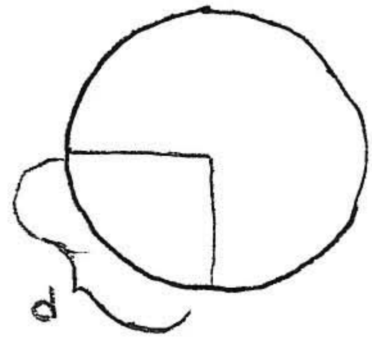
$x = V_{bxo} * t = 2.08\ m/s\ (t)$

for $t = .01\ s$ $x = .02\ m = .79\ in$

for $t = 0.37\ s$ $x = .77\ m = 30.31\ in.$

9 Iron

angle: 41°
Clublength: 36in = .914m
mass of ball: (Mb) = 46g
mass of club head: (Mc) = 280g



Circumference = 2 πr

Distance
$d = \frac{1}{4}(2\pi r) = \frac{1}{4}(2)(3.14)(36in) = 56.52\,in = 1.44m$

Time
$t = .55s$

Time ball is in flight from initi
launch to landing
t varying from .01s to 0.47s

Acceleration of gravity
$a = 9.8\,m/s/s$

At maximum time of .47s the ball traveled in x direction = 42in = 1.07

Calculations
Impact velocity $V_i = d/t = 1.44m/.55s = 2.62\,m/s = 5.86mp$
Partial V_i is the portion of V_i that propels the ball
$V_i^* = V_i(\cos 41°) = 2.62\,m/s(.755) = 1.96\,m/s = 4.38\,mph$

(1) Velocity of the ball after impact
$V_{b\,after} = (M_c V_i^*(1+e))/(M_c + M_b)$
$V_{b\,after} = [280g(1.96m/s)(1+0.85)]/(280g+46g) = 3.11m/s = 6.9$ mph

(2) Initial Velocity of the ball in the y direction
$V_{byo} = V_{b\,after} * \sin(\alpha) = 3.11m/s(.656) = 2.04\,m/s = 4.56mph$

(3) Position of y =
$y = V_{byo} * t + \frac{1}{2} a * t^2$
$y = 2.04\,m/s(t) + \frac{1}{2}(-9.8\,m/s/s(t^2))$
for $t = .01s$ $y = .02\,m = .79in$
for $t = .39\,s$ $y = .04m = 1.57in$

(4) Acceleration of the ball in the y direction is
$V_{by}^2 = (V_{by0})^2 + a * y$
maximum height = $V_{by}^2 = 0$
$y = (-V_{by0}^2)/a = (-2.04m/s)^2/(-9.8\,m/s/s) = .42\,m = 16.54\,in$

(5) Horizontal direction
$V_{bx0} = V_{b\,after} * \cos(\alpha) = 3.11\,m/s(.755) = 2.35m/s = 5.26mph$

(6) Since gravity does not act in this direction, the following equation will give us the position of x

$x = V_{bxo} * t = 2.35\ m/s\ (t)$

for $t = .015$ $x = .02\ m = .79\ in$

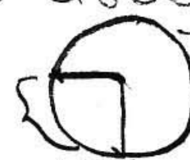
for $t = .39s$ $x = .92\ m = 36.22\ in$

8 IRON

Angle: 37° Club Length: 36.25in = .921m

Mass of Ball: 46g Mass of Club head: 280g

Circumference = $2\pi R$

d 

Distance

$\underline{d} = 1/4\,(2\pi R) = 1/4(2)(3.14)(36.25in) = 56.91\,in = 1.45m$

Time

$t = .55s$

Acceleration of Gravity

$a = 9.8m/s/s$

Time ball is in flight from initial launch to landing
t varying from .01s to .41s

At maximum time of .41s the ball traveled in X direction = 45in = 1.14 m

<u>Calculations</u>

Impact velocity $V_i = d/t = 1.45m / .55s = 2.64m/s = 5.91mph$

Partial vi is the portion of Vi that propels the ball

$V_i^* = V_i(\cos 37°) = 2.64m/s\,(.799) = 2.11m/S = 4.72\ mph$

(1) Velocity of the ball after impact

$V_{b\,after} = (m_c V_i^*(1+e))/(m_c + m_b)$

$V_{b\,after} = [280g(2.11m/s)(1+0.85)]\ 280g + 46g) = 3.35m/s = 7.49.$

(2) Initial Velocity of the ball in the y direction

$V_{b_{y0}} = V_{b\,after} * \sin(\alpha) = 3.35m/s\,(.602) = 2.02m/s = 4.52mph$

(3) Find position of y_2 using the following equation

$y = V_{b_{y0}} * t + 1/2\, a * t^2$

$y = 2.02m/s(t) + 1/2\,(-9.8m/s/s\,(t^2))$

for $t = .01s$ $y = .02m = .79\,in$

for $t = .41s$ $y = .004m = .16\,in$

(4) The acceleration of the ball in the y direction at any time i

$V_{b_y}^2 = (V_{b_{y0}})^2 + a^* y$

to get to the maximum height, $V_{b_y}^2 = 0$

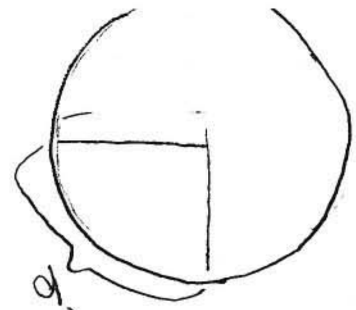
$y = (-Vb_{yo}^2)/a = (-2.02\,m/s)^2/(-9.8\,m/s/s) = .42\,m = 16.54\,in$

(5) Horizontal direction is
$Vb_{xo} = Vb_{after} * \cos(\alpha) = 3.35\,m/s(.799) = 2.68\,m/s = 5.99\,mph$

(6) Since gravity does not act in this direction, the following equation will give us the position of x
$x = Vb_{xo} * t = 2.68\,m/s(t)$
for $t = .01\,s$ $\quad x = .03\,m = 1.18\,in$
for $t = .41\,s$ $\quad x = 1.09\,m = 42.91\,in$

7 IRON

Angle = 34°
Club Length = 36.75 in = .933 m
mass of ball (m_b) = 46 g
Mass of the club head (m_c) = 280 g



Circumference = $2\pi R$
Distance; $d = \frac{1}{4}(2\pi R) = \frac{1}{4}(2)(3.14)(36.75 in) = 57.70 in = 1.47$
Time; t = .55 s
Acceleration of gravity
a = 9.8 m/s/s

Time ball is in flight from initial launch to landing
t varying from .01s to .39s

At maximum time of .39s the ball traveled in x direction = 48 in = 1.22 m

Calculations

Impact velocity $V_i = d/t = 1.47 m / .55 s = 2.67 m/s = 5.97$ mph

Partial V_i is the portion of V_i that propels the ball
$V_i^* = V_i (\cos 34°) = 2.67 m/s (.829) = 2.21 m/s = 4.94$ mph

1. Velocity of ball after impact
$V_{bafter} = (M_c V_i^* (1+e))/(M_c + M_b)$
$V_{bafter} = [280 g (2.21 m/s)(1+0.85)]/(280 g + 46 g) = 3.51 m/s = 7.85$ mph

2. Initial Velocity of the ball in the y direction
$V_{b_{yo}} = V_{baftee}{}^* \sin(d) = 3.51 m/s (.559) = 1.96 m/s = 4.38$ mph

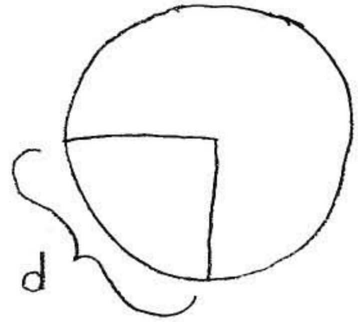
3. Find position of y using the following equation
$y = V_{b_{yo}}{}^* t + \frac{1}{2} a^* t^2$
$y = 1.96 m/s (t) + \frac{1}{2}(-9.8 m/s/s (t^2))$
for t = .01 s y = .02 m = .79 in
for t = .39 s y = .019 m = .75 in

4. The acceleration of the ball in the y direction at any time is $V_{by}^2 = (V_{b_{yo}})^2 + a^* y$
to get the maximum height, $V_{b_y}^2 = 0$
$y = (-V_{b_{yo}}^2)/a = (-1.96 m/s)^2/(-9.8 m/s/s) = .39 m = 15.35$ in

.5 Horizontal direction is
$Vb_{xo} = Vb_{after} * \cos(\alpha) = 3.51\ m/s\ (.829) = 2.91\ m/s = 6.51\ mph$

6. Since gravity does not act in this direction, the following equation will give us the position of x
$x = Vb_{xo} * t = 2.91\ m/s\ (t)$
for $t = .01s$ $x = .03m = 1.18in$
for $t = .39s$ $x = 1.14m = 44.88in$

6 IRON



6 iron angle is 31^0
Club length is 37.25 in = .95 m
Mass of the ball M_b = 46g
Mass of the club head = 280 g

Circumference = $2\pi r$

Distance
$d = \frac{1}{4}(2\pi r) = \frac{1}{4}(2)(3.14)(37.25 in) = 58.48 in. = 1.49m$

Time
$t = .55s$

Acceleration of gravity
$a = 9.8$ m/s/s

Time ball is in flight from initial launch to landing t varying from .01s to .38s

At maximum time of .38s the ball traveled in x direction = 50 in = 1.27 m

Calculations: Impact velocity $V_i = d/t = 1.49m/.55s = 2.71 m/s$ = 6.

Partial V_i is the portion of V_i that propels the ball
$V_1{}^* = V_i(\cos 31^0) = 2.71 m/s (.857) = 2.32 m/s = 5.19 mph$

1. Velocity of the ball after impact
$V_{bafter} = [M_c V_i{}^*(1+e)]/(M_c + M_b)$
$V_{bafter} = [280g(2.32 m/s)(1+0.85)]/(280g + 46g) = 3.69 m/s = 8.25 mph$

2. Initial Velocity of the ball in the y direction
$V_{byo} = V_{bafter} * \sin(\alpha) = 3.69 m/s (.515) = 1.90 m/s = 4.25 mph$

3. Find position of y using the following equation
$y = V_{byo} * t + \frac{1}{2} a * t^2$
$y = 1.90 m/s (t) + \frac{1}{2}(-9.8 m/s/s (t^2))$
for t = .01s y = .02 m = .79 in
for t = .38s y = .014m = .55 in

4. The acceleration of the ball in the y direction at any time is $Vby^2 = (Vbyo)^2 + 2a * y$ to get the maximum height, $Vby^2 = 0$ $y = (-Vbyo^2)/2a = (-1.90 m/s)^2 / (-9.8 m/s/s) = .37 m =$ 14.56 in

5. Horizontal direction is $Vb_{xo} = Vb_{after} * \cos(\alpha) = 3.64 m/s (.857)$ $= 3.16 m/s = 7.07 mph$

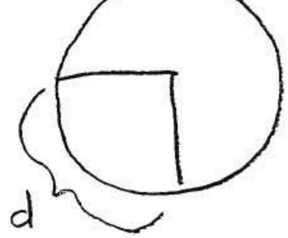
6. Since gravity does not act in this direction, the following equations will gives us the position of x

$x = Vb_{xo} * t = 3.16 m/s (t)$
for $t = .01s$ $x = .03 m = 1.18 in$
for $t = .38s$ $x = 1.20 m = 47.24 in.$

5 IRON

Angle: $28°$ Club Length: 37.75 in = .96 m
Mass of Ball (M_b): 46g Mass of Club Head (M_c): 280g

Circumference = $2\pi r$
Distance (d) = 1/4 (2)(3.14)(37.75 in.) = 59.27 in = 1.51 m
Time (t) = .55 s
Acceleration of Gravity (a) = 9.8 m/s/s



Time ball is in flight from initial launch to landing
t varying from .01 s to .35 s

At maximum time of .35s the ball traveled in x direction = 44 in
44 in = 1.12 m

Impact velocity $V_i = d/t$ = 1.51 m / .55 s = 2.75 m/s = 6.15 mph

Partial V_i is the portion of V_i that propels the ball
$V_i{}^* = V_i (\cos 28°)$ = 2.75 m/s (.883) = 2.43 m/s = 5.44 mph

(1) Velocity of the ball after impact
$Vb_{after} = (M_c V_i{}^* (1+e))/(M_c + M_b)$
$Vb_{after} = [280g (2.43 m/s)(1+.85)]/(280g + 46g)$ = 3.86 m/s
3.86 m/s = 8.63 mph

(2) Initial Velocity of the ball in the y direction
$Vb_{y0} = Vb_{after} * \sin(\alpha)$ = 3.86 m/s (.469) = 1.81 m/s = 4.05 mph

(3) Find position of y using the following equation
$y = Vb_{y0} * t + 1/2\ a * t^2$
y = 1.81 m/s (t) + 1/2 (−9.8 m/s/s(t^2))
for t = .01s y = .02 m = .79 in
for t = .35s y = .033m = 1.30 in

(4) The acceleration of the ball in the y direction at any time
$Vb_y{}^2 = (Vb_{y0})^2 + a * y$
to get maximum height, $Vb_y{}^2 = 0$
$y = (-Vb_{y0}{}^2)/a$ = (−1.81 m/s)^2 / (−9.8 m/s/s) = 33.m = 12.99

(5) Horizontal direction is
$Vb_{x0} = Vb_{after} * \cos(\alpha)$ = 3.86 m/s (.883) = 3.41 m/s = 7.63 mph

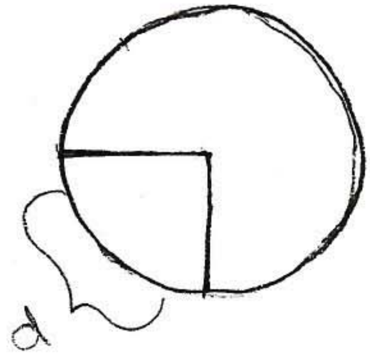
6) Since gravity does not act in this direction, the following equation will give us the position of x

$x = V_{bxo} * t = 3.41\ m/s\ (t)$

for $t = .01s$ $x = .03m = 1.18in$

for $t = .35s$ $x = 1.19m = 46.88in$

4 Iron



4 iron angle is 25°
Club length is 38.25 in = .97 m
Mass of the ball M_b = 46 g
Mass of the club head M_C = 280 g

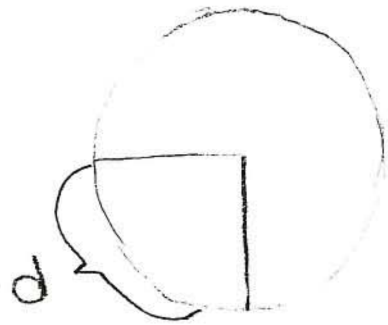
Circumference = $2\pi r$
Distance
$d = \frac{1}{4}(2\pi r) = \frac{1}{4}(2)(3.14)(38.25in) = 60.05in = 1.53m$
Time
$t = .55s$
Acceleration of gravity
$a = 9.8 m/s/s$

Time ball is in flight from initial launch to landing t varying from .01s to .39s
At maximum time of .34s the ball traveled in x direction = 53in = 1.35

Calculations
Impact velocity $V_i = d/t = 1.53m/.55s = 2.78 m/s = 6.22mph$
Partial V_i is the portion of V_i that propels the ball
$V_i^* = V_i(\cos 25°) = 2.78 m/s (.906) = 2.52 m/s = 5.64 mph$

1) Velocity of the ball after impact
$Vb_{after} = (M_C V_i^* (1+e))/M_C + M_b)$
$Vb_{after} = [280g(2.52m/s)(1+0.35)]/280g + 46g) = 4.00 m/s = 8.95mp$
(2) Initial velocity of the ball in the y direction
$Vb_{yo} = Vb_{after} * \sin(\alpha) = 4.00 m/s(.422) = 1.69 m/s = 3.78 mph$
(3) Find position of y using the following equation
$y = Vb_{yo} * t + \frac{1}{2} a * t^2$
$y = 1.69 m/s(t) + \frac{1}{2}(-9.8m/s/s(t^2))$
for t = .01s y = .02m = .79
for t = .34s y = .009m = .35in
(4) The acceleration of the ball in the y direction at any time is
$Vb_y^2 = (Vb_{yo})^2 + a * y$
to get the maximum height, $Vb_y^2 = 0$
$y = (-Vb_{yo}^2)/a = (-1.64 m/s)^2/(9.8m/s/s) = .29m = 11.42in.$
(5) Horizontal direction is
$Vb_{xo} = Vb_{after} \cos(\alpha) = 4.00 m/s(.906) = 3.62 m/s = 8.10 mph$
(6) Since gravity does not act in this direction, the following equation will give us the position of x $x = Vb_{xo} * t = 3.62 m/s$
for t = .01s $x = .04 m = 1.57 in$ for t = .34s $y = 1.23m = 48.43in$

3 Iron



Angle: $22°$
Club Length: 38.75in = .98m
Mass of ball (MB) = 46g
Mass of the club head (mc) = 280g

Circumference = $2\pi r$
Distance
$d = 1/4(2\pi r) = 1/4(2)(3.14)(38.75in) = 60.84in = 1.55m$
Time
$t = .55s$
Acceleration of gravity
$a = 9.8 m/s/s$

Time ball is in flight from initial launch to landing
t varying from .01s to .29s
At maximum time of .29s the ball traveled in x direction = 38in = .97m

Calculations

Impact velocity $V_i = d/t = 1.55m/.55s = 2.73 m/s = 6.11 mph$

Partial Vi is the porportion of Vi that propels the ball
$V_i^* = V_i(\cos 22°) = 2.73 m/s(.927) = 2.53 m/s = 5.66 mph$

(1) Velocity of the ball after impact
$VB_{after} = (m_c V_i^*(1+e))/(m_c + m_b)$
$VB_{after} = [280g(2.53 m/s)(1+0.85)]/(280g + 46g) = 4.02 m/s = 8.99 mph$

(2) Initial Velocity of the ball in the y direction
$Vb_{yo} = VB_{after} {}^* \sin(\alpha) = 4.02 m/s(.375) = 1.51 m/s = 3.38 mph$

(3) Find position of y using the following equation
$y = Vb_{yo} {}^* t + 1/2\ a^* t^2$
$y = 1.51 m/s(t) + 1/2(-9.8 m/s/s(t^2))$
for t = .01s y = .02m = .79in
for t = .29s y = .026m = 1.02in

4) The acceleration of the ball in the y direction at any time is:

$Vby^2 = (Vbyo)^2 + a*y$

to get the maximum height, $Vby^2 = 0$

$y = (-Vbyo^2)/a = (-1.51 m/s)^2/(-9.8 m/s/s) = .23m = 9.06in$

(5) Horizontal direction is

$Vb_{xo} = Vb_{after} * \cos(\alpha) = 4.02 m/s(.927) = 3.73 m/s = 8.34 mph$

(6) Since gravity does not act in this direction, the following equation will give us the position of x

$x = Vb_{xo} * t = 3.73 m/s (t)$

for $t = .01s$ $x = .04 m = 1.57 in$

for $t = .29s$ $x = 1.08 m = 42.52 in$