Math Connections to Earth and Space Science

Glen Schuster

Endeavor

NASA

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

Phases of the Project

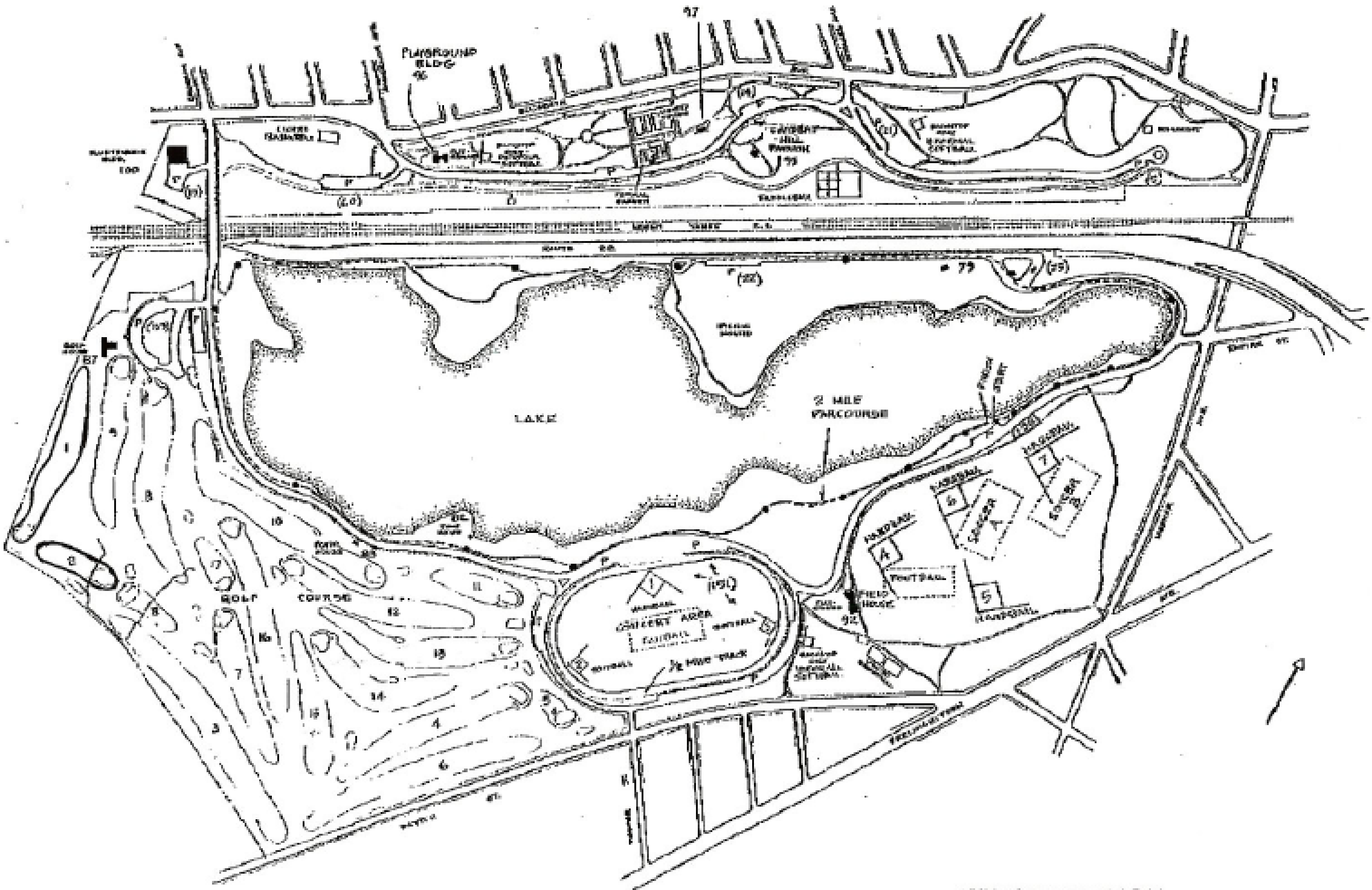
We started out by researching golf courses for our study. When doing our research we found that the word Weequahic is a Lenni Lenape name which means boundary. Since Weequahic Park is in our own backyard and its name is associated with math, we decided to use it for our project. We contacted Mr. Joseph 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.



P = PARKING AREA

( ) = NO. OF SPACES

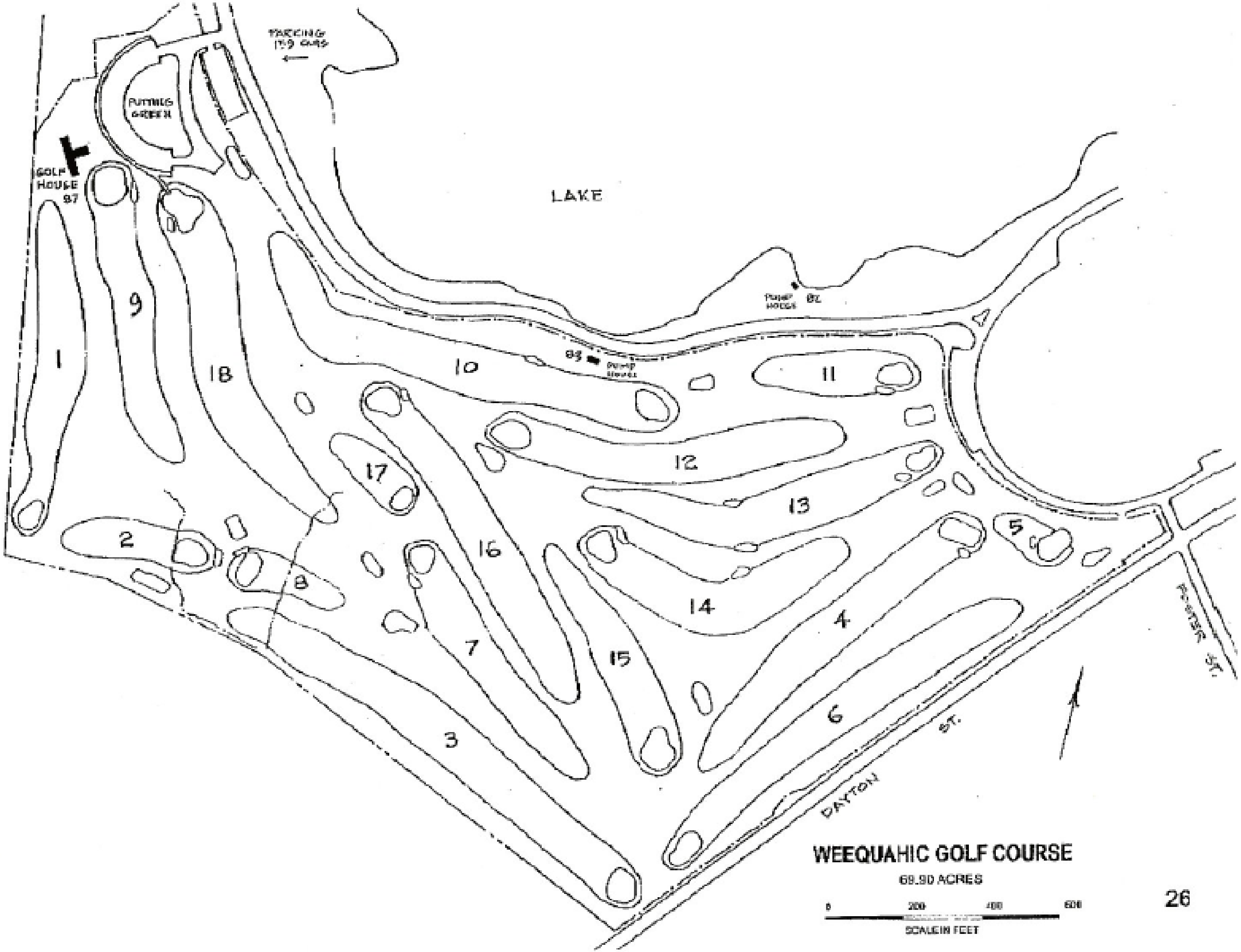
WEEQUAHIC PARK

311.33 ACRES

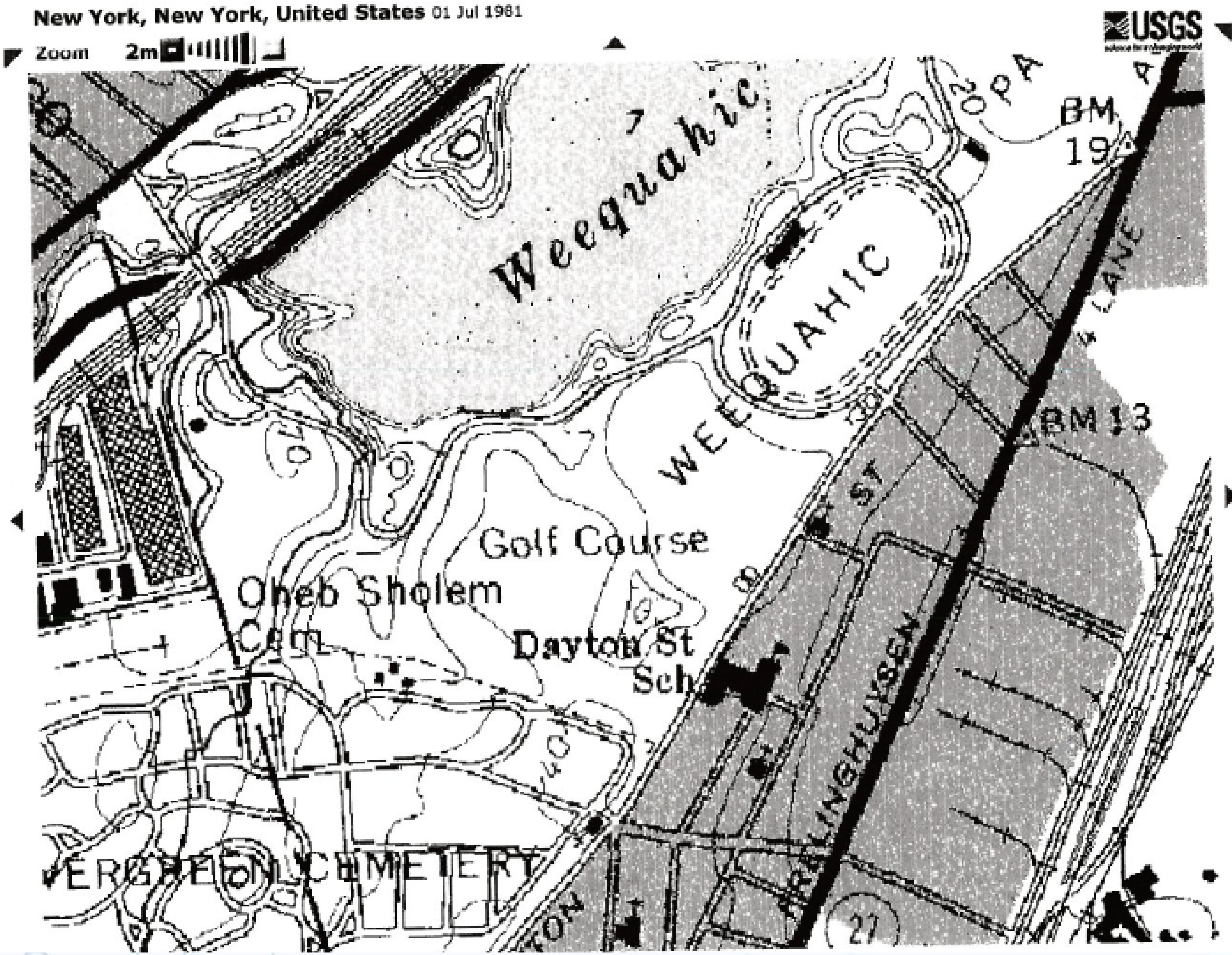
0 400 800 1200

SCALE IN FEET

2


PUTTING GREEN
GOLF HOUSE 87
LAKE
PUMP HOUSE
DAYTON ST.
FOSTER ST.
WEEQUAHIC GOLF COURSE
69.90 ACRES
0 200 400 600
SCALE IN FEET

Topo Map


New York, New York, United States 01 Jul 1981
Zoom
2m
USGS
Weequahic
WEEQUAHIC
BM 19
BM 13
LANE
ST
Golf Course
Oheb Sholem
Cem
Dayton St
Sch
FRELINGHUYSEN
27

Scale:
1in.=360ft.

Mathletics

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.	$\frac{360 ft.}{1 in.}$	967.5ft.	$\frac{1 yd.}{3 ft.}$	322.5 yds.
2	1.25in	$\frac{360 ft}{1 in.}$	450 ft.	$\frac{1 yd.}{3 ft.}$	150yds.
3	$4\frac{1}{16}$ in.	$\frac{360 ft.}{1 in.}$	1,462.5ft	$\frac{1 yd.}{3 ft.}$	487.5yds.
4	$3\frac{3}{16}$ in.	$\frac{360 ft.}{1 in.}$	1,147 ft.	$\frac{1 yd.}{3 ft.}$	382.5yds.
5	$\frac{14}{16}$ in.	$\frac{360 ft.}{1 in.}$	315 ft.	$\frac{1 yd.}{3 ft.}$	105yds.
6	4 in.	360ft.	1,440ft.	1yd.	480yds.

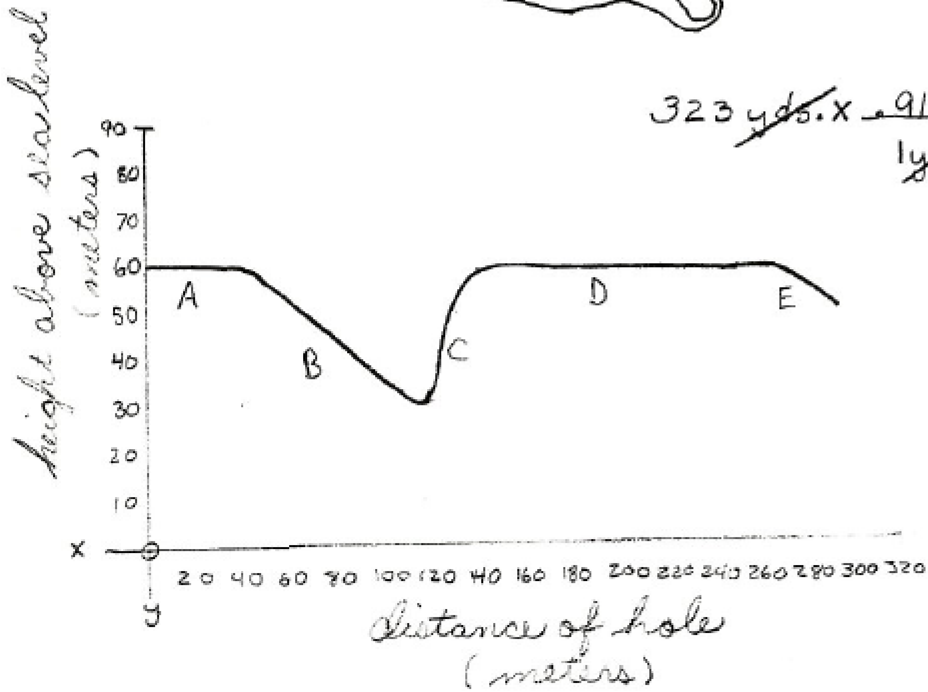
Weequahic Golf Course

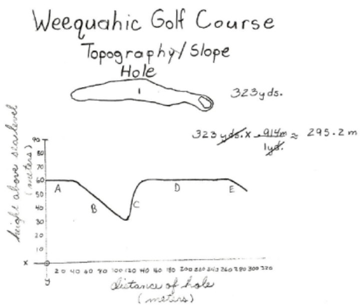
Topography/Slope

Hole

323yds.

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





A - Slope = 0

B - Vertical Change = -30

Horizontal Change = 80

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

C - Vertical Change = 30

Horizontal Change = 20

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

D - Slope = 0

E - Vertical Change = -10

Horizontal Change = 30

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

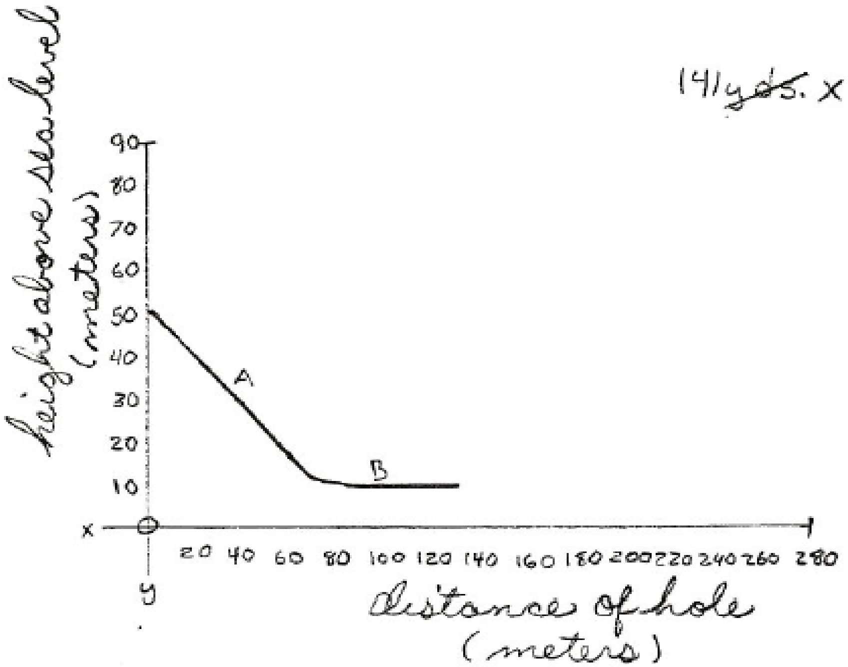
Weequahic Golf Course

Topography/Slope

Hole

141 yds.

$141\,\text{yds.} \times \dfrac{.914\,\text{m}}{1\,\text{yd}} \approx 129\,\text{m.}$



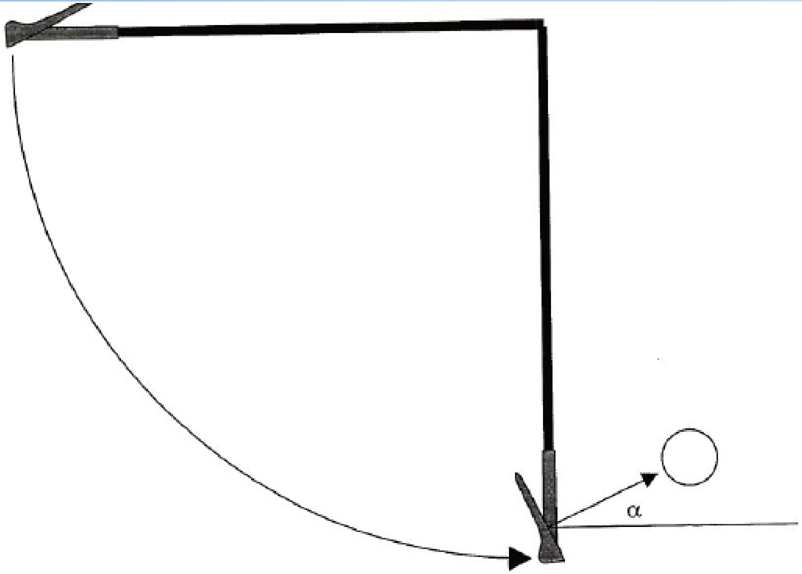
A = Vertical Change = −40

Horizontal Change = 70

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

B = Slope = 0

Velocity



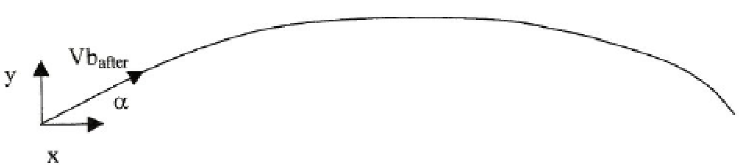
In your experiment you've released the club from 90° and timed how long it takes until impact. Knowing the time and distance traveled (calculated from the club length and the arc it makes with your "Wooden Byron) you can estimate an impact velocity, Vi.

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(α).

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

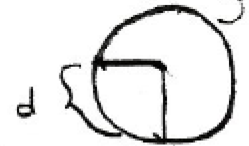
8 IRON

Angle: 37°

Club Length: 36.25in = .921m

Mass of Ball: 46g

Mass of Clubhead: 280g



Circumference = $2\pi R$

Distance

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

Time

$t = .55\text{s}$

Acceleration of Gravity

$a = 9.8\text{m/s/s}$

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

Calculations

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

Partial Vi is the portion of Vi that propels the ball
$Vi^* = Vi (\cos 37°) = 2.64 m/s (.799) = 2.11 m/s = 4.72$ mph

(1) Velocity of the ball after impact
$Vb_{after} = (mc Vi^* (1+e)) / (mc + mb)$
$Vb_{after} = [280g (2.11 m/s)(1+0.85)] 280g + 46g) = 3.35 m/s = 7.49$

(2) Initial Velocity of the ball in the y direction
$Vb_{y0} = Vb_{after} * \sin(\alpha) = 3.35 m/s (.602) = 2.02 m/s = 4.52$ mph

(3) Find position of y using the following equation
$y = Vb_{y0} * t + 1/2\, a * t^2$
$y = 2.02 m/s (t) + 1/2 (-9.8 m/s/s (t^2))$
for $t = .01s$ $y = .02m = .79$ in
for $t = .41s$ $y = .004 m = .16$ in

(4) The acceleration of the ball in the y direction at any time i
$Vb_y^2 = (Vb_{y0})^2 + a^* y$
to get to the maximum height, $Vb_y^2 = 0$

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

(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 $t = .01\ s$ $x = .03\ m = 1.18\ in$
for $t = .41\ s$ $x = 1.09\ m = 42.91\ in$