



Field Goal for the Win

Student Activity

Name _____

Class _____

Get Your Game On

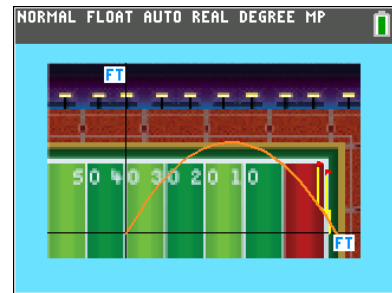
Four seconds left in the Big Game and the score is 27 to 28- you're behind. A 50-yard field goal wins the game. Your task is to use a mathematical model to demonstrate kicking a field goal to win the game.

1. The Kick

Turn on your TI-84, press `[prgm]`, and run the program THEKICK.

Follow the on-screen prompts to the main menu.

Press 1 to see the 50-yard kick.



- Is the field goal good? Write your guess here. (Note: To see the flight of the ball again press `[2nd][mode]` (quit) and press `[enter]` to run the program again.)
- Discuss with your group: When kicking a football, what things affect how far the ball travels downfield and how high the ball reaches?
- Press `[2nd][mode]` (quit). Then run the program again but this time select Option 3 (Custom distance and kick). Use:
Length of kick (Yards): 50 press `[enter]`
Angle of kick (DEG): 35 press `[enter]`
Velocity of kick (FT/S) 70 press `[enter]`
What do you notice about the kick?
- Professional kickers kick the football with a velocity between 70 and 88 feet per second (between 48 and 60 mph). The angle varies between 27 and 43 degrees. Press `[enter]` to view the Options menu. Using values in these ranges, take two minutes and explore several kicks using Options 2, 3, and 4.



1. The Kick (continued)

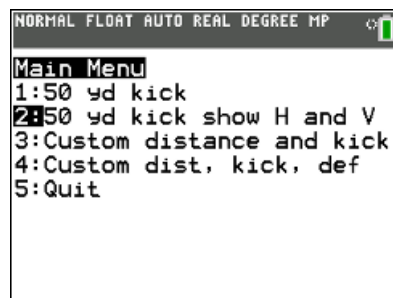
- e. Press **[enter]** to return to the Options menu. Press 6 (Main Menu). Then Option 1. Press **[trace]**. Look at the information on the screen. Notice the three variables, T, X, and Y. Press the right arrow three times and record the values to the nearest hundredth.

T=_____ X=_____ Y=_____

- f. Discuss what the values of these variables mean in this problem with your group. Include units in your discussions.

- g. Trace on the graph to where T is three-quarters of a second. (Note: just type 0.75 and press **[enter]**) . Discuss what these values mean with your group; include units in your discussion.

- h. Press **[2nd][mode]** (quit) and press **[enter]** to run the program again but this time select Option 2. (Note: To see this graph again, press **[enter]** then choose Option 1, Repeat). Discuss in your groups what the yellow, pink, and orange circles represent.



- i. Press **[enter]** to return to the Options menu. Press 6 (Main Menu). Press Option 1. Press **[trace]** and graphically investigate the time when the ball is 150 feet from where it was kicked in the horizontal direction. Between what two values of T is the ball 150 feet downfield? Record the times to the nearest tenth of a second and the corresponding distances to the nearest hundredth of a foot.



2. Modeling horizontal and vertical motion

In order to answer question 1i. (When is the ball 150 ft from where it was kicked?) with more precision, we need an expression to model the horizontal distance the ball travels downfield after it is kicked. Call it $x(t)$ (read “x of t”). We also need an expression to model the vertical distance (height) of the ball after it is kicked. Call it $y(t)$ (read “y of t”).

Both of these expressions involve ratios that are usually studied in geometry: sine and cosine. You may have been introduced to them in a pre-assignment.

For our kick, the football was kicked at an angle of 43° with a velocity of 72 ft/s.

The function for horizontal distance traveled downfield is:

$$x(t) = 72 \cdot \cos(43^\circ) \cdot t$$

The function for vertical distance (height):

$$y(t) = 72 \cdot \sin(43^\circ) \cdot t - 16 \cdot t^2$$

- a. Algebraically calculate how long it will take for the ball to travel 150 feet downfield. Store your answer in H.

- b. Press `trace` and trace to this value for H and explain what the numbers on the screen mean. Is the field goal good? Explain how you know.



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3. Application of the model

Run the program THEKICK again and select Option 3. You're going to kick a field goal to win the game. Professional kickers kick the ball with a velocity of about 70 to 88 ft/s (48 to 60 mph) and at an angle that varies between 27 and 43 degrees. Choose your velocity and kick angle and run the program to graph your kick.

```
NORMAL FLOAT AUTO REAL DEGREE MP
Main Menu
1:50 yd kick
2:50 yd kick show H and V
3:Custom distance and kick
4:Custom dist, kick, def
5:Quit
```

Length of kick (yards): 50 Angle (degrees): _____
Velocity (ft/s): _____

- Use the equations from Question 2 that model the horizontal and vertical positions of the ball to model the actual flight of the ball after it is kicked. Write the equations for your kick below
- Based on the graph, can you tell if the ball passes above the 10-foot crossbar on the goal posts? How can you tell?
- Solve algebraically for when the ball is 50 yards downfield. Use your solution to decide if the field goal is made or not. Explain your response.
- Attempt a 45-yard kick with a different angle or velocity and determine graphically if the kick is made using the program. Then use algebra to confirm your answer.

Angle _____

Velocity _____

Made (Y/N) _____



Extensions:

4. But what about the defense?

Run the program THEKICK again and select Option 4. You're going to kick a 50-yard field goal to win the game. Professional kickers kick the ball with a velocity of about 70 to 88 ft/s (48 to 60 mph) and at an angle that varies between 27 and 43 degrees. Choose your velocity and kick angle and run the program to graph your kick. The kicker kicks from 7 yards behind the line of scrimmage and the defense typically gets little or no rush (between 0 and 2 yards) and can reach about 8 to 9 feet in the air.

```
NORMAL FLOAT AUTO REAL DEGREE MP
Main Menu
1:50 yd kick
2:50 yd kick show H and V
3:Custom distance and kick
4:Custom dist, kick, def
5:Quit
```

Angle: _____ Velocity: _____

Rush: _____ Reach: _____

- Based on your model, will a defender block the kick? Defend your answer graphically and algebraically.
- Based on your model, will the ball pass above the 10-foot. crossbar on the goal posts? How can you tell? Defend your answer more than one way.
- Attempt the kick with a different angle or velocity and determine algebraically if the kick makes it over the defense and is good. Then use the program to confirm your answer.

Angle _____ Velocity _____ Rush _____ Reach _____

Blocked (Y/N) _____ Made (Y/N) _____



5. More Extensions

Graphically and algebraically find:

- When the ball hits the ground
- How far the ball travels horizontally
- The maximum height of the ball

Run the program and select Option 1 (1: 50-yard kick).

- a. to discover when the ball hits the ground and how far away the ball is from where it was kicked.

Write your answers below.

- b. Algebraically find when the ball hits the ground and use that value to find how far the ball is downfield when it hits the ground. Include units in your answers and do not round the answers.

- c. Trace to discover when the ball attains its maximum height and what is the maximum height?

- d. Algebraically find when the ball attains its maximum height and use that value to find the maximum height. Include units in your answers and do not round the answers.