

Team Ford First



EXCEL
as an
Evaluation and Simulation Tool

by

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Team Ford FIRST



What is EXCEL?

- Spreadsheet Program that lets you work with numbers and text in a large grid of cells called a worksheet.
- Creates graphs and charts from numbers stored in the worksheet.
- Works like a data base of information when numbers and text are stored in a record and field format.

Cells

- Each worksheet has 16,777,216 cells
 - 256 COLUMNS (A – Z, AA – ZZ, up to IV)
 - 65,536 ROWS (1 to 65,536)
- The intersection of a COLUMN and a ROW is a CELL.
- CELLS are named (or addressed) as ColumnRow.
 - A1 is the top left cell.



Create an EXCEL File

- Start the Excel Program **EXCEL**.
- Automatically get a new empty spreadsheet
- Notice the Columns start at A going across.
- Notice the Rows start at 1 going down.
- Select a Cell by left click of the mouse.
- Save the file as excel.xls



Cell Contents

- A CELL can hold:
 - Value
 - Text
 - Logical Value (Will NOT present)
 - Formula
 - Nothing (a cell that has nothing entered, sometimes referred to as a NUL cell)



Value

- Click on cell A1
- Type in the number 123<Enter>
- Cell automatically moves to A2
- Type in the number -200<Enter>
- Cell automatically moves to A3
- Type in 10000000000000<Enter> (12 0's)
- Note the cell shows 1E+12
- Click on A3 (Formula line shows 10000000000000 as entered)



Text

- Click on Cell B1
- Type the letter a<Enter>
- In Cell B2 Type the word robot<Enter>
- In Cell B3 Type the words Team Ford
FIRST<Enter>
- Save the file (Click on the "Disk" icon)

Formula

- Select Cell C1
- Type =; point to A1; <Enter> for C1 = A1
- Select Cell A1; 456<Enter>;
Both A1 and C1 changed to 456
C1 = A1 is the formula to make that happen.
- Select Cell C2; Type =; click on A3; Type /
for division; click on A2<Enter>
C2 = A3 divided by A2



Functions

- Click on Cell C3; Type =, Click on fx icon
- Click on Math and Trig
- Click ABS; Click <OK>
- Formula Box shows what fields are required and explains the function of the formula
- Click on Cell A2, Click <OK>
- Cell C3 contains the Absolute Value of A2

Use EXCEL for Weight

- Track Weight of Robot
- Open file **weight**
- Notice how parts are listed and per unit weights are provided.
- See how total weight is calculated
 - =SUM(H6:H185) => SUM all the cells from H6 through H185
- Do you see how to keep Robot COST?

Use EXCEL for lists

- List and Sort names or counts
- Open file **workshop attendance**
- Select the data from A2 to K18:
 - Click on A2; Drag to K18
 - or Click on A2; <Shift>Click on K18
- Sort the data in reverse order by team number
 - Pull down <Data>
 - Click <Sort><Column A><Descending><No Header Row> and <OK>

Use EXCEL for Data Plots

- Enter and plot motor curves
- Open file **motor_curves**
- FIRST Motors and specifications are listed
- Click on the worksheet tab (CIM Data) at bottom of the screen.
- Click on the tab (CIM Plot) – these plots help design gear boxes.



Use EXCEL for robot dimensions

- Enter coordinates of robot and game pieces
- Open file **robot**
- Do you see a robot on the plot?
- Do you see the moveable goal on the plot?
- Do you see the stationary goal on the plot?
- Compare to **pictures** of the robot

Simulate different Conditions

- Change length of gripper to 16 "closes on a ball"
- Move either goal to check if ball can be loaded
- Experiment with mounting dimensions to see the change in arm paths
- Change arm lengths to see change in arm paths
- Confirm that robot still fits in the 36" by 30" by 60" box.

How is this done???

- Lets do new game pieces.
 - Need a post with pegs 5 ft, 7 ft, and 9 ft above the floor.
 - In inches that is 60 in, 84 in, and 108 in
- To plot the post is a line from the x,y coordinates 0,0 to 0,108
- Use the first file in a new worksheet to set up the post.



Plot the Post

- Select the two x,y pairs by clicking on the first x and dragging to the second y
- Click on the icon <Graph Wizard>
- Under <Standard Graphs> select <X-Y (Scatter)>
- Select the <Scatter with data points connected by lines> option and <Next >>
- Select <Series> tab then <Next>>

Add Axis descriptors

- Title Tab:
 - Chart Title: New Game Layout
 - Value (X) Axis: Distance from Pole in inches.
 - Value (Y) Axis: Height in inches
- Axes Tab: Show Values on X and Y
- Gridline Tab
 - Turn ON both X and Y Major gridlines
- NO Legend and NO Data Tags
- Click <Next>>



Display the Graph

- Select displaying the Graph on the current worksheet.
- Click <Finish>

Make Pole Visible

- Click on the "Pole" which is "Series 1"
- RIGHT Click on the "Pole"
- Click on <Format Data Series>
- Make the line <Custom> and as wide as possible.
- Make the marker <Custom> with a size of 12
- Click <OK>



Make the "field" longer

- We need a longer distance from the post.
- Click on the "X-Axis" then RIGHT Click it.
- Select <Format Axis>
- Scale Tab: Make Maximum 120, Major Unit 10, and Minor Unit 5
- Click <OK>



Make the Pole Scale the same

- The Pole scale should be the same as the field (for our eye's sake)
- Click on the "Y-Axis" then RIGHT click it.
- Select <Format Axis>
- Scale Tab: Make Maximum 120, Major Unit 10, and Minor Unit 5
- Click <OK>



Make the Grid "Square"

- Click on the non-grid part of the graph.
- "Pull" one corner of the grid until the graph has "square" grid lines (each grid should look like it has the same width as height).
- Save the file using the disk icon.



Add the Pegs to the Post

- Need pegs at 60 in, 84 in, and 108 in.
- Let's make each peg 6 in long.
- The three pegs have start and end x,y coordinates of:
 - 0,60 and 6,60
 - 0,84 and 6,84
 - 0,108 and 6,108
- Add those coordinates to the sheet

Plot the Pegs

- On the graph, click on the "Post" (data series 1)
- RIGHT Click the "Post"
- Select Source Data Tab:
 - Click <Add Series>
 - Click in the box for X Values, then Select the peg 1 x values
 - Click in the box for Y Values, highlight the values already there, then Select the peg 1 y values
- In the same way <Add Series> for peg 2 and peg 3
- Click <OK>



Make the Pegs visible

- Follow the same process as the Post.
- Click on each peg
- Right Click each peg then <Format Data Series>
- Make the line as wide as possible.
- Change the color if it makes it easier to see.
- Save the file when done.

Add the Robot Chassis

- The Robot Chassis will be approximately 36" long and 8" high.
- The width of 30" will not be seen.
- Add the Robot Chassis coordinates to form a rectangle on the field graph.
- The x,y coordinates should be:

Top Front 0,8 36,8 Rear

Bottom Front 0,0 36,0 Rear



Make the Start x,y "adjustable"

- Assign Starting coordinates, say 12, 10
 - A y=10 means this robot can "fly"
- Assign Chassis Dimensions, say 36, 8
- Equations will be entered into the coordinates for the chassis like:

$12 + 0, 10 + 8$	$12 + 36, 10 + 8$
$12 + 0, 10 + 0$	$12 + 36, 10 + 0$
- Add the chassis as a new series of data like was done with the pegs; make the chassis visible.
- Save the file



Add an arm to the robot

- An arm should be added to the top of the chassis.
- The length of the arm should be adjustable.
- The angle of the arm should be adjustable.
- Assign start coordinates for the arm and the starting angle for the arm.
- Calculate the coordinates for the end of the arm.



Calculate arm coordinates

- When the length of an arm is known and the angle of the arm is known, the x,y coordinates of the end of the arm can be calculated using the sin and cos functions.
- The x value is the starting coordinate plus the length times the cos of the angle.
- The y value is the starting coordinate plus the length times the sin of the angle.
- Enter those equations in the spreadsheet, then add the plot for the arm.
- Save the file.



What Next???

- Obviously, the robot arm can NOT reach any of the pegs – it's too short.
- Looks like we need to add another arm.
- This arm needs to ride at the end of the first arm.



Add second arm to the robot

- An arm should be added to the end of the first arm.
- The length of the arm should be adjustable.
- The angle of the arm should be adjustable.
- The start coordinates for the second arm should be set equal to the end coordinates of the first arm.
- Set the starting angle for the arm.
- Calculate the coordinates for the end of the arm.



Calculate arm coordinates

- When the length of an arm is known and the angle of the arm is known, the x,y coordinates of the end of the arm can be calculated using the sin and cos functions.
- The x value is the starting coordinate plus the length times the cos of the angle.
- The y value is the starting coordinate plus the length times the sin of the angle.
- Enter those equations in the spreadsheet, then add the plot for the second arm.
- Save the file.

Check if this reaches the pegs

- With both arms at 90 degrees, does it reach?
- Can the arms be made any longer?
- What else can be done to reach?
- Will the robot fall over while putting parts on the highest peg?
- Can the piece be picked up from the floor?
- On and On and On with the simulation.
- Is the robot able to meet the start envelope?



"Virtual" Prototype

- Can you see how we have done significant development of a prototype robot without cutting a single piece of steel or wood?
- Can you see how this can save money and time by knowing what size to cut the pieces or where to mount the arm to make the robot do the job?

Use EXCEL to test C Programs

- Consider the C Program to drive the robot using one joystick.
- The Y Axis of the Joystick (Fore and Aft) is 127 to stop, 0 for full speed reverse, and 255 for full speed forward.
- The X Axis (Right and Left) of the Joystick is 127 to go straight, 0 for hard right turn, and 255 for hard left turn.

Proposed C Program Statements

Right_Motors = Limit_Mix(2000 + p1_y + p1_x -
127);

Left_Motors = Limit_Mix(2000 + p1_y - p1_x + 127);

The Limit_Mix function sets the MINimum to 2000 and the MAXimum to 2254 before subtracting 2000 and returns a value between 0 and 254.

Motors STOP with a value of 127, go full speed forward with a value of 254, and go full speed reverse with a value of 0.

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Will this C Program Work???

- Create an EXCEL file to check it out.
- Save the file with the name
Joystick_Limit_Mix

Enter Column Titles

Enter titles across the top for Columns A through F:

A: p1_y: 255 = FWD, 127 = STOP, 0 = REV

B: p1_x: 255 = Left, 127 = Straight, 0 = Right

C: Left = $2000 + p1_y + p1_x - 127$

D: Right = $2000 + p1_y - p1_x + 127$

E: Limit (Left)

F: Limit (Right)

Enter the Joystick Values

- Go to Row 2 to enter the values to study.
- We will want to look at going:
forward, reverse, and stopped
while going:
straight, left, and right
- Set up p1_y (speed and direction) and p1_x
(left, right, or straight) in the first two
columns.



Enter the Equations to Limit_Mix

- $\text{Left} = 2000 + p1_y + p1_x - 127$
- In the cell under that title:
 - type =2000+
 - click on the value of p1_y in the same row
 - type the +
 - click on the value of p1_x in the same row
 - type -127 and <Enter>
- The result of the calculation should be there.



Enter the Equations to Limit_Mix

- $\text{Right} = 2000 + p1_y - p1_x + 127$
- In the cell under that title:
 - type =2000+
 - click on the value of p1_y in the same row
 - type the -
 - click on the value of p1_x in the same row
 - type +127 and <Enter>
- The result of the calculation should be there.

What functions or formulas can Limit the Maximum and Minimum values of a calculation?

- The C Program is:
if (mix > 2254) value = 2254;
else if (mix < 2000) value = 2000;
else value = mix;
result = value – 2000;
- We will do that in EXCEL



Use the EXCEL IF function

- EXCEL has an IF function
IF(logical test, value if TRUE, value if FALSE)
- Use the same logic as the C Program:
`if(mix>2254,2254,if(mix<2000,2000,mix))-2000`



Do the Left Limit_Mix

- Click on the cell under Limit Left.
- Click on the formula icon in the top toolbar.
- With All highlighted, move to the right box and type the letter i
- Roll until IF shows up
- Click on IF and an entry template will appear.
- In the top box, click on cell C2, the left mix value then type > 2254 .
- Click to the second box

Continue the Left Limit_Mix

- Enter 2000 in the second box
- Click to the third box
- Click on Cell C2 then Click OK.
- Click at the end of the formula line then type -2000 then <Enter>
- The Cell shows the Limit_Mix result for the left motor.



Copy to the rest of the table

- Drag copy the result to the cell to the right.
- Since the cell equations use only one cell, the drag right will adjust the equation for the limit right.
- Mark the last 2 cells with the limit mix results.
- Drag copy them down for all of the $x - y$ joystick values entered.



Does the Joystick Mix work?

- Compare the results with what is expected.
- Do they all agree?
- Is there a problem going straight?
- Is there a problem with forward turns?
- Is there a problem with reverse turns?
- Is there a problem with stopped turns (spin)?



Why Bother???

- Let's just wait until we run the robot, then we'll know.
- This is a simple example. At least we will have an idea of what to try IF we get a chance to run the robot before it ships.
- Most teams will agree that there **IS NEVER ENOUGH TIME TO TEST SOFTWARE.**

Test Robot Position Tracking

- Open the **Navigation file**.
- New count values can be entered in the yellow cells.
- This should give a good start point for tracking the position of the robot on the playing field.
- Counts will need to be converted to inches to have a better relation to the field.

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Credits

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Thank you!!

Any Questions??