Meyer Prony Brake

Prony Brake Excel Workbook User's Guide

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Contents

Introduction

The referenced Workbook is meant to be used with Prony Brake dynamometers of any size. Measurements of force and brake speed are input and processed to provide charting and report maximum levels of horsepower and torque. A "torque multiplication factor" is utilized to report actual engine speed and torque[1] rather than brake torque[2].
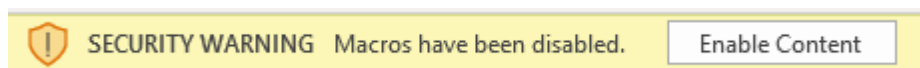
A means to input relevant data from Nebraska Tests is provided in the Workbook for a comparison to the tractor being tested. A SAE-based weather correction factor is provided to standardize tests across conditions and locations. An overspeed indication is available when a tractor's governed speed exceeds the manufacturer's rated speed by a certain percentage.

The Workbook makes extensive use of VBA macros[3] which are tested with the latest version of Microsoft Office 365 for Windows. Older versions may work, but are not supported. *Microsoft Office for Mac, Microsoft Office on mobile devices, OpenOffice, Libre Office, Apple Numbers, etc. are not able to use VBA macros.* The Workbook can still be used without macros with some missing features and at a lower user efficiency. Email features require the Microsoft Outlook desktop application.

The Workbook uses US customary units exclusively. Modifications would need to be made to use metric units.

This document assumes, and the Workbook requires, a decent working knowledge of Excel. Testing tractors in front of a crowd that is expecting a show can be stressful. That's not the place to be learning how to navigate a spreadsheet! VBA macro knowledge or experience is not required to use the existing macros.

Note: Excel will warn you the first time a .xlsm workbook is opened that it contains external VBA code. You must choose "Enable Content" to be able to use any VBA macros.

Common Excel Terminology	
Workbook	The entire Excel document.
Worksheet	A single sheet or tab.
Formula	A set of instructions to perform calculations on data.
	Cells with formulas display data, but the cell is not meant to be typed in directly.
G3:H8	Range of cells beginning in Cell G3 and ending in Cell H8.
Setup!B22	Cell B22 on the Setup worksheet.

VBA code for Serial live data[4] input into the spreadsheet exists, but it is not currently documented or supported. Contact Daniel if you are interested in making this work.

For assistance, please contact Daniel Meyer at dmeyer302@gmail.com

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[1] Engine speed and torque refers to measurements that would be taken at the crankshaft.
[2] Brake speed and torque refers to measurements that would be taken at the brake shaft, which the brake blocks and arms ride on.
[3] Custom code that can be run from within Excel and other Microsoft applications.
[4] *Serial:* A type of digital communication, commonly used with USB cabling.

Part I: Workbook Tour

Calculations Sheet

The Calculations sheet is where test data is entered and processed. A chart of data is shown, and various statistics are displayed. This sheet works well as a live display to spectators, or as a summary of information.

Cell or Range	Description
Columns A and B	Raw data entered from the Prony Brake.
Column C	Horsepower calculated using the following factors: • Brake RPM (Column A) • Brake force (pounds) (Column B) • Brake arm length (feet) (Setup!B22) • Weather correction factor (Setup!D11)
Column D	Engine torque calculated using the following factors: • Brake force (pounds) (Column B) • Brake arm length (feet) (Setup!B22) • Torque Multiplication Factor (Setup!G6) • Weather correction factor (Setup!D11) • Nebraska Rated Engine Speed (Crankshaft RPM) (Setup!H2)
Column E	Engine speed calculated using the following factors: • Brake RPM (Column A) • Torque Multiplication Factor (Setup!G6) • Nebraska Rated Engine Speed (Crankshaft RPM) (Setup!H2)
G3:H8	Owner and test date information. May be entered manually or by using the START macro.
G11:H12	Current HP and Current Torque used with live Serial recording. Not currently supported.
G14:H15	Max HP and Max Torque values found in Columns C and D.
G16:H17	Percent of factory HP rating indication. Calculated by dividing maximum tested HP (G15) by Nebraska Rated HP (I38)
G19:H22	Indication of the Weather Correction Factor currently being used. Referenced to Setup!D11
G23:H24	Indication of the drive type currently being used. Referenced to Setup!B6
G26:H27	Indication of the amount a tractor's engine speed is greater than the Nebraska Rated Engine Speed.[5] This indication is hidden until RPM exceeds the limit set by Setup!B9
G32:I39	Indication of the Nebraska Test Information currently being used. Referenced to Setup! Row 2
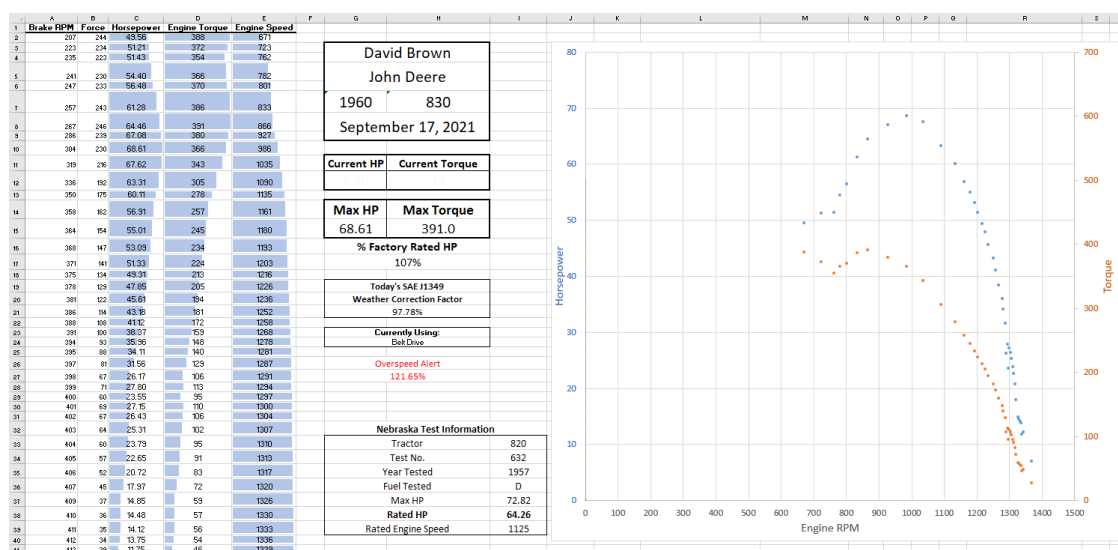
[5] This is useful for tractor pullers subject to division RPM limits.

Setup Sheet

The Setup sheet sets variables for each run, and constants for your particular Prony Brake. Nebraska Test data is inserted to this sheet where it is utilized in a variety of calculations. Other information for post-processing is stored here as well, such as the tractor owner's email address.
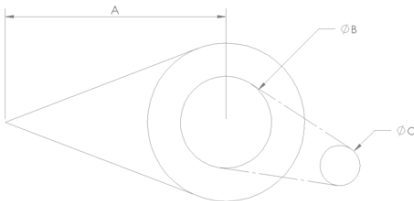
Cell or Range	Description
A2:K2	Nebraska Test data pasted from the corresponding test on the Nebraska Test Database worksheet.
B6	Switch used to set a machine variable for various drive types. Affects the *Torque Multiplication Factor* in cell G6.
B9	Variable used for Overspeed Indication. Affects *Overspeed Alert* in cell `Calculations!G27`
D7	Local temperature at time of test (°F). May be entered manually or by using the START macro.
E7	Local temperature at time of test (°C). Conversion to metric from cell D7.
D9	Local barometric pressure at time of test (inHg). May be entered manually or by using the START macro.
E9	Local barometric pressure at time of test (mB). Conversion to metric from cell D9.
D11	Weather correction factor based on SAE J1349 (August 2004).[6] This percentage affects all horsepower and torque readings. For Missouri summers this value is typically around 96-98%.
D14:E15	Setup values used with live Serial recording. Not currently supported.
G6	Torque Multiplication Factor This factor calculates the drivetrain ratio from the engine to the Brake. For belt applications, the calculated factors are: • Rated engine speed (RPM) (source: Nebraska Tests) • Belt pulley speed (RPM) (source: Nebraska Tests) • Tractor belt pulley diameter (inches) (source: Nebraska Tests) • Brake main belt pulley diameter (inches) (C22) For PTO applications, the calculated factors are: • Engine speed (RPM) (source: Nebraska Tests). • An assumption is made that PTO speed is 540 at rated engine speed. This is probably not exactly true in most cases, but it should be very close. If an exact ratio is known, there is no provision currently in the Workbook to use this ratio. • Brake jackshaft belt pulley size (D18) • Brake main belt pulley size (C22)
G9	Owner's email address May be entered manually or by using the START macro. Used for post-processing and export.
G13	PDF Save Location .pdf and .png files must be saved to a directory somewhere on your computer before they can be sent via email. Used for post-processing and export.
B22	Arm length, measured in Feet. Most brakes are 5.25 feet. For best calibration, enter this value as exactly as it is possible to measure.
C22	Drive pulley diameter, measured in Inches. For best calibration, enter this value as exactly as it is possible to measure.
D22	PTO or jackshaft pulley diameter. For best calibration, enter this value as exactly as it is possible to measure.

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[6] SAE J1349 is a SAE standard to account for environmental differences across weather conditions and locations. For further reading, see this link.

	A	B	C	D	E	F	G	H	I	J	K
1	Year	Nebraska Test No.	Make	Model	Max HP	Rated HP	Fuel	Rated Engine Speed	Belt Pulley Speed	Belt Pulley Dia.	HP-Hrs/Gal
2	1957	632	John Deere	820	72.82	64.26	D	1125	1125	12.219	18.03
3											
4											
5		Enter 1 for Belt, 2 for PTO			SAE J1349 Correction			Torque Multiplication Factor			
6		1		Temp (°F)		Temp (°C)		0.308360			
7				88		31.11111111					
8		Over Speed Alert		Pressure (inHg)		Pressure (mB)		Owner's Email			
9		120%		30.1		1019.30339		38deere@gmail.com			
10				Weather Correction Factor							Yellow Cells are updated each run
11		NATPA RPM Rules		97.78439034%				PDF Save Location			Green Cells are machine setup
12		Div. 1: 100%		Based on Ideal Weather: 77°F, 29.234 inHg				(Folder only including final \)			Blue Cells are calculations used elsewhere - DO NOT MODIFY
13		Div. II-III: 110%						C:\Users\Daniel\Downloads\			
14		Div. IV: 120%		COM Port		Baud Rate					
15		Div. V: 130%		COM3		9600					
16											
17								Continue Recording			
18											
19											
20			Machine Setup								
21		A: Arm Length (ft)	B: Drive Pulley Diameter	C: PTO Pulley Diameter				Clear Data and Start Recording			
22		5.2708333	39.625	18							

Note: It is important to mind the color coding, as formulas in blue cells can be overwritten quite easily. For best results:

- Only type in yellow boxes (except during machine setup when the updating of green cells is permissible).
- Select a cell with a single click, then use the "Delete" or "Backspace" key to overwrite a value without destroying any formatting.

Database

The Database sheet stores test information for archival purposes and to recall at the end of the day for batch exporting of PDF test reports. While macros are not strictly required to use this page, they are highly recommended.
If a test is stored properly, it can be recalled exactly as it was originally displayed including:

- Owner information
- Tractor information
- Nebraska Test information
- Whether the test was performed with PTO or Belt drive
- Environmental data

Test points are stored beginning with `Column T` as a comma separated value pair with values (RPM, Force)
Test points are stored as direct readings from the Brake. All other calculations are done after being written to the spreadsheet.

Nebraska Test Database

The Nebraska Test Database worksheet stores pertinent information sourced from official University of Nebraska Tractor Test Laboratory documents. These tests are a source of unbiased, professional, baseline data that can be used to compare the relative performance of tractors today.

Most tests can be found by simply doing a web search for "Nebraska test xyz", where xyz represents the make and model of the tractor in question, or the test sequence number, if that is known.

All data on this sheet has been hand entered, so occasional typographical errors may exist. No known APIs exist that would provide for a faster and more accurate importation of data.

It is to my best understanding that the Rated Horsepower Test (usually labeled "Test D") is most representative of the tests done on most Prony Brakes today, as Test D is performed with the engine's governor in use. All comparisons are made to Test D Rated Horsepower.

Export Chart

This Chart Sheet is formatted specifically for PDF export. It is a nice, simple layout that could be printed for framing, etc.

This chart is what is sent when using VBA Macros for email.

The box at the top containing Max HP and Max Torque is updated only with VBA Macros; it does not update automatically. Therefore, it is not recommended to use this Chart Sheet for live crowd displays.

David Brown's 1960 John Deere 830, 9/17/2021

Max HP: 68.6 at 986 RPM
Max Torque: 391 ft-lbs at 866 RPM
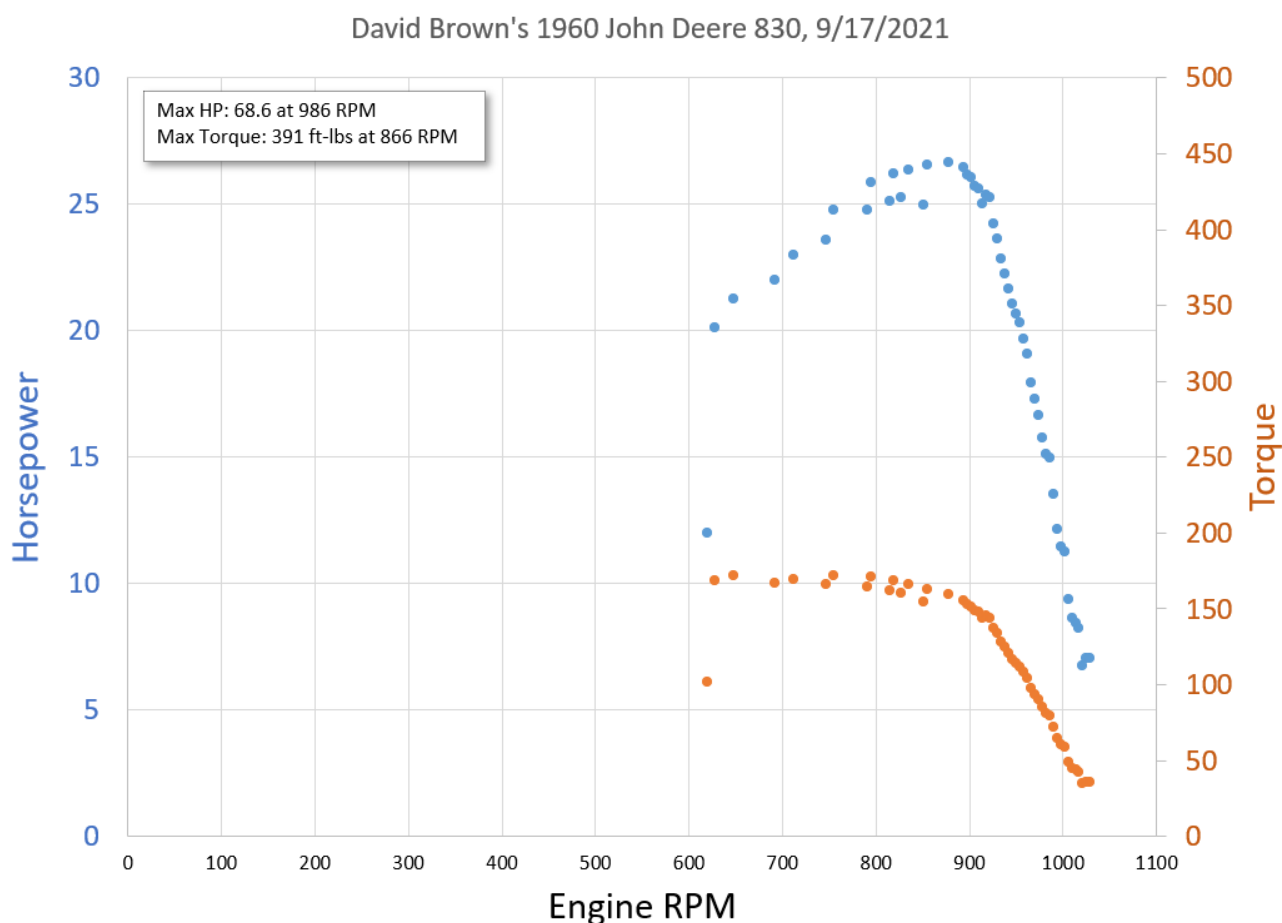
Part II: Setup

Machine Setup

1. **Drive Pulley Diameters (Cells `Setup!C22` and `Setup!D22`)**

    The Workbook is structured to match the configuration found on the Meyer Prony Brake. On this brake:
    - A main belt pulley is mounted directly to the brake shaft, for a 1:1 ratio.
    - A PTO drive is provided as a jackshaft which drives the main belt pulley via a short belt, with approximately a 2:1 ratio.

    For an illustration of this configuration, see the diagram on the `Setup` sheet.

    If your PTO shaft is a direct drive to the brake shaft, enter the same diameter values for `Setup!C22` and `Setup!D22` (1:1 ratio).

    Other configurations are possible, but this may require modifying the value in cell `Setup!D22` to achieve the proper ratio. If assistance is required, contact the author. Be ready with photos to help identify the machine configuration.

2. **Arm Length (Cell `Setup!B22`)**

    Arm length should be measured from the centerline of the brake shaft to the centerline of pressure onto the scale or load cell. Most tractor-sized Prony Brakes use a nominal arm length of 5.25 feet to simplify the hand calculation. When using a spreadsheet, however, no simplification is necessary, so take the time to carefully measure this distance for best calibration.
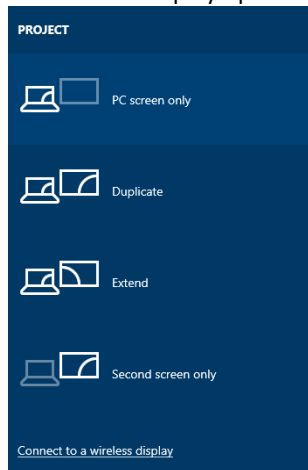
Display Setup

A Prony Brake at a steam show is arguably of more value as a show piece and working display than it is as a true data collection tool. A display that the crowd can watch, interact with, and use to understand the horsepower measuring process better is invaluable. Below are some tips to create the best display for your viewers.

1. **Dual Displays**

   Your display should be set up with a control screen (most likely the laptop that is running Excel) and one or more external monitors. The external monitors can be set to a presentation page that doesn't change for the crowd, while the operator is free to move about the workbook managing settings and database information.

   On a Windows computer, press ⊞ + P to activate the display options. Choose "Extend".

2. **Excel Setup**

   Excel has the ability to show multiple windows of the same data at any one time. To access this, navigate to the "View" Ribbon tab, then select "New Window".

   The new window should be dragged to the extended display, then pan and zoom the view as required. Note: zoom levels may be different than what is comfortable on your laptop screen.
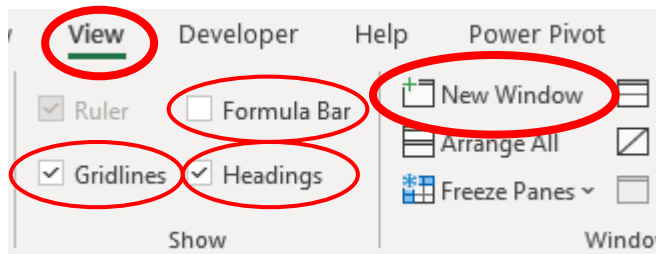
   For a cleaner view with less clutter, double-clicking on a Ribbon heading will minimize the ribbon. (example from above: double-click on "View")

   The Formula Bar and/or Headings can be hidden for additional viewing area. Gridlines can be deselected for a cleaner look.

Part III: Day of Show

This section details the process to set up a brake test, and be ready to enter data directly from the Prony Brake in real-time. If you are familiar with the routine, it can easily be performed in a minute or less. Practice this routine before show day; you don't want a crowd of people and an impatient tractor operator waiting on you.

1. ## Insert Nebraska Test
    a. Option: VBA Macros (best choice)
        i. Navigate to the `Nebraska Test Database` sheet.
        ii. Locate the relevant Nebraska Test and click on any cell in that row.

Ye	Nebraska Test N	Make	Model	Max HP (B)	Rated HP (D)	Fu	Rated Engine Spe	Belt Pulley Spe	Belt Pulley D	HP-Hrs/Gal (		
1922	88	Case	12-20			K						
1923	90	Case	40-72	91.42	72.40	K	800					
1923	91	Case	12-20	25.54	20.16	K	1050	1050	13.0			
1923	95	Farmall	10-20	21.84	20.09	K	1000	645	15.2			
1923	97	Hart-Parr	Hart-Parr 20-40	46.40	40.66	K	800		8.20			

Insert Selected Row — Insert and Begin New Record

2. Choose

1. Click once anywhere in the proper row

        iii. To *insert only Nebraska Test information but make no other changes,* choose "Insert Selected Row". Data will be copied to `Setup! Row 2`.
        iv. To *insert Nebraska Test information and immediately begin a new test record,* choose "Insert and Begin new Record". This will clear any existing data in `Columns A and B` of the "Calculations" worksheet.
            1. See instructions below for the "START" dialog box in section 5.

    b. Option: Manual copy and paste
        i. Navigate to the `Nebraska Test Database` sheet.
        ii. Locate the relevant Nebraska Test.
        iii. Click once on the row header to **select the entire row.**

34	1924	107	Hart-Parr	Hart-Parr E 12-24	26.97	24.24	K	800		9.44
35	1924	109	Case	K 18-32	36.73	32.08	K	1000		10.42
36	1924	110	Case	25-45	52.59	45.18	K	850		8.80
37	1925	117	Farmall	Farmall	20		K	1200		9.64
38	1925		oline	B 17-30	34.76	30.88	K	825		9.45

Left-click once here

        iv. Press Ctrl+C to copy the row of Nebraska Test Information.
        v. Navigate to the `Setup` sheet.
        vi. Click once on the Row 2 header to select the entire row.
        vii. Press Ctrl+V to paste the row of Nebraska Test Information.

2. ## Weather Data
    Weather data may be sourced from an app[7] or a portable weather station.[8] These values should be updated at least a few times per day as the temperature varies, but it is not necessary to update between each test.

    a. Option: VBA Macros (best choice)
        i. See instructions below for the "START" dialog box in section 5.
    b. Option: Manual entry
        i. Navigate to the `Setup` sheet.
        ii. Enter temperature and pressure values in Cells `D7` and `D9`.

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[7] WeatherBug is a convenient mobile app that provides temperature and pressure; other services likely do too.
[8] Example

3. Belt or PTO Drive

The system must know whether the tractor being tested is using belt or PTO drive for proper torque calculations. Horsepower remains the same regardless of this setting.
This setting must be updated at the beginning of each test.

      a. Option: VBA Macros (best choice)
           i. See instructions below for the "START" dialog box in section 5.
      b. Option: Manual entry
           i. Navigate to the `Setup` sheet.
          ii. In Cell `B6`:
               1. Enter the number 1 if using belt drive
               2. Enter the number 2 if using PTO drive

4. Owner Information

Owner and tractor information has no bearing on test data, but it is displayed and stored for reference purposes.

      a. Option: VBA Macros (best choice)
           i. See instructions below for the "START" dialog box in section 5.
      b. Option: Manual entry
           i. Navigate to the Setup sheet.
          ii. In Cell `G9`, enter the owner's email address if it is known.
         iii. Navigate to the Calculations sheet.
         iv. In Cells `G3:H8`, enter the owner's name and tractor information.
             Note how the fields are broken up. It is important to respect this formatting, so information gets stored into the database correctly.

Cell G3: Owner's Name

Cell G5: Tractor Make

Cell H7: Tractor Model

Cell G7: Tractor Year

Cell G8: Test Date

5. START Dialog

The START dialog box is the front end to a VBA macro that consolidates the settings from Sections 2-4 into one convenient page.

Any existing values are populated into the text fields and carried forward to the new test. If you would like to reuse these values, simply leave them without overwriting (for example, weather data that does not change often).

For values that need to change, overwrite the text boxes as required.

Tab indexes are set up for quick navigation through the dialog box. Use the Tab key to go down a row, and Shift+Tab to go up.

The START dialog can be initiated a number of ways:
- START button on the "Calculations" worksheet
- "Clear data and begin new record" button on the "Setup" worksheet
- "Insert and begin new record" on the "Nebraska Test Database" worksheet (also adds the selected Nebraska Test row to the "Setup" worksheet)

Note: Selecting "Start" clears Columns A and B on the "Calculations" worksheet without additional warning.

6. Data Entry

This is the exciting part! If you are ready for this step, it is assumed that:
- Machine constants are set up. (Part II)
- The appropriate Nebraska Test is chosen for comparison. (Part III Section 1)
- Environmental variables are set. (Part III Section 2 or Section 5)
- Tractor and owner variables are set. (Part III Sections 3-4 or Section 5)
- Columns A and B on the "Calculations" worksheet are clear of data. (Except headings)

Data points should always be entered as a pair of RPM and force values. Enough of these value pairs form horsepower and torque curves. The more data points that can be entered, the clearer the curves will be.

For a given tractor in an ideal situation, *there should be exactly one force value for each RPM value*. This is not always true in practice, but steps can be taken to approach this ideal situation.
- **Most importantly**: allow the engine speed to stabilize before taking a reading.
  - If engine speed is not stable, the hysteresis of the brake system will cause inaccurate readings.
    - This is most easily demonstrated just after releasing brake pressure. RPM is still low but suddenly the scale force has been greatly reduced.
  - Adding lubricant (fat) to the brake during a test will cause RPM to jump around undesirably.
- Load the tractor progressively.
  - Take a reading at 250 RPM, then 240, then 230, and so on.
- Complete the test as quickly as is practical.
- Be aware of possible flat belt slippage, usually indicated by belts not staying on pulley crowns.
- Be aware of possible engine clutch or PTO clutch slippage, indicated by a loss of brake speed but no change in engine sound.
  - It is very common for live PTO clutches to slip.

Enter a data pair in Columns A and B on the "Calculations" worksheet. The data point should be displayed on the Horsepower/Torque chart, and the Max HP and Max Torque displays should update as required. Continue to enter as many data pairs as possible. A typical hand-entered data set may be 10-20 readings.[9]

A "Sort Data" VBA Macro is available near the bottom of the "Calculations" worksheet. This sorts all data pairs by RPM in ascending order. It also removes any duplicates with RPM being the primary key. The highest force value is retained.
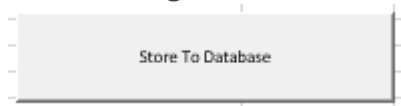

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[9] A handheld keyboard is useful for this task. Search for keyboards intended for home media center use. Example

7. Data Storage

Store To Database

When a test is complete, store it to the "Database" worksheet simply by using the "Store To Database" VBA Macro on the "Calculations" worksheet. This stores everything needed to recall the test, including:

- Test data points
- Tractor and owner information
- Environmental information
- Nebraska Test number

The VBA Macro makes the "Database" worksheet active, so you can verify that the data was stored properly on the next available line. (Note: Test data points begin in `Column T`. `Columns N-S` are reserved for possible future additions.)

Don't forget to save your Excel Workbook after each test! A computer crash or power failure will cause data loss if unsaved. In addition, it is advisable to periodically "Save a Copy" for archival purposes. The copy can be restored if the worst happens.

Part IV: Data Export and Post-Processing

Database Recall

An individual test may be recalled and written to the "Calculations" worksheet easily using VBA Macros. This can be used at the end of a show day, or during the show if an inquiry comes like *"How much horsepower did that previous tractor make?"*

All of the test data points and other relevant information that was stored in Part III Section 7 is written back to the various locations so that it is displayed just as if it had been entered the first time.

Navigate to the "Database" worksheet. Find the test that you would like written, and click anywhere in the test row. Select "Write Selected Line To Calculations Sheet".

A confirmation dialog will appear to help prevent you from overwriting unsaved data.

Save as .png or .pdf

Using VBA Macros, you can batch export several or all test records to .png or .pdf files.

A valid directory (folder) must be entered in cell `Setup!G13`. This can be any location accessible to the computer, including flash drives or network directories.

Note: If you are using this workbook on multiple computers, this folder path is most likely not the same on each computer. The field will need to be updated depending on which computer you are using.

PDF Save Location
(Folder only including final \)
C:\Users\Daniel\Downloads\

Select "Export Records" on the "Database" worksheet.

	Run ID	Date	Name	Email	Ye	Make	Model	Nebraska Tes	Belt/P	Pressu	Ten	Max H	Max Torq		Write Selected Line To Calculations Shee	Export Records	
2	1	9/18/2021	Noah Belles	randybockerhamer@gmail	1955	John Deere	70D	528	2	30.09	87	0	0				;
3	2	6/13/2020	Josh McCauley		1937	JD	AR	222	1	30.21	91	22.55474	132.652196				34
4	3	6/13/2020	AJ		1954	JD	60	472	1	30.21	91	25.77684	140.942958				36
5	4	6/13/2020	Ralph Moore		1949	JD	G	383	1	30.21	91	37.20067	229.941258				32
6	5	6/13/2020	Dalton Moore		1938	JD	A	222	1	30.21	91	17.86804	111.096214				23
7	6	6/13/2020	Andrew Peterson			Case	LA	480	2	30.21	91	55.99628	202.362824				35
8	7	6/13/2020	Caleb Jones		1958	JD	620	598	2	30.21	91	24.60517	117.4069				28

Enter the test number(s) to export. If only one test is to be exported, enter the same number in both text boxes. **Note:** Enter the "Run ID", not the Excel row number.

Select the check boxes to choose whether to export .png or .pdf files. (Email is discussed in the next section)

| Batch Export	✕
Beginning Test Number	
1	
Ending Test Number	
42	
☑ Save .png to folder	
☐ Save .pdf to folder ☐ Email .pdf	
Run	Cancel

Send Email

Note: Requires Microsoft Outlook desktop application with a working email account installed on the computer being used. The workbook can be moved to any computer with Outlook using a flash drive or similar to complete this task.

Email messages can be auto generated using VBA Macros. Emails are only attempted if the database record has an email address entered in `Column D`. If no email address exists, a .png and/or .pdf is generated, but no Outlook message will be created.

Messages are created automatically but must be sent manually. This is a good opportunity to verify that email addresses are synced up with the proper tests.

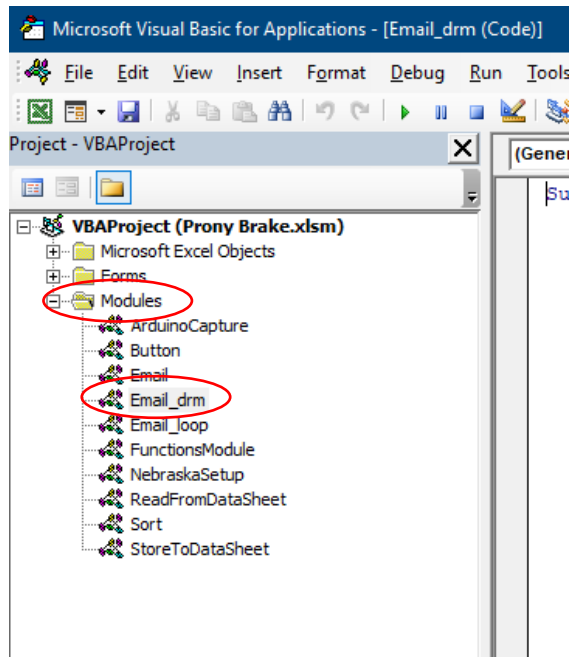To customize the automated message that is sent, follow these instructions:
1. Navigate to File > Options > Customize Ribbon. Check the "Developer" box. Press OK to close the Options dialog.
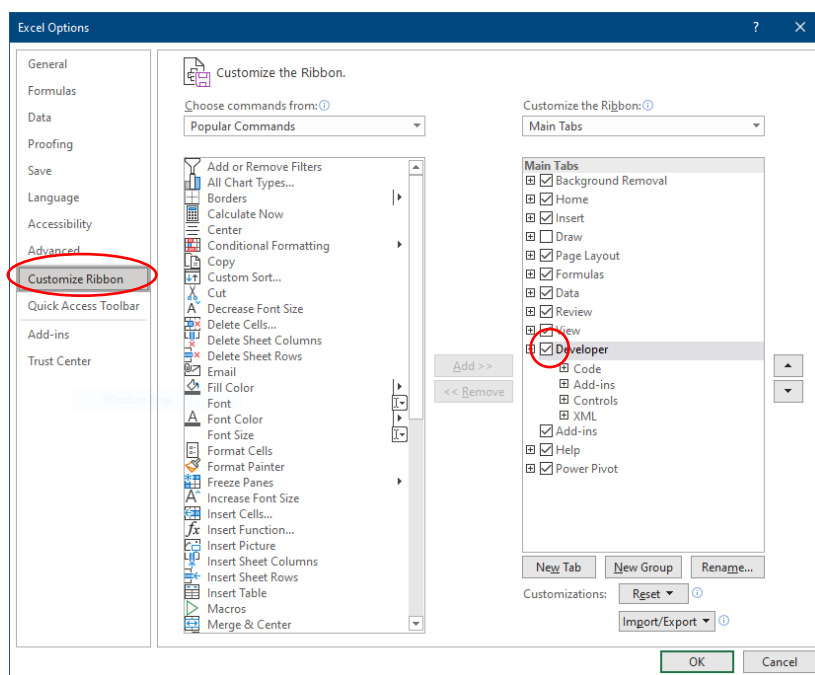
2. Navigate to Developer > Visual Basic.
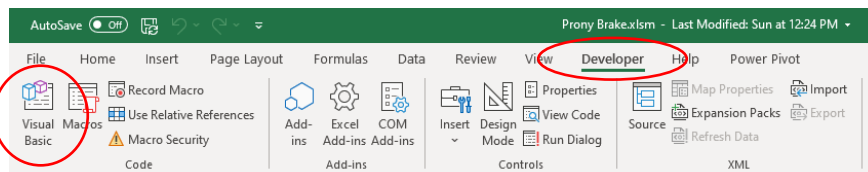
3. Navigate to the Modules folder and choose the "Email_drm" file.

4. Update the StrBody variable as required to create the message you would like to send. The message uses HTML formatting.[10]

```
If sendPdf = True Then
    If FileName <> "" Then
        RDB_Mail_PDF_Outlook FileNamePDF:=FileName, _
                    StrTo:=Worksheets("Setup").Cells(9, 7), _
                    StrCC:="", _
                    StrBCC:="", _
                    StrSubject:="Your Prony Brake Record", _
                    Signature:=False, _
                    Send:=False, _
                    StrBody:="<body>Dear " & Worksheets("Calculations").Cells(3, 7) & ",<br><br>" & _
                        "<body>Attached is the PDF copy of your tractor's test results that you requested.<br>" & _
                        "<body>This is an automated message, but you may reply to this address.<br>" & _
                        "<br>" & "Thanks for participating,<br>" & _
                        "Meyer Prony Brake</body>"
```

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[10] See this link for examples of HTML formatting.