

**Texas Instruments BAI PLUS Calculator Tutorial to accompany
Cyr, et. al. Contemporary Financial Management, 1st Canadian Edition, 2004
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Introduction

The Texas Instruments BAI PLUS calculator is an inexpensive tool (\$45 to \$65) for efficiently solving time value of money or TVM problems. TVM is the focus of Chapter 4. TVM calculations are then used throughout the rest of the book.

There are other cheaper financial calculators which can solve simple TVM problems. However the BAI PLUS is the cheapest financial calculator that efficiently performs more complex calculations. Examples from Chapter 4 include the present value of uneven cash flows (pp. 154-156) and a Canadian mortgage payment (p. 166), where the semiannual compounding period differs from the typical monthly, semimonthly, biweekly, or weekly payment period.

Turning the Calculator On and Off

The [ON/OFF] key is on the upper right corner of the keyboard. We will designate keys throughout this tutorial by the use of brackets. The [ON/OFF] key is a toggle switch. Press it once and the calculator turns on. Press it again and the calculator turns off. If you forget to turn off the calculator, it will automatically turn off about 10 minutes after your last keystroke.

Turn on your calculator. The display will show 0.00, unless you have changed the factory default setting of two decimal places. Press [1] [.] [2] [3] [ENTER]. Now 1.23 is displayed. Turn the calculator off and then on. Now 0.00 is again displayed.

The calculator has a continuous memory. So, turning it off does not affect any data stored in the calculator, but it will erase any number showing on the screen.

The [2nd] key

Almost every key on the BAI PLUS has two functions. Each key's primary function is noted on the key itself, while a key's secondary function is noted above the key. To invoke the second function of a key, press the [2nd] key first. The [2nd] key is near the upper left corner of the calculator keyboard.

Note that pressing the [2nd] key places a little "2nd" symbol in the upper left corner of the display. Press the [2nd] key again and the symbol goes away. The [2nd] key is a toggle key like the [ON/OFF] key. Repeatedly pressing the [2nd] key switches back and forth between the "regular" and the "2nd" functions mode. The [2nd] key is like the computer shift key. If the "2nd" symbol appears, look only at the writing above the keys.

Clearing the Calculator

The most commonly used methods of clearing data are:

| | |
|------------------------------|--|
| [2nd] [MEM] [2nd] [CLR Work] | clears all 10 memory locations and the display. |
| [CE/C] [2nd] [CLR TVM] | clears the TVM worksheet. (The [CE/C] keystroke is only needed if you currently are in another worksheet). |
| [2nd] [CLR Work] | clears the current worksheet other than the TVM worksheet. |
| [CE/C] | clears the entire display, but not the memory. |
| [→] | clears numbers on the display one at a time if you made a mistake entering data. |

Review your owner's manual for other methods of clearing information. Clearing the calculator is very important, since unwanted data in memory can result in improper calculations, and hence wrong answers. It is best to get into the habit of automatically clearing memory before starting a calculation. Occasionally, you may purposely want to save data, but, in general, you will be entering all new data. So, starting with a clear memory is the safest approach.

Changing the Display

To change decimals from 2 places to 4, press [2nd] [FORMAT] [4] [ENTER] [CE/C]. 0.0000 is displayed.

To change from 4 places to 2, press [2nd] [FORMAT] [2] [ENTER] [CE/C]. 0.00 is displayed.

We usually set the display to 2 places, which is especially convenient when working with dollars and percentages. However, we often use 4 or more places when dealing with interest rates and rates of return that are entered as decimals.

Payments per Year Setting

One important setting that can cause problems is the payments per year setting. To check the current setting, press [2nd] [P/Y]. The display shows the setting for payments/year.

The calculator usually is pre-set at 12 payments per year. That is, it assumes calculations will be done on a monthly basis. However, the problems in finance textbooks generally use 1 payment/year.

To change to 1 payment/year: Press [2nd] [P/Y] [1] [ENTER] [CE/C].
Now the calculator is set to assume one payment per year.

To confirm this setting, press [2nd] [P/Y]. Then press [CE/C] to leave the P/Y worksheet.
Unless needed for other work, we generally leave the calculator setting at 1 payment per year.

Time Value of Money (TVM)

The TVM keys are located on the third row from the top of the keyboard.

[N] [I/Y] [PV] [PMT] [FV]

[N] is the number of periods.
[I/Y] is the relevant interest rate.
[PV] is the present value.
[PMT] is the payment.
[FV] is the future value.

In general, TVM problems involve five variables — four are known and the fifth is unknown.

Lump Sums

To begin, we consider TVM calculations with single (lump) sums. In this situation, we do not have payments. So, be sure to either press [2nd] [CLR TVM] before entering any data, which sets PMT = 0, or enter 0 as the PMT when entering the input data.

Example 1 (p. 134) Future Value (FV):

What is the FV of \$1,000 after 20 years if the interest rate is 6 percent?

First make sure that the payments per year are set to one by pressing [2nd] [P/Y] [1] [ENTER] [CE/C]. Then, clear the TVM memory registers of any previous calculations by pressing [2nd] [CLR TVM].

Next, enter the data.

| KEYSTROKES | DISPLAY |
|----------------------|---|
| [2] [0] [N] | N = 20.00 |
| [6] [I/Y] | I/Y = 6.00 |
| [1] [0] [0] [0] [PV] | PV = 1,000.00 |
| [0] [PMT] | PMT = 0.00 (Optional if you started with [2nd] [CLR TVM]) |

Then, to determine the FV, press [CPT] [FV] and the FV of -\$3,207.14 is displayed.

The BAI PLUS is programmed so that if the PV of a lump sum is +, then the FV is displayed as - and vice versa. This is because the calculator assumes that one is an inflow and the other is an outflow (i.e. a negative inflow).

Example 2 (p. 140) Present Value (PV):

What is the PV of \$1,000 due in 20 years if the interest rate is 10 percent? As always, first, make sure that the payments per year are set to the desired number (it is one in this example). Then press [2nd] [CLR TVM] to clear the TVM memory registers. Next, enter the following data:

| KEYSTROKES | DISPLAY |
|----------------------------|---|
| [2] [0] [N] | N = 20.00 |
| [1] [0] [I/Y] | I/Y = 10.00 |
| [0] [PMT] | PMT = 0.00 (Optional if TVM memory registers are cleared) |
| [1] [0] [0] [0] [+/-] [FV] | FV = -1,000.00 (The [+/-] key changes the sign to minus) |

Press the [CPT] [PV] keys to reveal that \$148.64 will grow to \$1,000 in 20 years at a 10% rate.

Example 3 (p. 136) Rate of Return:

Assume an asset can be purchased today for \$1,000. It will return \$1,629 after 10 years. The asset pays no interest during its life. What rate of return would you earn if you bought the asset?

Set the payments per year to one and clear the TVM memory registers.

| KEYSTROKES | DISPLAY |
|----------------------------|--|
| [1] [0] [N] | N = 10.00 |
| [1] [0] [0] [0] [+/-] [PV] | PV = -1,000.00 (The [+/-] key changes the sign to minus) |
| [0] [PMT] | PMT = 0.00 |
| [1] [6] [2] [9] [FV] | FV = 1,629.00 |

When you press the [CPT] [I/Y] keys, the BAI PLUS calculates the rate of return to be 5.00 percent.

In this example, -\$1,000 represents the money invested (i.e. an outflow) to buy the asset and the \$1,629 represents the money returned (i.e. an inflow) when the asset matures. *Entering the PV and FV with opposite signs is consistent with the sign convention discussed in Example 1 above. If you enter both values as + numbers, you will receive the Error 5 message when you press the [CPT] [I/Y] keys. Furthermore, you must enter -\$1,000 as [1][0][0][0][+/-][PV]. If you try to enter it as [-][1][0][0][0][PV], you will find PV = 1,000.00 displayed!*

Now suppose you learn that the asset will actually cost \$1,019.31. What rate of return will you earn?

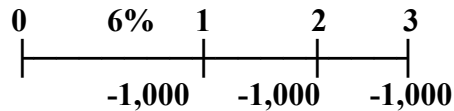
To change the PV, enter [1] [0] [1] [9] [.] [3] [1] [+/-] [PV]. Then press [CPT] [I/Y] to get 4.80 percent. If you pay more for the asset, you earn less on it. The important thing, though, is that you can do "what if" analyses with the calculator.

Now do nothing except press [ON/OFF] to turn off the calculator. Then turn on the calculator [ON/OFF]. The display shows 0.00. Is the memory erased? Not completely. What was on the screen is gone, but press [RCL] [I/Y] to get I/Y = 4.80.

Ordinary Annuities

Example 4 (p. 145) Future Value of an Annuity:

What is the FV of an annuity of \$1,000 paid at the end of each year for 3 years if the interest rate equals 6 percent?



Set the payments per year to one and clear the TVM memory registers.

| KEYSTROKES | DISPLAY |
|-----------------------------|-----------------|
| [3] [N] | N = 3.00 |
| [6] [I/Y] | I/Y = 6.00 |
| [0] [PV] | PV = 0.00 |
| [1] [0] [0] [0] [+/-] [PMT] | PMT = -1,000.00 |

Now press the [CPT] and [FV] keys, which display a FV of \$3,183.60.

Example 5 Present Value of an Annuity:

What is the PV of the same annuity?

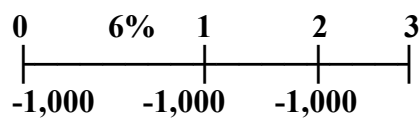
Leave the data in the calculator, but enter 0 as the FV to override the \$3,183.60. Then press [CPT] [PV] to get \$2,673.01. Note that the PV of this annuity is smaller than the FV. *This is always true for any annuity evaluated with a positive interest rate.*

Annuities Due

Each payment of an annuity due occurs at the beginning of the period instead of at the end as with a regular annuity. In essence, each payment occurs one period sooner. To analyze annuities due, press [2nd] [BGN] [2nd] [SET] [CE/C]. The word "BGN" appears on the screen and in the upper right hand corner of the display. Now the BAII PLUS analyzes the cash flows based on beginning of period payments. Change back to end mode by pressing [2nd] [BGN] [2nd] [SET] [CE/C].

Example 6 (p. 147) Future Value of an Annuity Due:

Redo Example 4 above as an annuity due.



Set the payments per year to one and clear the TVM memory registers. Then set the calculator, as discussed above, in the beginning of period mode. Make sure that "BGN" appears in the upper right hand corner of the display. The data are now entered as in Example 4.

| KEYSTROKES | DISPLAY |
|-----------------------------|-----------------|
| [3] [N] | N = 3.00 |
| [6] [I/Y] | I/Y = 6.00 |
| [0] [PV] | PV = 0.00 |
| [1] [0] [0] [0] [+/-] [PMT] | PMT = -1,000.00 |

Now press the [CPT] and [FV] keys, which display a FV of \$3,374.62.

Note that the FV of the annuity due is larger than the FV of the annuity. The PV of the annuity due is also larger than the PV of the annuity. Once again, these results are general results so long as evaluation is with a positive interest rate.

Since the usual situation in TVM calculations is for payments to be at the end of the period, we now strongly recommend that you press [2nd] [BGN] [2nd] [Set] [CE/C] to return the calculator to the end-of-period mode. "BGN" should no longer appear in the right hand corner of the display.

Interest Conversion

When using a scientific calculator, the following equation is used to convert a nominal rate to an effective rate.

$$i_{\text{eff}} = [1 + i_{\text{nom}}/m]^m - 1 \quad \text{(Equation 4.32)}$$

Example 7 (p. 164) Effective Rate Calculation:

Suppose: $i_{\text{nom}} = 12\%$ and $m = 4$ (i.e. quarterly compounding),

$$i_{\text{eff}} = [1 + 0.12/4]^4 - 1 = (1.03)^4 - 1 = 1.1255 - 1 = 0.1255 = 12.55\%.$$

Although such a scientific calculation can be done on a BAI PLUS, it is much easier to convert the rate using the I Conv worksheet of the calculator.

| KEYSTROKES | DISPLAY |
|------------------|----------------------|
| [2nd] [I Conv] | NOM = previous value |
| [2nd] [CLR Work] | NOM = 0.00 |
| [1] [2] [ENTER] | NOM = 12.00 |
| [↑] [4] [ENTER] | C/Y = 4.00 |
| [↑] [CPT] | EFF = 12.55 |

The effective rate of 12.55 percent is displayed on the screen.

Amortization

The BAI PLUS can also be used to calculate amortization schedules.

Example 8 (p. 151) Interest and Principal of an Amortized Loan:

Determine the interest and principal paid each year and the balance at the end of each year on a four year \$10,000 amortizing loan that carries an interest rate of 10.5 percent. The payments are due annually.

First, check payments/year and be sure it is 1. Then, perform the following steps:

| KEYSTROKES | DISPLAY |
|--------------------------|-----------------|
| [2nd] [CLR TVM] | 0.00 |
| [4] [N] | N = 4.00 |
| [1] [0] [.] [5] [I/Y] | I/Y = 10.50 |
| [1] [0] [0] [0] [0] [PV] | PV = 10,000.00 |
| [CPT] [PMT] | PMT = -3,188.92 |

A payment of -\$3,188.92 is displayed.

Now we will use the amortization worksheet to generate an amortization schedule for the loan:

| KEYSTROKES | DISPLAY |
|--------------------------------|--|
| [2nd] [Amort] [2nd] [CLR Work] | P1 = 1.00 (amortization will start from period 1). |
| [↓] | P2 = 1.00 (this will show information for each payment). |
| [↓] | BAL = 7,861.08 |
| [↓] | PRN = -2,138.92 |
| [↓] | INT = -1,050.00 |

To view the results for the second payment, begin by pressing [↓] [CPT]. This displays P1 = 2.00. Pressing [↓] again displays P2 = 2.00. Use the [↓] key repeatedly to view the second period ending balance, principal payment, and interest payment.

Repeat the above steps for the third and last payments.

| Year | Beginning Balance | Payment | Interest Portion | Principal Reduction | Remaining Balance |
|------|-------------------|------------|------------------|---------------------|-------------------|
| 0 | | | | | \$10,000.00 |
| 1 | \$10,000.00 | \$3,188.92 | \$1,050.00 | \$2,138.92 | \$7,861.08 |
| 2 | \$7,861.08 | \$3,188.92 | \$825.41 | \$2,363.51 | \$5,497.57 |
| 3 | \$5,497.57 | \$3,188.92 | \$577.24 | \$2,611.68 | \$2,885.89 |
| 4 | \$2,885.89 | \$3,188.92 | \$303.02 | \$2,885.90 | -0.01 |

Note that the ending balance is *negative* 1 cent. Thus, to exactly amortize this loan over four years, the last payment must be 1 cent less or \$3,188.91. This means that the principal payment will also be 1 cent less or \$2,885.89. This is shown in Table 4.5 on page 151. We should also note that the interest and principal repayments are shown as negative numbers on the BAI PLUS because they represent cash outflows. Furthermore, the total payment for each period is not displayed in the calculator's amortization worksheet.

Example 9 (p. 166) Canadian Mortgage:

Suppose you are considering buying a new home. The bank quotes a nominal annual mortgage interest rate of 6% with semiannual compounding for a 5-year term with amortization of 25 years.

Assume you want to make mortgage payments every month. Furthermore, assume you want to borrow \$200,000. What is the monthly mortgage payment that must be made if the mortgage is being amortized over 25 years?

KEYSTROKES

[2nd] [P/Y]
 [1] [2] [ENTER]
 [↓]
 [2] [ENTER]
 [CE/C] [2nd] [CLR TVM]
 [2] [5] [2nd] [xP/Y]
 [N]
 [6] [I/Y]
 [2] [0] [0] [0] [0] [0] [PV]
 [CPT] [PMT]

DISPLAY

Current value of P/Y
 P/Y = 12.00 (sets payments per year at 12)
 C/Y = 12.00
 C/Y = 2.00 (sets compounding per year at 2)
 0.00
 300.00
 N = 300
 I/Y = 6.00
 PV = 200,000.00
 PMT = -1,279.61

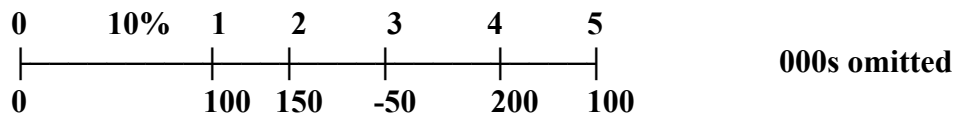
To construct a loan amortization schedule for this mortgage, follow the amortization steps in the preceding example.

Cash Flow Operations

We can also find the PV, FV, and IRR (internal rate of return) of unequal cash flows.

Example 10 (p. 156) Uneven Cash Flows:

Assume the following cash flows (CFs):



What is the PV of these CFs?

First, enter the cash flow worksheet by pressing [CF]. Then, clear any previous cash flow analyses by pressing [2nd] [CLR Work].

Next, enter the cash flows:

| KEYSTROKES | DISPLAY |
|-----------------------------------|--------------------|
| [↓][1][0][0][0][0][0][ENTER] | C01 = 100,000.00 |
| [↓][↓][1][5][0][0][0][0][ENTER] | C02 = 150,000.00 |
| [↓][↓][5][0][0][0][0][+/-][ENTER] | C03 = -\$50,000.00 |
| [↓][↓][2][0][0][0][0][0][ENTER] | C04 = 200,000.00 |
| [↓][↓][1][0][0][0][0][0][ENTER] | C05 = 100,000.00 |

The CFs from the time line are entered. Now enter the interest rate.

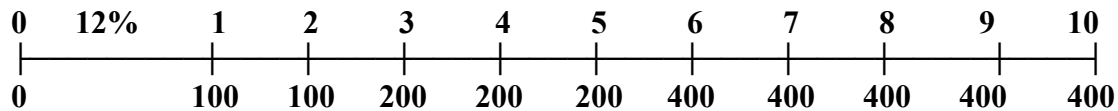
| KEYSTROKES | DISPLAY |
|--|-----------|
| [NPV] [2nd] [CLR Work] [1] [0] [ENTER] | I = 10.00 |

At this point, the BAI PLUS knows the cash flows, the number of periods, and the interest rate. To find the PV, press [↓] [CPT]. The PV is displayed as NPV = \$376,005.12.

Note that the calculator calls the cash flows C01, C02, etc. Why it does this will be clear with the next example.

Example 11: Present Value of Embedded Annuities.

We have these cash flows, which contain embedded annuities:



What is the PV?

First enter the cash flow worksheet by pressing [CF], then clear any previous cash flow analyses, [2nd] [CLR Work]. Next, enter the cash flows:

| KEYSTROKES | DISPLAY |
|-------------------------|--|
| [↓] [1] [0] [0] [ENTER] | C01 = 100.00 |
| [↓] [2] [ENTER] | F01 = 2.00 (repeats C01 value twice) |
| [↓] [2] [0] [0] [ENTER] | C02 = 200.00 |
| [↓] [3] [ENTER] | F02 = 3.00 (repeats C02 value 3 times) |
| [↓] [4] [0] [0] [ENTER] | C03 = 400.00 |
| [↓] [5] [ENTER] | F03 = 5.00 (repeats C03 value 5 times) |

Now the BAI PLUS knows that the cash flows $CF_1 = CF_2 = C01 = \$100$; $CF_3 = CF_4 = CF_5 = C02 = \200 ; and $CF_6 = CF_7 = CF_8 = CF_9 = CF_{10} = C03 = \400 . Thus, C01 represents the first annuity, C02 represents the second annuity, and C03 represents the third annuity. To enter the interest rate, press:

| KEYSTROKES | DISPLAY |
|--|-----------|
| [NPV] [2nd] [CLR Work] [1] [0] [ENTER] | I = 12.00 |

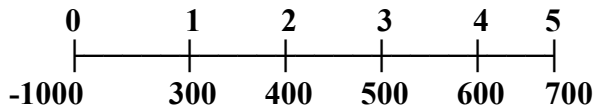
At this point, the BAI PLUS knows the cash flows, the number of periods, and the interest rate.

To find the PV of the cash flows, press [↓] [CPT]. The PV is displayed as NPV = \$1,370.13.

To check your entries, press [CF]. Then use the up and down arrow keys to view each cash flow.

Example 12: The Internal Rate of Return Offered by an Investment (IRR).

Assume that we invest \$1,000 now ($t = 0$) and then expect to receive an uneven set of cash flows. Here is the CF time line:



What rate of return will we earn?

First, enter the cash flow worksheet by pressing [CF]. Then clear any previous cash flow analyses by pressing [2nd] [CLR Work].

Next, enter the cash flows:

| KEYSTROKES | DISPLAY |
|-------------------------------|-----------------------------|
| [1] [0] [0] [0] [+/-] [ENTER] | CF ₀ = -1.000.00 |
| [↓] [3] [0] [0] [ENTER] | C01 = 300.00 |
| [↓] [↓] [4] [0] [0] [ENTER] | C02 = 400.00 |
| [↓] [↓] [5] [0] [0] [ENTER] | C03 = 500.00 |
| [↓] [↓] [6] [0] [0] [ENTER] | C04 = 600.00 |
| [↓] [↓] [7] [0] [0] [ENTER] | C05 = 700.00 |

Now the BAII PLUS knows the cash flows. Thus, simply press [IRR] [CPT] and the IRR of 34.12 percent is displayed.

You can also determine the NPV of this investment at an appropriate discount rate, say 8 percent.

To find the NPV, press [NPV] [2nd] [CLR Work] [8] [ENTER] [↓] [CPT] and the NPV of \$935.06 is displayed. Thus, the PV of the cash inflows exceeds the cost of the investment by \$935.06 at a discount rate of 8 percent.

Statistical Calculations

The BAII PLUS can also be used for several types of statistical calculations.

Example 13: Mean and Standard Deviation

| <u>Year</u> | <u>Sales</u> |
|-------------|--------------|
| 2002 | \$100 |
| 2003 | \$200 |
| 2004 | \$300 |

What is the mean (average) and standard deviation (σ) of sales over the 3 years?

First, select the data-entry portion of the Statistics worksheet by pressing [2nd] [Data]. Then clear any previous data entries by pressing [2nd] [CLR Work]. Next enter the data:

| KEYSTROKES | DISPLAY |
|-----------------------------|--------------|
| [1] [0] [0] [ENTER] | X01 = 100.00 |
| [↓] [↓] [2] [0] [0] [ENTER] | X02 = 200.00 |
| [↓] [↓] [3] [0] [0] [ENTER] | X03 = 300.00 |

Now select the statistical calculation portion of the statistics worksheet by pressing [2nd] [Stat]. Then clear any previous statistical entries by pressing [2nd] [CLR Work].

"LIN" should now be displayed on the screen. Press [2nd] [SET] repeatedly until "I-V" (one variable calculation method) is displayed.

Press the down arrow [\downarrow] key repeatedly to view the following:

| <u>Description</u> | <u>Display</u> |
|--|-------------------------|
| Sample size | n = 3.00 |
| Mean sales level | $\bar{x} = 200.00$ |
| Sample standard deviation | S _x = 100.00 |
| Population standard deviation (not relevant for a sample) | $\sigma_x = 81.65$ |

Example 14: Linear Regression

Beta coefficients can be calculated by using the BAI PLUS's linear regression capabilities. The X (independent variable) and Y (dependent variable) values must be entered in the proper sequence. X data is on the horizontal axis (market) and Y data is on the vertical axis (stock).

| <u>Year</u> | <u>Market (r_m)</u> | <u>Stock (k_j)</u> |
|-------------|-------------------------------|------------------------------|
| 1 | 60.1% | 50.6% |
| 2 | -10.2% | -25.8% |
| 3 | 8.8% | 7.8% |
| 4 | 18.2% | 15.3% |
| 5 | 28.9% | 36.6% |

First, select the data-entry portion of the Statistics worksheet by pressing [2nd] [Data]. Then, clear any previous data entries by pressing [2nd] [CLR Work]. Next, enter the data:

| KEYSTROKES | DISPLAY |
|--|----------------|
| [6] [0] [.] [1] [ENTER] | X01 = 60.10 |
| [\downarrow] [5] [0] [.] [6] [ENTER] | Y01 = 50.60 |
| [\downarrow] [1] [0] [.] [2] [+/-] [ENTER] | X02 = -10.20 |
| [\downarrow] [2] [5] [.] [8] [+/-] [ENTER] | Y02 = -25.80 |
| [\downarrow] [8] [.] [8] [ENTER] | X03 = 8.80 |
| [\downarrow] [7] [.] [8] [ENTER] | Y03 = 7.80 |
| [\downarrow] [1] [8] [.] [2] [ENTER] | X04 = 18.20 |
| [\downarrow] [1] [5] [.] [3] [ENTER] | Y04 = 15.30 |
| [\downarrow] [2] [8] [.] [9] [ENTER] | X05 = 28.90 |
| [\downarrow] [3] [6] [.] [6] [ENTER] | Y05 = 36.60 |

Now, select the statistical calculation portion of the statistics worksheet by pressing [2nd] [Stat]. Then, clear any previous statistical entries by pressing [2nd] [CLR Work]. "LIN" should now be displayed on the screen. Press the down arrow key repeatedly to find the following:

| <u>Description</u> | <u>Display</u> |
|--|--------------------|
| Number of observations | $n = 5.00$ |
| Average value of market return | $\bar{x} = 21.16$ |
| Sample standard deviation of market return | $S_x = 26.08$ |
| Population standard deviation (not relevant for a sample) | $\sigma_x = 23.33$ |
| Average value of stock return | $\bar{y} = 16.90$ |
| Sample standard deviation of stock return | $S_y = 29.29$ |
| Population standard deviation of stock return (not relevant for a sample) | $\sigma_y = 26.20$ |
| Vertical axis intercept of regression line | $a = -5.81$ |
| Estimated beta of stock (slope of regression line) | $b = 1.07$ |
| Coefficient of correlation | $r = 0.96$ |