Hand calculators can be used to do one-way ANOVA calculations. The calculator must have a key that calculates means and standard deviations. Suppose that there are \( i = 1, 2, \ldots, a \) treatments in the ANOVA, and each treatment has a sample size, \( n \), and an observed mean \( \bar{Y}_i \) with a standard deviation \( S_i \). The method (for balanced ANOVA's) is as follows:

**STEP 1:** Enter all values, \( Y_{ij} \), for one treatment to obtain \( \bar{Y}_i \) and \( S_i \) (or \( S_i^2 \)). Record using many decimal places. If possible accumulate \( S_i^2 \) in a memory (Step 3).

**STEP 2:** Repeat for each treatment.

**STEP 3:** Calculate the Sums of Squares Error (SSE) by: 

\[
\text{SSE} = (n-1) \sum S_i^2
\]

or the Mean Sums of Squares Error (MSE) by: 

\[
\text{MSE} = \frac{\sum S_i^2}{a}.
\]

**STEP 4:** Enter all the means, \( \bar{Y}_i \), to obtain \( S_m \), the standard deviation of the means. Use lots of decimal places when inputting the means to avoid round-off error.

**STEP 5:** Calculate the Sums of Squares Between (SSB) by: 

\[
\text{SSB} = n(a-1) S_m^2
\]

or the Mean Sums of Squares Between (MSB) by: 

\[
\text{MSB} = nS_m^2.
\]

**STEP 6:** Calculate the F-value as:

\[
F = \frac{\text{SSB}/(a-1)}{\text{SSE}/(a(n-1))} = \frac{\text{MSB}}{\text{MSE}} = \frac{anS_m^2}{\sum S_i^2}, \text{ with df = [(a-1), (a(n-1))]}.
\]

**Example:**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Data</th>
<th>Mean, ( \bar{Y}_i )</th>
<th>Deviation, ( S_i )</th>
<th>( S_i^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5 3 5 6 1</td>
<td>4.0000</td>
<td>2.0000</td>
<td>4.0000</td>
</tr>
<tr>
<td>2</td>
<td>1 2 2 0 3</td>
<td>1.6000</td>
<td>1.140175</td>
<td>1.3000</td>
</tr>
<tr>
<td>3</td>
<td>5 4 7 5 2</td>
<td>4.6000</td>
<td>1.816590</td>
<td>3.3000</td>
</tr>
<tr>
<td>Grand Mean:</td>
<td></td>
<td>3.4000</td>
<td>Sum:</td>
<td>8.6000</td>
</tr>
<tr>
<td>Std. Dev. ( S_m ):</td>
<td></td>
<td>1.587451</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In this case, \( a = 3, n = 5, \sum S_i^2 = 8.6000 \), and \( S_m^2 = 2.52000 \). Hence:

\[
\text{MSE} = \frac{\sum S_i^2}{a} = \frac{8.6000}{3} = 2.86666
\]

and

\[
\text{MSB} = nS_m^2 = 5(1.587451)^2 = 12.6000
\]

and

\[
F = \frac{12.6000}{2.86666} = 4.395 \text{ with } df = 2, 12
\]

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PROBLEMS FROM BI #21

The residual df for a simple regression on a dataset with 50 observations is 48. With three independent variables the df become 50 - 4 = 46. The df for a dataset with 3 numbers is 3 - 4 = -1. Since df must have positive values, this means that a multiple regression with 3 variables cannot be fit to a dataset with only 3 observations.

The residual df for a dataset with 70 observations divided into 6 groups would be df = 70 - 6 = 64. The df for the F-test is 5, 64.

The df for the usual contingency table \( \chi^2 \)-value is (3-1)(6-1) = 10.

The df for a t-test of a mean with a sample size of 80 is 78.

NEW PROBLEM

Calculate the SSB, MSE, and the F-test for the following data:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Data</th>
<th>Mean, ( \bar{Y}_i )</th>
<th>Deviation, ( S_i )</th>
<th>( S_i^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5 3 1 0 1</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>2</td>
<td>7 6 5 8 4</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>3</td>
<td>11 9 7 6 7</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>4</td>
<td>10 6 9 9 6</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>Grand Mean:</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>Std. Dev. ( S_m ):</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
</tbody>
</table>