population means of the first factor are equal. Second, the population means of the second factor are equal, and the third is that there is no interaction between the two factors.

Each factor will have at least two levels and the degrees of freedom (df) for each factor is one less than the number of levels. A Table indicating the treatment groups will be designated by the number of factor levels; for example, if factor one had three levels and factor two had four levels, then that would be 3 x 4 = 12 treatment groups. An interaction effect is an effect one factor has on another factor. An *F*-test is used for each hypothesis and is the mean square for each main effect and the interaction effect divided by the within variance.[60] Various formulas are used to develop the *F*-Table and determine the result. See **Figure 10.1**. See also the two-way table example shown in **Figure 10.2**.

$$\mathrm{MS}_A = \frac{\mathrm{SS}_A}{a-1} \qquad F_A = \frac{\mathrm{MS}_A}{\mathrm{MS}_W} \qquad F_{A\times B} = \frac{\mathrm{MS}_{A\times B}}{\mathrm{MS}_W}$$

$$\mathrm{MS}_B = \frac{\mathrm{SS}_B}{b-1} \qquad F_B = \frac{\mathrm{MS}_B}{\mathrm{MS}_W}$$

$$\mathrm{MS}_{A\times B} = \frac{\mathrm{SS}_{A\times B}}{(a-1)(b-1)} \qquad \mathrm{MS}_W = \frac{\mathrm{SS}_W}{ab(n-1)}$$

Source	SS	df	MS	*F*
Main Effect A	SS_A	a-1	$MS_A = SS_A$ / df	MS_A / MS_W
Main Effect B	SS_B	b-1	$MS_B = SS_B$ / df	MS_B / MS_W
Interaction Effect A x B	SS_{AxB}	(a-1)(b-1)	$MS_{A\ x\ B} = SS_AxB$ / df	MS_{AxB} / MS_W
Within (error)	SS_W	ab(n-1)	$MS_W = SS_W$ / df	
Total		N - 1, abn – 1		

Figure 10.1 Formulas for Two-Way ANOVA

An example of a two-way problem can involve the significance of using three different teaching methods (Factor A) and four Gender rows for Groups (Factor B). This would be a 3 x 4 = 12 values. For example, using the three teaching methods of (a) face to face, (b) online, and (c) Hybrid to four groups, the final grade percentages are shown. The four groups are (a) Males (18 < 25 years of age), (b) Males (25 years of age and over), (c) Females (18 under 25 years of age), and (d) Females (25 years of age and over.) A data table is shown below in **Example 10.5**.

[60] Other ANOVA tests can be three-way based upon the number of independent variables, but only two types are shown here. Online sources provide details of further ANOVA two-way and three-way type issues. An excellent review source of 56 slides is found at http://www.slideshare.net/snehkhatri/analysis-of-variance-anova.