1. True and False (7 Points) Circle (if .pdf) or Underline **T** or **F**

T F Current DOD policies encourage combining Testing and Training whenever possible.

T F Non-Developmental Items (NDI) and Commercial Off-the Shelf (COTS) items need not be tested since commercial testing is usually more than sufficient to meet military requirements

T F Contractors are normally not allowed to participate in the OPEVAL

T F Susceptibility is defined as P(Kill | Hit)*P(Hit)

T F Background Factors should not be measured because of the added instrumentation costs.

T F Live Fire Testing evaluates system survivability and weapon lethality

T F A Dendritic can be used as a tool for identifying systems functions and capabilities

2. With respect to **Factorial Designs** mark T or F (1 point each, total 6 points)

T F Significant interactions between factors could invalidate initial test conclusions.

T F If the variance within a factor (data scatter) is **increased**, the test becomes **more** sensitive and therefore it may be easier to determine the difference between factors.

T F A purpose of blocking is to decrease the experimental error ***within*** the primary factors.

T F In a Fractional Factorial test design, each trial run will contain at least one **ALIAS**

T F A Pareto chart may be used to rank the relative magnitude of factors when there are insufficient degrees of freedom to determine factor significance

T F The order of the trial runs should be randomized when possible

Multiple Choice (2 Points each) **Circle (if .pdf) or Underline BEST ANSWER**

3. The Fisher LSD family error rate for multiple comparisons is:
   a. The probability of correctly identifying a difference in pairs of factor means
   b. The probability of correctly finding no difference in pairs of factor means
   c. The probability of not finding a difference in factor means when there is one
   d. The probability of incorrectly identifying a difference between pairs of factor means when there is none

4. In a 2^4 Half Fractional Factorial with factors A, B, C, D, what is the Alias of the BD Interaction?
   a. CD
   b. ABC
   c. AC
   d. DB
   e. None of the Above

5. The three sections of an Effectiveness Test or Suitability Test are:
   a. Objective, Criteria, Analysis
   b. Objective, Procedure, Analysis
   c. Objective, Equations, Analysis
   d. Objective, Procedure, Resources

6. A test design variable matrix includes:
   a. Variables, Control Method, Instrumentation
   b. Variables, Factor/Levels, Instrumentation
   c. Control Method, Factor/Levels, Instrumentation
   d. Variables, Control Method, Factor/Levels

Matching (5 pts):

7. In the example Two Factor Test Design for the Radial Miss Distance of several Aircraft, match the following: (Only one Each) **Place letter in appropriate blank**

_C_	Aircrew	A.	Primary Factor
_E_	Radial Miss Distance	B.	Unmeasured Background Variable
_A_	Aircraft	C.	Blocking Factor
_D_	Weather factors	D.	Measured Background
_B_	Random Variations	E.	Dependent Variable

8. (4 pts) List Four DT&E Problems/Lessons Learned that were identified in the Army Testing Study reading:

   1. _PM should start test-planning earlier_________________
   2. _Historical data should be used to better estimate cost, schedule, and resources___
   3. _PM should plan for contingencies and not assume perfect success in the test process__
   4. _Decision makers should fully understand the risk reduction role of T&E in the SE process_

9. (16 pts) Three different IR Sensors were tested to determine differences in maximum detection range against a common target.

a. (12 pts) Using Anova, test the null hypothesis that there was no significant difference between IR Sensor detection ranges at α = 0.05 level of significance. (**SHOW ALL WORK**)

IR SENSORS (a_j) (1000 yds)		
Sensor A (a_1)	Sensor B (a_2)	Sensor C (a_3)
12 144	9 81	7 49
9 81	12 144	9 81
11 121	8 64	6 36
	8 64	6 36
32 1024	37 1369	28 784

unequal sample sizes

$= (97)^2 = \frac{9,409}{11} = 855.36$

One Way ANOVA formulas:

$$\sum_{j=1}^{k}\sum_{i=1}^{n} y_{ij}^2 = 901$$

$$C = \frac{T.^2}{N} = 855.36$$

T = Data total

N = Total (# of trials) = 11

$$SStr = \cancel{\sum_{j=1}^{k}\frac{T_j^2}{n}} - C = \text{ or } SStr = \sum_{j=1}^{k}\frac{T_j^2}{n_j} - C = \cancel{203.63}$$

$\cancel{\frac{T_j^2}{n} = \frac{3177}{3} = 1059 - 855.36}$

$$\frac{1024}{3} + \frac{1369}{4} + \frac{784}{4} = 879.5833$$

-855.3636

SStr = 24.2197

$$SST = \sum_{j=1}^{k}\sum_{i=1}^{n} y_{ij}^2 - C = 45.63636$$

$\sum$ square all individual data

$$SSE = SST - SStr = \cancel{127.1136}$$ 36.4166

Excel data analysis

Source	D.F.	Sums of Squares	Mean Squares	Fs	$F\alpha = 0.05$	Significant / Not Significant
IR Sensor	2	24.2197	12.10985	4.523523	0.048502	Significant
Exp. Error	8	21.41667	2.677083			
Total	10	116.9167				

b. (4 pts) Estimate the parameters: overall mean (u), and factors a_1, a_2, a_3

$u = 8.8181$ $a_1 = 0.8484$

$a_2 = 0.4318$ $a_3 = -1.8181$

10. (9 pts) Three Radar modifications were tested for detection range improvement using <u>five</u> trials each. The following single factor ANOVA Table presents the results:

Source	D.F.	Sums of Squares	Mean Squares	Fs	P
Radar Modification	2	139.6	69.8	5.72	0.018
Exp. Error	12	146.4	12.2		
Total	14	286.0			

The Mod sample means are: **Mod A = 31.4, Mod B = 28.6, Mod C = 24.0**

Using the Fisher LSD test, determine if any of the modifications were significantly different from each other at a level of significance of α = .05, and find the upper and lower confidence limits for the difference of means.

MSE = 12.2

$$LSD = t\alpha/2, k(n-1)\sqrt{\frac{2MSE}{n}} = 4.8158$$

$$t_{\alpha/2}, 3(5-1)\sqrt{\frac{2(12.2)}{5}} =$$

$$t_{0.025}, 12\sqrt{4.88} =$$

$$2.18\,(2.2091) = 4.8158$$

Results:

Comparison	Difference	LSD	Lower Conf. Limit.	Upper Conf. Limit	Significant or Not Significant
A – B	**31.4 – 28.6 = 2.8**	4.8158	-2.0158	7.6158	NS
B – C	**28.6 – 24.0 = 4.6**	4.8158	-0.2158	9.4158	NS
A – C	**31.4 – 24.0 = 7.4**	4.8158	2.5842	12.2158	Sign

If Ø goes through, it is not significant

11. (4 pts) The following Minitab table presents Fisher LSD 95% confidence intervals for the difference of pairs of three aircraft factor means.

F18 - F16 = 2.1 LSD = 2.919 NS

F5 - F16 = 4.8 LSD = 2.752 Sign.

```
Aircraft = F16 subtracted from:

Aircraft   Lower   Center   Upper   ---------+---------+---------+---------+
F18       -0.819    2.100   5.019             (------*-------)
F5         2.048    4.800   7.552                    (------*------)
                                    ---------+---------+---------+---------+
                                          -4.0       0.0       4.0       8.0
```

F5 - F18 = 2.7 LSD = 2.919 NS.

```
Aircraft = F18 subtracted from:

Aircraft   Lower   Center   Upper   ---------+---------+---------+---------+
F5        -0.219    2.700   5.619              (-------*------)
                                    ---------+---------+---------+---------+
                                          -4.0       0.0       4.0       8.0
```

a. **Circle or underline** the pairs of factor means that are significantly different from each other at a level of significance of α = .05: **F18-F16,** **F5-F16,** **F5-F18**

12. (7 pts) To compare **five** different formulations of fuel, **seven** different armored vehicles drove the identical route once with each fuel type. For each vehicle/fuel-type combination a fuel cost-of-operation value was determined. These numbers were analyzed with a **standard Two-Factor ANOVA** model yielding the table which is partially filled in below.

$n = 35$

$35 - (6 \times 4) = 11$

$\frac{SS}{DF}$ $\frac{MS_x}{MSE}$ $\frac{\text{Num DOF}_x}{\text{Den DOF}_E}$

Source	D.F.	Sums of Squares	Mean Squares	Fs	F α = .05
Armored Vehicle	6	82	13.667	3.417	0.0372
Fuel Types	4	48	**12**	3	0.0669
Exp. Error	11	44	**4**		
Total	34	**174**			

(total trials) − 1

A) Fill in the missing entries.

4 =

B) Making the normal assumptions, would you accept the hypothesis that there is no significant difference between the fuel cost of operations for each **vehicle type**, with α = .05? Why?

Reject due to p-value 0.0372 for vehicle type.

13. (10) A reduced regression model for predicting Sonar Detection Range included Water Depth (w), Sensor Modification (s), and Water Depth/SensorMod (ws) Interactions in the form:

$$\boxed{\hat{Y} = \beta_0 + \beta_1 w + \beta_2 s + \beta_{12} ws + e}$$

grand mean   1/2 factor effect for w β_2 = 1/2 factor effect for s

The 2^k factor settings, calculated factor effects and the grand mean of the data are below:

Factor	Settings
Water Depth (w)	200 ft (-)
	900 ft (+)
Sensor Modifications (s)	Mod I (-)
	Mod II (+)

Factor Effects:	
Grand Mean of Data	41.0
Water Depth (w):	3.8
Sensor Modification (s):	- 5.2
Water/Sensor Interaction (ws)	- 2.4

1. (3) Determine the coefficients for the reduced Regression Equation:

$$\beta_0 = \underline{41} \quad \beta_1 = \underline{1.9} \quad \beta_2 = \underline{-2.6} \quad \beta_{12} = \underline{-1.2}$$

2. (5) Predict the result for Run (5) (200 ft and Mod II):

$$\hat{y} = 41 + 1.9(-1) - 2.6 - 1.2(-1)$$
$$= 41 - 1.9 - 2.6 + 1.2 = 37.7$$

3. (2) The result for Run (5) was 35.5, what was the residual for Run (5)?

$$35 - 37.7 = -2.7$$

14. (15 pts) The following is a 2^4 **Half Fractional** Test Design. **Determine Contrasts, SS, MSE, Fs, Fα, factor effects, and Acceptance or Rejection** of the Null Hypothesis for Main factors **A & B** and Interaction **CD.** Test the Hypothesis **Ho: A = B = CD = 0** at a level of significance of **.05** i.e. no significant difference in factor levels or interaction. The Residual/Sum of Squares Error (SSE) is given below. **(Show All Work)**

$F_{0.05}(1,3) = 10.10$

$$SumSq = \frac{(Contrast)^2}{r2^k}$$

$0.5 \times (2^K)$

DOF = 1

r = 0.5

~~Contrast^2 / r2^k~~

2^4 Half Fractional Test Design

		A (-)		A (+)		Row Sum
		B (-)	B (+)	B (-)	B (+)	
C (+)	D (+)	24			25	49
	D (-)		23	16		39
C (-)	D (+)		20	21		41
	D (-)	17			21	38
Column Sum		41	43	37	46	167

Contrasts: sum +, −

A: $-41-43+37+46 = -1$

B: $-41+43-37+46 = 11$

CD: $49-39-41+38 = 7$

$\frac{(-1)^2}{0.5(2^2)} = \frac{1}{2}$

$\frac{(11)^2}{0.5(2^4)} = 15.1250$

$\frac{-1}{0.5(2^1)} = -1$

$\frac{11}{0.5(2^3)} = \frac{11}{4}$

same

MSx / MSE

contrast / $r2^{k-1}$

Fill in Blanks with Answers Here:

	Source	Deg. Of Freedom	Contrast	Sum Squares	Mean Squares	Fs	F.05	Factor Effect	Accept/Reject Ho:
	Main Factors								
k=2	A	1	−1	0.5	0.5	0.0833	10.10	−1	rej
k=4	B	1	11	15.1250	15.1250	2.5208	10.10	2.75	rej
	Interactions								
k=4	C-D	1	7	0.875	0.875	0.1458	10.10	1.75	rej
	Residual (SSE)	3		6.0	6.0				

15. (5 pts) Calculate and plot the **AD Interaction.** (Show Y-axis scaling). Would you expect this interaction to be significant? **Why or why not?**

AD Interaction: 5

~~-24+17+23+20-16+21+25-21...~~ 5

$-24 - 20 = -44/2 = -22$

$23 + 17 = 40/2 = 20$

$25 + 21 = 46/2 = 23$

$-16 - 21 = -37/2 = -18.5$