Note that the sign of the test statistics and, for one-sided tests, the critical value will depend on whether y – x or x – y is calculated.

1. A random sample of eleven students sat a Chemistry examination consisting of one theory paper and one practical paper. Their marks out of 100 are given in the table below.

Student	Theory Mark	Practical Mark
A	30	52
B	42	58
C	49	42
D	50	67
E	63	94
F	38	68
G	43	22
H	36	34
I	54	55
J	42	48
K	26	17

   Assuming differences in pairs to be normally distributed, test, at the 5% significance level, the hypothesis of no difference in mean mark on the two papers

2. A convenience food, known at 'Quicknosh', was introduced into the British market in 1992. After a poor year for sales, the manufacturers initiated an intensive advertising campaign during January 1993. The table records the sales, I thousands of pounds, for a one-month period before and a one-month period after the advertising campaign, for each of eleven regions.

Region	Sales Before Campaign	Sales After Campaign
A	2.4	3.0
B	2.6	2.5
C	3.9	4.0
D	2.0	4.1
E	3.2	4.8
F	2.2	2.0
G	3.3	3.6
H	2.1	4.0
I	3.1	3.3
J	2.2	4.2
K	2.8	3.9

   Determine, at the 5% level of significance, whether an increase in mean sales has occurred by using the t-test for paired values.

3. In an investigation to compare the accuracy of Crackshot and Fastfire 12-nore shotguns in clay pigeon shooting, ten competitors each fired 100 shots with each make of gun. Their scores are shown in the table.

Competitor	Crackshot	Fastfire
A	93	87
B	99	91
C	90	86
D	86	87
E	85	78
F	94	95
G	87	89
H	91	84
I	96	88
J	79	74

It may be assumed that the differences between pairs of scores are approximately normally distributed. Examine the claim that the Crackshot shotgun is the more accurate for clay pigeon shooting using the 5% level of significance.

4. In a study of memory recall, 12 students were given 10mins to try to memorize a list of 20 nonsense words. Each student was then asked to list as many of the words as he or she could remember both one hour and 24hours later. The numbers of words recalled correctly by each student are shown below:

Student	1 hours later	24 hours later
A	14	10
B	9	6
C	18	14
D	12	6
E	13	8
F	17	10
G	16	12
H	16	10
I	19	14
J	8	5
K	15	10
L	7	5

Stating any necessary assumptions, use a paired t-test to examine, at the 5% significance level, the claim that, for all such students, the mean number of words recalled after one hour exceeds that recalled after 24 hours by 5 words

5. The temperature of the earth may be measured either by thermometers on the ground (x) which is accurate but a tedious method, or by sensors mounted in space satellites (y) which is a less accurate method and may be biased. The following table gives readings (^oC) taken by both methods at eleven sites.

Site	Ground Therm.	Satellite Sensors
1	4.6	4.7
2	17.3	19.5
3	12.2	12.5
4	3.6	4.2
5	6.2	6.0
6	14.8	15.4
7	11.4	14.9
8	14.9	17.8
9	9.3	9.7
10	10.4	10.5
11	7.2	7.4

Given that all readings are normally distributed, investigate the hypothesis that the satellite sensors give, on average, significantly higher readings than the ground thermometers. Use the 5% level of significance.

6. Two analyzers are used in a hospital laboratory to measure blood creatinine levels. (These are used as a measure of kidney functions) To compare the performance of the two machines, a technician took eight specimens of blood and measured the creatinine level (in micromoles per liter) of each specimen using each machine. The results were as follows:

Specimen	Analyzer A	Analyzer B
1	119	106
2	173	153
3	100	83
4	99	95
5	77	69
6	121	123
7	84	84
8	73	67

The technician carried out a paired t-test and reported that there was a difference between analyzers at the 5% significance level. Verify that this is in fact the case, assuming a normal distribution

7. Two trainee estate agents, I and II, each valued independently a random sample of eight small properties. The valuations, in £000s are shown below

Property	Trainee I	Trainee II
A	83.7	79.6
B	58.8	59.2
C	77.7	75.8
D	85.1	84.3
E	91.9	90.1
F	66.4	65.2
G	69.8	66.9
H	48.5	53.8

Stating any assumptions necessary, use a paired t-test and the 5% level of significance to investigate whether there is evidence that the two trainees differ, on average in their valuations

8. As part of an investigation into the effects of alcohol on the human body at high altitude, ten male subjects were taken to a simulated altitude of 8000m and given several tasks to perform. Each subject was carefully observed for deterioration in performance due to lack of oxygen, and the time, in seconds, at which useful consciousness ended was recorded. Three days later, the experiment was repeated one hour after the same ten subjects had unknowingly consumed 1ml of 100% proof alcohol per 5kg of body weight. The time, in seconds, of useful consciousness was again recorded. The resulting data are given below

Subject	No alcohol	Alcohol
1	260	185
2	565	375
3	900	310
4	630	240
5	280	215
6	365	420
7	400	405
8	735	205
9	430	255
10	900	900

Using an appropriate parametric test, determine , using the 5% significance level, whether or not these data support the hypothesis that the consumption of the stated amount of alcohol reduces the mean time of useful consciousness at high altitudes.

9. Trace metals in drinking water affect the flavor of the water and high concentrations can pose a health hazard. The following table shows the zinc concentrations, in milligrams per 1000 liters, of water on the surface and on the river bed at each of 12 locations on the river

Location	Surface	Bed
1	387	435
2	515	532
3	721	817
4	341	366
5	689	827
6	599	735
7	734	812
8	541	669
9	717	808
10	523	622
11	524	576
12	445	487

Differences in zinc concentrations of water in this river may be assumed to be normally distributed.

Examine the claim, using the 5% significance level, that zinc concentration of water in this river is more than 50 milligrams per 1000 liters greater on the river bed than on the surface.

10. A sample of topsoil and a sample of subsoil were taken from each of eight randomly select6ed agricultural locations in a particular county.

Each soil sample was analyzed to determine its pH value with the following results

Location	Topsoil pH	Subsoil pH
A	6.58	6.78
B	5.98	6.14
C	5.69	5.80
D	5.91	6.07
E	5.98	6.10
F	6.19	6.01
G	6.23	6.18
H	5.68	5.88

(a) Use a paired t-test at the 5% significance level, to investigate for a mean difference in pH between topsoil and subsoil in the county

It is suggested that an F-test could be used to compare the variability in pH between topsoil and subsoil

(b) State why such a test would not be appropriate if applied to the above data