1. Suppose a manufacturer claims that the mean lifetime of a light bulb is at least 10,000 hours. In a sample of 30 light bulbs, it was found that they only last 9,900 hours on average. Assuming the population standard deviation to be 120 hours, at 0.05 significance level, can we reject the claim by the manufacturer?

Step1 : State Null and Alternative hypothesis.

H_o: $\mu \geq 10000$, H_1 : $\mu < 10000$; This implies a lower tail test

Remember: The position of the tail is dependent on H_1.

*If H_1 includes a < sign, then the **lower tail** is used.*

*If H_1 includes a > sign, then the **upper tail** is used.*

Step2 : Choose Statistic:

Given: sample size n = 30, sample mean ⍰´ = 9900, Population standard deviation σ = 120.

As the population standard deviation is given and sample size is large enough, we can choose z-statistic; Statistic = $(\bar{x} - \mu) / (\sigma/\sqrt{n})$

Step 3: Specify Significance level:

$\alpha = 0.05$

Step 4: Determine critical region; Compute critical value

The critical value @ 0.05 signif is = qnorm(0.05) = -1.64. (because it is lower tailed test)

Z-critical value = -1.64

Step 5: Determine the statistic value, and find its p-value;

Z-calculated = $(\bar{x} - \mu) / (\sigma/\sqrt{n}) = -4.56$

p-value in z-table for -4.56 does not exist in table, implies that its too small.

Step 6 : Does the calculated sample statistic value lie in the critical region?

- *Method 1: If Z-calculated is << Z-critical (in lower tail test) Or if If Z-calculated is >> Z-critical (in upper tail test), it implies the sample statistic we calculated is in critical region, which tells that we have enough evidence to reject the Null Hypothesis*

Method 2: If the p-value of Z-calculated is << p-value of Z-critical (in lower tail test) Or if the p-value Z-calculated is >> p-value of Z-critical (in upper tail test), it implies the sample statistic we calculated is in critical region, which tells that we have enough evidence to reject the Null Hypothesis

Now, as Z-calculated(-4.56) is << Z-critical(-1.64) (in lower tail test), the z-calculated is in critical region

Step 7: Make your decision:

We reject the Null hypothesis

2. Suppose a car manufacturer claims a model gets at least 25 mpg. A consumer group asks 10 owners of this model to calculate their mpg and the mean value was 22 with a standard deviation of 1.5. Is the manufacturer's claim supported at 95%confidence level.

Ans. R-code

```{r}
rm(list=ls(all=TRUE))
# Ho: mu >= 25, Ha : mu < 25.
n = 10
xBar = 22
mu = 25
s = 1.5
alpha = 0.05
# Since sample size is small, we will use Student's t distribution here.  This is lower tailed test.
se = s/sqrt(n)
test_Statistic = (xBar - mu)/ se
degrees_Of_Freedom = n-1
tValue= qt(alpha, degrees_Of_Freedom)
test_Statistic
tValue
# We reject the NUll Hypothesis since the observation falls in rejection/critical region.
```

3. An outbreak of Salmonella-related illness was attributed to ice cream produced at a certain factory. Scientists measured the level of Salmonella in 9 randomly sampled batches of ice cream. The levels (in MPN/g) were: *0.593 0.142 0.329 0.691 0.231 0.7930.519 0.392 0.418.* Is there evidence that the mean level of Salmonella in the ice cream is greater than 0.3 MPN/g.

Ans. R-code

```{r}
rm(list=ls(all=TRUE))
# One-sample t-tests
# H0 <= 0.3 vs H1 > 0.3
Salmonella_level = c(0.593, 0.142, 0.329, 0.691, 0.231, 0.793, 0.519, 0.392, 0.418)

######### t-test ###########################
# General form
```

```
#t.test(x, y = NULL, alternative = c("two.sided", "less", "greater"), mu = 0, paired = FALSE, var.equal = FALSE, conf.level = 0.95)

t.test(Salmonella_level, alternative="greater", mu=0.3)
tValue= qt(0.95, 8)
tValue

# Since test statistic value t = 2.2051 >tValue, we reject the null hypothesis.
```

4. A study was performed to test whether cars get better mileage on premium gas than on regular gas. Each of 10 cars was first filled with either regular or premium gas, decided by a coin toss, and the mileage for that tank was recorded. The mileage was recorded again for the same cars using the other kind of gasoline. Test to determine whether cars get significantly better mileage with premium gas.

   Reg : 16, 20, 21, 22, 23, 22, 27, 25, 27, 28.

   Prem : 19, 22, 24, 24, 25, 25, 26, 26, 28, 32.

   Ans. R-code

```{r}
rm(list=ls(all=TRUE))
#H0: Mileage on premium gas <= Mileage on regular gas
#H1: Mileage on premium gas > Mileage on regular gas
# A study was performed to test whether cars
# Below is the relevant R-code:
prem = c(19, 22, 24, 24, 25, 25, 26, 26, 28, 32)
reg = c(16, 20, 21, 22, 23, 22, 27, 25, 27, 28)
t.test(prem,reg,alternative="greater", paired=TRUE)
tValue= qt(0.95, 9)
tValue
# Since test statistic value t >tValue, we reject the null hypothesis.
```