Topics: Normal distribution, Functions of Random Variables

1. The time required for servicing transmissions is normally distributed with μ = 45 minutes and σ = 8 minutes. The service manager plans to have work begin on the transmission of a customer's car 10 minutes after the car is dropped off and the customer is told that the car will be ready within 1 hour from drop-off. What is the probability that the service manager cannot meet his commitment?

   A. 0.3875
   B. 0.2676
   C. 0.5
   D. 0.6987

Ans We have a normal distribution with = 45 and = 8.0. Let X be the amount of time i
t takes to complete the repair on a customer's car. To finish in one hour you must have X ≤ 50 so the question is to find Pr(X > 50).
Pr(X > 50) = 1 -Pr(X ≤ 50).
Z = (X -)/ = (X -45)/8.0
Thus the question can be answered by using the normal table to find
Pr(X ≤ 50) = Pr(Z ≤ (50 -45)/8.0) = Pr(Z ≤ 0.625)=73.4%
Probability that the service manager will not meet his demand will be = 100-73.4 = 26.6% or 0.2676

2. The current age (in years) of 400 clerical employees at an insurance claims processing center is normally distributed with mean μ = 38 and Standard deviation σ=6. For each statement below, please specify True/False. If false, briefly explain why.
   A. More employees at the processing center are older than 44 than between 38 and 44.
   B. A training program for employees under the age of 30 at the center would be expected to attract about 36 employees.

Ans We have a normal distribution with = 38 and = 6. Let X be the number of employees. So according to question
a)Probabilty of employees greater than age of 44= Pr(X>44)
Pr(X > 44) = 1 -Pr(X ≤ 44).
Z = (X -)/ = (X -38)/6
Thus the question can be answered by using the normal table to find
Pr(X ≤ 44) = Pr(Z ≤ (44 -38)/6) = Pr(Z ≤ 1)=84.1345%
Probabilty that the employee will be greater than
age of 44 = 100-84.1345=15.86%
So the probability of number of employees between 38-44 years of age
= Pr(X<44)-0.5=84.1345-0.5= 34.1345%
Therefore the statement that "More employees at the processing center are older than 44 than between 38 and 44" is TRUE.
b) Probabilty of employees less than age of 30 = Pr(X<30).

Z = (X -)/ = (30 -38)/6
Thus the question can be answered by using the normal table to find
Pr(X ≤ 30) = Pr(Z ≤ (30 -38)/6) = Pr(Z ≤ -1.333)=9.12%
So the number of employees with probability 0.912 of them being under age 30
=0.0912*400=36.48(or 36 employees).
Therefore the statement B of the question is also TRUE

3. If $X_1 \sim N(\mu, \sigma^2)$ and $X_2 \sim N(\mu, \sigma^2)$ are *iid* normal random variables, then what is the difference between 2 X_1 and $X_1 + X_2$? Discuss both their distributions and parameters.

Ans As we know that if X ∼N(μ1, σ1^2), and Y ∼N(μ2, σ2^2) are two independent random variables then X + Y ∼N(μ1 + μ2, σ1^2 + σ2^2) , and X − Y ∼N(μ1 − μ2, σ1^2 + σ2^2) .
Similarly if Z = aX + bY , where X and Y are as defined above, i.e Z is linear combination of X andY , then Z ∼N(aμ1 + bμ2, a^2σ1^2 + b^2σ2^2).
Therefore in the question
2X1~ N(2 u,4 σ^2) and
X1+X2 ~ N(μ + μ, σ^2 + σ^2) ~ N(2 u, 2σ^2)
2X1-(X1+X2) = N(4μ,6 σ^2)

4. Let X ~ N(100, 20^2). Find two values, *a* and *b*, symmetric about the mean, such that the probability of the random variable taking a value between them is 0.99.

   A. 90.5, 105.9
   B. 80.2, 119.8
   C. 22, 78
   D. 48.5, 151.5
   E. 90.1, 109.9

Ans. Since we need to find out the values of a and b, which are symmetric about the mean, such that the probability of random variable taking a value between them is 0.99, we have to,workout in reverse order.
The Probability of getting value between a and b should be 0.99.
So the Probability of going wrong, or the Probability outside the a and b area is 0.01 (ie. 1-0.99).
The Probability towards left from a = -0.005 (ie. 0.01/2).
The Probability towards right from b = +0.005 (ie. 0.01/2).
So since we have the probabilities of a and b, we need to calculate X, the random variable at a and b which has got these probabilities.
By finding the Standard Normal Variable Z (Z Value), we can calculate the X values.
Z=(X-μ) / σ
For Probability 0.005 the Z Value is -2.57 (from Z Table).
Z * σ + μ = XZ(-0.005)*20+100 = -(-2.57)*20+100 = 151.4
Z(+0.005)*20+100 = (-2.57)*20+100 = 48.6
So, option D is correct.

5. Consider a company that has two different divisions. The annual profits from the two divisions are independent and have distributions $Profit_1 \sim N(5, 3^2)$ and $Profit_2 \sim N(7, 4^2)$ respectively. Both the profits are in $ Million. Answer the following questions about the total profit of the company in Rupees. Assume that $1 = Rs. 45
    A. Specify a Rupee range (centered on the mean) such that it contains 95% probability for the annual profit of the company.
    B. Specify the 5th percentile of profit (in Rupees) for the company
    C. Which of the two divisions has a larger probability of making a loss in a given year?

Ans.
```
import numpy as np

from scipy import stats

from scipy.stats import norm

Mean = 5+7

print('Mean Profit is Rs', Mean*45,'Million')

SD = np.sqrt((9)+(16))

print('Standard Deviation is Rs', SD*45, 'Million')

print('Range is Rs',(stats.norm.interval(0.95,540,225)),'in Millions')

X= 540+(-1.645)*(225)

print('5th percentile of profit (in Million Rupees) is',np.round(X,))

print('Range is Rs',(stats.norm.interval(0.95,540,225)),'in Millions')

X= 540+(-1.645)*(225)

print('5th percentile of profit (in Million Rupees) is',np.round(X,))

stats.norm.cdf(0,5,3)

stats.norm.cdf(0,7,4)
```