# Solution to Gaussian 9.3.10

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Question A bag consists of 10 balls each marked with one of the digits 0 to 9. If 4 balls are drawn successively with replacement from the bag, what is the probability that none is marked with the digit 0?
**Solution:**

| Parameter | Values | Description |
|-----------|--------|-------------|
| $n$ | 4 | Number of balls drawn |
| $p$ | 0.1 | Probability that the ball drawn is marked zero |
| $\mu = np$ | 0.4 | Mean of distribution |
| $\sigma^2 = np\,(1-p)$ | 0.36 | Variance of distribution |
| $Y$ | 0,1,2,3,4 | Number of balls drawn which are zero |

$$Y \sim \mathcal{N}\left(\mu, \sigma^2\right) \tag{1}$$

The gaussian distribution function is defined as:

$$p_Y(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \tag{2}$$

The probability that none of the balls drawn is marked with zero is given by:

$$p_Y(0) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(-\mu)^2}{2\sigma^2}} \tag{3}$$

$$= 0.532 \tag{4}$$

**Using Binomial:** Let X be a random variable which denotes the number of balls drawn that are marked with zero,

$$p_X(k) = {}^nC_k p^k (1-p)^{n-k} \tag{5}$$
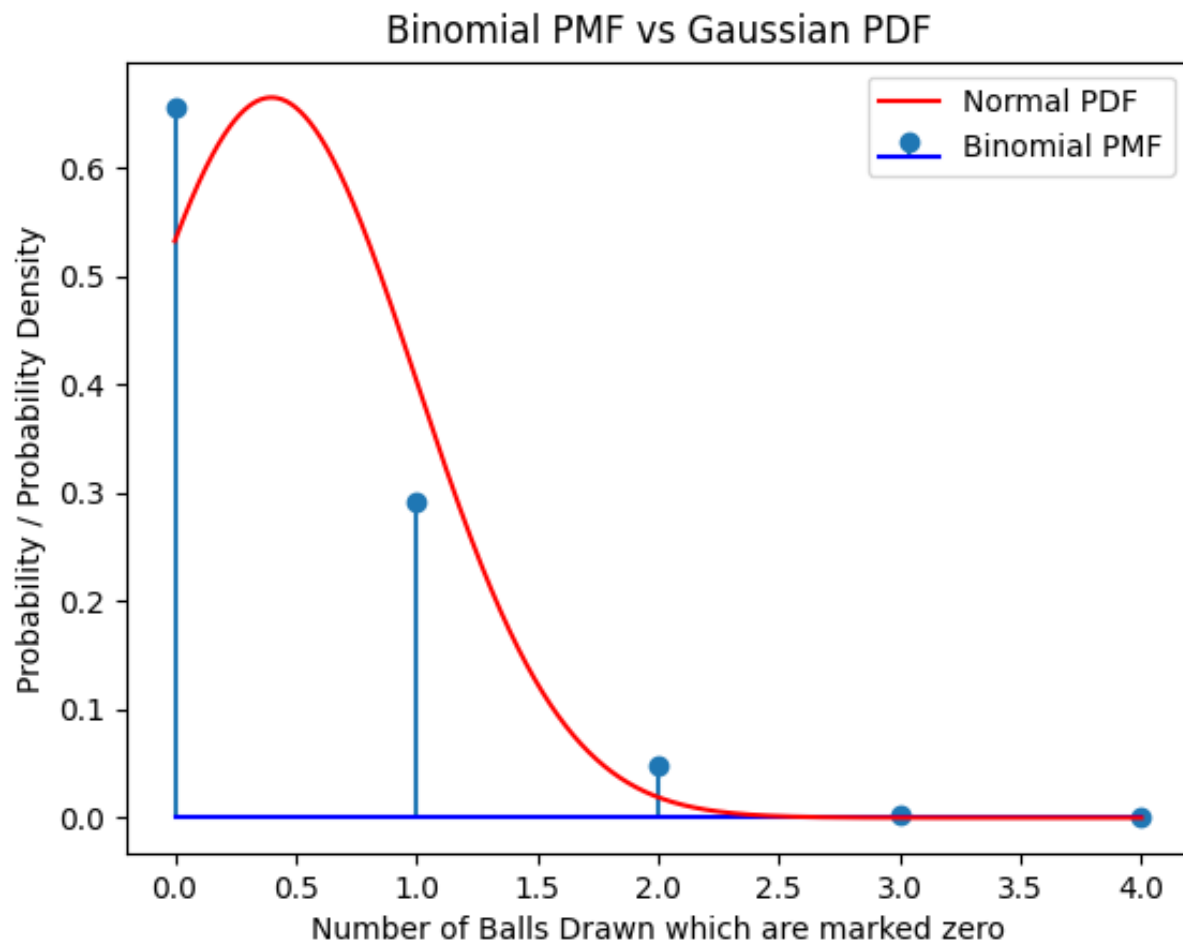
$$p_X(0) = {}^4C_0 (0.1)^0 (0.9)^4 \tag{6}$$

$$= 0.6561 \tag{7}$$

Fig. 0. Binomial PMF vs Gaussian PDF