

## MAT 1034 INTRODUCTION TO PROBABILITY

## Chapter 4: Multivariate Probability Distribution

**1. Joint Probability Distributions**

Our study of random variables and their probability distributions in the preceding chapters is restricted to one-dimensional sample spaces, where we recorded outcomes of an experiment as values assumed by a single random variable. There will be situations, however, where we may find it desirable to record the simultaneous outcomes of several variables. For example:

1. We might measure the amount of precipitate  $P$  and volume  $V$  of gas released from a controlled chemical experiment, giving rise to a two-dimensional sample space consisting of the outcomes  $(p, v)$ .
2. We might be interested in the hardness  $H$  and tensile strength  $T$  of cold-drawn copper, resulting in the outcomes  $(h, t)$ .
3. In a study to determine the likelihood of success in college based on high school data, we might use a three-dimensional sample space and record for each individual his or her aptitude test score, high school class rank, and grade-point average at the end of freshman year in college.

If  $X$  and  $Y$  are two discrete random variables, the probability distribution for their simultaneous occurrence can be represented by a function with values  $f(x, y)$  for any pair of values  $(x, y)$  within the range of the random variables  $X$  and  $Y$ . This function is referred to as the joint probability distribution of  $X$  and  $Y$ .

Hence, in the discrete case,

$$f(x, y) = P(X = x, Y = y)$$

that is, the values  $f(x, y)$  give the probability that outcomes  $x$  and  $y$  occur at the same time.

**Definition 1.1**

The function  $f(x, y)$  is a joint probability distribution or probability mass function of the discrete random variables  $X$  and  $Y$  if

1.  $f(x, y) \geq 0$  for all  $(x, y)$
2.  $\sum_x \sum_y f(x, y) = 1$
3.  $P(X = x, Y = y) = f(x, y)$

For any region  $A$  in the  $xy$  plane,  $P[(X, Y) \in A] = \sum_x \sum_y f(x, y)$

# Chapter 4 Multivariate Probability And Statistics

**SJ Ball**



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