PGE 337 Supplemental Lecture
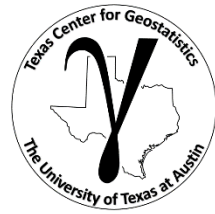
Lecture outline . . .

- Marginal, Conditional and Joint Probabilities
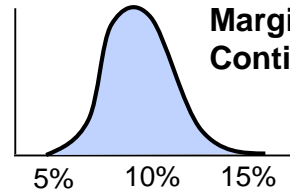
Marginal, Conditional and Joint Probability
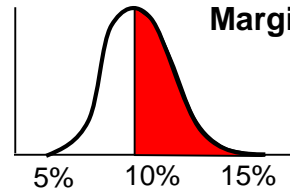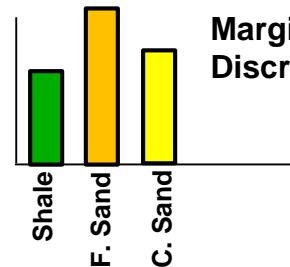
The Reservoir

Porosity at u_0? What kind of distribution is that?

Marginal Distribution
Continuous Probability Density Function

5%   10%   15%

Marginal Probability, Event A: $\varphi > 10\%$

5%   10%   15%

Marginal Distribution
Discrete Probability Density Function

Shale   F. Sand   C. Sand

Marginal Probability, Event B: Facies = C. Sand

Shale   F. Sand   C. Sand

Marginal, Conditional and Joint Probability

The Reservoir

Porosity and Permeability at u_0? What kind of distribution is that?

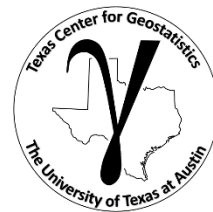**Joint Distribution**
Continuous Joint Probability Density Function

Joint Probability
Event A: 12% < φ < 14% and 600mD < k < 900mD
P(12% < φ < 14% ∩ 600mD < k < 900mD)

Joint Probability Density Function
Binned
(0% bins removed)

Univariate, Marginal Examples

Marginal Distribution
Continuous Probability Density Function

Marginal Probability, Event A: φ > 10%
P(φ > 10%)
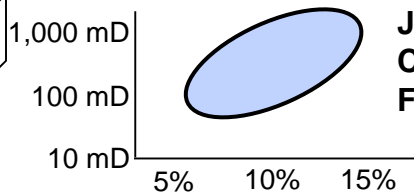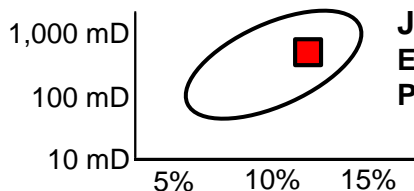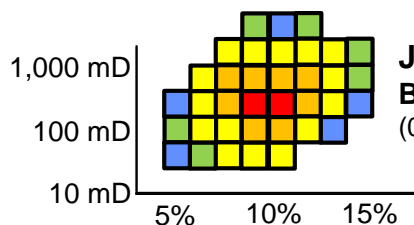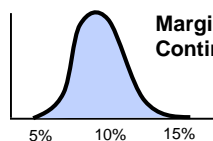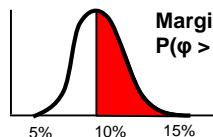

Marginal Distribution
Discrete Probability Density Function

Shale   F. Sand   C. Sand

Marginal Probability, Event B: Facies = C. Sand

Shale   F. Sand   C. Sand

Marginal, Conditional and Joint Probability

The Reservoir

Permeability Given Porosity = φ_1 at u_0? What kind of distribution is that?

Conditional Distribution
Continuous Conditional Probability Density Function

1,000 mD
100 mD
10 mD
5%   10%   15%

Conditional Probability
Event A: 12% < φ < 14% | 600mD < k < 900mD
P(12% < φ < 14% | 600mD < k < 900mD)

1,000 mD
100 mD
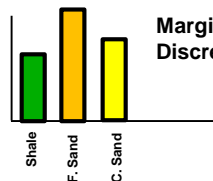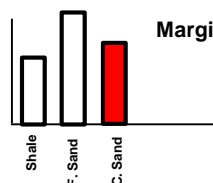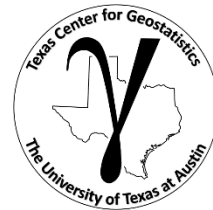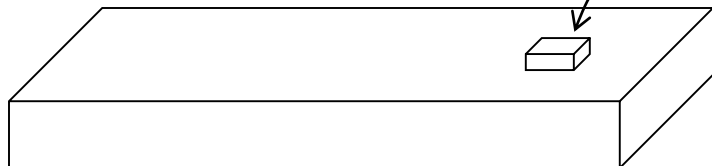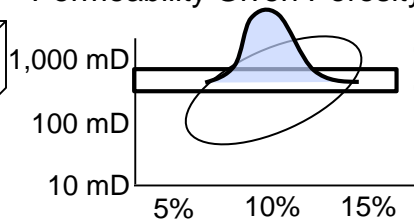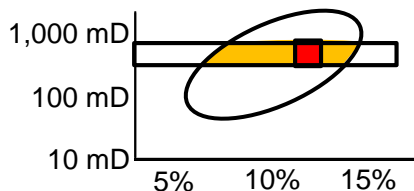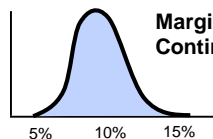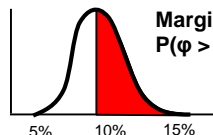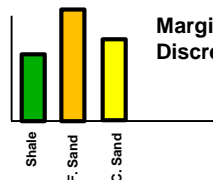10 mD
5%   10%   15%

Univariate, Marginal Examples

Marginal Distribution
Continuous Probability Density Function

5%   10%   15%

Marginal Probability, Event A: φ > 10%
P(φ > 10%)

5%   10%   15%

Marginal Distribution
Discrete Probability Density Function

Shale   F. Sand   C. Sand

Marginal Probability, Event B: Facies = C. Sand

Shale   F. Sand   C. Sand

Bivariate, Joint Examples

Joint Distribution
Continuous Joint Probability Density Function

1,000 mD
100 mD
10 mD
5%   10%   15%

Joint Probability
Event A: 12% < φ < 14% and 600mD < k < 900mD
P(12% < φ < 14% ∩ 600mD < k < 900mD)

1,000 mD
100 mD
10 mD
5%   10%   15%

Joint Probability Density Function
Binned
(0% bins removed)

1,000 mD
100 mD
10 mD
5%   10%   15%

Marginal, Conditional and Joint Probability

The Reservoir

Univariate, Marginal Examples

Marginal Distribution
Continuous Probability Distribution Function

5%   10%   15%

Marginal Probability, Event A: φ > 10%
P(φ > 10%)

5%   10%   15%

Marginal Distribution
Discrete Probability Distribution Function

Shale   F. Sand   C. Sand

Marginal Probability, Event B: Facies = C. Sand

Shale   F. Sand   C. Sand

Bivariate, Conditional Examples

1,000 mD

100 mD

10 mD

5%   10%   15%

Conditional Distribution
Continuous Conditional Probability Density Function

1,000 mD

100 mD

10 mD

5%   10%   15%

Conditional Probability
Event A: 12% < φ < 14% | 600mD < k < 900mD
P(12% < φ < 14% | 600mD < k < 900mD)

Bivariate, Joint Examples

1,000 mD

100 mD

10 mD

5%   10%   15%

Joint Distribution
Continuous Joint Probability Density Function

1,000 mD

100 mD

10 mD

5%   10%   15%

Joint Probability
Event A: 12% < φ < 14% and 600mD < k < 900mD
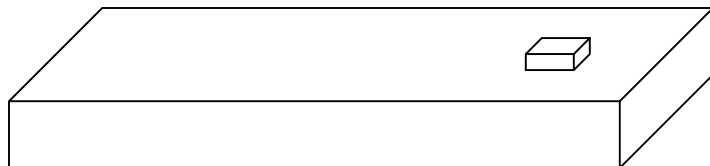**P(12% < φ < 14% ∩ 600mD < k < 900mD)**

1,000 mD

100 mD

10 mD

5%   10%   15%
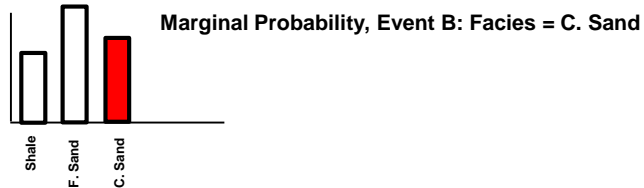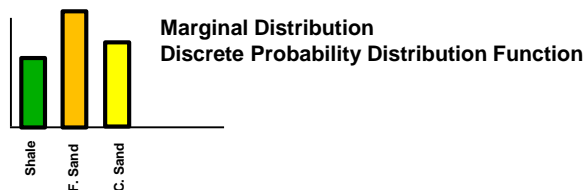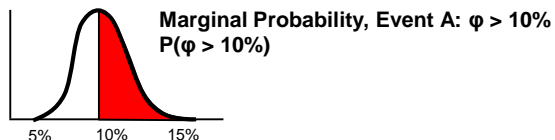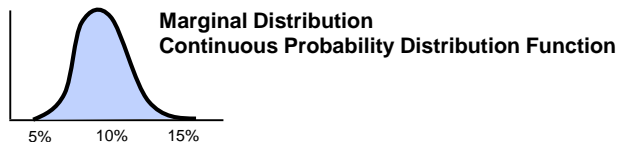
Joint Probability Density Function
Binned
(0% bins removed)

Marginal, Conditional and Joint Probability

The Reservoir

How to Calculate a Marginal Distribution from a Joint Distribution?

Joint Distribution
Continuous Joint Probability Density Function

Definition of a Marginal Distribution

$$f_X(x) = \int_{-\infty}^{+\infty} f_{XY}(x,y)\,dy \quad \text{or} \quad f_Y(y) = \int_{-\infty}^{+\infty} f_{XY}(x,y)\,dx$$

Marginal, Conditional and Joint Probability

The Reservoir

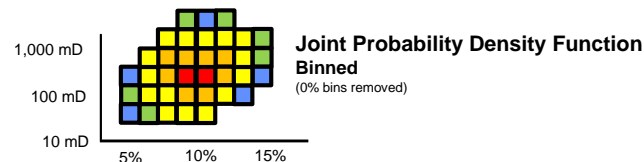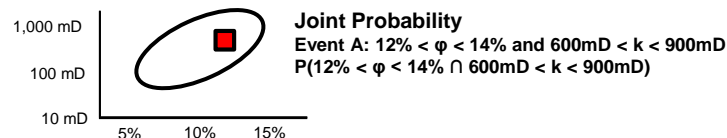Calculate a Conditional Distribution from a Joint Distribution?

Joint Distribution
Continuous Joint Probability Density Function

Definition of a Marginal Distribution

$$f_X(x) = \int_{-\infty}^{+\infty} f_{XY}(x,y)dy \quad \textbf{or} \quad f_Y(y) = \int_{-\infty}^{+\infty} f_{XY}(x,y)dx$$

Definition of a Conditional Distribution

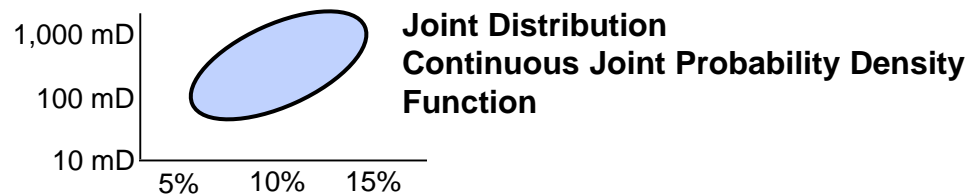$$f_{X|Y}(x \mid y) = \frac{f_{XY}(x,y)}{f_Y(y)} \quad \textbf{or} \quad f_{Y|X}(y \mid x) = \frac{f_{XY}(x,y)}{f_X(x)}$$
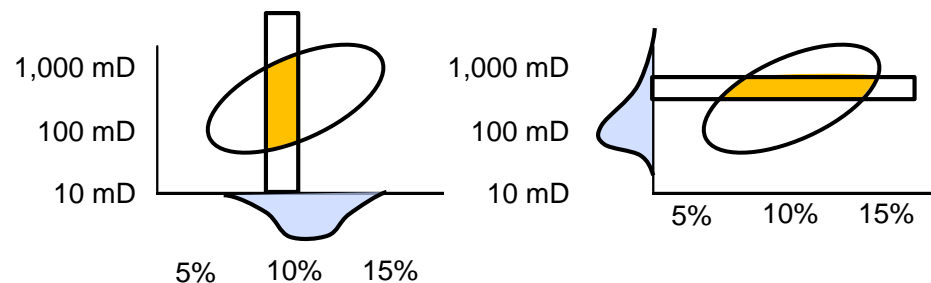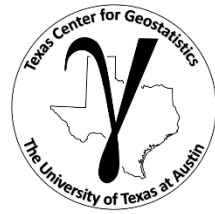
Marginal, Conditional and Joint Probability

The Reservoir

How to Calculate a Joint Distribution?

Definition of a Marginal Distribution

$$f_X(x) = \int_{-\infty}^{+\infty} f_{XY}(x,y)\,dy \quad \textbf{or} \quad f_Y(y) = \int_{-\infty}^{+\infty} f_{XY}(x,y)\,dx$$
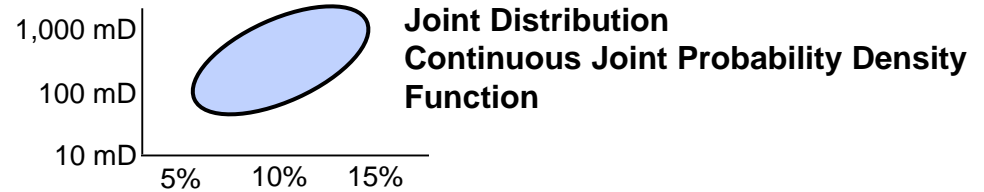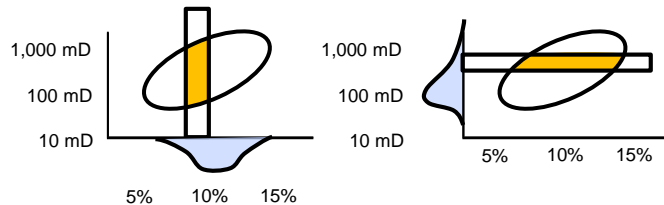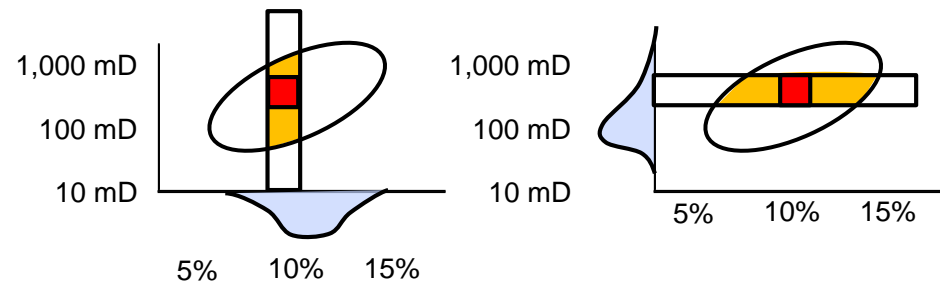

Definition of a Conditional Distribution

$$f_{X|Y}(x\,|\,y) = \frac{f_{XY}(x,y)}{f_Y(y)} \quad \textbf{or} \quad f_{Y|X}(y\,|\,x) = \frac{f_{XY}(x,y)}{f_X(x)}$$

Marginal, Conditional and Joint Probability

The Reservoir

How to Calculate a Joint Distribution?

Definition of a Marginal Distribution

$$f_X(x) = \int_{-\infty}^{+\infty} f_{XY}(x,y)dy \quad \text{or} \quad f_Y(y) = \int_{-\infty}^{+\infty} f_{XY}(x,y)dx$$
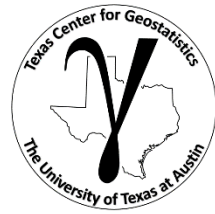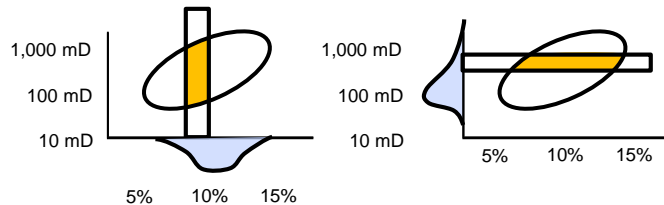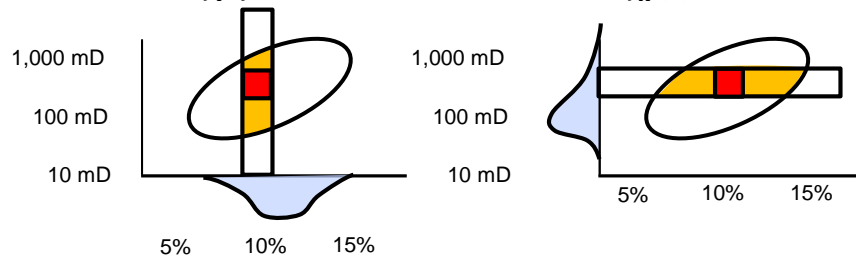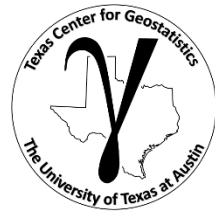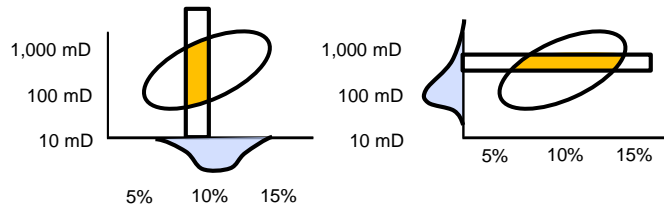
Definition of a Conditional Distribution

$$f_{X|Y}(x \mid y) = \frac{f_{XY}(x,y)}{f_Y(y)} \quad \text{or} \quad f_{Y|X}(y \mid x) = \frac{f_{XY}(x,y)}{f_X(x)}$$

Non-parametric - Counting Samples in Bins

	5%		10%		15%
1,000 mD	0	0	0	1	1
	0	1	2	3	1
100 mD	0	2	2	1	0
	1	3	2	1	0
10 mD	1	1	1	0	0

Fitting a Parametric Model

	5%		10%		15%
1,000 mD	0	0	0	4%	4%
	0	4%	8%	12%	4%
100 mD	0	8%	8%	4%	0
	4%	12%	8%	4%	0
10 mD	4%	4%	4%	0	0

Prof. Michael Pyrcz, Ph.D., P.Eng., the University of Texas at Austin, PGE 337 - Introduction to Geostatistics, @GeostatsGuy
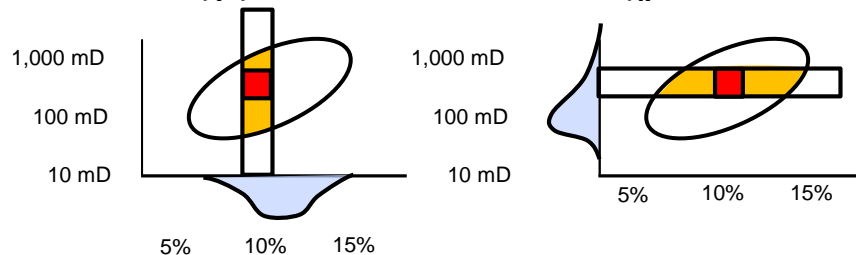
Marginal, Conditional and Joint Probability
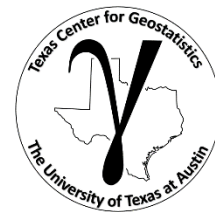
Learning Objectives:

- What is **Marginal, Conditional and Joint Probabilities**?

- How to calculate **Marginal, Conditional and Joint Probabilities**?