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Stat 104: Quantitative Methods

Class 8: Basic Probability Theory

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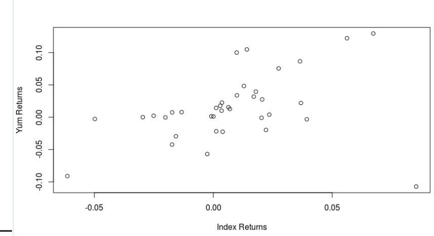
Quick Beta Review

- Regress stock returns on index returns



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Quick Beta Review

Yum! Brands, Inc. (YUM)

NYSE - Nasdaq Real Time Price. Currency in USD

Add to watchlist

77.25 +0.08 (+0.10%)

As of 12:39PM EDT. Market open.

Summary | Conversations | Statistics | Profile | Financials | Options | Holders | Histori

Previous Close	77.17	Market Cap	26.63B
Open	77.10	Beta	0.69
Bid	77.16 x 400	PE Ratio (TTM)	20.51
Ask	77.17 x 200	EPS (TTM)	3.77
Day's Range	76.89 - 77.57	Earnings Date	Oct 3, 2017 - Oct 9, 2017
52 Week Range	59.57 - 78.14	Dividend & Yield	1.20 (1.57%)
Volume	527,136	Ex-Dividend Date	2017-07-12
Avg. Volume	1,775,592	1y Target Est	79.37

1D 5D 1M 6M YTD 1

10 AM 12 PM

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Quick Beta Review

- The need for understanding uncertainty is important.

```
> fit=lm(yumret~spyret)
> coef(fit)
(Intercept)       spyret
0.009313668 0.665483628

> confint(fit)
                    2.5 %     97.5 %
(Intercept) -0.007322573 0.02594991
spyret       0.102563508 1.22840375
```

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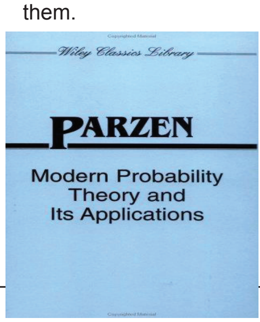
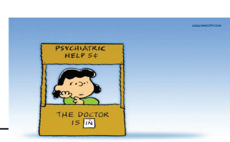
Mike and His Many Issues……

- I have many issues (surprise) and of course probability is one of them.



Hmmm. My name on a book-maybe I should read it someday??



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What is probability ?

- Probability is a measure of uncertainty.
- We can try to compute the probability of almost any **event** of interest.
- An **event** is the basic element to which probability can be applied; it is the result of an observation or experiment, or the description of some potential outcome.

Some examples of events

Example events we can assign probability to:

- Getting a head when we flip a coin
- Coca-Cola stock rises 5% next week
- Ford will produce a hybrid SUV that gets 50mpg by 2018.

Probability is important

Probability is useful to study since uncertainty plays a major role in economic decisions:

- Will our new product be successful ?
- How many yen will a dollar buy in currency markets a month from today?
- Will the manufactured part be defective ?
- Given you took a test drive, will you buy the car ?

Most people don't get probability

- Unfortunately, most people do not attempt to evaluate probability in a quantitative way. Instead, they rely on intuition, doubtful logic, misinterpreted experience, and emotion.
- As the famous American jurist, Oliver Wendell Holmes, put it: *Most people think dramatically, not quantitatively.*
- This section should help you start thinking about probability (uncertainty) in a clearer fashion and hence make more informed decisions.

The birthday problem

Often times, the results of using probability theory are surprising (to me at least).

- How many people need to be a room together so that there is a more than 50% chance of two people having the same birthday?

A) 300 **B) 183**

C) 91 **D) 23**

Number of people	Probability that 2 people share a birthday
10	
20	
23	
30	
50	
57	
100	
200	
366	100%

Last 40 Oscar-winning Best Actress Birthdays

Sandra Bullock	Jul 26
Kate Winslet	Oct 5
Marion Cotillard	Sep 30
Helen Mirren	Jul 26
Reese Witherspoon	Mar 22
Hilary Swank	Jul 30
Charlize Theron	Aug 7
Nicole Kidman	Jun 20
Halle Berry	Aug 14
Julia Roberts	Oct 28
Gwyneth Paltrow	Sep 27
Helen Hunt	Jun 15
Frances McDormand	Jun 23
Susan Sarandon	Oct 4
Jessica Lange	Apr 20
Holly Hunter	Mar 20
Emma Thompson	Apr 15
Jodie Foster	Nov 19
Kathy Bates	Jun 28
Jessica Tandy	Jun 7

Cher	May 20
Marlee Matlin	Aug 24
Geraldine Page	Nov 22
Sally Field	Nov 6
Shirley MacLaine	Apr 24
Meryl Streep	May 27
Katharine Hepburn	May 12
Sissy Spacek	Dec 25
Jane Fonda	Dec 21
Diane Keaton	Jan 5
Faye Dunaway	Jan 14
Louise Fletcher	Jul 22
Ellen Burstyn	Dec 7
Glenda Jackson	May 9
Liza Minnelli	Mar 12
Maggie Smith	Dec 28
Barbra Streisand	Apr 24
Elizabeth Taylor	Feb 27
Sophia Loren	Sep 20
Anne Bancroft	Sep 17

Last 40 Oscar-winning Best Actor Birthdays

Jeff Bridges	Dec 4
Daniel Day-Lewis	Apr 29
Forest Whitaker	Jul 15
Philip Seymour Hoffman	Jul 23
Jamie Foxx	Dec 13
Sean Penn	Aug 17
Adrien Brody	Apr 14
Denzel Washington	Dec 28
Russell Crowe	Apr 7
Kevin Spacey	Jul 26
Roberto Benigni	Oct 27
Jack Nicholson	Apr 22
Geoffrey Rush	Jul 6
Nicolas Cage	Jan 7
Tom Hanks	Jul 9
Al Pacino	Apr 25
Anthony Hopkins	Dec 31
Jeremy Irons	Sep 19
Dustin Hoffman	Aug 8
Michael Douglas	Sep 25

Paul Newman	Jan 26
William Hurt	Apr 20
F. Murray Abraham	Oct 24
Robert Duvall	Jan 5
Ben Kingsley	Dec 31
Henry Fonda	May 16
Robert De Niro	Aug 17
Jon Voight	Dec 29
Richard Dreyfuss	Oct 29
Peter Finch	Sep 28
Art Carney	Nov 4
Jack Lemmon	Feb 8
Marlon Brando	Apr 3
Gene Hackman	Jan 30
George C. Scott	Oct 18
John Wayne	May 26
Cliff Robertson	Sep 9
Rod Steiger	Apr 14
Paul Scofield	Jan 21
Lee Marvin	Feb 19

Random Experiments

- Probability deals with random experiments.
- But we put some structure on the random experiments and assume we know the possible <u>outcomes</u> that can occur on each trial of the phenomena.
- These <u>outcomes</u> can be defined in several ways.
- However, they must be <u>exhaustive</u> and <u>mutually exclusive</u>.

Properties of experiment outcomes

- <u>Exhaustive</u>: All possible results of the phenomena must be listed
- <u>Mutually exclusive</u>: It cannot be that the outcome of a phenomena can fall into two outcome categories simultaneously
- Sample space (S): A list of all possible outcomes from a random experiment S = {O1, O2,…, Ok}
- Note that the sample space could be infinite (we deal with that in a few classes).

Mutually Exclusive Events

- Two events are **mutually exclusive** if, when one event occurs, the other cannot, and vice versa

•**Experiment: Toss a die**

–A: observe an odd number

–B: observe a number greater than 2

Not Mutually Exclusive

–C: observe a 6

–D: observe a 3

Mutually Exclusive

Terminology Review

- A(n) (**random**) **<u>experiment</u>** is an activity involving chance. Each repetition or observation of an experiment is a **<u>trial</u>**, and each possible result is an **<u>outcome</u>**. The **<u>sample space</u>** of an experiment is the set of all possible outcomes.

Experiment	Rolling a number cube 	Tossing a coin 	Spinning a game spinner 
Sample Space	{1, 2, 3, 4, 5, 6}	{heads, tails}	{red, blue, green, yellow}

Example

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- We might study the random experiment of how \$AAPL closed today.
- We could define the events
  - {\$AAPL up, \$AAPL not up}
  - Or {\$AAPL up, \$AAPL unchanged, \$AAPL down}
  - Or {up more than 2%, up less than 2%, unchanged, down by less than 2%, down more than 2%}
  - Etc…

Examples

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It is useful to review these concepts with the help of the following example:

- \$AAPL rises and \$AAPL declines are mutually exclusive, but not collectively exhaustive outcomes.
- \$AAPL does not rise and \$AAPL does not decline are collectively exhaustive, but not mutually exclusive, outcomes.
- \$AAPL rises and \$AAPL does not rise are mutually exclusive and collectively exhaustive outcomes.

Example, random experiment=grade on an exam

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- Valid sample spaces:
  S = {Pass, Fail, Missed}
  S = {A, B, C, D, E, F, Missed}
  S = {[0,50),[50,60),[60,70),[70,80),[80,100], .}
- Invalid sample spaces (why?):
  S = {Fail}
  S = {[50,60),[60,70),[70,80),[80,100)}
  S = {[0,50),[50,100],[80,100], .}

Values of probabilities

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- We denote the probability of the event A as Prob(A), which we often abbreviate as Pr(A) or simply P(A).
- The probability of the event A is the chance that A will occur. Hence probabilities range from 0 (no chance of occurrence) to 1 (absolute chance of occurrence (a sure thing)).

$$0 \leq Prob(A) \leq 1$$

How is Probability Interpreted ?

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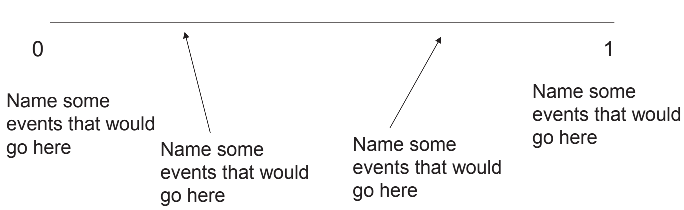

By the Way, How is Probability Defined?

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- We all know that the probability of getting a head when I flip a coin is 0.5.
- What about the probability of a 35 year old white male who hasn't smoked in 10 years of being diagnosed with lung cancer this year ?
- Where do probabilities come from ?

Three Types of Probability Assessment

- There are three basic ways of classifying probability. These three represent rather different conceptual approaches to the study of probability theory; in fact, experts disagree about which approach is the proper one to use. The three approaches are
    1) Subjective
    2) Logical
    3) Experimental

But the rules are the same……..

- Lucky for us, though, *no matter how the probabilities we work with are assigned*, be it objective or subjective, the rules governing the manipulation of the values are the same.
- So in some sense you can say forget this-but it is helpful to go over these different concepts once, just to understand some of the subtleties of probability theory.

Subjective Probabilities

- Subjective probability is the probability we assign to the outcome of an experiment that cannot be repeated. The growth of GNP next year is an experiment that can be observed only once, and thus cannot be assigned an objective probability.

- The importance of subjective probability stems from the fact that it is often an important input into decision making by groups and individuals.

Opinions on $ANF are Subjective

Upgrades & Downgrades History

Date	Research Firm	Action	From	To
Aug 23, 2013	Robert W. Baird	Downgrade	Outperform	**Neutral**
Aug 22, 2013	Janney	Downgrade	Buy	**Neutral**
Apr 2, 2013	Barclays	Initiated		**Underweight**
Dec 10, 2012	Robert W. Baird	Upgrade	Neutral	**Outperform**
Nov 14, 2012	Janney Mntgmy Scott	Upgrade	Neutral	**Buy**
Oct 3, 2012	Avondale	Initiated		**Mkt Perform**
Aug 2, 2012	Robert W. Baird	Downgrade	Outperform	**Neutral**
Aug 2, 2012	Caris & Company	Downgrade	Buy	**Average**
May 1, 2012	UBS	Upgrade	Neutral	**Buy**
Jan 9, 2012	Brean Murray	Downgrade	Buy	**Hold**

The main worry is that this person could be an idiot

❑Subjective probabilities are based on the belief of the person making the probability assessments.

❑In fact, subjective probability can be defined as the probability assigned to an event by an individual, based on whatever evidence is available. This evidence may be in the form of relative frequency of past occurrences, or it may just be an educated guess.

❑Subjective assessment of probability permits the widest flexibility of the three concepts we have discussed.

Subjective probabilities:

Rank	Statement	N	Mean	Median	σ	Range
1	Highly probable	187	0.89	0.90	0.04	.60-.99
2	Very likely	185	0.87	0.90	0.06	.45-.99
3	Very probably	187	0.87	0.89	0.07	.60-.99
4	Quite likely	188	0.79	0.80	0.10	.30-.99
5	Usually	187	0.77	0.75	0.13	.15-.99
6	Good Chance	188	0.74	0.75	0.12	.25-.96
7	Predictable	146	0.74	0.75	0.20	.01-.99
8	Likely	188	0.72	0.75	0.11	.25-.99
9	Probably	188	0.71	0.75	0.17	.01-.99
10	Rather likely	188	0.69	0.70	0.09	.15-.99
11	Pretty good chance	188	0.67	0.70	0.12	.25-.95
12	Fairly likely	188	0.66	0.70	0.12	.15-.95
13	Somewhat likely	187	0.59	0.60	0.18	.20-.92
14	Better than even	187	0.58	0.60	0.06	.45-.89
15	Rather	124	0.58	0.60	0.11	.10-.80
16	Slightly more than	188	0.55	0.55	0.06	.45-.80
	half the time					
17	Slight odds in favor	187	0.55	0.55	0.08	.05-.75
18	Fair chance	188	0.51	0.50	0.13	.20-.85
19	Tossup	188	0.5	0.50	0.00	.45-.52
20	Fighting chance	186	0.47	0.55	0.17	.05-.90

Rank	Statement	N	Mean	Median	σ	Range
21	Slightly less than	188	0.45	0.45	0.04	.05-.50
	half the time					
22	Slight odds against	185	0.45	0.45	0.11	.10-.99
23	Not quite even	180	0.44	0.45	0.07	.05-.60
24	Inconclusive	153	0.43	0.5	0.14	.01-.75
25	Uncertain	173	0.4	0.5	0.14	.01-.90
26	Possible	178	0.37	0.49	0.23	.01-.99
27	Somewhat unlikely	186	0.31	0.33	0.12	.03-.80
28	Fairly unlikely	187	0.25	0.25	0.11	.02-.75
29	Rather unlikely	187	0.24	0.25	0.12	.01-.75
30	Not very probably	187	0.21	0.2	0.12	.01-.60
31	Unlikely	188	0.18	0.16	0.1	.01-.45
32	Not much chance	186	0.16	0.15	0.09	.01-.45
33	Seldom	188	0.16	0.15	0.08	.01-.47
34	Barely possible	180	0.13	0.05	0.17	.01-.60
35	Fairly possible	184	0.13	0.05	0.16	.01-.60
36	Improbably	187	0.12	0.1	0.09	.01-.40
37	Quite unlikely	187	0.11	0.1	0.08	.01-.50
38	Very unlikely	186	0.09	0.1	0.07	.01-.50
39	Rare	187	0.07	0.05	0.07	.01-.30
40	Highly improbable	181	0.06	0.05	0.05	.01-.30

The Logical Approach

$$P(\text{event occurs}) = \frac{\text{number of outcomes where the event occurs}}{\text{total number of possible outcomes}}$$

- It must be emphasized that in order for this equation to work, each of the possible outcomes must be equally likely. This is a rather complex way of defining something that may seem intuitively obvious to us.
  - For example, when flipping a coin, we obtain $P(Head) = \frac{1}{1+1}$
  - When rolling a die, we obtain $P(roll\ 5) = \frac{1}{1+1+1+1+1+1}$

Example:

- Probability of throwing a 5 with a pair of dice

	⚀	⚁	⚂	⚃	⚄	⚅
⚀	2	3	4	5	6	7
⚁	3	4	5	6	7	8
⚂	4	5	6	7	8	9
⚃	5	6	7	8	9	10
⚄	6	7	8	9	10	11
⚅	7	8	9	10	11	12

The logical approach is useful when dealing with card games, dice games, coin tosses and the like, but has serious problems when we try to apply it to the less orderly decision problems we encounter in actual real-world applications.

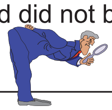
The Experimental Approach

- How do we determine the probability that a person lives past the age of 85 ?
- We could collect a lot of data on people and count how many actually live that long.
- The experimental method defines probability as essentially the observed relative frequency of an event in a very large number of trials.

$$\text{Probability} = \frac{\text{number of trials in which event did result}}{\text{total number of trials}}$$

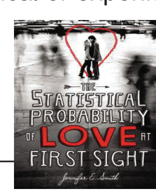
A Caveat on Relative Frequency

- One difficulty with the relative frequency approach is that people often use it without evaluating a sufficient number of outcomes.
- If you heard someone say “My aunt and uncle got the flu this year and both are over 65, so everyone in that age bracket will probably get the flu”, you would know that your friend did not base his assumptions on enough evidence.



Probability Rules

- There are some formal rules that govern how to manipulate and work with probabilities.
- Luckily, these rules work no matter if we are dealing with subjective, classical or experimental probability.



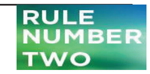
Rule 1

- We've seen this one already; probabilities are always between 0 and 1 (inclusive).
- Even if you think an event can't happen, its probability can't be less than 1. And a sure thing doesn't have a probability larger than 1.

A probability is a number between 0 and 1.
For any event A, $0 \leq P(A) \leq 1$.

- As you probably realize by know we use <u>capital letters</u> to denote events.

Rule 2



- The probability of the set of all outcomes must be 1 (denoted O_1, O_2, etc..)
- This means that on each trial of the random experiment we're studying, *something* has to happen.
- We can denote this as $\sum_{i=1}^{k} P(O_i) = 1$
- If this sum < 1 we are missing a possible outcome
- If this sum > 1 then 2 outcomes can happen at once which is a no-no.

Rule 3: The complement rule

- Suppose the probability that you get to class on time is 0.8.
- What's the probability that you don't get to class on time? Yes, it's 0.2.
- We denote not(A) as $\overline{A}$, and its called the complement of A.
- In symbols, $$P(\overline{A}) = 1 - P(A)$$

Birthday Problem [23 people]

- Let A = event no one in group shares same birthday.
- Then not(A) = event at least 2 people share same birthday

Assuming independence and using classical approach:

P(A) = 365/365 × 364/365 × … × 343/365

= 0.493

So, then P(not(A)) = 1 - 0.493 = 0.507

Contingency Tables

- Suppose that, over a period of 4 years, that is, 1,000 market days, \$AAPL and \$GPS have been observed to rise, remain unchanged, and decline.
- For somewhat obscure reasons such a table is referred to as a contingency table.

		\$AAPL				
		Rise	Decline	Unchanged		Total
	Rise	338	158	1		497
\$GPS	Decline	202	293	1		496
	Unchanged	3	4	0		7
	Total	543	455	2		1000

Contingency Tables

- Notice that the events listed horizontally, as well as those listed vertically, are mutually exclusive and collectively exhaustive. This must always be the case in contingency tables.

		\$AAPL				
		Rise	Decline	Unchanged		Total
	Rise	338	158	1		497
\$GPS	Decline	202	293	1		496
	Unchanged	3	4	0		7
	Total	543	455	2		1000

Probability Table

- By dividing by the table total, we can transform a contingency table into a probability table.

		$AAPL				
		Rise	Decline	Unchanged		Prob
	Rise	0.338	0.158	0.001		0.497
$GPS	Decline	0.202	0.293	0.001		0.496
	Unchanged	0.003	0.004	0		0.007
	Prob	0.543	0.455	0.002		1

Joint Probabilities

- The numbers inside the table are called **joint probabilities**, because they refer to two events happening at the same time.
- These nine joint probabilities are associated with nine mutually exclusive and collectively exhaustive events, so the sum of these probabilities has to equal 1.

		$AAPL				
		Rise	Decline	Unchanged		Prob
	Rise	0.338	0.158	0.001		0.497
$GPS	Decline	0.202	0.293	0.001		0.496
	Unchanged	0.003	0.004	0		0.007
	Prob	0.543	0.455	0.002		1

Joint Probabilities

- P($GPS rises AND $AAPL rises)= 0.338
- P($GPS rises AND $AAPL declines) = 0.158
- Etc….
- P(A and B) is called a joint probability.

Marginal Probabilities

- The entries in the right column and bottom row (both labeled total) give the so-called marginal probabilities. These probabilities are called marginal probabilities for the simple reason that they are written in the margin. We see, for example,

- P($AAPL rises) = 0.543
- P($GPS decline) = 0.496

- Marginal probabilities give only information concerning the behavior of one stock, either $AAPL or $GPS.

Marginal Probabilities

- Marginal probabilities give only information concerning the behavior of one stock, either $AAPL or $GPS.
- The marginal row and the marginal column both sum to 1, and this again is as it should be, for the events "rises," "is unchanged," and "declines" are mutually exclusive and collectively exhaustive.

Marginal Probabilities (cont)

		$AAPL				
		Rise	Decline	Unchanged		Prob
	Rise	0.338	0.158	0.001		0.497
$GPS	Decline	0.202	0.293	0.001		0.496
	Unchanged	0.003	0.004	0		0.007
	Prob	0.543	0.455	0.002		1

Obtain the marginal distribution

$AAPL	Prob		$GPS	Prob
Rise	0.543		Rise	0.497
Decline	0.455		Decline	0.496
Unchanged	0.002		Unchanged	0.007

The Addition Rule

- The addition rule is helpful when we have two events and are interested in knowing the probability that at least one of the events occurs.

The addition rule of probability *states that for any two events A and B*

P(A or B) = P(A) + P(B) – P(A and B)

The probability P(A or B) is the probability that A occurs, or that B occurs, or that both A and B occur.

Probability "or" is defined a bit weird…….

Example

- Look at the probability table

		$AAPL				
		Rise	Decline	Unchanged		Prob
	Rise	0.338	0.158	0.001		0.497
$GPS	Decline	0.202	0.293	0.001		0.496
	Unchanged	0.003	0.004	0		0.007
	Prob	0.543	0.455	0.002		1

P($AAPL rise OR $GPS rise) = 0.543 + 0.497 – 0.338 = 0.702

We need to subtract off the intersection so we don't double count.

Example

- Consider the following probability table

	Sierra Mist	Sprite
Male	0.4	0.15
Female	0.22	0.23

What is the probability that someone is a male or likes Sprite ?

Conditional Probability

- Random events are random (duh!) but sometimes it happens that we can get some information that sheds light on the issue.
- For example, suppose we want to know the probability that an 8 (as a sum)will turn up when we roll two dice.

SECOND DIE

FIRST DIE						
	(1, 1)	(1, 2)	(1, 3)	(1, 4)	(1, 5)	(1, 6)
	(2, 1)	(2, 2)	(2, 3)	(2, 4)	(2, 5)	(2, 6)
	(3, 1)	(3, 2)	(3, 3)	(3, 4)	(3, 5)	(3, 6)
	(4, 1)	(4, 2)	(4, 3)	(4, 4)	(4, 5)	(4, 6)
	(5, 1)	(5, 2)	(5, 3)	(5, 4)	(5, 5)	(5, 6)
	(6, 1)	(6, 2)	(6, 3)	(6, 4)	(6, 5)	(6, 6)

Pr(8)=5/36

Conditional Probability

- Now suppose we roll one of the dice first (rather than at the same time). Then we'll have a better idea of getting an 8.
- That is, if our first roll is a 1, what is the chance the sum of the two dice will be 8?
- If our first roll is a 3, what do we need for the second roll? What is the chance of that happening?

Conditional Probability

- Conditional probabilities ask, what is the chance that A happens, given that we *know* B happened ?
- If the package doesn't make it to Chicago by 9am tomorrow, what's the chance we lose the deal ?"
- "given we spend 10 million on research, what is the probability of inventing a successful competitor to the Ipod ?

- Note the use of the words **"if"** and **"given"**
- The notation is P(A|B) and we say the probability of event A *given* event B has happened.

Three DIFFERENT probability statements

- If a person has HIV, the probability that they will test positive on a screening test is 90%.
- If a person tests positive on a screening test, the probability that they have HIV is 90%.
- The probability that a person has HIV and tests positive on a screening test is 90%.

Conditional Probability

$$P(A|B)$$

Event of interest

"Given"

Conditioning Event

The probability that A occurs given that B occurs

Definition of conditional probability

$$P(A \mid B) = \frac{P(A \text{ and } B)}{P(B)}$$

Out of all the times B happens, how often does A also happen ?

Note that P(B) is assumed to not be zero.

Example

- 70% of your friends like Chocolate, and 35% like Chocolate AND like Strawberry.
- What percent of those who like Chocolate also like Strawberry?
- P(Strawberry|Chocolate)

  = P(Chocolate and Strawberry) / P(Chocolate)

Example

- A board game comes with a special deck of cards, some of which are black, and some of which are gold. If a card is randomly selected, the probability it is gold is 0.20, while the probability it gives a second turn is 0.16. Finally, the probability that it is gold and gives a second turn is 0.08.
- Suppose that a card is randomly selected, and it allows a player a second turn. What is the probability it was a gold card?

Example

- A survey asked full time and part time students how often they had visited the college's tutoring center in the last month. The results are shown below.

	Number of times students visited tutoring			
	One or fewer times	Two to three times	Four or more times	Total
Full time student	12	25	8	45
Part time student	2	5	6	13
Total	14	30	14	58

What is the probability the student visited the tutoring center four or more times, given that the student is full time?

Final Example

- **A survey of middle school students asked: What is your favorite winter sport? The results are summarized below**:

Grade	Snowboarding	Skiing	Ice Skating	TOTAL
6th	68	41	46	155
7th	84	56	70	210
8th	59	74	47	180
TOTAL	211	171	163	545

Grade	Snowboarding	Skiing	Ice Skating	
6th	0.12	0.08	0.08	**0.28**
7th	0.15	0.10	0.13	**0.39**
8th	0.11	0.14	0.09	**0.33**
	0.39	**0.31**	**0.30**	

- What is the probability of selecting a student whose favorite sport is skiing?
- What is the probability of selecting a 6th grade student?
- If the student selected is a 7th grade student, what is the probability that the student prefers ice-skating?

- If the student selected prefers snowboarding, what is the probability that the student is a 6th grade student?

Things you should know

- ❑What is probability
- ❑Random phenomena, events
- ❑Joint Probability, Marginal Probability
- ❑Addition rule
- ❑Conditional Probability