

Stat 19, Probability and Poker. Rick Paik Schoenberg

Outline for the day:

1. Discuss Addiction.
2. *R*.
3. Ly vs. Negreanu.
4. Counting and combinations.
5. $P(A\spadesuit \text{ after first ace})$.

Read harrington1.pdf for next time.

Think of 2 questions or comments for next time.

The course website is <http://www.stat.ucla.edu/~frederic/19/F18> .

BADDLEY, COOPER
BARRERA, JACK
BERGMAN-TURNBULL, LIANA
BUI, ALEXIS
CHENG, LU
GONG, LAURA
HUANG, STELLA
JACKSON, SOFIE
JONES, NOAH
LEE, EDDIE
LI, VINCENT
MARTINEZ, AARIN
NGUYEN, TIFFANY
REN, DIANA
SHARMA, DHRUV
SHOURYA, SHIVESH
VALDOVINOS, FELIPE
WORDLAW, ANDREA
ZHUO, MATTHEW

R. To download and install R, go directly to cran.stat.ucla.edu, or you can start at www.r-project.org, in which case you click on “download R”, scroll down to UCLA, and click on cran.stat.ucla.edu.

From there, click on “download R for ...”, and then get the latest version.

The R Project for Statistical Computing

http://www.r-project.org/

Graduate Ad... Committee KeepVid.com movies Capital One ...redit Cards Bleigiessen.html Author Central evite

The R Project for Statistical Computing

PCA 5 vars
princomp(x = data, cor = cor)

Fertility
Catholic
Examination
Education
Agriculture
(1-3) 60%

Clustering 4 groups

Factor 1 [41%]

Factor 3 [19%]

Groups
28
16
1
2

V. De Geneve

About R
[What is R?](#)
[Contributors](#)
[Screenshots](#)
[What's new?](#)

Download, Packages
[CRAN](#)

R Project
[Foundation](#)
[Members & Donors](#)
[Mailing Lists](#)
[Bug Tracking](#)
[Developer Page](#)
[Conferences](#)
[Search](#)

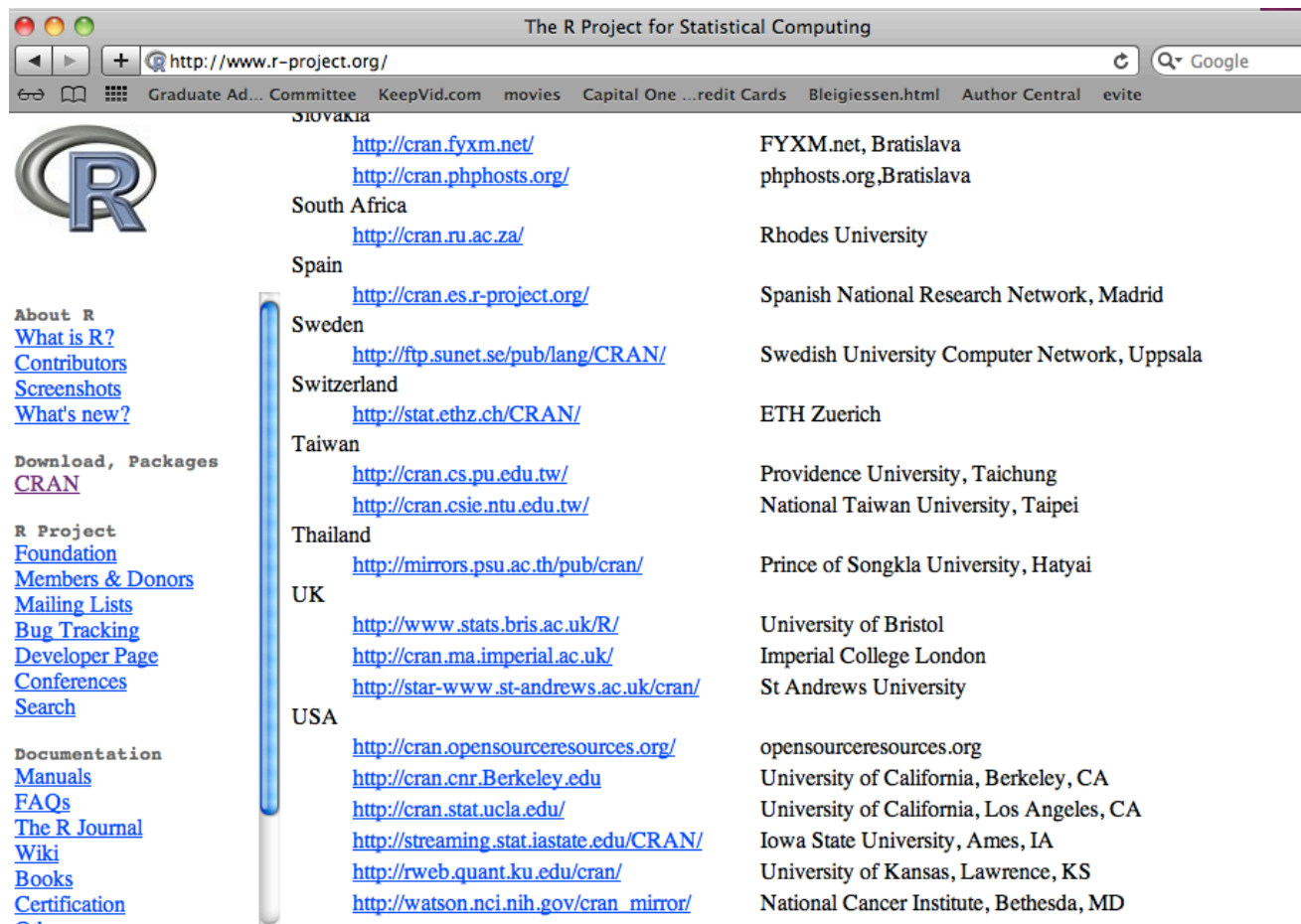
Documentation
[Manuals](#)
[FAQs](#)
[The R Journal](#)
[Wiki](#)
[Books](#)
[Certification](#)
[Other](#)

Getting Started:

- R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. To **download R**, please choose your preferred [CRAN mirror](#).
- If you have questions about R like how to download and install the software, or what the license terms are, please read our [answers to frequently asked questions](#) before you send an email.

To download and install *R*, go directly to cran.stat.ucla.edu, or you can start at www.r-project.org, in which case you click on “download *R*”, scroll down to UCLA, and click on cran.stat.ucla.edu.

From there, click on “download *R* for ...”, and then get the latest version.

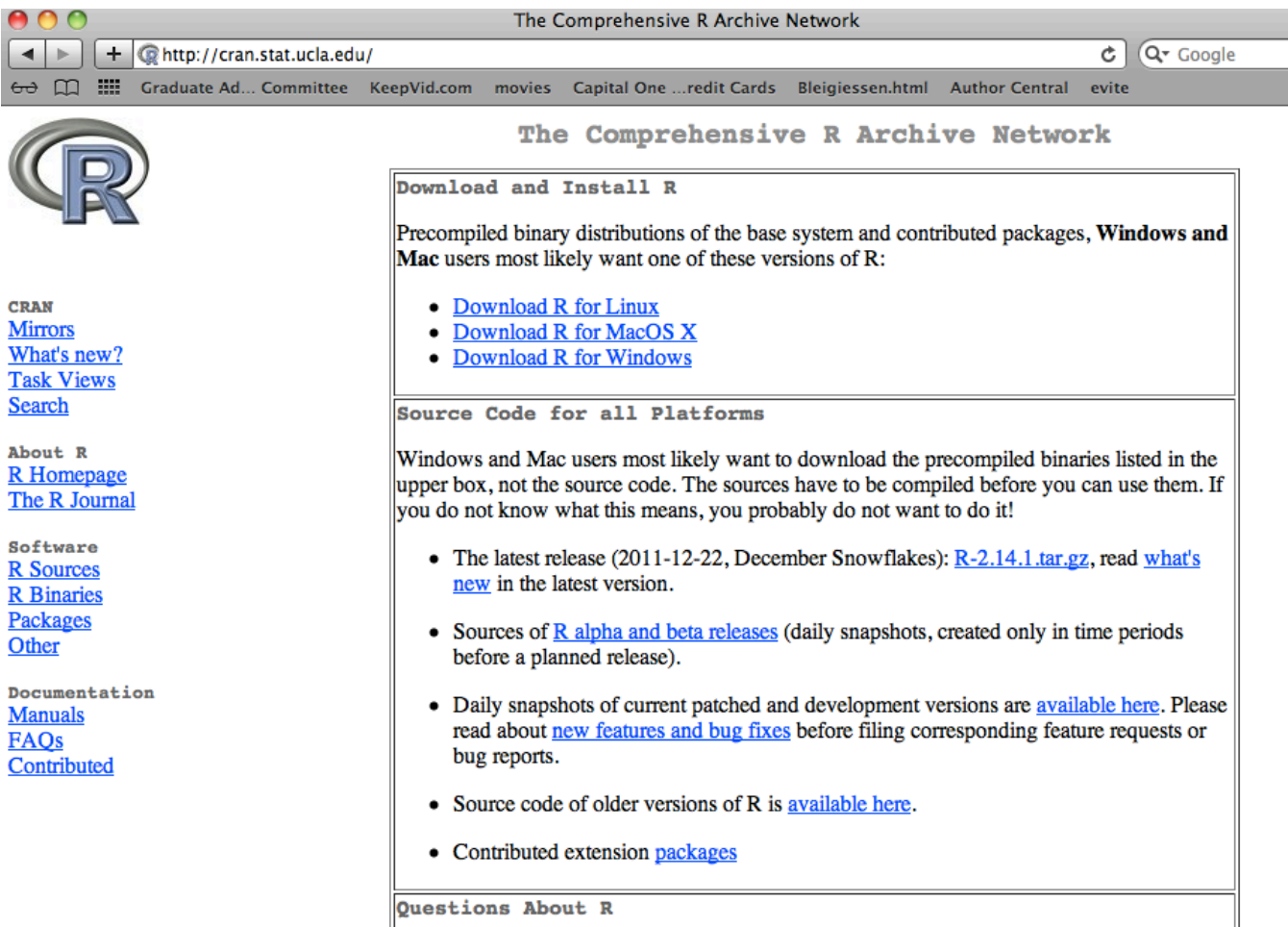


The screenshot shows a web browser window titled "The R Project for Statistical Computing" with the address bar at <http://www.r-project.org/>. The page features the R logo on the left and a list of mirrors on the right. The mirrors are organized by country, with each country name in bold. The list includes mirrors for Slovakia, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, UK, and USA. Each mirror entry consists of a URL and the name of the hosting institution.

Country	URL	Institution
Slovakia	http://cran.fyxm.net/	FYXM.net, Bratislava
	http://cran.phphosts.org/	phphosts.org, Bratislava
South Africa	http://cran.ru.ac.za/	Rhodes University
Spain	http://cran.es.r-project.org/	Spanish National Research Network, Madrid
Sweden	http://ftp.sunet.se/pub/lang/CRAN/	Swedish University Computer Network, Uppsala
Switzerland	http://stat.ethz.ch/CRAN/	ETH Zuerich
Taiwan	http://cran.cs.pu.edu.tw/	Providence University, Taichung
	http://cran.csie.ntu.edu.tw/	National Taiwan University, Taipei
Thailand	http://mirrors.psu.ac.th/pub/cran/	Prince of Songkla University, Hatyai
UK	http://www.stats.bris.ac.uk/R/	University of Bristol
	http://cran.ma.imperial.ac.uk/	Imperial College London
	http://star-www.st-andrews.ac.uk/cran/	St Andrews University
USA	http://cran.opensourceresources.org/	opensourceresources.org
	http://cran.cnr.Berkeley.edu	University of California, Berkeley, CA
	http://cran.stat.ucla.edu/	University of California, Los Angeles, CA
	http://streaming.stat.iastate.edu/CRAN/	Iowa State University, Ames, IA
	http://rweb.quant.ku.edu/cran/	University of Kansas, Lawrence, KS
	http://watson.nci.nih.gov/cran_mirror/	National Cancer Institute, Bethesda, MD

To download and install *R*, go directly to cran.stat.ucla.edu, or you can start at www.r-project.org, in which case you click on “download *R*”, scroll down to UCLA, and click on cran.stat.ucla.edu.

From there, click on “download *R* for ...”, and then get the latest version.



The screenshot shows a web browser window titled "The Comprehensive R Archive Network" with the address bar displaying "http://cran.stat.ucla.edu/". The browser's address bar also shows a search engine (Google) and a list of bookmarks including "Graduate Ad... Committee", "KeepVid.com", "movies", "Capital One ...redit Cards", "Bleigiessen.html", "Author Central", and "evite".

The main content area of the website is titled "The Comprehensive R Archive Network" and is divided into several sections:

- Download and Install R**

Precompiled binary distributions of the base system and contributed packages, **Windows and Mac** users most likely want one of these versions of R:

 - [Download R for Linux](#)
 - [Download R for MacOS X](#)
 - [Download R for Windows](#)
- Source Code for all Platforms**

Windows and Mac users most likely want to download the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!

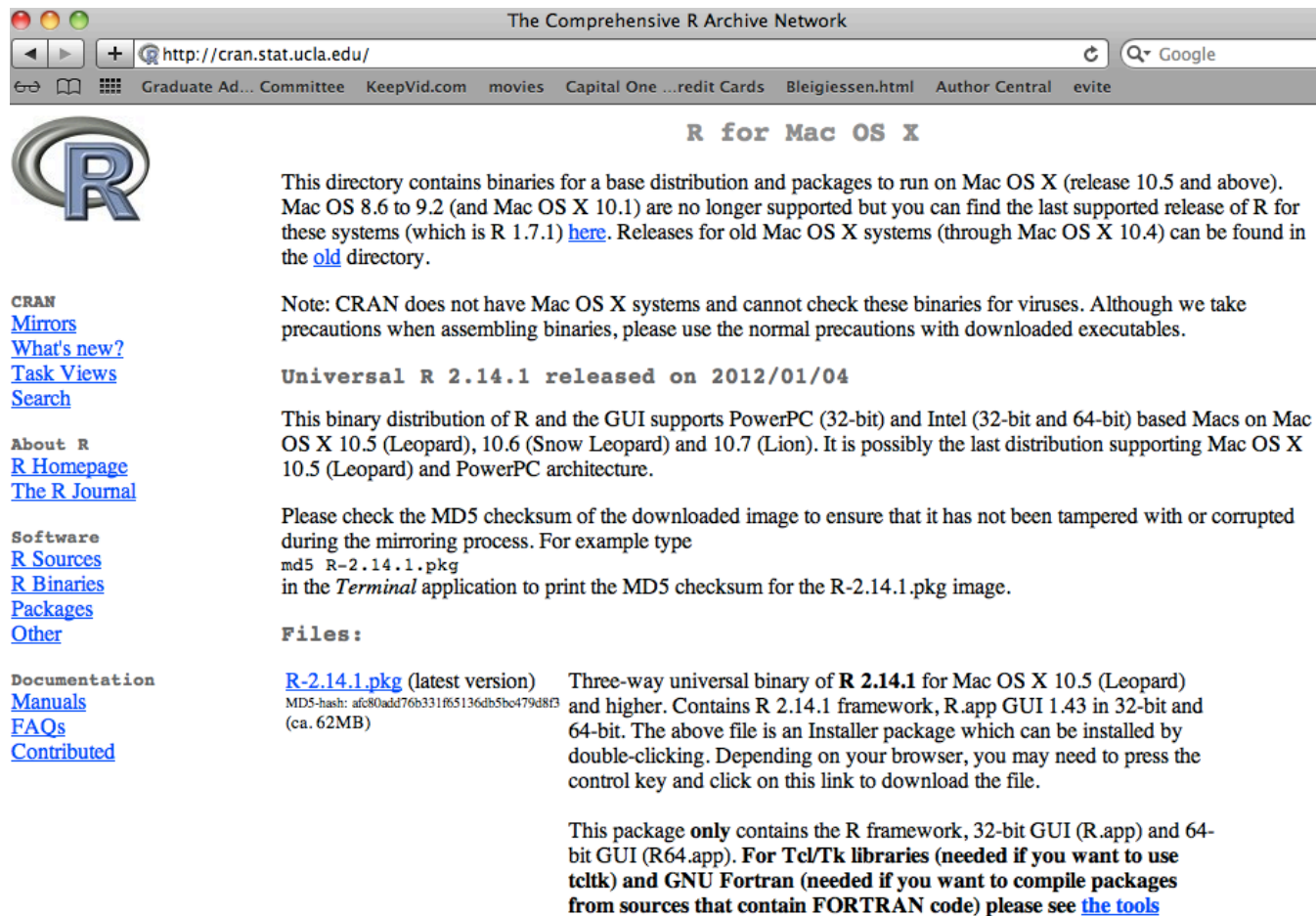
 - The latest release (2011-12-22, December Snowflakes): [R-2.14.1.tar.gz](#), read [what's new](#) in the latest version.
 - Sources of [R alpha and beta releases](#) (daily snapshots, created only in time periods before a planned release).
 - Daily snapshots of current patched and development versions are [available here](#). Please read about [new features and bug fixes](#) before filing corresponding feature requests or bug reports.
 - Source code of older versions of R is [available here](#).
 - Contributed extension [packages](#)
- Questions About R**

On the left side of the page, there is a navigation menu with the following links:

- CRAN
 - [Mirrors](#)
 - [What's new?](#)
 - [Task Views](#)
 - [Search](#)
- About R
 - [R Homepage](#)
 - [The R Journal](#)
- Software
 - [R Sources](#)
 - [R Binaries](#)
 - [Packages](#)
 - [Other](#)
- Documentation
 - [Manuals](#)
 - [FAQs](#)
 - [Contributed](#)

To download and install *R*, go directly to cran.stat.ucla.edu, or you can start at www.r-project.org, in which case you click on “download *R*”, scroll down to UCLA, and click on cran.stat.ucla.edu.

From there, click on “download *R* for ...”, and then get the latest version.



The Comprehensive R Archive Network

<http://cran.stat.ucla.edu/> Google

Graduate Ad... Committee KeepVid.com movies Capital One ...redit Cards Bleigiessen.html Author Central evite

R for Mac OS X

This directory contains binaries for a base distribution and packages to run on Mac OS X (release 10.5 and above). Mac OS 8.6 to 9.2 (and Mac OS X 10.1) are no longer supported but you can find the last supported release of R for these systems (which is R 1.7.1) [here](#). Releases for old Mac OS X systems (through Mac OS X 10.4) can be found in the [old](#) directory.

Note: CRAN does not have Mac OS X systems and cannot check these binaries for viruses. Although we take precautions when assembling binaries, please use the normal precautions with downloaded executables.

Universal R 2.14.1 released on 2012/01/04

This binary distribution of R and the GUI supports PowerPC (32-bit) and Intel (32-bit and 64-bit) based Macs on Mac OS X 10.5 (Leopard), 10.6 (Snow Leopard) and 10.7 (Lion). It is possibly the last distribution supporting Mac OS X 10.5 (Leopard) and PowerPC architecture.

Please check the MD5 checksum of the downloaded image to ensure that it has not been tampered with or corrupted during the mirroring process. For example type

```
md5 R-2.14.1.pkg
```

in the *Terminal* application to print the MD5 checksum for the R-2.14.1.pkg image.

Files:

R-2.14.1.pkg (latest version) <small>MD5-hash: afc80add76b331f65136db5bc479d8f3 (ca. 62MB)</small>	Three-way universal binary of R 2.14.1 for Mac OS X 10.5 (Leopard) and higher. Contains R 2.14.1 framework, R.app GUI 1.43 in 32-bit and 64-bit. The above file is an Installer package which can be installed by double-clicking. Depending on your browser, you may need to press the control key and click on this link to download the file.
---	---

This package **only** contains the R framework, 32-bit GUI (R.app) and 64-bit GUI (R64.app). **For Tcl/Tk libraries (needed if you want to use tcltk) and GNU Fortran (needed if you want to compile packages from sources that contain FORTRAN code) please see [the tools](#)**

CRAN
[Mirrors](#)
[What's new?](#)
[Task Views](#)
[Search](#)

About R
[R Homepage](#)
[The R Journal](#)

Software
[R Sources](#)
[R Binaries](#)
[Packages](#)
[Other](#)

Documentation
[Manuals](#)
[FAQs](#)
[Contributed](#)

Ly vs. Negreanu.

Ex. Suppose you have two ♣s, and there are exactly two ♣s on the flop. Given this info, what is $P(\text{at least one more } \spadesuit \text{ on turn or river})$?

Answer: $52-5 = 47$ cards left (nine ♣s, 38 others).

So $n = \text{choose}(47,2) = 1081$ combinations for next 2 cards.

Each equally likely (and obviously mutually exclusive).

Two-♣ combos: $\text{choose}(9,2) = 36$. One-♣ combos: $9 \times 38 = 342$.

Total = 378. So answer is $378/1081 = 35.0\%$.

Answer #2: Use the addition rule...

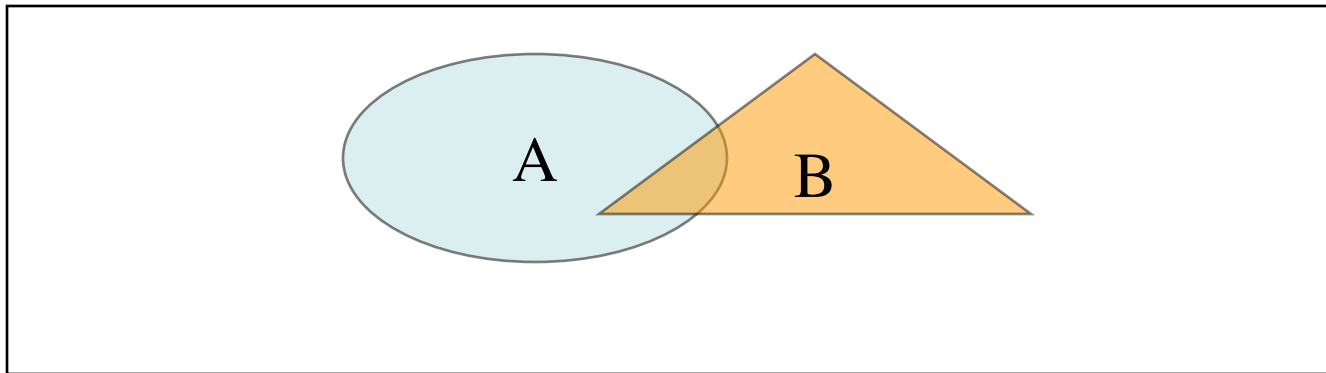
ADDITION RULE, revisited.....

Axioms (initial assumptions/rules) of probability:

- 1) $P(A) \geq 0$.
- 2) $P(A) + P(A^c) = 1$.
- 3) Addition rule:

If A_1, A_2, A_3, \dots are mutually exclusive, then

$$P(A_1 \text{ or } A_2 \text{ or } A_3 \text{ or } \dots) = P(A_1) + P(A_2) + P(A_3) + \dots$$



As a result, even if A and B might not be mutually exclusive,
 $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$.

Ex. You have two ♣s, and there are exactly two ♣s on the flop.
Given this info, what is $P(\text{at least one more } \clubsuit \text{ on turn or river})$?

Answer #1: $52-5 = 47$ cards left (nine ♣s, 38 others).

So $n = \text{choose}(47,2) = 1081$ combinations for next 2 cards.

Each equally likely (and obviously mutually exclusive).

Two- ♣ combos: $\text{choose}(9,2) = 36$. One-♣ combos: $9 \times 38 = 342$.

Total = 378. So answer is $378/1081 = 35.0\%$.

Answer #2: Use the addition rule.

$$\begin{aligned} P(\geq 1 \text{ more } \clubsuit) &= P(\clubsuit \text{ on turn OR river}) \\ &= P(\clubsuit \text{ on turn}) + P(\clubsuit \text{ on river}) - P(\text{both}) \\ &= 9/47 + 9/47 - \text{choose}(9,2)/\text{choose}(47,2) \\ &= 19.15\% + 19.15\% - 3.3\% = 35.0\%. \end{aligned}$$

Counting.

Fact: If A_1, A_2, \dots, A_n are equally likely & mutually exclusive,
and if $P(A_1 \text{ or } A_2 \text{ or } \dots \text{ or } A_n) = 1$,
then $P(A_k) = 1/n$.

[So, you can *count*: $P(A_1 \text{ or } A_2 \text{ or } \dots \text{ or } A_k) = k/n$.]

Ex. You have 76, and the board is KQ54. P(straight)?

[52-2-4=46.] $P(\text{straight}) = P(8 \text{ on river OR } 3 \text{ on river})$

$$= P(8 \text{ on river}) + P(3 \text{ on river}) = 4/46 + 4/46.$$

If there are a_1 distinct possible outcomes on experiment #1, and for each of them, there are a_2 distinct possible outcomes on experiment #2, then there are $a_1 \times a_2$ distinct possible *ordered* outcomes on both.

In general, with j experiments, each with a_i possibilities, the # of distinct outcomes *where order matters* is $a_1 \times a_2 \times \dots \times a_j$.

Permutations and combinations.

e.g. you get 1 card, opp. gets 1 card. # of distinct possibilities?
 52×51 . [ordered: (A♣, K♦) \neq (K♦, A♣) .]

Each such outcome, where order matters, is called a *permutation*.

Number of permutations of the deck? $52 \times 51 \times \dots \times 1 = 52!$

$$\sim 8.1 \times 10^{67}$$

A combination is a collection of outcomes, where order *doesn't* matter.

e.g. in hold'em, how many *distinct* 2-card hands are possible?

52 x 51 if order matters, but then you'd be double-counting each

[since now (A♣, K♦) = (K♦, A♣)].

So, the number of *distinct* hands where *order doesn't matter* is

$$52 \times 51 / 2.$$

In general, with n distinct objects, the # of ways to choose k *different* ones, *where order doesn't matter*, is

$$\text{"n choose k"} = \binom{n}{k} = \text{choose}(n,k) = \frac{n!}{k! (n-k)!} .$$

$$k! = 1 \times 2 \times \dots \times k. \quad [\text{convention: } 0! = 1.]$$

Deal til first ace appears. Let X = the *next* card after the ace.

$P(X = A\spadesuit)$? $P(X = 2\clubsuit)$?