

## Mathematics of Sports

**Professor:** Tom Cover  
Packard 254  
723-4505  
cover@stanford.edu  
Office hours: Wed 2-4

**TA:** Leonid Pekelis  
lpekelis@stanford.edu  
Office hours: TBA

**Corequisite:** Stat 116.

**Lectures:** Tuesdays and Thursdays, 11am-12:15pm, Hewlett, Room 101.

**Structure:** The course will have one exam and a paper. The running theme will be to find new strategies, techniques and statistics for sports.

### Topics:

#### A. Statistics in sports.

1. **Anomalies.** Do longer games favor the “better” player? (Answer: Not necessarily.) Are all games equally exciting? (Answer: In some sense yes.) Is football betting an efficient market? (Answer: More or less, but there are some edges and trends that can be found, even today.) Is there a “hot hands” phenomenon in basketball? What does the NFL point spread mean in terms of win probability? How much is a yard worth in football? Is there a good interpretation of the New York Times computer ranking of football teams? What is the value of a draft choice? Is the current method of ranking quarterbacks satisfactory? When is a game most exciting?
2. **Developing new statistics:** Find good measures of defensive performance in football, offensive performance in baseball, clutch factor, value of player to a team. Find a better golf handicapping system for large tournaments. Examine James’ notion of range in baseball. What happens when a great batter (.400) meets a great pitcher (.100)? What happens when two teams meet? (How do you combine records to determine the win probability?) Find a measure of skill vs. luck. Optimal gambling.

**B. Strategy in sports.** Which sports benefit most from strategic and tactical planning? Which sports require quick thinking, deep thinking, no thinking? What is meant by field vision in football? Is baseball over-managed? Develop new strategies for each sport. Is there a good measure of skill vs. luck? Applications of game theory to sports. Roshambo. Moneyball.

**C. Physics in sports.**

1. **Basics.** Billiards, basketball, sailing, golf, baseball. Knuckle balls, curves, sliders. Limits of pitching. Trajectories. Golf ball design. Why LeBron James floats (he lowers his legs). Why goaltending is often miscalled (the apogee is closer to the basket than to the shooter).
2. **Physical technique.** What is the best way to high jump? What would the high jump record be on the moon? Are gymnastic moves legal in the high jump? Polevault: Technique. Speed vs. strength. Golf. Batting.
3. **Physical limits of human performance.** What are the ultimate records? Are some events (like the long jump) basically long tailed? That is, do records get broken by large amounts and remain unbroken for long periods of time? Do sports like golf lead to superstars while other sports do not?
4. **Pure Sports.** Some sports require equipment, while others do not. How would one rank in order of pureness: Boxing, sprinting, pole vault, long jump, gymnastics, ice skating, tennis, golf, swimming? Which of these sports have had significant leaps in technique or equipment and why weren't these leaps achieved sooner? Are there leaps left?

**Source Books** (not required):

- Google
- “Management Science in Sports,” Ladany and Machol
- “Mathematics in Sports,” Townend
- “Mathletics,” Winston, Princeton University Press, 2009.