Schedule:

- HW 7C is due Friday, Dec 9, 2011.
- Final Exam is Wednesday, Dec 14th, 8:30pm-10:30pm.

Today we will cover 7.5: Rules of probability
Final Exam Breakdown

- Chapter 7: Probability
  - Counting based probability
  - Empirical probability
  - Conditional probability

- Cumulative
  - Ch 2: Setting up and reading the answer from a linear system
  - Ch 3: Graphically solving a 2 variable LPP
  - Ch 4: Setting up a multi-var LPP
  - Ch 4: Reading and interpreting answer form a multi-var LPP
Suppose we have the following table of young men and women with and without driver’s licenses:

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>M</td>
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</tr>
<tr>
<td>T</td>
<td>977</td>
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What are the odds a randomly selected person has a driver’s license?

What are the odds a randomly selected person is female?

What are the odds that a randomly selected non-driver is female?
Suppose we have the following table of young men and women with and without driver’s licenses:

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What are the odds a randomly selected person has a driver’s license? \( \frac{977}{1000} = 98\% \)

What are the odds a randomly selected person is female?
7.5: The Punnet square of probability

- Suppose we have the following table of young men and women with and without driver’s licenses:

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- What are the odds a randomly selected person has a driver’s license? \( \frac{977}{1000} = 98\% \)

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- What are the odds that a randomly selected non-driver is female?
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- What are the odds a randomly selected person has a driver’s license? \(\frac{977}{1000} = 98\%\)

- What are the odds a randomly selected person is female? \(\frac{500}{1000} = 50\%\)

- What are the odds that a randomly selected non-driver is female? \(\frac{14}{23} = 61\%\)

- Are females less likely to be drivers?
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What are the odds a randomly selected person is female? \( \frac{500}{1000} = 50\% \)

What are the odds that a randomly selected non-driver is female? \( \frac{14}{23} = 61\% \)

Are females less likely to be drivers?

Probability a female is a driver: \( \frac{486}{500} = 97\% \) nearly the same
7.5: Conditional probability

- Let’s redo this using the language of events:
  - M is the event the chosen person is male
  - F is the event the chosen person is female
  - Y is the event the chosen person has a driver’s license
  - N is the event the chosen person does not
Let’s redo this using the language of events:

- $M$ is the event the chosen person is male
- $F$ is the event the chosen person is female
- $Y$ is the event the chosen person has a driver’s license
- $N$ is the event the chosen person does not

$Pr(M) = Pr(F) = 50\%, \ Pr(Y) = 97.7\%$
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What about the 61\% probability of a non-driver being female?
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\[ Pr(M) = Pr(F) = 50\% , \quad Pr(Y) = 97.7\% \]

What about the 61% probability of a non-driver being female?

We calculated it as \( Pr(N \cap F)/Pr(N) \)
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- N is the event the chosen person does not

\[ \Pr(M) = \Pr(F) = 50\%, \quad \Pr(Y) = 97.7\% \]

What about the 61% probability of a non-driver being female?

We calculated it as \( \Pr(N \cap F) / \Pr(N) \)

We need a name for this calculation, **conditional probability**

\[ \Pr(F|N) = \Pr(N \cap F) / \Pr(N) \] is the probability of \( F \) given \( N \)
7.5: Does more information help

- If we didn’t know the person’s gender, then there was a 98% chance of them driving, but if we knew they were female it was a 97% chance.
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- If we didn’t know the person’s gender, then there was a 98% chance of them driving, but if we knew they were female it was a 97% chance.

- These are nearly the same, does not tell us much to know the gender.
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- These are nearly the same, does not tell us much to know the gender.

- If we didn’t know whether they drove, then there was a 50% chance of them being female, but if we knew they did not drive, then it was a 61% chance.

If \( \Pr(A) \) versus \( \Pr(A | B) \) if they are equal then the events are independent.
If we didn’t know the person’s gender, then there was a 98% chance of them driving, but if we knew they were female it was a 97% chance.

These are nearly the same, does not tell us much to know the gender.

If we didn’t know whether they drove, then there was a 50% chance of them being female, but if we knew they did not drive, then it was a 61% chance.

These are fairly different, so it does tell us something.
7.5: Does more information help

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- These are fairly different, so it does tell us something.

- We want to compare the probabilities of \( Pr(A) \) versus \( Pr(A|B) \) if they are equal then the events are independent.
7.5: Slow your roll

- The game is to roll two dice. If the total is 2, 3, 5, 7, or 11 you win. What are the odds of winning?
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Just count!

\[
\begin{array}{cccccccc}
\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot, & \cdot\cdot\cdot, \\
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\end{array}
\]

\[15/36 \approx 42\%\]
7.5: Slow your roll

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15/36 ≈ 42%

- What if you roll ⬜ first, and then roll the other die. What are your odds now?
7.5: Slow your roll

- The game is to roll two dice. If the total is 2, 3, 5, 7, or 11 you win. What are the odds of winning?

- Just count!

  15/36 \approx 42\%

- What if you roll \(\Box\) first, and then roll the other die. What are your odds now?

  - Just count!

  4/6 \approx 67\%
Your friend notices your slow-rollin skills, and decides to change the game. **Odds** you win. What are your chances now?
7.5: That was odd

- Your friend notices your slow-rollin skills, and decides to change the game. **Odds** you win. What are your chances now?

- Just count!

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   6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 6
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\[ 18/36 = 50\% \]
7.5: That was odd

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\[ \begin{array}{ccccccc}
\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, \\
\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, & \cdot\cdot\cdot, \\
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\end{array} \]
```

18/36 = 50%

- You roll a \[
\begin{array}{ccc}
\end{array}
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- Just count!

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\[ 18/36 = 50\% \]

- You roll a \( \Box \) first. What are your chances now?

- Just count!

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```

\[ 3/6 = 50\% \]
7.5: That was odd

- Your friend notices your slow-rollin skills, and decides to change the game. **Odds** you win. What are your chances now?

- Just count!

18/36 = 50%

- You roll a □ first. What are your chances now?

- Just count!

3/6 = 50%

- The first die had no effect on the outcome! The two events are said to be **independent**.
You’re looking over the proposed budget cut for your business. In the cut, 85 out of 340 managers will be laid off. A total of 230 out of 940 employees will be laid off, including the managers.
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That’s a lot of jobs; a lot of chances for a lawsuit. Is the plan biased?
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- What is the probability that an employee will be laid off?
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- What is the probability that an employee will be laid off? 
  \( \frac{230}{940} \approx 24\% \)

- What is the probability that a manager will be laid off?
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What is the probability that an employee will be laid off? 
\[ \frac{230}{940} \approx 24\% \]

What is the probability that a manager will be laid off? 
\[ \frac{85}{340} \approx 25\% \]

Are the events “getting laid off” and “being a manager” independent?
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That’s a lot of jobs; a lot of chances for a lawsuit. Is the plan biased?

What is the probability that an employee will be laid off?

\[ \frac{230}{940} \approx 0.24 \approx 24\% \]

What is the probability that a manager will be laid off?

\[ \frac{85}{340} \approx 0.25 \approx 25\% \]

Are the events “getting laid off” and “being a manager” independent?

“Mostly”. The probabilities are not equal, but they are close.
Suppose 50% of the time the coke machine gives you a coke, and 50% of the time the coke machine eats your money. If it costs $1.25 to play, how many cokes would $125.00 buy on average?

That is 100 chances to play, 50% of the time you get a coke, so 50 cokes.

Suppose 60% of the time the chip machine gives you your chips, 30% of the time it moves chips around and eats your money, and 10% of the time it gives you double chips. If it costs $0.80 to play, how many chips would $80.00 buy on average?

That is 100 chances to play, 60 give 1 chips, 30 give none, 10 give 2, so a total of 80 bags of chips.
Expectations

- Suppose 50% of the time the coke machine gives you a coke, and 50% of the time the coke machine eats your money. If it costs $1.25 to play, how many cokes would $125.00 buy on average?

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Weighted averages
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- Weighted averages.
Two stage expectations

- What if you need to use a courier, you best friend and petty criminal “Shifty” Teddy

  90% of the time Teddy recalls the deep personal bond you share and gives the money to the coke machine, 10% of the time he takes the money and runs.

  How many cokes would $125 buy ($1.25 a day)?

  That's 100 days, 90 days of which he goes to the coke machine, 45 of which he ends up getting the coke, so 45 cokes.

  What is the probability of getting a coke?

  45%, right?
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- That’s 100 days, 90 days of which he goes to the coke machine, 45 of which he ends up getting the coke, so 45 cokes.

- What is the probability of getting a coke?

- 45%, right?
Reasoning backwards

- Shifty Teddy is spending some time on the gameshow “Who’s Gow?” and so you have to use his pal, Shifty Eddy, to run cokes for you. You end up with a coke 30% of the time. How often does he take the money and run?

This is the critical deduction in medical and criminal trials. Call the probability that he runs $x$. Then you get cokes $(1 - x) = 0.30$, so solve $0.30 = 1 - x = 0.70$, $x = 40\%$.

Let $E$ be the event he takes the money to the coke machine, and $F$ be the event that you get a coke. $Pr(F) = 30\%$, and we want to find $Pr(E)$ which we calculated to be 60%, but where do we use the 50%?
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- This is the critical deduction in medical and criminal trials.

- Call the probability that he runs $x$. Then you get cokes $(1 - x)/2$ of the time, so solve $30\% = (1 - x)/2$, $x = 40\%$. 
Reasoning backwards

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This is the critical deduction in medical and criminal trials.

Call the probability that he runs \( x \). Then you get cokes \( (1 - x)/2 \) of the time, so solve 30\% = (1 - x)/2, \( x = 40\% \).

Let \( E \) be the event he takes the money to the coke machine, and \( F \) be the event that you get a coke.

\( Pr(F) = 30\% \), and we want to find \( Pr(E) \) which we calculated to be 60\%, but where do we use the 50\%?
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$Pr(F) = 30\%$, and we want to find $Pr(E)$ which we calculated to be $60\%$, but where do we use the $50\%$?

The coke machine is $50\%$ likely to give you a coke IF Eddy gives it the money, so we say $Pr(F|E) = 50\%$, the probability of $F$ given $E$ is $50\%$.
Let $E$ be the event he takes the money to the coke machine, and $F$ be the event that you get a coke.

$Pr(F) = 30\%$, and we want to find $Pr(E)$ which we calculated to be $60\%$, but where do we use the $50\%$?

The coke machine is $50\%$ likely to give you a coke IF Eddy gives it the money, so we say $Pr(F|E) = 50\%$, the probability of F given E is $50\%$

**Bayes’s Law**: $Pr(E \cap F) = Pr(F|E) \cdot Pr(E)$ – a weighted average!
A drug test is 98% accurate: out of 100 drug users, 98 will get a positive result, and 2 a negative; out of 100 non-users 98 will get a negative result, and 2 a positive. A company (somehow) knows that exactly 1 of its 100 employees is a drug user, but (somehow) does not know which one.

An employee is picked at random to be tested, and tests positive. What is the probability that they are the drug user, given that they tested positive? Hint: It is NOT 98%.

The company wants to be sure, and so tested the employee again. Positive. again. What is the probability that an employee is the drug user, given that they tested positive twice?
A drug test is 98% accurate: out of 100 drug users, 98 will get a positive result, and 2 a negative; out of 100 non-users 98 will get a negative result, and 2 a positive. A company (somehow) knows that exactly 1 of its 100 employees is a drug user, but (somehow) does not know which one.

What is the probability that the drug test would correctly report on all 100 employees?

An employee is picked at random to be tested twice, and tests positive once and negative once. What is the probability an employee is the drug user, given that they tested positive once and negative once?