Matlab primer

A Matlab Cheat-sheet (MIT 18.06, Fall 2007)

Basics:

`save 'file.mat'` save variables to *file.mat*
`load 'file.mat'` load variables from *file.mat*
`diary on` record input/output to file *diary*
`diary off` stop recording
`whos` list all variables currenly defined
`clear` delete/undefine all variables
`help command` quick help on a given *command*
`doc command` extensive help on a given *command*

Defining/changing variables:

`x = 3` define variable x to be 3
`x = [1 2 3]` set x to the 1×3 row-vector (1,2,3)
`x = [1 2 3];` same, but don't echo x to output
`x = [1;2;3]` set x to the 3×1 column-vector (1,2,3)
`A = [1 2 3 4;5 6 7 8;9 10 11 12];`
set A to the 3×4 matrix with rows 1,2,3,4 etc.
`x(2) = 7` change x from (1,2,3) to (1,7,3)
`A(2,1) = 0` change $A_{2,1}$ from 5 to 0

Arithmetic and functions of numbers:

`3*4, 7+4, 2-6 8/3` multiply, add, subtract, and divide numbers
`3^7, 3^(8+2i)` compute 3 to the 7th power, or 3 to the 8+2i power
`sqrt(-5)` compute the square root of –5
`exp(12)` compute e^{12}
`log(3), log10(100)` compute the natural log (ln) and base-10 log ($\log_{10}$)
`abs(-5)` compute the absolute value |–5|
`sin(5*pi/3)` compute the sine of 5π/3
`besselj(2,6)` compute the Bessel function $J_2(6)$

Arithmetic and functions of vectors and matrices:

`x * 3` multiply every element of x by 3
`x + 2` add 2 to every element of x
`x + y` element-wise addition of two vectors x and y
`A * y` product of a matrix A and a vector y
`A * B` product of two matrices A and B
`x * y` not allowed if x and y are two column vectors!
`x .* y` element-wise product of vectors x and y
`A^3` the square matrix A to the 3rd power
`x^3` not allowed if x is not a square matrix!
`x.^3` every element of x is taken to the 3rd power
`cos(x)` the cosine of every element of x
`abs(A)` the absolute value of every element of A
`exp(A)` e to the power of every element of A
`sqrt(A)` the square root of every element of A
`expm(A)` the matrix exponential e^A
`sqrtm(A)` the matrix whose square is A

Constructing a few simple matrices:

`rand(12,4)` a 12×4 matrix with uniform random numbers in [0,1)
`randn(12,4)` a 12×4 matrix with Gaussian random (center 0, variance 1)
`zeros(12,4)` a 12×4 matrix of zeros
`ones(12,4)` a 12×4 matrix of ones
`eye(5)` a 5×5 identity matrix I ("eye")
`eye(12,4)` a 12×4 matrix whose first 4 rows are the 4×4 identity
`linspace(1.2,4.7,100)`
row vector of 100 equally-spaced numbers from 1.2 to 4.7
`7:15` row vector of 7,8,9,…,14,15
`diag(x)` matrix whose diagonal is the entries of x (and other elements = 0)

Portions of matrices and vectors:

`x(2:12)` the 2nd to the 12th elements of x
`x(2:end)` the 2nd to the last elements of x
`x(1:3:end)` every third element of x, from 1st to the last
`x(:)` all the elements of x
`A(5,:)` the row vector of every element in the 5th row of A
`A(5,1:3)` the row vector of the first 3 elements in the 5th row of A
`A(:,2)` the column vector of every element in the 2nd column of A
`diag(A)` column vector of the diagonal elements of A

Solving linear equations:

`A \ b` for A a matrix and b a column vector, the solution x to $Ax=b$
`inv(A)` the inverse matrix A^{-1}
`[L,U,P] = lu(A)` the LU factorization $PA=LU$
`eig(A)` the eigenvalues of A
`[V,D] = eig(A)` the columns of V are the eigenvectors of A, and the diagonals `diag(D)` are the eigenvalues of A

Plotting:

`plot(y)` plot y as the y axis, with 1,2,3,… as the x axis
`plot(x,y)` plot y versus x (must have same length)
`plot(x,A)` plot columns of A versus x (must have same # rows)
`loglog(x,y)` plot y versus x on a log-log scale
`semilogx(x,y)` plot y versus x with x on a log scale
`semilogy(x,y)` plot y versus x with y on a log scale
`fplot(@(x) …expression…,[a,b])`
plot some expression in x from $x=a$ to $x=b$
`axis equal` force the x and y axes of the current plot to be scaled equally
`title('A Title')` add a title *A Title* at the top of the plot
`xlabel('blah')` label the x axis as *blah*
`ylabel('blah')` label the y axis as *blah*
`legend('foo','bar')` label 2 curves in the plot *foo* and *bar*
`grid` include a grid in the plot
`figure` open up a new figure window

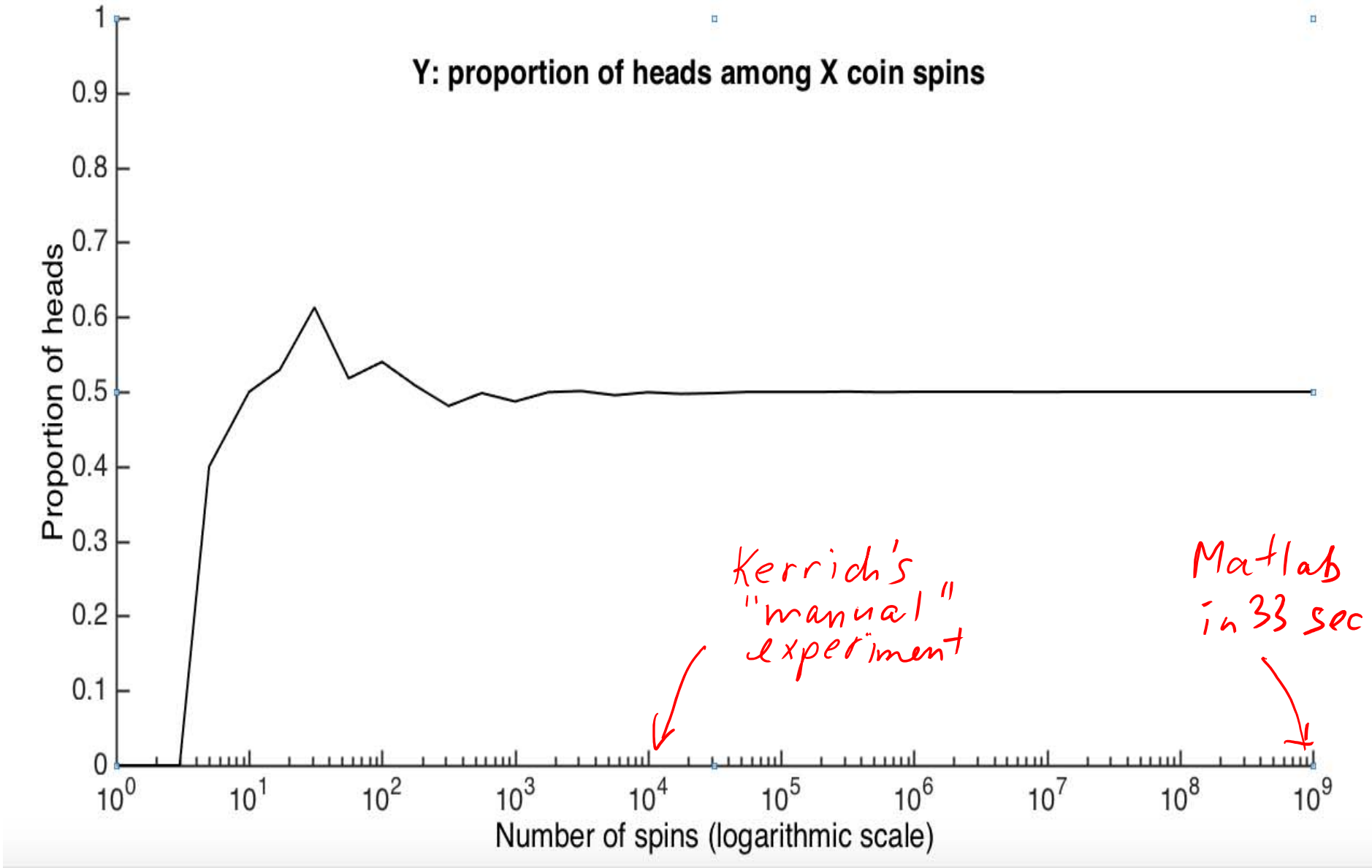
Transposes and dot products:

`x.', A.'` the transposes of x and A
`x', A'` the complex-conjugate of the transposes of x and A
`x' * y` the dot (inner) product of two *column* vectors x and y
`dot(x,y), sum(x.*y)` …two other ways to write the dot product
`x * y'` the *outer* product of two *column* vectors x and y

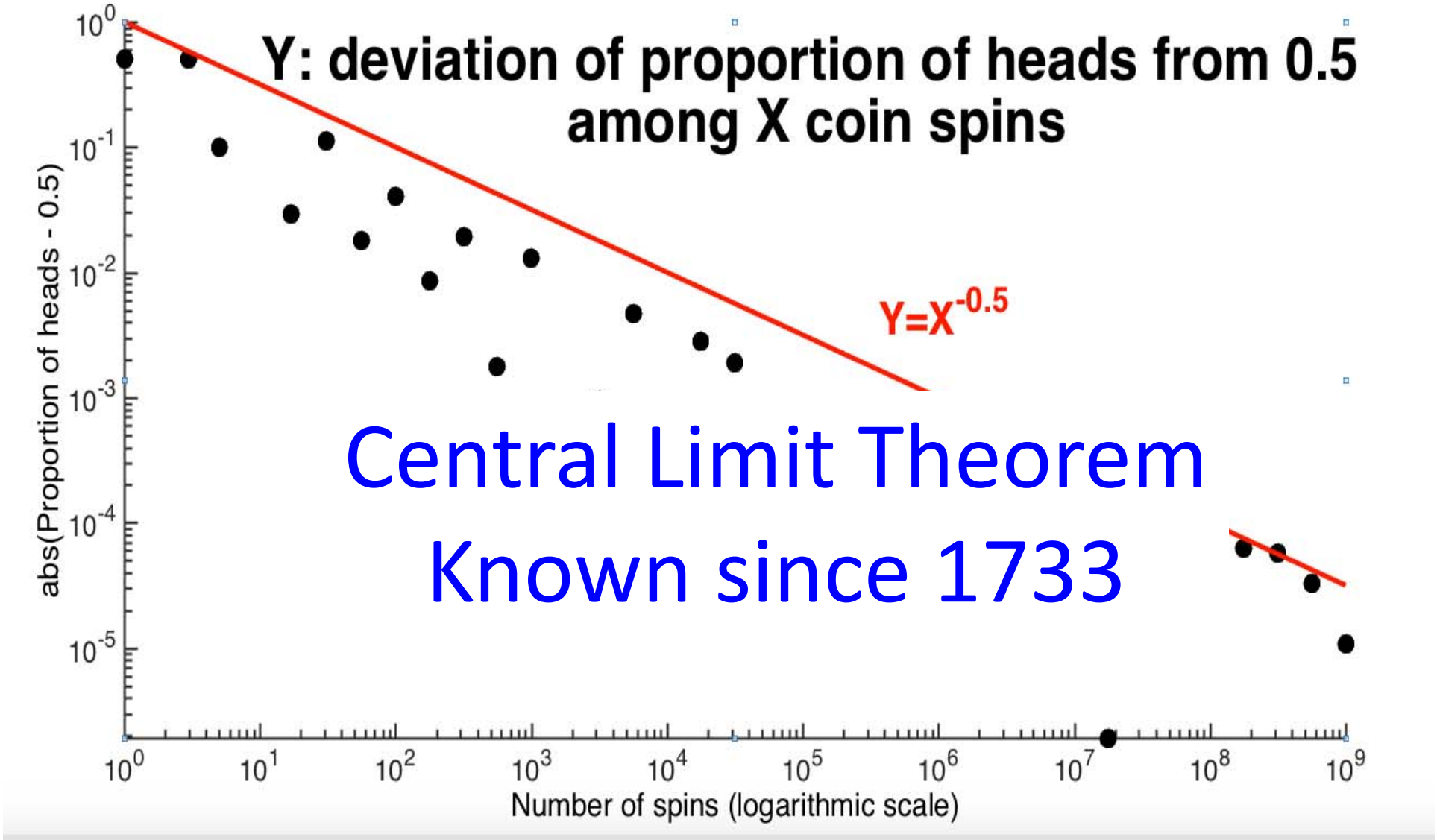
http://web.mit.edu/18.06/www/Spring09/matlab-cheatsheet.pdf

How I did it

- Stats=1e7;
- r0=rand(Stats,1);
- r1=floor(2.*r0);
- n_heads(1)=r1(1);
- for t=2:Stats; n_heads(t)=n_heads(t-1)+r1(t); end;
- tp=[1, 10,100,1000, 10000, 100000, 1000000, 10000000]
- np=n_heads(tp)
- fp=np./tp
- figure; semilogx(tp,fp,'ko-');
- hold on; semilogx([1,10000000],[0.5,0.5],'r--');
- figure; loglog(tp,abs(fp-0.5),'ko-');
- hold on; loglog(tp,0.5./sqrt(tp),'r--');



Proportion of heads among 1,000,000,000 coin tosses
(10^5 more than Kerrich) took me 33 seconds on my Surface Book



ABS(Proportion of heads-0.5)
among 100,000,000 coin tosses

Two definitions of probability

- (1) STATISTICAL PROBABILITY: the relative frequency with which an event occurs in the long run

- (2) INDUCTIVE PROBABILITY: the degree of belief which it is reasonable to place in a proposition on given evidence

Bulmer, M. G.. Principles of Statistics (Dover Books on Mathematics)

Inductive Probability

An inductive probability of an event the degree of belief which it is rational to place in a hypothesis or proposition on given evidence.

Logical

Principle of indifference

- Principle of Indifference states that two events are equally probable if we have no reason to suppose that one of them will happen rather than the other. (Laplace, 1814)

- Unbiased coin:

probability Heads =
probability Tails = ½

- Symmetric die:

probability of each side = 1/6

Pierre-Simon, marquis de Laplace
(1749 –1827)
French mathematician, physicist, astronomer

Inductive probability can lead to trouble

- Glass contains a mixture of wine and water
- We know: proportion of water to wine can be anywhere between 1:1 and 2:1
- We can argue that the proportion of water to wine is equally likely to lie between 1 and 1.5 as between 1.5 and 2.
- Consider now the ratio of wine to water. This quantity must lie between 0.5 and 1, and we can use the same argument to show that it is equally likely to lie between 1/2 and 3/4 as it is to lie between 3/4 and 1.
- But this means that the water to wine ratio is equally likely to lie between 1 and 4/3=1.333… as it is to lie between 1.333.. and 2
- This is clearly inconsistent with the previous calculation

Bertrand's paradox

Inductive probability
relies on combinatorics
or the art of counting
combinations

Counting – Multiplication Rule

- Multiplication rule:
  - Let an operation consist of k steps and
    - n_1 ways of completing step 1,
    - n_2 ways of completing step 2, … and
    - n_k ways of completing step k.
  - Then, the total number of ways or outcomes are:
    - $n_1 * n_2 * \ldots * n_k$
- Example:
  - $S = \{A, C, G, T\}$ the set of 4 DNA bases
  - Number of k-mers is $4^k = 4*4*4\ldots*4$ (k –times)
    Important example: 64 triplets in the genetic code
  - A protein-coding part of the gene is typically 1000 bases long
    There are $4^{1000} = 2^{2000} \sim 10^{600}$ possible sequences of just one gene. Or $(10^{600})^{25,000} = 10^{15,000,000}$ of 25,000 human genes.
    For comparison, the Universe has between 10^{78} and 10^{80} atoms and is $4*10^{17}$ seconds old.

Counting – Permutation Rule

- A permutation is a unique sequence of distinct items.
- If $S = \{a, b, c\}$, then there are 6 permutations
  - Namely: abc, acb, bac, bca, cab, cba (order matters)
- # of permutations for a set of n items is n!
- n! (factorial function) = n*(n-1)*(n-2)*…*2*1
- 7! = 7*6*5*4*3*2*1 = 5,040
- By definition: 0! = 1

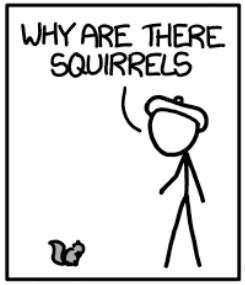
Counting - Similar Item Permutations

- Used for counting the sequences when not all the items are different.
- The number of permutations of:
  - $n = n_1 + n_2 + \ldots + n_r$ items of which
    - n_1 are identical,
    - n_2 are identical, … , and
    - n_r are identical.
- Is calculated as:

$$\frac{n!}{n_1!n_2!\ \ldots n_r!}$$

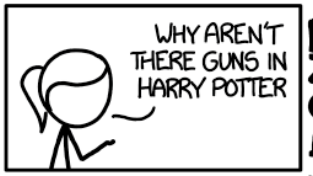
Credit: XKCD comics

QUESTIONS
FOUND IN GOOGLE AUTOCOMPLETE

WHY DO WHALES JUMP
WHY ARE WITCHES GREEN
WHY ARE THERE MIRRORS ABOVE BEDS
WHY DO I SAY UH
WHY IS SEA SALT BETTER
WHY ARE THERE TREES IN THE MIDDLE OF FIELDS
WHY IS THERE NOT A POKEMON MMO
WHY IS THERE LAUGHING IN TV SHOWS
WHY ARE THERE DOORS ON THE FREEWAY
WHY ARE THERE SO MANY SVCHOST.EXE RUNNING
WHY AREN'T THERE ANY COUNTRIES IN ANTARCTICA
WHY ARE THERE SCARY SOUNDS IN MINECRAFT
WHY IS THERE KICKING IN MY STOMACH
WHY ARE THERE TWO SLASHES AFTER HTTP
WHY ARE THERE CELEBRITIES
WHY DO SNAKES EXIST
WHY DO OYSTERS HAVE PEARLS
WHY ARE DUCKS CALLED DUCKS
WHY DO THEY CALL IT THE CLAP
WHY ARE KYLE AND CARTMAN FRIENDS
WHY IS THERE AN ARROW ON AANG'S HEAD
WHY ARE TEXT MESSAGES BLUE
WHY ARE THERE MUSTACHES ON CLOTHES
WHY ARE THERE MUSTACHES ON CARS
WHY ARE THERE MUSTACHES EVERYWHERE
WHY ARE THERE SO MANY BIRDS IN OHIO
WHY IS THERE SO MUCH RAIN IN OHIO
WHY IS OHIO WEATHER SO WEIRD
WHY ARE THERE MALE AND FEMALE BIKES
WHY ARE THERE BRIDESMAIDS
WHY DO DYING PEOPLE REACH UP
WHY AREN'T THERE VARICOSE ARTERIES
WHY ARE OLD KLINGONS DIFFERENT
WHY ARE THERE SQUIRRELS

WHY IS PROGRAMMING SO HARD
WHY IS THERE A 0 OHM RESISTOR
WHY DO AMERICANS HATE SOCCER
WHY DO RHYMES SOUND GOOD
WHY DO TREES DIE
WHY IS THERE NO SOUND ON CNN
WHY AREN'T POKEMON REAL
WHY AREN'T BULLETS SHARP
WHY DO DREAMS SEEM SO REAL
WHY ARE THERE TINY SPIDERS IN MY HOUSE
WHY DO SPIDERS COME INSIDE
WHY ARE THERE HUGE SPIDERS IN MY HOUSE
WHY ARE THERE LOTS OF SPIDERS IN MY HOUSE
WHY ARE THERE SPIDERS IN MY ROOM
WHY ARE THERE SO MANY SPIDERS IN MY ROOM
WHY DO SPIDER BITES ITCH
WHY IS DYING SO SCARY
WHY IS THERE NO GPS IN LAPTOPS
WHY DO KNEES CLICK
WHY AREN'T THERE E GRADES
WHY IS ISOLATION BAD
WHY DO BOYS LIKE ME
WHY DON'T BOYS LIKE ME
WHY IS THERE ALWAYS A JAVA UPDATE
WHY ARE THERE RED DOTS ON MY THIGHS
WHY IS LYING GOOD
WHY IS SEX SO IMPORTANT

WHY ARE THERE SLAVES IN THE BIBLE
WHY DO TWINS HAVE DIFFERENT FINGERPRINTS
WHY ARE AMERICANS AFRAID OF DRAGONS
WHY IS HTTPS CROSSED OUT IN RED
WHY IS THERE A LINE THROUGH HTTPS
WHY IS THERE A RED LINE THROUGH HTTPS ON FACEBOOK
WHY IS HTTPS IMPORTANT
WHY AREN'T MY ARMS GROWING

WHY ARE THERE WEEKS
WHY DO I FEEL DIZZY
WHY IS YKK ON ALL ZIPPERS
WHY ARE THERE SWARMS OF GNATS
WHY IS THERE PHLEGM
WHY ARE THERE SO MANY CROWS IN ROCHESTER, MN
WHY AREN'T ECONOMISTS RICH
WHY DO AMERICANS CALL IT SOCCER
WHY ARE MY EARS RINGING
WHY ARE THERE SO MANY AVENGERS
WHY ARE THE AVENGERS FIGHTING THE X MEN
WHY IS WOLVERINE NOT IN THE AVENGERS
WHY IS THERE LAVA
WHY IS PSYCHIC WEAK TO BUG
WHY DO CHILDREN GET CANCER
WHY IS POSEIDON ANGRY WITH ODYSSEUS
WHY IS THERE ICE IN SPACE
WHY ARE THERE ANTS IN MY LAPTOP
WHY IS EARTH TILTED
WHY IS SPACE BLACK
WHY IS OUTER SPACE SO COLD
WHY ARE THERE PYRAMIDS ON THE MOON
WHY IS NASA SHUTTING DOWN
WHY ARE THERE GHOSTS

WHY IS THERE AN OWL IN MY BACKYARD
WHY IS THERE AN OWL OUTSIDE MY WINDOW
WHY IS THERE AN OWL ON THE DOLLAR BILL
WHY DO OWLS ATTACK PEOPLE
WHY ARE AK 47S SO EXPENSIVE
WHY ARE THERE HELICOPTERS CIRCLING MY HOUSE
WHY ARE THERE GODS
WHY ARE THERE TWO SPOCKS
WHY IS MT VESUVIUS THERE
WHY DO THEY SAY T MINUS
WHY ARE THERE OBELISKS
WHY ARE WRESTLERS ALWAYS WET
WHY ARE OCEANS BECOMING MORE ACIDIC
WHY IS ARWEN DYING
WHY AREN'T MY QUAIL LAYING EGGS
WHY AREN'T MY QUAIL EGGS HATCHING
WHY AREN'T THERE ANY FOREIGN MILITARY BASES IN AMERICA
WHY ARE CIGARETTES LEGAL
WHY ARE THERE DUCKS IN MY POOL
WHY IS JESUS WHITE
WHY IS THERE LIQUID IN MY EAR
WHY DO Q TIPS FEEL GOOD
WHY DO GOOD PEOPLE DIE
WHY AREN'T THERE GUNS IN HARRY POTTER

WHY ARE ULTRASOUNDS IMPORTANT
WHY ARE ULTRASOUND MACHINES EXPENSIVE
WHY IS STEALING WRONG
WHY ARE DOGS AFRAID OF FIREWORKS
WHY IS THERE NO KING IN ENGLAND
WHY IS LIFE SO BORING
WHY ARE THERE FEMALE MR MIMES
WHY IS GPS FREE
WHY IS THERE HELL IF GOD FORGIVES
WHY DO IGUANAS DIE
WHY AREN'T THERE DINOSAUR GHOSTS