Contents

1 Mathematical and Statistical Commands

1.1 Basic Mathematical Calculations

Basic operations addition + subtraction - division / multiplication $*$ power
Mathematical functions

- abs() - Absolute value
- exp() - The exponential
- log(,b) - logarithm to the base "b". The default setting is the natural log.

trigonometrics functions

pi - to 6 decimal places.
tan() ,cos(), sin() - Common trigonometric functions
Precision floor() The floor function x ceiling() The ceiling function x

- round() Round to the nearest integer
- round(,2) Round to two decimal places
- Exercise: write π with 4 decimal places.

```
Complex numbers
x = -1 ;  sqrt(x)  ;  str(x) ;  # variable is defined as numeric, not complex.
y = -1 +0i ;  sqrt(y)  ;  str(y) ;     #variable is defined as complex .
Trigonometric  Functions
pi #returns the value of pi to six decimal places
sin(3.5*pi) # correct answer is -1
cos(3.5*pi) # correct answer is zero
```

1.2 Basic Calculations

We will briefly look at how R accomplished basic calculations.

```
x*y # multiplication
x/z # division

x^2 # powers
sqrt(x) # square root

exp(z)  # exponentials
log(y)  # logarithms

pi             # returns the value of pi to six decimal places
```

Complex numbers , Trigonometric Functions and Binomial Coefficients
Binomial coefficients are computed using the choose() command.

```
J = -1 ;  sqrt(J)  ;  str(J) ;      # variable is defined as numeric, not complex.
K = -1 +0i ;  sqrt(K)  ;  str(K) ;  # variable is defined as complex .
```

1.3 Useful Mathematical Operators

- Factorials $n! = n \times n-1 \times \ldots \times 2 \times 1$
- Binomial Coefficients

$$\binom{n}{k} = \frac{n!}{(n-k)! \times k!}$$

The R commands are `factorial()` and `choose()` respectively.

Matrices and Linear Algebra Factorials and permutations The Choose Function

$$\binom{6}{3} = \frac{654}{321} = 20$$

```
> factorial(6)
[1] 720
> choose(6,3)
[1] 20
>
```

1.4 Mathematical Precision Functions

Three commonly used mathematical precision functions are:

- Absolute Value Function $|x|$ - distance on the number line from zero.
- Ceiling Function $\lceil x \rceil$ - rounds a value up to the nearest integer.
- Floor Function $\lfloor x \rfloor$ - rounds a value down to the nearest integer.
- `floor()` Floor function of x, $\lfloor x \rfloor$.
- `ceiling()` Ceiling function of x, $\lceil x \rceil$.
- `round()` Rounding a number to a specified number of decimal places.

```
pi
floor(pi)
ceiling(pi)
```

```
> pi
[1] 3.141593
>
> floor(pi)
[1] 3
>
> ceiling(pi)
[1] 4
>
```

We can also round numbers to a specified number of decimal places, using the `round()` command.

```
round(pi,3)
round(pi,2)
```

```
> round(pi,3)
[1] 3.142
> round(pi,2)
[1] 3.14
```

1.5 Truncation and discretization

The functions "floor" and "ceiling" can be used to discretize outcomes. In this instance we should use "ceiling".

ceiling(X) floor(X) round(X,2)

X=ceiling(X)

The expected value is 3.5.

The variance from first principles we can calculate the variance using

1.6 Managing Precision

- `floor()` Floor function of x, $\lfloor x \rfloor$.
- `ceiling()` Ceiling function of x, $\lceil x \rceil$.
- `round()` Rounding a number to a specified number of decimal places.

1.7 Sequences

1.8 Sampling

Types of Sampling

- Sampling With Replacement
- Sampling Without Replacement

The R command we use to perform sampling is sample().

All elements in either X or Y

```
> X=c(4,5)
>
> sample(X,2)
[1] 4 5
```

```
>
> sample(X,1);sample(X,1);sample(X,1);
[1] 4
[1] 5
[1] 5
```

When x is a single value, the function sample() behaves differently.

```
> Y=c(4)
>
> sample(Y,1)
[1] 2
>
> sample(Y,2)
[1] 3 1
```

Generate a quick pick : pick 6 numbers from 1 to 42. (Same number cant be selected more than once)

Generate five values from a die (Same number can be selected more than once).

```
> Lotto = 1:42
> Dice = 1:6
>
> sample(Lotto,6)
[1] 38 25 34 30 22 29
>
> sample(Dice,5,replace = TRUE)
[1] 4 3 2 3 3
>
```

1.9 Useful Statistical Commands

- `mean()` mean of a data set
- `median()` median of a data set
- `length()` Sample Size
- `IQR()` Inter-Quartile Range of a sample
- `var()` Variance of a sample
- `sd()` Standard Deviation of a sample

- `range()` Range of a data set
- `fivenum()` Tukey's five number summary

1.10 Set Theory Operations

- `union()` union of sets A and B
- `intersect()` intersection of sets A and B
- `setdiff()` set difference A-B (order is important)

```
x = 5:10
y = 8:12
union(x,y)
intersect(x,y)
setdiff(x,y)
setdiff(y,x)
```

1.11 Set Theory with R

- Union
- Intersection
- Set Diffference

```
X = 5:10
Y = 8:12
```

```
union(X,Y)
# [1]  5  6  7  8  9 10 11 12
intersect(X,Y)
# [1]  8  9 10
```

1.12 Set Theory Operations

- `union()` union of sets A and B
- `intersect()` intersection of sets A and B
- `setdiff()` set difference A-B (order is important)

```
x = 5:10
y = 8:12
union(x,y)
intersect(x,y)
setdiff(x,y)
setdiff(y,x)
```

1.13 The Birthday function

The R command `pbirthday()` computes the probability of a coincidence of a number of randomly chosen people sharing a birthday, given that there are n people to choose from. Suppose there are four people in a room. The probability of two of them sharing a birthday is computed as about 1.6 %

```
> pbirthday(4)
[1] 0.01635591
```

How many people do you need for a greater than 50% chance of a shared birthday? (choose from 23,43,63,83)?

1.14 Other Mathematical Functions

Complex numbers

```
x = -1 ;  sqrt(x)  ;  str(x) ;  # variable is defined as numeric, not complex.
y = -1 +0i ;  sqrt(y)  ;  str(y) ;     #variable is defined as complex .
```

Trigonometric Functions

```
pi #returns the value of pi to six decimal places
sin(3.5*pi) # correct answer is -1
cos(3.5*pi) # correct answer is zero
```

1.15 Generating Random Numbers

R is very useful for performing simulations.

```
#generate a random number between 0 and 1
runif(1)
#generate four random numbers between 0 and 6
runif(4,min=0,max=6)
```

Random numbers can be discretized using the "floor()" or "Ceiling()" functions. Suppose we wish to simulate four throws of a dice.

X = ceiling (runif(4,min=0,max=6)) Y = floor (runif(4,min=1,max=7)) X+Y

1.16 Section 2: Basic Mathematical operations

Trigonometric and power functions

Integration

```
integrate(sin, lower =0, upper = 3)
integrate(dnorm, -1.96, 1.96)  # standard normal distribution
integrate(dnorm, 0, Inf)    # standard normal distribution
```

Complex numbers