# 02424 Week 1 — Solution

## Exercise 1

Calculate the probability for each of the following events:

a) A standard normally distributed variable is larger than 2.

```
> 1 - pnorm(2)
```

```
[1] 0.02275013
```

b) A normally distributed variable with mean 40 and variance equal to 9 is smaller than 34.

```
> pnorm(34, mean = 40, sd = sqrt(9))
```

```
[1] 0.02275013
```

c) Getting 9 successes out of 10 trials in a binomial experiment with $p = 0.8$.

```
> dbinom(9, size = 10, prob = 0.8)
```

```
[1] 0.2684355
```

d) $X > 6.2$ in a $\chi^2$ distribution with 2 degrees of freedom.

```
> 1 - pchisq(6.2, df = 2)
```

```
[1] 0.0450492
```

## Exercise 2

Such a model is easy to estimate in R. The observations are listed here:

```
x   y
-1  1.4
0   4.7
1   5.1
2   8.3
3   9.0
4   14.5
5   14.0
6   13.4
7   19.2
8   18
```

Read the data into R and fit the linear model using the `lm()` function.

```
> linRegData <- read.table("linregdata.tab", header = TRUE)
> fit <- lm(y ~ x, data = linRegData)
> fit

Call:
lm(formula = y ~ x, data = linRegData)

Coefficients:
(Intercept)            x
      4.078        1.909
```

**Exercise 3 (possibly difficult)**

Use the following observations from a negative binomial distribution.

```
> x <- c(13, 5, 28, 28, 15, 4, 13, 4, 10, 17, 11, 13, 12, 17, 3)
```

R has a function for minimizing functions, which is called `optim()`. It works in the following way:

```
> fun <- function(x) {
+     (x[1] - 3)^2 + x[2]^2
+ }
> fit <- optim(par = c(2, 2), fn = fun)
> fit$par

[1] 2.999923e+00 1.699310e-06
```

Try to use these principles – as well as the likelihood method – to estimate the parameters of the negative binomial distribution.

```
> x <- c(13, 5, 28, 28, 15, 4, 13, 4, 10, 17, 11, 13, 12, 17, 3)
> nll <- function(theta) {
+     -sum(dnbinom(x, size = theta[1], prob = theta[2], log = TRUE))
+ }
> fit <- optim(c(1, 0.5), nll, lower = 0, upper = c(Inf, 1), hessian = TRUE)
> fit$convergence

[1] 0
```

```
> estimates <- fit$par
> std.dev <- sqrt(diag(solve(fit$hessian)))
> cbind(estimates, std.dev)

     estimates    std.dev
[1,] 3.6756063 1.73114063
[2,] 0.2221958 0.08556651
```