Q1

Take the derivative of sum(w * (x - mu) ^ 2):

$$
\begin{aligned}
w \cdot (x - mu)^2 &= 2\,(1.57 - mu)^2 + 2\,(1.25 - mu)^2 + (2.8 - mu)^2 + (0.43 - mu)^2 \\
\frac{dS}{d_{mu}} &= -4(1.57 - mu) - 4(1.25 - mu) - 2(2.8 - mu) - 2(0.43 - mu) = 0 \\
mu &= 1.48
\end{aligned}
$$

Q2

```r
raw_dat = read.table('shhs1.txt',header = 1)
raw_dat$'log(rdi4p + 1)' = log(raw_dat$rdi4p + 1)
fit = lm(log(rdi4p + 1) ~ waist + age_s1 + gender + bmi_s1, data = raw_dat)
summary(fit)
```

```
##
## Call:
## lm(formula = log(rdi4p + 1) ~ waist + age_s1 + gender + bmi_s1,
##     data = raw_dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.3200 -0.6681 -0.0510  0.6216  3.2937
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -2.281392   0.112558 -20.269  < 2e-16 ***
## waist        0.007058   0.001546   4.564 5.12e-06 ***
## age_s1       0.019982   0.001171  17.058  < 2e-16 ***
## gender       0.517821   0.026890  19.257  < 2e-16 ***
## bmi_s1       0.063068   0.004036  15.627  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9144 on 5411 degrees of freedom
##   (388 observations deleted due to missingness)
## Multiple R-squared:  0.2518, Adjusted R-squared:  0.2512
## F-statistic: 455.3 on 4 and 5411 DF,  p-value: < 2.2e-16
```

Q3

```r
newdata = data.frame(waist = 100,age_s1 = 60,bmi_s1 = 30,gender = 1)
rdi4p = exp(predict(fit,newdata))-1
rdi4p
```

```
##        1
## 6.638665
```

Q4

Interpretation:

$$log(rdi4p + 1) = -2.281392 + 0.007058waist + 0.019982age + 0.517821gender + 0.063068bmi$$

Coefficient means increase or decrease of log(rdi4p + 1) given one unit change of predictor holding other predictors at a fixed level.

Q5

```r
library(tidyverse)
# 0 for rdi4p < 7, 1 for 7 <= rdi4p < 15, 2 for 7 <= rdi4p < 15, 3 for 30 <= rdi4p
raw_dat2 = mutate(raw_dat, cutrdi4p = ( (7<=rdi4p )*1 + (15<=rdi4p)*1 + (30 <= rdi4p)*1))
raw_dat2$cutrdi4p = factor(raw_dat2$cutrdi4p)
# raw_dat3 = model.matrix(~cutrdi4p, data = raw_dat2
fit = glm(HTNDerv_s1 ~ cutrdi4p , data = raw_dat2, family = binomial())
# anova(fit)
summary(fit)
```

```
##
## Call:
## glm(formula = HTNDerv_s1 ~ cutrdi4p, family = binomial(), data = raw_dat2)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.3328  -0.9805  -0.9805   1.2007   1.3880
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -0.48267    0.03384 -14.262  < 2e-16 ***
## cutrdi4p1    0.42811    0.06917   6.189 6.04e-10 ***
## cutrdi4p2    0.47044    0.08522   5.521 3.38e-08 ***
## cutrdi4p3    0.84073    0.11377   7.390 1.47e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 7921.7  on 5803  degrees of freedom
## Residual deviance: 7824.8  on 5800  degrees of freedom
## AIC: 7832.8
##
## Number of Fisher Scoring iterations: 4
```

Q6

```r
#age, gender, bmi, waist and smokstat_s1
fit = glm(HTNDerv_s1 ~ cutrdi4p + age_s1 + gender + bmi_s1 + waist+  smokstat_s1  ,
          data = raw_dat2, family = binomial())
# anova(fit)
summary(fit)
```

```
##
## Call:
## glm(formula = HTNDerv_s1 ~ cutrdi4p + age_s1 + gender + bmi_s1 +
```

```
##     waist + smokstat_s1, family = binomial(), data = raw_dat2)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.9029  -1.0234  -0.6827   1.1240   2.1408
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.574954   0.294145 -18.953  < 2e-16 ***
## cutrdi4p1    0.149463   0.076874   1.944 0.051865 .
## cutrdi4p2    0.111258   0.095271   1.168 0.242886
## cutrdi4p3    0.452920   0.126855   3.570 0.000356 ***
## age_s1       0.055657   0.002937  18.952  < 2e-16 ***
## gender       0.012453   0.065102   0.191 0.848310
## bmi_s1       0.044391   0.009553   4.647 3.37e-06 ***
## waist        0.004466   0.003620   1.234 0.217298
## smokstat_s1 -0.023995   0.031149  -0.770 0.441097
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 7380.2  on 5383  degrees of freedom
## Residual deviance: 6837.8  on 5375  degrees of freedom
##   (420 observations deleted due to missingness)
## AIC: 6855.8
##
## Number of Fisher Scoring iterations: 4
```

Interpretation:

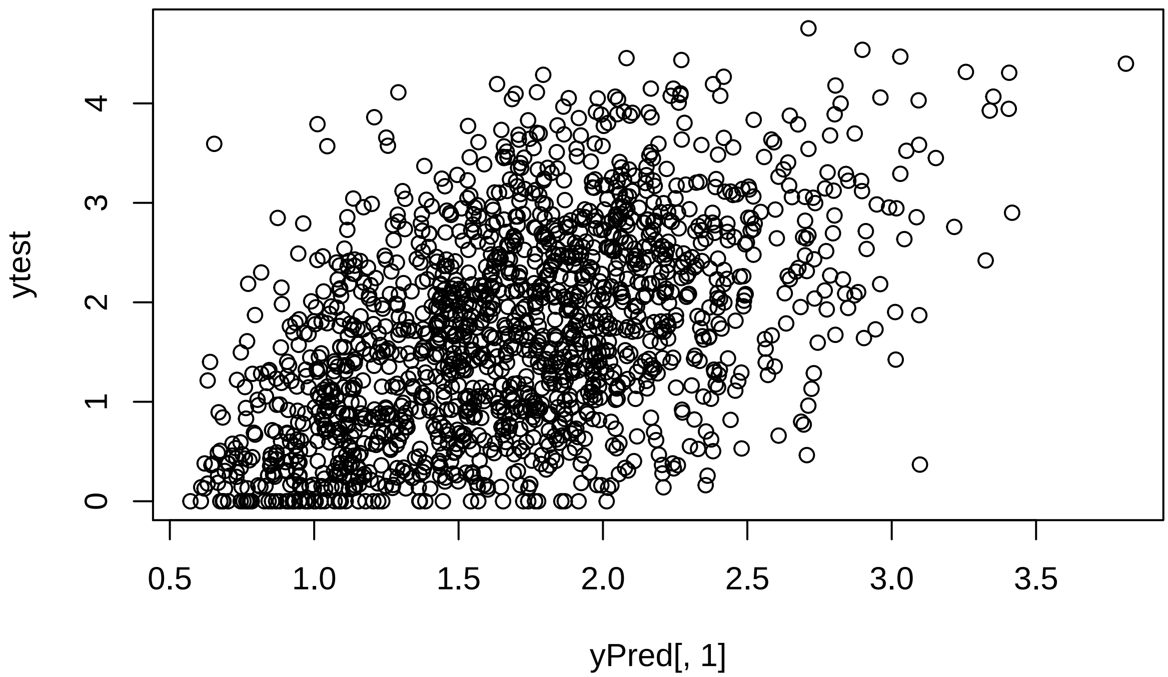
$$\begin{aligned} logit(p) = -5.574954 + 0.149463 * I(mildsleepapnea) + 0.111258 * I(sleepapnea) + 0.452920 * I(severesleepapnea) \\ +0.055657 age + 0.012453 gender + 0.044391 bmi + 0.004466 waist - 0.023995 smokstat \\ I(mildsleepapnea) = \begin{cases} 1, 7 <= rdi4p < 15 \\ 0, otherwise \end{cases} \\ I(sleepapnea) = \begin{cases} 1, 15 <= rdi4p < 30 \\ 0, otherwise \end{cases} \\ I(severesleepapnea) = \begin{cases} 1, 30 <= rdi4p \\ 0, otherwise \end{cases} \end{aligned}$$

For categorical variable, coeffients are based on the baseline(Intercept:rdi4p < 7). For continuous predictor, the coeffients represent the change of log odds of probability of being hypertension or not given one unit change of predictor holding other predictors at fixed level.

Q7

```r
library(tidyverse)
library(keras)

dat = read.table("shhs1.txt", header = TRUE)
```

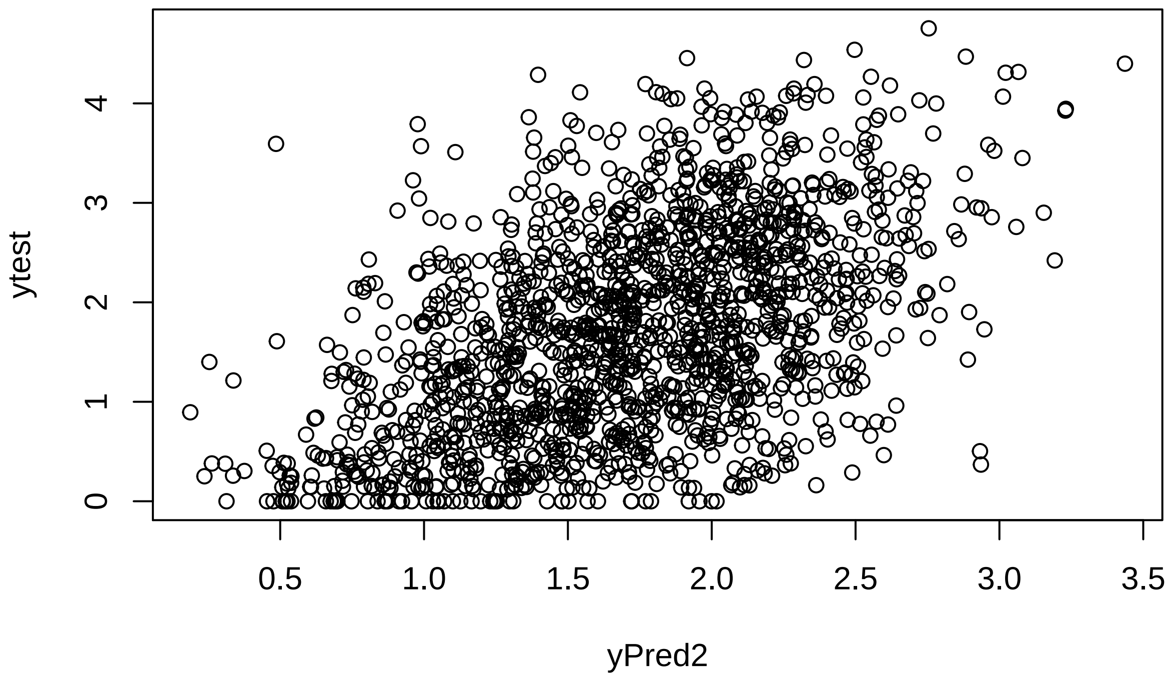
```r
analyticDat = dat %>%
  select(rdi4p, waist, COPD15, HTNDerv_s1, gender, age_s1, bmi_s1)%>%
  # select(rdi4p, waist, smokstat_s1, HTNDerv_s1, gender, age_s1, bmi_s1) %>%
 na.omit()



y = log(analyticDat$rdi4p + 1)
x = analyticDat %>% select(-rdi4p) %>% as.matrix()

trainIdx = sample(c(TRUE, FALSE), length(y), replace = TRUE, prob = c(.7, .3))

ytrain = y[trainIdx]
xtrain = x[trainIdx, ] %>% scale()

mns = attr(xtrain, "scaled:center")
sds = attr(xtrain, "scaled:scale")

xtest = x[!trainIdx, ] %>% scale(center = mns, scale = sds)
ytest = y[!trainIdx]

model = keras_model_sequential() %>%
 layer_dense(units = 4, activation = "relu",
             use_bias = TRUE,
             input_shape = dim(xtrain)[2]) %>%
 layer_dense(units = 2, activation = "relu") %>%
 layer_dense(units = 1)


model %>% compile(
 loss = "mse",
 optimizer = optimizer_rmsprop(),
 metrics = list("mean_absolute_error")
)


history = model %>% fit(
 xtrain,
 ytrain,
 epochs = 20,
 validation_split = 0.2,
 verbose = 1,
)

## compare with the test data
yPred = model %>% predict(xtest)

## plot
plot(yPred[,1], ytest)
```




```r
cor(yPred[,1], ytest)
```

```
## [1] 0.5044432
```

```r
## compare with ordinary regression
fit = lm(ytrain ~ xtrain)
yPred2 =  cbind(1, xtest) %*% coef(fit)
plot(yPred2, ytest)
```




```
cor(yPred2, ytest)
```

```
##            [,1]
## [1,] 0.5060187
```

Q8

```
library(tidyverse)
library(keras)


dat = read.table("shhs1.txt", header = TRUE)

analyticDat = dat %>%
 select(rdi4p, waist, COPD15, HTNDerv_s1, gender, age_s1, bmi_s1) %>%
 na.omit()



y = analyticDat$HTNDerv_s1
y = cbind(y, 1 - y)
x = analyticDat %>% select(-HTNDerv_s1) %>% as.matrix()

trainIdx = sample(c(TRUE, FALSE), dim(x)[1], replace = TRUE, prob = c(.7, .3))

ytrain = y[trainIdx, ]
```

```r
xtrain = x[trainIdx, ] %>% scale()

mns = attr(xtrain, "scaled:center")
sds = attr(xtrain, "scaled:scale")

xtest = x[!trainIdx, ] %>% scale(center = mns, scale = sds)
ytest = y[!trainIdx, ]

model = keras_model_sequential() %>%
 layer_dense(units = 2^8, activation = "relu",
             use_bias = TRUE,
             input_shape = dim(xtrain)[2]) %>%
 layer_dropout(rate = .8) %>%
 layer_dense(units = 2 ^ 4, activation = "relu") %>%
 layer_dropout(rate = .8) %>%
 layer_dense(units = 2, activation = "softmax")


model %>% compile(
 loss = "categorical_crossentropy",
 optimizer = optimizer_rmsprop(),
 metrics = list("accuracy")
)


history = model %>% fit(
 xtrain,
 ytrain,
 epochs = 30,
 validation_split = 0.2,
 verbose = 1,
)

## compare with the test data


## predict classes gives the index (counting from 0)
## of the category. So, it gives 1 for the second column (which is HTN=0)
## and 0 for the first column (which is HTN=1). So to get it to agree
## I 1 - the output
yPred = 1 - (model %>% predict_classes(xtest))

## loot at the comaprison
ptab = table(yPred, ytest[,1])
ptab
```

```
##
## yPred   0   1
##     0 727 431
##     1 171 263
```

```r
## accuracy
sum(diag(ptab)) / sum(ptab)
```

```
## [1] 0.6218593
```

```r
## compare with ordinary logistic regression
fit = glm(HTNDerv_s1 ~ ., family = "binomial", data = analyticDat, subset = trainIdx)
yPred2 =  (predict(fit, analyticDat[!trainIdx,], type = "response") > 0.5) * 1

ptab2 = table(yPred2, ytest[,1])
sum(diag(ptab2)) / sum(ptab2)
```

```
## [1] 0.6369347
```

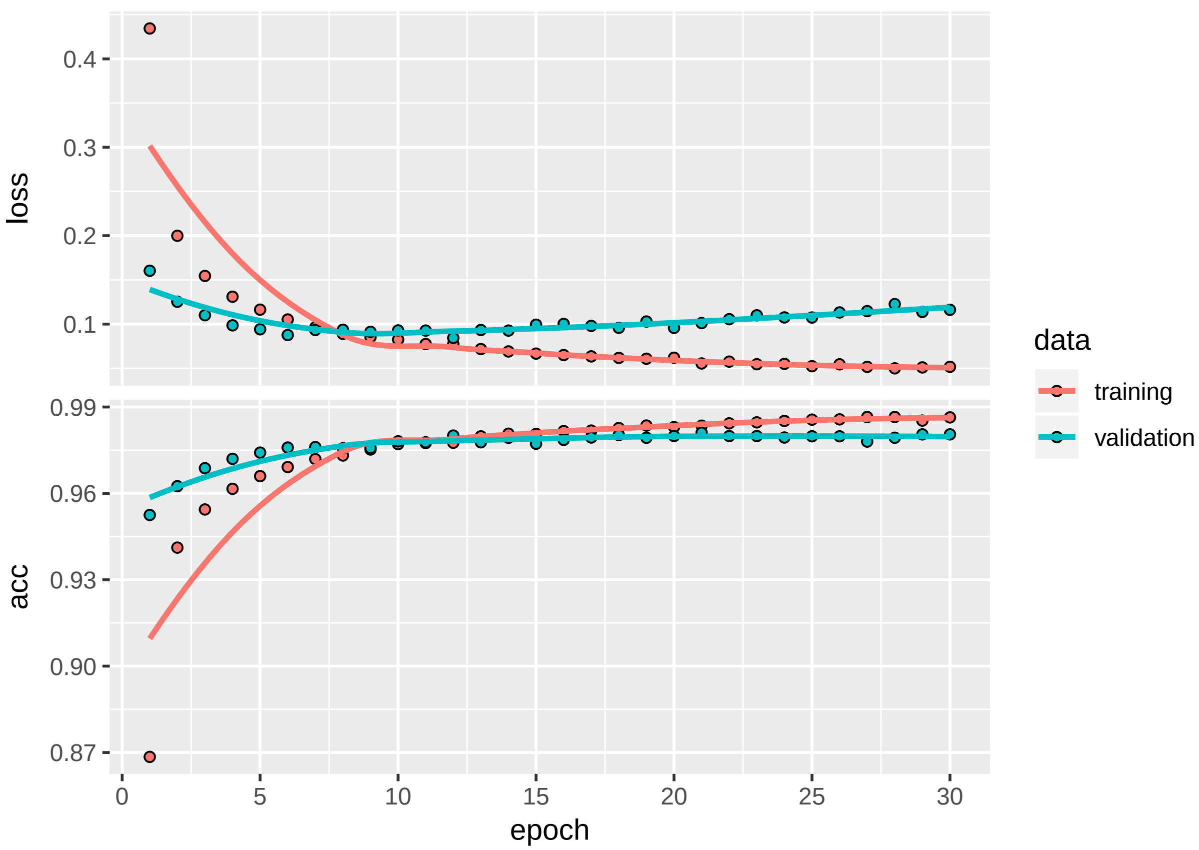
Q9

```r
library(keras)
mnist <- dataset_mnist()
x_train <- mnist$train$x
y_train <- mnist$train$y
x_test <- mnist$test$x
y_test <- mnist$test$y


# reshape
x_train <- array_reshape(x_train, c(nrow(x_train), 784))
x_test <- array_reshape(x_test, c(nrow(x_test), 784))
# rescale
x_train <- x_train / 255
x_test <- x_test / 255

y_train <- to_categorical(y_train, 10)
y_test <- to_categorical(y_test, 10)



model <- keras_model_sequential()
model %>%
  layer_dense(units = 256, activation = 'relu', input_shape = c(784)) %>%
  layer_dropout(rate = 0.4) %>%
  layer_dense(units = 128, activation = 'relu') %>%
  layer_dropout(rate = 0.3) %>%
  layer_dense(units = 10, activation = 'softmax')

summary(model)
```

```
## ________________________________________________________________________________
## Layer (type)                        Output Shape                  Param #
## ================================================================================
## dense_6 (Dense)                     (None, 256)                   200960
## ________________________________________________________________________________
## dropout_2 (Dropout)                 (None, 256)                   0
## ________________________________________________________________________________
## dense_7 (Dense)                     (None, 128)                   32896
## ________________________________________________________________________________
## dropout_3 (Dropout)                 (None, 128)                   0
## ________________________________________________________________________________
## dense_8 (Dense)                     (None, 10)                    1290
```

```
## ===========================================================================
## Total params: 235,146
## Trainable params: 235,146
## Non-trainable params: 0
## ___________________________________________________________________________
```

```
model %>% compile(
  loss = 'categorical_crossentropy',
  optimizer = optimizer_rmsprop(),
  metrics = c('accuracy')
)


history <- model %>% fit(
  x_train, y_train,
  epochs = 30, batch_size = 128,
  validation_split = 0.2
)

plot(history)
```




```
model %>% evaluate(x_test, y_test)
```

```
## $loss
## [1] 0.106643
##
## $acc
```

```
## [1] 0.9807
```

```r
model %>% predict_classes(x_test)
```

```
##    [1] 7 2 1 0 4 1 4 9 5 9 0 6 9 0 1 5 9 7 3 4 9 6 6 5 4 0 7 4 0 1 3 1 3 4
##   [35] 7 2 7 1 2 1 1 7 4 2 3 5 1 2 4 4 6 3 5 5 6 0 4 1 9 5 7 8 9 3 7 4 6 4
##   [69] 3 0 7 0 2 9 1 7 3 2 9 7 7 6 2 7 8 4 7 3 6 1 3 6 9 3 1 4 1 7 6 9 6 0
##  [103] 5 4 9 9 2 1 9 4 8 7 3 9 7 4 4 4 9 2 5 4 7 6 7 9 0 5 8 5 6 6 5 7 8 1
##  [137] 0 1 6 4 6 7 3 1 7 1 8 2 0 2 9 9 5 5 1 5 6 0 3 4 4 6 5 4 6 5 4 5 1 4
##  [171] 4 7 2 3 2 7 1 8 1 8 1 8 5 0 8 9 2 5 0 1 1 1 0 9 0 3 1 6 4 2 3 6 1 1
##  [205] 1 3 9 5 2 9 4 5 9 3 9 0 3 6 5 5 7 2 2 7 1 2 8 4 1 7 3 3 8 8 7 9 2 2
##  [239] 4 1 5 9 8 7 2 3 0 2 4 2 4 1 9 5 7 7 2 8 2 6 8 5 7 7 9 1 8 1 8 0 3 0
##  [273] 1 9 9 4 1 8 2 1 2 9 7 5 9 2 6 4 1 5 8 2 9 2 0 4 0 0 2 8 4 7 1 2 4 0
##  [307] 2 7 4 3 3 0 0 3 1 9 6 5 2 5 9 7 9 3 0 4 2 0 7 1 1 2 1 5 3 3 9 7 8 6
##  [341] 3 6 1 3 8 1 0 5 1 3 1 5 5 6 1 8 5 1 7 8 4 6 2 2 5 0 6 5 6 3 7 2 0 8
##  [375] 8 5 4 1 1 4 0 3 3 7 6 1 6 2 1 9 2 8 6 1 9 5 2 5 4 4 2 8 3 8 2 4 5 0
##  [409] 3 1 7 7 5 7 9 7 1 9 2 1 4 2 9 2 0 4 9 1 4 8 1 8 4 5 9 8 8 3 7 6 0 0
##  [443] 3 0 2 0 6 9 9 3 3 3 2 3 9 1 2 6 8 0 5 6 6 6 3 8 8 2 7 5 8 9 6 1 8 4
##  [477] 1 2 5 9 1 9 7 5 4 0 8 9 9 1 0 5 2 3 7 0 9 4 0 6 3 9 5 2 1 3 1 3 6 5
##  [511] 7 4 2 2 6 3 2 6 5 4 8 9 7 1 3 0 3 8 3 1 9 3 4 4 6 4 2 1 8 2 5 4 8 8
##  [545] 4 0 0 2 3 2 7 7 0 8 7 4 4 7 9 6 9 0 9 8 0 4 6 0 6 3 5 4 8 3 3 9 3 3
##  [579] 3 7 8 0 2 2 1 7 0 6 5 4 3 8 0 9 6 3 8 0 9 9 6 8 6 8 5 7 8 6 0 2 4 0
##  [613] 2 2 3 1 9 7 5 1 0 8 4 6 2 6 7 9 3 2 9 8 2 2 9 2 7 3 5 9 1 8 0 2 0 5
##  [647] 2 1 3 7 6 7 1 2 5 8 0 3 7 2 4 0 9 1 8 6 7 7 4 3 4 9 1 9 5 1 7 3 9 7
##  [681] 6 9 1 3 3 8 3 3 6 7 2 8 5 8 5 1 1 4 4 3 1 0 7 7 0 7 9 4 4 8 5 5 4 0
##  [715] 8 2 1 6 8 4 8 0 4 0 6 1 9 3 2 6 7 2 6 9 3 1 4 6 2 5 9 2 0 6 2 1 7 3
##  [749] 4 1 0 5 4 3 1 1 7 4 9 9 4 8 4 0 2 4 5 1 1 6 4 7 1 9 4 2 4 1 5 5 3 8
##  [783] 3 1 4 5 6 8 9 4 1 5 3 8 0 3 2 5 1 2 8 3 4 4 0 8 8 3 3 1 7 3 5 9 6 3
##  [817] 2 6 1 3 6 0 7 2 1 7 1 4 2 4 2 1 7 9 6 1 1 2 4 8 1 7 7 4 8 0 7 3 1 3
##  [851] 1 0 7 7 0 3 5 5 2 7 6 6 9 2 8 3 5 2 2 5 6 0 8 2 9 2 8 5 8 8 7 4 9 3
##  [885] 0 6 6 3 2 1 3 2 2 9 3 0 0 5 7 8 3 4 4 6 0 2 9 1 4 7 4 7 3 9 8 8 4 7
##  [919] 1 2 1 2 2 3 7 3 2 3 9 1 7 4 0 3 5 5 8 6 3 2 6 7 6 6 3 2 7 8 1 1 7 5
##  [953] 6 4 9 5 1 3 3 4 7 8 9 1 1 6 9 1 4 4 5 4 0 6 2 2 3 1 5 1 2 0 3 8 1 2
##  [987] 6 7 1 6 2 3 9 0 1 2 2 0 8 9 9 0 2 5 1 9 7 8 1 0 4 1 7 9 5 4 2 6 8 1
## [1021] 3 7 5 4 4 1 8 1 3 8 1 2 5 8 0 6 2 1 1 2 1 5 3 4 6 9 5 0 9 2 2 4 8 2
## [1055] 1 7 2 4 9 4 4 0 3 9 2 2 3 3 8 3 5 7 3 5 8 1 2 4 4 6 4 9 5 1 0 6 9 5
## [1089] 9 5 9 7 3 8 0 3 7 1 3 6 7 8 5 9 7 9 6 9 6 3 7 4 6 5 3 5 4 7 8 7 8 0
## [1123] 7 6 8 8 7 3 3 1 9 5 2 7 3 5 1 1 2 1 4 7 4 7 5 4 5 4 0 8 3 6 9 6 0 2
## [1157] 7 4 4 4 4 6 6 4 7 9 3 4 5 5 8 7 3 7 2 7 0 2 4 1 1 6 8 9 2 8 7 2 0 1
## [1191] 5 0 9 1 7 0 6 0 8 6 8 1 8 0 3 3 7 2 3 6 2 1 6 1 1 3 7 9 0 8 0 5 4 0
## [1225] 2 8 2 2 9 8 4 0 6 5 8 5 1 2 1 3 1 7 4 5 7 2 0 3 8 8 6 2 5 4 1 9 2 1
## [1259] 5 8 7 0 2 4 4 3 6 8 8 2 4 0 5 0 4 4 7 9 3 4 1 5 9 7 3 5 8 8 0 5 3 3
## [1293] 6 6 0 1 6 0 3 7 4 4 1 2 9 1 4 6 9 9 3 9 8 4 4 3 1 3 1 3 8 7 9 4 8 8
## [1327] 7 9 8 1 4 5 6 0 5 2 2 2 1 5 5 2 4 9 6 2 7 7 2 2 1 1 2 8 3 7 2 4 1 7
## [1361] 1 7 6 7 8 2 7 3 1 7 5 8 2 6 2 2 5 6 5 0 9 2 4 3 3 9 7 6 6 8 0 4 1 3
## [1395] 8 3 9 1 8 0 6 7 2 1 0 5 5 2 0 2 2 0 2 4 9 8 0 9 9 4 6 5 4 9 1 8 3 4
## [1429] 9 9 1 2 2 1 1 9 6 4 0 9 4 8 3 8 6 0 2 5 1 9 6 2 9 4 0 9 6 0 6 2 5 4
## [1463] 2 3 8 4 5 5 0 3 8 5 3 5 8 6 5 7 6 3 3 9 6 1 1 2 9 0 4 3 3 6 9 5 7 3
## [1497] 7 7 7 8 7 9 8 3 0 7 2 7 9 4 5 4 9 3 2 1 4 0 2 3 7 5 9 8 8 5 0 1 1 4
## [1531] 7 3 9 0 0 0 6 6 2 3 7 8 4 7 7 9 2 4 1 6 5 2 4 3 8 1 8 4 0 9 8 4 8 7
## [1565] 7 0 7 8 8 6 0 4 8 8 2 4 7 6 6 6 4 7 1 8 8 2 3 6 3 0 0 3 7 6 9 7 9 9
## [1599] 5 4 3 3 6 1 2 3 7 3 3 2 0 3 3 8 4 3 6 3 5 0 2 0 9 0 7 4 6 9 3 5 1 9
## [1633] 6 1 4 5 4 5 0 5 9 5 2 1 2 9 1 9 9 4 0 8 4 5 2 9 2 1 2 1 7 3 6 8 8 4
## [1667] 9 1 9 8 5 7 5 1 1 8 6 5 2 4 4 7 2 3 5 6 8 8 6 2 3 1 0 5 8 9 2 9 6 7
## [1701] 0 4 8 7 1 7 4 1 0 3 7 2 0 0 9 1 7 0 7 8 4 7 2 0 4 6 0 3 1 1 3 3 9 6
```

```
## [1735] 7 4 1 5 3 0 8 7 3 9 6 9 3 5 0 2 7 2 5 1 2 5 8 0 8 8 1 5 0 3 0 3 1 4
## [1769] 0 3 7 2 7 1 8 0 7 0 4 3 1 9 8 7 7 1 4 9 9 3 8 1 7 9 0 2 0 3 3 7 6 9
## [1803] 2 3 3 7 7 0 0 7 5 2 9 2 7 4 4 2 6 6 1 9 6 8 2 9 0 8 3 1 1 6 3 5 1 1
## [1837] 1 3 1 2 3 0 2 0 1 3 5 5 7 4 8 9 6 9 6 8 3 6 6 8 5 1 4 2 4 4 5 1 1 9
## [1871] 0 2 4 9 5 7 1 8 3 5 6 9 8 7 1 1 6 7 6 3 2 2 0 8 9 2 5 1 0 8 1 4 5 7
## [1905] 9 6 9 0 6 1 5 5 8 3 8 2 6 5 0 7 4 6 1 3 4 7 3 2 3 4 2 5 2 7 1 7 2 6
## [1939] 4 1 5 7 8 6 0 1 8 2 5 7 7 6 3 3 5 8 4 2 4 0 8 8 3 4 9 2 7 5 8 6 5 6
## [1973] 0 8 6 7 3 6 4 9 4 6 6 3 2 4 1 0 1 4 6 2 9 1 1 0 6 3 9 5 6 5 6 5 3 4
## [2007] 6 4 3 9 1 3 4 1 9 1 7 1 1 9 3 5 4 0 9 3 6 1 7 5 5 3 3 0 1 5 7 5 8 6
## [2041] 5 1 0 8 2 3 4 6 7 9 8 1 8 9 9 2 8 6 2 7 0 0 6 7 5 8 6 0 9 3 7 1 3 5
## [2075] 4 3 3 5 5 6 3 0 2 3 4 2 3 0 9 9 4 7 2 1 4 7 0 6 2 8 5 2 8 5 7 3 0 8
## [2109] 2 7 2 8 2 5 5 7 6 4 0 8 4 8 2 7 4 5 2 0 3 9 4 6 7 2 5 1 1 1 2 3 6 7
## [2143] 8 7 6 4 8 9 4 8 6 3 8 3 1 0 6 2 2 5 6 9 5 8 1 4 1 7 8 4 6 1 8 4 3 1
## [2177] 2 8 0 8 5 9 2 4 2 0 2 7 0 9 0 2 5 7 6 7 9 4 2 6 2 4 4 8 0 4 4 5 8 0
## [2211] 6 8 9 8 5 6 9 0 4 8 7 1 3 4 5 8 0 9 1 3 3 6 9 8 7 1 0 5 7 1 7 5 2 7
## [2245] 9 1 8 5 2 4 9 4 7 2 2 3 4 9 1 9 2 1 7 9 4 4 1 6 7 2 7 8 8 1 9 7 1 1
## [2279] 7 5 3 3 5 1 3 7 6 1 3 8 7 5 9 0 0 0 2 8 8 2 3 7 1 3 0 3 4 4 3 8 9 2
## [2313] 3 9 7 1 1 7 0 4 9 6 5 9 1 7 0 2 0 2 4 6 7 0 7 1 4 6 4 5 4 9 9 1 7 9
## [2347] 5 3 3 8 2 3 6 2 2 1 1 1 1 1 6 9 8 4 3 7 1 6 4 5 0 4 7 4 2 4 0 7 0 1
## [2381] 9 8 8 6 0 0 4 1 6 8 2 2 3 8 4 8 2 2 1 7 5 4 4 0 4 3 4 7 3 1 0 1 2 5
## [2415] 9 2 1 0 1 8 9 1 4 8 3 8 9 3 6 2 8 3 2 2 1 0 4 2 9 2 4 3 7 9 1 5 2 4
## [2449] 9 0 3 8 5 3 6 0 9 4 6 2 5 0 2 7 4 6 6 8 6 6 8 6 9 1 7 2 5 9 9 0 7 2
## [2483] 7 6 7 0 6 5 4 4 7 2 0 9 9 2 2 9 4 4 2 3 3 2 1 7 0 7 6 4 1 3 8 7 4 5
## [2517] 9 2 5 1 8 7 3 7 1 5 5 0 9 1 4 0 6 3 3 6 0 4 9 7 5 1 6 8 9 5 5 7 9 3
## [2551] 8 3 8 1 5 3 5 0 5 5 3 8 6 7 7 7 3 7 0 5 9 0 2 5 5 3 1 7 7 8 6 5 9 3
## [2585] 8 9 5 3 7 9 1 7 0 0 3 7 2 3 2 1 8 6 2 9 5 7 5 7 8 6 2 5 1 4 8 4 5 8
## [2619] 3 0 6 2 7 3 3 2 1 0 7 3 4 0 3 9 3 2 8 9 0 3 8 0 7 6 5 4 7 3 5 0 8 6
## [2653] 2 5 1 1 0 0 4 4 0 1 2 3 2 7 7 8 5 2 5 7 6 9 1 4 1 6 4 2 4 3 5 4 3 9
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