UNIVERSITY OF OSLO

Faculty of Mathematics and Natural Sciences

Examination in:	STK9900 — Statistical methods and applications.
Day of examination:	8 June 2010.
Examination hours:	09.00 – 12.00.
This problem set consists of 6 pages.	
Appendices:	Tables for the standard normal distribution, the chi-square distributions, the t distributions, and the F distributions.
Permitted aids:	All printed and hand-written resources. Approved calculator.

Please make sure that your copy of the problem set is complete before you attempt to answer anything.

Problem 1

In this problem we will study the influence that some variables have on the birth weight of a child. Our analysis is based on a sample of 500 birth weights from pregnancies where the pregnancy lasted at least 38 weeks.

The response variable, `WEIGHT`, is the weight of a child (in kg), and the covariates we will consider are the following:

`SEX`	Sex of child (0: boy; 1: girl)
`WEEKS`	Length of pregnancy (in weeks)
`AGE`	Age of mother at start of pregnancy (in years)
`FIRST`	Firstborn child or not (0: firstborn child; 1: not firstborn child)

First we fit a linear regression model with the covariates `SEX`, `WEEKS`, and `AGE` (model 1). This gives the following result:

Model 1:

```
Call:
lm(formula=WEIGHT~SEX+WEEKS+AGE)

             Estimate   Std. Error   t value   Pr(>|t|)
(Intercept) -3.064382     0.909318    -3.370    0.00081
SEX         -0.118337     0.038491    -3.074    0.00223
WEEKS        0.161909     0.022345     7.246   1.65e-12
AGE          0.008538     0.003985

(edited output)
```

(Continued on page 2.)

a) Use an appropriate hypothesis test to decide if there is a significant effect of the age of the mother.

We then fit a model where also the covariate `FIRST` is taken into account (model 2):

Model 2:

```
Call:
lm(formula=WEIGHT~SEX+WEEKS+AGE+FIRST)

             Estimate   Std. Error   t value   Pr(>|t|)
(Intercept) -2.941529     0.896679    -3.280    0.00111
SEX         -0.115891     0.037938    -3.055    0.00237
WEEKS        0.160624     0.022023     7.293   1.21e-12
AGE          0.002061     0.004254
FIRST        0.164852     0.041616     3.961   8.55e-05

(edited output)
```

b) Is there a significant effect of the age of the mother in this model? Discuss why model 1 and model 2 give different estimates for the effect of mother's age.

Finally we fit a model with the three covariates `SEX`, `WEEKS`, and `FIRST` (model 3):

Model 3:

```
Call:
lm(formula=WEIGHT~SEX+WEEKS+FIRST)

            Estimate   Std. Error   t value   Pr(>|t|)
(Intercept) -2.85704      0.87888    -3.251    0.00123
SEX         -0.11428      0.03776    -3.026    0.00261
WEEKS        0.15971      0.02193     7.284   1.28e-12
FIRST        0.17260      0.03839     4.496   8.63e-06

(edited output)
```

c) Give an interpretation of the effects of `SEX`, `WEEKS`, and `FIRST`. Predict the weight of a newborn girl who is the second child of her mother, and where the length of the pregnancy is 40 weeks.

(Continued on page 3.)

Problem 2

Byssinosis, also called "brown lung disease", is a chronic asthma-like disease of the lungs caused by breathing in cotton dust or dusts from other vegetable fibers. In this problem we will look at data from a study of workers in the cotton industry. The variable of interest is presence of byssinosis, and we will relate this to the following categorical covariates (factors):

`DUST`	Dustiness of the workplace (1: high; 2: medium; 3: low)
`EMPLOY`	Length of employment in the cotton industry (1: less than 10 years; 2: between 10 and 20 years; 3: more than 20 years)
`SMOKE`	Smoking status (1: smoker, 2: nonsmoker)

For all combinations of the levels of the three factors, we know the number of workers who suffer from byssinosis (`NOBYS`) as well as the total number of workers (`NOTOT`).

a) Explain why logistic regression is an appropriate model for analysing the data.

When we fit the logistic regression model with `DUST` as the only covariate (model 1), we get the result:

Model 1:

```
Call:
glm(formula=cbind(NOBYS,NOTOT-NOBYS)~factor(DUST),family=binomial)

              Estimate   Std. Error   z value   Pr(>|z|)
(Intercept)    -1.6811       0.1063   -15.817     <2e-16
factor(DUST)2  -2.5847       0.2601    -9.939     <2e-16
factor(DUST)3  -2.7151       0.1881   -14.431     <2e-16

    Null deviance: 290.739  on 17  degrees of freedom
Residual deviance:  38.630

(edited output)
```

b) Describe how the dustiness of the workplace influences the probability that a worker will suffer from byssinosis.

(Continued on page 4.)

Next we fit a model with the covariates `DUST` and `EMPLOY` (model 2):

Model 2:

```
Call:
glm(formula=cbind(NOBYS,NOTOT-NOBYS)~factor(DUST)+factor(EMPLOY),
            family=binomial)

                Estimate   Std. Error   z value   Pr(>|z|)
(Intercept)      -2.0146       0.1446   -13.934    < 2e-16
factor(DUST)2    -2.6083       0.2608   -10.002    < 2e-16
factor(DUST)3    -2.7613       0.1893   -14.589    < 2e-16
factor(EMPLOY)2   0.5643       0.2479     2.277   0.022810
factor(EMPLOY)3   0.6732       0.1808     3.724   0.000196

    Null deviance: 290.739  on 17  degrees of freedom
Residual deviance:  23.527

(edited output)
```

c) Estimate the odds ratio between workers who have been employed between 10 and 20 years and those who have been employed less than 10 years. Also estimate the odds ratio between workers who have been employed more than 20 years and those who have been employed between 10 and 20 years. Describe what the estimated odds ratios tell you.

Finally we fit a model with the three covariates `DUST`, `EMPLOY`, and `SMOKE` (model 3):

Model 3:

```
Call:
glm(formula=cbind(NOBYS,NOTOT-NOBYS)~factor(DUST)+factor(EMPLOY)
            +factor(SMOKE),family = binomial)

                Estimate   Std. Error   z value   Pr(>|z|)
(Intercept)      -1.8336       0.1525   -12.026    < 2e-16
factor(DUST)2    -2.5493       0.2614    -9.753    < 2e-16
factor(DUST)3    -2.7175       0.1898    -14.314    < 2e-16
factor(EMPLOY)2   0.5060       0.2490     2.032   0.042119
factor(EMPLOY)3   0.6728       0.1813     3.710   0.000207
factor(SMOKE)2   -0.6210

    Null deviance: 290.739  on 17  degrees of freedom
Residual deviance:  12.094

(edited output)
```

(Continued on page 5.)

d) Use an appropriate hypothesis test to decide if smoking has a significant effect on the risk of suffering from byssinosis.

Problem 3

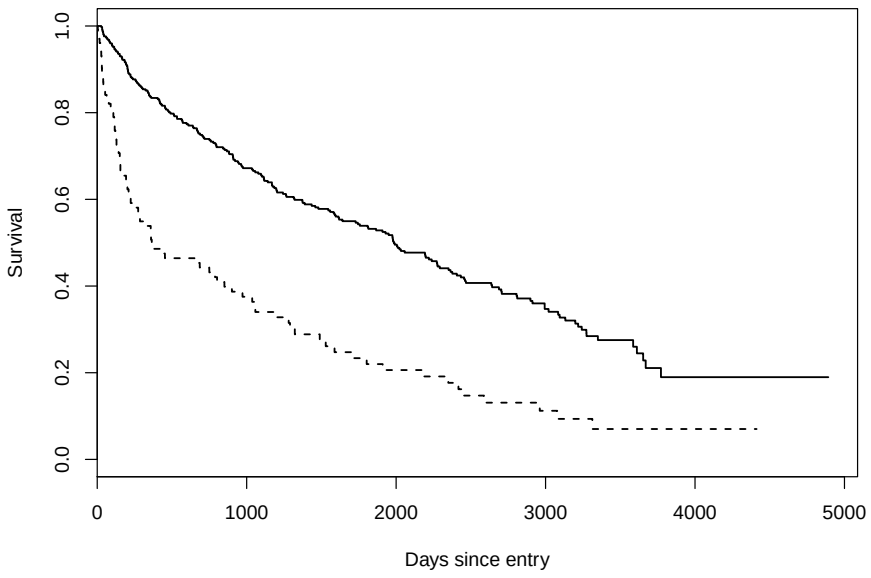
From 1962 to 1969, 488 patients with liver cirrhosis at several hospitals in Copenhagen were included in a study. A number of covariates were recorded when the patients entered the study, and the patients were followed until death or to the end of the study October 1st, 1974.

In this problem we will consider the two binary covariates:

`SEX` Gender (0=female; 1=male)

`ASC` ascites (excess fluid in the abdomen) at start of treatment (0: absent; 1: present)

In addition to the two covariates, we for each patient know the time (in days) from entry into the study to death/censoring (`TIME`) and an indicator for death/censoring (`STATUS`).



a) The plot above gives Kaplan-Meier estimates for patients with ascites (dashed line) and patients without ascites (drawn line). Describe what you may learn from the plot.

(Continued on page 6.)

b) Explain why Cox regression is an appropriate model for studying the effect of the covariats `ASC` and `SEX`.

When we fit a Cox regression model with the two covariates, we get the result:

```
Call:
coxph(formula = Surv(TIME, STATUS) ~ ASC + SEX, data = cirrhosis)

          coef    se(coef)
ASC     0.8941      0.1317
SEX     0.2373      0.1208

(edited output)
```

c) Define the hazard ratio (relative risk) between patients with ascites and patients without ascites. Estimate the hazard ratio and derive a 95% confidence interval for it. Describe what the estimated hazard ratio and the confidence interval tell you.