Advanced Data Analysis
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1. Consider a multiple linear regression model

a). Investigate whether there is any multicollinearity:
There is multicollinearity. Although there does not exist a VIF larger than 10, the mean VIF is greater than 1 which indicates a serious multicollinearity

```
> vif(multiLinearModel)
     age      lwt     race    smoke      ptl       ht       ui
1.125945 1.177116 1.224579 1.206096 1.124835 1.087378 1.087593
     ftv
1.076820

> mean(vif(multiLinearModel))
[1] 1.138795
```

b). Run a ridge regression analysis and compare the results with (i):
The coefficients from ridge regression model are somewhat shrunken comparing to linear regression

Comparison:

	Linear Regression	Ridge Regression
(Intercept)	3129.46	3125.3122
age	-0.2658	-0.1828
lwt	3.4351	3.4173
race	-188.4895	-187.0416
smoke	-358.4552	-355.6267
ptl	-51.1526	-52.0323
ht	-600.6465	-596.6093
ui	-511.2512	-508.5071
fty	-15.5358	-15.2083

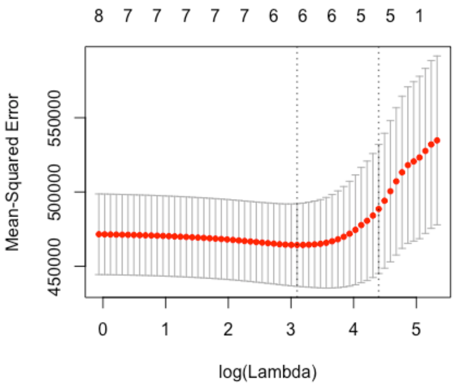
```
> summary(multiLinearModel)$coef
               Estimate Std. Error     t value     Pr(>|t|)
(Intercept) 3129.459388 344.242352  9.09086104 1.783264e-16
age           -0.265810   9.594740 -0.02770372 9.779291e-01
lwt            3.435131   1.699899  2.02078565 4.478380e-02
race        -188.489514  57.733892 -3.26479832 1.311221e-03
smoke       -358.455188 107.517228 -3.33393256 1.039609e-03
ptl          -51.152559 103.000275 -0.49662546 6.200592e-01
ht          -600.646526 204.345418 -2.93936870 3.720106e-03
ui          -511.251254 140.279187 -3.64452677 3.503426e-04
ftv          -15.535798  46.935377 -0.33100402 7.410265e-01

> lm.ridge(bwt ~ age + lwt + race + smoke + ptl + ht + ui + ftv, data = birthwt, lambda = 1)
                      age          lwt         race        smoke
3125.3122243   -0.1827917    3.4173081 -187.0415935 -355.6267387
         ptl           ht           ui          ftv
 -52.0323232 -596.6093106 -508.5071287  -15.2082711
```

2. Compare models selected using LASSO and a stepwise procedure

Lasso:

According to the result of cross validation, choose lambda:



The coefficients of lasso are:

```
> coef
9 x 1 sparse Matrix of class "dgCMatrix"
                      1
(Intercept) 3104.597034
age            .
lwt            2.725628
race        -157.669973
smoke       -301.555511
ptl          -29.212313
ht          -479.296453
ui          -462.170874
ftv            .
```

Stepwise Procedure:

```
Coefficients:
(Intercept)          lwt         race        smoke           ht
   3104.438        3.434     -187.849     -366.135     -595.820
         ui
   -523.419
```

Comparison:

	Lasso	Stepwise
(Intercept)	3104.5970	3104.438
age	0	0
lwt	2.7256	3.434
race	-157.6700	-187.849
smoke	-301.5555	-366.135
ptl	-29.2123	0
ht	-479.2965	-595.820
ui	-462.1709	-523.419
fty	0	0

3. For the procedures listed in Table 1 next page, give appropriate ranks with respect to the listed attributes:

	OLS	Ridge	Lasso	Elastic Net
Performance when p >> n	3	2	1	1
Performance under multicollinearity	3	1	2	1
Unbiased estimators	1	3	3	3
Model selection capability	3	3	1	1
Simplicity Computation, Inference, Interpretation	1	2	3	3