**Question 3.** (*15 points*)

Ornitologists and bird watchers are involved not only with counting birds but also with obtaining basic information about the birds such as their size and age. In a small study, the wing lengths of thirteen young sparrows of various ages were measured; the values are shown in the table below.

| Age (days) | Wing length (cm) |
|---|---|
| 3 | 1.4 |
| 4 | 1.5 |
| 5 | 2.2 |
| 6 | 2.4 |
| 8 | 3.1 |
| 9 | 3.2 |
| 10 | 3.2 |
| 11 | 3.9 |
| 12 | 4.1 |
| 14 | 4.7 |
| 15 | 4.5 |
| 16 | 5.2 |
| 17 | 5.0 |

Use the data of the table and any of the attached Minitab listings to answer to the questions.

**a)** Formulate a statistical model for the data to establish a relationship between sparrow's age and wing length. Give estimates and, if possible, also confidence intervals for the model parameters. Comment briefly on the strength of the relationship between the two variables.

**b)** Once a dispute broke out between two bird watchers. Jones reported a 14 days old sparrow to have a wing length of 5.0 cm, but Peters claimed that a bird of that size would have been older than 14 days. Can you use the present data to settle the dispute? Discuss what statements you are able to make about the dispute, and the assumptions they rely on.

**c)** In the field, it is of practical importance to be able to estimate the age of observed birds. Assume that a bird with a wing length of 4.5 cm is found. Use the present data to estimate its age. If time permits, discuss how one might proceed to obtain a confidence interval for the estimate.

(*Minitab listing on the following pages.*)

*Minitab listing for Question 3*:

```
MTB > Correlation 'age' 'wlength'.
Correlations: age, wlength

Pearson correlation of age and wlength = 0.987
P-Value = 0.000


MTB > Regress 'age' 1 'wlength';
SUBC>   Constant;
SUBC>   Predict 'wlength';
SUBC>   Brief 2.
Regression Analysis: age versus wlength

The regression equation is
age = - 2.39 + 3.64 wlength

Predictor     Coef  SE Coef      T      P
Constant   -2.3889   0.6467  -3.69  0.004
wlength     3.6356   0.1787  20.34  0.000

S = 0.785274   R-Sq = 97.4%   R-Sq(adj) = 97.2%

Analysis of Variance

Source          DF      SS      MS       F      P
Regression       1  255.22  255.22  413.87  0.000
Residual Error  11    6.78    0.62
Total           12  262.00

Predicted Values for New Observations

New
Obs     Fit  SE Fit       95% CI            95% PI
  1   2.701   0.420  ( 1.777,  3.625)  ( 0.741,  4.661)
  2   3.064   0.405  ( 2.174,  3.955)  ( 1.120,  5.009)
  3   5.609   0.307  ( 4.934,  6.284)  ( 3.754,  7.465)
  4   6.336   0.283  ( 5.714,  6.958)  ( 4.500,  8.173)
  5   8.881   0.225  ( 8.387,  9.376)  ( 7.084, 10.679)
  6   9.245   0.221  ( 8.759,  9.731)  ( 7.449, 11.040)
  7   9.245   0.221  ( 8.759,  9.731)  ( 7.449, 11.040)
  8  11.790   0.235  (11.273, 12.307)  ( 9.986, 13.594)
  9  12.517   0.250  (11.966, 13.068)  (10.703, 14.331)
 10  14.698   0.317  (14.000, 15.397)  (12.834, 16.563)
 11  13.971   0.292  (13.327, 14.615)  (12.127, 15.816)
 12  16.152   0.373  (15.332, 16.973)  (14.239, 18.066)
 13  15.789   0.358  (15.000, 16.578)  (13.889, 17.689)
```

```
Values of Predictors for New Observations

New
Obs  wlength
  1     1.40
  2     1.50
  3     2.20
  4     2.40
  5     3.10
  6     3.20
  7     3.20
  8     3.90
  9     4.10
 10     4.70
 11     4.50
 12     5.10
 13     5.00


MTB > Regress 'wlength' 1  'age';
SUBC>   Constant;
SUBC>   Predict  'age';
SUBC>   Brief 2.
Regression Analysis: wlength versus age

The regression equation is
wlength = 0.728 + 0.268 age

Predictor     Coef  SE Coef      T      P
Constant    0.7283   0.1444   5.04  0.000
age        0.26794  0.01317  20.34  0.000

S = 0.213183   R-Sq = 97.4%   R-Sq(adj) = 97.2%

Analysis of Variance

Source          DF      SS      MS       F      P
Regression       1  18.809  18.809  413.87  0.000
Residual Error  11   0.500   0.045
Total           12  19.309

Predicted Values for New Observations

New
Obs     Fit  SE Fit       95% CI            95% PI
  1  1.5321  0.1095  (1.2911, 1.7732)  (1.0046, 2.0596)
  2  1.8001  0.0987  (1.5828, 2.0173)  (1.2830, 2.3171)
  3  2.0680  0.0885  (1.8732, 2.2628)  (1.5600, 2.5760)
  4  2.3359  0.0792  (2.1616, 2.5102)  (1.8354, 2.8365)
```

```
  5  2.8718  0.0647  (2.7293, 3.0143)  (2.3814, 3.3622)
  6  3.1398  0.0606  (3.0064, 3.2731)  (2.6520, 3.6275)
  7  3.4077  0.0591  (3.2776, 3.5378)  (2.9208, 3.8946)
  8  3.6756  0.0606  (3.5423, 3.8090)  (3.1878, 4.1634)
  9  3.9436  0.0647  (3.8011, 4.0860)  (3.4532, 4.4339)
 10  4.4794  0.0792  (4.3051, 4.6537)  (3.9789, 4.9800)
 11  4.7474  0.0885  (4.5526, 4.9422)  (4.2393, 5.2554)
 12  5.0153  0.0987  (4.7981, 5.2326)  (4.4983, 5.5324)
 13  5.2833  0.1095  (5.0422, 5.5243)  (4.7558, 5.8108)

Values of Predictors for New Observations

New
Obs   age
  1   3.0
  2   4.0
  3   5.0
  4   6.0
  5   8.0
  6   9.0
  7  10.0
  8  11.0
  9  12.0
 10  14.0
 11  15.0
 12  16.0
 13  17.0
```