**One-way ANOVA**

**Question 6: 2009**

You are working for a biotech company in Sydney that develops anti-fouling products incorporated into paints. The company has developed a new product to prevent barnacles from colonizing pylons and they ask you to determine if their new product (X) reduces the numbers of colonizing limpets compared to three other traditional heavy metal based compounds (A, B, C) used by their competitors. For each compound, you determine the mean number of barnacles settled from 8 trials involving separate plates placed on the Maroubra rock platform for each compound. Each plate is 20cm x 20cm bolted to the rock platform and then painted in the compound, and the key response is the number of barnacles found encrusting the plate after 6 weeks. The mean numbers of settlers per plate for the 3 groups were: X=11.2, A=13.4, B=14.2, C = 10.2. All of the assumptions for an ANOVA were fulfilled by the data. ANOVA on the data gave a residual (within) sums of squares of 2.10.

1. Draw up an ANOVA table and complete it as far as possible with the data provided above. Give your calculations. (10 marks)
2. In general terms, what does the P value in an ANOVA table tell you? (i.e. what is it a measure of?) (3 marks)
3. In general, did the new compound reduce colonization by barnacles compared to competing products? Justify your conclusions. (5 marks)
4. State you conclusions about whether compound X will give the best protection against encrusting barnacles for the compounds used in these trials? (2 marks)

**QUESTION 4.** 2010

You’ve been asked by the NSW Egg Board to test whether there is a taste difference between battery hen eggs, free range eggs and organic eggs. You organise a taste test with volunteers who will rate the taste on a scale of 1 (bad) to 10 (great) of the three types of eggs, which have been cooked by poaching. To avoid “egg-saturation” effects— the phenomenon where by the eating of too many eggs can lead to lower rating for eggs eaten later in a sequence— each taster only tastes and ranks one egg. There are 15 tasters per egg type and they do not know which type of egg they are tasting.

The mean ratings for the three egg types are battery hen = 3.2, free range=5.2, organic=7.2. All of the assumptions for an ANOVA were fulfilled by the data. ANOVA on the data gave a residual (within) sums of squares of 627.

Answer both parts 4A and 4B.

**4A)** Draw up an ANOVA table and complete it as far as possible with the data provided above. Give your calculations. (10 marks**)**

**4B)** In general, was the organic egg rated more highly for taste than the other eggs. Justify your conclusions. (10 marks)

**QUESTION 5. 2012**

You are working for a scientist in Sydney who is investigating bat feeding behavior in an urban park, a rural roadside reserve and a forested reserve. She sets out Anabat data loggers to record the feeding behaviour in one species of bat. You are asked to determine if the bat feeds more frequently in the forested reserve (A) than in the roadside reserve (B) and the urban park (C). For each habitat, you listen to the mean number of feeding buzzes recorded for the target species each evening. For the different treatments, n=10 nights are surveyed, and the key response is the number of feeding buzzes recorded at dusk. The mean number of feeding buzzes for the treatments were: A=5.87, B=4.401 and C=2.25. All of the assumptions for an ANOVA were fulfilled by the data. ANOVA on the data gave a residual (within) sums of squares of 11.896.

Answer all parts 5A-5C.

**5A)** Draw a diagram of the experimental design. (5 marks)

**5B)** Draw up an ANOVA table and complete it as far as possible with the data provided above. Give your calculations. (9 marks)

**5C)** In general, did the bats feed more in the forested reserve? Justify your conclusions. (6 marks)

**QUESTION 5. 2013**

You are a scientist working in the Murray-Darling Basin who is investigating invertebrate productivity in a free-flowing river, a restored river and a regulated river. You collect micro-crustacean samples with a bilge pump within each river. You are asked to determine if the micro-crustaceans have higher densities in the free-flowing river (A) than in the restored river (B) and the regulated river (C). For each river, you record the mean number of micro-crustaceans per litre. For the different treatments, n = 10 samples are collected, and the key response is the number of micro-crustaceans per litre. The mean number of micro-crustaceans per litre for the treatments were: A = 970.5, B = 117.5 and C = 9.7. All of the assumptions for an ANOVA were fulfilled by the data. ANOVA on the data gave a residual (within) sums of squares of 2165035.6.

Answer all parts 5A-5C.

**5A)** Draw a diagram of the experimental design. (5 marks)

**5B)** Draw up an ANOVA table and complete it as far as possible with the data provided above. Give your calculations. (9 marks)

**5C)** In general, did the micro-crustaceans have higher densities in the free-flowing river than the restored and regulated rivers? Justify your conclusions. (6 marks)

**QUESTION 5.** 2014

You are a soil scientist in Dubbo who is investigating the storage of carbon in floodplain sediments dry for 14, 4 and 1 years. You collect sediment samples and process the percentage of organic matter in the laboratory. You want to determine if there is more organic matter stored in soils flooded 1 year ago (A) than 4 years ago (B) and 14 years ago (C).

For the different treatments, n = 9 samples are collected, and the key response is the percentage of organic matter. The mean percentages of organic matter for the treatments were: A = 30.3, B = 30.3 and C = 14.4. All of the assumptions for an ANOVA were fulfilled by the data. ANOVA on the data gave a residual (within) sums of squares of 2073.887.

Answer all parts 5A to 5C.

**5A)** Draw a diagram of the experimental design. (5 marks)

**5B)** Draw up an ANOVA table and complete it as far as possible with the data provided above. Give your calculations. (9 marks)

**5C)** In general, did increased drying of floodplain sediments decrease organic matter in floodplain sediments? Justify your conclusions. (6 marks)

**QUESTION 7: 2006**

You are working for a biotech company in Sydney that is developing antibacterial agents derived from wallaby milk. The company has developed a new product designed to kill bacteria on contact lenses and they ask you to determine if their new product (X) kills more bacteria than three other traditional compounds (A, B, C) used by their competitors. For each compound, you determine the mean number of types of bacteria that appear on treated contact lenses in 10 trials involving different wearers. Contact lenses are normally rapidly covered by bacteria in a short period. For the different treatments, lenses are coated with the relevant deterrent compound, and the key response is the number of bacteria strains found on the lens after 10 days. The mean numbers of bacteria strains per lens for the groups were: X=2.2, A=8.4, B=5.1, C = 3.2. All of the assumptions for an ANOVA were fulfilled by the data. ANOVA on the data gave a residual (within) sums of squares of 1.90.

1. Draw up an ANOVA table and complete it as far as possible with the data provided above. Give your calculations. 10 marks
2. In general, did the new compound deter bacteria better than the competing products? Justify your conclusions. 10 marks

**QUESTION 7: 2006 supp**

You are working as a biosecurity agent for a pesticide company. The company has developed a new poison to kill cockroaches and they want to market the product as the fastest acting cockroach killer. They ask you to determine if their new poison (X) kills cockroaches faster than than the other 3 market leaders (A,B,C). For each product, you determine the mean time to death of cockroaches from trials involving 9 separate small aquaria for each product, each with a single cockroach, and measuring the knockdown time after exposure to 1 spray (1ml) of the pesticide. The mean knockdown times (in seconds) for the 4 groups were: X=2.3, A=3.4, B=4.2, C=3.7. All of the assumptions for an ANOVA were fulfilled by the data. ANOVA on the data gave a residual (within) mean square of 0.212.

1. Draw up an ANOVA table and complete it as far as possible with the data provided above (7 marks). Show your working
2. What are the identifiable sources of variation in this dataset (5 marks).
3. Draw a diagram that shows heterogenous versus homogenous variance using this dataset as the example. (3 marks)
4. In general, did you your companies’ product kill cockroaches faster than the other products available? Justify your conclusions with working (5 marks).

**QUESTION 7: 2007**

You are working for a biotech company in Sydney that is developing herbivore deterrents derived from predator urine. The company has developed a new product designed to deter wallabies from feeding on treated trees to help improve tree survival in reforestation efforts as part of a carbon-trading scheme. They ask you to determine if their new product (X) is better at deterring wallabies than two other traditional compounds (A, B) used by their competitors.

For each compound, you determine the mean number of leaves chewed on seedlings in a wallaby enclosure. For the different treatments, n=15 seedlings are coated with the relevant deterrent compound, and the key response is the leaves chewed by wallabies on replicate seedlings after 2 days. The mean numbers of leaves chewed per seedling for the treatments were: X=3.2, A=5.2, B=7.2. All of the assumptions for an ANOVA were fulfilled by the data. ANOVA on the data gave a residual (within) sums of squares of 1.90.

1. Draw up an ANOVA table and complete it as far as possible with the data provided above. Give your calculations. 10 marks
2. In general, did the new compound deter wallabies better than the competing products? Justify your conclusions. 10 marks